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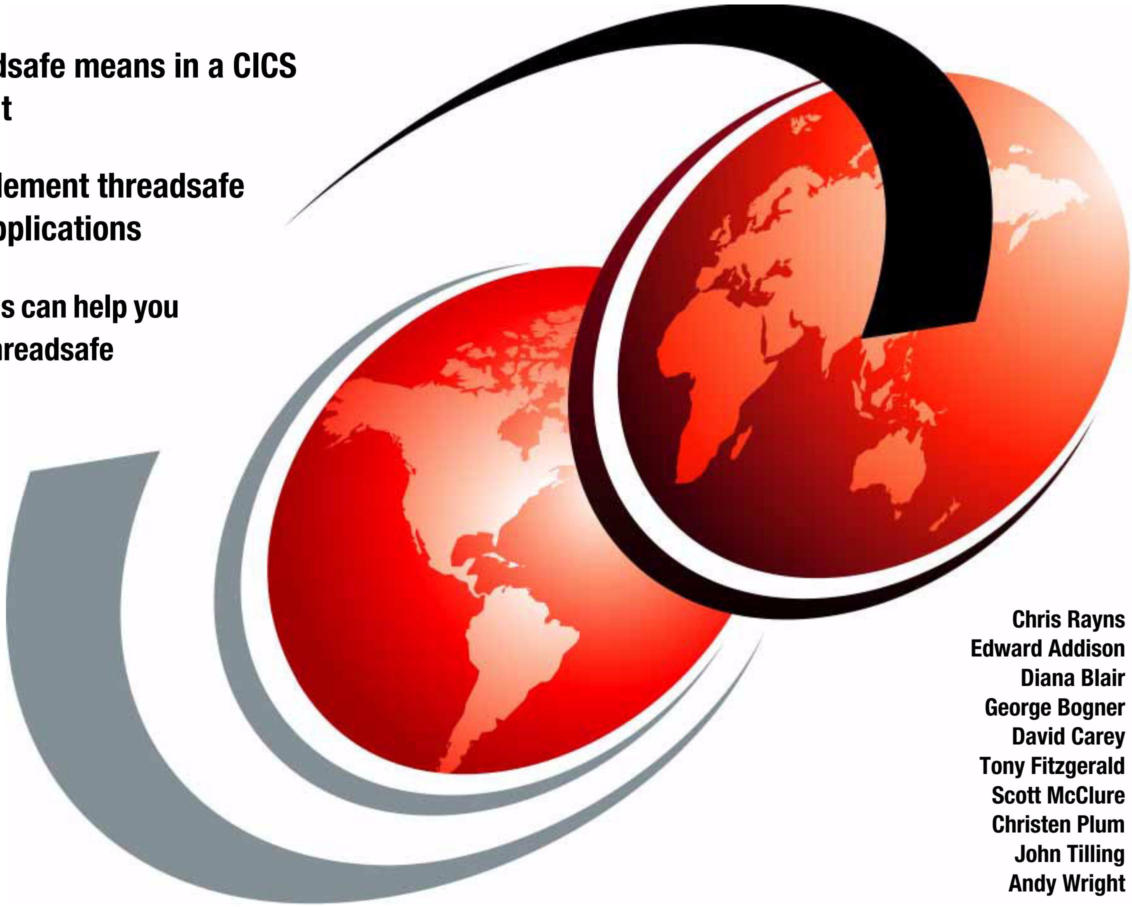
SG24-6351-03

Threadsafe considerations for CICS

What threadsafe means in a CICS environment

How to implement threadsafe exits and applications

How the Tools can help you migrate to threadsafe



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Threadsafe considerations for CICS

July 2010

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Note: Before using this information and the product it supports, read the information in "Notices" on page xi.

First Edition (July 2010)

This edition applies to Version ???, Release ???, Modification ??? of ???insert-product-name??? (product number ????-???).

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Preface

This IBM® Redbooks® document is a comprehensive guide to threadsafe concepts and implementation in the context of CICS. In addition to providing detailed instructions for implementing threadsafe in your environment, it describes the real world experiences of users migrating applications to be threadsafe, along with our own experiences. It also presents a discussion of the two most critical aspects of threadsafe, system performance and integrity.

Originally, CICS employed a single TCB to process everything (such as application code, task dispatching, terminal control, file control, and so on) executed on what today is known as the *application* or Quasi-reentrant (QR) TCB. Over time, CICS added specialized TCBs to help offload management tasks from the overcrowded QR TCB. VSAM subtasking, the VTAM® High Performance Option, and asynchronous journaling were all implemented on separate TCBs. Of course, the DB2® and MQ Series attachment facilities also employ TCBs apart from the application TCB. Distributing processing among multiple TCBs in a single CICS address space is not new, but customers and ISVs had little control over which TCB CICS is selected to dispatch a given function.

Beginning with CICS Version 2, all of that has changed. Applications can execute on TCBs apart from the QR TCB. This has positive implications for improving system throughput and for implementing new technologies inside of CICS. Use of the MVS JVM inside CICS and enabling listener tasks written for other platforms to be imported to run under CICS are examples of implementing new technologies.

CICS Transaction Server for z/OS® Version 3 Release 2 provides additional functions and enhancements. This updated book covers the latest features, including local and RLS File Control threadsafe commands, threadsafe CICS journaling commands, threadsafe definition for system autoinstalled global user exits (GLUE), and threadsafe WMQ commands.

The team that wrote this book

This book was produced by a team of specialists from around the world working at the International Technical Support Organization, Poughkeepsie Center.

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Summary of changes

This section describes the technical changes made in this edition of the book and in previous editions. This edition may also include minor corrections and editorial changes that are not identified.

Summary of Changes for SG24-6351-03
Threadsafe considerations for CICS
as created or updated on July 30, 2010.

July 2010, First Edition

This revision reflects the addition, deletion, or modification of new and changed information described below.

- Chapter 5 updated for CICS Explorer

Part 1

Introducing threadsafe

In Part 1 we introduce threadsafe concepts and definitions, provide an overview of threadsafe considerations in CICS, and discuss techniques for ensuring that applications will operate as expected in a multi-processing environment.

1

Introduction

In this chapter we provide some introductory information about the CICS Open Transaction Environment (OTE), including:

- The benefits of CICS OTE:
  - Increased throughput
  - Non-CICS API introduced
  - Improved performance
- CICS data integrity of shared resources
- Benefits of migrating applications to threadsafe

1.1 The concept of CICS Open Transaction Environment

CICS Open Transaction Environment (OTE) is an architecture that was introduced mainly for three purposes:

- To increase throughput via more concurrency
- To improve performance
- To introduce the possibility to use non-CICS APIs

Prior to OTE, all application code runs under the main CICS TCB called the Quasi-reentrant (QR) TCB (except for some specific VSAM execution, and other specialized activity such as FEPI, security calls, and file opens and closes, which used other TCBs). The CICS dispatcher sub-dispatches the use of the QR TCB between the different CICS tasks. Each task voluntarily gives up control when it issues a CICS service, which then can cause a CICS dispatcher wait. Only one CICS task can be active at any one time on the QR TCB.

But the one and only QR TCB could only execute on one CPU, so CICS execution was only using one physical CPU at a time. For that reason the limit of of a specific CICS system's execution capacity was set by the MIPS size of the single CPU of the related MVS system.

SQL calls were done on attached TCBs to prohibit blocking of the QR TCB when a CICS program was waiting for a conclusion of a DB2 request. This feature was called the CICS/DB2 attachment facility.

CICS Transaction Server Version 3 has now expanded OTE usage to not only those applications making DB2 calls, but to any application by means of a new keyword on the program definition.

z/OS Communications Server Version 1 Release 7 has been enhanced to allow the IP CICS Sockets task-related user exit (TRUE) to be enabled as OPENAPI. At the time of writing we now have three TRUEs that can be enabled as OPENAPI: DB2, IP CICS Sockets, and Websphere MQ.

Note: Blocking means the TCB is halted by an MVS wait.

1.1.1 Improved throughput

OTE introduces a new class of TCB, which can be used by applications, called an *open TCB*. An open TCB is characterized by the fact it is assigned to a CICS task for its sole use, and multiple OTE TCBs can run concurrently in CICS. There are several modes of open TCBs used to support various functions, such as

Java™ in CICS, open API programs, and C and C++ programs, which have been compiled with the XPLink option.

There is no sub-dispatching of other CICS tasks on an open TCB.

The OTE introduces a lot of new engines (TCBs) to CICS program execution. Each new TCB can execute on one CPU in parallel (concurrently). This gives the potential of increased throughput for a single CICS system, as long as the necessary CPU power is present.

1.1.2 Improved performance

Each new TCB represents a thread where a CICS program can execute in parallel. When the CICS program continues to execute on the open TCB, it is called a *threadsafe* execution of the program. The result is a reduced number of TCB switches between the open TCB and the QR TCB. This, in turn, results in reduced CPU consumption corresponding to the number of saved TCB switches. The more CICS commands that are made threadsafe the more probability you will remain executing on the open TCB.

1.2 CICS data integrity for shared resources

This section discusses the concept of quasi-reentrant execution and threadsafe execution in relation to access to shared resources.

1.2.1 Quasi-reentrant and threadsafe programs

Programs are said to be quasi-reentrant programs because they take advantage of the behavior of the CICS dispatcher and the QR TCB—in particular there is only ever one CICS task active under the QR TCB. This means that although the same program can be being executed by multiple CICS tasks, only one of those CICS tasks is active at any given point in time. Compare this with a situation in which multiple instances of the same program are each executing under a separate TCB. In this scenario, multiple tasks would be active in the same program at the same time and the program would have to be fully MVS reentrant at the very least. For a program to be threadsafe, it must go beyond being fully reentrant and use appropriate serialization techniques when accessing shared resources.

Quasi-reentrant programs always run under the QR TCB and can access shared resources such as the Common Work Area (CWA) or shared storage obtained via EXEC CICS GETMAIN SHARED safe in the knowledge they are the only CICS user task running at that point in time. This is because running under the QR TCB guarantees serialized access to those shared resources. An example would be a program that updates a counter in the CWA. The program is sure to be alone to update this counter, and when it stops or gets suspended by the CICS dispatcher, it is sure to know that the counter still has the value that was assigned.

1.2.2 Shared application resources

Since multiple tasks can potentially access shared resources simultaneously, when executing under an open TCB, applications that access shared resources (such as the CWA) must bear the responsibility of ensuring the integrity of those resources by implementing an appropriate serialization technique.

1.2.3 Shared CICS resources

CICS assumes responsibility for ensuring integrity of all the resources it manages. Either the CICS code has been amended to run on multiple TCBs safely (for example, the CICS code that handles temporary storage requests) or CICS will ensure that the code runs on the QR TCB.

The use of non-threadsafe CICS commands that must run on the QR TCB can, depending on the application, have a performance penalty. This is because of the need to switch TCBs when a non-threadsafe CICS command is encountered. If there are many non-threadsafe CICS commands in a program that is otherwise threadsafe, the extra switching back to the QR TCB will have a detrimental effect on performance. However, there will be no risk to data integrity.

In our example of a program using a CWA counter, by implementing an appropriate serialization technique this formerly quasi-reentrant program would run in an OTE environment. Therefore, this allows multiple instances of this program to execute at the same time. The counter value in the CWA could be changed by multiple executors at the same time and one instance would always be sure about the counter value when it stops or gets suspended.

1.2.4 Threadsafe applications

For the purposes of this book, we define the term *threadsafe application* as a collection of application programs that employ an agreed-upon form of serialized access to shared application resources. A program written to *threadsafe standards*, then, is a program that implements the agreed-upon serialization techniques. It is important to understand that a single program operating without the agreed-upon serialization technique can destroy the predictability and therefore the integrity of an entire system of otherwise threadsafe programs. Therefore, an application system cannot be considered *threadsafe* until all programs that share a common resource implement that application's threadsafe standards.

Note: An application that does not use any of the shared resources, which will be discussed later, can be said to be threadsafe even if it uses non-threadsafe CICS commands, unless it is self-modifying and therefore not reentrant.

1.3 Benefits of migrating applications to adhere to threadsafe standards

In this section we identify and outline the potential business drivers that lead CICS customers to migrate their applications to a threadsafe environment.

There are three principle drivers, which are covered in the following sections:

- Improving performance
- Reducing cost
- Exploitation of OTE

This section concludes with a warning: There is a risk associated with defining an application as threadsafe, and this risk must be understood and eliminated before migration is attempted.

1.3.1 Improve performance

Customers who should benefit most from migrating to a threadsafe environment are those who experience poor response times for any of the following reasons:

- The CICS QR TCB is CPU constrained.
- Application programs are waiting excessively for the QR TCB.
- The CICS region in general is CPU constrained.

These situations are described in detail in the following sections.

CICS QR TCB is CPU constrained

In this scenario, the CICS QR TCB is consistently reaching system CP SHARE (QR TCB is running at 100% CPU) and has to wait to be dispatched by the operating system. Every task running under the QR TCB is being delayed.

Defining transactions as threadsafe, processing as many tasks as possible on an open TCB will remove this constraint on the QR TCB and reduce the response times of both threadsafe and non-threadsafe transactions.

> **CP SHARE calculation:** CP SHARE is the amount of a CP an LPAR is guaranteed before it is eligible to have the CP removed. For CICS to perform well, the CP SHARE for the LPAR where it is executing must be fairly high (90+% is great; 80% is good; 70% is workable).
>
> ```
> CP SHARE = ((# available physical CP * 100)/(# logical CP in LPAR)) * FAIR SHARE.
> ```

See Chapter 12, “Diagnosing performance problems” on page 299 for more details on performance.

Application tasks are waiting excessively for the QR TCB

In this scenario, the QR TCB is not CPU constrained, but application tasks are contending for their share of QR.

Again, defining transactions as threadsafe and moving as many tasks as possible to an open TCB will reduce contention for the QR TCB, and reduce the response times of both threadsafe and non-threadsafe transactions.

CICS region in general is CPU constrained

In this scenario, the system as a whole is at or approaching 100% busy, and CICS is being constrained along with everything else.

Depending on how an application is designed, defining it as threadsafe can significantly reduce the path length of application tasks. The transactions that will achieve the greatest CPU reduction are likely to be DB2 applications that have the following characteristics:

- A significant number of EXEC SQL calls are invoked per task.
- All programs invoked between the first and last EXEC SQL or WMQ call in each task are defined as threadsafe.
- All exits invoked as part of an EXEC SQL call are defined as threadsafe, and only contain threadsafe EXEC CICS commands.
- All exits invoked between the first and last EXEC SQL or WMQ call in each task are defined as threadsafe.
- All EXEC CICS statements invoked between the first and last EXEC SQL or WMQ call in each task are threadsafe.

Defining transactions with the preceding characteristics as threadsafe will all but eliminate TCB switches for the associated CICS tasks.

1.3.2 Reduce the cost of computing

Reducing the CPU consumption of an application does not always necessarily result in improved response times. An application may be a heavy user of CPU, but if the processor has spare capacity and the application is not CPU constrained, then a reduction in path length may have a negligible impact on response times.

However, for many customers, the financial cost incurred running their applications is related to the amount of CPU consumed. Under these circumstances, the CPU savings gained by migrating appropriate applications to a threadsafe environment can equate to a financial saving. As we show in Chapter 9, "Migration scenario" on page 227, the CPU savings for some applications can be substantial.

1.3.3 Exploitation of OTE

OTE in CICS has been implemented in three stages, over several releases of the CICS Transaction Server:

- Stage 1 - OTE function introduced: Delivered in CICS TS 1.3
- Stage 2 - TRUEs can exploit OTE: Delivered in CICS TS 2.2
- Stage 3 - Full application use of open TCBs: Delivered in CICS TS 3.1

Applications that can be defined as threadsafe in CICS Transaction Server Version 2 will be able to exploit the enhancements provided at CICS Transaction Server Version 3.1 with minimum migration effort. Moreover, it is a recommendation from IBM that all new application programs should be written to threadsafe standards at whatever level of CICS they are developed.

1.3.4 Understand the application - a warning

What do we mean when we say an application is *threadsafe*?

A threadsafe program is defined as a program that does one of the following:

- Uses appropriate serialization techniques, such as Compare and Swap or enqueue, when accessing any shared application resources. It must be capable of running concurrently on multiple TCBs, and must not rely on quasi-reentrancy to serialize access to shared resources and storage.
- Uses no shared application resources whatsoever.

For an application to meet these conditions and therefore be considered threadsafe, the application must do both of the following:

- Incorporate threadsafe application logic (which means that the native language code in between the EXEC CICS commands must be threadsafe).
- Be defined to CICS as threadsafe.

Important rule: Only once it is understood whether an application is threadsafe, and all access to all shared resources is serialized, should any of its programs be defined as threadsafe. Failure to follow this rule may result in unpredictable results and put the integrity of application data at risk.

2

OTE and threadsafe overview

In this chapter we begin by discussing the different program types in CICS:

- Quasi-reentrant
- Threadsafe
  - CICSAPI
  - OPENAPI

We explain what determines each type, how to define the associated Program definition, and the requirements CICS expects of each.

We also look at the history of open transaction environment (OTE) in CICS.

The OTE is discussed with regard to open TCBs, task-related user exits (TRUEs), and TCB limits.

2.1 Overview of quasi-reentrant and threadsafe programs

Definitions of important terms that are relevant to the open transaction environment are provided in this section.

2.1.1 Quasi-reentrant programs

CICS runs user programs under a CICS-managed task control block (TCB). If a program is defined as quasi-reentrant, using the CONCURENCY attribute of the program resource definition, CICS will always invoke the program under the CICS quasi-reentrant (QR) TCB. The requirements for a quasi-reentrant program, in a multithreading context, are less stringent than if the program were to execute concurrently on multiple TCBs.

CICS requires an application program to be reentrant to guarantee a consistent state. A program is considered reentrant if it is read only and does not modify storage within itself. In practice, an application program may not be truly reentrant; CICS expects *quasi-reentrancy*. This means the application program should be in a consistent state when control is passed to it, both on entry to the program as well as before and after each EXEC CICS command. Such quasi-reentrancy guarantees that each invocation of an application program is unaffected by previous runs or by concurrent multithreading through the program by multiple CICS tasks.

CICS quasi-reentrant user programs (application programs, user-replaceable modules, global user exits, and task-related user exits) are given control by the CICS dispatcher under the QR TCB. When running under this TCB, a program can be sure that no other quasi-reentrant program can run until it relinquishes control during a CICS request. The user task is suspended at this point, leaving the program still *in use*. The same program can then be re-invoked by another task. This means the application program can be in use concurrently by more than one task although only one task at a time can actually be executing.

To ensure that programs cannot interfere with each other's working storage, CICS obtains a separate copy of working storage for each execution of an application program. Therefore, if a user application program is in use by 11 user tasks, there are 11 copies of working storage in the appropriate dynamic storage area (DSA).

Quasi-reentrancy allows programs to access globally shared resources, for example, the CICS common work area (CWA), without the need to protect those resources from concurrent access by other programs. Such resources are effectively locked by the running program until it relinquishes control. Therefore, an application can update a field in the CWA without using Compare and Swap (CS) instructions or locking (enqueuing on) the resource.

> **Important:** The CICS QR TCB provides protection through exclusive control of global resources *only* if all user tasks accessing those resources run under the QR TCB. It does not provide automatic protection from other tasks that execute concurrently under another (*open*) TCB.

Specifying Quasirent on the program definition *COncurrency* attribute is supported for all executable programs.

2.1.2 Threadsafe programs

In the CICS open transaction environment, threadsafe application programs, OPENAPI task-related user exits, global user exit programs, and user-replaceable modules cannot rely on quasi-reentrancy because they can run concurrently on multiple open TCBs. Furthermore, even quasi-reentrant programs are at risk if they access resources that can also be accessed by a user task running concurrently under an open TCB. This means that the techniques used by user programs to access shared resources must take into account the possibility of simultaneous access by other programs. Programs that use appropriate serialization techniques when accessing shared resources are described as threadsafe.

> **Note:** The term *fully reentrant* is sometimes used but this can be misunderstood; therefore, *threadsafe* is the preferred term.

CICS resources

For CICS resources, such as temporary storage queues, transient data queues and VSAM files, CICS processing automatically ensures access in a threadsafe manner. CICS ensures that its resources are accessed in a threadsafe way either because the CICS API code has been made threadsafe or because CICS ensures that the command is executed on the QR TCB, which effectively serializes access to the resource.

Application resources

For application-maintained shared resources, it is the responsibility of the application program to ensure that the resource is accessed in a threadsafe manner. Typical examples of shared storage are the CICS CWA, global user exit global work areas, and storage acquired explicitly by the application program with the shared option. You can check whether your application programs use these types of shared storage by looking for occurrences of the following EXEC CICS commands:

- ADDRESS CWA
- EXTRACT EXIT
- GETMAIN SHARED

Application programs using these commands *may* not be threadsafe because they allow access to global storage areas that could be updated concurrently by several tasks running on different open TCBs. To ensure it is threadsafe, an application program must include the necessary synchronization logic to guard against concurrent update. To help you find occurrences of these commands, CICS provides DFHEIDTH, a sample command table you can use with the load module scanner utility, DFHEISUP. See Figure 4-2 on page 64 for information about the load module scanner.

> **Important:** It is very important that you understand that DFHEIDTH is not testing the scanned programs for non threadsafe CICS commands, but is merely identifying whether the application is using CICS commands that give rise to the *possibility* that the application logic is non threadsafe.

During your investigation process of identifying programs that use shared resources, you should include any program that modifies itself. Such a program is effectively sharing storage and should be considered at risk.

2.1.3 CICSAPI programs

A program that is CICSAPI is restricted to use only the CICS API. By definition this is:

- The command-level application programming interface (API)
- The system programming interface (SPI)
- The resource manager interface (RMI)
- The exit programming interface (XPI) - for global user exits
- The system application architecture (SAA) common programming interfaces
  - CPI-C and CPI-RR
- LE callable services

A CICSAPI program commences execution on the QR TCB. Calls to an OPENAPI-enabled TRUE cause a switch to an open TCB to execute the TRUE. Whether the program is defined as threadsafe or quasi-reentrant will dictate whether control returns to the application from the TRUE on the open TCB or the QR TCB.

2.1.4 OPENAPI programs

From CICS Transaction Server Version 3 it is now possible for programs to run on an open TCB from the start of the program. This kind of program is an OPENAPI program.

An OPENAPI program is a program that has been written to threadsafe standards and does not rely on a call to a TRUE to move the program to an open TCB. An OPENAPI program is a program that *must* be run on an open TCB.

An OPENAPI program is also not restricted to the CICS API. An OPENAPI program can use both non CICS APIs as well as CICS APIs. However, the CICS Transaction Server Version 3.1 documentation states that using a non CICS API is entirely at the risk of the user. No testing of non CICS APIs has been performed by IBM.

Note: An OPENAPI program must always be threadsafe.

2.2 Open transaction environment - a brief history

This section charts the history of the open transaction environment and outlines the enhancements that have been introduced in each release of CICS Transaction Server for z/OS.

Figure 2-1 shows the key OTE enhancements introduced in recent releases of CICS, and these are discussed in more detail in the following sections.

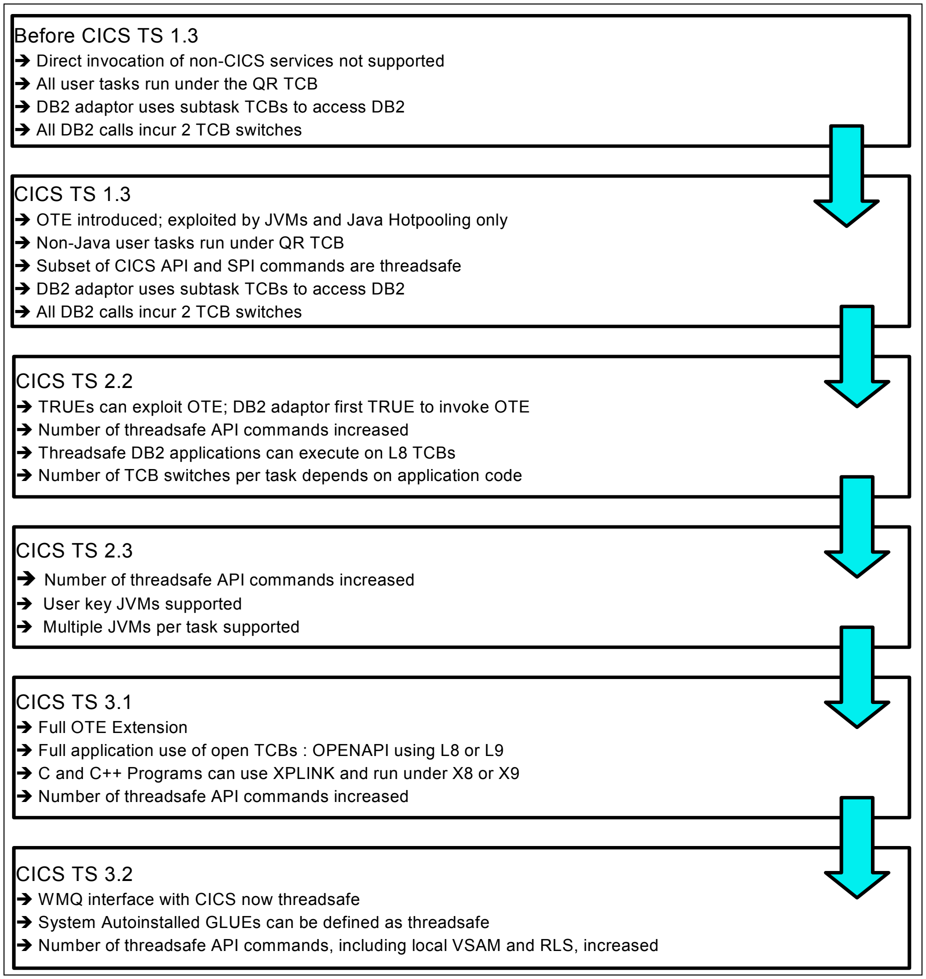

Figure 2-1 OTE enhancements in recent releases of CICS Transaction Server

2.2.1 Before CICS Transaction Server 1.3

Prior to CICS Transaction Server for OS/390® Version 1 Release 3, user applications and user exits operated in a restricted, or closed, environment. Although the applications could use the functionally rich CICS application programming interface (API), direct invocation of other services was not supported. This is because CICS ran all user transactions under a single z/OS TCB, known as the CICS quasi-reentrant (QR) TCB. Direct invocation of other services outside the scope of the CICS-permitted interfaces could interfere with the use by CICS of the QR TCB. In particular, requests resulting in the suspension (*blocking*) of the QR TCB, which happens when an MVS wait is issued, causes all CICS tasks to wait.

CICS-DB2 interface prior to CICS TS 1.3

The CICS DB2 attachment facility created and managed its own subtask thread TCBs with which to access DB2 resources, therefore ensuring that waits for DB2 resources would not block the QR TCB.

CICS used the QR TCB for the CICS DB2 task-related user exit and for the application program's code. The subtask thread TCBs were used for requests to DB2, and switching between the subtask TCB and the QR TCB took place for every DB2 request.

This would continue to be the case in CICS Transaction Server 1.3 (see the following section).

Figure 8-1 on page 203 shows the TCB switches involved in a typical DB2 transaction running under CICS TS 1.3.

2.2.2 CICS Transaction Server 1.3

The open transaction environment function was introduced in CICS Transaction Server for OS/390 Version 1 Release 3 to be exploited initially by Java Virtual Machines and Java Hotpooling applications.

OTE is an environment where CICS application code can use non-CICS services (facilities outside the scope of the CICS API) within the CICS address space, without interfering with other transactions. Applications that exploit OTE run on their own open TCB, rather than on the QR TCB. Unlike the QR TCB, CICS does not perform sub dispatching on an open TCB. If the application running on an open TCB invokes a non-CICS service that blocks the TCB, the TCB blocking does not affect other CICS tasks. For example, some services provided by DB2, MVS, UNIX® System Services, or TCP/IP, might result in TCB blocking.

CICS-DB2 interface under CICS TS 1.3

Although OTE became available in CICS TS 1.3, it was not yet enabled for task-related user exits, and therefore not yet exploited by the CICS DB2 attachment facility. As under previous CICS releases, subtask thread TCBs were used to access DB2 resources to ensure that waits for DB2 resources would not block the QR TCB.

CICS continued to use the QR TCB for the CICS DB2 task-related user exit and for application program code. Subtask thread TCBs are used for requests to

DB2, and switching between the subtask TCB and the QR TCB took place for every DB2 request.

Figure 2-2 shows the TCB switches involved in typical DB2 transactions running under CICS TS 1.3.

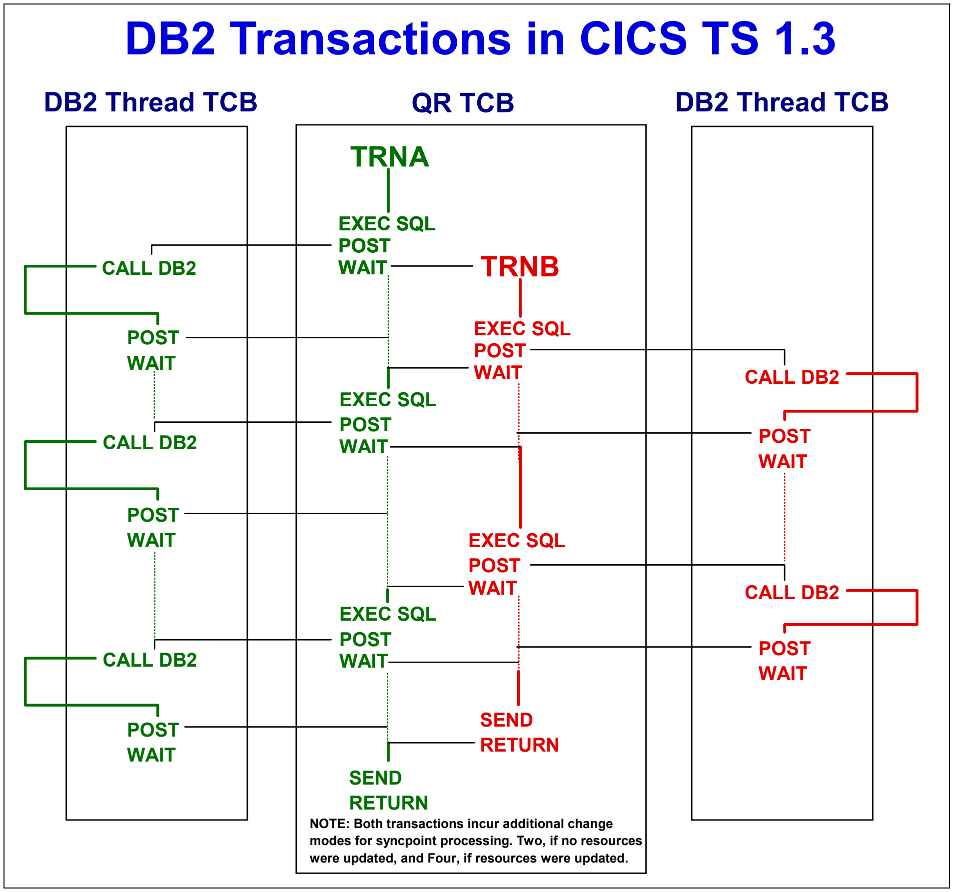

Figure 2-2 DB2 transactions in CICS TS 1.3

2.2.3 CICS Transaction Server 2.2

Enhancements introduced in CICS Transaction Server for z/OS Version 2 Release 2 made it possible for task-related user exits (TRUEs) to exploit the open transaction environment. The CICS DB2 adaptor supplied with this release was the first TRUE to utilize OTE.

Note: The CICS DB2 task-related user exit was converted to exploit this feature and operate as an open API TRUE when CICS is connected to DB2 Version 6 or later, therefore using L8 TCBs for DB2 request processing.

Applications that involve a TRUE enabled using the OPENAPI option on the ENABLE PROGRAM command can exploit OTE to provide performance benefits. Task-related user exits like this are known as OPENAPI TRUEs. An OPENAPI TRUE is given control under an open TCB in L8 mode (known as an L8 TCB) and can use non-CICS APIs without having to create, manage, and switch between subtask TCBs.

CICS DB2 interface under CICS TS 2.2

From CICS TS 2.2, the CICS DB2 attachment facility no longer creates subtask thread TCBs to access DB2 resources, unless connected to DB2 V5 or earlier. Instead, by exploiting OTE, L8 TCBs are used to process EXEC SQL statements. If an application is *not* defined as threadsafe (the default), each task will return to the QR TCB on completion of the EXEC SQL statement.

Existing or new CICS DB2 applications written in any language that accesses DB2 Version 6 or later now have the opportunity to gain the performance benefits provided by OTE. These performance benefits can be gained because open TCBs, unlike the QR TCB or subtask thread TCBs, may be used for both non-CICS API requests (including requests to DB2) and application code. Because application code can be run on the open TCB, the number of TCB switches is significantly reduced.

With OTE, the same L8 TCB can be used by the CICS DB2 task-related user exit.

Figure 2-3 on page 20 shows the TCB switches involved in typical DB2 transactions running under CICS TS 2.2. Threadsafe and non threadsafe tasks are both shown.

2.2.4 CICS Transaction Server 2.3

CICS Transaction Server for z/OS Version 2 Release 3 does not introduce any fundamental changes to the open transaction environment. However, this release does make it easier to maximize the performance improvements that can be achieved by defining appropriate applications as threadsafe.

Issuing non threadsafe EXEC CICS commands will cause a threadsafe program running on an L8 TCB to switch back to the QR TCB, and CICS TS 2.3 helps to prevent this by increasing the number of threadsafe EXEC CICS commands to include, among others, ASKTIME and FORMATTIME.

CICS DB2 interface under CICS TS 2.3

The CICS DB2 attachment facility in CICS Transaction Server 2.3 operates exactly as it does in Version 2.2. Refer to “CICS DB2 interface under CICS TS 2.2” on page 19 for details. The EXEC CICS commands made threadsafe in CICS Transaction Server Version 2.3 will make it easier for some applications to reap the full performance benefits associated with being defined as threadsafe.

Figure 2-3 shows the TCB switches involved in typical DB2 transactions running under CICS TS 2.3. Threadsafe and non threadsafe tasks are both shown.

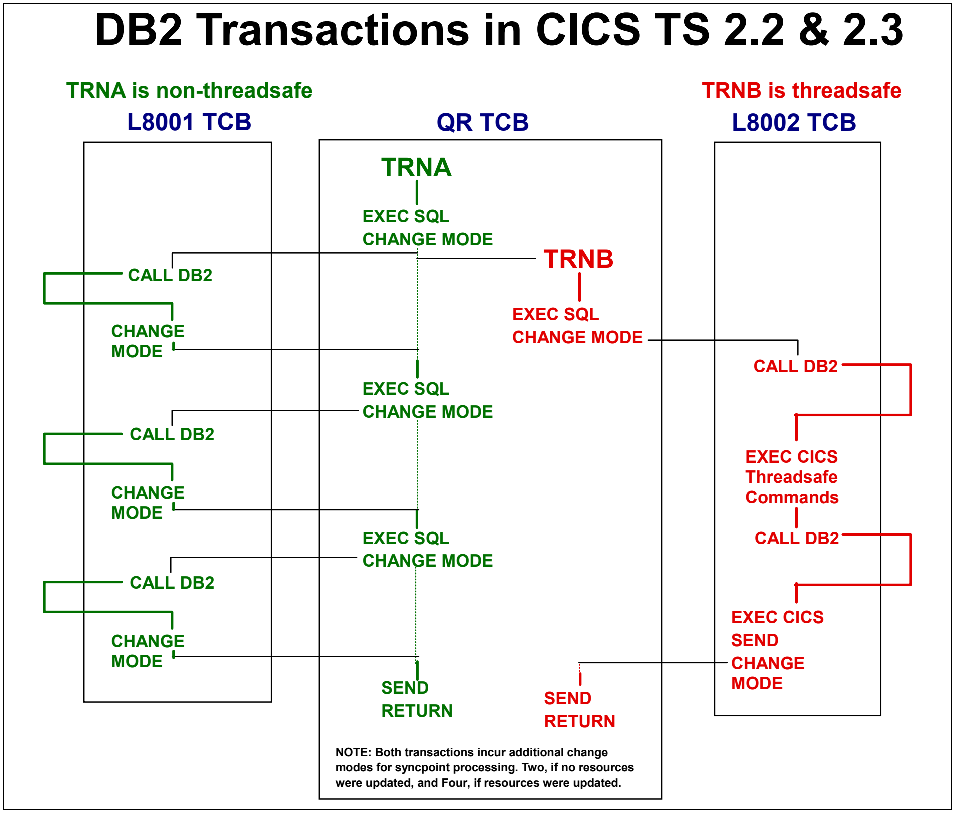

Figure 2-3 DB2 transactions in CICS TS 2.2 and 2.3

2.2.5 CICS Transaction Server 3.1

In CICS TS 3.1, programs can now be defined with API(OPENAPI) and so run almost independently of the QR TCB. Any program defined this way will run on an L8 or L9 open TCB depending on its EXECKEY value. Any program that can be defined as COncurrency(Threadsafe) can now also be defined as API(OPENAPI) and exploit the benefits of running on an open TCB regardless of whether it accesses DB2. For this reason we recommend that *all* programs should be written to threadsafe standards.

Prior to CICS TS 3.1, the OPENAPI option was only available to task-related user exits (TRUEs).

The effect of using the new OPENAPI definition can be seen in Figure 2-4.

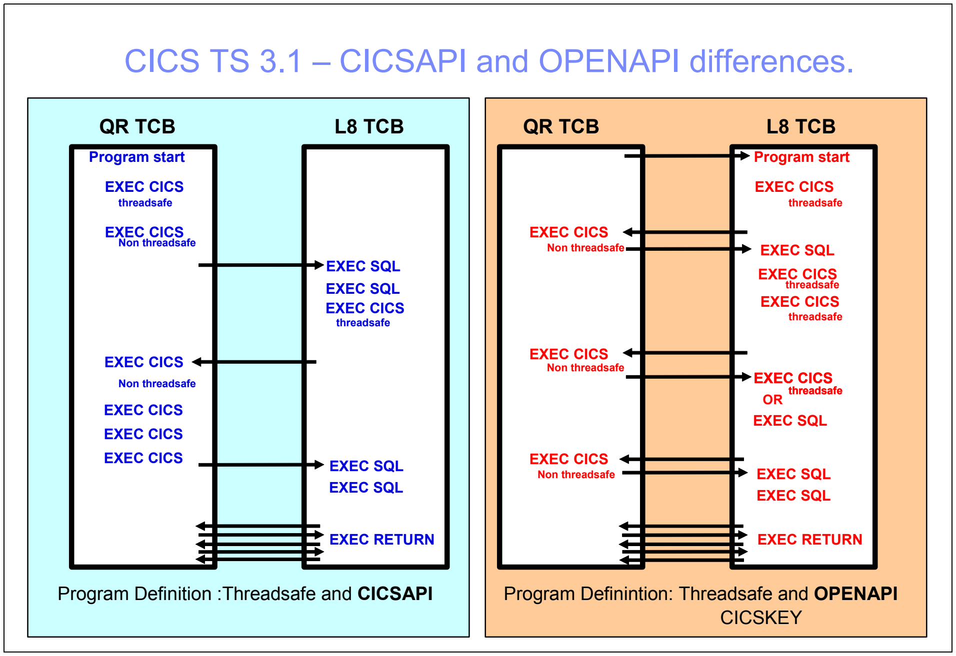

Figure 2-4 OPENAPI programs in CICS TS 3.1

In the example on the left we have a program defined as API(CICSAPI). In this example the behavior is the same as in CICS TS V2, whereby CICS will switch to an L8 TCB when a DB2 command is encountered and will remain there until a non threadsafe CICS command causes a switchback to the QR TCB. The switch to the L8 TCB in this case is made because the CICS DB2 task-related user exit is enabled in OPENAPI mode.

The example on the right of Figure 2-4 on page 21 shows the behavior when an application program is defined using the API(OPENAPI). Using OPENAPI for this program is telling CICS that this program *must* run on an open TCB. CICS immediately moves the task to an L8 or L9 TCB at the start of the program. Only if a non threadsafe CICS command is encountered does CICS move the task to the QR TCB and then *only* for the duration of the CICS command.

Note: A program defined as API(OPENAPI) is not required to have *any* DB2 or WMQ commands.

If our CICS program is now defined as API(OPENAPI) and with EXECKey(UserKey), then CICS will switch to an L9 TCB for execution rather than an L8 TCB. However, CICS will switch the task to an L8 TCB for every DB2 command because OPENAPI TRUEs *must* run in CICS key on an L8 TCB. This is demonstrated in Figure 2-5.

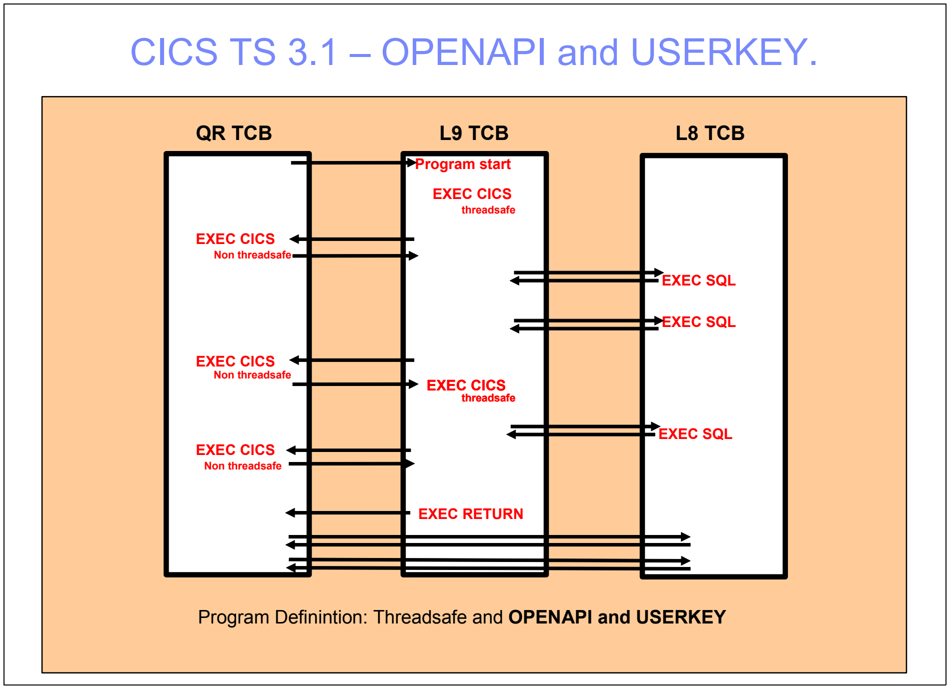

Figure 2-5 Program defined as OPENAPI and EXECKEY(USER)

OPENAPI and CICSAPI candidates

The combination of OPENAPI and EXECKEY attributes at CICS Transaction Server Version 3.1 could therefore lead to extra TCB switching, which would be undesirable. It is important that applications are analyzed correctly before using the OPENAPI attribute, as there are some rules that define what is a good candidate for the OPENAPI attribute (and, by implication, what is a bad candidate). A summary of what are considered good candidates for OPENAPI and CICSAPI can be seen in “OPENAPI good and bad candidates” on page 53.

This is also discussed further in 8.3, “OPENAPI programs and additional TCB switching” on page 215.

XPLINK

Another enhancement to OTE in CICS TS 3.1 is the facility to allow C and C++ programs compiled with the XPLINK option to run under an X8 or X9 open TCB depending on its EXECKey definition.

XPLink is Extra Performance Linkage. It was introduced at OS/390 2.10 to provide a high performance subroutine call and return mechanism for C and C++ programs. XPLink is enabled by using the XPLINK compiler option when compiling C and C++ programs.

A C or C++ program compiled with the XPLINK option will execute on an X8 or an X9 TCB depending on the EXECKEY attribute of the program definition.

TCB switching will still occur when:

- Using non threadsafe CICS commands
- Making SQL calls
- LINKing to a different program
- Using the CICS C++ foundation classes (Currently only non XPLINK versions are available.)

XPLINK programs can be considered a special case of OPENAPI programs. They execute on X8/X9 because XPLINK utilizes batch LE rather than CICS LE. There will be a separate LE enclave for each X8/X9 TCB. However, the storage is still allocated from CICS storage. DFHAPXPO can be used to change the batch LE runtime options.

> **Note:** The same considerations for OPENAPI programs apply to XPLINK programs.

2.2.6 CICS Transaction Server 3.2

Enhancements introduced in CICS Transaction Server for z/OS Version 3 Release 2 include local and RLS file control threadsafe commands, threadsafe CICS journalling commands, threadsafe definition for system autoinstalled global user exits (GLUE), and threadsafe WMQ commands.

CICS File Control interface under CICS TS 3.2

In CICS TS 3.2, the commands for accessing local and Record-Level Sharing (RLS) VSAM files are now threadsafe. These changes will result in improved performance for threadsafe applications that contain a mixture of DB2 and File Control. Also, for pure VSAM applications running on an open TCB, there will be a higher throughput due to utilization of concurrent CPUs. The number of TCB switches will be reduced as well.

The commands that are now threadsafe are READ, READ UPDATE, REWRITE, DELETE, UNLOCK, STARTBR, RESETBR, READNEXT, READPREV, and ENDBR. In addition, the SPI command INQUIRE FILE is also threadsafe.

Note: The commands for accessing files using other methods (remote files, Shared Data Tables, Coupling Facility Data Tables, and BDAM files) remain non-threadsafe.

Threadsafe CICS Journalling commands under CICS TS 3.2

The journalling commands that are now threadsafe are WRITE JOURNALNAME, WRITE JOURNALNUM, WAIT JOURNALNAME and WAIT JOURNALNUM. Also, the XPI command WRITE_JOURNAL_DATA is threadsafe.

Threadsafe definition for system autoinstalled GLUEs

CICS TS 3.2 enables system autoinstalled GLUE programs to be defined as threadsafe. GLUE programs required early during CICS initialization are required to be configured to CICS using the ENABLE command. The ENABLE command can now be specified with an override of THREADSAFE.

WebSphere MQ interface under CICS TS 3.2

The components to connect CICS TS 3.2 and WMQ have been integrated into CICS. This allows the components to become threadsafe. These components are CICS-MQ adapter, the CICS-MQ trigger monitor, and the CICS-MQ bridge.

2.2.7 Open TCB modes in CICS Transaction Server Version 2

The following open TCB modes are available from CICS Transaction Server Version 2:

J8 CICS key JVM requirements
J9 USER key JVM requirements (only at CICS TS 2.3)
L8 OPENAPI TRUEs (TRUEs must run in the CICS key)
H8 High performance Java programs

2.2.8 Open TCB modes in CICS Transaction Server Version 3

CICS Transaction Server V3.1 has extended the number of TCB modes available to CICS. The open TCB modes now available for application use are:

J8 CICS key JVM requirements

J9 User key JVM requirements

L8 OPENAPI TRUEs (TRUEs must run in the CICS key.)

CICS key OPENAPI applications

L9 User key OPENAPI applications

X8 CICS key C and C++ applications compiled with XPLINK

X9 User key C and C++ applications compiled with XPLINK

In addition, there is the S8 TCB mode, which is used internally by CICS for SSL.

2.3 Techniques to ensure threadsafe processing

There are many different techniques you can use to ensure threadsafe processing when accessing a shared resource. The following techniques are only a subset of the possibilities.

For further information please refer to Chapter 3, “Techniques for threadsafety” on page 43.

- Enqueue on the resource to obtain exclusive control and ensure no other program can access the resource.
  - An EXEC CICS ENQ command within an application program
  - An XPI ENQUEUE function call within a global user exit program
- Perform accesses to shared resources only in a program defined as Quasirent.

  A linked-to program defined as quasi-reentrant runs under the QR TCB and can take advantage of the serialization provided by CICS quasi-reentrancy. Note that even in quasi-reentrant mode, serialization is provided *only* for as long as the program retains control and does not wait. This is not a recommended technique.
- Place all transactions that access the shared resource into a restricted transaction class(TRANCLASS) defined with the number of active tasks specified as MAXACTIVE(1).

  This approach effectively provides a very coarse locking mechanism, but may have a severe impact on performance.

> **Attention:** Although the term threadsafe is defined in the context of individual programs, a user application as a whole can *only* be considered threadsafe if all the application programs that access shared resources obey the rules. A program written to threadsafe standards cannot safely update shared resources if another program accessing the same resources does not obey the threadsafe rules.

2.4 Program definition

In this section we discuss program definitions.

CONCURRENCY attribute

The CONCURRENCY attribute of the program definition is used to define a program as either Quasirent or threadsafe. Quasirent is the default value.

The CONCURRENCY attribute applies to:

- User application programs
- PLT programs
- User-replaceable programs
- Global user exit programs
- Task-related user exit programs

API attribute

The API attribute, which applies only from CICS Transaction Server V3.1, specifies whether the program is to be defined as CICSAPI or OPENAPI.

The API attribute applies to:

- User application programs
- PLT programs
- User-replaceable programs
- Global user exit programs (CICS always forces CICSAPI)
- Task-related user exit programs

A program defined as API(CICSAPI) will commence on the QR TCB and subsequent behavior will be the same as in CICS versions prior to CICS Transaction Server V3.1

A program that is defined as API(OPENAPI) will commence its execution on an L8 or an L9 TCB depending on the value of its EXECKEY attribute. It switches to the QR TCB for non threadsafe CICS commands and to the L8 TCB (if it started on L9) to execute SQL commands. Defining a program as API(OPENAPI) automatically implies that the program is also threadsafe.

The main benefit of being able to use the OPENAPI attribute at CICS TS 3.1 is that more applications can now be moved off the QR TCB. Non DB2 applications and highly CPU intensive applications can now benefit from running on an open TCB.

Figure 2-6 on page 27 shows an example program definition as viewed by the CEDA transaction.

```
OBJECT CHARACTERISTICS                                     CICS RELEASE = 0640
 CEDA  View PROGram( DB2PROG5 )
  PROGram        : DB2PROG5
  Group          : THDSAFE
  DEscription    :
  Language       :                   COBol | Assembler | Le370 | C | Pli
  RELoad         : No                No | Yes
  RESident       : No                No | Yes
  USAge          : Normal            Normal | Transient
  USElpacopy     : No                No | Yes
  Status         : Enabled           Enabled | Disabled
  RSl            : 00                0-24 | Public
  CEdf           : Yes               Yes | No
  DAtalocation   : Any               Below | Any
  EXECKey        : User              User | Cics
  COncurrency    : Quasirent         Quasirent | Threadsafe
  Api            : Cicsapi           Cicsapi | Openapi
 REMOTE ATTRIBUTES
  DYnamic        : No                No | Yes

                                                     SYSID=PJA6 APPLID=SCSCPJA6
```

Figure 2-6 Program definition

The CONCURRENCY and API attribute can both be specified using a program autoinstall exit. The IBM-supplied sample program autoinstall exit defaults to QUASIRENT and CICSAPI.

Important: It is important to understand that the program definition keyword CONCURRENCY(THREADSAFE) is telling CICS that the application logic is threadsafe, not whether CICS commands are threadsafe. CICS will ensure threadsafety of its own logic either because CICS logic can execute on an open TCB or it cannot, and so will be switched to the QR TCB before it executes. In either case, the resource is accessed in a threadsafe way.

A threadsafe application can use non threadsafe CICS commands. It will suffer the overhead of TCB switching, but resource integrity is maintained.

If an application containing non threadsafe logic is incorrectly defined to CICS as CONCURRENCY(THREADSAFE), the results are unpredictable.

2.5 Task-related user exit APIs

Task-related user exits (TRUEs) can be enabled with or without the OPENAPI option. Without the OPENAPI option, the TRUE is enabled as CICSAPI.

- CICSAPI: The TRUE is enabled as either Quasirent or threadsafe without the OPENAPI option. The TRUE is restricted to the CICS-permitted programming interfaces.
- OPENAPI: The TRUE is also enabled as threadsafe when the OPENAPI option is specified. The program is assumed to be written to threadsafe standards (serially reusable) and is permitted to use non-CICS APIs. CICS will give control to the TRUE under an L8 mode open TCB, which is dedicated for use by the calling CICS task and is separate from the CICS QR TCB.

For additional information about the OPENAPI option, reference the *CICS Customization Guide*, SC34-6227, for CICS Transaction Server Version 2, and *CICS Transaction Server for z/OS V3.1 CICS Customization Guide,* SC34-6429, for CICS Transaction Server Version 3.

2.5.1 CICS DB2 task-related user exit

The CICS DB2 adapter supplied by CICS is the first to supply a task-related user exits that can be enabled with the OPENAPI attribute. This was first supplied at CICS TS 2.2. This enabled DB2 calls to be executed on an open TCB. As we have already seen, this allowed us to create applications that could remain on the open TCB following a DB2 call depending on the CONCURRENCY attribute of the program definition.

2.5.2 CICS WebSphere MQ task-related user exit

The components that are threadsafe in CICS TS V3.2 are the CICS-MQ adapter, the CICS-MQ trigger monitor, and the CICS-MQ bridge. Exploitation of the Open Transaction Environment will benefit threadsafe applications using WMQ. TCB switching can now be avoided, resulting in saving of CPU and an increase in throughput, since WMQ applications can now run multiple open TCBs.

2.5.3 IP sockets task-related user exit

The IP CICS Sockets component of the Communications Server at z/OS Version 1.7 has been enhanced so that the calls to the IP CICS Sockets task-related user exits can now execute using the CICS Open Transaction Environment. So in the same way that a DB2 call will execute on an L8 TCB, an IP socket call can now run on an L8 TCB.

However, for IP CICS Sockets API calls to utilize OTE it is necessary for the IP CICS Socket configuration file be updated to turn this facility on. Unlike DB2, the TRUE for IP CICS Sockets can be enabled as either OPENAPI or CICSAPI. The default action is for IP sockets to continue managing its own sub task TCBs (that is, be enabled as CICSAPI).

The installation and configuration of IP CICS Sockets is described in detail in *z/OS Communications Server IP CICS Sockets Guide Version 1 Release 7* SC31-8807. The following two sections are a a summary to show where the OTE-related parameters need to be defined.

Building the configuration file using macro EZACICD

The IP CICS Sockets configuration file is initially built from a macro called EZACICD. Once created, the file can be incorporated into CICS using RDO and modified using the supplied configuration transactions.

The macro will create configuration records for each CICS region that uses IP sockets and a configuration record for every listener within each CICS region.

The definition of the CICS region is where OTE for IP sockets is enabled, an example of which can be seen in Example 2-1.

Example 2-1 An example of a CICS region definition in an EZACICD macro

```
EZACICD TYPE=CICS,      CICS record definition              X
      APPLID=CICSPRDB,  APPLID of CICS region using OTE     X
      TCPADDR=TCPIP,    Job/Step name for TCP/IP            X
      CACHMIN=15,       Minimum refresh time for cache      X
      CACHMAX=30,       Maximum refresh time for cache      X
      CACHRES=10,       Maximum number of resident resolvers X
      ERRORTD=CSMT,     Transient data queue for error msgs X
      TCBLIM=12,        Open API TCB Limit                  X
      OTE=YES,          Use Open Transaction Environment    X
      TRACE=NO,         Trace CICS Sockets                  X
      SMSGSUP=NO        STARTED Messages Suppressed?
```

The two parameters that are related to OTE are OTE=YES and TCBLIM=12.

OTE

When OTE=YES is specified, the IP CICS Sockets interface enables its TRUE as OPENAPI, and therefore CICS switches all EZASOKET calls and all IP CICS C socket functions from the QR TCB to an L8 TCB.

TCBLIM

This parameter defines that maximum number of OTE TCBs that the IP CICS Socket TRUE can use. It is a subset of the number of TCBs allocated to the pool of TCBs defined by the MAXOPENTCBS SIT parameter in CICS. This is the same pool of TCBs used by the DB2 TRUE if DB2 is also in use.

Once the socket call is complete, CICS will either leave the task on the L8 TCB or return to the QR TCB depending on the CONCURRENCY attribute of the application program definition. So if the program is defined as CONCURRENCY(THREADSAFE), the program will remain on the L8 until task end or a non threadsafe CICS API command is encountered. If the program is defined as CONCURRENCY(QUASIRENT), the task will be moved back to the QR TCB on completion of the IP socket call. This is exactly the same behavior as for the DB2 task-related user exits. Additionally, at CICS TS 3.1 the application program may be defined as API(OPENAPI) if appropriate, which will enable the program to commence execution on an open TCB. For further information see “OPENAPI good and bad candidates” on page 53.

> **Note:** If you intend to use OTE=YES for IP sockets programs *and* to define the IP sockets application program as threadsafe then you *must* ensure that the programs *are* threadsafe before defining them as such.

Customizing the configuration file

Once the configuration file has been created and defined to the CICS region it can be modified using the supplied configuration transaction EZAC. For example, using EZAC it is possible to turn OTE on or off and to modify the TCBLIM attribute. This transaction is described in detail in *z/OS Communications ServerIP CICS Sockets Guide Version 1 Release 7,* SC31-8807.

2.6 TCB limits

As we have described earlier, CICS manages a number of different TCB pools. For example, at CICS TS 3.1 we have pools for JVM TCBs (J8/J9), OPENAPI and TRUE TCBs(L8/L9), SSL TCBs (S8) and XPLINK TCBs (X8/X9). CICS imposes a limit for each of these TCB pools by means of a SIT parameter for each. The SIT parameter for each pool is as follows:

MAXOPENTCBS Limits the number of TCBs in the pool of L8 and L9 mode open TCBs

MAXSSLTCBS Limits the number of TCBs in the pool of S8 mode open TCBs

MAXXPTCBS Limits the number of TCBs in the pool of X8 and X9 mode open TCBs

MAXJVMTCBS Limits the number of TCBs in the pool of J8 and J9 mode open TCBs

2.6.1 MAXOPENTCBS

The pool of L8/L9 mode TCBs is managed by the CICS dispatcher. The maximum number of TCBs that will be allocated to the pool is defined by the MAXOPENTCBS System Initialization Table (SIT) parameter. There can be any combination of L8/L9 TCBs in use (allocated to running tasks) and free.

MAXOPENTCBS has a default value of 12 at CICS TS 3.1. It is important to understand which functions now utilize the pool of TCBs defined by MAXOPENTCBS so that a sensible value can be assigned to MAXOPENTCBS. In addition to application programs defined with the OPENAPI attribute or programs calling TRUEs enabled with OPENAPI, CICS itself will perform some tasks on an open TCB taken from the pool of MAXOPENTCBS. Usage of L8 and L9 TCBs can be summarized as follows:

- L9 mode TCBs are used for user key OPENAPI application programs.
- L8 mode TCBs are used:
  - For CICS key OPENAPI application programs
  - For OPENAPI task-related user exits (task-related user exits always run in CICS key)
    - The CICS-DB2 Attachment Facility
    - The IP CICS Sockets interface
    - The CICS-MQ Adapter
  - And by CICS itself, because CICS uses OPENAPI CICS key programs that run on L8 TCBs:
    - When accessing doctemplates and HTTP static responses that are stored on the Hierarchical File System (HFS)
    - When processing Web Service requests and parsing XML

Choosing a value for MAXOPENTCBS will therefore need to take into account all of these factors depending, on which are being used.

Task-related user exit imposed limits

There are currently three TRUEs that can be enabled in CICS using the OPENAPI attribute. They are the TRUEs supplied by the CICS DB2 Attachment Facility, the CICS WMQ Attachment Facility, and the IP CICS Sockets interface. Some of these TRUEs have their own parameter that can be set to limit the number of TCBs that can be used by that TRUE. The TCB limit for each of these TRUEs is part of the TCBs allocated to the pool defined by MAXOPENTCBS.

DB2

The DB2 parameter is TCBLIMIT, which is specified in the DB2CONN definition. TCBLIMIT defines the maximum number of TCBs that can be associated with the CICS DB2 attachment.

WMQ

There is no parameter to limit the number of open TCBs used by WMQ. Therefore, the limit for WMQ is the same as the MAXOPENTCBS parameter.

IP CICS Sockets

The parameter for limiting the number of open TCBs that can be associated with the IP CICS Sockets TRUE is the TCBLIM parameter. This is used when the IP CICS Sockets interface is configured with OTE=YES.

Transaction isolation

When transaction isolation (TRANISO) is used, MAXOPENTCBS should be set equal to or higher than the max task value. When a task defined as using TRANISO is initiated and has accessed DB2 in prior executions of the transaction, CICS assigns an L8 TCB with the correct subspace. This will eliminate TCB stealing on the first DB2 access.

Non transaction isolation

If you are not using transaction isolation you can calculate MAXOPENTCBS using the following steps:

1. Find the value specified for TCBLIMIT in your DB2CONN definition. This represents the number of L8 TCBs required for your DB2 workload.
2. Add a value for the expected peak number of concurrent CICS tasks accessing WMQ.
3. Add a value for the expected peak number of tasks using Web services, XML, DOCTEMPLATEs residing on z/OS UNIX.
4. Add a value for the expected peak number of tasks running as OPENAPI applications that are non DB2.

Note: An application that uses sockets, WMQ, and DB2 will use one L8 open TCB for both purposes. If you have a separate sets of applications that use sockets and DB2 then ensure that MAXOPENTCBS is set greater than or equal to the sum of TCBLIMIT and TCBLIM.

How L8/L9 mode TCBs are allocated

The process for allocating an L8/L9 mode TCB is:

1. If the transaction already has an L8 or L9 mode TCB allocated, it is used. At most only one L8 and L9 TCB is allocated to a task.
2. If a free L8/L9 mode TCB exists for the correct subspace, it is allocated and used.

   Note: If TRANISO is not in use, all tasks use the same space.

3. If the number of open TCBs is below the MAXOPENTCBS limit, a new L8/L9 mode TCB is created and associated with the task's subspace.
4. If the number of open TCBs is at the MAXOPENTCBS limit and there are free L8/L9 mode TCBs with the wrong subspace, the dispatcher will destroy the free TCB and create a new TCB for the required subspace. This avoids suspending the task until the number of TCBs is reduced below the pool limit. This action is reflected in the count of *TCB steals* in the CICS dispatcher TCB mode statistics.
5. If the number of open TCBs is at the MAXOPENTCBS limit and there are no TCBs available to steal, the task is suspended, with an OPENPOOL wait, until one becomes free or the MAXOPENTCBS limit is increased.

Important: CICS TS 2.2 APAR PQ75405 changes the allocation algorithm and should be installed. This code is included in the base level of subsequent CICS releases

2.7 Open TCB performance

Currently, the following IBM software makes use of OTE within CICS:

- The CICS-DB2 Attachment Facility
- The CICS-MQ Adapter
- The IP CICS Sockets interface

2.7.1 DB2

The CICS DB2 attachment facility includes a CICS DB2 task-related user exit, DFHD2EX1, which is written to threadsafe standards and enabled as an open API task-related user exit program. The TRUE is automatically enabled with the OPENAPI option on the ENABLE PROGRAM command during startup of the CICS-DB2 Attachment Facility. This enables the TRUE to receive control on an open L8 mode TCB. DB2 calls are made on this same L8 TCB, so it therefore acts as the thread TCB as well. This results in better performance, as there is no need to switch to a subtask TCB.

2.7.2 WMQ

At CICS TS V3.2 and WebSphere MQSeries® for z/OS the CICS WMQ attachment facility includes a task-related user exit, DFHMQTRU, which is written to threadsafe standards and enabled as an open API task-related user exit program. The TRUE is automatically enabled with the OPENAPI option on the ENABLE PROGRAM during startup of the CICS-MQ Adapter. This enables the TRUE to receive control on an open L8 mode TCB.

2.7.3 IP CICS Sockets

The IP CICS Sockets interface includes a task-related user exit, EZACIC01, which is written to threadsafe standards and can be enabled as an open API task-related user exit program. It will be enabled as OPENAPI only if the OTE parameter in the IP CICS Sockets configuration file for that CICS region is set to YES.

2.7.4 Performance considerations

To gain the best possible performance within an OTE environment:

- Ensure that all applications and exits within the TRUE path are written to threadsafe standards and defined to CICS as threadsafe. Common exits to consider are XPCFTCH, XEIIN, XEIOUT, XRMIIN, XRMIOUT, and Dynamic Plan exits.

  For the DB2, the default sample Dynamic Plan exit, DSNCUEXT, is not defined to CICS as threadsafe.

  – CICS Transaction Server Version 2.3 and Version 3.1 both ship an alternative sample Dynamic Plan exit, DFHD2PXT, which is defined to CICS as threadsafe.

  – For CICS Transaction Server Version 2.2, APAR PQ67351 supplies the alternative sample Dynamic Plan exit, DFHD2PXT.

- Minimize or eliminate the use of non threadsafe CICS commands. Reference "Threadsafe API commands" on page 38, "Threadsafe SPI commands" on page 41, and "Threadsafe XPI commands" on page 42.

  If you are unable to eliminate all non threadsafe commands, consider, if possible, re-arranging the commands within your application so they are not interspersed with SQL calls or IP CICS Sockets calls.

- When using transaction isolation (TRANISO), set MAXOPENTCBS equal to or greater than max task (MXT) coded within the CICS System Initialization Table.

Mode switching, in regard to OTE, is the act of switching from the QR TCB to an open TCB or vice versa.

- For non threadsafe exits, a switch occurs from the open TCB to the QR TCB and returns back to the open TCB when the exit program completes.
- For non threadsafe commands issued from a threadsafe program, a switch occurs from the L8 TCB to the QR TCB and remains there until the next SQL or WMQ call, which would cause a switchback from the QR TCB to the L8 TCB.
- For non threadsafe commands issued from an OPENAPI program, a switch occurs from the open TCB to the QR TCB for the duration of the EXEC CICS command. On return to the application, a switchback from the QR TCB to the open TCB occurs.

2.8 TCB considerations with UNIX System Services

When defining the numbers of TCBs that are allowed in a CICS region, you also need to consider the settings in UNIX System Services that control the number of processes that can run within a CICS region.

In UNIX System Services, the MAXPROCUSER parameter specifies the maximum number of processes one UNIX user identifier (UID) can have concurrently active, regardless of how the processes were created. The value can be in the range 3 to 32767. The default is 25. The MAXPROCUSER parameter is specified in SYS1.PARMLIB member BPXPRMxx. The *z/OS MVS Initialization and Tuning Reference,* SA22-7592, gives guidance on the setting of MAXPROCUSER.

MAXPROCUSER is independent of any particular user ID. However, there is an equivalent RACF® setting to limit the number of processes by user ID for a particular user. This is PROCUSERMAX. It sets the maximum number of processes per user ID field of the RACF OMVS SEGMENT of a user ID's profile.

The following TCBs all contribute to the potential number of processes associated with a particular CICS region:

- MAXOPENTCBS - The maximum number of L8 and L9 TCBs that can exist
- MAXJVMTCBS - The maximum number of J8 and J9 TCBs that can exist
- MAXSSLTCBS - The maximum number of S8 TCBs that can exist
- MAXXPTCBS - The maximum number of X8 and X9 TCBs that exist
- The SO TCB - Used to issue the necessary UNIX System Services and CEEPIPI calls for the socket domain
- The SL TCB - Provides a listening environment for sockets domain requests
- The SP TCB - Owns the S8 TCBs and the SSL cache
- TCBs used by the separate *TCP/IP Socket Interface for CICS* component of the z/OS Communications Server (if applicable)

By adding the number of TCBs from the above list, it is possible to obtain the total number of processes that might be associated with a given CICS region. This total represents a possible upper limit for the region.

Where you have CICS systems that share the same user ID, add the totals together to give the maximum number of processes associated with that user ID. This is because MAXPROCUSER is the number of processes for a UID, not for each job.

When you have determined the total possible number of processes associated with each user ID for your CICS regions, use the largest number and add an extra 10% to this figure when calculating the value of MAXPROCUSER.

If you have a particular user ID with a high result for the total number of processes required, due to several CICS systems sharing the same user ID, setting MAXPROCUSER to such a figure might not be appropriate. In this situation, use the PROCUSERMAX parameter on the OMVS segment of the RACF profile for the user ID to set a suitably high value to accommodate the requirements of the user ID.

The setting of the MAXPROCUSER and PROCUSERMAX parameters does not in itself consume extra resources. These are limiting values. CICS does not generate the open TCBs until they are needed, meaning that processes and system resources are not associated with TCBs until required. Note that TCBs specified in the SSLTCBS system initialization parameter are created at CICS system initialization. The setting of the TCPIP system initialization parameter does not affect the use of open TCBs by OTE. Also, if you specify TCPIP=NO and no OTE-managed services are used by CICS, then two of the MAXPROCUSER entries will be used in the initialization of the sockets domain.

2.8.1 The implications of setting MAXPROCUSER too low

If you do not set a large enough value for MAXPROCUSER for the CICS environment, you might get a number of warning and error messages. These are described below.

Message BPXI040I

This is a UNIX System Services warning message that alerts the operator that system resources are being consumed. The message notifies the operator when a threshold of 85% of the MAXPROCUSER value for a given UNIX Process Identifier (PID) has been reached. It is possible for the percentage to exceed 100%. This is because two special UIDs are allowed to create more processes than MAXPROCUSER would normally allow. The superuser (UID=0) can exceed many of the limits set in BPXPRMxx. Also, the default-UID can exceed the MAXPROCUSER setting. This is because many users can make use of the default-UID, and they each have independent processes. If each user were given an individual UID, then each would be subject to MAXPROCUSER independently. The default-UID refers to a RACF user ID without an OMVS segment defined for it; as such, it uses the default OMVS segment. The default-UID should not to be confused with the CICS default user.

Message DFHKE0500

This message is issued by the CICS TS for z/OS Version 3.1 Kernel when MAXPROCUSER has been exceeded for the user ID of the CICS system. This could occur because a number of CICS systems are sharing the same user ID on UNIX System Services and have a requirement to use a number of TCBs that is greater than the value defined in the MAXPROCUSER parameter.

2.9 Static and dynamic calls

If you defined a program with CONCURRENCY(THREADSAFE), all routines that are statically or dynamically called from this program (for example, COBOL routines) must also be coded to threadsafe standards.

When an EXEC CICS LINK command is used to link from one program to another, the program link stack level is incremented. However, a routine that is statically or dynamically called does not involve passing through the CICS command-level interface. Therefore, it does not cause the program link stack level to be incremented.

With COBOL routines, a static call causes a simple branch and link to an address resolved at link-edit time. For a dynamic call a program definition is required to allow Language Environment to load the program. After the load, a simple branch and link is still used. When a routine is called using either method, CICS does not receive control and is therefore unaware of the program execution change. The program that called the routine is still considered to be executing and its program definition is still considered to be the current program definition.

If the program definition for the calling program states CONCURRENCY(THREADSAFE), the called routine must also comply with this specification. Programs with the CONCURRENCY(THREADSAFE) attribute remain on an open TCB when they return from a DB2 call or any threadsafe EXEC CICS command, which is not appropriate for a program that is not threadsafe. For example, consider a situation in which the initial program of a transaction, program A, issues a dynamic call to program B, which is a COBOL routine. Because the CICS command-level interface was not involved, CICS is unaware of the call to program B and considers the current program to be program A. Program B issues a DB2 call. On return from the DB2 call, CICS needs to determine whether the program can remain on the open TCB or whether the program must switch back to the QR TCB to ensure threadsafe processing. To do this, CICS examines the CONCURRENCY attribute of what it considers to be the current program (program A in this example). If program A is defined as CONCURRENCY(THREADSAFE), CICS allows processing to continue on the open TCB. Program B is currently running. Therefore, if processing is to continue safely, program B must be coded to threadsafe standards. For further details refer to 8.5, “COBOL calls” on page 221.

2.10 Threadsafe API commands

If you write and define a CICS program as threadsafe, it can receive control on an open transaction environment (OTE) TCB. To obtain the maximum performance benefit from OTE, write your CICS programs in a threadsafe manner to avoid CICS having to switch TCBs. However, be aware that not all EXEC CICS commands are threadsafe, and issuing any of the non threadsafe commands causes CICS to switch your task back to the QR TCB to ensure serialization. The CICS API commands that are threadsafe are indicated in the command syntax diagrams in the *CICS Application Programming Reference,* SC34-6232, for CICS Transaction Server Version 2, and *CICS Transaction Server for z/OS V3.1 CICS Application Programming Reference,* SC34-6434, for CICS Transaction Server Version 3, with the statement `This command is threadsafe`.

Figure 2-7 on page 39 shows CICS V1 and V2 threadsafe API commands. Figure 2-8 on page 40 shows CICS TS V3.1 threadsafe API commands. Figure 2-9 on page 41shows CICS TS V3.2 threadsafe API commands.

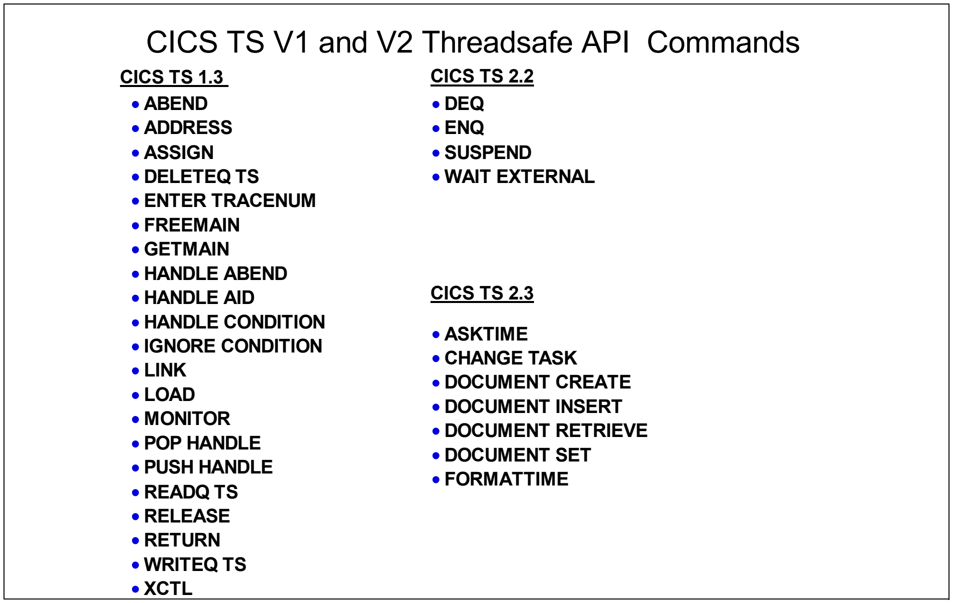

Figure 2-7 Threadsafe API commands for CICS 1.3, 2.2, and 2.3

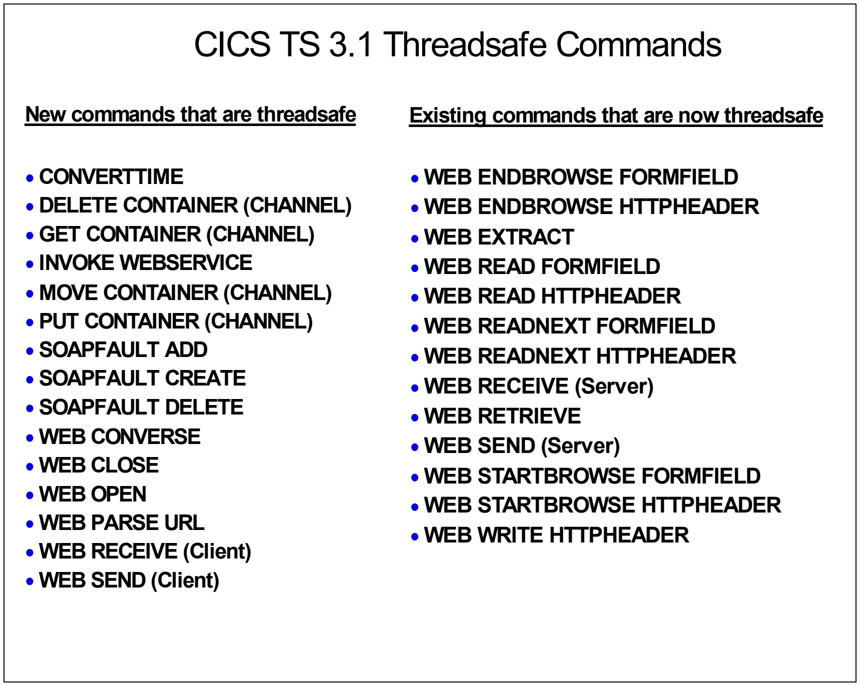

Figure 2-8 CICS TS 3.1 threadsafe commands

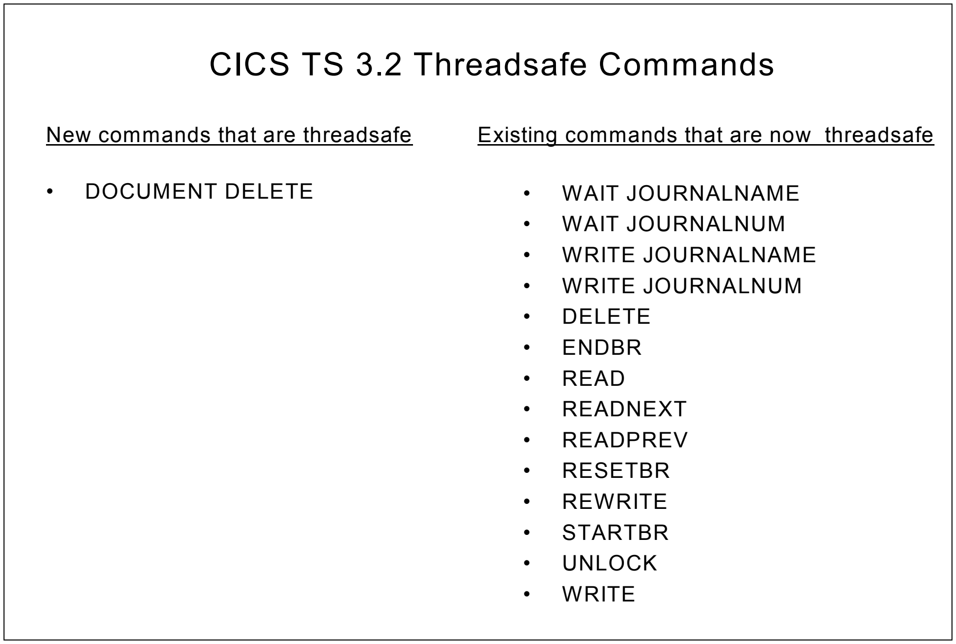

Figure 2-9 CICS TS 3.2 threadsafe commands

Note: The File Control API commands in figure 2-9 are threadsafe if the file to which they refer to is defined as either local VSAM or RLS. If the file is defined as remote, or is a shared data table, a coupling facility data table, or a BDAM file the commands are not threadsafe.

2.11 Threadsafe SPI commands

The CICS SPI commands that are threadsafe are indicated in the command syntax diagrams in the manual *CICS System Programming Reference*, SC34-6233, with the statement `This command is threadsafe`.

Figure 2-10 shows the threadsafe SPI commands and the respective CICS release in which the command was made threadsafe.

CICS TS Version V1, V2 and V3 Threadsafe SPI Commands

CICS TS V1.3

- INQUIRE EXITPROGRAM
- INQUIRE TASK

CICS TS V3.2

- INQUIRE ASSOCIATION
- INQUIRE ASSOCIATION LIST
- INQUIRE IPCONN
- INQUIRE LIBRARY
- SET IPCONN
- PERFORM JVMPOOL
- SET DOCTAMPLATE
- INQUIRE FILE

CICS TS v2.2

- DISCARD DB2CONN
- DISCARD DB2ENTRY
- DISCARD DB2TRAN
- INQUIRE DB2CONN
- INQUIRE DB2ENTRY
- INQUIRE DB2TRAN
- SET DB2CONN
- SET DB2ENTRY
- SET DB2TRAN

CICS TS V2.3

INQUIRE WORKREQUEST
SETWORKREQUEST
INQUIRE DOCTEMPLATE
DISCARD DOCTEMPLATE

Figure 2-10 Threadsafe SPI commands

2.12 Threadsafe XPI commands

All the XPI commands are threadsafe with the *exception* of:

- DFHDUDUX TRANSACTION_DUMP

2.13 Function shipping considerations

Terminal control, including Multi-Region Operation (MRO) and Inter System Communication (ISC), is not threadsafe. Therefore CICS must issue a mode switch to the QR TCB in order to function ship a request to a remote region.

This means that any command that is listed as threadsafe will be treated as such when executed locally, but will incur the overhead of a TCB switch if function shipped. See 8.4, “Function shipped commands” on page 216, for more details.

3

Techniques for threadsafety

This chapter is a discussion of some techniques that can be used when migrating to CICS threadsafe.

The following serialization techniques are covered:

- CICS API enqueue/dequeue
- CICS XPI enqueue/dequeue
- Compare and swap

3.1 Threadsafe standards

IBM recommends that all new CICS application programs be written to threadsafe standards. This purpose of this section is to provide the application and system programmer with guidance on how to ensure that this is achieved. By following the rules listed here, existing and new applications will maximize the benefits to be gained from being defined as threadsafe.

1. Ensure that all programs are written to current CICS standards, as documented in the *CICS Application Programming Guide*, SC34-6231, for CICS Transaction Server V2, and *CICS Transaction Server for z/OS V3.2 CICS Application Programming Guide,* SC34-6433, for CICS Transaction Server V3. In particular, programs should:

   – Be compiled and link-edited as reentrant, and reside in read-only storage (SIT parameter RENTPGM=PROTECT).

     This is not an absolute requirement for threadsafe programming, but if a program is capable of overwriting itself, then the program itself is effectively shared storage, and access to it should be serialized. See 3.2, “Serialization techniques” on page 46, for a discussion of appropriate serialization techniques.

   – Use only published CICS interfaces to external resources.

     Again, this is not an absolute requirement for threadsafe programming, but the use of native MVS calls under CICS will, prior to OTE, most likely cause the QR TCB to enter an MVS WAIT state, thereby stopping the whole of CICS. For this reason they are disallowed. This restriction is removed in CICS Transaction Server Version 3.1 by use of OPENAPI programs because they never execute application code on the QR TCB. However, it should be noted that use of non CICS APIs is at the user’s own risk and is not formally supported even in CICS Transaction Server 3.1.

     If existing programs are accessing shared application resources, then access should be serialized before defining the programs as threadsafe. See 3.2, “Serialization techniques” on page 46, for a discussion of appropriate serialization techniques.

2. Use of the CICS common work area (CWA) should be avoided if at all possible (that is, set SIT parameter WRKAREA=0). Shared resources that are accessed via CICS APIs can be used instead (for example, CICS temporary storage). If use of the CWA is unavoidable, and the data in it is updated, ensure that an appropriate serialization technique is used by all programs to access it. See 3.2, “Serialization techniques” on page 46, for a discussion of appropriate serialization techniques.

3. All programs (including PLT programs, user exits, and user-replaceable modules) should not create or access shared storage (that is, as created by the EXEC CICS GETMAIN SHARED command). Shared resources that are accessed via CICS APIs can be used instead (for example, CICS temporary storage). If use of shared storage is unavoidable, and the data in it is updated, ensure that an appropriate serialization technique is used by all programs to access it. See 3.2, “Serialization techniques” on page 46, for a discussion of appropriate serialization techniques.
4. Try to avoid the use of global work areas (GWAs) in user exits, that is, as created by the GALENGTH option of the EXEC CICS ENABLE PROGRAM command, and referenced via parameter UEPGAA in the exit, or via the EXTRACT EXIT command from other application programs. Depending on the exit point, it may be possible to use shared resources that are accessed via CICS APIs instead. If use of a GWA is necessary, and the data in it is updated, ensure that an appropriate serialization technique is used by all user exits and application programs to access it. For example, an application program could use EXEC CICS ENQ / DEQ and a user exit could use XPI ENQUEUE and DEQUEUE as long as they both use the same resource argument. See 3.2, “Serialization techniques” on page 46, for a discussion of appropriate serialization techniques.
5. All programs, user exits, and URMs should use only threadsafe EXEC CICS commands. Check the command syntax diagrams in the *CICS Application Programming Reference* and the *CICS System Programming Reference* for the statement `This command is threadsafe`. If the use of non threadsafe commands is unavoidable, design the application to minimize the performance impact. See 3.3, “Application design considerations” on page 51, for a discussion of threadsafe application design.
6. Ensure that all programs that have been written or identified as threadsafe are defined to CICS with the CONCURRENCY(THREADSAFE) attribute. If program autoinstall is enabled, remember to amend your autoinstall control program to ensure that the correct CONCURRENCY value is set for each program. Alternatively, use the CICS environment variable CICSVAR. This is discussed in 6.2.2, “CICS environment variable CICSVAR” on page 154.
7. Review the use of function shipping within the application. Function shipped commands will cause threadsafe EXEC CICS commands to become non threadsafe, so pay particular attention to temporary storage requests and to EXEC CICS LINK requests that are converted to distributed program links (DPLs). See 8.4, “Function shipped commands” on page 216, for more details. Note that accessing shared temporary storage in a coupling facility is threadsafe, but accessing remote TS queues in a queue owning region is non threadsafe.
8. Check with IBM for the latest threadsafe-related APARs, and apply any maintenance that is appropriate to your environment.

9. Check with your independent software vendors to ensure that their programs and exits comply with threadsafe standards and are defined as threadsafe. If they are not threadsafe, or issue non threadsafe EXEC CICS commands, understand the implications for your application.

3.2 Serialization techniques

As discussed in Chapter 6, “Application review” on page 139, all access to updatable application shared resources (if they exist) must be serialized before the associated programs can be defined as threadsafe. This section outlines a number of techniques that can be used to achieve this. As we will see, some techniques are preferable to others.

Whatever technique is selected, it is important that a shop standard is established, and all programs that access the same resource use the same serialization technique. No program is threadsafe until *all* programs that access the resource have been changed to include serialization.

The following sections discuss a number of serialization techniques.

3.2.1 Recommended serialization techniques

This section outlines techniques that are recommended by the authors of this book.

CICS API enqueue /dequeue

The EXEC CICS ENQUEUE and DEQUEUE commands are ideally suited for CICS application programs to serialize access to shared resources. Both commands are threadsafe, and so will not incur the performance overhead of switching a task back to the QR TCB.

Refer to the *CICS Application Programming Reference*, SC34-6232 for CICS Transaction Server V2, and *CICS Transaction Server for z/OS V3.1 CICS Application Programming Reference,* SC34-6434, for CICS Transaction Server V3, for full details on coding EXEC CICS ENQUEUE and DEQUEUE commands.

CICS XPI enqueue/dequeue

An enhancement to the exit programming interface (XPI) introduced with CICS Transaction Server 1.3 was the DFHNQEDX macro function call, which provides the same ENQUEUE and DEQUEUE capability provided by the CICS API. The XPI commands are threadsafe, so will not incur the performance overhead of switching a task back to the QR TCB.

The XPI ENQUEUE / DEQUEUE is ideal for use within a user exit to serialize access to a global work area (GWA) or any other shared resource. Refer to the *CICS Customization Guide*, SC34-6227, for CICS Transaction Server V2, and *CICS Transaction Server for z/OS V3 CICS Customization Guide,* SC34-6429, for CICS Transaction Server V3, for full details on coding XPI commands.

Compare and swap

Assembler applications and user exits can use one of the conditional swapping instructions, COMPARE AND SWAP (CS) or COMPARE DOUBLE AND SWAP (CDS), to serialize access to shared resources. Refer to the appropriate Principles of Operation manual for full details on coding these instructions.

3.2.2 Comparison of recommended options

Table 3-1 presents a comparison of the recommended options.

Table 3-1 Comparison of options

Option	Advantages	Disadvantages
Compare and swap assembler instruction on shared data element	► Potentially best performance. ► Easiest non-CICS API implementation. ► New locking mechanism is nondisruptive. It can be installed one program at a time.	► Cannot be used for fields greater than 4 bytes (8 bytes for CDS instruction). ► For fields less than 4 bytes, activity on adjacent bytes could cause additional failed lock attempts. ► Storage access is not threadsafe until all programs have been converted. ► Requires assembly language program or subroutine.

Option	Advantages	Disadvantages
Use test and set/Compare and Swap assembler instruction on separate *lock* byte	► New locking mechanism is nondisruptive. It can be installed one program at a time. ► *Lock* granularity is single byte or word. ► *Lock* may be defined for non-contiguous areas. ► If using CS, *Locked* status could be something that indicates which CICS task owns the resource (that is, task number, terminal identifier, and so on).	► Application failure while holding a lock will cause other TCBs to spin until lock is manually cleared (the effects of this can be mitigated somewhat by adding a retry counter to the lock loop, but access to the resource will still be denied until the lock is cleared). ► Storage access is not threadsafe until all programs have been converted. ► Requires assembly language program or subroutine.
Use Compare and Swap assembler instruction after moving the shared data element to a new fullword	► No interference from non-related tasks. ► Guarantees all accesses to shared resource have been identified. ► Viable option if a limited number of programs are involved.	► No migration path—all affected programs must be installed at the same time. ► Not a viable option if a large number of programs are involved. ► Requires assembly language program or subroutine.
CICS ENQ (API or XPI)	► *Lock* granularity is single byte. ► Application failure will not result in held lock. ► No knowledge of assembly language required.	► Costs more CPU than non-CICS API techniques. ► Always has to perform ENQ/DEQ even when no other tasks are interested in the resource. ► Must consider implications of MAXLIFETIME option.

3.2.3 Generalized Compare and Swap routine

The following discussion is predicated on the assumption that most accesses to shared resources are for maintaining flags, counters, or chain pointers. In general where this assumption applies, it may be possible to implement a single subroutine (written in assembly language) that protects the integrity of the shared resources, is generally more efficient than ENQ/DEQ, and insulates the application programmer from the details of implementing Compare and Swap instructions for every shared data element.

Except for the actual operation to be performed (increment, decrement, OR, AND, and so on), most Compare and Swap implementations follow exactly the same pattern. For example, to increment a 4-byte counter, the code will always follow the pattern shown in Example 3-1.

Example 3-1 Compare and Swap implementation example

```
* Increment a 4-byte field
INCREMENT DS    0H
          L     ROLD,SHARED          get shared data
RETRY     LR    RNEW,ROLD            save Shared value
          LA    RNEW,1(,RNEW)        increment value
          CS    ROLD,RNEW,SHARED     store new value
          BNZ   RETRY                serialization failed
          B     RETURN               successful completion
```

Retrying the operation without embedding some form of delay may be disconcerting to some in that it looks as though there is a high potential for a CPU loop. This point is addressed in *z/Architecture Principles of Operation*, SA22-7832, and shown in the following note.

Note: This type of a loop differs from the typical *bitspin* loop. In a bitspin loop, the program continues to loop until the bit changes. In this example, the program continues to loop only if the value does change during each iteration. If a number of CPUs simultaneously attempt to modify a single location by using the sample instruction sequence, one CPU will fall through on the first try, another will loop once, and so on until all CPUs have succeeded.

Implementing a retry counter mitigates this worry. A retry counter also provides a convenient method for tracking potential resource contention at a very granular level—simply log the retry count somewhere such as in a CICS trace or monitor entry for offline analysis. Adding a retry counter in the code yields the results shown in Example 3-2. The symbol RCOUNT is a register other than ROLD or RNEW.

Example 3-2 Retry count example

```
* Increment a 4-byte field
INCREMENT DS    0H
          XR    RCOUNT,RCOUNT        clear retry counter
          L     ROLD,SHARED          get shared data
RETRY     LA    RCOUNT,1(,RCOUNT)    increment retry count
          CL    RCOUNT,MAXTRIES      too many attempts?
          BNL   ERROR                yes, quit trying
          LR    RNEW,ROLD            save original value
          LA    RNEW,1(,RNEW)        increment value
          CS    ROLD,RNEW,SHARED     store new value
```

```
            BNZ   RETRY                   serialization failed-retry
            B     RETURN                  return to caller
ERROR       DS    OH
      < Too many retry attempts >
```

While there are many ways to implement the retry count, the important point to note is that the logic required to set up the CS instruction is always the same.

Likewise, the *increment value* instruction [LA   RNEW,1(,RNEW)] is the only instruction in either of these patterns that has to change to implement a different operation (decrement, AND, OR, and so on). Placing this code in a subroutine in which SHARED is passed by reference could allow the creation of a generalized routine for manipulating shared memory elements. Such a subroutine should handle the most common updates of shared memory.

3.2.4 Non-recommended techniques

This section outlines some other techniques that can be used to serialize access to resources. These techniques are not recommended by the authors of this book, due to the disadvantages associated with each of them.

LINK to a QUASIRENT program

A linked-to program defined as QUASIRENT runs under the QR TCB, and can therefore take advantage of the serialization provided by CICS quasi-reentrancy. Remember, even in quasi-reentrant mode, serialization is provided only for as long as the program retains control and does not wait.

A valid serialization technique is therefore to move all shared resource access to a single program and define it as quasi-reentrant. All other application programs can then be defined as threadsafe, on the condition that they always link to the quasi-reentrant program to access the shared resource.

Although this technique is valid, in that it will protect the integrity of the shared resource, it will not result in the same performance gain as one of the recommended techniques, such as enqueue/dequeue. Whereas the recommended techniques will allow the program to remain on an open TCB (assuming it is there already), this technique will incur the performance overhead of a TCB switch to QR.

CICS transaction class

User-defined CICS transaction classes (TRANCLASS) allow the systems programmer to limit the number of concurrent tasks for transactions that belong to each class. Creating a transaction class with a MAXACTIVE value of 1 is a very crude method of serializing resource access. All transactions belonging to the class will be single threaded.

This technique has one advantage in that it can be achieved without changing any application code. However, even in a moderately busy system, it is likely to have a severe impact on transaction response times, and runs contrary to the whole objective of implementing threadsafe applications in the first place (that is, improved performance).

MVS enqueue/dequeue

Prior to CICS Transaction Server Version 3, issuing non CICS API calls from a CICS program is not supported in releases of CICS Transaction Server (up to and including Version 2 Release 3) because CICS cannot guarantee that such calls will not be issued from the QR TCB. Even if the application and system programmers design the system so that such a call is issued from an open TCB, there is always the risk that a future program change, such as the insertion of a non threadsafe EXEC CICS command, will cause the call to be issued from QR and block all CICS tasks.

The same applies in CICS Transaction Server Version 3 unless the program is defined as THREADSAFE and OPENAPI, which ensures that the program runs on an open TCB. Even in this situation we recommend using CICS services, as CICS provides better facilities to release enqueues in error situations.

3.3 Application design considerations

An ideal candidate application to define as THREADSAFE and CICSAPI, and therefore exploit OTE, is one that contains threadsafe application code, contains only threadsafe EXEC CICS commands, and uses only threadsafe user exit programs. An application like this moves to an L8 TCB when it makes its first call to an OPENAPI TRUE (such as a SQL request, an IP CICS sockets request or a WMQ request), and then continues to run on the L8 TCB through any number of such requests and application code, requiring no TCB switching.

Even if a number of application programs are not threadsafe, or programs contain non threadsafe EXEC CICS commands, it is still possible to design application transactions to minimize the number of TCB switches and obtain the performance benefits associated with running threadsafe.

As can be seen from Figure 2-3 on page 20, the execution path between the first and the last SQL call is key to the performance of a CICS DB2 task running under OTE. It follows that by placing non threadsafe code and commands either prior to the first SQL call or after the final SQL call, the application will avoid incurring the CPU overhead that placing the same code between SQL calls would incur. The same is true for WMQ as well in CICS Transaction Server Version 3.2.

So, to return to the example of the application with both DB2 and VSAM data, pre CICS Transaction Server Version 3.2, by designing the transactions so the VSAM and DB2 calls are not interspersed, an application of this nature can at least partially exploit OTE.

3.3.1 Application design considerations for CICS TS 3.2

At CICS Transaction Server Version 3.2 we now have further enhancements to OTE. It is now possible to define an application program to commence execution on an open TCB rather than wait for a call to an OPENAPI TRUE(DB2, MQ or IP CICS Sockets) to move the task to an open TCB.

Care needs to be taken, however, with applications that are calling OPENAPI-enabled TRUEs. There may be a temptation to define an application that is currently defined as threadsafe, as OPENAPI, so that it commences execution on the open TCB rather than wait for the call to an OPENAPI TRUE. The danger here is that if an application program is defined as OPENAPI and it is also defined as EXECKEY(USER), then the task will begin on an L9 TCB. Then when a call to an OPENAPI TRUE is encountered a switch to an L8 TCB will occur because OPENAPI-enabled TRUEs always run in the CICS key. This situation can lead to TCB switching across three TCBs (QR, L8, and L9). If there are non threadsafe CICS API commands in the program as well, then the performance impact could be very undesirable. This situation can be seen in Figure 2-5 on page 22. The preceding situation is dependant on storage protection being active within the CICS region.

File control

File control for local VSAM and VSAM RLS access is now available via threadsafe API and SPI commands. These include:

- READ
- REWRITE
- WRITE
- DELETE
- UNLOCK
- STARTBR, READNEXT, READPREV, RESETBR, ENDBR
- SPI - INQUIRE FILE

BDAM, SDT, CFDTs and remote files have no threadsafe API.

File control functions that are not threadsafe will still run on the QR TCB. These include:

- Open/Close
- Enable/Disable
- Quiesce functions
- INQ DSNAME
- SET SPI functions

File control exits must be made to be threadsafe, otherwise there will be a switch to the QR TCB when the exit is called and then a switch back when the exit processing completes. Products that have previously located the FCT (File Control Table) via control block interrogation need to be changed because this will no longer be safe to do.

The official interface for access to information in the FCT is via the INQUIRE FILE SPI. No interface to return the addresses of FCT entries, DSNBs, or any other File Control control block will be available.

OPENAPI good and bad candidates

The previous example shows that not all threadsafe application programs are necessarily good candidates to be defined as OPENAPI. If we assume that the program being defined is written to threadsafe standards then we need to decide whether the program is to be defined as CICSAPI or OPENAPI.

There are some guidelines for this, which can be summarized in Figure 3-1 on page 54.

Bad candidates for OPENAPI are user key DB2, IP CICS Sockets, and WMQ programs. This is because the application will start on an L9 TCB and will have to switch to an L8 TCB and back again for each call to an OPENAPI TRUE. Likewise for non threadsafe CICS commands we will switch to QR and back again.

The best candidates for OPENAPI are DB2, IP CICS Sockets, or WMQ programs that have only threadsafe CICS API commands and are defined as EXECKEY(CICS). Also, CPU-intensive programs (that is, those programs that do a lot of processing without giving up control to CICS) are good candidates for OPENAPI, as they can perform the intensive processing without affecting other tasks that might be waiting to execute on the QR TCB.

> **Note:** If storage protection is not active (STGPROT=NO), then the user key is the same as the CICS key and both types of programs run on L8 TCBs if defined as OPENAPI.

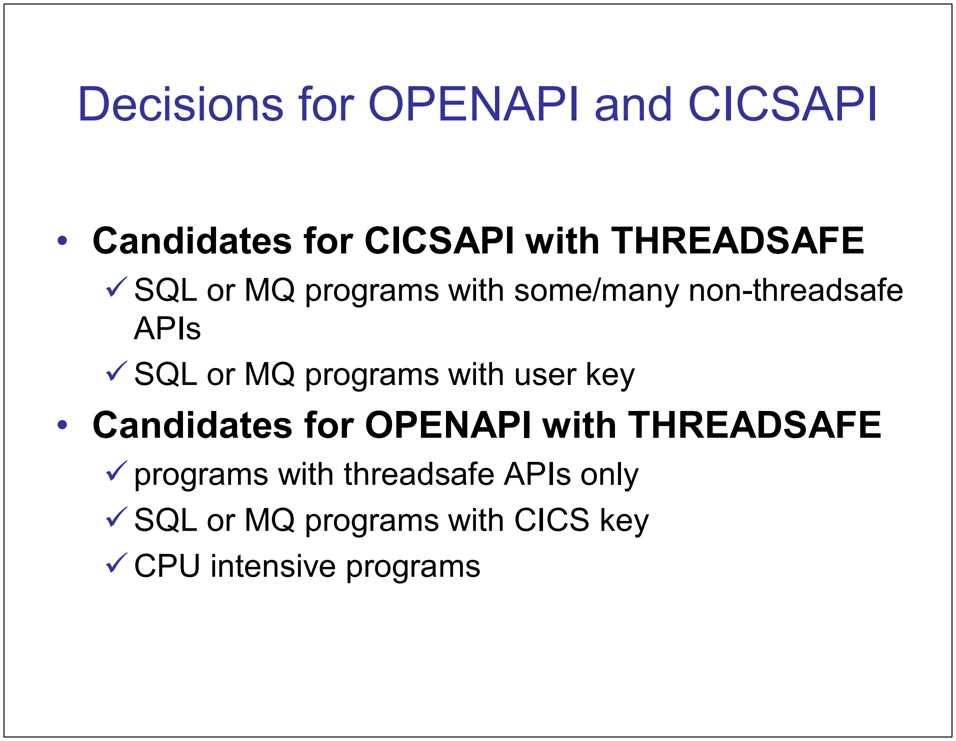

Figure 3-1 Decisions for OPENAPI and CICSAPI

Part 2

Threadsafe implementation

In Part 2 we discuss the implementation tasks and system programmer tasks and provide a review of application code and a migration scenario.

4

Threadsafe tasks

This chapter identifies the tasks that are necessary to make a CICS DB2 application threadsafe, thereby allowing it to continue to run on an L8 TCB, following a DB2 command being issued.

While this chapter identifies the tasks needed to make a DB2 application threadsafe, the same principles apply for an application calling one of the other OPENAPI TRUEs, namely Websphere MQSeries or IP Sockets for CICS.

Additionally, this chapter describes how to use a number of tools to identify those programs that contain commands that will cause an application to switch unnecessarily to the QR TCB or wrongly use shared resources. The tools discussed are:

- CICS load module scanner (DFHEISUP)
- CICS Interdependency Analyzer
- CICS Performance Analyzer

4.1 Threadsafe migration planning

Making your application threadsafe is more complex than just defining your application programs as threadsafe and then sitting back to reap the performance benefits. The truth is that without some careful planning and a staged implementation, you could cause a performance degradation to your system or more seriously jeopardize your application's data integrity.

In this section we discuss the high-level plan to safely get you converted from your existing non threadsafe environment to a fully functional threadsafe one.

4.1.1 CICS Transaction Server upgrade/migration path

To achieve your threadsafe goals you need to be running CICS Transaction Server Version 2 or later and DB2 Version 6 or later. Since the OTE enhancements to the CICS-DB2 Attachment Facility are only exploited from DB2 Version 6 or later, you need to be running the correct release of DB2 to realize the benefits of threadsafe technology.

If you upgrade to CICS Transaction Server Version 2 or later, and change program definitions to CONCURRENCY(THREADSAFE) without performing a review of your exits, you will do more harm than good. This brings up the question: In which order should you upgrade your CICS and DB2 products, or does it matter? The answer is that it depends.

There are a couple of ways in which you can approach your threadsafe implementation, as shown in Table 4-1 and Table 4-2, although the method in Table 4-2 on page 59 is recommended.

Table 4-1 Convert to CICS TS V2 or higher first

Task	Description
1	Migrate to CICS TS V2 or later and DB2 V7 or later.
2	Perform a threadsafe analysis of *all* exits defined to CICS.
3	Make any adjustments or conversions to your exits.
4	Use CEDA to define your exit programs as threadsafe.
5	Analyze and convert your applications to be threadsafe.

Table 4-2 Review your exits first

Task	Description
1	Perform a threadsafe analysis of all exits defined to CICS.
2	Make any adjustments or conversions to your exits.
3	Use CEDA to define your exit programs as threadsafe.
4	Migrate to CICS TS V2 or later and DB2 V6 or later.
5	Retest your exits.
6	Analyze and convert your applications to be threadsafe.

We highly recommend that you follow method 2 listed in Table 4-2. The reason for this is the way CICS Transaction Server Version 2 or Version 3 handles exits in the threadsafe environment. Once you are running on the new L8 TCBs, each call to a non threadsafe defined exit in the DB2 path will force a return to the QR TCB to run the exit, and then afterwards return to the L8 TCB, therefore incurring extra TCB switches. See Figure 8-2 on page 204 for more information.

4.1.2 High-level threadsafe migration path

We recommend migration path 2 since the system exits themselves can increase the number of TCB switches you incur when they are defined as non threadsafe. If you are already running a CICS Transaction Server Version 2 or Version 3 system and have not converted your exits, you still may be in good shape since not all exits are directly in the DB2 path.

As mentioned in the previous section, the CICS system exits are a critical point of analysis in ensuring that you receive the benefits of threadsafe applications. A simple way of looking at this is to say that *all exits* must be converted and defined as threadsafe as part of your migration to CICS Transaction Server Version 2 or Version 3.

As well as any exits that you may have written, it is vitally important that you contact vendors of any OEM products you may have installed. They should be able to advise as to whether their exits are already threadsafe or of any maintenance you need to apply to make them threadsafe. Additionally, there may be information about problems known to IBM that can be found by searching the CICS Support Web pages, and that can be found by clicking the support link on the CICS home page:

http://www.ibm.com/cics

A review of the output produced by DFH0STAT will list all your exits and also whether they have already been defined as threadsafe, which may be the case if you have installed a vendor package that installed the exits as threadsafe. An example of DFH0STAT can be found in 7.4.3, “Running DFH0STAT” on page 176.

Table 4-3 outlines a safe migration path that can be followed no matter what release of CICS or DB2 you are currently running.

Table 4-3 High-level threadsafe migration plan

Task	Description
1	Migrate to DB2 V7 or later.
2	Install pre-req CICS PTFs.
3	Install pre-req DB2 PTFs.
4	Review FORCEQR SIT parameter.
5	Address your exits: ► Identify all your exits. ► Contact vendors if necessary about their exits. ► Review each exit for non threadsafe commands. ► Review each exit for use of shared resources. ► Make any coding adjustments and test. ► Define them as threadsafe.
6	Review system parameters and make adjustments: ► MAXOPENTCBS ► TCBLIMIT ► THREADLIMIT ► MXT
7	Upgrade to CICS TS V2 or V3.
8	Retest exits in a threadsafe environment.
9	Create a threadsafe application review plan.
10	Review and identify your candidate applications.
11	Make necessary program changes to conform to threadsafe standards.
12	Define applications that have passed your review or have been converted to threadsafe practices as THREADSAFE to CICS.

We break each of the preceding steps down into further detail in the next two chapters, but first we discuss the use of some tools you can use to analyze your applications.

We are going to treat system exits and application code both as simple applications for our analysis. You review all your code for two basic non threadsafe practices:

1. EXEC CICS commands that generate TCB switches to the QR TCB
2. EXEC CICS commands that reference shared resources:
   – ADDRESS CWA
   – EXTRACT EXIT
   – GETMAIN SHARED

You can use the CICS-supplied load module scanner (DFHEISUP) to scan your code for occurrences of non threadsafe commands that would generate a switchback to the QR TCB and to help you find occurrences of the three CICS commands listed above. In addition, the CICS Interdependency Analyzer (discussed later) includes a similar function.

4.2 Load module scanner: DFHEISUP

The utility DFHEISUP is provided by CICS to allow you to search load modules for specific CICS API and SPI commands. It locates all the EXEC CICS commands in your load modules, and then applies the filter to report on those commands that you have specified.

It returns one of two types of report:

- A summary report, giving a list of modules containing the commands specified by your filter, and the number of these commands in each module. This can be used as input to the detailed report to get more information about those modules.
- A detailed report shows, for each module, the specific commands it contains, and the offset of the command. Also included is EDF information, if available.

CICS provides an example job DFHEILMS in SDFHINST, which can be edited and used to execute the load module scanner. Its use is documented in the *CICS Operations and Utilities Guide,* SC34-6229, for CICS Transaction Server Version 2, and *CICS Transaction Server for z/OS V3 CICS Operations and Utilities Guide,* SC34-6431, for CICS Transaction Server Version 3.

Important: CICS Transaction Server Version 2.2 users should apply PQ78531 before you run DFHEISUP. This APAR fixes storage problems that occur when running DFHEISUP against very large load libraries or very large load library concatenations. The APAR fix is present at the base code level in later releases of CICS.

4.2.1 DFHEISUP filter tables

Two sample filter tables are provided for use in detemining whether an application is threadsafe:

- DFHEIDTH
- DFHEIDNT

These CICS-supplied filter tables can be found in the SDFHSAMP library on your system.

DFHEIDTH

The first of these, DFHEIDTH, contains a list of the three commands that are *threadsafe inhibitor*, (that is, those commands that *may* cause the program not to be threadsafe because they allow access to shared storage).

The three commands that are listed in DFHEIDTH as being threadsafe inhibitors are:

- EXTRACT EXIT GASET
- GETMAIN SHARED
- ADDRESS CWA

All of these commands return addresses of data areas that can be shared between programs. This means that multiple updates of the data areas pointed at by those addresses may occur by concurrently running tasks.

If your installation has an application standard that allows use of assembler data tables (see “Assembler data tables” on page 150) as a form of shared storage, then you should consider amending DFHEIDTH to add the **`LOAD *`** command to find which applications load and use this form of shared storage. By default, the LOAD command is not included as part of DFHEIDTH because it would find *too* many legitimate uses of EXEC CICS LOAD (for example, loading a read-only program into a read-only DSA).

If any of these commands are identified as being used in any one application program, then a more detailed analysis of the whole application *must* be performed. This is to identify how and when the addresses returned by these commands are used to access the underlying data. It is possible the address returned by one of these commands can be passed to another program that does none of the above commands itself, but will still modify the data at the address passed to it. Only when you have identified how the address is used can you decide how to serialize access to the data.

DFHEIDNT

The second filter table contains a list of all those commands that *will* cause a TCB switchback to the QR TCB. Note that this table is provided by APAR PQ82603 for both CICS Transaction Server Version 2.2 and Version 2.3. The tables are provided at the base code level in CICS Transaction Server Version 3.

Use of these commands will not prevent you from defining the program as threadsafe. They could, however, prevent your application from achieving the performance benefits of allowing programs to stay on an open TCB following a DB2 call.

4.2.2 DFHEISUP - summary mode

Running the load module scanner run in summary mode produces two groups of information. Both groups will be written to SYSPRINT DD:

- A summary of the whole load library detailing how many modules were scanned, how many modules are in the library, how many were not scanned, and how many of the requested commands were found in the whole library.

```
LOAD LIBRARY STATISTICS
 =======================
 Total modules in library                            =     41
 Total modules Scanned                               =     41
 Total CICS modules/tables not scanned               =      0
 Total modules possibly containing requested commands =     19
```

Figure 4-1 Load library statistics

- A list of members in the library that contain any of the commands that have been specified in the filter table. The list will specify how many commands are in the load module and in what language the program was originally written. See Figure 4-2.

```
SUMMARY LISTING OF CICSRS3.U.LOAD
=====================================
Module Name                Commands Found  Language
'CICSRS3.U.LOAD(DB2MANY)'               2  Assembler
'CICSRS3.U.LOAD(DB2ONCE)'               3  Assembler
'CICSRS3.U.LOAD(DB2PGMA)'               1  Assembler
'CICSRS3.U.LOAD(DB2PGMB)'               1  Assembler
'CICSRS3.U.LOAD(DB2PGMO)'               1  Assembler
'CICSRS3.U.LOAD(DB2PROGA)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG1)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG2)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG3)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG4)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG5)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG6)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG7)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG8)'              2  Assembler
'CICSRS3.U.LOAD(DB2PROG9)'              2  Assembler
'CICSRS3.U.LOAD(DB2SAMPL)'              1  Assembler
'CICSRS3.U.LOAD(FUNCSHIP)'              1  Assembler
'CICSRS3.U.LOAD(INITXIT)'               1  Assembler
'CICSRS3.U.LOAD(INITXIT2)'              1  Assembler
```

Figure 4-2 Module listing from summary report

This list of modules can also be optionally written to a file that is allocated to the DFHDTL DD statement by specifying the DETAILMODS parameter along with the SUMMARY parm on the EXEC statement of the jobstep. Example 4-1 demonstrates this.

Example 4-1 DFHEILMS summary run

```
//DFHSCNR  JOB (accounting information),CLASS=A,MSGCLASS=A
//DFHSCAN  EXEC PGM=DFHEISUP,PARM=('SUMMARY, DETAILMODS'),REGION=512M
//STEPLIB  DD DSN=&HLQ.SDFHLOAD,DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//* Filter table
//DFHFLTR  DD DSN=&HLQ.FILTER,DISP=SHR
//* Module list for input to detail run
```

```
//DFHDTL   DD DSN=&HLQ.MODLIST,DISP=(NEW,CATLG,DELETE),
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000),SPACE=(CYL,(1,1))
//DFHIN    DD DSN=&HLQ.SDFHLOAD,DISP=SHR
```

This file can then be fed into the detail run via the DFHLIST DD statement. Again the report is written out to the SYSPRINT DD statement.

4.2.3 DFHEISUP - detail mode

The load module scanner, when run in detail mode, writes a report to the SYSPRINT DD statement showing exactly which commands are in each of the load modules scanned. An example of the JCL to run the detail report is shown in Example 4-2.

Example 4-2 DFHEILMS detail run

```
//DFHSCNR  JOB (accounting information),CLASS=A,MSGCLASS=A
//DFHSCAN  EXEC PGM=DFHEISUP,PARM=('DETAIL'),REGION=512M
//STEPLIB  DD DSN=&HLQ.SDFHLOAD,DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//* Filter table
//DFHFLTR  DD DSN=&HLQ.FILTER,DISP=SHR
//* Module list for input to detail run
//DFHIN    DD DSN=&HLQ.SDFHLOAD,DISP=SHR
//* Module list from the summary run - DO NOT SPECIFY ALL with this
//DFHLIST  DD DSN=&HLQ.MODLIST,DISP=SHR
```

The detail run will scan only those modules listed in the input file pointed to by DD DFHLIST unless you add ALL to the parm statement.

An example of the output from a detail run is shown in Figure 4-3. Most of the entries have been edited from the example to save space.

```
 CICS LOAD MODULE SCANNER UTILITY
  SCAN PERFORMED ON Thu May  6 16:18:04 2004 USING TABLE RSTABLE2.3

  DETAILED LISTING OF DD:DFHLIST
  =====================================

  Module Name        'CICSRS3.U.LOAD(DB2MANY)'
  Module Language    Assembler
  Offset/EDF         Command
  -----------------  ------------------------------------------
  00001962/no-edf    START TRANSID FROM LENGTH INTERVAL
  00001971/no-edf    SEND TEXT FROM LENGTH FREEKB TERMINAL

  Module Name        'CICSRS3.U.LOAD(DB2ONCE)'
  Module Language    Assembler
  Offset/EDF         Command
  -----------------  ------------------------------------------
  00001961/no-edf    INQUIRE CLASSCACHE PROFILE
  00001974/no-edf    INQUIRE JVM PROFILE
  00002000/no-edf    ASKTIME ABSTIME

  Module Name        'CICSRS3.U.LOAD(DB2PGMA)'
  Module Language    Assembler
  Offset/EDF         Command
  -----------------  ------------------------------------------
  00000840/no-edf    START TRANSID INTERVAL

Module Name        'CICSRS3.U.LOAD(INITXIT2)'
  Module Language    Assembler
  Offset/EDF         Command
  -----------------  ------------------------------------------
  00000716/no-edf    EXTRACT EXIT PROGRAM GASET GALENGTH

  Total possible commands located = 32

  LOAD LIBRARY STATISTICS
  =======================
  Total modules in library                            =     19
  Total modules Scanned                               =     19
  Total CICS modules/tables not scanned               =      0
  Total modules possibly containing requested commands =     19
```

Figure 4-3 Detail report from DFHEISUP

4.2.4 DFHEISUP summary

For CICS Transaction Server Version 2.2 ensure that APAR PQ78531 is applied if you intend to scan very large libraries of load modules in a single run (the APAR fix is present at the base code level in higher releases). This will prevent possible storage problems when running against load libraries with 80 or more load modules. DFHEISUP is still a CPU intensive program and will obviously take longer to run against larger load libraries or load library concatenations.

The summary run is specified by PARM=SUMMARY on the PARM statement. Specifying PARM='SUMMARY,DETAILMODS' will direct a copy of the load module list to the file pointed to by DFHDTL as well as writing this information to SYSPRINT. This file can then be used as input to the detail run.

The detail run is specified by PARM=DETAIL on the PARM statement. If you supply, as input to the detail run, the module list generated by the summary run, do not specify PARM='DETAIL,ALL', as this will override the list of modules in this file and scan the whole library again. If ALL is omitted only those modules listed in the DFHLIST DD will be scanned.

5

5

CICS migration tools

This chapter focuses on the CICS tools that can assist you in migrating your applications to be threadsafe. The following topics are covered:

- CICS Performance Analyzer for z/OS (CICS PA)
- CICS Interdependency Analyzer for z/OS (CICS IA)
- CICS Configuration Manager for z/OS (CICS CM)
- A note about CICS VSAM Transparency for z/OS (CICS/VT)
- Application case study using CICS Tools Four Step Process

5.1 CICS Performance Analyzer for z/OS(CICSPA)

This section describes CICS Performance Analyzer for z/OS (CICS PA) and how it can help with threadsafe decisions.

For details of how you can use CICS PA to compare CICS performance before and after application threadsafe conversion, see *Migration Considerations for CICS Using CICS CM, CICS PA, and CICS IA*, SG24-7294.

CICS Performance Analyzer complements IBM Tivoli® OMEGAMON® XE for CICS on z/OS by helping you to respond quickly to online performance issues by drilling down deeply into CICS performance data to identify the cause of the problem. When used in conjunction with OMEGAMON XE for CICS, you can create CICS Performance Analyzer reports that detail your application's use of Adabas, CA-Datacom, SUPRA, and CA-IDMS, as well as reporting on those transactions that have exceeded OMEGAMON XE for CICS resource-limiting thresholds.

Simplified and extended integration with OMEGAMON XE for CICS allows CICS Performance Analyzer to process SMF type 112 records containing third-party database management systems, and OMEGAMON XE for CICS resource-limiting metrics can give you better insight into all of your CICS data resources.

5.1.1 CICS PA overview

CICS PA provides comprehensive performance reporting and analysis for CICS Transaction Server and related subsystems, including DB2, WMQ, IMS (DBCTL), and the z/OS System Logger. It provides information on the performance of your CICS systems and applications, and helps you tune, manage, and plan your CICS systems effectively. CICS PA also provides a historical database facility to help you manage CICS statistics and performance data for your CICS transactions.

It produces reports and extracts using data normally collected by your system in MVS System Management Facility (SMF) data sets:

- CICS Monitoring Facility (CMF) performance class, exception class, and transaction resource class data in SMF 110 records
- CICS statistics and server statistics data in SMF 110 records
- CICS Transaction Gateway statistics data in SMF 111 records
- DB2 accounting data in SMF 101 records
- WebSphere MQ accounting data in SMF 116 records

- System Logger data in SMF 88 records
- IBM Tivoli OMEGAMON XE for CICS on z/OS (OMEGAMON XE for CICS) data in SMF 112 records, containing transaction data for Adabas, CA-Datacom, CA-IDMS, and Supra database management systems

Use the CICS PA Interactive System Productivity Facility (ISPF) dialog to generate your report and extract requests. The CICS PA dialog assists you in building the reports and extracts requests specific to your requirements. This avoids having to understand the complexity of the CICS Monitoring Facility (CMF) data, CICS statistics, CICS server statistics data, CICS Transaction Gateway Statistics, CICS System Logger data, DB2 accounting and WMQ accounting data. It has extensive online help facilities and a powerful command language that is used to select, sort, and customize the report formats and data extracts.

CICS PA provides a comprehensive suite of reports and data extracts for use by:

- System programmers, to track overall CICS system performance and evaluate the effects of CICS system tuning efforts
- Applications programmers, to analyze the performance of their applications and the resources they use
- DBAs, to analyze the usage and performance of CICS Resource Managers such as WMQ, and database systems such as DB2 and IMS (DBCTL)
- MQ Administrators to analyze the usage and performance of their WebSphere MQ messaging systems.
- Managers, to ensure that transactions are meeting their required service levels and measure trends to help plan future requirements and strategies

The Historical Database (HDB) facility provides a flexible and easy way to manage and report historical performance and statistics data for your CICS systems.

- First define a HDB template with customized data for historical reporting, then load it to the HDB.
- Once loaded, PA can extract it to a CSV file or export it to DB2 for reporting with the CICS Explorer™ in a spreadsheet view, charts and graphs.

The CICS PA plug-in for CICS Explorer (PA plug-in) is an Eclipse plug-in that operates on top of the IBM CICS Explorer to help you analyze CICS performance data.

Using the PA plug-in, you can perform the following tasks:

- View and sort the CSV or database data in a spreadsheet viewer.

- Select single or multiple transaction for analysis.
- Perform CPU time analysis.
- Perform file analysis.
- Perform response time analysis.
- Perform storage analysis.
- Perform threadsafe analysis.

For more information about the IBM CICS Explorer, see

http://www.ibm.com/cics/explorer.

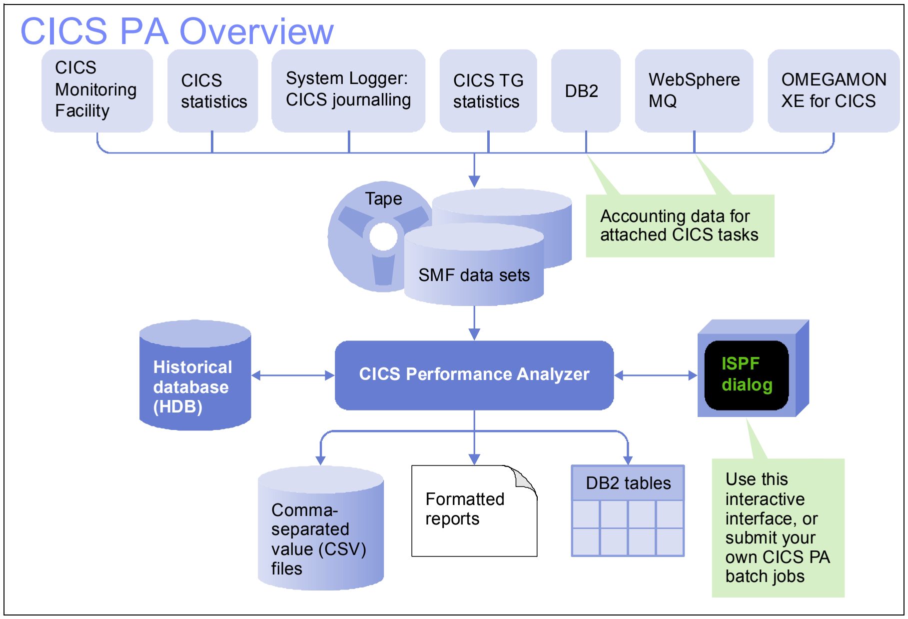

Figure 5-1 CICS PA overview: The big picture

5.1.2 Reports and extracts

Report sets are where you specify, save, and run your report requests. A report set contains a set of report and extract requests to be submitted and run as a single job. You can define any number of report sets, and any number of reports and extracts can be included in a single report set. CICS PA provides a comprehensive set of reports, graphs, and data extracts:

- The performance list, list extended, and summary reports provide detailed analysis of CICS transaction activity and performance.

- The performance wait analysis report provides a detailed analysis of transaction activity by wait time. This report summarizes, by transaction ID, the resources that cause a transaction to be suspended and highlights the CICS system resource bottlenecks that may be causing bad response time.
- The cross-system work report combines the CICS CMF performance class records from connected CICS (via MRO or ISC) systems to produce a consolidated network unit-of-work (UOW) report.
- The DB2 reports combine CICS CMF (SMF 110) performance class records and DB2 accounting (SMF 101) records to produce detail or summary reports of the DB2 usage by your CICS systems. The DB2 list report shows the DB2 activity of each transaction and the DB2 summary report (short or long) summarizes the DB2 activity by transaction and program within an APPLID.
- The transaction profiling report benchmarks before and after results with detailed reporting. It can show differences between the report data and the baseline data as a delta (report data values minus their equivalent baseline data values) and as the percentage of change.
- The extracts produce data sets intended for use by software applications, including CICS PA itself. The extract export facility creates a delimited text file that can be used in spreadsheet analysis or as input into the CICS Explorer.
- For more information about CICS PA see the IBM Redbooks publication *CICS Performance Analyzer,* SG24-6063.

5.1.3 How to use CICS PA to identify threadsafe candidates

CICS PA can be used to help answer the following questions:

- Which TCBs did my transactions use?
  - How many different TCB modes did my transaction use?
- How much dispatch and CPU time did they use?
- How many TCB switches (change modes) were there?
  - What was the change mode delay time?
- Which transactions did the highest number of TCB switches?
- Which transactions used the most CPU?

5.1.4 How to use CICS PA to benchmark results

CICS Explorer PA Perspective

The CICS PA plug-in is an Eclipse plug-in that operates on top of the IBM CICS Explorer to help you analyze CICS performance data.

The CICS Monitoring Facility (CMF) produces performance class data, which is stored in a database or formatted as comma-separated variable (csv) files using the CICS Performance Analyzer for z/OS. The data is then analyzed using the CICS PA plug-in.

Using the CICS PA plug-in you can perform the following tasks:

- View and sort the csv or database data in a spreadsheet viewer
- Select single or multiple transaction for analysis
- Perform CPU time analysis
- Perform file analysis
- Perform response time analysis
- Perform storage analysis.
- Perform threadsafe analysis
- Perform response time analysis

CICS PA reports and extracts

CICS PA performance summary, performance list, and performance list extended reports answer these questions. CICS PA provides extensive sample report forms that show CPU and TCB usage, TCB delays, change mode delays, and more, as shown in Figure 5-2.

```
File  Confirm  Samples  Options  Help
                               Report Forms                    Row 1 to 14 of 14
Command ===> _______________________________________________    Scroll ===> PAGE

Report Forms Data Set . . : CBAKER.CICSPA1.FORM

/  Name     Type            Description                  Changed         ID
_ CPULEXTR LIST    CPU Analysis and Extract         2005/03/25 00:00 CICSPA
_ CPULST   LIST    Transaction CPU Analysis         2005/03/25 00:00 CICSPA
_ CPULST1  LIST    Transaction CPU Analysis (1)     2005/03/25 00:00 CICSPA
_ CPUSEXTR SUMMARY CPU Analysis and Extract         2005/03/25 00:00 CICSPA
_ CPUSUM   SUMMARY Transaction CPU Analysis         2005/03/25 00:00 CICSPA
_ CPUSUM1  SUMMARY Transaction CPU Analysis (1)     2005/03/25 00:00 CICSPA
_ CPU3LEXT LIST    CPU Analysis and Extract (V3)    2005/03/25 00:00 CICSPA
_ CPU3SEXT SUMMARY CPU Analysis and Extract (V3)    2005/03/25 00:00 CICSPA
_ CPU8LST  LIST    Transaction CPU Analysis (Key 8) 2005/03/25 00:00 CICSPA
_ CPU8SUM  SUMMARY Transaction CPU Analysis (Key 8) 2005/03/25 00:00 CICSPA
_ CPU9LST  LIST    Transaction CPU Analysis (Key 9) 2005/03/25 00:00 CICSPA
_ CPU9SUM  SUMMARY Transaction CPU Analysis (Key 9) 2005/03/25 00:00 CICSPA
_ TCB3LST  LIST    CICS TCB Usage and Delays (V3)   2005/03/25 00:00 CICSPA
_ TCB3SUM  SUMMARY CICS TCB Usage and Delays (V3)   2005/03/25 00:00 CICSPA
******************************* Bottom of data ********************************
```

Figure 5-2 CICS PA report forms for transaction CPU and TCB usage

An example of a CICS TCB CPU analysis report is shown in Figure 5-3.

V1R4M0 CICS Performance Analyzer
Performance Summary

SUMM0001 Printed at 14:58:28 8/15/2005 Data from 10:45:23 2/20/2005 to 11:18:07 2/20/2005 Page 1

Transaction CICS TCB CPU Analysis - Summary

Tran	#Tasks	Avg Response Time	Max Response Time	Avg Dispatch Time	Avg User CPU Time	Avg Suspend Time	Avg DispWait Time	Avg QR CPU Time	Avg MS CPU Time	Avg RO CPU Time	Avg KY8 CPU Time	Avg KY9 CPU Time
ABRW	7	.0506	.2705	.0456	.0050	.0050	.0008	.0013	.0037	.0014	.0000	.0000
ADT1	4	1.2787	5.0652	1.2782	.2160	.0005	.0005	.0007	.0005	.0005	.0000	.2147
CALL	4	2.1675	2.2519	.0061	.0014	2.1614	.0003	.0007	.0006	.0006	.0001	.0000
CATA	2	.0241	.0420	.0190	.0033	.0051	.0001	.0019	.0013	.0013	.0000	.0000
CATR	1	.0109	.0109	.0108	.0027	.0001	.0000	.0005	.0022	.0022	.0000	.0000
CBAM	1	4.3257	4.3257	.0106	.0033	4.3152	.0001	.0010	.0023	.0023	.0000	.0000
CEBR	2	7.4248	11.1982	.0498	.0044	7.3749	.0001	.0013	.0031	.0031	.0000	.0000
CECI	2	31.7902	33.4010	.0523	.0078	31.7378	.0003	.0036	.0042	.0042	.0000	.0000
CEDA	4	10.5878	17.3655	.4513	.1893	10.1366	.0013	.1653	.0235	.0047	.0005	.0000
CEJR	3	.0337	.0622	.0209	.0030	.0128	.0121	.0006	.0006	.0006	.0018	.0000
CEMT	12	17.7283	116.4639	.0691	.0093	17.6592	.0038	.0060	.0033	.0016	.0000	.0000
....												
CFQR	1	1955.858	1955.858	.0002	.0003	1955.858	.0003	.0003	.0000	.0000	.0000	.0000
CFQS	1	1955.858	1955.858	.0077	.0023	1955.851	.0025	.0005	.0018	.0018	.0000	.0000
CGRP	1	.0944	.0944	.0196	.0025	.0748	.0138	.0007	.0017	.0017	.0000	.0000
CMAC	13	.0628	.7314	.0602	.0054	.0026	.0002	.0010	.0044	.0005	.0000	.0000
CPIR	9	.2211	.6758	.1688	.0030	.0523	.0021	.0011	.0004	.0004	.0016	.0000
....												
CXRE	1	.0808	.0808	.0238	.0021	.0570	.0569	.0004	.0018	.0018	.0000	.0000
ENAB	1	.0776	.0776	.0775	.0054	.0001	.0001	.0005	.0048	.0048	.0000	.0000
STAT	5	137.5680	335.4007	.8607	.6560	136.7072	.0025	.6503	.0057	.0057	.0000	.0000
Total	106	154.0982	1955.858	.2038	.0647	153.8944	.0130	.0513	.0051	.0031	.0002	.0081

Figure 5-3 CICS PA transaction CICS TCB CPU analysis: Summary

An example report showing TCB usage and number of change modes is shown in Figure 5-4.

V1R4M0 CICS Performance Analyzer
Performance Summary

SUMM0004 Printed at 14:58:28 8/15/2005 Data from 10:45:23 2/20/2005 to 11:18:07 2/20/2005 Page 1

CICS TCB Usage and Delays (V3) - Detail

Tran	#Tasks	Avg TCBAtach Count	Avg DSTCBHWM Count	Max DSTCBHWM Count	Avg DSCHMDLY Count	Max DSCHMDLY Count	Avg DSTCBMWT Count	Avg MaxJTDly Count	Avg MaxOTDly Count	Avg MAXSTDLY Count	Avg MAXXTDLY Count	Avg KY8 Disp Count	Avg KY9 Disp Count
ABRW	7	0	0	0	2	14	0	0	0	0	0	0	0
ADT1	4	0	1	1	5	8	0	0	0	0	0	0	2
CALL	4	0	1	1	6	8	0	0	0	0	0	3	0
CATA	2	0	0	0	1	2	0	0	0	0	0	0	0
CATR	1	0	0	0	2	2	0	0	0	0	0	0	0
CBAM	1	0	0	0	2	2	0	0	0	0	0	0	0
CEBR	2	0	0	0	3	6	0	0	0	0	0	0	0
CECI	2	0	0	0	3	6	0	0	0	0	0	0	0
CEDA	4	0	0	1	15	26	0	0	0	0	0	1	0
CEJR	3	0	0	1	2	6	0	0	0	0	0	1	0
CEMT	12	0	0	0	3	36	0	0	0	0	0	0	0
CESD	1	0	0	0	0	0	0	0	0	0	0	0	0
CESN	5	0	0	0	2	6	0	0	0	0	0	0	0
CETR	1	0	0	0	8	8	0	0	0	0	0	0	0
CFQR	1	0	0	0	0	0	0	0	0	0	0	0	0
CFQS	1	0	0	0	2	2	0	0	0	0	0	0	0
CGRP	1	0	0	0	2	2	0	0	0	0	0	0	0
CMAC	13	0	0	0	2	30	0	0	0	0	0	0	0
CPIR	9	0	0	1	11	56	0	0	0	0	0	5	0
....													
CWBG	1	0	0	0	2	2	0	0	0	0	0	0	0
CXRE	1	0	0	0	2	2	0	0	0	0	0	0	0
ENAB	1	0	0	0	4	4	0	0	0	0	0	0	0
STAT	5	0	0	0	6	20	0	0	0	0	0	0	0
Total	106	0	0	1	5	118	0	0	0	0	0	0	0

Figure 5-4 CICS PA TCB usage and delays

Note: Prior to CICS Transaction Server Version 3, the field in the CICS SMF 110 record that contained the count of TCB switches (change modes) is called CHMODECT.

In CICS Transaction Server Version 3 the CHMODECT field has been removed and replaced by a composite field called DSCHMDLY. This composite field consists of a time and a count:

- The time portion represents the elapsed time the user task waited for redispatch after change mode requests. For example, a change mode request from an L8 TCB back to the QR TCB may have to wait for the QR TCB because another task is currently dispatched on the QR TCB.
- The count portion represents the number of change modes and is equivalent to CHMODECT in previous releases.

An example report on shared storage use is shown in Figure 5-5.

```
V1R4M0                                                   CICS Performance Analyzer
                                                              Performance List

LIST0003 Printed at 13:53:01  8/16/2005    Data from 10:45:24  2/20/2005                                 Page    1
Transaction Shared Storage Analysis - Detail

 Tran Userid      TaskNo Stop          SC24SGet  SC24GShr  SC24FShr  SC31SGet  SC31GShr  SC31FShr
                         Time
 CSSY CBAKER          11 10:45:24.716         0         0         0         0         0         0
 CSSY CBAKER          14 10:45:25.133         0         0         0         0         0         0
 CSSY CBAKER         III 10:45:32.173         8    208032      2096         1       288         0
 CPIR CBAKER          23 10:45:32.183         0         0         0         0         0         0
```

Figure 5-5 CICS PA transaction shared storage analysis

5.2 CICS Interdependency Analyzer for z/OS (CICS IA)

This section covers the CICS IA tool, including its purpose, components, architecture, and detailed steps for configuring and using it for threadsafe analysis.

5.2.1 CICS IA overview

The CICS Interdependency Analyzer for z/OS (CICS IA) is a runtime and batch system for use with CICS Transaction Server for z/OS (CICS TS). It is used for the following two purposes:

- To identify CICS application resources and their interdependencies

  This function enables you to understand the makeup of your application set, such as:

  – Which transactions use which programs

  - Which programs use which resources (files, maps, queues, and so on)
  - Which resources are no longer used
  - What applications does a CICS region contain
  - What commands within programs provide integrity exposures for threadsafe
  - What commands cause a TCB mode switch
- To analyze transaction affinities

  Affinities require particular groups of transactions to be run either in the same CICS region or in a particular region.

  Affinities information is useful in a dynamic routing environment, since you need to know of any restrictions that *prevent* particular transactions from being routed to particular application-owning regions (AORs) or that *require* particular transactions to be routed to particular AORs.

CICS IA captures information on affinities, interdependencies or both concurrently while CICS is running and stores it in VSAM files. Subsequently the VSAM files are used to load the DB2 database tables. Sample SQL queries are provided to analyze the DB2 tables, or the users can use the online query interface. Detailed batch reports can be produced from the VSAM files, if desired.

Many large organizations have been using CICS since the early 1970s and their systems have grown and evolved with the business. During this time, many techniques for implementing applications have been used as a result of new functions, changing corporate standards, technical requirements, and business pressures.

Frequently, this growth has not been as structured as it might have been, with the result that many applications and services share common resources, and changes in one area typically affect many other areas. This can reach such a level that the system can no longer develop in a controlled manner without a full understanding of these interrelationships. CICS IA can help you achieve this understanding.

For example, if you need to change the content or structure of a file, you need to know which programs use this file, because they will need to be changed also. CICS IA can tell you this, as well as the transactions that drive the programs. CICS IA records the interdependencies between resources (such as files, programs, and transactions) by monitoring programming commands that operate on resources.

The application that issues such a command has a dependency on the resource named in the command. For example, if an application program issues the command EXEC CICS WRITE FILE(myfile), it has a dependency on the file called myfile. It might have similar dependencies on transient data queues, temporary storage queues, transactions, other programs, and so on.

The commands that are monitored are typically CICS application programming interface (API) and system programming interface (SPI) commands that operate on CICS resources. However, you can also instruct CICS IA to monitor some types of non-CICS commands that operate on non-CICS resources, for example:

- WMQ calls
- DLI calls to IMS Database resources
- DB2 calls
- Dynamic COBOL calls to other programs

The following features and capabilities are in CICS Interdependency Analyzer:

- An Eclipse-based graphical user interface to analyze collected data
  - Sample queries with toolbar searches for common resources
  - Custom queries to interrogate dependency and affinity database objects
  - Integrated with the CICS Explorer providing participation in cross-tooling capability from performance to resource definitions
- Timer-based collector control

  This control allows the user to start the collector for a given time of day to enable targeted data collection. For example, you can set the tool to schedule collection in different regions throughout the data collection process.

  It helps you to:

  - Work around high volume time periods
  - Target collection for when an application is active
- Enhanced single point of control capabilities
  - You can turn data collection for multiple CICS regions on and off with a single CINT command to speed selection
  - You can select default options for all your CICS regions with a single setting or you can specify collection options to be region specific
- A selective program and transaction Exclude list eliminates extraneous data and reduces overhead during data capture
- Provision of CSD data set name and group-list information
- Automation of tracking of runtime impact on application change by providing program version information, enabling removal of old data by version and comparison of data by program version
- Command Flow Feature for enhanced threadsafe analysis and tracking.

5.2.2 The components of CICS IA

The CICS IA architecture is described later in this chapter. This section describes the components that make up CICS IA.

The design of CICS IA centers around the concept of examining the EXEC CICS commands used by applications and systems programmers. Each command and its parameters indicates the resources that will be used by the program. An analysis of these calls provides a view of resource interdependencies.

The scanner component

It is possible to write a program to examine the program load modules and report on the EXEC CICS commands and their parameters. The *scanner* component of CICS IA is just such a program. It produces a report that tells, for each program, the commands issued, the programming language used, and the resources involved. The scanner also indicates whether the command is a possible affinity, a possible dependency, or both.

The collector component

The problem with only using the scanner is that it does not show the execution-time path through the code and which commands are, in fact, executed. An approach is needed that intercepts the commands as they are executed and captures the name of the program and its context (for example, which program called it, which transaction initiated it, and so on). The *collector* component is that part of CICS IA that does this capture function and stores the data in an MVS data space.

The collector function can be activated across multiple CICS regions from a single point of control, and the data can be collected across these regions and written to a VSAM file shared between these regions using a file owning region (FOR) or using RLS. The collector can collect either dependency or affinity information; it cannot collect both at once. At specified intervals or on operator command the data space is written to VSAM files.

From the interactive interface of CICS IA you can control collectors running on multiple regions.

Note: To ensure that you monitor as many potential dependencies or affinities as possible, use CICS IA with all parts of your workload, including rarely used transactions and abnormal situations. It is possible to store the collected information from several CICS regions into the same database. You can then review the collected dependencies and affinities using CICS IA's query interface, or produce your own SQL queries based on samples provided.

Once the data is collected, CICS IA provides a set of utilities to enable this data to be loaded into a DB2 database. Having the data in DB2 provides many opportunities for detailed analysis using standard SQL queries or using the online CICS BMS interface that CICS IA provides. This analysis can help you to:

- Use CICS resources more efficiently.
- Balance application workload for continuous availability.
- Improve the speed and reduce the cost of application maintenance.
- Minimize the impact of routine application maintenance for the end user.
- Plan reuse of existing applications as e-business applications and build new applications more efficiently.

The reporter component

The *reporter* component is a set of batch programs that can produce reports from these files. A summary report can be run or, if desired, a detailed report can be run.

- Dependency Reporter consists of a batch job that converts the dependency data collected by the Collector into reports that present the data in a readable format.
- Affinities Reporter consists of a batch job that converts the affinity data collected by the Collector into reports presenting the data in a readable format. It can also be used to create a file of affinity-transaction-group definitions in a syntax approximating the batch API of CICSPlex® SM. This file is used as input to the Builder component.
- Threadsafe Reporter consists of a batch job that produces reports displaying the threadsafe status of each command in the requested programs.
- CICS IA also provides sample SQL queries for use with SPUFI or other DB2 query tools from IBM or other ISVs.

The Builder component

The Builder is a batch utility that takes as input a file of basic affinity-transaction-group definitions created by the Reporter. It produces a file of combined affinity-transaction-group definitions suitable for input to CICSPlex SM.

The CICS Explorer IA Perspective

The CICS IA plug-in provides an Eclipse-based infrastructure to identify CICS application resources and their interdependencies and to analyze transaction affinities.

The CICS IA plug-in consists of two parts:

The Collector monitors all calls to CICS and captures them in DB2 database tables. Each call to CICS is called an interaction. Each interaction consists of a number of pieces of information such as the region, transaction ID, and the name of the program that issues the CICS call. Details about the CICS call itself, such as the function name and the resource type, are also captured, with additional information such as the transient control block and whether the transaction is associated with a terminal.

The graphical user interface (GUI) client. Use the CICS IA plug-in to analyze and explore the collected data about CICS interactions and CICS, Affinity, IMS, DB2, and MQ resources. The CICS IA plug-in requires the location of the DB2 database in which the Interdependency Analyzer has stored data. Use the Connection preferences window to enter this information. When you have made a successful connection between the CICS IA plug-in and the DB2 collector tables, you can search to find resources and analyze their usage and their dependencies.

The Command Flow Feature

The Command Flow feature enables you to capture all EXEC CICS, SQL, MQ and IMS calls in chronological order.

- Trace command flows for up to 5 transactions
- Written to a CICS Journal which uses the MVS logger
- View in graphic format in the CICS IA Explorer
- Highlights TCB mode switches, non-zero return codes, getmain freemain addresses, and much more

5.2.3 CICS IA architecture

The components of CICS IA described in the previous section are shown in Figure 5-6 & 5-7. Detailed discussion about how to use the components is in subsequent sections.

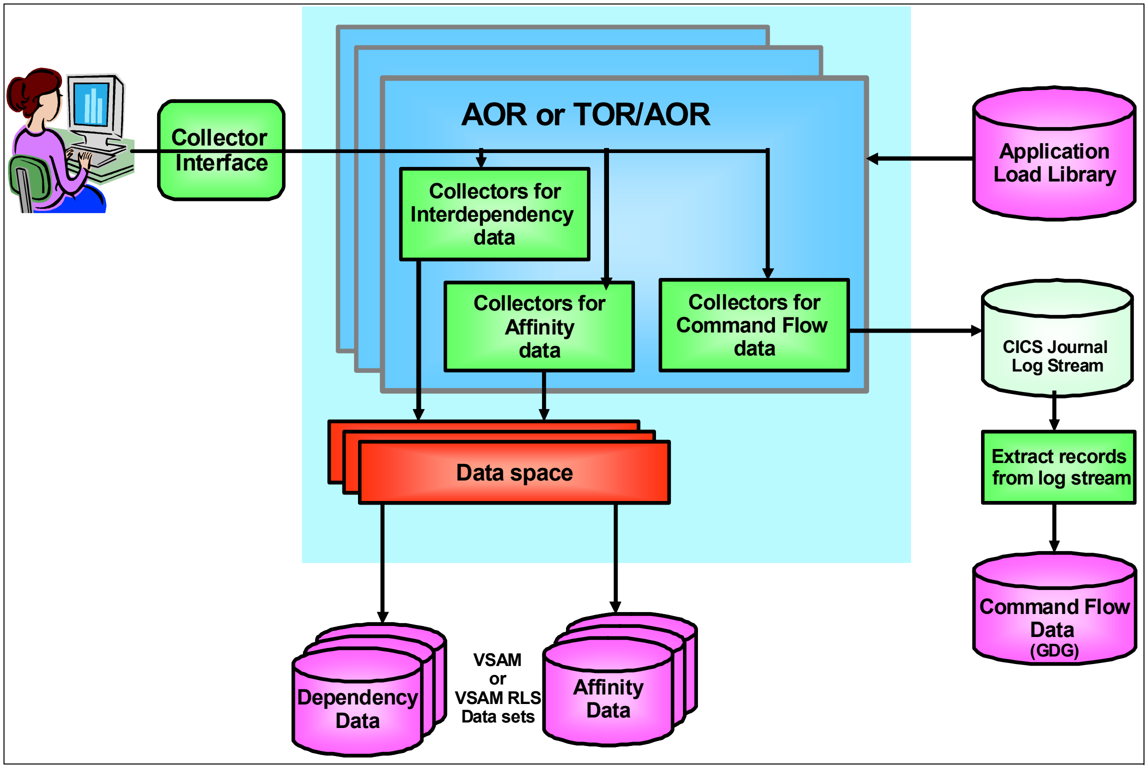

Figure 5-6 CICS IA architecture: The collector structure

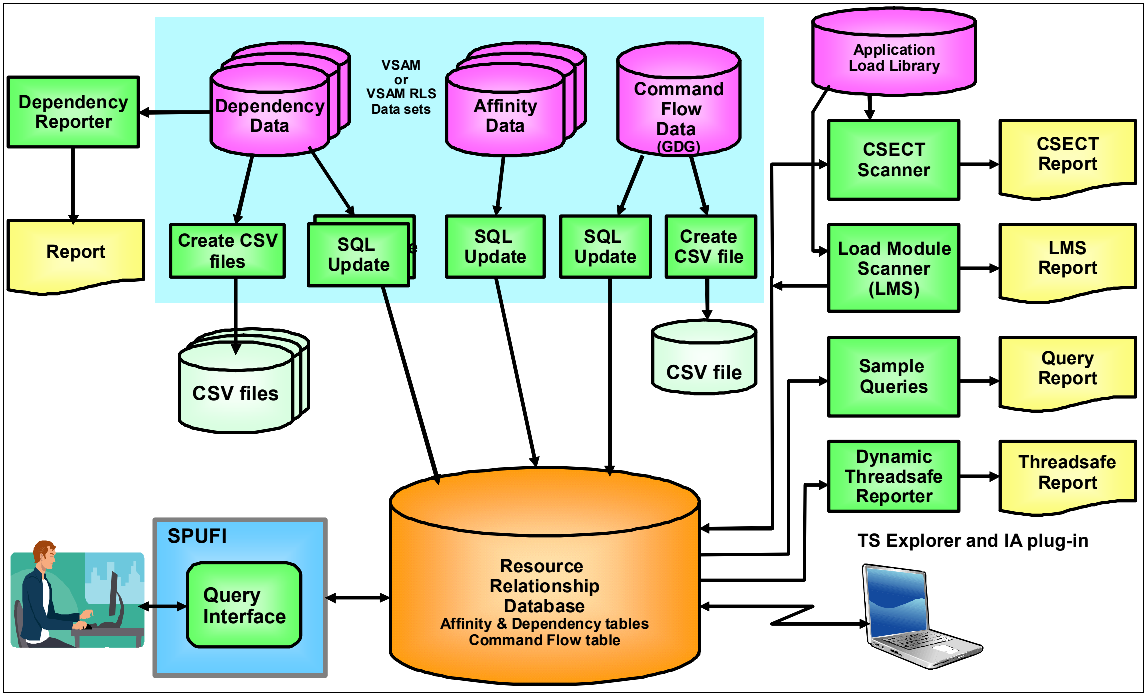

Figure 5-7 CICS IA architecture: The reporting structure

5.2.4 How to prepare CICS IA for threadsafe analysis

Before we go into the Application Case study in the following chapters, we need to prepare CICS IA for dependency collection using the Collector.

Using the CICS IA Collector

The collector consists of:

- A control transaction, CINT
- An autosave transaction, CINB
- A number of global user exit programs

Details for configuring the collector and loading the data can be found in the CICS IA User's Guide and Reference. In this section we describe important parameters for threadsafety.

Collector Setup for Threadsafe Analysis

Verify the resource options for threadsafe collection. From the Main Admin Menu, select option **2** (Configure Region Options), then choose the appropriate region or the defaults and enter the **4** action code for Options. Finally choose option **3** (CICS Options for API's).

To collect all dependencies make sure all options are set to **Y** for YES or **D** for Detail.

```
CIU240       CICS Interdependency Analyzer for z/OS - V3R1M0        2009/12/05
                      CICS Resources Options for                    11:37:19PM
          CICS Sysid   : DFTS     CICS Applid   : DEFAULTS

Modify the options and press Enter to update, or PF12 to Cancel.

Detect command types: Y=Yes, N=No
                      D=Yes+Detail ( Only for API types marked with * )
APIs
*Programs . . . D *Files. . . . . D *Transactions . D  Task Control . Y
 Presentation . Y *TS Queues  . . D *TD Queues  . . D  Journals . . . Y
 DTP  . . . . . Y  Counters . . . Y  FEPI . . . . . Y *WEB Services . D
*Exits  . . . . D  Others . . . . Y  EVENT proc . . Y  ATOMServices . Y
 XMLtransform . Y  WSAddressing . Y
```

Figure 5-8 CINT: CICS Resource Options for API

Threadsafe analysis requires capture of interdependency data in CICS IA. After completing steps in the Resource options screen, **PF3** back to the Resource

Options menu. Select **1** for General Options. Set Data to Collect to **I** for Interdependency.

```
CIU260        CICS Interdependency Analyzer for z/OS - V3R1M0        2009/12/05
                           General Options for                       11:48:14PM
          CICS Sysid   : DFTS     CICS Applid   : DEFAULTS

Modify the options and press Enter to update, or PF12 to Cancel.

Control options
  Data to Collect . . . . . . . : I    (A=Affinity, I=Interdependency, B=Both)
  Perform periodic saves . . . : Y    (Y=Yes, N=No)
  Trigger for CINB start . . . : 1___ (2 to 9999 thousand record updates)
  Inquire for DB2 resources. . : Y    (Y=Yes, N=No)
  Restore data on start  . . . : Y    (Y=Yes, N=No)
  Multiple signon with same id : N    (Y=Yes, N=No)
  Maintain usage counts  . . . : N    (Y=Yes, N=No)
  Size of dataspace  . . . . . : 16__ (10 to 2000 Mbytes)
  Transid prefix (optional). . : ____ (1 to 4 characters)
  Program exclude list . . . . : CIUXPROG (1 to 8 characters)
  Transaction exclude list . . : CIUXTRAN (1 to 8 characters)
  Resource prefix list . . . . : CIUPFXTB (1 to 8 characters)
```

Figure 5-9 CINT: General Options

Starting the collector

To start the collector enter transaction **CINT** and choose option **1** to select the operations menu. Enter option **1** to start CICS IA for all regions or a selected region.

CICS IA then asks you to confirm the start of the region. Press enter to confirm.

The operations panel will then refresh to show CICS IA running and collecting dependencies.

```
CIU100       CICS Interdependency Analyzer for z/OS - V3R1M0        2009/12/06
                                Operations Menu                     12:28:28AM

Type action code then press ENTER.                                 More :   +

1= Start 2= Stop 3= Pause 4= Continue 5= Statistics 6= Refresh Run Options

     CICS       CICS                  Start        Start
 Act Applid     Sysid Status          Date         Time         Collecting
     ALL        ALL
  _  IYDZEJ0A   EJ0A  UNCONNECTED
  _  IYDZEJ0B   EJ0B  UNCONNECTED
  *  IYDZEJ02   EJ02  RUNNING         2009/12/06   12:28:24AM   Dependencies
  _  IYDZEJ03   EJ03  STOPPED
  _  IYDZEJ04   EJ04  UNCONNECTED
  _  IYDZEJ05   EJ05  UNCONNECTED
  _  IYDZEJ06   EJ06  UNCONNECTED
  _  IYDZEJ07   EJ07  UNCONNECTED
  _  IYDZEJ08   EJ08  UNCONNECTED

CICS Sysid:  EJ02   CICS Applid:  IYDZEJ02   TermID:  TC10
CIU2115I Dependency files are emptied
```

Figure 5-10 CINT: Collecting dependencies

Stopping the collector

To stop the collector enter transaction **CINT** and choose option **1** from the operations menu.

Select **2** to stop CICS IA.

When the collector is stopped, data collected while the collector is on is externalized to the VSAM files.

CICS IA asks you to confirm the stop of the region. Press Enter to confirm.

Loading the collected data into DB2

Refer to the CICS IA User's Guide and Reference for details and the JCL to populate the DB2 database. To load the collected data from the VSAM files into DB2, we must edit and run the customized job CIUUPDB. It is a composite job including steps from individual jobs CIURESLD, CIUUPDB1, CIUUPDB2, CIUUPDB3, and CIUUPDB4. These jobs update the individual CICS, DB2, MQ, and IMS dependency tables.

The load job produces output to indicate how many records were extracted from the VSAM file and how many were added/updated in the DB2 table.

With the data loaded into DB2, CICS IA is now ready for multiple query and reporting options available for threadsafe analysis.

Setup and run Command Flow

Command Flow Jobs

- CIUJCLDS - defines the LOGSTREAM for the CICS IA COMMAND TRACE journal. You should only need to do this once per region.
- CIUJCLCG - defines the GDG's used to offload the COMMAND trace journal. Again only once per region.
- CIUJLCPY - offloads the logstream into the GDG files
- CIUJLDEL - deletes the logstream data
- CIUUPDB5 - loads the command flow data from GDG into the DB2 database
- CIUUDB4 - copies the command flow data into.csv files

Run the Command Flow

- You may want to run job CIUJLDEL to delete any previous logstreams before you start
- In CICS issue the CINT transaction
- From the Main Admin Menu, select option **2** (Configure Region Options), then choose the appropriate region or the defaults and enter the **4** action code for Options. Finally choose option **6** (Command Flow Options).

```
CIU295        CICS Interdependency Analyzer for z/OS - V3R1M0       2010/02/19
                        Task Resource Options for                   12:17:23AM
                CICS Sysid:  DFTS  CICS Applid:  DEFAULTS

Modify the option and specify the Transactons to monitor.
Press Enter to update, or PF12 to Cancel

Command Flow Option . : Y   Y=Yes, N-No

Command Flow Id . . . : WORK02

Transaction ID List . : TXM1 TXM2 TXM3 TXM4 TXM5
                       (Up to 5 transaction IDs )
```

Figure 5-11 CINT: Command Flow Options

- Enter up to 5 transactions (TXM1 - TXM5 are transactions in the case study)
- You can assign a Command Flow ID to keep track on each step in the threadsafe analysis process.
- Start the collector
- Run your test script
- Stop the collector
- Run job CIUJLCPY

- Run CIUUPDB5 to load the data into your database or CIUDB4 to load it into a CSV file for immediate review

5.3 CICS Configuration Manager (CICS CM)

5.3.1 CICS CM overview

CICS Configuration Manager provides a single point of control for editing, reporting, and migrating CICS resource definitions across an enterprise. It provides change management capabilities to CICS resource definitions. Change control package definitions and audit history reporting for the life cycle of CICS resource definitions.

The main components of CICS Configuration Manager are the server, which is a CICS application that can read from and write to CICS system definition (CSD) files and CICSPlex SM contexts, and the supplied clients: an interactive ISPF dialog interface and a batch command interface. The clients communicate with the server by exchanging SOAP messages over an HTTP network. For a more detailed description of these and other components of CICS Configuration Manager, see Components.

As an alternative to using the supplied clients, you can use CICS Explorer with the CICS Configuration Manager plug-in, or you can develop your own clients.

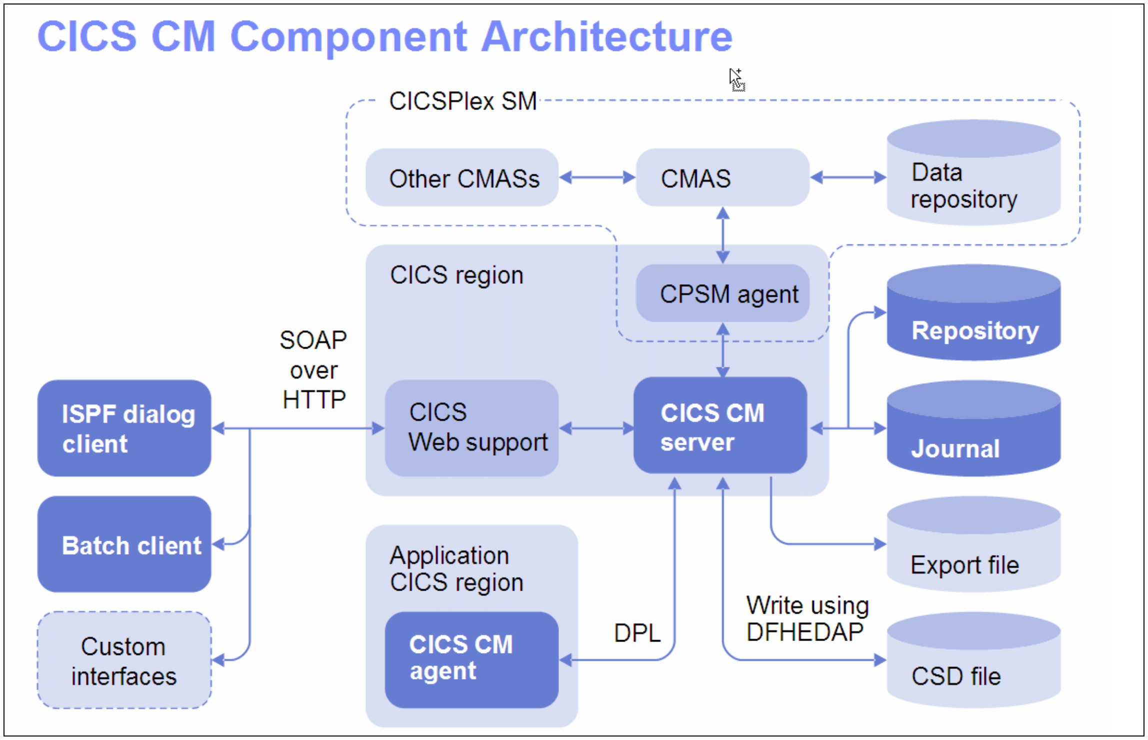

Figure 5-12 CICS CM Component Architecture

5.3.2 CICS Configuration Manger Components

CICS Configuration Manager consists of a client, a server, an agent, a repository, and a journal:

Client

A user interface that allows you to send commands to, and receive responses from, the CICS Configuration Manager server. The client and server communicate by exchanging SOAP messages via TCP/IP sockets.

CICS Configuration Manager is supplied with two clients: an ISPF dialog and a batch command interface. As an alternative to using the supplied clients, you can use CICS Explorer with the CICS Configuration Manager plug-in, or you can develop your own custom clients.

CICS Explorer and the CICS Configuration Manager plug-in are available separately: they are not supplied with CICS Configuration Manager. CICS Explorer with the CICS Configuration Manager plug-in provides an Eclipse-based graphical user interface to many of the CICS Configuration Manager functions available in the supplied ISPF user interface. CICS Explorer also provides an integrated interface to various CICS functions and other CICS tools. For more information about CICS Explorer and the CICS Configuration Manager plug-in, see www.ibm.com/cics/explorer/.

For information about developing your own custom clients, see API reference.

Server

A set of CICS programs that performs the actions requested by a client.

Repository

A VSAM key-sequenced data set (KSDS) that stores current CICS Configuration Manager data:

Journal

A VSAM key-sequenced data set (KSDS) that records historical CICS Configuration Manager data:

Summaries of processing events, such as updates to resource definitions

"Before" and "after" copies of CICS resource definitions that have been updated by CICS Configuration Manager

Agent

A CICS Configuration Manager program, running in a target CICS region, that performs actions on that target CICS region on behalf of the CICS Configuration Manager server. When a CICS Configuration Manager client requests install, newcopy, or discard actions for a target CICS region, the server uses a CICS distributed program link (DPL) to invoke the agent in that region. The agent then performs the action: a CICS CEDA INSTALL, a CICS EXEC DISCARD, or a CICS EXEC SET PROGRAM (specifying either NEWCOPY or PHASEIN).

This agent is required only if you want to perform install, newcopy, or discard actions on an active CICS region whose resource definitions are stored in a CSD file. You need to make this program available within that CICS region in the same manner as any other application program. This agent is not used for CICS regions that are managed by CICSPlex SM; for those regions, CICS Configuration Manager uses the CICSPlex SM API to perform these actions.

5.3.3 How to use CICS CM to change resource definitions

CICS CM ISPF interface

Menu panels display several options, from which you can select one. List panels display several items, with each item on a separate line: you can enter a line action against one or more items. The available line actions depend on the type of item.

The CICS Configuration Manager primary option menu presents these options:

- 0 Settings
  - Customize the ISPF dialog for each user, and store the settings in each user's ISPF profile:
    - Whether to show a prompt for confirmation of save and cancel commands
    - Whether to automatically translate to uppercase some mixed-cased resource definition attributes
    - Default job control information and stepped library for CICS Configuration Manager batch jobs
    - CICS Configuration Manager server connection details such as IP address and port number
  - These options are specific to each user, and are stored in each user's ISPF profile.
- 1 Administer
  - Set system options that affect all users, and maintain the records for working with resource definitions:
  - CICS configurations
  - Migration schemes
  - Approval profiles
  - Transformation rules
- 2 CICS Resources
  - Work with resource definitions. Edit, compare, or package current resource definitions; view, compare, or restore historical versions.
- 3 Packages
  - Work with change packages.
- 4 Reports
  - Display sets of resource definitions that match a variety of selection criteria, including historical versions of resource definitions.

CICS Explorer - CM perspective

CICS CM plug-in provides an Eclipse-based infrastructure to view and manage CICS Configuration Manager (CICS CM) resource definitions across an enterprise. It supports a subset of the function available in CICS CM.

CICS CM provides a single point of control for editing, reporting, and migrating CICS resource definitions across an enterprise. CICS CM is a CICS application that can read from and write to a CICS system definition (CSD) files and CICSPlex SM contexts. For more information about CICS CM see the CICS CM for z/OS User's Guide.

Using the CICS CM plug-in, you can perform the following tasks:

- View all the CICS CM configurations
- View all lists in a configuration and groups in a list
- View all groups in a configuration
- View orphaned resources and groups in a CICSPlex SM configuration
- View orphaned groups in a configuration
- View history for, resource definitions, configurations and groups and restore changes made to a resource definition
- View, edit, and delete resource definitions
- Search across one or more configurations and search across one or more groups in a configuration
- Create new resources
- Install resources from a Configuration in one or more active CICS systems
- Compare two lists in the same configuration, two groups in the same or different configurations, or two of the same type of definition
- Search for groups
- Search the history for a configuration or a group
- Install a group if you have a CICSPlex SM connection

5.4 CICS VT performance on CICS TS V3.2

CICS VSAM Transparency (CICS VT) enables the migration of data from VSAM files to DB2 tables and ensures continued access to this data without modification to existing CICS and batch application programs. CICS VT supports CICS TS supported releases without any modification.

The threadsafe File Control API in CICS TS V3.2 provides significant performance benefits for CICS VT.

CICS VT uses File Control GLUE programs to intercept File Control API calls and processes these requests as SQL calls to DB2. Although these GLUE programs have always been threadsafe, non-threadsafe CICS File Control APIs in releases of CICS TS prior to CICS TS V3.2 had resulted in a switch back to the QR TCB for every File Control API call.

Basic tests were completed in a laboratory controlled environment using sample CICS applications and comparing CICS VT running in CICS TS V3.1 and CICS TS V3.2 regions. The same workload showed overall CPU improvement ranging from 3.5% to 15.4% when running on CICS TS V3.2. The number of TCB switches dropped from 74 down to 8. Most importantly, up to 80% of the CPU usage shifted from the QR TCB to an L8 TCB. This allowed the QR TCB to process other work that could not run on an OPEN TCB, thus allowing for greater throughput.

5.5 CICS tools four step process for applications

5.5.1 Step 1 - CICS PA - Identify candidates and capture baseline

Determine which applications and transactions are good candidates for Threadsafe. Start with transactions that will bring the largest benefit with the smallest amount of work.

- Identify transactions using large amounts of CPU because of TCB switching
- How many switches (change modes) occurred?
- What was the delay as the result?
- How much CPU time did they use?
- What is this costing me?

Use CICS PA supplied reports, Historical Database, Explorer and/or Excel charts and graphs, and CSV files to answer the above questions

- CPU Usage, Delays, Change Mode Delays
- TCB Analysis Report
- Excel Spreadsheet charts and graphs
- CICS Explorer Extracts
- Run test script with baseline data to use as input to the Transaction Profiling Report.

5.5.2 Step 2 - CICS IA - Analyze program behavior and make modifications

Having used PA to determine candidate applications based on transaction performance characteristics, you can now determine good candidate programs for Threadsafe based on program behavior. CICS IA will assist you in answering the following questions:

- What programs can be made threadsafe without program modification?
- Which commands are threadsafe or not in a program?
- What programs and how many have commands that need investigation to determine if they have data integrity issues.
- What commands need serialization wrapped around them?
- What is the offset of the suspect command into the load module?
- What TCB does the command currently run on?
- What commands will cause a TCB mode switch because the API is not threadsafe and must run on the QR TCB?
- Which transactions use GETMAIN SHARED, who GETMAINed it, and where?
- Are transactions FREEMAINing shared storage?
- What is the affect on the transaction flow after you change the program(s) to threadsafe compliance?

- Once you make programs threadsafe, how do you insure that a change will not regress threadsafe status?

To select candidate programs and verify change results, use the CICS IA database collection for Interdependency data or the scanners.

Start CICS IA Collection

- Follow steps in Section 5.2.4 - How to prepare CICS IA for threadsafe analysis
- Turn on CICS IA Interdependency collection
- Turn on Command Flow collection for transactions
- Run test script from Step 1
- Turn off Interdependency and Command Flow collection
- Follow steps in Section 5.2.4 - How to prepare CICS IA for threadsafe analysis - Loading the collected data into DB2.

Analyze the collected CICS IA data

Once the data is collected in the CICS IA database, you can use the various tools within CICS IA to analyze the data for threadsafe conformance.

Threadsafe Dynamic Analysis report

- The Threadsafe Status (Y, N, I) value within the report provides a quick view to determine if the program can be made threadsafe.
  - **Threadsafe (Y)** - EXEC CICS commands that do not cause a TCB swap
  - **Non-Threadsafe (N)** - EXEC CICS commands that cause a TCB swap
  - **Indeterminate Threadsafe (I)** - EXEC CICS commands where it cannot be determined if the call causes a TCB swap
  - **Threadsafe Inhibitor (*)** - EXEC CICS commands that need to be investigated further because they may cause a data integrity issue if defined as threadsafe. (Indicated with an * under the Threadsafe heading to the right of the status)

    ADDRESS CWA
    EXTRACT EXIT
    GETMAIN SHARED
    LOAD
- Detail Report (default) - Lists the threadsafe status for each command within a program with summary totals
- Summary Report - lists only the totals

Command Flow

- Trace all commands invoked by a transaction
- Switches by command
- What TCB did this command run on?

- Getmain addresses

CICS IA Explorer supplied Threadsafe queries

- All programs that issue a GETMAIN SHARED
- All programs that issue an ADDRESS CWA
- All programs that issue an EXTRACT EXIT
- All programs that issue a LOAD
- All programs which may have threadsafe data integrity issues
- CICS commands by TCB mode and program
- DB2 commands by TCB mode and program
- IMS commands by TCB mode and program
- MQ commands by TCB mode and program

Sample SQL Batch Reports

Sample JCL for running batch SQL is provided by the CIUJSAMP job. Within the sample job there are sections which can be run individually.

- CIUSAMPC - Threadsafe analysis queries for Scan detail table
  - CUISAMPD - Threadsafe analysis queries for command flow table

> **Note:** An alternate to real-time capture is to use the CICS IA Scanners. See Section 5.7.1 - Additional Samples.

5.5.3 Step 3 - CICS CM - Change program definitions to threadsafe

Simplify and provide controlled management of CICS Threadsafe resources definition changes using CICS Configuration Manager.

- Change resource definitions to make programs threadsafe from quasirent
- Create transformation rules for mass changes to threadsafe
  - Can be across multiple regions and/or environments
- Package change, promote and install
- Maintain audit history of CICS resource modifications
- Back-out-to-previous state if required
- CICS Explorer provides CM integration

5.5.4 Step 4 - Test and benchmark results

If possible, use the same test script as used in Step 1. Make program and definition changes then repeat the process outlined in Steps 1 and 2. Make sure you test the application, and review the results after every change.

- Make program and definition changes as required in Steps 2 and 3.
- Run test script
- Update databases for PA and IA with the collected data.

- Run the PA Transaction Profiling report to verify results of change.
- Rerun reports and queries from Step 2 to compare results.
- Analyze Command Flow data and verify improvement in switching.

If after making a program threadsafe, you still experience high change mode switching, it may be necessary to change the program to remove or change placement of non-threadsafe commands that are causing you to switch back to the QR TCB.

5.6 Application case study using CICS tools 4 step process

For this case study we use the Redbook application for DB2. It is a COBOL DB2 and VSAM application. It consists of a driver program, DRIVERP, and a application program that performs the DB2/VSAM work, WORKM. You will learn more about the application as we go through the scenario using the CICS Tools.

In this section we pick a transaction to make threadsafe. Once the transaction program(s) are identified, we take a non-threadsafe application program and make it threadsafe. We use the ENQ/DEQ method to serialize any use of shared storage.

Prior to enabling any application program to be defined as threadsafe, a review of the application code must be performed. This cannot be emphasized strongly enough. It is necessary for two reasons:

- To maintain application data integrity

  Prior to CICS Transaction Server 2.2 user applications and exits ran on the QR TCB, which is a restricted or closed environment. CICS provided the serialization needed to ensure that application data integrity was never compromised. In this environment programs could be sure that no more than one quasi-reentrant program could run at the same time. For applications that have DB2 calls, or MQ calls if CICS TS V3.2 and above (or calls to other TRUEs that have been enabled as OPENAPI), it is possible for two or more programs to be running concurrently on different open TCBs and the QR TCB. Therefore it becomes very important that shared resources used by an application are serialized to prevent any application integrity problems due to more than one program accessing the same resource at the same time.

- To ensure that once CICS moves an application over to an open TCB it remains there for as long as possible after the DB2 call has been completed

  CICS will switch the application program back to the QR TCB in order to execute CICS API or SPI commands that are non threadsafe. CICS must do this to maintain the integrity of such things as the CSA and other control blocks used by the commands.

In order to demonstrate the potential problems with defining an application as threadsafe we use our simple Redbook file update application. Details on the analysis and program tests results are section 5.6.2.

In this section we demonstrate the following:

- Step1 - CICS PA - Identify candidates and capture baseline
- Step 2 - CICS IA - Analyze program behavior and make modifications

- Step 3 - CICS CM - Change program definitions to threadsafe
- Step 4 - Test and benchmark results

5.6.1 Step 1 - Identify candidates and capture baseline

In this section we will use CICS PA to analyze SMF data and pick a candidate transaction for our case study. We will also position ourselves for benchmarking results to verify our anticipated savings.

- Set up and run a baseline test script for use in comparison for the threadsafe project.
  - Make sure CICS SMF data capture is setup as documented in the CICS PA User’s Guide
  - Turn on CICS IA Interdependency data collection as outlined in Section 5.2.4 - How to prepare CICS IA for threadsafe analysis
  - Turn on CICS IA Command Flow as outlined in Section 5.
  - Run your test script
  - Copy the SMF110 data to a save place for use in Step4

> **Note:** An alternative to this would be to load the data into the PA Historical Database. This could be accomplished at the same time as the report extract.

- Use the CICS PA ISPF interface to create the extract data for use with the CICS the PA Explorer.
- Load into DB2 or use the CSV file extract. For this scenario, we are using the CSV extract file.
- Run a CICS PA extract with the following form against the test script time frame:
  - Form Explorer3 - CICS TS V3.x
  - Form Explorer4 - CICS TS V4.x
- Use the CICS Explorer Resource perspective to query the database or file using the CICS PA plug-in.
- Download the CSV file from System z® to your desktop as a text file with a file extension of .CSV.
- In the Resource Perspective
  - Right click in the white space under the Project tab
  - Select New Project
  - A pop-up Wizard will appear with project highlighted, just click next
  - Enter a meaningful name in the Project Name box
  - Click finish
- You will see your new Project in the Project Explorer Resource tab
- Drag and drop your CSV file into your newly created Project folder
- Now you are ready to Query your data

- Open your new Project folder
- Open your CSV file
- right click on the on the date for all time frames
- left click Performance history
- left click Threadsafe

Your are now presented with a Chart to choose the transactions with highest number of change modes and using the most CPU. In this scenario we only have 1 transaction, TXM1 with 406 TCB change modes. In a real world environment, you should see many transactions with potential for savings.

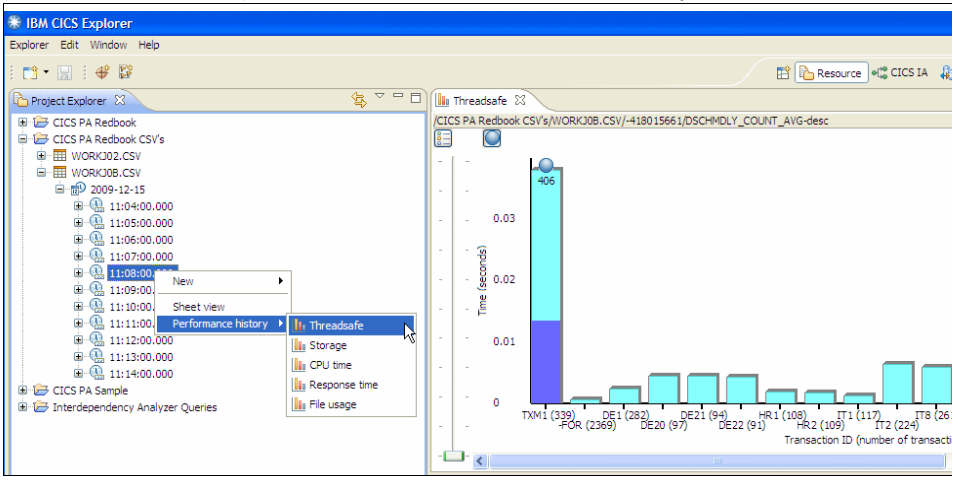

Figure 5-13 CICS PA Explorer - Threadsafe Chart - TXM1 is non-threadsafe

Threadsafe bar chart

- This view shows transaction TXM1 executed 339 times
- The bubble at the top of the bar indicates that it had 406 TCB mode switches
- Transactions with the highest number of TCB mode switches are listed on the left

Note: TXM1 has multiple colors in the bar to indicate CPU on the QR TCB (turquoise), and the L8 TCB (blue). You can hover over the bar to see the respective times for each TCB.

From this chart you can jump right into the Transaction Detail Analysis.

- Double left click the bar for the TXM1 transaction to display details. This view shows the CPU time breakdown by TCB type.

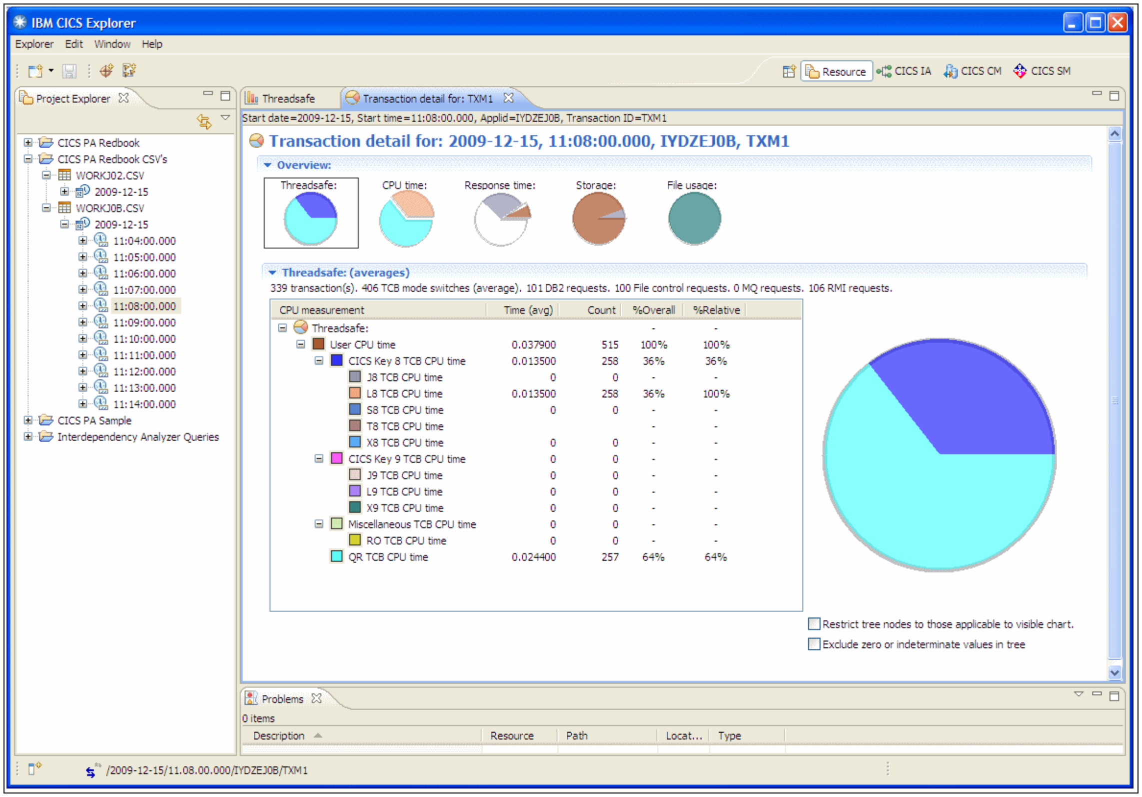

Figure 5-14 *CICS PA Explorer - Threadsafe Detail View - TXM1 is not Threadsafe*

Figure 5-15 CICS PA Explorer Threadsafe View

Transaction Detail for TXM1

- 339 transactions were executed
- 406 TCB mode switches on the average
- 101 DB2 request
- 100 file control request
- 0 MQ request
- 106 RMI requests

Left click on a color in the Pie Chart. The corresponding TCB time is highlighted.

Additional detail reports are available by double left clicking one of the report pies listed in the top of the view.

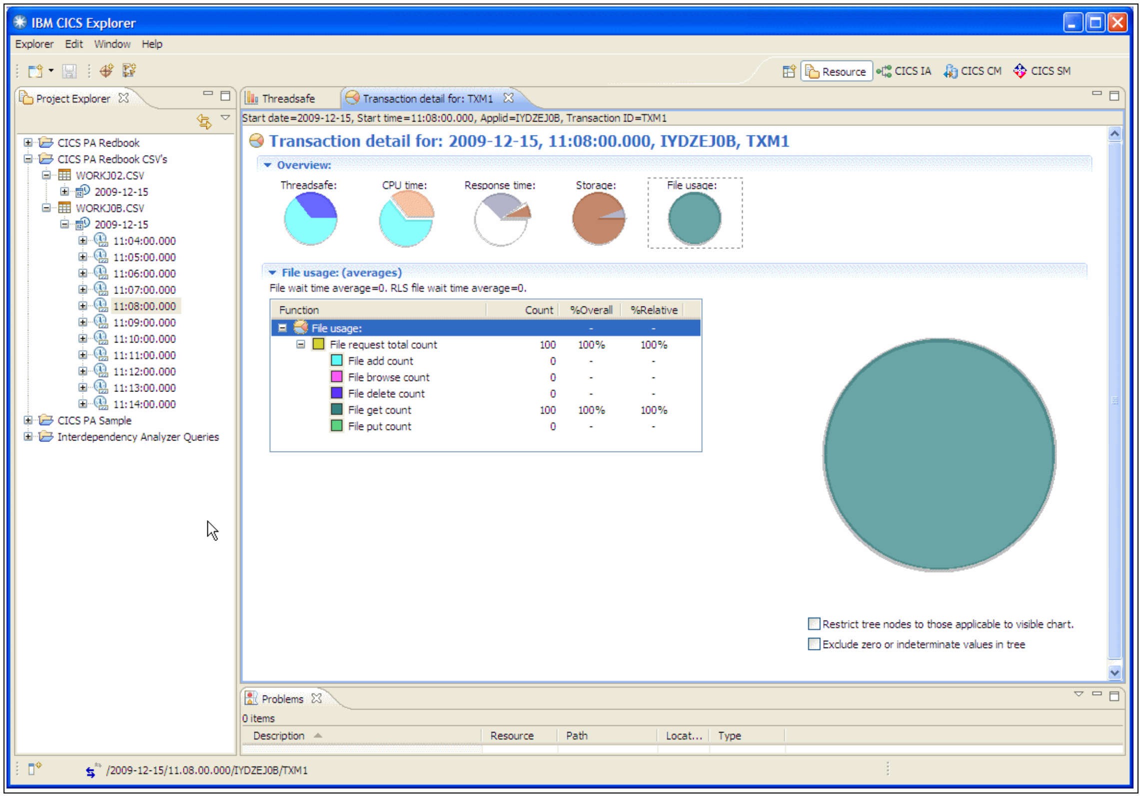

Figure 5-16 CICS PA Explorer - Detail View - File Usage

File Usage detail for TXM1

- There were 100 file requests
- 100% were get requests

5.6.2 Step 2 - Analyze program behavior and make modifications

Now that we know transaction TXM1 includes DB2 and local VSAM, transaction resource analysis can be performed with CICS IA to determine if it is a threadsafe candidate.

To analyze the application from the CICS IA Explorer, you must perform the steps outlined in Section 5.2.4 - How to prepare CICS IA for threadsafe analysis. Then run the Test Script form Step 1.

CICS Explorer integration - Jump to CICS IA for Analysis

Find the resources used by transactions TXM1.

- In the CICS Explorer, you can initiate the view of CICS IA resources used by TXM1 directly from PA or within the CICS IA Perspective.
  - CICS PA
  - Place your cursor within the transaction bar or from within the detail view on the pie or a CPU category
    - Right click and select dependencies and used resources
  - Open the tree structures to see the names of the resources used as detailed in the following example

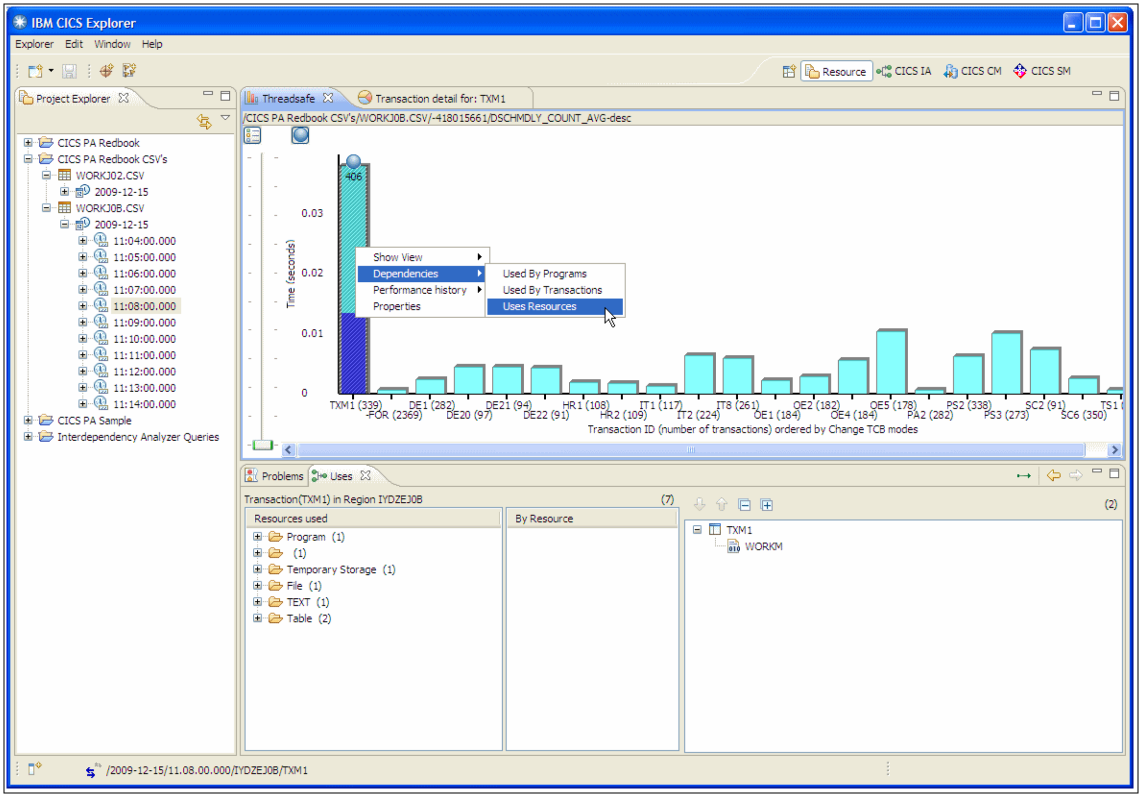

Figure 5-17 CICS PA Explorer - PA to IA Integration

For a more detailed view, go to the CICS IA perspective.

- Click on the CICS IA perspective tab at the top right of the CICS Explorer.

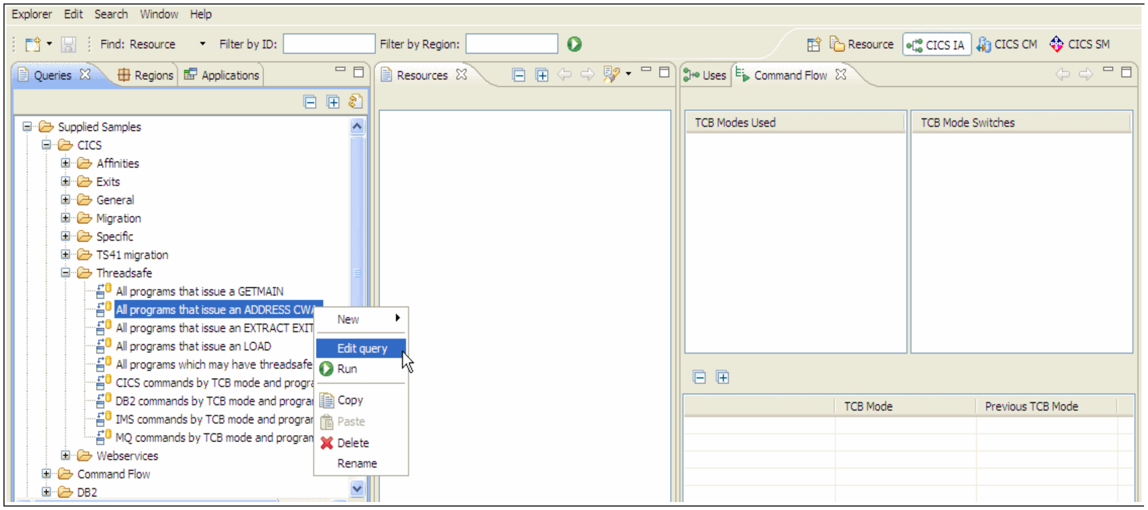

Figure 5-18 CICS IA Explorer - Edit query

- From within Queries tab at the top left, under the Supplied Samples, open the CICS/Threadsafe folder
- Double left click on the All programs that issue an ADDRESS CWA
- This will bring up all programs that have an ADDRESS CWA.
- Now modify this query to add the offset of the command.
- Right click on the previous query and select Edit query

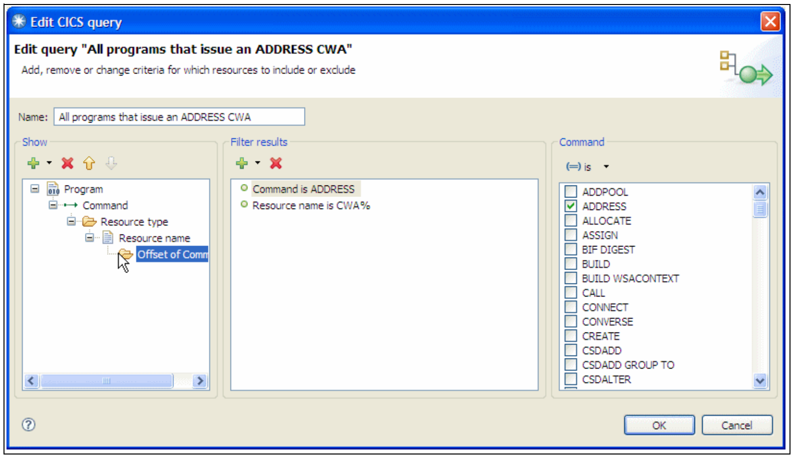

Figure 5-19 CICS IA Explorer - Edit query

- Left click on the green pull down under Show
- Left click on Offset of Command. It will be added after Resource Name
- Click OK to save

- Now double click the query again. It will display under Resources in the middle with the CWA command address listed

> **Note:** In the CICS Explorer, previous views populated by queries issued remain until a new query causes the view to be overlaid.

You may also want to view used resources for the transaction from the previous display you executed while in the CICS PA perspective.

- Under the Queries tab, you will see the Programs and Transactions tab
- Left click on the Transactions tab
- Type TXM into the search box under the Programs tab
- This will bring up a list of transactions starting with TXM
- Right click on TXM1 and select Used Resources/Specific Region
- The same display you viewed from the PA perspective is displayed under the Uses tab on the top right.
- Open each of the folders to reveal the details of the commands
- Note that transaction TXM1 is using program WORKM.

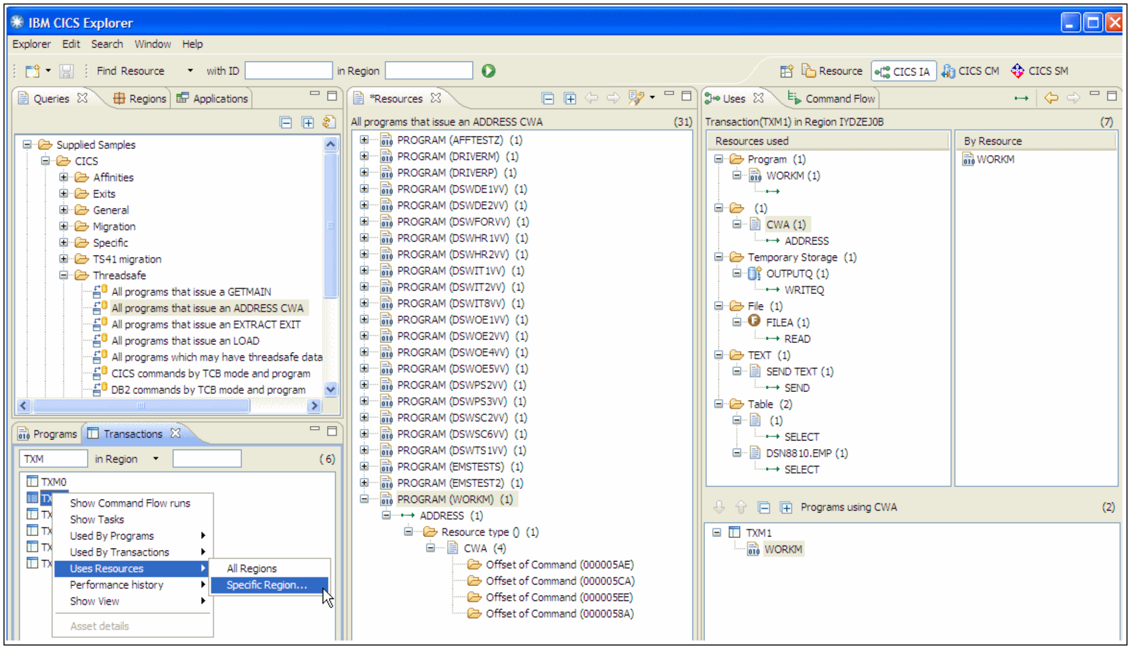

Figure 5-20 CICS IA Explorer - TXM1 Used Resource

At this point we know that transaction TXM1, which we identified earlier as a threadsafe candidate, only uses program WORKM.

CICS IA provides multiple tools for identifying the threadsafety status of EXEC CICS commands as follows:

- Dynamic Threadsafe Analysis report
- Command Flow
- CICS IA Explorer provided Threadsafe Queries
- Load module Scanners and Reporters
  - Useful if real-time interdependency data is not available
  - Sample JCL is provided in Section 5.7 - Additional Samples
- CICS IA sample SQL Query provided in job CIUJSAMP, report CIUSAMPC

For the purposes of this exercise we will use the Dynamic Threadsafe Analysis Report, the Command Flow and the Explorer provided Threadsafe Queries.

Setup and Run the Dynamic Threadsafe Analysis Report

- Input to the report is from the CICS IA collector for detail interdependency API's, then externalized to DB2. The following tables are used.
  - CIU_PROGRAM_DETAIL
  - CIU_CICS_DATA
  - CIU_THREADSAFE_CMD
  - CIU_FILE_DETAIL
  - This data was collected from following the steps in Section 5.2.4 - How to prepare CICS IA for threadsafe analysis
- Prior to running the CIUJSTSQ2 reporting job for the first time after database creation or migration, the CIUTSLOD in the SCIUSAMP data set must be run to establish the threadsafe table information with the appropriate CICS release levels.
- Modify job CIUJTSQ2 in the sample library to include a detail report

```
Program Dynamic Analysis - THREADSAFE DETAIL LISTING FOR CICS TS 3.1

APPLID   Program  Linkedit   Execution   Concurrency APIST   Storage  CICS  LIB Dataset Name
                   Date       Key                            Protect  Rel
-------- -------- ---------- ----------- ----------- ------- -------- ----- ---------------------------------

                  CMD  Function               Type            Resource                          Offset   Program  Use      Threadsafe
                  Type                                                                                   Length   Count
                  ---- ---------------------- --------------- ------------------------------   -------- -------- -------  ----------


IYDZEJOB DRIVERM  0001-01-01 USER       QUASIRENT   CICSAPI INACTIVE 0640
                  CICS ADDRESS                                CWA                                  502     1668         1    N  *
                  CICS DELETEQ                TSQUEUE AUX     OUTPUTQ                              4BE     1668         1    Y
                  CICS INQUIRE                PROGRAM         WORKM                                6CA     1668         1    N
                  CICS SEND                   TEXT            SEND TEXT                            7E6     1668         1    N
                  CICS WRITEQ                 TSQUEUE AUX     OUTPUTQ                              78A     1668         1    Y
  Total CICS calls:         5  Threadsafe:          2  Non-Threadsafe:                 3  Indeterminate Threadsafe:       0
                               DB2 calls:           0  MQ calls:                       0  IMS calls:                      0
                               Dynamic Calls:       0  Threadsafe Inhibitor calls:     1

IYDZEJOB WORKM    0001-01-01 USER       QUASIRENT   CICSAPI INACTIVE 0640
                  CICS ADDRESS                                CWA                                  5CA     1928         1    N  *
                  CICS ADDRESS                                CWA                                  58A     1890         1    N  *
                  CICS READ                   FILE            FILEA                                8B2     1890         1    N
                  CICS READ                   FILE            FILEA                                8F2     1928         1    N
                  CICS SEND                   TEXT            SEND TEXT                            9A2     1928         1    N
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              912     1890         1    Y
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              952     1928         1    Y
                  CICS ADDRESS                                CWA                                  5CA     1928         1    N  *
                  CICS ADDRESS                                CWA                                  58A     1890         1    N  *
                  CICS READ                   FILE            FILEA                                8B2     1890         1    N
                  CICS READ                   FILE            FILEA                                8F2     1928         1    N
                  CICS SEND                   TEXT            SEND TEXT                            9A2     1928         1    N
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              912     1890         1    Y
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              952     1928         1    Y
                  CICS ADDRESS                                CWA                                  5CA     1928         1    N  *
                  CICS ADDRESS                                CWA                                  58A     1890         1    N  *
                  CICS READ                   FILE            FILEA                                8B2     1890         1    N
                  CICS READ                   FILE            FILEA                                8F2     1928         1    N
                  CICS SEND                   TEXT            SEND TEXT                            9A2     1928         1    N
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              912     1890         1    Y
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              952     1928         1    Y
                  CICS ADDRESS                                CWA                                  5CA     1928         1    N  *
                  CICS ADDRESS                                CWA                                  58A     1890         1    N  *
                  CICS READ                   FILE            FILEA                                8B2     1890         1    N
                  CICS READ                   FILE            FILEA                                8F2     1928         1    N
                  CICS SEND                   TEXT            SEND TEXT                            9A2     1928         1    N
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              912     1890         1    Y
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              952     1928         1    Y
                  CICS ADDRESS                                CWA                                  5CA     1928         1    N  *
                  CICS ADDRESS                                CWA                                  58A     1890         1    N  *
                  CICS READ                   FILE            FILEA                                8B2     1890         1    N
                  CICS READ                   FILE            FILEA                                8F2     1928         1    N
                  CICS SEND                   TEXT            SEND TEXT                            9A2     1928         1    N
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              912     1890         1    Y
                  CICS WRITEQ                 TSQUEUE         OUTPUTQ                              952     1928         1    Y
                  DB2  SELECT                 TABLE                                                64A     1890         1    Y
                  DB2  SELECT                 TABLE           DSN8810.EMP                          68E     1928         1    Y
                  DB2  SELECT                 TABLE                                                64A     1890         1    Y
                  DB2  SELECT                 TABLE           DSN8810.EMP                          68E     1928         1    Y
                  DB2  SELECT                 TABLE                                                64A     1890         1    Y
                  DB2  SELECT                 TABLE           DSN8810.EMP                          68E     1928         1    Y
                  DB2  SELECT                 TABLE           DSN8810.EMP                          68E     1928         1    Y
                  DB2  SELECT                 TABLE           DSN8810.EMP                          68E     1928         1    Y
  Total CICS calls:        35  Threadsafe:         10  Non-Threadsafe:                25  Indeterminate Threadsafe:       0
                               DB2 calls:           8  MQ calls:                       0  IMS calls:                      0
                               Dynamic Calls:       0  Threadsafe Inhibitor calls:    10
```

Figure 5-21 Detail Dynamic Threadsafe Analysis Report - Quasirent

This report tells us that we need to take a closer look at the program because we have 10 Threadsafe Inhibitor calls. A review of the commands with * flags shows us the inhibitor is ADDRESS CWA. This could cause an integrity issue if we make the program threadsafe without code review and/or modification.

Run Command Flow

To further analyze the program, a command flow capture is recommended for a chronological view of the commands executed. It will capture the current flow and place a red decorator on each TCB mode switch.

Verify CICS IA is setup for command flow capture as described in Section 5.2.4 *Set up and run Command Flow.*

Run the Command Flow

- You may want to run job CIUJLDEL to delete any previous logstreams before you start
- In CICS issue the CINT transaction and turn on command flow for transaction TXM1
- Start the collector
- Run the Test Script as defined in Step 1
- Stop the collector
- Run job CIUJLCPY
- Run CIUUPDB5 to load the data into your database or CIUDB4 to load it into a CSV file for immediate review

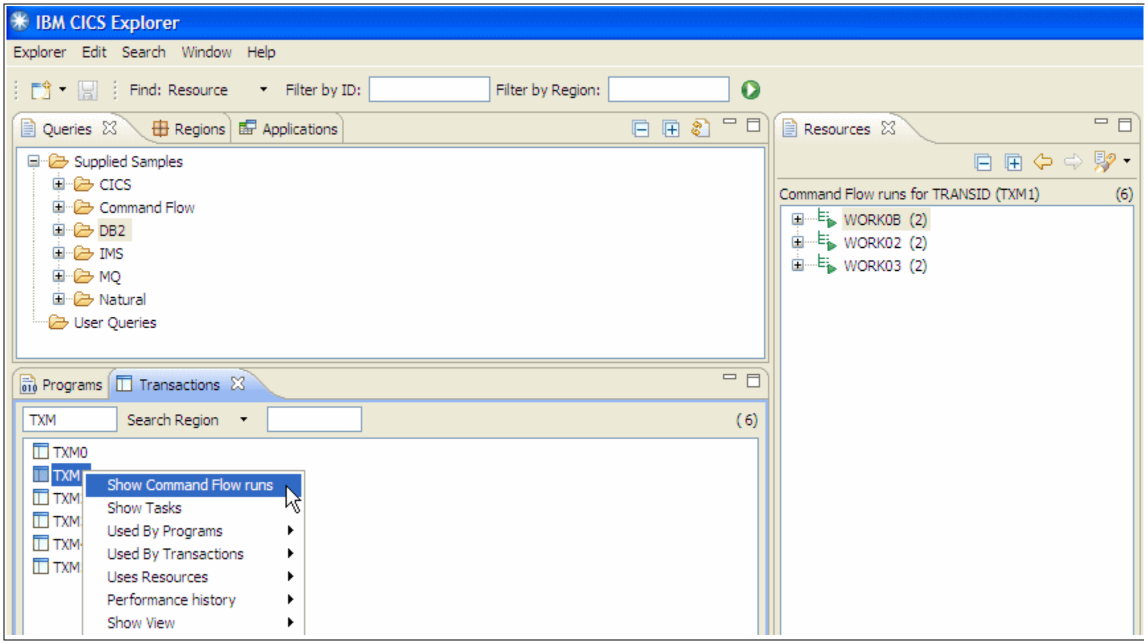

Figure 5-22 CICS IA Explorer - Select Command Flow runs for transaction TXM1

In this example we list transactions starting with TXM. Then we right click on transaction TXM1 and the pop-up appears allowing us to select Show Command Flow runs. The display under the Resources tab list the Command flow runs that we setup for collection for transaction TXM1.

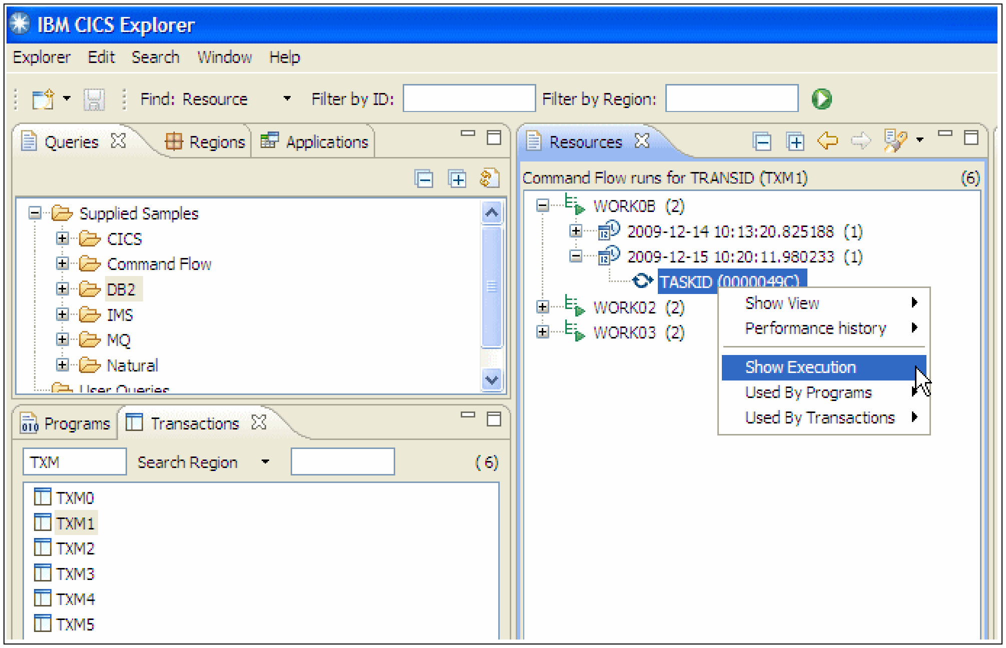

Figure 5-23 CICS IA Explorer - Select Command Flow Run for WORK0B (quasirent TXM1 capture)

WORK0B is the name assigned for the command flow of transaction TXM1 defined as quasirent running on a CICS TS V3.1 region.

Note: The time and taskid of the transaction is displayed after opening the tree structure. Selecting Show Execution lists the details of the commands.

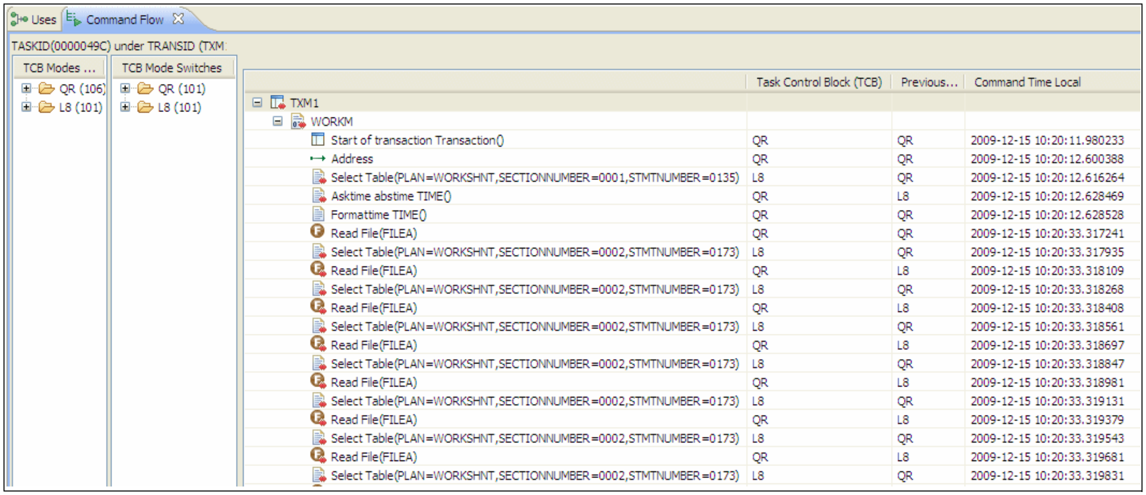

Figure 5-24 CICS IA Explorer - Command Flow execution from WORK0B (quasirent TXM1 capture)

Show Execution lists each command, the TCB mode the command runs on, and the TCB mode of the previous command. The red decorator on the command icon indicates a TCB mode switch has occurred. Decorators are propagated to the top of the tree structure to show the program or transaction encountered a TCB mode switch.

Observe the first command is ADDRESS also listed in the Dynamic Threadsafe Analysis Report. In this case it is an ADDRESS CWA. Then WORKM starts processing in DB2 and VSAM. Since WORKM is defined as quasirent, each DB2 command causes a switch to the L8 then immediately switches back to the QR. Each VSAM request runs on the QR because it is quasirent in a CICS TS V3.1 region.

Our goal for this program is to eliminate the switches caused by processing DB2 and VSAM in the quasirent mode.

In our WORKM program we write out the value of our counter to the temporary storage queue to verify any data integrity exposures. When running program WORKM as QUASIRENT, no duplicates were listed in the temporary storage queue for the counter value used by multiple transactions. So as expected a data integrity exposure did not exist because only one copy of the program was running under the QR TCB.

At this point we are curious to see what happens if we just change the program definition to threadsafe and migrate the application to a CICS V4.1 system to take advantage of VSAM running on the L8. We are ignoring the ADDRESS CWA command. (Of course this is not recommended, however for this case study we perform this action to show you the integrity exposure of reckless threadsafe changes.)

Update the Program definition with CICS CM

- Go to Step 3, section 5.6.3 -CICS CM - Change program definitions to threadsafe and follow the steps listed.
  - View the program definition
  - Change the program definition
  - Install the program definition
- Return back to this point in the case study to analyze the affect of making this program threadsafe.

Analyze data integrity exposure in the application case study

As identified previously our case study uses programs DRIVERP and WORKM, which are both non threadsafe. Both programs issue an EXEC CICS ADDRESS CWA.

The sample application program, DRIVERP, initializes the counter in the CWA to zero and sets up the temporary storage queue.

Our sample application program, WORKM, shown in the outline in the following figure, simply addresses the CWA and uses an integer value in the CWA as a counter. In a non threadsafe environment (that is, with the program running on the QR TCB) we would not expect there to be any duplicate counter values since there is only one instance of this program executing at the time of addressing the CWA, incrementing its value and using the increment value as the counter in the subsequent WRITE command.

In order to test this application, we invoke transactions TXM1 - TXM5 multiple times using our Test Script form Step 1. All of the transactions invoke the WORKM program.

```
004400 LINKAGE SECTION.
004500 01  SHARED-AREA.
004600     03  SHARED-COUNTER                  PIC S9(8) COMP.
004800 PROCEDURE DIVISION.
005710*    Access our shared storage area - in the CWA
005720     EXEC CICS ADDRESS CWA(WS-PTR) END-EXEC.
005722*    map our linkage section to the address of the shared area
005730     Set address of shared-area to ws-ptr.
006500*    Make DB2 Call which will transfer to the L8
006700     EXEC SQL
006800         SELECT count(*)
006900         INTO :ws-count FROM DSN8810.EMP
007000         WHERE EMPNO = "000990"
007100     END-EXEC.
008000*    read the value in shared storage.
008100     move shared-counter to ws-counter.
008200*    ... and change its value
008300     Add 1 to ws-counter.
008500*    ** Do some important processing **
       ===> Missing code section to loop for a period of time
       ===>   SQL and VSAM file requests
009300*    update the shared storage with our new value
009400     Move ws-counter to shared-counter.
010400*    output the results ......
010500*    exec cics
010600*      writeq ts main queue(ws-queue) from(ws-msg)
010700*    end-exec.
010800     EXEC CICS SEND TEXT FROM(WM-MSG) ERASE FREEKB END-EXEC.
010900     exec cics return end-exec.
```

Figure 5-25 - Extract of sample application program WORKM

Threadsafe output with unchanged program

The WORKM program definition was changed to be THREADSAFE.

> **Note:** During the testing of this program it was determined that program WORKM was not compiled and linked with the RENT option. All programs defined as threadsafe must be reentrant.

We again ran the same test script which invokes transactions TXM1 - TXM5 multiple times. On this occasion, multiple instances of program WORKM were executing concurrently on L8 TCBs, so there was the potential for the same CWA counter value to be used more than once. This did in fact happen, as shown in the following figure.

```
 CEBR  TSQ OUTPUTQ          SYSID EJ03 REC   289 OF   601    COL     1 OF   107
 ENTER COMMAND ===> _
00288 TXM4 Counter value :- 00000266 Date/Time : Mon, 30 Nov 2009 14:12:33 GMT
00289 TXM3 Counter value :- 00000267 Date/Time : Mon, 30 Nov 2009 14:12:33 GMT
00290 TXM4 Counter value :- 00000268 Date/Time : Mon, 30 Nov 2009 14:12:35 GMT
00291 TXM3 Counter value :- 00000269 Date/Time : Mon, 30 Nov 2009 14:12:35 GMT
00292 TXM1 Counter value :- 00000269 Date/Time : Mon, 30 Nov 2009 14:12:35 GMT
00293 TXM5 Counter value :- 00000269 Date/Time : Mon, 30 Nov 2009 14:12:35 GMT
00294 TXM5 Counter value :- 00000270 Date/Time : Mon, 30 Nov 2009 14:12:35 GMT
00295 TXM4 Counter value :- 00000271 Date/Time : Mon, 30 Nov 2009 14:12:35 GMT
00296 TXM1 Counter value :- 00000272 Date/Time : Mon, 30 Nov 2009 14:12:36 GMT
00297 TXM5 Counter value :- 00000273 Date/Time : Mon, 30 Nov 2009 14:12:36 GMT
00298 TXM4 Counter value :- 00000274 Date/Time : Mon, 30 Nov 2009 14:12:36 GMT
00299 TXM1 Counter value :- 00000275 Date/Time : Mon, 30 Nov 2009 14:12:37 GMT
00300 TXM5 Counter value :- 00000276 Date/Time : Mon, 30 Nov 2009 14:12:37 GMT
00301 TXM4 Counter value :- 00000277 Date/Time : Mon, 30 Nov 2009 14:12:37 GMT
00302 TXM1 Counter value :- 00000278 Date/Time : Mon, 30 Nov 2009 14:12:38 GMT
00303 TXM5 Counter value :- 00000279 Date/Time : Mon, 30 Nov 2009 14:12:38 GMT
00304 TXM4 Counter value :- 00000280 Date/Time : Mon, 30 Nov 2009 14:12:38 GMT

PF1 : HELP               PF2 : SWITCH HEX/CHAR     PF3 : TERMINATE BROWSE
PF4 : VIEW TOP           PF5 : VIEW BOTTOM         PF6 : REPEAT LAST FIND
PF7 : SCROLL BACK HALF   PF8 : SCROLL FORWARD HALF PF9 : VIEW RIGHT
```

Figure 5-26 Temporary Storage Records showing multiple transactions with the same counter value

Now we see the data integrity exposure by making WORKM threadsafe without serialization.

> **Note:** TXM3, TXM1 and TXM5 transactions all have a counter value of 269

Another observation of running threadsafe and on a CICS TS V4.1 system is illustrated by a Command Flow execution in the following figure. We have eliminated most of the TCB mode switching. DB2 and threadsafe now run on the L8 TCB. If we read the VSAM file 100 times in our program, we save 400,000 instructions. So now let us take a look at the program to see if we can fix the data integrity problem.

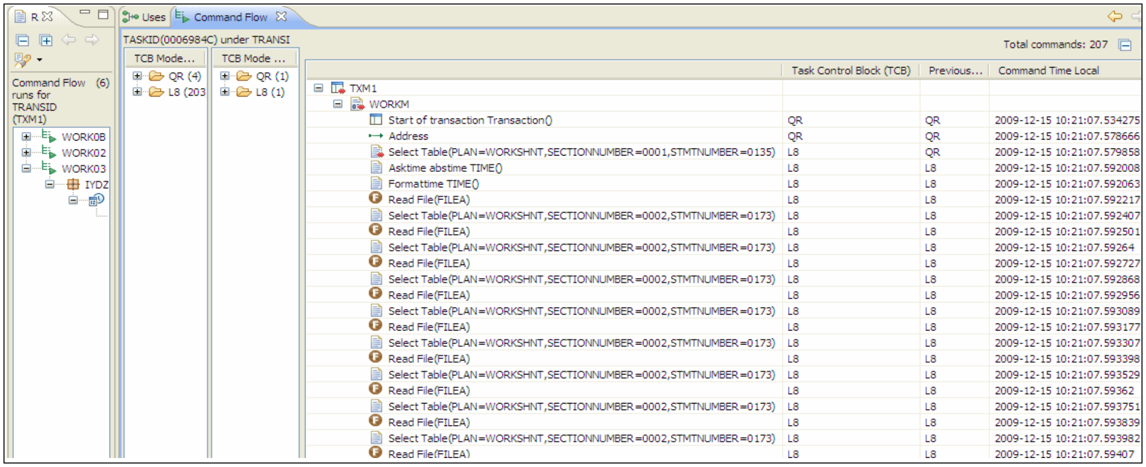

Figure 5-27 CICS IA Explorer - Command Flow execution from WORK03 (threadsafe TXM1 capture)

One solution to enable our sample application to run as threadsafe is to put an ENQ and DEQ around the address CWA and its subsequent increment. We did this and again ran our test script for WORKM. The results this time were the same as the non threadsafe example (that is, there were no transactions with duplicate counter values in examination of the temporary storage records).

```
006302*    Single stream access to the shared area using ENQ *
006310     exec cics
006320        enq resource(shared-area)
006330     end-exec.
006400*        read the value in shared storage.
006500         move shared-counter to ws-counter.
006600*        ... and change its value
006700         Add 1 to ws-counter.
006900*        ** Do some important processing **
      ===> Missing code section to loop for a period of time
      ===>   SQL and VSAM file requests
007601*        update the shared storage with our new value
007602         Move ws-counter to shared-counter.
007604*    remove the enqueue from the shared resource update *
007610     exec cics
007620        deq resource(shared-area)
007630     end-exec.
```

Figure 5-28 - Extract of sample application program WORKM with ENQ/DEQ

The following figure shows us the EXEC CICS COMMANDS called when running program WORKM with the changes described previously. We can now see that the ADDRESS CWA command is serialized by using the ENQ/DEQ technique.

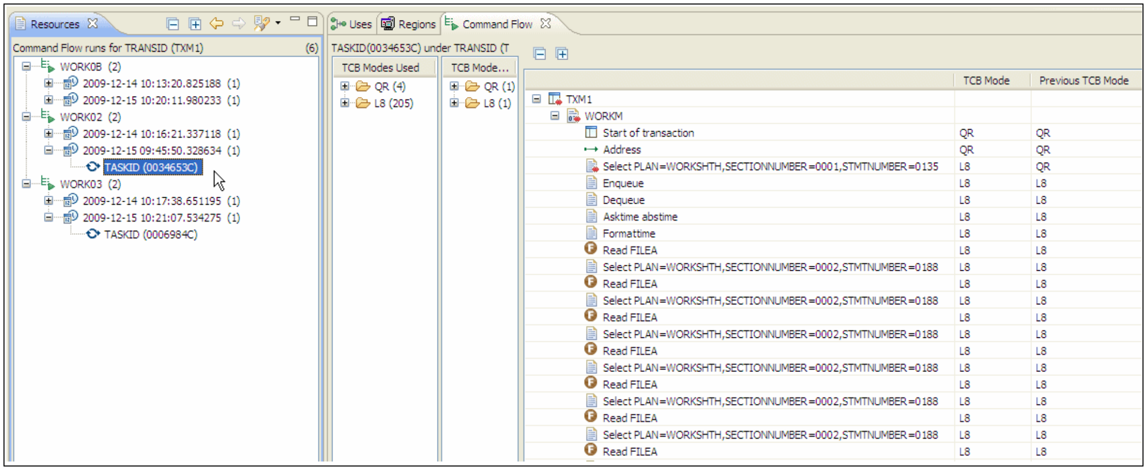

Figure 5-29 CICS IA Explorer - Command Flow execution from WORK02 (threadsafe TXM1 capture)

> **Note:** Since Local VSAM can run Threadsafe in CICS TS V3.2 or above, the file control local VSAM requests are now running on the L8 without eliminating the switch back to the QR.
>
> Make sure you change the default DFHSIT FCQRONLY parm from YES to **NO.**
>
> FCQRONLY YES Threadsafe FC runs on QR TCB - This is the default

You could now run the Dynamic Threadsafe Analysis Detail report again to further verify your results.

```
APLID    Program   Linkedit   Execution  Concurrency  APIST   Storage  CICS  LIB Dataset Name
                     Date        Key                           Protect  Rel
-------- -------- ---------- ---------- ----------- ------- -------- ----- --------------------------------

                  CMD  Function                 Type            Resource                          Offset   Program  Use     Threadsafe
                  Type                                                                                     Length   Count
                  ---- ----------------------- --------------- ------------------------------- -------- -------- ------- ----------


IYDZEJ02 DRIVERM  0001-01-01 USER        QUASIRENT   CICSAPI INACTIVE 0660  REDTOOLS.WORKSEM.LOADLIB2
                  CICS ADDRESS                                  CWA                                   502     1668        1    N  *
                  CICS DELETEQ                  TSQUEUE AUX     OUTPUTQ                               4BE     1668        1    Y
                  CICS INQUIRE                  PROGRAM         WORKM                                 6CA     1668        1    N
                  CICS SEND                     TEXT            SEND TEXT                             7E6     1668        1    N
                  CICS WRITEQ                   TSQUEUE AUX     OUTPUTQ                               730     1668        1    Y
                  CICS ADDRESS                                  CWA                                   502     1668        1    N
                  CICS DELETEQ                  TSQUEUE AUX     OUTPUTQ                               4BE     1668        1    Y
                  CICS INQUIRE                  PROGRAM         WORKM                                 6CA     1668        1    N
                  CICS SEND                     TEXT            SEND TEXT                             7E6     1668        1    N
                  CICS WRITEQ                   TSQUEUE AUX     OUTPUTQ                               730     1668        1    Y
  Total CICS calls:         10  Threadsafe:            4  Non-Threadsafe:                   6  Indeterminate Threadsafe:       0
                                DB2 calls:             0  MQ calls:                         0  IMS calls:                      0
                                Dynamic Calls:         0  Threadsafe Inhibitor calls:       2

IYDZEJ02 WORKM    0001-01-01 USER        THREADSAFE  CICSAPI INACTIVE 0660  REDTOOLS.WORKSEM.LOADLIB2
                  CICS ADDRESS                                  CWA                                   5EE     1930        1    N  *
                  CICS DEQUEUE                  ENQNAME         ADDR                                  7A2     1930        1    I
                  CICS ENQUEUE                  ENQNAME         ADDR                                  6EA     1930        1    I
                  CICS READ                     FILE            FILEA                                 994     1930        1    Y
                  CICS SEND                     TEXT            SEND TEXT                             A2E     1930        1    N
                  CICS WRITEQ                   TSQUEUE         OUTPUTQ                               9DE     1930        1    Y
                  CICS ADDRESS                                  CWA                                   5EE     1930        1    N  *
                  CICS DEQUEUE                  ENQNAME         ADDR                                  7A2     1930        1    I
                  CICS ENQUEUE                  ENQNAME         ADDR                                  6EA     1930        1    I
                  CICS READ                     FILE            FILEA                                 994     1930        1    Y
                  CICS SEND                     TEXT            SEND TEXT                             A2E     1930        1    N
                  CICS WRITEQ                   TSQUEUE         OUTPUTQ                               9DE     1930        1    Y
                  CICS ADDRESS                                  CWA                                   5EE     1930        1    N  *
                  CICS DEQUEUE                  ENQNAME         ADDR                                  7A2     1930        1    I
                  CICS ENQUEUE                  ENQNAME         ADDR                                  6EA     1930        1    I
                  CICS READ                     FILE            FILEA                                 994     1930        1    Y
                  CICS SEND                     TEXT            SEND TEXT                             A2E     1930        1    N
                  CICS WRITEQ                   TSQUEUE         OUTPUTQ                               9DE     1930        1    Y
                  .......
                  .......
                  DB2  SELECT                   TABLE           DSN8810.EMP                           6B2     1930        1    Y
                  DB2  SELECT                   TABLE           DSN8810.EMP                           6B2     1930        1    Y
                  DB2  SELECT                   TABLE           DSN8810.EMP                           6B2     1930        1    Y
                  DB2  SELECT                   TABLE           DSN8810.EMP                           6B2     1930        1    Y
                  DB2  SELECT                   TABLE           DSN8810.EMP                           6B2     1930        1    Y
                  DB2  SELECT                   TABLE                                                 66E     1928        1    Y
                  DB2  SELECT                   TABLE                                                 66E     1928        1    Y
                  DB2  SELECT                   TABLE                                                 66E     1928        1    Y
  Total CICS calls:         45  Threadsafe:           16  Non-Threadsafe:                  13  Indeterminate Threadsafe:      16
                                DB2 calls:             8  MQ calls:                         0  IMS calls:                      0
                                Dynamic Calls:         0  Threadsafe Inhibitor calls:       8
```

Figure 5-30 Detail Dynamic Threadsafe Analysis Report - WORKM Threadsafe

In this case study, we demonstrated how we could quickly analyze the candidate program, WORKM and make a quick modification, then verify the results with multiple CICS IA reporting tools.

5.6.3 Step 3 - Change program definitions to threadsafe

In this section we will use the application test case to demonstrate how to simplify and provide controlled management of CICS threadsafe resource definition changes using CICS Configuration Manager. This can be accomplished using the CICS CM ISPF interface or with the CICS Explorer CM plug-in. For this exercise we will use the CM plug-in.

View the Program definition

- Click on the CICS CM perspective tab at the top right of the CICS Explorer.
- Under the Configurations tab, you will see a list of configurations which on this system have been defined for CSDs that apply to specify CICS regions.
- Left click on the REDDEV31 configuration
  - This brings up a tab below the configurations for Lists
  - Below the Lists you will see the Groups tab
- Right click on REDDEV31, select Search, select Search Programs
- Enter WORKM in the Resource Name, click OK
  - REDDEV31 will automatically be placed in the Configuration
  - * will be automatically be placed in Group to wildcard search all groups
  -
- WOKRKM is displayed at the top middle of the perspective under the Search Results tab
- To view the definition, do 1 of the following:
  - Double left click on WORKM
  - Right click, select open
- You will be presented the Overview of the program attributes as follows

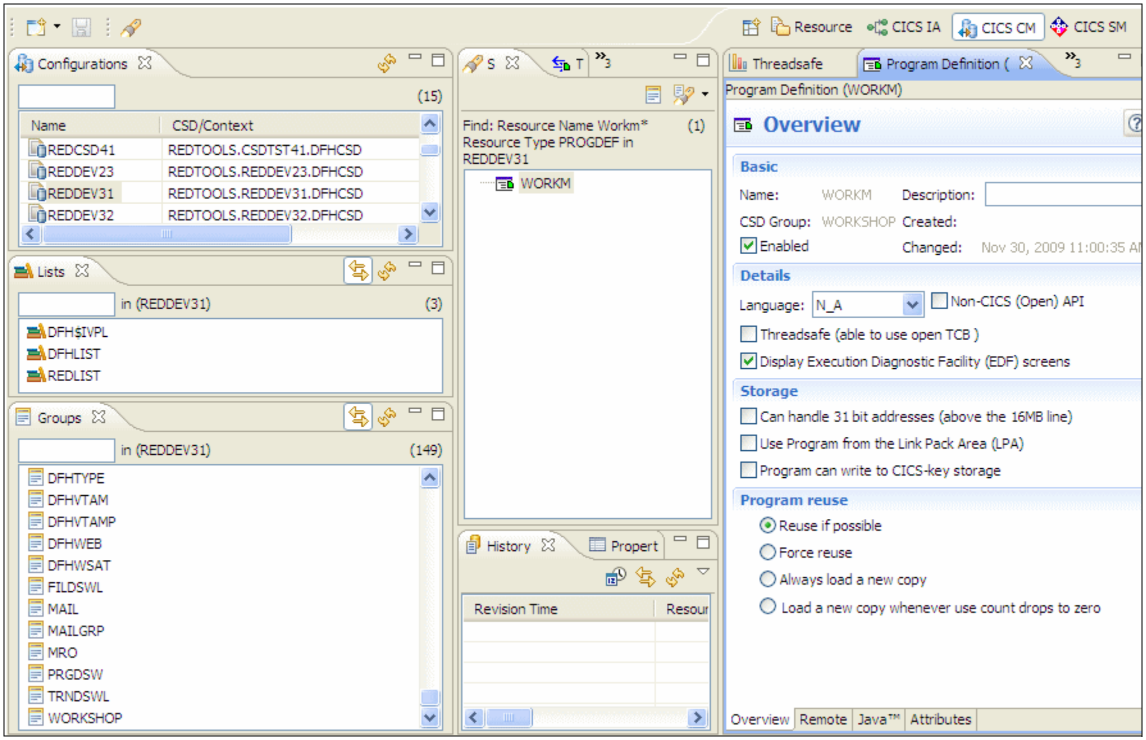

Figure 5-31 CICS CM Explorer - View of program WORKM Quasirent

In this Overview you are presented common resource attributes that you may want to change or that would be needed for a new definition. Notice that the Threadsafe box is not check. You could also view the detailed attributes by clicking the Attributes tab at the bottom right.

Change the program definition

You could change the definition to threadsafe by simply clicking in the Threadsafe box. However, let us take a look at the detail of the Attributes.

- Left click on the Attributes tab where you are presented the details of the resource
- Right click on the value for Concurrency which is QUASIRENT

You are presented with the following detail view of the resource attributes.

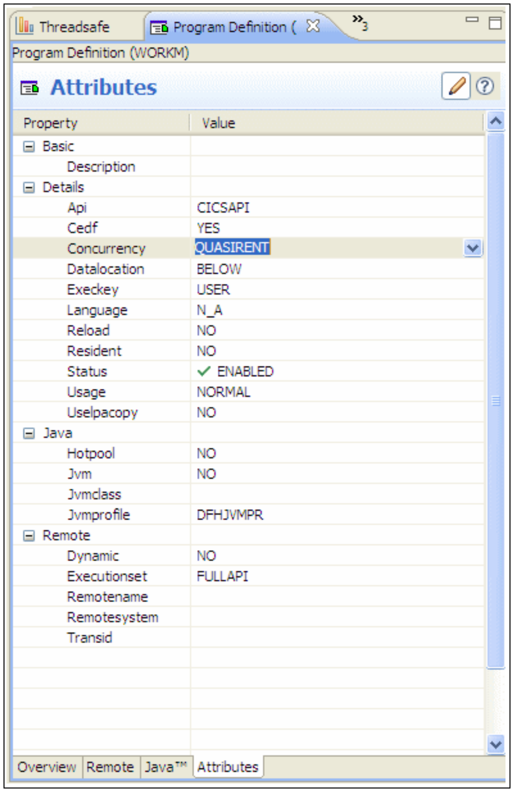

Figure 5-32 CICS CM Explorer - WORKM detail Attributes Quasirent

Since our application test case executes in 3 different regions with 3 different CSDs, we will simply choose the configuration where the next test script will be executed. However, in your environment, you could create a change package under the CICS CM ISPF interface and migrate the change through your change management life cycle.

Now choose the next region for the application test case, REDTST41.

- Repeat the steps from above, starting with View the Program Definition, until you get to this point.
- Right click on the value for Concurrency which is QUASIRENT
- The pull down tab gives you a list of available options
  - N_A
  - QUASIRENT
  - THREADSAFE

> **Note:** This is true for all editable attributes.

- Click on THREADSAFE
- Close the Program Definition tab by clicking on the X
  - The change that you made will be highlighted and you will be asked to save the change
  - Click YES to save the change

Install the program definition

To implement the program change, the resource definition must be installed in the CICS Region. The CICS CM Explorer view should still have the program displayed under the Search Results tab.

- Right click on the WORKM program and select Install
- Under the CICSplex pull-down, select the CICSplex where the region is defined. In our case it is the REDBPLEX.
- Under the Target, choose the region where you would like the resource installed. In our case it is REDDEV41.
- Click OK to install the definition.

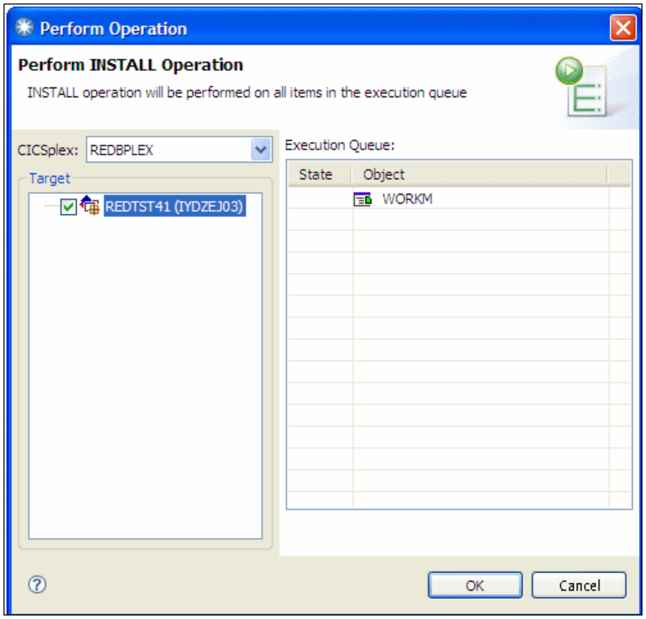

Figure 5-33 CICS CM Explorer - Install Program WORKM

This completes the process for changing the program definition to concurrency, threadsafe. You should now go back to Step 2 to complete the analysis.

View Audit history

To understand the history of a resource you can View Audit history for details on who, what, when and where a resource changed.

View all changes for a configuration

- Click on the name, REDTST41
- Right click to get the pull-down
- Select history

You are presented with the History for that configuration. In this case the only change was the WORKM program. There are multiple paths to display the history. You could also simply click on the displayed resource, in this example WORKM under Program Definitions, and the History will populate for the selected resource.

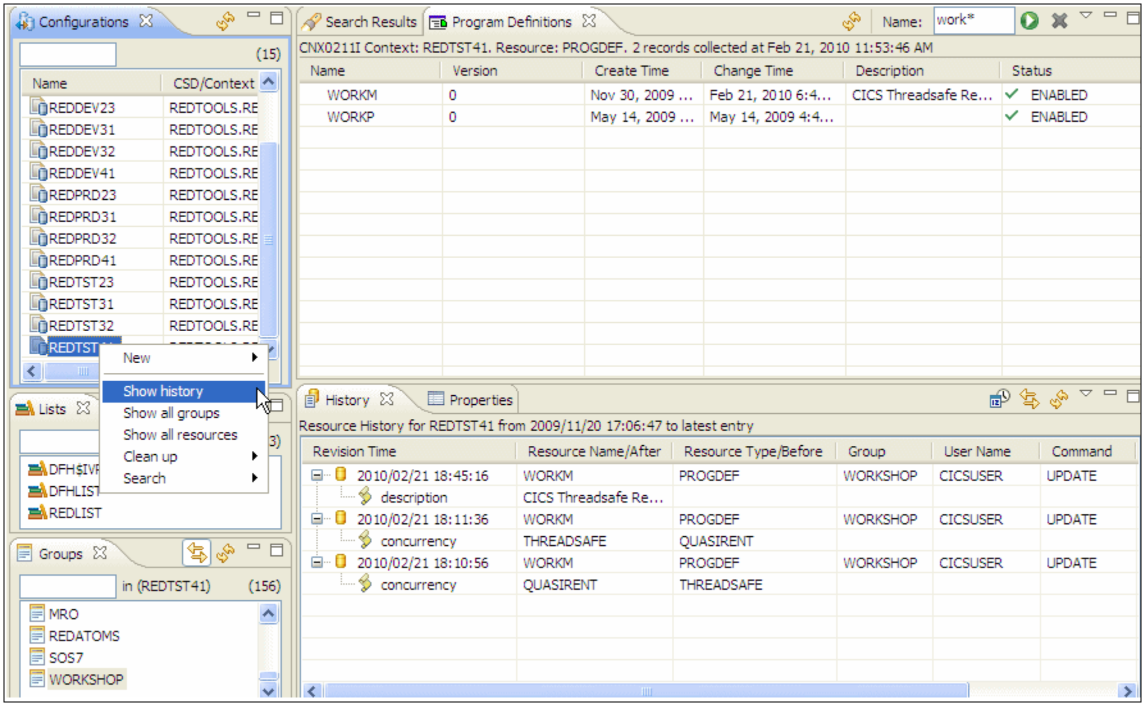

Figure 5-34 CICS CM Explorer - View History

From the History display for WORKM

- Who - CICSUSER
  - Because this is a test region, security is not setup. However, in your environment with security on, you will see the actual userid.
- What - description/concurrency - Command was UPDATE

  – In 1 case the description changed. The before and after is displayed.
  – In 2 other cases the concurrency changed. The before and after is displayed.
- When - The Revision Time is listed for each update
- Where - Group is WORKSHOP in REDTST41

Compare Resource Definitions

You may wish to compare resource definitions to see if the attributes are different. In this example we will compare the resource WORKM which is defined in REDDEV31 and REDTST41. For this exercise we will use the CICS CM ISPF interface.

- From the CICS CM main menu in ISPF, select option 4 for Reporting
- Select option 1 Multiple Configs
- Place a S in the selection field for REDDEV31 and REDTST41, press enter
- On the Filter line enter WORKM for the Name and PROGRAM for the Type, press enter
- Type CM (compare multiple) on the command line next to both WORKM entries, press enter

```
   File  Menu  Settings  Hilite  Help
 ------------------------------------------------------------------------
 Compare                             Program
 Command ===> _________________________________________________________

     Program . . . : WORKM                        WORKM
     ResGroup  . . : WORKSHOP                     WORKSHOP
 ==> Location  . . : REDTOOLS.REDDEV31.DFHCSD     REDTOOLS.REDTST41.DFHCSD
 ==> Change Date . : 2009/11/30 11:00:35          2010/02/21 18:44:52
 ==> Description . :                          >   CICS Threadsafe Redbook Pr >
                                                                 More:     +
     Language  . . : N_A                          N_A
     Reload  . . . : NO                           NO
     Resident  . . : NO                           NO
     Usage . . . . : NORMAL                       NORMAL
     UseLPAcopy  . : NO                           NO
     Status  . . . : ENABLED                      ENABLED
     CEDF  . . . . : YES                          YES
     DataLocation  : BELOW                        BELOW
     ExecKey . . . : USER                         USER
 ==> Concurrency . : QUASIRENT                    THREADSAFE
     API . . . . . : CICSAPI                      CICSAPI

    Remote Attributes
     Dynamic . . . : NO                           NO
     RemoteSystem  :
     RemoteName  . :
     TransID . . . :
     ExecutionSet  : FULLAPI                      FULLAPI

    JVM Attributes
     JVM . . . . . : NO                           NO
```

Figure 5-35 CICS CM ISPF - Compare Resources

The highlighted attributes indicate a difference in the definition. The Concurrency shows that the REDDEV31 region has WORKM defined QUASIRENT, and REDTST41 is defined as THREADSAFE.

5.6.4 Step 4 - Test and benchmark results

The tests for the application case study were performed in Section 5.6.2 as we analyzed programs and changed concurrency to threadsafe.

For each test that we ran we took note of the date/time for each test script for use in CICS PA Transaction profile reporting. We also copied our SMF 110 records to a file for safe keeping.

Run the Application Test Script

For the purpose of the application test case we ran the test script 3 times as follows:

- WORK0B script - Quasirent, CICS TS V3.1 - Non-threadsafe baseline
  - APPLID - IYDZEJ0B
  - From 12/15/2009 11:04:59.00
  - To 12/15/2009 11:14:58.00
- WORK03 script - Threadsafe CICS TS V4.1 - No Serialization for CWA
  - Since this was an interim step in exposing the data integrity problem, the SMF data was not captured as it is not important in the final results.
- WORK02 script - Threadsafe CICS TS V4.1 - CWA serialized
  - APPLID - IYDZEJ0B
  - From 12/15/2009 11:04:59.00
  - To 12/15/2009 11:14:58.00

Update CICS IA with the collected data.

- Each time we ran the test script, the interdependency data was loaded into the CICS IA database as defined in Section 5.2.4
- Each time we ran the Command Flow collection we loaded the logstream data into the CICS IA data base as defined in Section 5.2.4

Update CICS PA with the collected SMF data.

- If using the Historical Database in PA, load the collected SMF data into the database
- For this exercise we copied the SMF data into a dataset for reporting
  - From the CICS PA ISPF interface, we ran a take-up of the SMF file to identify our systems to CICS PA.

Run the PA Transaction Profiling report to verify results

- In the CICS PA ISPF main menu, select option 8 for Profiling
- Enter the fields as show in the following figure

```
 File  Systems  Options  Help
 ---------------------------------------------------------------------------
                          Run Transaction Profiling
Command ===> _______________________________________________________________

Specify Profiling data sources and options, then SUBmit to run.
                                                                  More:     +
Report System Selection:                ----- Report Interval -------
 APPLID . . IYDZEJ02  +                     MM/DD/YYYY  HH:MM:SS.TH
 Image  . . MV2F____  +                 From 12/15/2009  11:29:59.00
 Group  . . WORKSHOP  +                 To   12/15/2009  11:39:59.00

Baseline System Selection:              ---- Baseline Interval ------
 APPLID . . IYDZEJ0B  +                     MM/DD/YYYY  HH:MM:SS.TH
 Image  . . MV2F____  +                 From 12/15/2009  11:04:59.00
 Group  . . WORKSHOP  +                 To   12/15/2009  11:14:58.00

Report Format:
 Report Form . . . ________   +         Baseline Form . . ________   +
 Title  . . CICS Threadsafe Redbook Transaction Profiling _________________
            _______________________________________________________________

Summary Options:                       Reporting Options:
 Time Interval . . 01:00:00 (hh:mm:ss)  Lines . . . . /  Report  /  Baseline
 Totals Level  . . 8  (blank or 0-8)                 /  Delta   /  Change
                                        Threshold . . ___ % Above
Selection Criteria:                                  ___ % Below Baseline
 _  Performance  *                      Exclude . . . _  Within threshold
                                                     /  Blank lines

Execution Option:                       Missing SMF Files Option:
    Use External Sort                   1  1. Issue error message
```

Figure 5-36 CICS PA ISPF Interface - Transaction Profiling Report selection criteria

- The Report and Baseline Intervals are the same as we noted for the application test script executions.
- Performance selection was made to only include transaction TXM1
- We took the default for the Report Form to select the Performance Report
- Enter Sub to run the report

The following is the result of the report execution

```
 V3R1M0                                                      CICS Performance Analyzer
                                                               Transaction Profiling

PROF0001 Printed at  0:37:37  2/22/2010         Report   Data from 11:29:59 12/15/2009 to 11:39:58 12/15/2009
                                                Baseline Data from 11:04:58 12/15/2009 to 11:14:57 12/15/2009
CICS Threadsafe Redbook Transaction Profiling

                               Avg      Avg      Avg      Avg      Avg         Avg       Avg        Avg      Avg      Avg
Tran                   #Tasks Response Dispatch User CPU Suspend DispWait FC Wait   FCAMRq IR Wait SC24UHWM SC31UHWM
                                 Time     Time     Time     Time     Time     Time     Count     Time    Count    Count
TXM1      Report        3583    .0371    .0296    .0215    .0076    .0028    .0000      100    .0000        0    34016
TXM1      Baseline      3465    .5621    .0518    .0378    .5103    .1480    .0000      100    .0000        0    34000
          Delta         +118   -.5250   -.0222   -.0163   -.5028   -.1453    .0000        0    .0000        0      +16
          Change%      +3.41   -93.39   -42.92   -43.13   -98.51   -98.13      .00      .00      .00      .00     +.05

Total     Report        3583    .0371    .0296    .0215    .0076    .0028    .0000      100    .0000        0    34016
          Baseline      3465    .5621    .0518    .0378    .5103    .1480    .0000      100    .0000        0    34000
          Delta         +118   -.5250   -.0222   -.0163   -.5028   -.1453    .0000        0    .0000        0      +16
          Change%      +3.41   -93.39   -42.92   -43.13   -98.51   -98.13      .00      .00      .00      .00     +.05
```

Figure 5-37 CICS PA ISPF Interface - Transaction Profiling default report

- Avg Response improved by 93%
- Avg time the transaction was dispatched improved by 42%
- Avg CPU improved by 43%
- Avg Suspend time was almost eliminated with a 98% improvement
- Avg Dispatch Wait was almost eliminated with a 98% improvement

From this report you can easily see remarkable improvements by making 1 small program change and running as threadsafe.

Let us take a look at another Transaction Profiling report that details the TCB's. Use the same selection criteria as with the default report, but this time enter a form name of CPUSUMTS. This is a customized report form created from CPUSUM as follows:

```
                    EDIT SUMMARY Report Form - CPUSUMTS     Row 1 of 13 More: >
Command ===> _____________________________________________ Scroll ===> PAGE

Description . . . Transaction Threadsafe CPU ______  Version (VRM): 620

Selection Criteria:
 _  Performance                                     Page width . . 132_

    Field       Sort
/   Name +      K  O Type     Fn   Description
__  TRAN_____   K  A _______  ___  Transaction identifier
__  TASKCNT__      _ _______  ___  Total Task count
__  RESPONSE_      _ _______  AVE  Transaction response time
__  RESPONSE_      _ _______  MAX  Transaction response time
__  DISPATCH_      _ TIME___  AVE  Dispatch time
__  CPU______      _ TIME___  AVE  CPU time
__  SUSPEND__      _ TIME___  AVE  Suspend time
__  QRCPU____      _ TIME___  AVE  CICS QR TCB CPU time
__  L8CPU____      _ TIME___  AVE  CICS L8 TCB CPU time
__  DSCHMDLY_      _ TIME___  AVE  Redispatch wait time caused by change-TCB mode
__  DSCHMDLY_      _ COUNT__  AVE  Redispatch wait time caused by change-TCB mode
    EOR                            ---------------- End of Report ----------------
```

Figure 5-38 CICS PA ISPF Interface - Modified report form from CPUSUM

```
 V3R1M0                                                   CICS Performance Analyzer
                                                            Transaction Profiling

PROF0001 Printed at 23:31:23  2/21/2010      Report   Data from 11:29:59 12/15/2009 to 11:39:58 12/15/2009
                                             Baseline Data from 11:04:58 12/15/2009 to 11:14:57 12/15/2009
CICS Threadsafe Redbook CPUSUM Transaction Profiling

                                      Avg      Max      Avg      Avg      Avg      Avg      Avg      Avg      Avg
Tran                         #Tasks Response Response Dispatch User CPU  Suspend  QR CPU   L8 CPU DSCHMDLY DSCHMDLY
                                        Time     Time     Time     Time     Time     Time     Time     Time    Count
TXM1      Report               3583    .0371    .5399    .0296    .0215    .0076    .0005    .0210    .0027        4
TXM1      Baseline             3465    .5621   2.7829    .0518    .0378    .5103    .0243    .0135    .1324      406
          Delta                +118   -.5250  -2.2430   -.0222   -.0163   -.5028   -.0239  +.0075   -.1297     -402
          Change%             +3.41   -93.39   -80.60   -42.92   -43.13   -98.51   -98.00  +55.78   -97.94   -99.01

Total     Report               3583    .0371    .5399    .0296    .0215    .0076    .0005    .0210    .0027        4
          Baseline             3465    .5621   2.7829    .0518    .0378    .5103    .0243    .0135    .1324      406
          Delta                +118   -.5250  -2.2430   -.0222   -.0163   -.5028   -.0239  +.0075   -.1297     -402
          Change%             +3.41   -93.39   -80.60   -42.92   -43.13   -98.51   -98.00  +55.78   -97.94   -99.01
```

Figure 5-39 CICS PA ISPF Interface - Transaction Profiling report using modified form

- Avg QR CPU Time as almost eliminated with a 98% improvement
- Avg L8 CPU time increased by 56% which is what we wanted by off loading the workload from the QR to the L8
- Avg DSCHMDLY Time improved by 97%. This is the time we were wasting by TCB change mode switches
- Avg DSCHMDLY Count went from 406 TCB mode switches to 4 per transaction. This accounts for the savings in time in the respective time buckets.

Run CICS PA Explorer performance queries

In additional to the CICS PA Transaction Profiling reports, you can also run the same queries as we did in Step 1 to view the improvements.

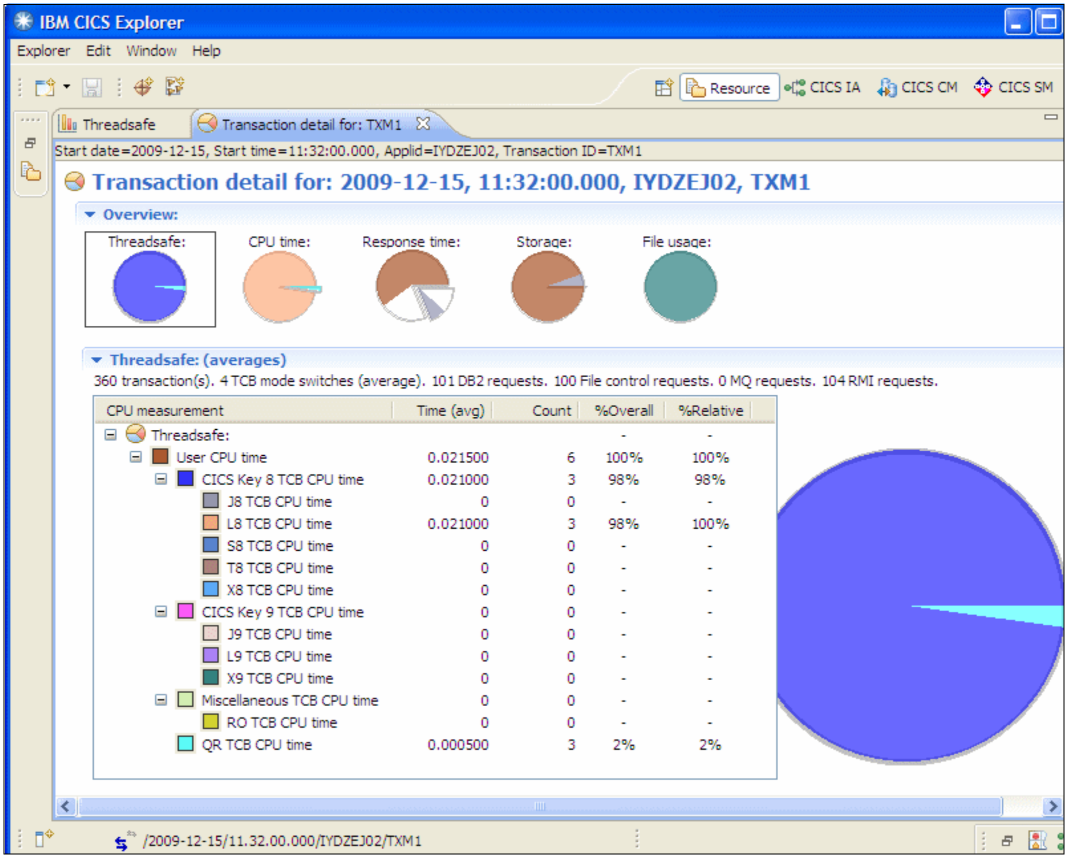

Figure 5-40 CICS PA Explorer - Threadsafe Detail View - TXM1 is Threadsafe

As observed in the CICS PA Transaction Profiling Report, the majority of the time is spent on the L8 TCB and the number of TCB mode switches has dropped to an average of 4 from an average of 406 as observed in this same query in Step 1.

5.6.5 Application case study conclusions

Step 1

In Step 1 of the application case study we reviewed performance data from CICS PA to determine that the transaction TXM1 was a good candidate to make threadsafe. We based this on the high volume of TCB mode switches that were occurring and that it contained a good amount of DB2 activity. It also contained a fair amount of VSAM file activity. We knew that moving this transaction to a CICS

TS V4.1 region would allow us to take advantage of VSAM running threadsafe on the L8 TCB.

Step 2

In Step 2 we analyzed the resources used by transactions TXM1 and determined that program WORKM could be made threadsafe. We found that it used an ADDRESS CWA command, but instead of code analysis we decided to make the program threadsafe to see what improvements could be realized. We found that making the program threadsafe caused a data integrity problem where a counter value got overlaid because the ADDRESS CWA was not serialized. So we reviewed the code and placed an ENQ/DEQ around the counter value update which resolved the data integrity problem. We then tested the program again and found that it was safe to move ahead with the threadsafe enablement.

Step 3

In Step 3 we changed the WORKM program definition with CICS Configuration Manager to make it threadsafe. We observed some of the capabilities of the product such as the Audit History of the change to the resource definition. We also viewed a report showing the difference in the program definition from one region to another.

Step 4

In Step 4 we quantified the efforts by showing a dramatic reduction in CPU and CICS resource consumption.

- Avg Response improved by 93%
- Avg time the transaction was dispatched improved by 42%
- Avg CPU improved by 43%
- Avg Suspend time was almost eliminated with a 98% improvement
- Avg Dispatch Wait was almost eliminated with a 98% improvement
- Avg QR CPU Time as almost eliminated with a 98% improvement
- Avg L8 CPU time increased by 56% which is what we wanted by off loading the workload from the QR to the L8
- Avg DSCHMDLY Time improved by 97%. This is the time we were wasting by TCB change mode switches
- Avg DSCHMDLY Count went from 406 TCB mode switches to 4 per transaction. This accounts for the savings in time in the respective time buckets.

Conclusion

This is a good example of how a controlled environment can show CPU savings with the ability to increase throughput. Each environment and threadsafe project will be different. However, with results driven tools as demonstrated in this case study, you will be able to realize similar savings and provide significant savings to your corporation.

5.7 Additional Samples

Using the CICS IA Scanners

CICS IA has two load module scanners:

- The original load module scanner that reports on possible affinities and dependencies in a program. It also reports the program language. It produces a batch report and populates two DB2 tables:
  - CIU_SCAN_SUMMARY
  - CIU_SCAN_DETAIL
- The additional CSECT scanner that reports on linkage and compiler attributes of all CSECTs within a program. It produces a batch report and populates two DB2 tables:
  - CIU_CSECT_INFO
  - CIU_PROGRAM_INFO

Running the load module scanner

To run the load module scanner we must first edit and run the customized job CIUJCLTS to produce a summary report.

The job appears in Example 5-1. The values that require editing in this job are:

scan The load library to be scanned. We scan REDBK23.APPL.LOADLIB.

ciudet The output data set to be used as input to the detailed job CIUJCLTD. We use REDBK23.APPL.DETMODS.

Example 5-1 CIUJCLTS: IA summary scanner JCL

```
//CIUJCLTS JOB USER=EYJ,NOTIFY=EYJ,
//         CLASS=A,MSGCLASS=Y,REGION=0M
//*********************************************************************
//*                                                                   *
//* JCL NAME = CIUJCLTS                                               *
//*                                                                   *
//* DESCRIPTIVE NAME = IBM CICS INTERDEPENDENCIES UTILITY             *
//*                    RUN SCANNER IN SUMMARY MODE WITH DB2 OUTPUT    *
//*                                                                   *
//* CHANGES TO BE MADE                                                *
//*                                                                   *
```

```
//*   1) CHANGE THE JOB CARD TO SUIT YOUR SYSTEM CONVENTIONS          *
//*   2) CHANGE THE FOLLOWING PARAMETERS:-                            *
//*   DB2P                                                            *
//*   THE DB2 ID                                                      *
//*   CIU                                                             *
//*   DATASET HLQ FOR CIU PRODUCT                                     *
//*   DSN710                                                          *
//*   DATASET HLQ FOR DB2 SDSNLOAD and RUNLIB.LOAD                    *
//*   _scan_                                                          *
//*   CICS LOAD DATASET TO BE SCANNED                                 *
//*   _ciudet_                                                        *
//*   Output dataset created by SCANNER SUMMARY JOB                   *
//*   3) EDIT THE MEMBER CIUDB2BT IN                                  *
//*      REDBK23.MIG23T31.SCIUCLIS                                    *
//*      AND CHANGE THE FOLLOWING:-                                   *
//*   CIU                                                             *
//*   DATASET HLQ FOR CIU PRODUCT                                     *
//*                                                                   *
//*********************************************************************
//* FUNCTION =                                                        *
//*    Sample JCL to run the Load Module Scanner component of the     *
//*    Interdependencies Utility (SUMMARY mode, DB2 output).          *
//*********************************************************************
//SCAN     EXEC PGM=IKJEFT1B,DYNAMNBR=20,
//              PARM=('%CIUDB2BT','SYS(DB2P)','PROG(CIULMS)',
//              'PLAN(CIUBTCH4)','PARM(''$SUMMARY,DETAILMODS,TABLE'')')
//STEPLIB  DD DSN=CIU.SCIULOAD,DISP=SHR
//         DD DSN=CIU.SCIULODE,DISP=SHR
//         DD DSN=DSN710.SDSNLOAD,DISP=SHR
//SYSPROC  DD DSN=REDBK23.MIG23T31.SCIUCLIS,DISP=SHR
//INPUT    DD DSN=REDBK23.APPL.LOADLIB,DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
//SYSTSIN  DD DUMMY
//SYSTSPRT DD SYSOUT=*
//SYSABOUT DD SYSOUT=*
//SYSOUT   DD SYSOUT=*
//INTMOD   DD DSN=REDBK23.APPL.DETMODS,DISP=(NEW,CATLG,DELETE),
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000),SPACE=(CYL,(1,1))
//DETAIL   DD DUMMY
//
```

The output from this job can be seen in Example 5-2.

Example 5-2 IA scanner summary output

```
CICS INTERDEPENDENCY ANALYZER  Version 2.1.0
LOAD MODULE SCANNER -  SUMMARY LISTING OF REDBK23.APPL.LOADLIB
```

```
Module      Module     Module       Language   Possible statements......
Name        Length     Language     Version    Affinities   Dependencies
--------   --------   ----------   --------   ----------   ------------
CCVSREMP   00003E28   ASSEMBLER                       70             72
CDCB001#   00001F38   COBOL         Non LE             0              2
CDCB0010   00002090   COBOL         Non LE             0              2
CDCB0020   000020D0   COBOL         Non LE             0              5
CDCB0510   00002090   COBOL         Non LE             0              2
CDCB0710   00002090   COBOL         Non LE             0              2
CICB0010   000020B8   COBOL         Non LE             0              7
CICB0020   00001EB0   COBOL         Non LE             0              8
CICB0030   00001EB0   COBOL         Non LE             0              8
CICB0050   00001A90   COBOL         Non LE             0              5
COBOLVS1   00001318   COBOL         Non LE             1              2
COBOLVS2   00001318   COBOL         Non LE             1              2
CSCB0010   00001358   COBOL         Non LE             0              1
CSCB0030   00004BC0   COBOL         Non LE             0              2
CSCB0200   00001250   COBOL         Non LE             0              1
REDBK1     00001630   C/370         LE                 4              6
REDBK1A    00001630   C/370         LE                 4              6
REDBK1B    00001630   C/370         LE                 4              6
REDBK1C    00001630   C/370         LE                 4              6
REDBK1D    00001630   C/370         LE                 4              6
REDBK1E    00001630   C/370         LE                 4              6
REDBK2     000026D8   PL/I          LE                 6              6
REDBK3     00001720   C/370         LE                 0              4
REDBK4     00001738   COBOL         Non LE             0              1
REDBK5     00001780   C/370         LE                 2              6
CICS INTERDEPENDENCY ANALYZER  Version 2.1.0
LOAD MODULE SCANNER -  SUMMARY LISTING OF REDBK23.APPL.LOADLIB

                    LOAD LIBRARY STATISTICS
=================================================================
Total modules in library                              =        25
Total modules scanned                                 =        25
Total CICS modules/tables (not scanned)               =         0
Total modules in error (not scanned)                  =         0
Total modules containing possible MVS POSTs           =         0
Total modules containing possible Dependency commands =        25
Total modules containing possible Affinity commands   =        11
  Total ASSEMBLER modules                             =         1
  Total C/370 modules                                 =         8
  Total COBOL modules                                 =        15
  Total COBOL II modules                              =         0
  Total PL/I modules                                  =         1
```

To run the detailed report for the load module scanner we must edit and run the customized job CIUJCLTD. The job appears in Example 5-3. The values that require editing in this job are:

scan The load library to be scanned. We scan REDBK23.APPL.LOADLIB.

ciudet The input data set created by the summary job. We use REDBK23.APPL.DETMODS.

Example 5-3 CIUJCLTS - IA detailed scanner

```
//CIUJCLTD JOB USER=EYJ,NOTIFY=EYJ,
//         CLASS=A,MSGCLASS=Y,REGION=0M
//*********************************************************************
//* JCL NAME = CIUJCLTD                                               *
//*                                                                   *
//* DESCRIPTIVE NAME = IBM CICS INTERDEPENDENCIES UTILITY             *
//*                    RUN SCANNER IN DETAIL MODE WITH DB2 OUTPUT     *
//*                                                                   *
//* CHANGES TO BE MADE                                                *
//*                                                                   *
//*   1) CHANGE THE JOB CARD TO SUIT YOUR SYSTEM CONVENTIONS          *
//*   2) CHANGE THE FOLLOWING PARAMETERS:-                            *
//*   DB2P                                                            *
//*   THE DB2 ID                                                      *
//*   CIU                                                             *
//*   DATASET HLQ FOR CIU PRODUCT                                     *
//*   DSN710                                                          *
//*   DATASET HLQ FOR DB2 SDSNLOAD and RUNLIB.LOAD                    *
//*   _scan_                                                          *
//*   The load library to be scanned                                  *
//*   _ciudet_                                                        *
//*   Input dataset created from a SCANNER SUMMARY JOB                *
//*                                                                   *
//*   3) EDIT THE MEMBER CIUDB2BT IN                                  *
//*      REDBK23.MIG23T31.SCIUCLIS                                    *
//*      AND CHANGE THE FOLLOWING:-                                   *
//*   CIU                                                             *
//*   DATASET HLQ FOR CIU PRODUCT                                     *
//*                                                                   *
//*********************************************************************
//* FUNCTION =                                                        *
//*                                                                   *
//*    Sample JCL to run the Load Module Scanner component of the     *
//*    Interdependencies Utility (DETAIL mode, DB2 output).           *
//*                                                                   *
//SCAN     EXEC PGM=IKJEFT1B,DYNAMNBR=20,
//             PARM=('%CIUDB2BT','SYS(DB2P)','PROG(CIULMS)',
//             'PLAN(CIUBTCH4)','PARM(''$DETAIL,TABLE'')')
```

```
//STEPLIB  DD DSN=CIU.SCIULOAD,DISP=SHR
//         DD DSN=CIU.SCIULODE,DISP=SHR
//         DD DSN=DSN710.SDSNLOAD,DISP=SHR
//SYSPROC  DD DSN=REDBK23.MIG23T31.SCIUCLIS,DISP=SHR
//INPUT    DD DSN=REDBK23.APPL.LOADLIB,DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
//SYSTSIN  DD DUMMY
//SYSTSPRT DD SYSOUT=*
//SYSABOUT DD SYSOUT=*
//SYSOUT   DD SYSOUT=*
//DETAIL   DD DSN=REDBK23.APPL.DETMODS,DISP=(OLD,DELETE)
//INTMOD   DD DUMMY
//
```

The output from this job is shown in Example 5-4.

Example 5-4 IA Scanner detailed output

```
CICS INTERDEPENDENCY ANALYZER  Version 2.1.0                                                    06/27/06     Page      1
LOAD MODULE SCANNER - DETAILED LISTING OF REDBK23.APPL.LOADLIB

Module Name - REDBK1    /  Load Module Length - 00001630  /  Module Entry Point - 00000028
Offset    Storage Content (HEX)                                EDF DEBUG  Possible Command              Depcy   Affinity
--------  --------------------------------------------------  ---------  ----------------------------  ------  --------
000008A4  020880002F1F000000000000000000000000000000000000      00007000   ASSIGN   APPLID                 Yes
00000904  020280002F020000000000000000000000000000000000000     00007400   ADDRESS  CWA                    Yes     Trans
00000924  0A02E0002F00004100                                    00007800   WRITEQ   TS                     Yes     Trans
00000964  0604F0002F28004400                                    00010000   WRITE    FILE                   Yes
00000978  0A02E0002F00004100                                    00010600   WRITEQ   TS                     Yes     Trans
0000098C  0A02E0002F00004100                                    00011000   WRITEQ   TS                     Yes     Trans
Total possible Affinity commands   =        4
Total possible Dependency commands =        6
Total possible MVS POSTs           =        0

CICS INTERDEPENDENCY ANALYZER  Version 2.1.0                                                    06/27/06     Page     10
LOAD MODULE SCANNER - DETAILED LISTING OF REDBK23.APPL.LOADLIB

                    LOAD LIBRARY STATISTICS
=================================================================
Total modules in DETAIL file                            =        25
Total modules scanned                                   =        25
Total CICS modules/tables (not scanned)                 =         0
Total modules in error (not scanned)                    =         0
Total modules containing possible MVS POSTs             =         0
Total modules containing possible Dependency commands =          25
Total modules containing possible Affinity commands   =          11
  Total ASSEMBLER modules                               =         1
  Total C/370 modules                                   =         8
  Total COBOL modules                                   =        15
  Total COBOL II modules                                =         0
  Total PL/I modules                                   =      1
```

Running the CSECT scanner

In order to use the CSECT scanner we must first populate the DB2 table CIU_CIU_TRANSLATORS with a list of translator and compiler names. To do this we must edit and run the customized job CIUTLOAD. To run the CSECT scanner we must edit and run the customized job CIUJCLCS. The job appears in

Example 5-5. The value that requires editing in this job is **`_scan_`**, the load library to be scanned. We scan REDBK23.APPL.LOADLIB.

Example 5-5 CIUJCLCS - IA CSECT Scanner JCL

```
//CIUJCLCS JOB USER=EYJ,NOTIFY=EYJ,
//         CLASS=A,MSGCLASS=Y,REGION=0M
//*********************************************************************
//* JCL NAME = CIUJCLCS                                               *
//* DESCRIPTIVE NAME = IBM CICS INTERDEPENDENCIES UTILITY             *
//*                    Sample JCL for running CSECT Scanner with      *
//*                    DB2 output.                                    *
//*                                                                   *
//* CHANGES TO BE MADE                                                *
//*                                                                   *
//*   1) CHANGE THE JOB CARD TO SUIT YOUR SYSTEM CONVENTIONS          *
//*   2) CHANGE THE FOLLOWING PARAMETERS:-                            *
//*   DB2P                                                            *
//*   THE DB2 ID                                                      *
//*   CIU                                                             *
//*   DATASET HLQ FOR CIU PRODUCT                                     *
//*   DSN710                                                          *
//*   DATASET HLQ FOR DB2 SDSNLOAD and RUNLIB.LOAD                    *
//*   _scan_                                                          *
//*   CICS LOAD DATASET TO BE SCANNED                                 *
//*                                                                   *
//*   3) EDIT THE MEMBER CIUDB2BT IN                                  *
//*      REDBK23.MIG23T31.SCIUCLIS                                    *
//*      AND CHANGE THE FOLLOWING:-                                   *
//*   CIU                                                             *
//*   DATASET HLQ FOR CIU PRODUCT                                     *
//*                                                                   *
//*********************************************************************
//SCAN     EXEC PGM=IKJEFT1B,DYNAMNBR=20,
//             PARM=('%CIUDB2BT','SYS(DB2P)','PROG(CIUCSS)',
//             'PLAN(CIUBTCH4)','PARM(''$TABLE'')')
//STEPLIB  DD DSN=CIU.SCIULOAD,DISP=SHR
//         DD DSN=CIU.SCIULODE,DISP=SHR
//         DD DSN=DSN710.SDSNLOAD,DISP=SHR
//SYSPROC  DD DSN=REDBK23.MIG23T31.SCIUCLIS,DISP=SHR
//LOADLIB  DD DSN=REDBK23.APPL.LOADLIB,DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
//SYSTSIN  DD DUMMY
//SYSTSPRT DD SYSOUT=*
//SYSABOUT DD SYSOUT=*
//SYSOUT   DD SYSOUT=*
//
```

The output from this job can be seen in Example 5-6.

Example 5-6 IA CSECT scanner output

```
CICS INTERDEPENDENCY ANALYZER Version 2.1.0                06/27/06    Page  1
CSECT SCANNER - LISTING OF: REDBK23.APPL.LOADLIB
REDBK4    00001738  00000020   5695PMB01  01.07  2006163104940    24     24
   DFHECI    1997256 569623400   01.02
   REDBK4    2006163 5740CB103   02.04
   ILBOCOM0  1983194 5734AS100   05.01      1983194 RSI31940368
   ILBOSRV    1983194 5734AS100  05.01      1983194 RSI31940563
   ILBOMSG    1983194 5734AS100  05.01      1983194 RSI31940572
   ILBOBEG    1983194 5734AS100  05.01      1983194 RSI31940346
```

Identifying non threadsafe programs

To identify which programs are non threadsafe we can query either the CIU_SCAN_DETAIL table populated by job CIUJCLTD (load module scanner) or the CIU_CICS_DATA table populated by data from the collector.

Querying the CIU_SCAN _DETAIL table

The following query tells us all programs that have possible commands that would cause the program to be non threadsafe (that is, the program executes a LOAD, EXTRACT, GETMAIN, or ADDRESS CWA). The query is restricted to the REDBK23.APPL.LOADLIB data set only. This is shown in Example 5-1 on page 130.

Example 5-7 Threadsafe query using the scan detail table

```
--Show me all possible programs that are not threadsafe in data set
--REDBK23.APPL.LOADLIB using the load module scanner detail
  SELECT PROGRAM , COMMAND , RESOURCE_TYPE
  FROM CIU_SCAN_DETAIL
  WHERE COMMAND IN ('LOAD    ', 'EXTRACT ', 'GETMAIN ', 'ADDRESS ')
  AND DSNAME='REDBK23.APPL.LOADLIB';
---------+---------+---------+---------+---------+---------+---------+--------+
PROGRAM   COMMAND   RESOURCE_TYPE
---------+---------+---------+---------+---------+---------+---------+--------+
COBOLVS1  ADDRESS   CWA
COBOLVS2  GETMAIN   SHARED
REDBK1    ADDRESS   CWA
REDBK1A   ADDRESS   CWA
REDBK1B   ADDRESS   CWA
REDBK1C   ADDRESS   CWA
REDBK1D   ADDRESS   CWA
REDBK1E   ADDRESS   CWA
REDBK5    ADDRESS   CWA
DSNE610I NUMBER OF ROWS DISPLAYED IS 9
DSNE616I STATEMENT EXECUTION WAS SUCCESSFUL, SQLCODE IS 100
```

```
---------+---------+---------+---------+---------+---------+---------+--------+
```

Querying the CIU_CICS _DATA table

The query in Example 5-8 shows us all resources used in CICS region REDBKV23.

Example 5-8 All resources query for region REDBKV23 using CICS table

```
--Show me all resources in region REDBKV23
--from the collector
  SELECT DISTINCT PROGRAM , FUNCTION,  TYPE , OBJECT
  FROM CIU_CICS_DATA
  WHERE APPLID='REDBKV23'
  ORDER BY 1;
---------+---------+---------+---------+---------+---------+---------+--------+
PROGRAM   FUNCTION  TYPE      OBJECT
---------+---------+---------+---------+---------+---------+---------+--------+
REDBK1    ADDRESS   CWA       CWA
REDBK1    ASSIGN    APPLID    REDBKV23
REDBK1    WRITE     FILE      REDBOOKF
REDBK1    WRITEQ    TD        CESE
REDBK1    WRITEQ    TSSHR     REDBOOKQ
REDBK2    START     TRANSID   RDBA
REDBK2    START     TRANSID   RDBB
REDBK2    START     TRANSID   RDBC
REDBK2    START     TRANSID   RDBD
REDBK2    START     TRANSID   RDBE
REDBK2    START     TRANSID   RDB1
REDBK3    ASSIGN    APPLID    REDBKV23
REDBK3    ENDBR     FILE      REDBOOKF
REDBK3    READNEXT  FILE      REDBOOKF
REDBK3    STARTBR   FILE      REDBOOKF
REDBK4    LINK      PROGRAM   REDBK3
REDBK5    ADDRESS   CWA       CWA
REDBK5    ASSIGN    APPLID    REDBKV23
REDBK5    ENDBR     FILE      REDBOOKF
REDBK5    READNEXT  FILE      REDBOOKF
REDBK5    STARTBR   FILE      REDBOOKF
DSNE610I NUMBER OF ROWS DISPLAYED IS 21
DSNE612I DATA FOR COLUMN HEADER OBJECT COLUMN NUMBER 4 WAS TRUNCATED
DSNE616I STATEMENT EXECUTION WAS SUCCESSFUL, SQLCODE IS 100
```

Note: The output from this query only shows programs that have actually been executed while the CICS IA collector was running. For example, program COBOLVS1 in the output in Example 5-7 is not in the output in Example 5-8 because it has not been executed.

The query shown in Example 5-9 will tell us all programs that have possible commands that would cause the program to be non threadsafe (that is, the program executes a LOAD, EXTRACT, GETMAIN, or ADDRESS CWA). The query is restricted to the CICS region that is to be migrated, REDBKV23.

Example 5-9 Threadsafe query using CICS table

```
--Show me all programs that are not threadsafe in region REDBKV23
--from the collector
  SELECT DISTINCT PROGRAM , FUNCTION, OBJECT
  FROM CIU_CICS_DATA
  WHERE FUNCTION IN ('LOAD    ', 'EXTRACT ', 'GETMAIN ', 'ADDRESS ')
  AND APPLID='REDBKV23'
  ORDER BY 1;
---------+---------+---------+---------+---------+---------+---------+--------+
PROGRAM   FUNCTION  OBJECT
---------+---------+---------+---------+---------+---------+---------+--------+
REDBK1    ADDRESS   CWA
REDBK5    ADDRESS   CWA
DSNE610I NUMBER OF ROWS DISPLAYED IS 2
DSNE612I DATA FOR COLUMN HEADER OBJECT COLUMN NUMBER 3 WAS TRUNCATED
DSNE616I STATEMENT EXECUTION WAS SUCCESSFUL, SQLCODE IS 100
```

Programs REDBK1 and REDBK5 contain EXEC CICS ADDRESS CWA commands and therefore would need careful investigation prior to being defined as threadsafe. If the reference to the CWA is for read-only purposes then these programs could potentially be defined as an OPENAPI program, which allows them to run under their own OTE TCB from the start.

In Example 5-8 on page 137 we can see that program REDBK2 consists of only EXEC CICS STARTs and could be considered to be defined as threadsafe.

Chapter 6.

Application review

This chapter describes the actions necessary to make a CICS DB2 application threadsafe, therefore allowing it to continue to run on an L8 TCB following a DB2 command being performed.

While this chapter demonstrates a DB2 application, the same principles will apply for an application calling one of the other OPENAPI TRUEs, namely WebSphere MQSeries or IP Sockets for CICS.

This chapter addresses three different areas which must be investigated before defining your application as threadsafe:

- Use of non threadsafe native code
- Use of shared resources
- Use of non threadsafe CICS commands

The chapter concludes with a short example of a COBOL program using File Control commands. This is to demonstrate how, at CICS Transaction Server Version 3.2, file control commands will execute on an open TCB.

6.1 Application code review

Prior to enabling any application as threadsafe, a review of the application code *must* be performed. This is necessary for two reasons:

- First, application data integrity must be maintained. Prior to CICS Transaction Server 2.2 all user applications and exits ran on the QR TCB, which is a restricted or closed environment. CICS provided the serialization needed to ensure that application data integrity was never compromised. In this environment programs could be sure that no more than one quasi-reentrant program could run at the same time. Now, for applications that make calls to TRUEs that have been enabled as OPENAPI or, for application programs that have been defined as OPENAPI, it is possible for two or more programs to be running concurrently on different open TCBs and the QR TCB. Therefore it is now imperative that shared resources used by an application are serialized to prevent any application integrity problems due to more than one program accessing the same resource at the same time.
- The second reason for conducting a review of your application code is to ensure that once CICS moves an application over to an open TCB it remains there for as long as possible. CICS will switch the application program back to the QR TCB in order to execute CICS API or SPI commands that are non threadsafe. CICS must do this to maintain the integrity of such things as the CSA and other control blocks used by these commands.

6.1.1 Ensure that the program logic is threadsafe

There are several things that must be reviewed in order to ensure that the program logic is threadsafe.

Check native code

The native language logic is the application code in between any CICS commands. This code must be also be threadsafe. If you define a program to be threadsafe but the application logic is not threadsafe, then unpredictable results could occur that could compromise your data integrity.

To be threadsafe the first thing that needs to happen is that the program must be reentrant. Language Environment (LE) programs can be guaranteed reentrant by compiling with the RENT option. This means that the compiler for the language concerned will generate fully reentrant (and therefore) threadsafe code. Pre-LE language compilers cannot be guaranteed to be reentrant, and so programs compiled using a pre-LE compiler cannot be made threadsafe.

Assembler programs are probably the most common place where non threadsafe code can be generated. For example, this can be achieved by storing variable data in a DC in a CSECT. In doing this the program is altering itself to store variable data and is therefore creating a shared resource that could be updated by more than one transaction running the same program at the same time.

Test for non reentrant native code

The simplest way to check that the native code in between EXEC CICS commands is reentrant is to link-edit the program with the RENT option. CICS then places any program linked with the RENT option into a read-only DSA (the RDSA for RMODE(24) programs and the ERDSA for RMODE(ANY) programs). By default, the storage for these DSAs is allocated from read-only, key-0, protected storage. This protects any modules loaded into a read-only DSA, from being modified, by all programs except those running in key-0 or in supervisor state. So, as long as CICS is *not* initialized with RENTPGM=NOPROTECT, any attempt by a program to modify itself will result in an ASRA abend. We would suggest that this be done in a pre production environment where the application can be tested thoroughly to identify any possible programs that are not reentrant.

Check for shared resources

The next stage in identifying issues that can make an application non threadsafe is to analyze the use of shared resources by your applications. Shared resources are those storage areas that result from use of the following:

- The CWA
- Shared getmains
- Global work areas for global user exits
- Loaded assembler data tables

Using these resources does not automatically imply that a program is not threadsafe. The application must be analyzed to determine how these areas are subsequently used by the application as a whole. In particular, if the shared area is updated at any point then *all* accesses to the shared area will need to be serialized.

DFHEISUP

CICS provides a utility (DFHEISUP) that can be used to scan load modules in order to identify the CICS commands associated with these shared areas. Its use is described fully in 4.2, “Load module scanner: DFHEISUP” on page 61.

The load module scanner should be used against the application load modules with the supplied filter table DFHEIDTH. This will identify all the programs that contain any of the above commands.

In addition to DFHEISUP, the CICS Interdependency Analyzer (CICS IA) provides the ability to scan for these commands both statically and at runtime. This is discussed in 5.2.4, "How to prepare CICS IA for threadsafe analysis" on page 83.

> **Important:** If any of these commands are identified as being used in any one application program then a more detailed analysis of the whole application *must* be performed to identify how and when the addresses returned by these commands are used to access the underlying data.

It is possible that the address returned by one of these commands can be passed to another program that does none of the above commands itself but will still modify the data at the address passed. Hence, just because the scanner utility does not report any of these commands as being present in a particular load module, this does not necessarily mean a module is threadsafe.

If you can determine that the shared resource is *never* updated by any of your application programs (for example, it could have been initialized by a PLT startup program and then only ever read by the rest of the application), then no further action needs to be taken for that shared resource.

How to serialize

Once analysis of your application has determined that the shared data area is updated, you will need to decide how to serialize access to the data using techniques such as:

- Compare and swap
- Enqueue/dequeue
- Accessing the shared storage only from quasi-reentrant programs

6.1.2 Example showing the use of shared resources

The following example application will be used to demonstrate how use of shared resources can compromise data integrity if resources are not serialized.

Starter program CWAPROG

The example application consists of one starter program that initializes some shared storage, in this case the CWA, and then passes on the address of the CWA to five transactions. Each instance of these five transaction uses this address to access and update the data in the shared area. The five transactions are started 25 times each, and each transaction will start the same program: TXNPROG.

CWAPROG is listed in Example 6-1 on page 143.

Example 6-1 CWAPROG

```
 IDENTIFICATION DIVISION.
 PROGRAM-ID. CWAPROG.
 ENVIRONMENT DIVISION.
 DATA DIVISION.
 WORKING-STORAGE SECTION.

 01  ws-queue                      pic x(08)
      value 'OUTPUTQ'.
 01  ws-ptr                        pointer.

 LINKAGE SECTION.
 01  common-work-area.
     03  cwa-counter               pic s9(8) comp.

 PROCEDURE DIVISION.
*    Delete the output TSQ - don't worry if its not there
     EXEC CICS DELETEQ TS QUEUE(WS-QUEUE) NOHANDLE END-EXEC.

*    Access our shared storage area - this time the CWA
     EXEC CICS ADDRESS CWA(ADDRESS OF COMMON-WORK-AREA) END-EXEC.

*    Save address of our shared area so we can pass it on
     set ws-ptr to address of common-work-area.

*    Initialize the counter in our shared area
     move zero to cwa-counter.

*
*    Start our 5 transactions 25 times passing the address of the
*      CWA (which contains our counter) so that each transaction
*      can access it
*
     Perform 25 times
         EXEC CICS START TRANSID('TXN1') FROM(WS-PTR) END-EXEC

         EXEC CICS START TRANSID('TXN2') FROM(WS-PTR) END-EXEC

         EXEC CICS START TRANSID('TXN3') FROM(WS-PTR) END-EXEC

         EXEC CICS START TRANSID('TXN4') FROM(WS-PTR) END-EXEC

         EXEC CICS START TRANSID('TXN5') FROM(WS-PTR) END-EXEC
     End-Perform.

     EXEC CICS RETURN
END-EXEC.
```

Program TXNPROG

The program executed by each of the transactions, TXNPROG, does the following:

1. Retrieves the address of the shared storage passed to it
2. Makes an EXEC SQL call that causes a switch to an L8 TCB
3. Takes a copy of the counter value in the shared storage and increments it by one
4. Does some processing
5. Writes the new counter value back to the shared storage
6. Writes the result to a temporary storage queue

The program is shown in Example 6-2.

Example 6-2 TXNPROG

```
IDENTIFICATION DIVISION.
PROGRAM-ID. TXNPROG.
ENVIRONMENT DIVISION.
DATA DIVISION.
WORKING-STORAGE SECTION.

01 ws-enq-queue                    pic x(08) value ‘ENQUEUE’.
01 ws-enqueue-yes-no               pic x(03) value ‘NO’.
   88 enqueue-yes                            value ‘YES’.

01 ws-ptr                          pointer.
01 ws-counter2                     pic s9(8) comp.
01 ws-count                        pic s9(8) comp.
01 ws-queue                        pic x(08)
       VALUE ‘OUTPUTQ’.
01 WS-MSG.
   03 WS-TXN                       pic x(05).
   03 filler                       pic x(17)
       value “Counter value :- “.
   03 ws-counter                   pic 9(8).

01 ws-cwa-ptr                      usage is pointer.

    EXEC SQL
          DECLARE DSN8710.EMP TABLE (
          EMPNO                        CHAR(6),
          FIRSTNME                     CHAR(12),
          MIDINIT                      CHAR(1),
          LASTNAME                     CHAR(15),
          WORKDEPT                     CHAR(3),
```

```
          PHONENO                     CHAR(4),
          HIREDATE                    DATE,
          JOB                         CHAR(8),
          EDLEVEL                     SMALLINT,
          SEX                         CHAR(1),
          BIRTHDATE                   DATE,
          SALARY                      DECIMAL,
          BONUS                       DECIMAL,
          COMM                        DECIMAL )
    END-EXEC.

    EXEC SQL INCLUDE SQLCA END-EXEC.

LINKAGE SECTION.
01  SHARED-AREA.
    03  SHARED-COUNTER                  PIC S9(8) COMP.

PROCEDURE DIVISION.
    EXEC CICS READQ TS
        QUEUE(WS-ENQ-QUEUE)
        ITEM(1)
        INTO(WS-ENQUEUE-YES-NO)
        NOHANDLE
     END-EXEC.
     MOVE EIBTRNID TO WS-TXN.

*   get the address of the shared area which has been passed
    EXEC CICS RETRIEVE INTO(WS-PTR) END-EXEC.

*   map our linkage section to the address of the shared area
    Set address of shared-area to ws-ptr.
*
*   Make DB2 Call which will transfer to the L8
*
    EXEC SQL
       SELECT count(*)
       INTO :ws-count FROM DSN8710.EMP
              WHERE EMPNO = "000990"
    END-EXEC.

    if enqueue-yes
*       enqueue before we change the shared storage
        EXEC CICS
             ENQ RESOURCE(shared-area)
        END-EXEC
    end-if.

*   read the value in shared storage.
    move shared-counter to ws-counter.
```

```
*    ... and change its value
     Add 1 to ws-counter.

*    ** Do some important processing **
     move ws-counter to ws-counter2.
     Perform 100000 Times
       add 2 to ws-counter2
       subtract 1 from ws-counter2
     End-Perform.
*    **********************************

*    update the shared storage with our new value
     Move ws-counter to shared-counter.

     if enqueue-yes
*        remove the enqueue now we have finished updating
*          the shared storage
         EXEC CICS
             DEQ RESOURCE(shared-area)
         END-EXEC
     end-if.

*    output the results ......
     EXEC CICS
       WRITEQ TS MAIN QUEUE(WS-QUEUE) FROM(WS-MSG)
     END-EXEC.

     EXEC CICS RETURN END-EXEC.
```

Results when run as quasi-reentrant

When the program TXNPROG is defined as quasi-reentrant each occurrence of the transaction will be serialized by CICS because only one occurrence of the program can be running at any one time, always on the QR TCB. So, the results will be as expected: each program will process a unique counter, as demonstrated by the output in Figure 6-1.

```
 CEBR  TSQ OUTPUTQ         SYSID PJA6 REC     1 OF    25    COL     1 OF    30
 ENTER COMMAND ===>
      **************************  TOP OF QUEUE
00001 TXN1 Counter value :- 00000001
00002 TXN2 Counter value :- 00000002
00003 TXN1 Counter value :- 00000003
00004 TXN5 Counter value :- 00000004
00005 TXN4 Counter value :- 00000005
00006 TXN3 Counter value :- 00000006
00007 TXN2 Counter value :- 00000007
00008 TXN3 Counter value :- 00000008
00009 TXN4 Counter value :- 00000009
00010 TXN5 Counter value :- 00000010
00011 TXN1 Counter value :- 00000011
00012 TXN2 Counter value :- 00000012
00013 TXN3 Counter value :- 00000013
00014 TXN4 Counter value :- 00000014
00015 TXN5 Counter value :- 00000015
00016 TXN1 Counter value :- 00000016

PF1 : HELP                PF2 : SWITCH HEX/CHAR     PF3 : TERMINATE BROWSE
PF4 : VIEW TOP            PF5 : VIEW BOTTOM         PF6 : REPEAT LAST FIND
PF7 : SCROLL BACK HALF    PF8 : SCROLL FORWARD HALF PF9 : UNDEFINED
PF10: SCROLL BACK FULL    PF11: SCROLL FORWARD FULL PF12: UNDEFINED
```

Figure 6-1 Results when run as quasi-reentrant

Results when defined as threadsafe - without enqueue

If we now take the definition of program TXNPROG and change it to be threadsafe *without* taking any action to ensure the update of the CWA is serialized, the output will look very different. Each instance of TXNPROG will remain on an L8 TCB after completing the EXEC SQL call. The result of this will be that we will have several instances of TXNPROG running concurrently on multiple TCBs. Each instance of the program cannot then rely on the value of the counter in the CWA because access to it is not serialized. So, we end up with a scenario that looks as follows:

- TXN1 reads counter (0).
- TXN1 increments counter (1).
- TXN2 reads counter (0).
- TXN1 writes incremented value (1).
- TXN2 writes incremented value (1).
- TXN3 reads counter (1).
- And so on.

The output written to the temporary storage queue will be as shown in Figure 6-2.

```
CEBR  TSQ OUTPUTQ         SYSID PJA6 REC     1 OF    25    COL     1 OF    30
 ENTER COMMAND ===>
      **************************  TOP OF QUEUE  ***************************
00001 TXN4 Counter value :- 00000001
00002 TXN1 Counter value :- 00000001
00003 TXN3 Counter value :- 00000001
00004 TXN2 Counter value :- 00000002
00005 TXN5 Counter value :- 00000002
00006 TXN1 Counter value :- 00000002
00007 TXN2 Counter value :- 00000003
00008 TXN3 Counter value :- 00000003
00009 TXN5 Counter value :- 00000004
00010 TXN1 Counter value :- 00000004
00011 TXN4 Counter value :- 00000004
00012 TXN2 Counter value :- 00000005
00013 TXN3 Counter value :- 00000005
00014 TXN4 Counter value :- 00000005
00015 TXN1 Counter value :- 00000006
00016 TXN5 Counter value :- 00000006

PF1 : HELP               PF2 : SWITCH HEX/CHAR     PF3 : TERMINATE BROWSE
PF4 : VIEW TOP           PF5 : VIEW BOTTOM         PF6 : REPEAT LAST FIND
PF7 : SCROLL BACK HALF    PF8 : SCROLL FORWARD HALF PF9 : UNDEFINED
PF10: SCROLL BACK FULL    PF11: SCROLL FORWARD FULL PF12: UNDEFINED
```

Figure 6-2 Results when run as threadsafe without enqueues

In Figure 6-2 we can see that our data has been compromised because each transaction is attempting to concurrently update the counter value.

The solution to this problem is to add an ENQ and DEQ command around the code that reads and then updates the counter value. In our example we have enqueued upon the address of the shared area, which is currently pointed to by linkage section item *shared-area*. Adding the enqueue and dequeue commands will cause the results to return to those seen when the program was defined as quasi-reentrant, as shown in Figure 6-1 on page 147.

The example program uses an IF statement to enclose the enqueue and dequeue commands. This was done so that the ENQUEUE/DEQUEUE can be switched on and off easily without recompiling the program. See Figure 6-3.

```
 if enqueue-yes
* enqueue before we change the shared storage
    EXEC CICS
       ENQ RESOURCE(shared-area)
    END-EXEC
 end-if.
```

Figure 6-3 Enqueue statement

To switch the enqueue on dynamically all that needs to be done is to write the word YES to a temporary storage queue called ENQUEUE.

Example summary

The previous example shows how a program uses the CWA to store a counter value. Under a quasi-reentrant scenario access to this counter value will be serialized by CICS and the counter value returned will always be unique and the next in the series. However, under a threadsafe scenario the serialization must be done by the application. Otherwise, with concurrent tasks running on separate TCBs the counter returned can no longer be relied upon to be unique.

It is important to note that the enqueue and dequeue commands should only enclose the minimum number of program statements that are necessary to ensure that the resource is not updated before this program is ready. In our simple example we could make the enqueue-to-dequeue path shorter by updating the shared resource and dequeuing before we do the *important processing* section of code.

In the example we use the CWA as our shared resource. This could easily be changed to utilize any of the other shared resources listed in “Check for shared resources” on page 141 by replacing the ADDRESS CWA command in Example 6-1 on page 143 with one of these other commands.

> **Important:** If there are several programs (as in our example) that access the shared resource, they must *all* use the *same* serialization technique to serialize access to the shared resource. In our example, if there was another program accessing our CWA area, then it must also ENQUEUE and DEQUEUE on the same resource (in this case the address of the CWA).

Assembler data tables

A technique that has often been used in the past is to load a data-only assembler program containing only DC entries in a CSECT. If the load is done with the HOLD option, the empty assembler program will remain in storage and will therefore become a shared resource that can be updated concurrently from several programs. For example, the following program could be assembled and link edited into a library on the DFHRPL concatenation (Example 6-3).

Example 6-3 Assembler data table

```
TABLE    CSECT
FILLER1  DC    CL16'COUNTER VALUE >>'
COUNTER  DC    F'99'
FILLER2  DC    CL16'<< COUNTER VALUE'
         END
```

It could then be loaded into storage by any program, with an EXEC CICS LOAD command, which could map the data in the table onto a linkage section structure such as in Example 6-4.

Example 6-4 Linkage section

```
LINKAGE SECTION.
01  TABLE-AREA.
    03  filler                  pic x(16).
    03  LS-COUNTER              PIC S9(8) COMP.
    03  filler                  pic x(16).
```

The address of this area could be passed on and used in the same way the address of the CWA is used in the previous example. This technique would not work if the table is linked with the RENT option and CICS is started with RENTPGM=PROTECT.

6.1.3 Ensure only threadsafe CICS commands are used

Once a program has been switched over to an open TCB it is very important to minimize the number of times CICS switches back to the QR TCB, therefore allowing applications to reap the benefits of running multiple tasks concurrently across different TCBs.

The main inhibitor to staying on an open TCB are those CICS API and SPI commands that are not threadsafe. When a CICS API or SPI command command is executed CICS will execute code that could update any number of CICS control blocks (for example, the CSA). If CICS had not been changed to serialize access to these control blocks and multiple tasks are allowed to run that cause these control blocks to be updated concurrently from several tasks, then the integrity of CICS itself could be compromised and unpredictable results could occur.

To ensure that CICS is not compromised, CICS will automatically switch back to the QR TCB when its is about to execute any API or SPI command that it knows to be non threadsafe. The current list of commands that *are* threadsafe is listed in the appendixes of the *CICS Application Programming Reference*, and the *CICS System Programming Reference*.

Note: If a command is *not* listed in either of these appendixes it is *not* threadsafe and it *will* cause a switch to the QR TCB.

These commands can be identified, again, using the load module scanner, DFHEISUP with filter table DFHEIDNT, or CICS IA.

Note: Using a CICS command that is non threadsafe does not prevent the program from being defined as threadsafe and does not compromise data integrity.

Including these commands will, however, cause CICS to switch back to the QR TCB each time a non threadsafe command is encountered while on an open TCB. Therefore the use of non threadsafe commands has a *performance* penalty, not an *integrity* penalty.

The worst case scenario, in terms of performance, for a DB2 application program would be one where there are many EXEC SQL calls interspersed with non threadsafe EXEC CICS commands, as in Example 6-5.

Example 6-5 Non threadsafe commands causing TCB switches

```
EXEC CICS
EXEC SQL
EXEC CICS <non threadsafe>
EXEC SQL
EXEC CICS <threadsafe>
EXEC CICS <non threadsafe>
EXEC SQL
EXEC CICS <non threadsafe>
EXEC SQL
EXEC CICS <non threadsafe
EXEC SQL

RETURN
```

In this example we would see a TCB switch for each DB2 request and then a switchback to the QR TCB when a non threadsafe EXEC CICS command follows an EXEC SQL call. This clearly would not provide the optimal performance threadsafe applications can deliver due to the number of non threadsafe CICS commands and their distribution throughout the program.

This example could be restructured in such a way that most, or all, of the non threadsafe commands could either be removed or moved to the start of the program before any DB2 request is made. This would remove the excessive number of mode switches and will deliver the performance benefits we are looking for. See Example 6-6.

This kind of simple reorganization is obviously not going to be possible for every program. Once the commands have been identified as being present in the program only then can you assess what, if any, changes can be made.

Example 6-6 Non threadsafe commands moved or deleted

```
EXEC CICS
EXEC CICS <non threadsafe>
EXEC CICS <non threadsafe>
EXEC CICS <non threadsafe>

EXEC SQL
EXEC SQL
EXEC CICS <threadsafe>
EXEC SQL
EXEC SQL

EXEC SQL

RETURN
```

6.2 Change program definitions

Once the applications have been changed or verified to be threadsafe then the final action that is needed to make the application stay on the open TCB is to change the definition of all the programs concerned to define them as threadsafe.

This will be done either by changing the RDO definition of the program, or by modifying your autoinstall exit to install the program as threadsafe, or by using the LE environment variable CICSVAR, which is discussed in 6.2.2, “CICS environment variable CICSVAR” on page 154.

6.2.1 RDO definition

Figure 6-4 shows the RDO definition.

```
OBJECT CHARACTERISTICS                                    CICS RELEASE = 0640
   CEDA  View PROGram( DB2MANY  )
    PROGram        : DB2MANY
    Group          : THDSAFE
    DEscription    :
    Language       :                   CObol | Assembler | Le370 | C | Pli
    RELoad         : No                No | Yes
    RESident       : No                No | Yes
    USAge          : Normal            Normal | Transient
    USElpacopy     : No                No | Yes
    Status         : Enabled           Enabled | Disabled
    RSl            : 00                0-24 | Public
    CEdf           : Yes               Yes | No
    DAtalocation   : Any               Below | Any
    EXECKey        : User              User | Cics
    COncurrency    : Threadsafe        Quasirent | Threadsafe
    Api            : Cicsapi           Cicsapi | Openapi
   REMOTE ATTRIBUTES
    DYnamic        : No                No | Yes
 +  REMOTESystem   :

                                                      SYSID=PJA7 APPLID=SCSCPJA7

 PF 1 HELP 2 COM 3 END            6 CRSR 7 SBH 8 SFH 9 MSG 10 SB 11 SF 12 CNCL
```

Figure 6-4 RDO program definition using CEDA

6.2.2 CICS environment variable CICSVAR

Prior to CICS Transaction Server Version 3.1, changing the definitions of programs that were autoinstalled, but had now been made threadsafe, required the introduction of logic into the autoinstall program. This was so it could know which programs were to be auto installed as threadsafe and which were not.

CICS Transaction Server Version 3.1 introduced an environment variable called CICSVAR to allow the CONCURRENCY and API program attributes to be closely associated with the application program by using the ENVAR runtime option. While it may be used in a CEEDOPT CSECT to set an installation default, it is most useful when set in a CEEUOPT CSECT link-edited with an individual program, or set via a #pragma statement in the source of a C or C++ program, or set via a PLIXOPT statement in a PL/I program.

For example, when a program has been coded to threadsafe standards it can be defined as such without having to change a PROGRAM resource definition, or adhere to an installation-defined naming standard to allow a program autoinstall exit to install it with the correct attributes. CICSVAR can be used for the Language Environment conforming assembler, for PLI, for COBOL, and for C and C++ programs (both those compiled with the XPLINK option and those compiled without it) that have been compiled using a Language Environment conforming compiler. CICSVAR cannot be used for assembler programs that are not Language Environment conforming or for Java programs.

Note: Use of CICSVAR overrides the settings on a PROGRAM resource definition installed via standard RDO interfaces or via program autoinstall.

Until a program is executed the first time, an INQUIRE PROGRAM command shows the keyword settings from the program definition. Once the application has been run once, an INQUIRE PROGRAM command shows the settings with any CICSVAR overrides applied.

CICSVAR can take one of three values: QUASIRENT, THREADSAFE, or OPENAPI.

6.2.3 CICSVAR values

The following values for CICSVAR will result in the values shown for CONCURRENCY and API:

CICSVAR=QUASIRENT Results in a program with attributes QUASIRENT and CICSAPI

CICSVAR=THREADSAFE Results in a program with attributes THREADSAFE and CICSAPI

CICSVAR=OPENAPI Results in a program with attributes THREADSAFE and OPENAPI

6.2.4 How to code ENVAR

The following sections show how to code the ENVAR runtime option for different programming environments.

ENVAR CSECT example

Following is an example of ENVAR coded in a CEEUOPT CSECT:

```
CEEUOPT CSECT
CEEUOPT AMODE ANY
CEEUOPT RMODE ANY
        CEEXOPT ENVAR=('CICSVAR=THREADSAFE')
        END
```

This can be assembled and link-edited into a load module and then the CEEUOPT load module link-edited together with any language program supported by Language Environment, as explained above.

ENVAR pragma runopts example

For C and C++ programs, add the following statement at the start of the program source before any other C statements:

```
#pragma runopts(ENVAR(CICSVAR=THREADSAFE))
```

ENVAR PLIXOPT example

For PL/I programs add the following statement after the PL/I MAIN procedure statement:

```
DCL PLIXOPT CHAR(25) VAR STATIC EXTERNAL INIT('ENVAR(CICSVAR=THREADSAFE)');
```

6.2.5 An example file control application

CICS Transaction Server Version 3.2, released in June 2007, expanded the number of API commands that have been made threadsafe to include the file control commands. This would allow applications which currently are not good candidates to be made threadsafe to be converted and enabled as threadsafe.

The following is a simple example of a program that browses through a file. We will demonstrate that a file control API call will now remain on an OPEN TCB, whereas in previous releases of CICS it would have switched back the QR TCB to execute the command.

The program shown in Figure 6-5 browses through the entire FILEA file supplied by CICS.

```
Identification Division.
Program-ID. KSDSPR01.
Environment Division.
Data Division.
Working-storage Section.

01  ws-file                  pic x(8) value 'FILEA'.

01  ws-record                pic x(80) value low-values.
01  ws-rid                   pic x(06) value low-values.
01  ws-browse-rid            pic x(06) value low-values.

01  ws-resp                  pic s9(8) comp value zero.
01  ws-resp2                 pic s9(8) comp value zero.


Procedure Division.

    exec cics
      startbr file(ws-file)
      ridfld(ws-browse-rid)
      resp(ws-resp)
      resp2(ws-resp2)
    end-exec.

    perform until ws-resp not = dfhresp(normal)
       initialize ws-record
       exec cics
         readnext file(ws-file)
             into(ws-record)
             ridfld(ws-rid)
             resp(ws-resp)
             resp2(ws-resp2)
       end-exec
    end-perform.

    exec cics
       endbr file(ws-file)
    end-exec.

    exec cics return end-exec.
```

Figure 6-5 Example File Control Program

This program was defined as OPENAPI. Therefore, as soon as it begins CICS switches the task to an open TCB, where it will remain until the end of the task or until a non threadsafe CICS command is encountered. In this case an L8 TCB (L8005) is used. This can be seen in the trace snippet shown in Figure 6-6. The trace snippet shows trace entries for *one* of the READNEXT commands.

```
00061 L8005 AP 00E1 EIP   ENTRY READNEXT                           0004,266A9900 ..r.,0800060E ....          =000898=
00061 L8005 AP E110 EISR  ENTRY TRACE_ENTRY     266A99F0                                                     =000899=
00061 L8005 AP E160 EXEC  ENTRY READNEXT     'FILEA   ' AT X'266AB040',AT X'266AB048',80 AT X'266AAD18',AT X'266AB
                                                                                                             =000900=
00061 L8005 AP E111 EISR  EXIT  TRACE_ENTRY/OK                                                               =000901=
00061 L8005 AP 04F0 EIFC  ENTRY PROCESS_EXEC_ARGUMENTS 266A99F0,0005C308                                     =000902=
00061 L8005 AP 04E0 FCFR  ENTRY READ_NEXT_INTO  FILEA,266AB048,50,00000000,266AB098,0,FCT_VALUE,KEY,NO,NO     =000903=
00061 L8005 AP 04B0 FCVS  ENTRY READ_NEXT_INTO  FILEA,266AB048,50,00000000,26F393B0,266AB098,26DA2100,0,FCT_VALUE,KEY
                                                                                                             =000904=
00061 L8005 AP 0492 FCVR  EVENT ISSUE_VSAM_RPL_REQUEST GET,SEQ ASY,000000000000                              =000905=
00061 L8005 AP 0493 FCVR  EVENT RETURN_FROM_VSAM   0000,F0F0F0F1F0F0                                         =000906=
00061 L8005 AP 04B1 FCVS  EXIT  READ_NEXT_INTO/OK  50,50,6,00000000,,LENGTH_OK,NO,NO                         =000907=
00061 L8005 AP 04E1 FCFR  EXIT  READ_NEXT_INTO/OK  50,50,6,00000000,,LENGTH_OK,NO,NO                         =000908=
00061 L8005 AP 04E2 FCFR  EXIT  FRAB_FLAB_AND_FRTE                                                           =000909=
00061 L8005 AP 04F1 EIFC  EXIT  PROCESS_EXEC_ARGUMENTS/OK                                                    =000910=
00061 L8005 AP E110 EISR  ENTRY TRACE_EXIT         266A99F0                                                  =000911=
00061 L8005 AP E161 EXEC  EXIT  READNEXT     'FILEA ' AT X'266AB040',' 000100S. D. BORMAN    SURREY, ENGLAND  =000912=
00061 L8005 AP E111 EISR  EXIT  TRACE_EXIT/OK                                                                =000913=
00061 L8005 AP 00E1 EIP   EXIT  READNEXT    OK                         00F4,00000000 ....,0000060E ....      =000914=
```

Figure 6-6 File control trace snippetsh

7

System programmer tasks

This chapter describes the tasks and steps the CICS System Programmer will normally be responsible for with respect to implementing threadsafe applications.

7.1 The role of the system programmer

Here we discuss the role of the system programmer in making an application threadsafe. In essence, the system programmer does not make an application threadsafe, but prepares the environment and makes it threadsafe so it can efficiently run the customer applications. Additionally, the system programmer may coordinate and guide the conversion of the applications.

To summarize, the system programmer might perform the following actions:

- Analyze the CICS regions
- Provide a threadsafe CICS operating environment
- Coordinate and drive individual application conversions
- Monitor and tune the CICS regions to ensure that they are making efficient use of the open TCBs

7.2 Understanding threadsafe operation

Before we start analyzing and preparing your CICS regions, we go over a few of the concepts to help understand why some of the conversions are necessary.

7.2.1 Threadsafe performance issues

Simply stated, the way to gain the performance benefit of threadsafe applications is to eliminate TCB switches between the QR and open TCBs.

Under CICS Transaction Server Version 2, your program commenced execution on the QR TCB, and when a DB2 call was encountered, your program was swapped over to run on an open TCB. If your program was defined to CICS as CONCURRENCY(THREADSAFE), it would then continue to execute all further instructions on the open TCB until program termination or until a non threadsafe command or exit was encountered.

This behavior is also true, by default, under CICS Transaction Server Version 3. The API attribute of a program definition was introduced in CICS TS Version 3.1 and defaults to a value of CICSAPI. CICSAPI means that the program exploits the traditional CICS programming interfaces. CICSAPI mirrors the behavior of a threadsafe application in CICS TS Version 2. This means that CICS Transaction Server Version 3 CICSAPI applications use open TCBs in the same way as described above for CICS Transaction Server Version 2.

Note: Under CICS Transaction Server Version 3, a threadsafe program may be defined as API(OPENAPI), in which case it will be switched to run under an L8 or L9 TCB *during its initialization*. The open TCB mode that it runs under depends upon the program's EXECKEY parameter. An OPENAPI program will continue to execute its instructions under its L8 or L9 TCB *until program termination*. Any calls to exits or non threadsafe commands requiring TCB switches will be handled by CICS, and upon completion the OPENAPI program will receive control back under its open TCB once more. OPENAPI programs therefore have more extensive threadsafe zones than CICSAPI programs.

Originally, the only TRUE to exploit OTE was the CICS DB2 TRUE. When reviewing the use of L8 TCBs and TCB switching, it was therefore reasonable to discuss this just in terms of CICS DB2 applications. Since then, CICS Transaction Server Version 3.2 has provided an OTE-enabled TRUE for WMQ. In addition, the z/OS Communications Server IP CICS Sockets has also been written to exploit OTE if enabled to do so. As well as these enhancements, CICS Transaction Server Version 3 provides the ability to define applications as OPENAPI programs, to execute under their own L8 or L9 TCBs.

A major enhancement to threadsafe support in CICS Transaction Server Version 3.2 is the change to make the CICS file control API threadsafe for applications. This means that the path for EXEC CICS file control commands should also be reviewed to ensure that this does not result in unwanted TCB switching activity.

The use of open TCBs within CICS has grown. Having said that, the objectives of a system programmer role in terms of preparing CICS for OTE can still be described in terms of calling DB2, since the same basic principles of serialization and data integrity apply, regardless of the reason why open TCBs are being used.

An important objective in reviewing your application or exit programs is to ensure that if a program is executing on an L8 TCB, it stays there until all DB2, WMQ, or IP CICS sockets work has completed. Another objective is to ensure that programs defined as OPENAPI in CICS Transaction Server Version 3 avoid TCB switching if possible. Minimizing TCB switches is a key performance goal for threadsafe implementation.

Let us consider the general case for threadsafe code logic, where a threadsafe CICS application program issues calls to an OTE-enabled TRUE such as DB2 or WMQ. For simplicity, we will assume it is defined as CICSAPI in the CICS Transaction Server Version 3 environment. This can appear as shown in Figure 7-1. Once your program starts to execute on the L8 TCB you are in the threadsafe zone and you need to ensure that you do not get moved off the L8 TCB by executing a non threadsafe command or exit.

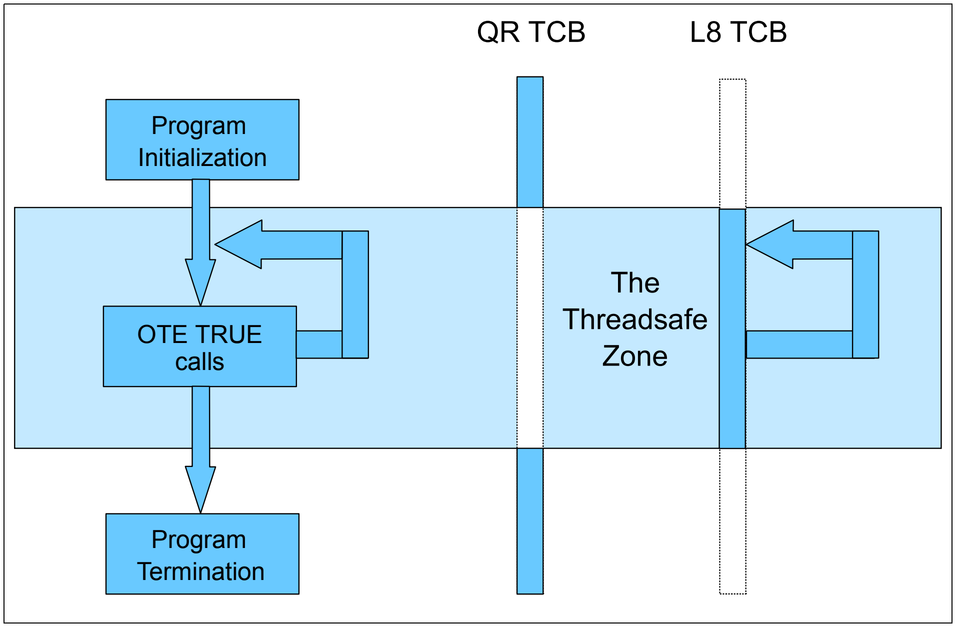

Figure 7-1 CICSAPI program running on an L8 TCB in the threadsafe zone

No matter how your CICSAPI program is coded, it will always start on the QR TCB and finish up on the QR TCB. Therefore, ideally you can place all your non threadsafe EXEC CICS commands at the beginning and end of your application program.

The goal of the system programmer must be to keep the application programs running in the threadsafe zone by not generating TCB switches to the QR TCB in system exits such as GLUEs or URMs, DB2 dynamic plan exits, or the CICS-WMQ API crossing exit CSQCAPX.

Now let us compare this with the case in which an OPENAPI CICS Transaction Server Version 3.2 application program is defined with EXECKEY(USER). (For OPENAPI programs the key of the TCB must match the EXECKEY setting. For an explanation of execution keys in an OPENAPI environment see 9.6, “Additional considerations for OPENAPI programs” on page 270.)

The program issues various threadsafe and non threadsafe EXEC CICS commands, along with a call to WMQ (for example, an MQGET) and an EXEC SQL call to DB2. Note that this combination is not recommended, because it results in additional TCB switching between L9 and L8 TCBs. However, for this very reason it is important to visualize this type of scenario, so we show it graphically in Figure 7-2.

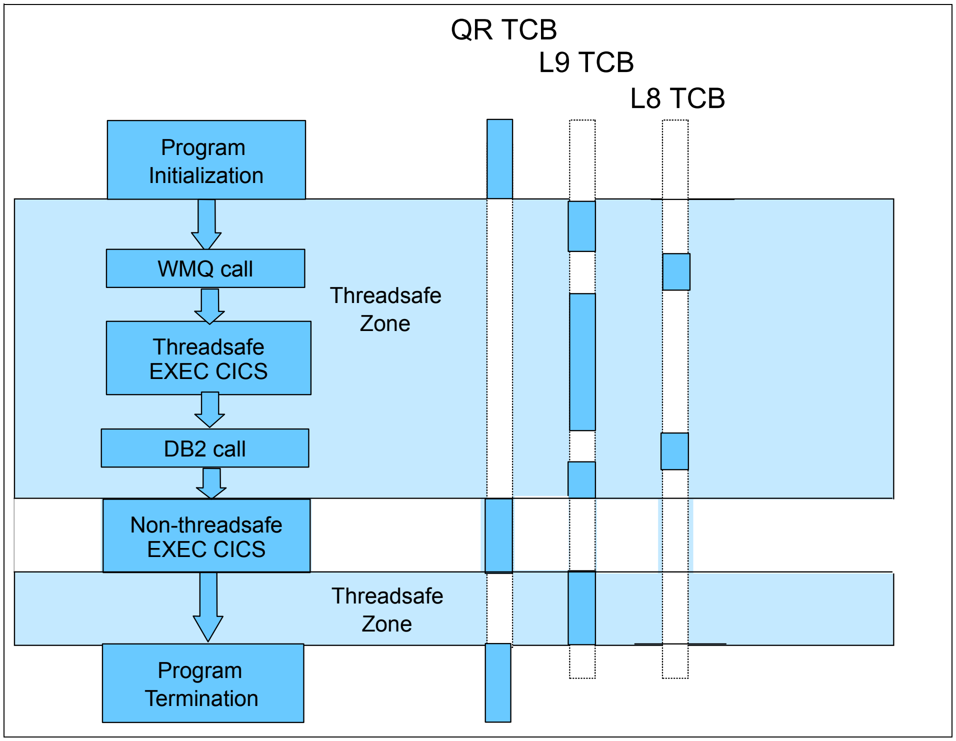

Figure 7-2 OPENAPI user key program running on QR, L9 and L8 TCBs

Here we see that an OPENAPI program enters the threadsafe zone during its program initialization. In fact, an OPENAPI application receives its initial control under an open TCB, so it has to be threadsafe by definition. OPENAPI programs always receive control under their open TCB, both when they start to run and when they receive control back after an EXEC CICS command or a call to a TRUE. The application logic itself has to execute under the open TCB. The key of this open TCB depends upon the program's EXECKEY attribute. As we have chosen to show a user key program, the open TCB selected by CICS is from the pool of L9 TCBs.

In this example, the application runs under this TCB until it issues a call to WMQ. Since WMQ calls run under an L8 TCB in CICS Transaction Server Version 3.2, CICS switches TCBs for the duration of the request. Upon completion, the application receives control back on its L9 TCB. Here we demonstrate what can happen if the application then issues threadsafe EXEC CICS commands. These have no TCB affinity, and so can be processed under the program's L9 TCB. The application then issues an EXEC SQL call to DB2. As before, the flow of control moves from the L9 to the L8 TCB for the duration of the call to this other OTE-enabled TRUE. Once again, the TCBs are then switched back from L8 to L9 at the end of the call. The application then issues a non threadsafe EXEC CICS command. This must be processed under the QR TCB so CICS switches from the L9 to the QR TCB for the duration of the command. Once again, it switches back to the original L9 TCB when the command completes. The application then terminates, and eventually the L9 TCB returns control to the QR TCB during program termination.

For clarity, this example does not show any additional TCB switches required during any syncpoint processing (for example, at end of task processing if there are no further programs in the task).

7.2.2 Threadsafe data integrity issues

The second type of threadsafe issue you can encounter is data integrity exposures. Once your programs are now enabled to run concurrently on multiple open TCBs you expose your shared resources to update conflicts due to the multiple concurrent program instances running on parallel open TCBs.

> **Note:** Shared resources in this context refers to application shared resources (for example, EXEC CICS GETMAIN SHARED storage), not resources managed by CICS.

In general just removing non threadsafe commands and changing the CICS definition to threadsafe is only half the conversion process. You then must ensure that any shared resource is serialized to prevent data corruption.

To correct this problem you may suggest that application programmers make coding modifications to their programs. Figure 7-3 emphasizes the fact that once you leave the serialized zone and enter the threadsafe zone, you are now in an execution zone where CICS does not provide you with single threaded program execution. All shared resources are now relying on the programmer to code the logic into the program to ensure that multiple instances of the program executing concurrently do not corrupt the shared data. Again, for this example, a CICSAPI program environment with an L8 TCB is shown.

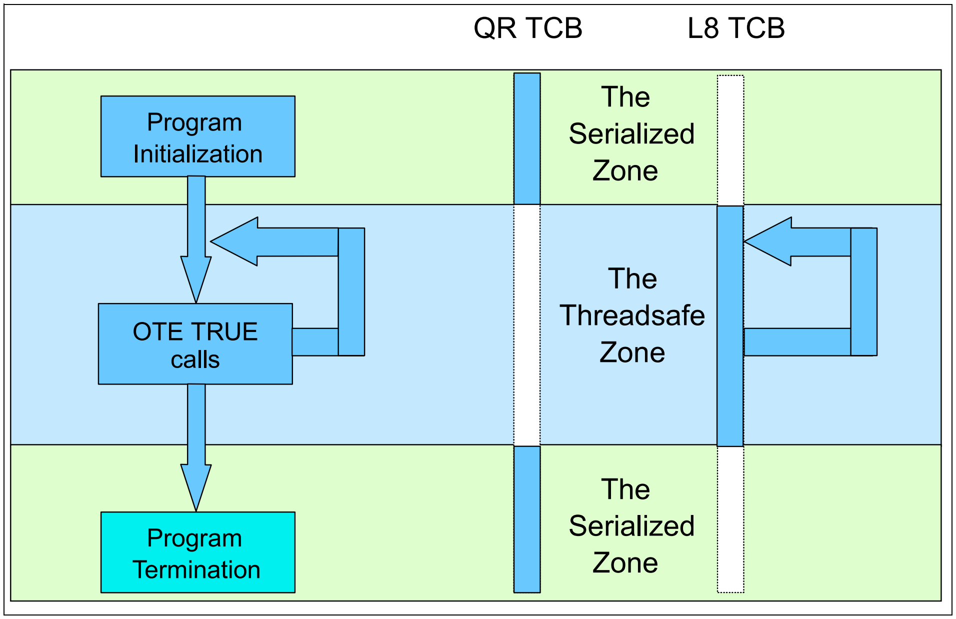

Figure 7-3 Shared data in threadsafe zone must be serialized by your own code logic

Figure 7-4 shows how a non threadsafe program would work. Since all programs execute on the QR TCB, a shared resource is always updated in a serialized fashion forced by the single QR TCB. All secondary instances of your program are waiting for their chance to run on the QR TCB.

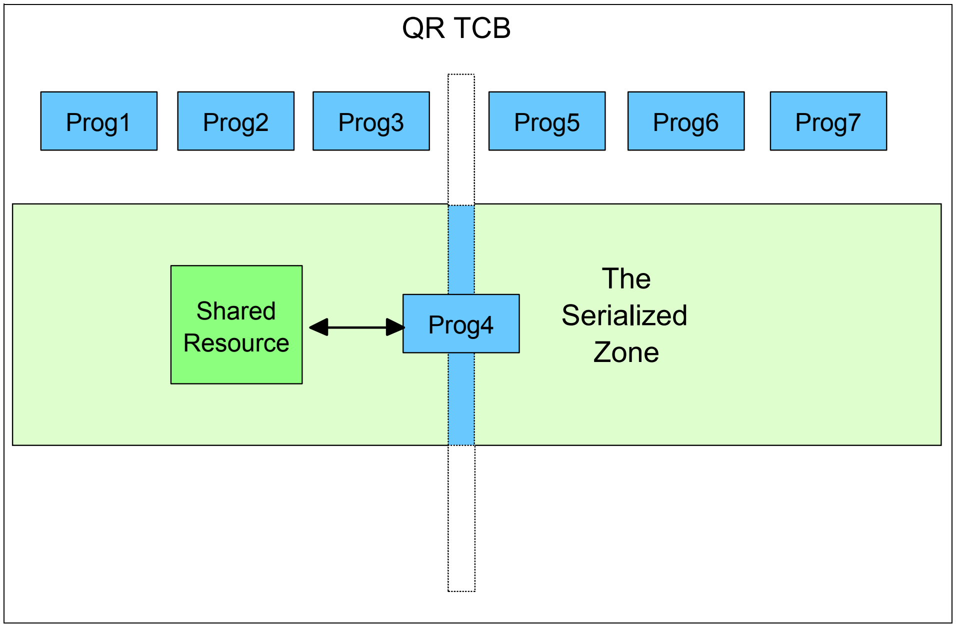

Figure 7-4 Single threaded serialized resource on the QR TCB

Figure 7-5 shows a threadsafe environment where concurrent instances of your CICSAPI program are all running at the same time on their own L8 TCB, all sharing the same common resource.

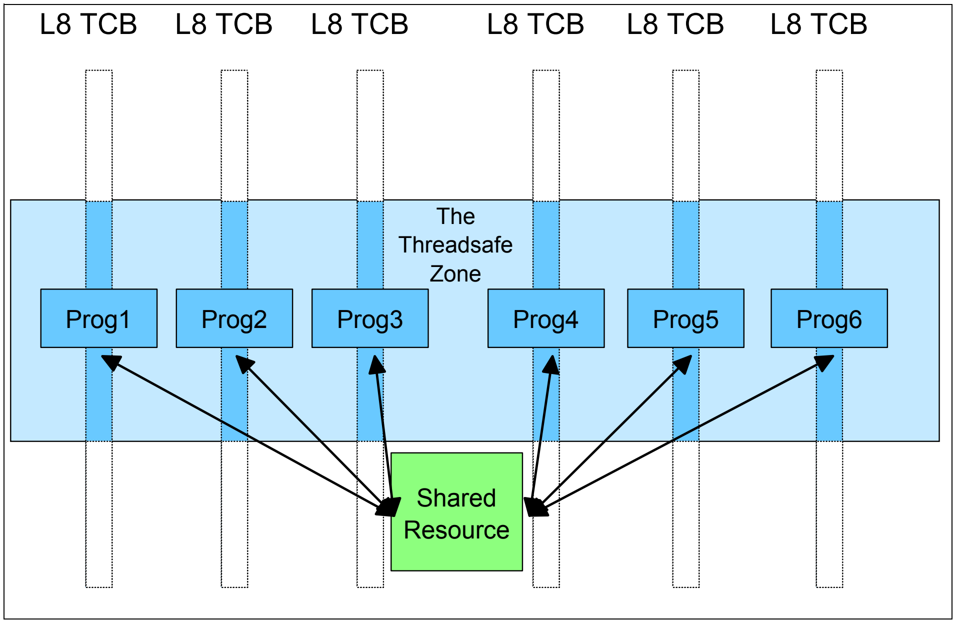

Figure 7-5 Multi-threaded shared resource on multiple concurrent L8 TCBs

The preceding charts help to show how a shared resource can become corrupted due to the nature of threadsafe programs running on open TCBs. Therefore just checking CICS Auxiliary Trace reports and defining a program as threadsafe does not guarantee that a program is threadsafe. Someone needs to review the source code carefully and verify that every shared resource is properly serialized. Such a detailed and thorough analysis is vital, since corruption of shared resources may well not become apparent until some considerable time after it occurs, *if it is noticed at all*. Not all such corruption would result in an abend, for example.

7.3 Analyze the CICS regions

Before converting and running your applications and system exits in threadsafe mode, it is wise to review the status of each individual CICS region to ensure that you have the proper pre-reqs in place. In the next few sections we discuss software and system parameters to be reviewed.

7.3.1 The DB2 version

With CICS Transaction Server Version 2.2, the CICS-DB2 attach code was re-architected to take advantage of the open transaction environment. To enable this change the DB2 product code required an enhancement to facilitate the management of the DB2 side connection control blocks.

From Version 6 onwards, DB2 Universal Database™ utilized the L8 open TCBs provided by the OTE environment. These give the potential for threadsafe applications to see performance improvements over the previous CICS-DB2 attach mechanism, with its pool of subtask TCBs. From this DB2 version onwards, your applications automatically utilize L8 TCBs for their calls to DB2.

> **Note:** For more information about the CICS-DB2 Interface see 2.2, “Open transaction environment - a brief history” on page 15.

7.3.2 The WMQ version

With CICS Transaction Server Version 3.2, the CICS-WMQ attach code was also re-architected to take advantage of the open transaction environment. The CICS-WMQ attach code provided with this release of CICS works with all of the currently supported releases of WMQ (that is, Version 5.3.1 and Version 6).

The CICS Transaction Server Version 3.2 CICS-WMQ attach code utilizes L8 open TCBs. As with the CICS-DB2 attach mechanism, these give the potential for performance improvements over the previous CICS-WMQ attachment mechanism with its proprietary subtask TCBs. From this CICS release onwards, your applications automatically utilize L8 TCBs for their calls to WMQ.

WMQ Version 5.3.1 APAR PK39200 and WMQ Version 6 APAR PK42616 have been shipped to provide support for the new CICS-MQ Adapter in CICS Transaction Server Version 3.2. When WMQ is connected with a CICS Transaction Server Version 3.2 system, the CICS shipped versions of the CICS-WMQ adapter, the CICS-WMQ trigger monitor and the CICS-WMQ bridge must be used. The WMQ APARs ensure that the WMQ shipped versions of the components are immediately terminated if executed when WMQ is connected with a CICS Transaction Server Version 3.2 system. In this circumstance message CSQC330E will be written to the CICS system log and to the CSMT transient data destination.

> **Note:** WMQ will continue to ship its original version of the CICS-WMQ attachment mechanism for use with CICS Transaction Server Version 3.1 and earlier.

7.3.3 Required CICS, DB2 and WMQ product maintenance

Before implementing threadsafe applications you should review and apply the product maintenance listed in Appendix A, “CICS, DB2, and WMQ maintenance” on page 329. Several APARs have been generated to improve performance and system stability. Therefore you should not attempt to run CICS Transaction Server without these APARs.

7.3.4 DB2 system parameters

The CTHREAD parameter, also listed as MAX USERS, is a DB2 subsystem tuning parameter that defines the maximum number of threads that can be concurrently allocated to a DB2 subsystem from any source except for DDF. Since CICS is just one possible front end to DB2, you need to ensure that the value you set for TCBLIMIT is well below the CTHREAD threshold. This parameter is relevant to all currently supported releases of CICS Transaction Server. However, if you have not checked this parameter before, you may want to check with your DB2 support team.

These parameters are set in the DB2 ZPARM.

7.3.5 WMQ system parameters

The CTHREAD parameter is a WMQ subsystem tuning parameter that specifies the total number of threads that can connect to a queue manager. This includes batch, TSO, IMS and CICS.

Prior to CICS Transaction Server Version 3.2, each CICS region took up nine of the threads specified here, plus one thread for each task initiator (CKTI). This is because the original CICS-WMQ attachment mechanism utilized a pool of eight subtask TCBs. In CICS Transaction Server Version 3.2, there is no such hard-coded number of TCBs used for the CICS-WMQ attachment; TCBs are allocated from the OTE pool of L8 TCBs, subject to availability and the limitation set by MAXOPENTCBS. Therefore, to account for the extra threads of work resulting from CICS Transaction Server Version 3.2, the CTHREAD parameter may need to be increased to a higher value.

These parameters are set by the WMQ SET SYSTEM command.

7.3.6 CICS system parameters

To effectively enable threadsafe applications you have to set or tune several CICS system parameters. The parameters described in this section are located in different areas within CICS, and some can be dynamically altered via CEMT commands.

We review each parameter, give you guidelines to start with, indicate where it is defined, and, if possible, show you how to override it.

SIT Parm: MXT

This is not directly a threadsafe-related parameter, but it comes into play when setting your MAXOPENTCBS and TCBLIMIT parameters. If you are running with transaction isolation turned on you should make MAXOPENTCBS greater than or equal to MXT to prevent possible TCB stealing.

Set in the SIT or SYSIN.

Overridden via CEMT SET SYSTEM.

SIT Parm: MAXOPENTCBS

The MAXOPENTCBS parameter sets the maximum number of L8 and L9 TCBs allowed for the CICS region. See 2.6.1, "MAXOPENTCBS" on page 31, for information to assist setting this parameter.

Set in the SIT or SYSIN.

Overridden via CEMT SET DISPATCHER.

Note: MAXOPENTCBS should always be set greater than or equal to TCBLIMIT. Additionally, when running with transaction isolation turned on, MAXOPENTCBS should be set equal to or higher than MXT.

DB2CONN Parm: TCBLIMIT

TCBLIMIT specifies the maximum number of TCBs that can be used to run DB2(R) threads. It is a subset of the MAXOPENTCBS parameter described previously.

Set in the DB2CONN RDO definition.

Overridden via CEMT SET DB2CONN.

Note: Your TCBLIMIT must be greater than or equal to the total of all your THREADLIMIT parameters.

DB2CONN Parm: THREADLIMIT

The DB2CONN THREADLIMIT specifies the maximum number of active DB2 threads for the pool.

Set in the DB2CONN RDO definition.

Overridden via CEMT SET DB2CONN.

DB2ENTRY Parm: THREADLIMIT

The DB2ENTRY THREADLIMIT specifies the maximum number of active DB2 threads for a specific transaction or group of transactions.

Set in the DB2ENTRY RDO definition.

Overridden via CEMT SET DB2ENTRY.

In general you will start at the top of the preceding list, make sure DB2 and WMQ can handle your thread volume, then move up into CICS, set your MXT to the total number of active tasks that can run in your CICS region, and then set your limit for open TCBs via the MAXOPENTCBS parameter.

Furthermore, for DB2, you can then use TCBLIMIT to throttle the number of L8 TCBs used from the MAXOPENTCBS pool. Also ensure that your DB2 Entry and Pool THREADLIMITs total up to a value less than or equal to your TCBLIMIT.

Note that there are also the MAXSSLTCBS, MAXJVMTCBS, and MAXXPTCBS parameters relating to the other types of open TCBs used by OTE. These are not directly relevant when implementing a threadsafe environment in CICS. However, they are important from the overall CICS system programming perspective.

There are two further CICS system parameters that are related to threadsafety:

SIT Parm: FORCEQR

FORCEQR is at first confusing because most people think that it allows you to turn off TCB switching, which is not true, nor is it possible. The FORCEQR parameter is really only used as an emergency stopgap to shift programs back onto the QR TCB to provide resource serialization in the event that you realize that your supposedly threadsafe programs are in fact not threadsafe with respect to data integrity.

FORCEQR overrides all API(CICSAPI),CONCURRENCY(THREADSAFE) program definitions in the CICS region so that they all run as though defined as API(CICSAPI),CONCURRENCY(QUASIRENT).

FORCEQR will not affect the fact that the CICS-DB2 and CICS-WMQ attachment facilities now use L8 TCBs. All DB2 and WMQ calls run on an L8 TCB. FORCEQR will just ensure that you swap back to the QR TCB when returning to the application.

Set in the SIT or SYSIN.

Overridden via CEMT SET SYSTEM.

> **Note:** A change to the FORCEQR parm does not affect programs already running. New tasks that start will use the new FORCEQR setting, but there will be a delay for long-running tasks to pick up the change.
>
> The FORCEQR parameter does not affect API(OPENAPI),CONCURRENCY(THREADSAFE) programs because these *must* run on an open TCB.

SIT Parm: FCQRONLY

FCQRONLY forces CICS Transaction Server Version 3.2 to execute file control requests under the QR TCB, in the same manner as they were in prior releases of CICS. By default, these commands are now threadsafe and so will execute under an open TCB if an application were running under an L8 or L9 TCB at the time a file control command was issued. FCQRONLY also bypasses some of the shared storage locking and concurrency implementations that are required for threadsafe file control support. FCQRONLY defaults to NO. It is provided as a means of deactivating threadsafe file control support for those environments that may choose to do so, perhaps during application testing or validation.

> **Note:** The default for the FCQRONLY parameter will be changed in APAR PK45354. With this APAR the default is now FCQRONLY=YES.

Set in the SIT or SYSIN.

Overridden via CEMT SET SYSTEM.

7.4 Providing a threadsafe CICS operating environment

Now that you have checked each region to make sure that you are running the proper software and have reviewed the system parameters, let us take a look at the major part of the CICS system programmer's conversion process.

7.4.1 CICS exits

Global user exits (GLUEs) are the primary area of concern for the system programmer since a poorly tuned CICS subsystem can experience a performance degradation due to excessive TCB switching caused by non threadsafe exits. To get a better idea of your objective, it can be simplified by saying that all global user exits should be made threadsafe before migrating to CICS Transaction Server Version 2 or later.

With the exploitation of OTE in CICS Transaction Server Version 2.2 and later, the switchover to an L8 TCB happens earlier in the processing of a DB2 request than the switchover to the subtask TCB in pre-CICS Transaction Server Version 2.2 releases. Therefore all your exits now run, or try to run, on L8 TCBs. If you have not converted your GLUEs and defined them as CONCURRENCY(THREADSAFE), then invocation of your exit programs will cause a switchback to the QR TCB for processing and then immediately return back to the L8 TCB to continue processing the DB2 call. This can generate a TCB thrashing effect that results in poor performance.

The same effect is true for exit programs driven during calls to WMQ in CICS Transaction Server Version 3.2.

The design of CICS forces CICSAPI application programs and exit programs to react differently. When an exit program is swapped back to the QR TCB for processing, it always swaps back to the L8 TCB on return. Then if your application program encounters a non threadsafe CICS command, it again swaps back to the QR TCB, but unlike the exits, threadsafe application programs stay on the QR TCB until another call to an OTE-enabled TRUE such as DB2 or WMQ is encountered. (Note that in CICS Transaction Server Version 3, OPENAPI programs are treated in a similar manner to exits in this respect, since they always receive control back under their open TCB, if they happen to invoke non threadsafe commands that require switching to the QR TCB for processing).

Figure 7-6 on page 174 shows the flow of a DB2 call from a threadsafe CICSAPI program, showing how the GLUEs cause processing to bounce between the QR TCB and an L8 TCB.

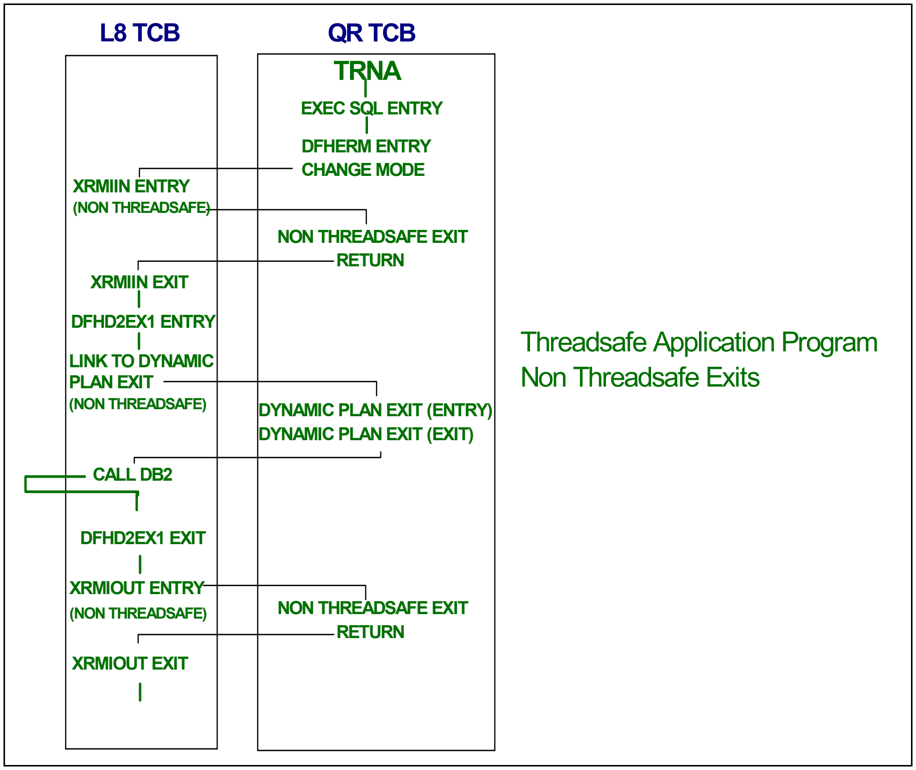

Figure 7-6 Exit flow between the QR and L8 TCBs

The preceding flow shows the application program starting execution on the QR TCB when a DB2 call is encountered and execution is swapped over to an L8 TCB to process the DB2 call. Once on the L8 TCB, the XRMIIN exit is encountered, and due to it being non threadsafe, its processing is swapped back over to the QR TCB. When the XRMIIN exit is complete the process flow is returned to the L8 TCB. CICS will always return back to the TCB where the exit was invoked.

Processing continues on the L8 TCB until the dynamic plan exit is invoked, at which point processing is again swapped back to the QR TCB. On completion of the dynamic plan exit, processing is swapped back onto the L8 TCB to make the actual DB2 call.

Once the DB2 call is complete the XRMIOUT exit is invoked and processing swaps over to the QR TCB to process the exit and then back to the L8 TCB after the exit is complete. At this point all processing would continue on the L8 TCB until either the program terminates, a non threadsafe command is encountered, or a non threadsafe exit is encountered.

Figure 7-6 on page 174 is an example of the switching that might be encountered for exits on the path of a DB2 call. In the case of calls to WMQ in CICS Transaction Server Version 3.2, the same principles apply now that the CICS-MQ Adapter is an OTE-enabled TRUE as well. For WMQ, there is not a dynamic plan exit, but there is the API crossing exit CSQCAPX instead. Note that this is defined as threadsafe in the program definition as supplied in CICS Transaction Server Version 3.2. This means that (by default) the supplied version of CSQCAPX is threadsafe, so if it is active it will not result in a switch back from the L8 to the QR TCB for the link to the CICS-WMQ API crossing exit. Should this exit be changed, take care to ensure that any alterations to its logic are implemented in a threadsafe manner.

Now that we understand that non threadsafe exits are the cause of extra switching in the threadsafe zone, we can start the analysis and conversion process. The preceding discussion has highlighted the fact that the XRMIIN, XRMIOUT, DB2 dynamic plan exit, and CICS-WMQ API crossing exit are key exits to review. Note also that any EXEC CICS command will potentially drive exit programs defined to run at the XEIIN and XEIOUT exit points. Finally, CICS Transaction Server Version 3.2 now provides the EXEC CICS file control commands as threadsafe, so exits invoked from within file control should also be reviewed for potential TCB switching activity. This means analysis of the XFCREQ and XFCREQC exit points.

Additionally, any EXEC CICS calls made in one of the key exit programs may pull in other exits such as XEIIN, XEIOUT, XPCFTCH, or XTSQRIN. Therefore all exits that get invoked during the execution path of a DB2 or WMQ call, or an EXEC CICS file control request, need to be converted to be threadsafe to eliminate a TCB switching.

7.4.2 Analyzing your exits

The first thing you need to do is identify what exits (TRUEs, GLUEs, and dynamic plan exits) are in your system and determine whether they need any modifications to the code or their definition to make them threadsafe. If you are extremely lucky you have no exits and can skip the rest of this section and move on to converting the applications themselves, but those are only a lucky few.

Tools used to identify your exits

The easiest way to get a picture of what exits (TRUEs, GLUEs, and dynamic plan exits) are running in your CICS region is to use the DFH0STAT utility shipped with CICS. Running the STAT transaction generates a report that lists all your TRUE and GLUE exits along with a listing of your DB2 Pool and Entry resources.

You can use the report to identify what exits you have and if they are defined as THREADSAFE or QUASIRENT. The report also helps you identify whether your system exits are using a global work area, which could be a shared resource.

For information on CSQCAPX (the CICS-WMQ API crossing exit), use CEMT or equivalent to review its program definition CONCURRENCY attribute. As mentioned previously, as provided it is defined as threadsafe and written to threadsafe standards. The name of the crossing exit is fixed and cannot be changed. The CKQC display panel will show whether it is active or not.

Note: A shared global work area could be utilized as a non-serialized shared resource and therefore classify your exit program as non threadsafe, in which case you would be required to add serialization techniques to your code. Later we discuss how to serialize shared resources.

7.4.3 Running DFH0STAT

Ensure that the CSD group DFH$STAT has been installed, then run the STAT transaction to get the main menu for DFH0STAT (Figure 7-7).

```
 Sample Program - CICS Statistics Print                           07/20/2007 13:10:00

 Type in destination fields if required. Press Enter to print

     Jobname. . . : SCSCPJA6
     Applid . . . : SCSCPJA6
     Sysid. . . . : PJA6

     Node . . . . . *          Type in a valid Node. * is default
     Userid . . . . *          Type in a valid Userid. * is default
     Class. . . . . A          Type in a valid Class. A is default

     Abbreviated. . B          Type U or N for abbreviated report. B is default

 Current Statistics Settings

     Statistics Recording. : OFF       Collection Interval . . . : 03:00:00
     Last Reset Time . . . : 00:00:00   Elapsed Time Since Reset. : 13:10:00
     Next Collection . . . : 00:00:00   End-of-Day Time . . . . . : 00:00:00


F1=Help F2=Refresh F3=Exit F4=Report Selection F5=Print
```

Figure 7-7 Initial CICS STAT/DFH0STAT screen

Using the PF4 key, access the report selection menu (Figure 7-8).

```
Sample Program - CICS Statistics Print Report Selection          07/20/2007 13:10:00

Select the statistics reports required and press 'Enter' to validate

 DB2 Connection . . . . . . . . . . . Y   WebSphere MQ Connection. . . . . . N
 DB2 Entries. . . . . . . . . . . . . Y   Program Autoinstall. . . . . . . . N
                                          Terminal Autoinstall and VTAM. . . N
 JVM Pool and Class Cache . . . . . . N   Connections and Modenames. . . . . N
 JVMs . . . . . . . . . . . . . . . . N
 JVM Profiles . . . . . . . . . . . . N   TCP/IP . . . . . . . . . . . . . . N
 JVM Programs . . . . . . . . . . . . N   TCP/IP Services. . . . . . . . . . N
                                          URIMAPs. . . . . . . . . . . . . . N
 CorbaServers and DJARs . . . . . . . N   Virtual Hosts. . . . . . . . . . . N
 DJARs and Enterprise Beans . . . . . N   PIPELINEs. . . . . . . . . . . . . N
 Requestmodels. . . . . . . . . . . . N   WEBSERVICEs. . . . . . . . . . . . N
 EJB System Data Sets . . . . . . . . N   Document Templates . . . . . . . . N

 Trace Settings and Levels. . . . . . N   Recovery Manager . . . . . . . . . N
 User Exit Programs . . . . . . . . . Y   Enqueue Manager. . . . . . . . . . N
 Global User Exits. . . . . . . . . . Y   Enqueue Models . . . . . . . . . . N


F1=Help    F3=Return to Print    F7=Back        F10=Save        F12=Restore
```

Figure 7-8 DFH0STAT report selection menu

Select the **DB2 Connection and Entries** and the **User Exit Pgms/Global User Exits** report with a Y and press Enter, then PF3 to return to the main menu. Press Enter to print your report.

Example 7-1 on page 178 is a sample of the Exit Programs and Global User Exits sections of the DFH0STAT report.

Example 7-1 Output from the DFH0STAT utility showing the exits reports

```
Exit Programs
_____________
                   <---- Global Area ---->No.                                                  Task   <-- Task Related User Exit -->
  Program   Entry   Entry          Use   of   Program         Concurrency  Qual-     Area   Task         Shut
   Name      Name    Name  Length  Count Exits  Status   API   Status       ifier    Length start  EDF   down  Indoubt  SPI
________________________________________________________________________________________________________________________
  DFHEDP    DLI                  0      0    0  Started  Cics  Quasi Rent               284    No     No    No   No Wait   No
  DFHD2EX1 DSNCSQL DSNCSQL      16      1    0  Started  Open  Thread Safe   D7Q2      222    No    Yes   Yes     Wait   Yes
  DFHMQTRU MQM      MQM         32      1    0  Started  Open  Thread Safe   MQ8G      224    No     No   Yes     Wait   Yes
  XXXEI     XXXEI                0      0    2  Started  Cics  Quasi Rent                 0    No     No    No   No Wait   No
  XXXRMI    XXXRMI               0      0    2  Started  Cics  Quasi Rent                 0    No     No    No   No Wait   No
  XXXTS     XXXTS    XXXTS      64      1    1  Started  Cics  Quasi Rent                 0    No     No    No   No Wait   No
__________________________________________________________________________________________________________________________
Global User Exits
_________________
    Exit    Program     Entry    <------- Global Area ------->  Number    Program
    Name     Name        Name    Entry Name  Length  Use Count  of Exits  Status
_________________________________________________________________________________
  XTSQRIN   XXXTS      XXXTS      XXXTS         64          1         1   Started
  XEIIN     XXXEI      XXXEI                     0          0         2   Started
  XEIOUT    XXXEI      XXXEI                     0          0         2   Started
  XRMIIN    XXXRMI     XXXRMI                    0          0         2   Started
  XRMIOUT   XXXRMI     XXXRMI                    0          0         2   Started
```

The first section of the report, Exit Programs lists the exit programs in the system. The Concurrency Status column shows the concurrency setting for each program.

The other item of interest is the Global Area section of the exit programs or global user exits reports. The Use Count column identifies whether an exit is using a global work area.

In our sample report in Example 7-1, we have exits XTSQRIN, XEIIN, XEIOUT, XRMIIN, and XRMIOUT in use. Of those, exit XTSQRIN has a global work area in use, which could be a shared resource, as identified by the Length and Use Count fields being 64 and 1, respectively.

The User Exit Programs and Global User Exits reports identify your exits. Note, however, that the dynamic plan exit is not defined as a CICS exit. Therefore you need to search the DB2 connection and DB2 entries reports to identify and list all DB2 dynamic plan exits.

The same is true for the CICS-WMQ API crossing exit CSQCAPX. It is not defined as a CICS exit either, and so should be investigated using, for example, CEMT, CKQC, and so forth.

The sample DFH0STAT report in Example 7-2 shows a pool dynamic plan exit called PLANEXIT in use and an entry definition for MIG also using the same dynamic plan exit. Unfortunately, the DFH0STAT report does not indicate whether PLANEXIT is defined as threadsafe or Quasirent. You need to issue a CEMT I PROG to determine its status.

Example 7-2 Output from the DFH0STAT utility showing the DB2 resources

DB2 Connection

```
DB2 Connection Name. . . . . . . . . . . :  DB2F
DB2 Sysid. . . . . . . . . . . . . . . . :  D7Q2
DB2 Release. . . . . . . . . . . . . . . :   7.1.0
DB2 Connection Status. . . . . . . . . . :  CONNECTED           DB2 Connect™ Date and Time . . . :  05/12/2004  09:47:01.38478
DB2 Connection Error . . . . . . . . . . :  SQLCODE
DB2 Standby Mode . . . . . . . . . . . . :  RECONNECT
DB2 Pool Thread Plan Name. . . . . . . . :
DB2 Pool Thread Dynamic Plan Exit Name . :  PLANEXIT
Pool Thread Authtype . . . . . . . . . . :  SIGNID
Pool Thread Authid . . . . . . . . . . . :
Command Thread Authtype. . . . . . . . . :  USERID
Command Thread Authid. . . . . . . . . . :
Signid for Pool/Entry/Command Threads. . :  CICSTS
Create Thread Error. . . . . . . . . . . :  N906D               Message TD Queue 1. . . . . . . . . . . :  CDB2
Protected Thread Purge Cycle . . . . . . :  00.30               Message TD Queue 2. . . . . . . . . . . :
Deadlock Resolution. . . . . . . . . . . :  ROLLBACK            Message TD Queue 3. . . . . . . . . . . :
Non-Terminal Intermediate Syncpoint. . . :  RELEASE
Pool Thread Wait Setting . . . . . . . . :  WAIT                Statistics TD Queue . . . . . . . . . . :  CDB2
Pool Thread Priority . . . . . . . . . . :  LOW                 DB2 Accounting records by . . . . . . . :  NONE
Current TCB Limit. . . . . . . . . . . . :         130
Current number of TCBs . . . . . . . . . :         110
Peak number of TCBs. . . . . . . . . . . :         110
Current number of free TCBs. . . . . . . :         108
Current number of tasks on TCB Readyq. . :           0
Peak number of tasks on TCB Readyq . . . :           0
Pool Thread Limit. . . . . . . . . . . . :           5          Number of Calls using Pool Threads. . . . . :            0
Current number of Pool Threads . . . . . :           0          Number of Pool Thread Signons . . . . . . . :            0
Peak number of Pool Threads. . . . . . . :           0          Number of Pool Thread Commits . . . . . . . :            0
Number of Pool Thread Waits. . . . . . . :           0          Number of Pool Thread Aborts. . . . . . . . :            0
                                                                Number of Pool Thread Single Phase. . . . . :            0
Current number of Pool Tasks . . . . . . :           0          Number of Pool Thread Reuses. . . . . . . . :            0
Peak number of Pool Tasks. . . . . . . . :           0          Number of Pool Thread Terminates. . . . . . :            0
Current Total number of Pool Tasks . . . :           0
Current number of Tasks on Pool Readyq . :           0
Peak number of Tasks on Pool Readyq. . . :           0
Current number of DSNC Command threads . :           0          Number of DSNC Command Calls. . . . . . . . :            0
Peak number of DSNC Command threads. . . :           0          Number of DSNC Command Signons. . . . . . . :            0
DSNC Command Thread Limit. . . . . . . . :           1          Number of DSNC Command Thread Terminates. . :            0
                                                                Number of DSNC Command Thread Overflows . . :            0
```

DB2 Entries

```
DB2Entry Name. . . . . . . . . . . . . . :  MIG                 DB2Entry Status . . . . . . . . . . . . :  ENABLED
DB2Entry Static Plan Name. . . . . . . . :                      DB2Entry Disabled Action. . . . . . . . :  POOL
DB2Entry Dynamic Plan Exit Name. . . . . :  PLANEXIT            DB2Entry Deadlock Resolution. . . . . . :  ROLLBACK
DB2Entry Authtype. . . . . . . . . . . . :  SIGNID              DB2Entry Accounting records by. . . . . :  NONE
DB2Entry Authid. . . . . . . . . . . . . :
                                                                Number of Calls using DB2Entry. . . . . . . :    2,139,282
DB2Entry Thread Wait Setting . . . . . . :  POOL                Number of DB2Entry Signons. . . . . . . . . :            0
                                                                Number of DB2Entry Commits. . . . . . . . . :            0
DB2Entry Thread Priority . . . . . . . . :  LOW                 Number of DB2Entry Aborts . . . . . . . . . :            0
DB2Entry Thread Limit. . . . . . . . . . :         120          Number of DB2Entry Single Phase . . . . . . :        2,140
Current number of DB2Entry Threads . . . :           1          Number of DB2Entry Thread Reuses. . . . . . :        2,140
Peak number of DB2Entry Threads. . . . . :           2          Number of DB2Entry Thread Terminates. . . . :            0
                                                                Number of DB2Entry Thread Waits/Overflows . :            0
DB2Entry Protected Thread Limit. . . . . . . . . :         120
Current number of DB2Entry Protected Threads . . :           1
Peak number of DB2Entry Protected Threads. . . . :           2
Current number of DB2Entry Tasks . . . . . . . . :           1
Peak number of DB2Entry Tasks. . . . . . . . . . :           2
Current Total number of DB2Entry Tasks . . . . . :       2,141
Current number of Tasks on DB2Entry Readyq . . . :           0
Peak number of Tasks on DB2Entry Readyq. . . . . :           0
```

7.4.4 Which exits need to be reviewed

Previously we stated that all system exits must be threadsafe before migrating to CICS Transaction Server Version 2 or later. Actually, the word *all* is a little bit strong. You cannot go wrong if you review all your exits, but the real answer is that exits in the DB2 and WMQ call path must be converted to be threadsafe, along with those exits driven during the processing of threadsafe EXEC CICS commands, in particular those for heavily used API options such as EXEC CICS file control requests.

The DFH0STAT report helps you identify which exits are in your system. However, you may have many and may not be sure which ones need to be converted. A good way to determine which exits are actually in the DB2, WMQ, or EXEC CICS file control command path is to turn on a CICS Auxiliary Trace for a specific DB2, WMQ, or file control application program and review the trace for that one transaction, making notes of all the TCB switching and identifying which exits were involved.

The following CICS Auxiliary Trace shows a typical TCB switch (change mode) from the QR to the L8 TCB to process a DB2 call.

Example 7-3 Sample CICS Auxiliary Trace output for a single TASK

```
04488 QR    AP 00E1 EIP   EXIT  ASKTIME                OK
04488 QR    AP 2520 ERM   ENTRY ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )
04488 QR    US 0401 USXM  ENTRY INQUIRE_TRANSACTION_USER
04488 QR    US 0402 USXM  EXIT  INQUIRE_TRANSACTION_USER/OK 00000000
04488 QR    RM 0301 RMLN  ENTRY ADD_LINK               RMI,2302E1E4 , 01010101 ,
04488 QR    RM 0302 RMLN  EXIT  ADD_LINK/OK            0111005A,2302E1E4 , 010101
04488 QR   DS 0002 DSAT  ENTRY CHANGE_MODE       L8      Example 7-4 on page 181
04488 QR    DS 0018 DSDS4 ENTRY ALLOC_OPEN             1,22E4A060
04488 QR    DS 0019 DSDS4 EXIT  ALLOC_OPEN/OK
DSTCB QR    DS 0016 DSDS3 ENTRY PARTITION_EXIT         21D03030
DSTCB QR    DS 0032 DSDS3 EVENT DSDS3_SCAN_HAND_POSTABLES
DSTCB QR    DS 0022 DSDS3 EVENT MVS_WAIT_ENTRY
04488 L8014 DS 0003 DSAT  EXIT  CHANGE_MODE/OK
04488 L8014 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM TSTXEII AT EXIT POINT XRMIIN
04488 L8014 DS 0002 DSAT  ENTRY CHANGE_MODE            QR
DSTCB L8014 DS 0016 DSDS3 ENTRY PARTITION_EXIT         23133148
DSTCB L8014 DS 0022 DSDS3 EVENT MVS_WAIT_ENTRY
DSTCB QR    DS 0023 DSDS3 EVENT MVS_WAIT_EXIT
DSTCB QR    DS 0017 DSDS3 EXIT  PARTITION_EXIT/OK
DSTCB QR    DS 0042 DSTCB EVENT TRACE_DOUBLE_CHAIN_GET
04488 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK
04488 QR    AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM TSTXEII WITH RETURN CODE 0
04488 QR    DS 0002 DSAT  ENTRY CHANGE_MODE            L8
DSTCB QR    DS 0032 DSDS3 EVENT DSDS3_SCAN_HAND_POSTABLES
DSTCB QR    DS 0022 DSDS3 EVENT MVS_WAIT_ENTRY
DSTCB QR    DS 0016 DSDS3 ENTRY PARTITION_EXIT         21D03030
DSTCB L8014 DS 0023 DSDS3 EVENT MVS_WAIT_EXIT
DSTCB L8014 DS 0017 DSDS3 EXIT  PARTITION_EXIT/OK
DSTCB L8014 DS 0042 DSTCB EVENT TRACE_DOUBLE_CHAIN_GET
04488 L8014 DS 0003 DSAT  EXIT  CHANGE_MODE/OK
04488 L8014 AP 3180 D2EX1 ENTRY APPLICATION            REQUEST EXEC SQL SELECT
```

In the preceding example, the program is running on the QR TCB when it performs a DB2 call and then it jumps to an L8 TCB. It then encounters a non threadsafe exit and jumps back to the QR TCB to run it. Upon completion of the exit it returns back to the L8 TCB to process the application's SQL request.

7.4.5 Identifying exits in the DB2, WMQ, and file control call paths

The technique to find exits that are invoked during the DB2, WMQ, or file control call path is to turn on a CICS Auxiliary Trace, then search the output report looking for CHANGE_MODE entry records to the QR TCB followed by RETURN-FROM-USER-EXIT-PROGRAM events and make a note of the exit that was involved.

You may have to make several iterations of your report, for example, turn on your CICS Auxiliary Trace for a short time, run a general report, then look for the CHANGE_MODE records. Then pick one task and re-run the report for that single task only to eliminate extraneous report records and then use the following technique.

The following CICS Auxiliary Trace snippet, an excerpt from the Auxiliary Trace sample in Example 7-3 on page 180, shows a task already running on the L8 TCB linking to exit TSTXEII and then issuing a CHANGE_MODE to the QR TCB.

Shortly after the change mode to the QR TCB you see a few trace records on the QR TCB. One of them is the RETURN-FROM-USER-EXIT-PROGRAM event record showing a return from TSTXEII.

Example 7-4 CICS Auxiliary Trace entries showing the return from an exit

```
04488 L8014 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM TSTXEII AT EXIT POINT XRMIIN
04488 L8014 DS 0002 DSAT  ENTRY CHANGE_MODE          QR
DSTCB L8014 DS 0016 DSDS3 ENTRY PARTITION_EXIT       23133148
DSTCB L8014 DS 0022 DSDS3 EVENT MVS_WAIT_ENTRY
DSTCB QR    DS 0023 DSDS3 EVENT MVS_WAIT_EXIT
DSTCB QR    DS 0017 DSDS3 EXIT  PARTITION_EXIT/OK
DSTCB QR    DS 0042 DSTCB EVENT TRACE_DOUBLE_CHAIN_GET
04488 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK
04488 QR    AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM TSTXEII WITH
04488 QR    DS 0002 DSAT  ENTRY CHANGE_MODE          L8
```

These four trace records in this sequence mean that you just invoked a non threadsafe exit, TSTXEII. You can now add TSTXEII to your list of exits you are going to review.

You will need to repeatedly perform the preceding process to identify all your exits in the DB2 or WMQ call paths, and EXEC CICS file control operations.

Note: For CICS Transaction Server Version 2.3, APAR PQ78987 introduced a performance change to eliminate all CHANGE_MODE trace records from DS level 1 traces, and instead write them when DS Level 2 tracing is active.

APAR PQ89845 further refined this for CICS Transaction Server Version 2.3 so the trace entries are written when either DS Level 2 or DS Level 3 trace is active. Both these changes are present at the base code level for CICS Transaction Server Version 3.

If you are not getting any CHANGE_MODE trace records then use CETR to turn on DS Level 2 or Level 3 tracing.

7.4.6 Identifying dynamic plan exits in the DB2 call path

To identify the dynamic plan exits in the DB2 call path, we again use the CICS Auxiliary Trace output.

The following Auxiliary Trace sample, Example 7-5, shows the invocation of a dynamic plan exit called DB2PLAN. Notice that we are already on an L8 TCB, as seen by the second column containing L8000, which is the name of the TCB. Therefore we are in the middle of the DB2 call path.

Example 7-5 Auxiliary Trace showing invocation of a Dynamic Plan exit DB2PLAN

```
00258 L8000 AP 3180 D2EX1 ENTRY APPLICATION          REQUEST EXEC SQL SELECT
00258 L8000 PG 0A01 PGLU  ENTRY LINK_URM             DB2PLAN,22BE7678 , 0000001C,NO,NO
00258 L8000 DD 0301 DDLO  ENTRY LOCATE               21C27B70,22BE7574,PPT,DB2PLAN
00258 L8000 DD 0302 DDLO  EXIT  LOCATE/OK            D7D7E3C5 , 22DA5B88
00258 L8000 LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM      22C87258
00258 L8000 LD 0002 LDLD  EXIT  ACQUIRE_PROGRAM/OK   A43002D8,243002B0,D8,0,REUSABLE,ESDSA,OLD_COPY
00258 L8000 AP 1940 APLI  ENTRY START_PROGRAM        DB2PLAN,CEDF,FULLAPI,URM,NO,22F89C10,22BE7678
00258 L8000 DS 0002 DSAT  ENTRY CHANGE_MODE          QR
00258 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK
00258 QR    SM 0C01 SMMG  ENTRY GETMAIN              190,YES,00,TASK
00258 QR    SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788
00258 QR    AP 00E1 EIP   ENTRY RETURN 0004,226E1798 .>.q,08000E08 ....
00258 QR    AP E160 EXEC  ENTRY RETURN               ASM
00258 QR    SM 0301 SMGF  ENTRY FREEMAIN             226E1788,TASK
00258 QR    SM 0302 SMGF  EXIT  FREEMAIN/OK
00258 QR    AP 1941 APLI  EXIT  START_PROGRAM/OK     ....,NO,DB2PLAN
00258 QR    LD 0001 LDLD  ENTRY RELEASE_PROGRAM      22C87258,A43002D8
00258 QR    LD 0002 LDLD  EXIT  RELEASE_PROGRAM/OK   243002B0,D8,ESDSA
00258 QR    DS 0002 DSAT  ENTRY CHANGE_MODE          L8
00258 L8000 DS 0003 DSAT  EXIT  CHANGE_MODE/OK       QR
00258 L8000 PG 0A02 PGLU  EXIT  LINK_URM/OK
00258 L8000 AP 3250 D2D2  ENTRY DB2_API_CALL         230D7030
00258 L8000 AP 3251 D2D2  EXIT  DB2_API_CALL/OK
00258 L8000 AP 3181 D2EX1 EXIT  APPLICATION-REQUEST  SQLCODE 0 RETURNED ON EXEC SQL SELECT
00258 L8000 MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME  DSNCSQL
```

As part of invoking the dynamic plan exit, DB2PLAN, CICS detects that the exit is not threadsafe and immediately switches to the QR TCB, and upon return from the dynamic plan exit it switches back to the L8 TCB.

The following three CICS Auxiliary Trace snippets, pulled from the AUX Trace sample in Example 7-5 on page 182, shows a task already running on an L8 TCB that invokes a user replaceable module (URM), in this case our dynamic plan exit DB2PLAN.

Shortly after the LINK_URM record we see CICS starting program DB2PLAN and then detecting that it is not threadsafe, causing a switch to the QR TCB.

Example 7-6 Auxiliary Trace entries showing

```
00258 L8000 PG 0A01 PGLU  ENTRY LINK_URM             DB2PLAN,22BE7678 , 0000001C,NO,NO
00258 L8000 DD 0301 DDLO  ENTRY LOCATE               21C27B70,22BE7574,PPT,DB2PLAN
00258 L8000 DD 0302 DDLO  EXIT  LOCATE/OK            D7D7E3C5 , 22DA5B88
00258 L8000 LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM      22C87258
00258 L8000 LD 0002 LDLD  EXIT  ACQUIRE_PROGRAM/OK   A43002D8,243002B0,D8,0,REUSABLE,ESDSA,OLD_COPY
00258 L8000 AP 1940 APLI  ENTRY START_PROGRAM        DB2PLAN,CEDF,FULLAPI,URM,NO,
00258 L8000 DS 0002 DSAT  ENTRY CHANGE_MODE          QR
```

The sequence of trace records shown in Example 7-6 identifies all your dynamic plan exits in the DB2 call path.

You can now add DB2PLAN to your list of exits you are going to review.

You will need to repeatedly perform this process to identify all your dynamic plan exits in the DB2 call path.

7.4.7 Contacting the owner of vendor product exits

If you have various monitors and debugging products installed, you may see their product exits in the DB2 and WMQ call paths. If so, you need to contact the product vendor directly to have them determine the exit's threadsafe status and make adjustments according to their recommendations.

7.5 Making your exits threadsafe

Now that you have identified what exits are in your system and reviewed their source code for potential code changes it is time to make the code adjustments to make them threadsafe.

The steps required to make your programs threadsafe are:

1. Serialize shared resources.
2. Change your exit programs CONCURRENCY definition to THREADSAFE.

Additionally, we recommend removing non threadsafe EXEC CICS commands if possible. While the existence of such commands in the exit does not make the exit non threadsafe, it will cause additional TCB switching, which should be avoided if at all possible. This is especially important for exits that are invoked on the mainline DB2 and WMQ call paths.

7.5.1 Remove non threadsafe commands

For those exit programs that run at exit points where CICS allows use of the CICS command-level API, review your exit code for use of EXEC CICS commands that would cause a switch to the QR TCB. Consider ways of eliminating use of these commands. Can an XPI command be used instead? For a complete list of threadsafe commands, see these publications:

- Appendix L, “Threadsafe Command List,” in the *CICS Application Programming Reference*, SC34-6232, for CICS Transaction Server Version 2, and *CICS Application Programming Reference,* SC34-6434, for CICS Transaction Server Version 3.
- Appendix D, “Threadsafe SPI commands,” in the *CICS System Programming Reference*, SC34-6233, for CICS Transaction Server Version 2, and *CICS System Programming Reference,* SC34-6435, for CICS Transaction Server Version 3.
- Appendix G, “Threadsafe XPI commands,” in the *CICS Customization Guide*, SC34-6227, for CICS Transaction Server Version 2, and *CICS Customization Guide*, SC34-6429, for CICS Transaction Server Version 3.

If your assembler exit program links other high-level language programs then these need to be reviewed and changed as required.

The DFHEISUP utility can be used to search for non threadsafe commands.

7.5.2 Serializing shared resources

This step is a bit more difficult. It basically involves modifying your program code to add serialization techniques around code that is accessing application-shared resources.

The following EXEC CICS commands can be used to access a shared resource and are the key commands to search for in your code:

- ADDRESS CWA
- EXTRACT EXIT
- GETMAIN SHARED

Techniques that you can use to serialize access to your shared storage are:

- Assembler language Compare and Swap instructions
- EXEC CICS ENQ / DEQ commands
- XPI ENQUEUE / DEQUEUE commands

"Serialize access to GWAs" on page 251 walks through the process of converting an exit and shows use of the Compare and Swap instruction to serialize an application shared resource.

Compare and swap techniques

You may have read about using Compare and Swap as one of the possible serialization techniques. You can find more information about Compare and Swap in the manual *z/Architecture Principles of Operations*, SA22-7832.

There are several instructions you can use, and Compare and Swap is one of many. The following is the recommended list from the manual *z/Architecture Principles of Operations*, SA22-7832:

- Compare and Swap
- Compare and Swap and purge
- Compare double and Swap
- Test and set
- Perform locked operation

Additionally, when using one of the preceding techniques you must also pay attention to what instructions you used to load your data initially. In our example code we are using a COMPARE DOUBLE AND SWAP instruction, which acts on two words of data at once. Therefore when we loaded the initial two words of data, there was a small window of opportunity between each individual word being loaded where they could change. The answer, again from the *Principles of Operations* manual, is to use the LOAD MULTIPLE instruction to load your data. It acts like the COMPARE AND SWAP instruction where the storage is locked during the time the instruction executes.

7.5.3 Change your exit program's CONCURRENCY definition to THREADSAFE

In this section we go through a sample exit, running it in both quasirent and threadsafe modes, and making modifications to the code to remove a data integrity issue created by running it in threadsafe mode

Display the program in question via CEMT and if necessary change its definition via CEDA to be threadsafe.

Example 7-7 CEMT display showing both a Quasirent and threadsafe program

```
I PROG(RMIXIT*)
STATUS:  RESULTS - OVERTYPE TO MODIFY
 Prog(RMIXIT  ) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr Cic
 Prog(RMIXIT2 ) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Qua Cic
```

In the preceding display program RMIXIT shows up as `Thr`, which means it is defined to CICS as CONCURRENCY(THREADSAFE), and program RMIXIT2 shows up as `Qua`, which means it is defined to CICS as CONCURRENCY(QUAISRENT). Note also that the programs are both defined to CICS as API(CICSAPI).

The CEDA definitions for the preceding programs are listed here (Example 7-8).

Example 7-8 Quasirent program RMIXIT2

```
CEDA  ALter PROGram( RMIXIT2  )
 PROGram        : RMIXIT2
 Group          : THDSAFEE
 DEscription  ==>
 Language     ==>                   CObol | Assembler | Le370 | C | Pli
 RELoad       ==> No                No | Yes
 RESident     ==> No                No | Yes
 USAge        ==> Normal            Normal | Transient
 USElpacopy   ==> No                No | Yes
 Status       ==> Enabled           Enabled | Disabled
 RSl            : 00                0-24 | Public
 CEdf         ==> Yes               Yes | No
 DAtalocation ==> Any               Below | Any
 EXECKey      ==> User              User | Cics
 COncurrency  ==> Quasirent         Quasirent | Threadsafe
 Api          ==> Cicsapi           Cicsapi | Openapi
REMOTE ATTRIBUTES
 DYnamic      ==> No                No | Yes
 REMOTESystem ==>
```

Example 7-9 Threadsafe program RMIXIT

```
CEDA  View PROGram( RMIXIT   )
 PROGram        : RMIXIT
 Group          : THDSAFEE
 DEscription    :
 Language       :                  COBol | Assembler | Le370 | C | Pli
 RELoad         : No               No | Yes
 RESident       : No               No | Yes
 USAge          : Normal           Normal | Transient
 USElpacopy     : No               No | Yes
 Status         : Enabled          Enabled | Disabled
 RSl            : 00               0-24 | Public
 CEdf           : Yes              Yes | No
 DAtalocation   : Any              Below | Any
 EXECKey        : User             User | Cics
 COncurrency    : Threadsafe       Quasirent | Threadsafe
 Api            : Cicsapi          Cicsapi | Openapi
REMOTE ATTRIBUTES
 DYnamic        : No               No | Yes
 REMOTESystem   :
```

7.6 Non threadsafe data integrity example

Since data integrity threadsafe exposures are hard to diagnose and find, we give you a short example of an exit that does not serialize a shared global work area and show you the disastrous effects.

A short simple assembler GLUE exit program will be used that shares a global work area (GWA) that simulates a storage chain. The data structure used by the sample exit program is a two-word header containing the next available address of storage to update and a counter of how many updates are being made.

The program reads in the two-word header, bumps the address value in the first word to the next address, and increments the counter in the second word by one. It then saves the header back into the shared storage area and processes the header chain by using the address value to store a word of information. In this example we are exclusive ORing ones into memory so that you can see the changes.

If the storage is serialized then each program picks up then next sequential chain address stored in the header and builds a sequential list of ones and increments the counter by one. When the program fails to serialize the shared storage, the address value gets re-used and instead of ORing ones into the shared storage it can reverse the effect and turn a word of ones into zeros. Therefore, you would see pockets of zeros interspersed throughout the shared storage area. Additionally, the counter will not be incremented sequentially and will have an invalid total.

7.6.1 Sample non threadsafe code example

Example 7-10 shows a GLUE exit program called RMIXIT, which is not threadsafe, as the shared storage is not serialized.

Example 7-10 Sample GLUE with non threadsafe code

```
RMIXIT   DFHEIENT
RMIXIT   AMODE 31
RMIXIT   RMODE ANY
         LR    R2,R1              DFHUEPAR PLIST PROVIDED BY CALLER
         USING DFHUEPAR,R2        ADDRESS UEPAR PLIST
         L     R4,UEPGAA          GET GWA ADDRESS
         LA    R4,12(R4)          BUMP TO A DOUBLE WORD ADDR
         USING GWA,R4             ADDRESSABILITY
*
         L    R6,0(R4)            LOAD SAVED PGM ADDR
         L    R7,4(R4)            LOAD CTR
         LA   R8,4(R6)            BUMP SAVED PGM ADDR BY 4
         LA   R9,1(R7)            BUMP CTR BY 1
         L    R5,LOOPCTR          DELAY LOOP TO GET SOME OVERLAP
LOOP     EQU  *                    SO THAT WE CAN GENERATE SOME
         BCT  R5,LOOP              TCB CONTENTION
         ST   R8,0(R4)            STORE PGM ADDR AT HEADER ADDR
         ST   R9,4(R4)            STORE THE CTR AT WORD 2 IN HEADER
         L    R7,0(R8)            LOAD DATA AT PGM ADDR
         X    R7,ONES             FLIP THE BITS
         ST   R7,0(R8)            STORE THE DATA AT PGM ADDR
*
         LA    R15,UERCNORM       SET OK RESPONSE
         ST    R15,RETCODE          IN WORKING STORAGE
*
RETURN   EQU   *
         L     R15,RETCODE        FETCH RETURN CODE
         DFHEIRET RCREG=15        RETURN TO CICS
*********************************************************************
          DC    F'0'
ONES      DC    X'11111111'       ONES
LOOPCTR   DC    F'00777777'       TIME DELAY LOOP
*********************************************************************
         LTORG
         END   RMIXIT
```

DFH0STAT report showing RMIXIT defined to the system

Using the DFH0STAT we generated a report to show how the program is defined to the system and to show the global work area we are using.

Note: The DFH0STAT report in Example 7-11 was run under CICS TS 2.3, as opposed to the report in Example 7-1 on page 178. You can see a slight difference in the report formats.

Example 7-11 DFH0STAT report showing XRMIIN and XRMOUT using a global work area

```
User Exit Programs
__________________
                      <---- Global Area ---->   No.
  Program    Entry    Entry              Use    of    Program    Program    Exit Program
    Name      Name     Name    Length  Count  Exits  Status   Concurrency    Use Count
  ________________________________________________________________________________________
  DFHEDP     DLI                    0      0      0  Started  Quasi Rent                0
  DFHD2EX1   DSNCSQL   DSNCSQL     16      1      0  Started  Quasi Rent                6
  RMIXIT     RMIXIT    RMIXIT   2,008      1      2  Started  Quasi Rent                0

______________________________________________________________________________________________________________
  Program    Entry          Concurrency                      <------- Task Related User Exit Options -------->
    Name      Name     API     Status     Qualifier  Length   Taskstart  EDF  Shutdown  Indoubt  SPI  Purgeable
  ____________________________________________________________________________________________________________
  DFHEDP     DLI       Base  Quasi Rent                 284         No    No      No    No Wait   No        No
  DFHD2EX1   DSNCSQL   Open  Thread Safe  D7Q2          222         No   Yes     Yes       Wait  Yes       Yes
  RMIXIT     RMIXIT    Base  Quasi Rent                   0         No    No      No    No Wait   No        No
Applid SCSCPJA7  Sysid PJA7  Jobname SCSCPJA7    Date 05/04/2004  Time 09:14:11                CICS 6.3.0
______________________________________________________________________________________________________________

Global User Exits
_________________
    Exit    Program    Entry    <------- Global Area ------->  Number   Program    Program
    Name      Name      Name    Entry Name  Length  Use Count  of Exits  Status   Concurrency
  _____________________________________________________________________________________________
  XRMIIN    RMIXIT    RMIXIT      RMIXIT     2,008          1         2  Started  Quasi Rent
  XRMIOUT   RMIXIT    RMIXIT      RMIXIT     2,008          1         2  Started  Quasi Rent
```

The report shows that program RMIXIT is in use at two exit points, XRMIIN and XRMIOUT, which means that it will get invoked twice for each DB2 call. Both exits share the same global work area using the first two words as a header to communicate between programs.

QUASIRENT results running on the QR TCB

We initially defined the program as QUASIRENT to show that the program runs successfully on the QR TCB.

Figure 7-9 shows the header format used by RMIXIT. The first word is the next available storage address in the global work area to be updated and the second word represents the number of words updated in the global work area.

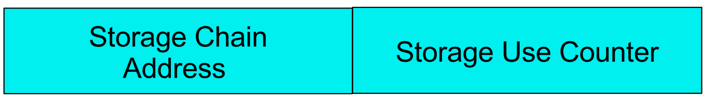

Figure 7-9 Sample header format

While running in QUASIRENT mode on the QR TCB you can see the last address updated was 00412B8. If you look down to the end of the storage area you can see that the word at 00412BC is all zeros, since it has not been used yet. See Example 7-12.

The third word of the storage area is always skipped and left blank, so technically you could say the header is three words. Starting at 004103C program RMIXIT has inserted sequential words of ones all the way up to and including address 00412B8.

The storage use counter has a hex value of A0, which translates to decimal 160. When RMIXIT starts out the header address is initialized to 0041038, so 00412B8 - 0041038 = 000280, which translates to decimal 640, and dividing this by 4 gives you 160 words updated (4 bytes per word).

Example 7-12 Results of running the non threadsafe GLUE defined as QUASIRENT

```
0041030   00000C   000412B8 000000A0 00000000 11111111
0041040   00001C   11111111 11111111 11111111 11111111
0041050   00002C   11111111 11111111 11111111 11111111
0041060   00003C   11111111 11111111 11111111 11111111
0041070   00004C   11111111 11111111 11111111 11111111
0041080   00005C   11111111 11111111 11111111 11111111
0041090   00006C   11111111 11111111 11111111 11111111
00410A0   00007C   11111111 11111111 11111111 11111111
00410B0   00008C   11111111 11111111 11111111 11111111
00410C0   00009C   11111111 11111111 11111111 11111111
00410D0   0000AC   11111111 11111111 11111111 11111111
00410E0   0000BC   11111111 11111111 11111111 11111111
00410F0   0000CC   11111111 11111111 11111111 11111111
0041100   0000DC   11111111 11111111 11111111 11111111
0041110   0000EC   11111111 11111111 11111111 11111111
0041120   00000C   11111111 11111111 11111111 11111111
0041130   00001C   11111111 11111111 11111111 11111111
0041140   00002C   11111111 11111111 11111111 11111111
0041150   00003C   11111111 11111111 11111111 11111111
0041160   00004C   11111111 11111111 11111111 11111111
0041170   00005C   11111111 11111111 11111111 11111111
0041180   00006C   11111111 11111111 11111111 11111111
0041190   00007C   11111111 11111111 11111111 11111111
00411A0   00008C   11111111 11111111 11111111 11111111
00411B0   00009C   11111111 11111111 11111111 11111111
00411C0   0000AC   11111111 11111111 11111111 11111111
00411D0   0000BC   11111111 11111111 11111111 11111111
00411E0   0000CC   11111111 11111111 11111111 11111111
00411F0   0000DC   11111111 11111111 11111111 11111111
0041200   0000EC   11111111 11111111 11111111 11111111
0041210   00000C   11111111 11111111 11111111 11111111
```

```
0041220    00001C    11111111 11111111 11111111 11111111
0041230    00002C    11111111 11111111 11111111 11111111
0041240    00003C    11111111 11111111 11111111 11111111
0041250    00004C    11111111 11111111 11111111 11111111
0041260    00005C    11111111 11111111 11111111 11111111
0041270    00006C    11111111 11111111 11111111 11111111
0041280    00007C    11111111 11111111 11111111 11111111
0041290    00008C    11111111 11111111 11111111 11111111
00412A0    00009C    11111111 11111111 11111111 11111111
00412B0    0000AC    11111111 11111111 11111111 00000000
```

THREADSAFE results of running on an L8 TCB

Running the exact same exit with no modifications but redefining it as THREADSAFE shows that we have exposed an underlying data integrity problem.

The RMIXIT program does not contain any EXEC CICS commands that would move it off the L8 TCB. Therefore once it is defined as THREADSAFE to CICS, it always runs on an L8 TCB. If a programmer performed a quick code review someone could actually think the code is threadsafe and go ahead and allow it to be defined as THREADSAFE, but as you can see, the results would be disastrous.

Example 7-13 Results of running the non threadsafe GLUE defined as THREADSAFE

```
0041030    00000C    00041104 00000033 00000000 11111111
0041040    00001C    11111111 11111111 11111111 11111111
0041050    00002C    11111111 00000000 00000000 00000000
0041060    00003C    11111111 00000000 11111111 00000000
0041070    00004C    11111111 11111111 11111111 11111111
0041080    00005C    00000000 00000000 00000000 00000000
0041090    00006C    11111111 11111111 11111111 11111111
00410A0    00007C    11111111 11111111 11111111 11111111
00410B0    00008C    11111111 11111111 11111111 11111111
00410C0    00009C    11111111 11111111 11111111 11111111
00410D0    0000AC    11111111 11111111 11111111 11111111
00410E0    0000BC    11111111 11111111 11111111 11111111
00410F0    0000CC    11111111 11111111 11111111 11111111
0041100    0000DC    11111111 11111111 00000000 00000000
0041110    0000EC    00000000 00000000 00000000 00000000
```

Interestingly enough, we had to add a loop in the middle of the program to slow it down to generate the contention. Without the loop the program appears to run OK, which means that it could run like this for years, and then all of a sudden corrupt some data.

7.6.2 Threadsafe code example

To make the code threadsafe in regards to data integrity, we have to make a few code changes. We will review the changes necessary in a later section, but for now here is the complete code snippet with the adjustments. In our example we chose to use the Compare and Swap method to serialize the storage. Due to the header being two words long we had to use the compare double and swap instruction.

This method allows you to read the data and update it, and then a single instruction that is serialized across all CPUs in the LPAR does a final compare against storage to verify what you originally read in is still in storage. It then stores the new changed results or fails and makes you retry via a code loop.

Example 7-14 Sample GLUE with threadsafe code

```
RMIXIT   DFHEIENT
RMIXIT   AMODE 31
RMIXIT   RMODE ANY
         LR    R2,R1                DFHUEPAR PLIST PROVIDED BY CALLER
         USING DFHUEPAR,R2          ADDRESS UEPAR PLIST
         L     R4,UEPGAA            GET GWA ADDRESS
         LA    R4,12(R4)            BUMP TO A DOUBLE WORD ADDR
         USING GWA,R4               ADDRESSABILITY
*
         LM   R6,R7,0(R4)           LOAD PGM ADDR AND CTR
AGAIN    EQU  *
         LA   R8,4(R6)              BUMP SAVED PGM ADDR BY 4
         LA   R9,1(R7)              BUMP CTR BY 1
         L    R5,LOOPCTR            DELAY LOOP TO GET SOME OVERLAP
LOOP     EQU  *                      SO THAT WE CAN GENERATE SOME
         BCT  R5,LOOP                TCB CONTENTION
         CDS  R6,R8,0(R4)           SAVE DATA VIA THD SAFE CMD
         BC   7,AGAIN               THD SAFE COMP LOOP
         L    R7,0(R8)              LOAD DATA AT PGM ADDR
         X    R7,ONES               FLIP THE BITS
         ST   R7,0(R8)              STORE THE DATA AT PGM ADDR
*
         LA    R15,UERCNORM         SET OK RESPONSE
         ST    R15,RETCODE            IN WORKING STORAGE
RETURN   EQU   *
         L     R15,RETCODE          FETCH RETURN CODE
         DFHEIRET RCREG=15          RETURN TO CICS
*********************************************************************
          DC    F'0'
ONES      DC    X'11111111'         ONES
LOOPCTR   DC    F'00777777'         TIME DELAY LOOP
```

```
***********************************************************************
         LTORG
         END   RMIXIT
```

QUASIRENT results running on the QR TCB

Running the fully threadsafe version of our exit in QUASIRENT mode worked perfectly, as we expected. Therefore there is no reason to show the results. So let us move on to the real test.

THREADSAFE results of running on an L8 TCB

We redefined the RMIXIT program as THREADSAFE, disabled it, copied it, and reenabled the GLUE at XRMIIN and XRMIOUT for another test.

Running in THREADSAFE mode on L8 TCBs we are now hitting the single shared global work area from multiple programs running concurrently. The data integrity has been maintained due to the compare double and swap logic we added to the program. We can now run our new RMIXIT in any mode with the knowledge that we are not going to corrupt any data.

Comparing the first two words of data against the previous run in Example 7-12 on page 190 shows that our count is again correct at 0A0 and the next address is again 00412B8.

Example 7-15 Results of running the threadsafe GLUE defined as THREADSAFE

```
0041030   00000C   000412B8 000000A0 00000000 11111111
0041040   00001C   11111111 11111111 11111111 11111111
0041050   00002C   11111111 11111111 11111111 11111111
0041060   00003C   11111111 11111111 11111111 11111111
0041070   00004C   11111111 11111111 11111111 11111111
0041080   00005C   11111111 11111111 11111111 11111111
0041090   00006C   11111111 11111111 11111111 11111111
00410A0   00007C   11111111 11111111 11111111 11111111
00410B0   00008C   11111111 11111111 11111111 11111111
00410C0   00009C   11111111 11111111 11111111 11111111
00410D0   0000AC   11111111 11111111 11111111 11111111
00410E0   0000BC   11111111 11111111 11111111 11111111
00410F0   0000CC   11111111 11111111 11111111 11111111
0041100   0000DC   11111111 11111111 11111111 11111111
0041110   0000EC   11111111 11111111 11111111 11111111
0041120   00000C   11111111 11111111 11111111 11111111
0041130   00001C   11111111 11111111 11111111 11111111
0041140   00002C   11111111 11111111 11111111 11111111
0041150   00003C   11111111 11111111 11111111 11111111
0041160   00004C   11111111 11111111 11111111 11111111
0041170   00005C   11111111 11111111 11111111 11111111
```

```
0041180   00006C   11111111 11111111 11111111 11111111
0041190   00007C   11111111 11111111 11111111 11111111
00411A0   00008C   11111111 11111111 11111111 11111111
00411B0   00009C   11111111 11111111 11111111 11111111
00411C0   0000AC   11111111 11111111 11111111 11111111
00411D0   0000BC   11111111 11111111 11111111 11111111
00411E0   0000CC   11111111 11111111 11111111 11111111
00411F0   0000DC   11111111 11111111 11111111 11111111
0041200   0000EC   11111111 11111111 11111111 11111111
0041210   00000C   11111111 11111111 11111111 11111111
0041220   00001C   11111111 11111111 11111111 11111111
0041230   00002C   11111111 11111111 11111111 11111111
0041240   00003C   11111111 11111111 11111111 11111111
0041250   00004C   11111111 11111111 11111111 11111111
0041260   00005C   11111111 11111111 11111111 11111111
0041270   00006C   11111111 11111111 11111111 11111111
0041280   00007C   11111111 11111111 11111111 11111111
0041290   00008C   11111111 11111111 11111111 11111111
00412A0   00009C   11111111 11111111 11111111 11111111
00412B0   0000AC   11111111 11111111 11111111 00000000
```

7.6.3 Code changes to make RMIXIT threadsafe

First let us go through the code and break it down by function so the new changes make sense (Example 7-16). In our example we chose to use the compare double and swap instruction to serialize our data. We could also have used ENQ/DEQ. In fact, we used both methods. We include the ENQ/DEQ sample later.

Example 7-16 Code broken down into function

```
         (A) Load the two word header

         L     R6,0(R4)              LOAD SAVED PGM ADDR
         L     R7,4(R4)              LOAD CTR

         (B) Update the Header Address value and counter

         LA    R8,4(R6)              BUMP SAVED PGM ADDR BY 4
         LA    R9,1(R7)              BUMP CTR BY 1

         (C) Artificial loop used to simulate real program workload

         L     R5,LOOPCTR            DELAY LOOP TO GET SOME OVERLAP
LOOP     EQU   *                      SO THAT WE CAN GENERATE SOME
         BCT   R5,LOOP                TCB CONTENTION
```

```
         (D) Save the updated header back into the shared storage

         ST   R8,0(R4)              STORE PGM ADDR AT HEADER ADDR
         ST   R9,4(R4)              STORE THE CTR AT WORD 2 IN HEADER

         (E) Store Ones into the shared storage using the header address value

         L    R7,0(R8)              LOAD DATA AT PGM ADDR
         X    R7,ONES               FLIP THE BITS
         ST   R7,0(R8)              STORE THE DATA AT PGM ADDR
```

Sections (A) and (D) need to be modified. Sections (B) and (E) stay the same, and section (C) is an artificial loop added to the code to create real-world processing time delays to generate concurrent TCB contention.

Section (A) loads the header from shared storage via two load instructions. For our case only, the manual *z/Architecture Principles of Operation*, SA22-7832, recommends using a load multiple to load both registers without introducing a window between the two loads where the data could be changed.

Example 7-17 Modifying section (A), loading the header

```
LM   R6,R7,0(R4)           LOAD PGM ADDR AND CTR
```

In section (D) we convert the two store instructions into a single compare double and swap instruction.

Example 7-18 Modifying section (D), saving the updated header

```
AGAIN    EQU  *
         LA   R8,4(R6)              BUMP SAVED PGM ADDR BY 4
         LA   R9,1(R7)              BUMP CTR BY 1
         L    R5,LOOPCTR            DELAY LOOP TO GET SOME OVERLAP
LOOP     EQU  *                      SO THAT WE CAN GENERATE SOME
         BCT  R5,LOOP                TCB CONTENTION
         CDS  R6,R8,0(R4)           SAVE DATA VIA THD SAFE CMD
         BC   7,AGAIN               THD SAFE COMP LOOP
```

What the Compare and Swap instruction does is compare what you originally loaded with what is in storage and, based on the result, do one of following two actions:

- If the original data is unchanged it stores your new updates, as in registers 8 and 9, in the storage location.
- If the original data changed, it reloads registers 6 and 7 with the new values from storage.

You then check the return codes from the CDS command and branch accordingly. In our case, for option 1 we drop through the code into unchanged section (E) to store our ones into memory. The address we have is already locked in and is ours, so we can perform this function after the fact.

For option 2 the CDS instruction simulates section (A) for us so we need to go backwards in the code and redo our updates and then retry to store our data again. Notice that this is actually coded as an infinite loop, which could be dangerous. It might have been cleaner to put a loop counter in there and abend the transaction if it cannot serialize the data. However, due to the fact it was difficult getting contention, we felt it was a very low chance we would ever go into an infinite loop.

7.7 Coordinating and driving individual application conversions

Once you have converted all appropriate GLUEs, TRUEs, URMs, and exits, the next step in the conversion process is the application programs themselves. Depending on how each shop is set up, you may have a varying role in helping coordinate the application conversions to threadsafe applications.

Your key role may be to identify what CICS region is ready for the conversion or you may have, in your region-by-region analysis, collected statistics on how many TCB switches are taking place for individual application programs. Armed with performance data on TCB switches you may be the key person to help identify the application conversion selection order.

Obviously applications that perform large amounts of DB2 calls, as opposed to single table lookups, will benefit the most from the conversion. The same principle applies to applications with large volumes of WMQ calls.

By using tools like CICS PA the systems programmer can help identify which applications are the best candidates for conversion first. See 5.1.3, “How to use CICS PA to identify threadsafe candidates” on page 73.

Chapter 6, "Application review" on page 139, describes the process of making applications threadsafe.

7.7.1 Changing your program definitions

Once the applications have been changed or verified to be threadsafe, then the final action that is needed to make the application stay on the L8 TCB is to change the definition of all the programs concerned to define them as threadsafe.

```
 OBJECT CHARACTERISTICS                                    CICS RELEASE = 0630
  CEDA  View PROGram( DB2MANY  )
   PROGram        : DB2MANY
   Group          : THDSAFE
   DEscription    :
   Language       :                  CObol | Assembler | Le370 | C | Pli
   RELoad         : No               No | Yes
   RESident       : No               No | Yes
   USAge          : Normal           Normal | Transient
   USElpacopy     : No               No | Yes
   Status         : Enabled          Enabled | Disabled
   RSl            : 00               0-24 | Public
   CEdf           : Yes              Yes | No
   DAtalocation   : Any              Below | Any
   EXECKey        : User             User | Cics
   COncurrency    : Threadsafe       Quasirent | Threadsafe
   Api            : Cicsapi          Cicsapi | Openapi
REMOTE ATTRIBUTES
   DYnamic        : No               No | Yes
 + REMOTESystem   :

                                                      SYSID=PJA7 APPLID=SCSCPJA7

 PF 1 HELP 2 COM 3 END              6 CRSR 7 SBH 8 SFH 9 MSG 10 SB 11 SF 12 CNCL
```

Figure 7-10 Changing program definitions

For more information about changing a program's concurrency definition see 7.5.3, "Change your exit program's CONCURRENCY definition to THREADSAFE" on page 185.

7.8 Post-conversion monitoring

The concept of making a program threadsafe can seem simple. However, in reality it can be extremely complex. Identifying which EXEC CICS commands may cause a program to have excessive TCB switching is straightforward. You can look up a list of all the threadsafe commands and search your code and then make the appropriate adjustments.

Making a program threadsafe is much harder because you first have to identify any shared resources. This may be disguised due to the fact that the address of shared storage is obtained from a commarea passed into the program.

There really is no tool or process you can use to monitor for changes in application programs. However, you can periodically monitor your region for TCB switches via tools such as CICS PA. The fact is that a programmer could introduce a non threadsafe EXEC CICS command into a program that has already been converted and therefore introduce extra TCB switches.

To help combat this you may want to alter any existing performance reports you currently run to add change mode counts to your reports then if you can identify any changes in TCB switching.

7.9 Summary

In review, the system programmer is responsible for making the CICS environment threadsafe so that application programs can take advantage of the performance benefits of threadsafe DB2 and WMQ applications.

To make the CICS environment threadsafe the system programmer will need to:

- Review the DB2 version and system parameters.
- Review the WMQ environment and system parameters.
- Review and adjust the CICS system parameters.
- Review and convert any GLUEs in the DB2 and WMQ call paths to threadsafe standards.
- Do the same for those GLUEs on the path of threadsafe EXEC CICS commands, particularly for heavily used API options such as file control.
- Assist application programmers with analyzing their programs by using utilities such as DFH0STAT and DFHEISUP, or tools such as CICS IA and CICS PA.
- Potentially work with the application teams to help prioritize their application threadsafe migrations.
- Convert the actual program definition changes to CONCURRENCY(THREADSAFE).

- The autoinstall program needs to be modified to change the CONCURRENCY value if used, or the environment variable CICSVAR can be used.

Additionally, system programmers may perform periodic reviews of their CICS regions using tools such as CICS PA to monitor the L8 to QR TCB statistics checking to see if applications are really in effect running on the L8 TCBs.

Note: Prior to CICS Transaction Server Version 3, the field in the CICS SMF 110 record that contained the count of TCB switches (change modes) is called CHMODECT.

In CICS Transaction Server Version 3 the CHMODECT field has been removed and replaced by a composite field called DSCHMDLY. This composite field consists of a time and a count.

- The time portion represents the elapsed time the user task waited for redispatch after change mode requests. For example, a change mode request from an L8 TCB back to the QR TCB may have to wait for the QR TCB because another task is currently dispatched on the QR TCB.
- The count portion represents the number of change modes and is equivalent to CHMODECT in previous releases.

8

Migration pitfalls

In this chapter we highlight some of the pitfalls you might encounter when migrating a CICS region. In particular we discuss the following:

- The need to examine the use of CICS global user exits for applications that call DB2 or WMQ
- Use of OPENAPI and additional TCB switching
- Function shipping in your CICS systems
- Use of COBOL Call
- The CSACDTA/CSAQRTCA field

8.1 Migrating CICS DB2 regions

When migrating a CICS region to CICS Transaction Server Version 2 or Version 3 you must ensure that your DB2 applications do not suffer any adverse effects because of the change to using open TCBs for calls to DB2. This is independent of whether you are intending to make your application code threadsafe.

8.1.1 The potential pitfall

The CICS DB2 adapter includes the task-related user exit (TRUE) DFHD2EX1. This TRUE is THREADSAFE and automatically enabled with the OPENAPI option on the ENABLE PROGRAM command during the connect process. If your program is defined as THREADSAFE (rather than OPENAPI), when your program makes a DB2 call, CICS switches the task to an OPEN L8 TCB by performing a TCB switch from the QR TCB to the L8 TCB.

If your program is defined as QUASIRENT and you are running exits XRMIIN, XRMIOUT, or a dynamic plan exit enabled as QUASIRENT, there is the potential of experiencing additional TCB switches back to the QR TCB. These switches are easily avoided if these exits are written to threadsafe standards and then enabled as THREADSAFE.

The following two scenarios show the program flow and TCB switches of a program making one DB2 call.

- The first scenario is from a CICS Transaction Server Version 1.3 region.
- The second shows the same application running in a CICS Transaction Server Version 2 or Version 3 region with exits XRMIIN, XRMIOUT, and a dynamic plan exit all enabled as QUASIRENT.

DB2 application in CICS Transaction Server 1.3

Figure 8-1 shows transaction TRANA running in a CICS Transaction Server Version 1.3 environment and making one DB2 call. Notice that the application as well as all exit programs run on the QR TCB, and the actual call to DB2 is made on the thread TCB. The diagram shows that two TCB switches are made around the call to DB2—one to switch to the thread TCB and one to switch back to the QR TCB afterwards.

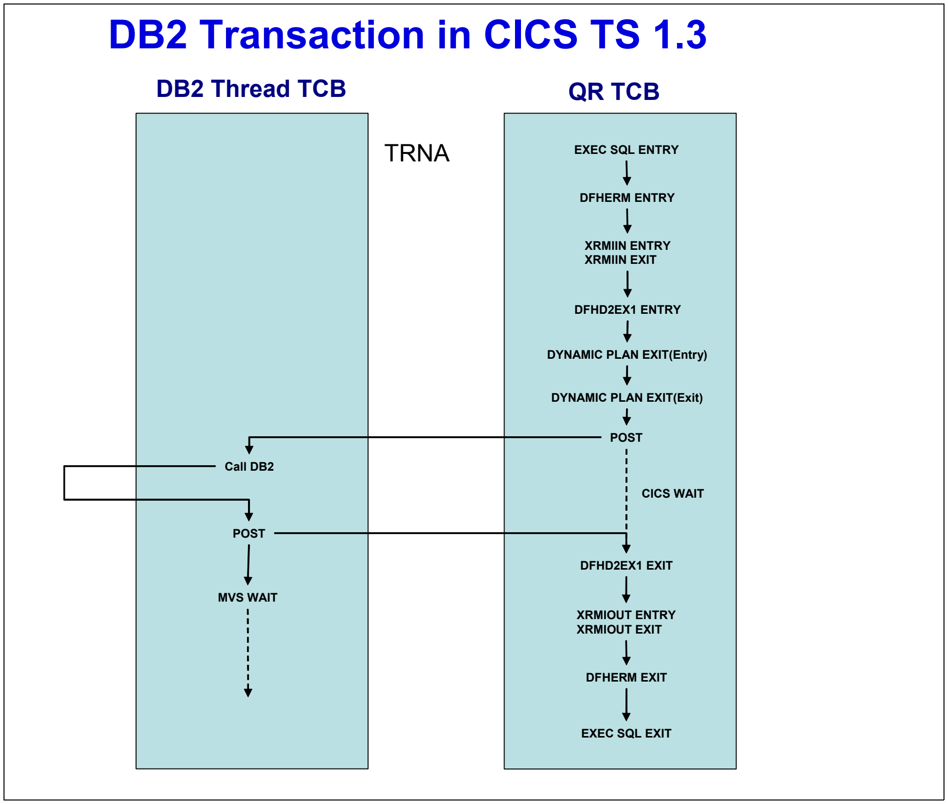

Figure 8-1 TCB switch in CICS TS 1.3

DB2 application in CICS Transaction Server 2 or 3

Figure 8-2 on page 204 shows the same transaction, TRANA, running in a CICS Transaction Server Version 2 or Version 3 environment and making one DB2 call. The transaction was migrated to CICS Transaction Server Version 2 or Version 3 with *no* consideration of threadsafe, which means that the program associated with transaction TRANA is defined as QUASIRENT and all exits are enabled as QUASIRENT. This diagram shows that there is a potential to experience additional TCB switches from the L8 TCB to the QR TCB and back. The non threadsafe exits must run on the QR TCB to ensure that serialization occurs. In this example we see eight TCB switches occur, compared with two switches in the previous example. If the exits were written to threadsafe standards and then enabled as THREADSAFE their associated programs would be allowed to continue running on the L8 TCB and the additional switches would not be necessary. This is shown in the next section.

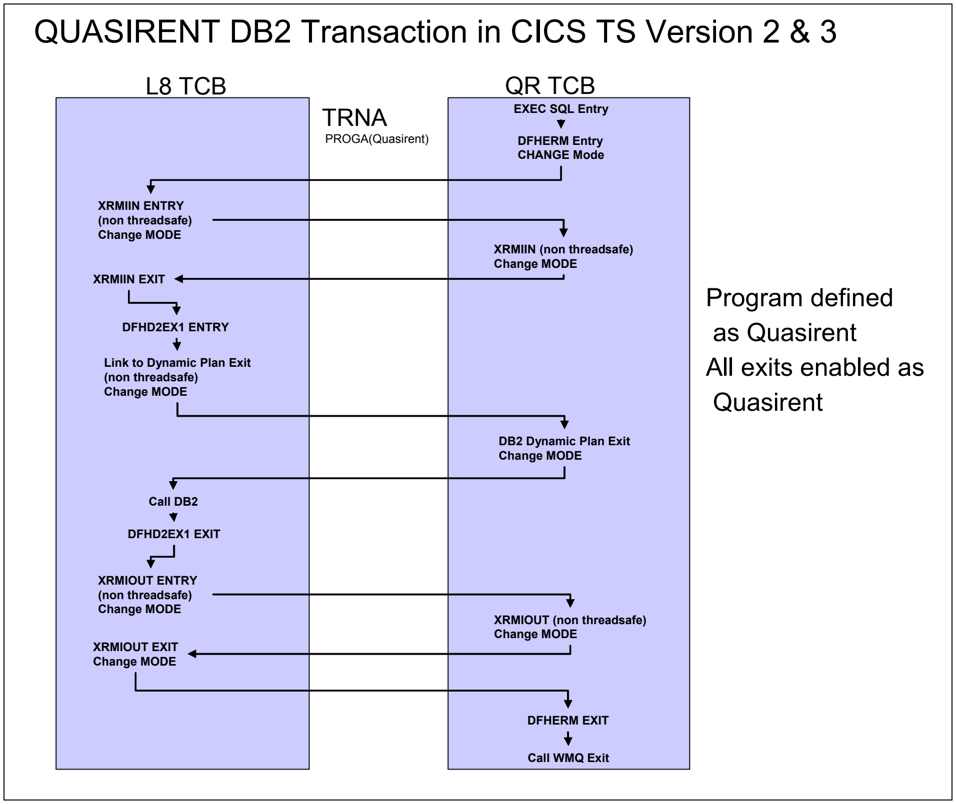

Figure 8-2 TCB switches before exits are enabled as threadsafe on CICS TS Version 2 and Version 3

Example 8-1 is a CICS auxtrace showing the additional TCB switches shown in Figure 8-2 on page 204.

Example 8-1 CICS trace of potential switches with non threadsafe exits

```
00258 QR    AP 2520 ERM   ENTRY ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                                    =003356=
00258 QR    US 0401 USXM  ENTRY INQUIRE_TRANSACTION_USER                                                                        =003357=
00258 QR    US 0402 USXM  EXIT  INQUIRE_TRANSACTION_USER/OK 00000000                                                            =003358=
00258 QR    RM 0301 RMLN  ENTRY ADD_LINK             RMI,22F914A4 , 00000000 , 00000008,000949D0 , 00000000 , 00000008,22F =003359=
00258 QR    RM 0302 RMLN  EXIT  ADD_LINK/OK          01C80006,22F914A4 , 00000000 , 00000008,000949D0 , 00000000 , 0000000 =003360=
00258 QR    DS 0002 DSAT  ENTRY CHANGE_MODE          0000000C                                                               =003361=
00258 L8000 DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                                  =003369=
00258 L8000 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIIN                                           =003370=
00258 L8000 DS 0002 DSAT  ENTRY CHANGE_MODE          QR                                                                     =003371=
00258 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                                  =003377=
00258 QR    SM 0C01 SMMG  ENTRY GETMAIN              198,YES,00,TASK                                                        =003378=
00258 QR    SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788                                                               =003379=
00258 QR    SM 0D01 SMMF  ENTRY FREEMAIN             226E1788                                                               =003380=
00258 QR    SM 0D02 SMMF  EXIT  FREEMAIN/OK          USER storage at 226E1788                                               =003381=
00258 QR    AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                                         =003382=
00258 QR    DS 0002 DSAT  ENTRY CHANGE_MODE          L8                                                                     =003383=
00258 L8000 DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                                  =003384=
00258 L8000 AP 3180 D2EX1 ENTRY APPLICATION          REQUEST EXEC SQL SELECT                                                =003385=
00258 L8000 PG 0A01 PGLU  ENTRY LINK_URM             DB2PLAN,22BE7678 , 0000001C,NO,NO                                      =003386=
00258 L8000 DD 0301 DDLO  ENTRY LOCATE               21C27B70,22BE7574,PPT,DB2PLAN                                          =003387=
00258 L8000 DD 0302 DDLO  EXIT  LOCATE/OK            D7D7E3C5 , 22DA5B88                                                    =003388=
00258 L8000 LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM      22C87258                                                               =003389=
00258 L8000 LD 0002 LDLD  EXIT  ACQUIRE_PROGRAM/OK   A43002D8,243002B0,D8,0,REUSABLE,ESDSA,OLD_COPY                         =003390=
00258 L8000 AP 1940 APLI  ENTRY START_PROGRAM        DB2PLAN,CEDF,FULLAPI,URM,NO,22F89C10,22BE7678 , 0000001C,3             =003391=
00258 L8000 DS 0002 DSAT  ENTRY CHANGE_MODE          QR                                                                     =003392=
00258 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                                  =003393=
00258 QR    SM 0C01 SMMG  ENTRY GETMAIN              190,YES,00,TASK                                                        =003394=
00258 QR    SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788                                                               =003395=
00258 QR    AP 00E1 EIP   ENTRY RETURN                                      0004,226E1798 .>.q,08000E08 ....                =003396=
00258 QR    AP E160 EXEC  ENTRY RETURN               ASM                                                                    =003397=
00258 QR    SM 0301 SMGF  ENTRY FREEMAIN             226E1788,TASK                                                          =003398=
00258 QR    SM 0302 SMGF  EXIT  FREEMAIN/OK                                                                                     =003399=
00258 QR    AP 1941 APLI  EXIT  START_PROGRAM/OK     ....,NO,DB2PLAN                                                        =003400=
00258 QR    LD 0001 LDLD  ENTRY RELEASE_PROGRAM      22C87258,A43002D8                                                      =003401=
00258 QR    LD 0002 LDLD  EXIT  RELEASE_PROGRAM/OK   243002B0,D8,ESDSA                                                      =003402=
00258 QR    DS 0002 DSAT  ENTRY CHANGE_MODE          L8                                                                     =003403=
00258 L8000 DS 0003 DSAT  EXIT  CHANGE_MODE/OK       QR                                                                     =003404=
00258 L8000 PG 0A02 PGLU  EXIT  LINK_URM/OK                                                                                     =003405=
00258 L8000 AP 3250 D2D2  ENTRY DB2_API_CALL         230D7030                                                               =003406=
00258 L8000 AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                                 =003407=
00258 L8000 AP 3181 D2EX1 EXIT  APPLICATION-REQUEST  SQLCODE 0 RETURNED ON EXEC SQL SELECT                                  =003408=
00258 L8000 MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME  DSNCSQL                                                                =003409=
00258 L8000 MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                                          =003410=
00258 L8000 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIOUT                                          =003411=
00258 L8000 DS 0002 DSAT  ENTRY CHANGE_MODE          QR                                                                     =003412=
00258 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                                  =003413=
00258 QR    SM 0C01 SMMG  ENTRY GETMAIN              198,YES,00,TASK                                                        =003414=
00258 QR    SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788                                                               =003415=
00258 QR    SM 0D01 SMMF  ENTRY FREEMAIN             226E1788                                                               =003416=
00258 QR    SM 0D02 SMMF  EXIT  FREEMAIN/OK          USER storage at 226E1788                                               =003417=
00258 QR    AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                                         =003418=
00258 QR    DS 0002 DSAT  ENTRY CHANGE_MODE          L8                                                                     =003419=
00258 L8000 DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                                  =003420=
00258 L8000 RM 0301 RMLN  ENTRY SET_LINK             01C80006,22F914AC , 0000000C , 00000008,YES,NECESSARY                  =003421=
00258 L8000 RM 0302 RMLN  EXIT  SET_LINK/OK          22F914AC , 0000000C , 00000008,                                        =003422=
00258 L8000 DS 0002 DSAT  ENTRY CHANGE_MODE          00000001                                                               =003423=
00258 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                                  =003424=
00258 QR    AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                                    =003425=
```

8.1.2 The solution

In order to demonstrate how to avoid this pitfall we now examine two additional scenarios:

- The first shows the effect of having only the exits on the DB2 call path written to threadsafe standards and enabled as threadsafe (XRMIIN and XRMIOUT exits and the dynamic plan exit).
- The second shows the true benefit threadsafe has to offer having coded *both* the application program and programs associated with all the exits on the DB2 call path to threadsafe standards and defining them as THREADSAFE.

Enable exits on the DB2 call path to be THREADSAFE

Figure 8-3 on page 207 shows the same transaction, TRNA, running in a CICS Transaction Server Version 2 or Version 3 environment and making one DB2 call. The transaction was migrated to CICS Transaction Server Version 2 or Version 3 *with* threadsafe consideration in mind.

The program associated with transaction TRANA is still defined as Quasirent. However, XRMIIN, XRMIOUT, and the dynamic plan exits have been coded to threadsafe standards and then enabled as THREADSAFE. This diagram shows that the number of TCB switches is back to the original two switches, as seen in the CICS Transaction Server Version 1.3 scenario. However, a TCB switchback to the QR TCB must still take place upon completion of the DB2 call due to TRNA's program not being threadsafe. Therefore, there are two TCB switches for each DB2 call.

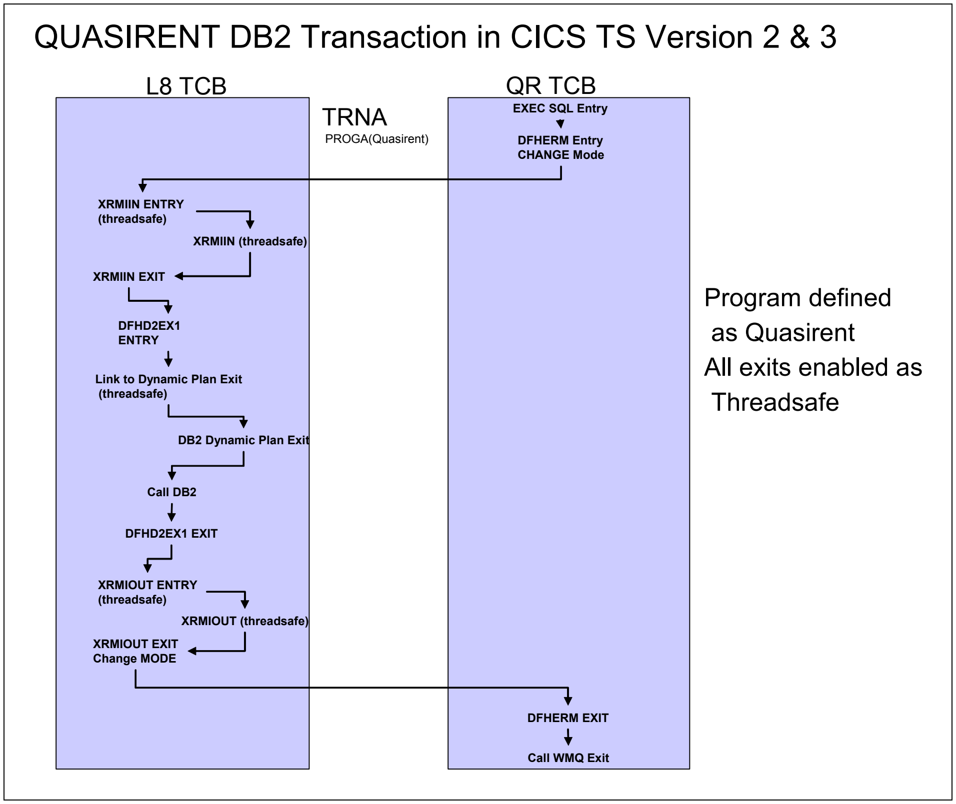

Figure 8-3 TCB switches after exits are made threadsafe on CICS TS Version 2 and Version 3

Example 8-2 on page 208 is a CICS auxiliary trace that demonstrates the TCB switches described by Figure 8-3.

Example 8-2 CICS trace of TCB switches with threadsafe exits

```
00307 QR    AP 2520 ERM   ENTRY ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                          =000266=
00307 QR    US 0401 USXM  ENTRY INQUIRE_TRANSACTION_USER                                                              =000267=
00307 QR    US 0402 USXM  EXIT  INQUIRE_TRANSACTION_USER/OK 00000000                                                  =000268=
00307 QR    RM 0301 RMLN  ENTRY ADD_LINK            RMI,22F914A4 , 00000000 , 00000008,000949D0 , 00000000 , 00000008,22F =000269=
00307 QR    RM 0302 RMLN  EXIT  ADD_LINK/OK         01C80011,22F914A4 , 00000000 , 00000008,000949D0 , 00000000 , 0000000 =000270=
00307 QR    DS 0002 DSAT  ENTRY CHANGE_MODE         0000000C                                                              =000271=
00307 L8000 DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                            =000279=
00307 L8000 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIIN                                     =000280=
00307 L8000 SM 0C01 SMMG  ENTRY GETMAIN             198,YES,00,TASK                                                       =000281=
00307 L8000 SM 0C02 SMMG  EXIT  GETMAIN/OK          226E1788                                                              =000282=
00307 L8000 SM 0D01 SMMF  ENTRY FREEMAIN            226E1788                                                              =000283=
00307 L8000 SM 0D02 SMMF  EXIT  FREEMAIN/OK         USER storage at 226E1788                                              =000284=
00307 L8000 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                                   =000285=
00307 L8000 AP 3180 D2EX1 ENTRY APPLICATION         REQUEST EXEC SQL SELECT                                               =000286=
00307 L8000 PG 0A01 PGLU  ENTRY LINK_URM            DB2PLAN,22BE7678 , 0000001C,NO,NO                                     =000287=
00307 L8000 DD 0301 DDLO  ENTRY LOCATE              21C27B70,22BE7574,PPT,DB2PLAN                                         =000288=
00307 L8000 DD 0302 DDLO  EXIT  LOCATE/OK           D7D7E3C5 , 22DA5B30                                                   =000289=
00307 L8000 LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM     22C871A0                                                              =000290=
00307 L8000 LD 0002 LDLD  EXIT  ACQUIRE_PROGRAM/OK  A43002D8,243002B0,D8,0,REUSABLE,ESDSA,OLD_COPY                        =000291=
00307 L8000 AP 1940 APLI  ENTRY START_PROGRAM       DB2PLAN,CEDF,FULLAPI,URM,NO,22F89A94,22BE7678 , 0000001C,3            =000292=
00307 L8000 SM 0C01 SMMG  ENTRY GETMAIN             190,YES,00,TASK                                                       =000293=
00307 L8000 SM 0C02 SMMG  EXIT  GETMAIN/OK          226E1788                                                              =000294=
00307 L8000 AP 00E1 EIP   ENTRY RETURN                                          0004,226E1798 .>.q,08000E08 ....          =000295=
00307 L8000 AP E160 EXEC  ENTRY RETURN              ASM                                                                   =000296=
00307 L8000 SM 0301 SMGF  ENTRY FREEMAIN            226E1788,TASK                                                         =000297=
00307 L8000 SM 0302 SMGF  EXIT  FREEMAIN/OK                                                                               =000298=
00307 L8000 AP 1941 APLI  EXIT  START_PROGRAM/OK    ....,NO,DB2PLAN                                                       =000299=
00307 L8000 LD 0001 LDLD  ENTRY RELEASE_PROGRAM     22C871A0,A43002D8                                                     =000300=
00307 L8000 LD 0002 LDLD  EXIT  RELEASE_PROGRAM/OK  243002B0,D8,ESDSA                                                     =000301=
00307 L8000 PG 0A02 PGLU  EXIT  LINK_URM/OK                                                                               =000302=
00307 L8000 AP 3250 D2D2  ENTRY DB2_API_CALL        230D7030                                                              =000303=
00307 L8000 AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                           =000309=
00307 L8000 AP 3181 D2EX1 EXIT  APPLICATION-REQUEST   SQLCODE 0 RETURNED ON EXEC SQL SELECT                               =000310=
00307 L8000 MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME   DSNCSQL                                                             =000311=
00307 L8000 MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                                    =000312=
00307 L8000 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIOUT                                    =000313=
00307 L8000 SM 0C01 SMMG  ENTRY GETMAIN             198,YES,00,TASK                                                       =000314=
00307 L8000 SM 0C02 SMMG  EXIT  GETMAIN/OK          226E1788                                                              =000315=
00307 L8000 SM 0D01 SMMF  ENTRY FREEMAIN            226E1788                                                              =000316=
00307 L8000 SM 0D02 SMMF  EXIT  FREEMAIN/OK         USER storage at 226E1788                                              =000317=
00307 L8000 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                                   =000318=
00307 L8000 RM 0301 RMLN  ENTRY SET_LINK            01C80011,22F914AC , 0000000C , 00000008,YES,NECESSARY                 =000319=
00307 L8000 RM 0302 RMLN  EXIT  SET_LINK/OK         22F914AC , 0000000C , 00000008,                                       =000320=
00307 L8000 DS 0002 DSAT  ENTRY CHANGE_MODE         00000001                                                              =000321=
00307 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                            =000322=
00307 QR    AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                          =000323=
00307 QR    AP 00E1 EIP   ENTRY RETURN                                          0004,226E1458 .>..,08000E08 ....          =000324=
```

Enable both the application program and all exits on the DB2 call path to be THREADSAFE

Figure 8-4 on page 209 shows the same transaction, TRANA, running in a CICS Transaction Server Version 2 or Version 3 environment and making one DB2 call.

The transaction was migrated to CICS Transaction Server Version 2 or Version 3 *with* threadsafe consideration in mind. The program associated with transaction TRANA *and* the programs associated with XRMIIN, XRMIOUT, and the dynamic plan exits are all written to threadsafe standards and defined as THREADSAFE.

This diagram shows a TCB switch from the QR TCB to the L8 TCB for the first DB2 call. Upon completion of the DB2 call the program remains on the L8 TCB. The number of DB2 calls that could be made without another TCB switch is only limited by the design of the application. There would only have to be a TCB switchback to the QR TCB at task termination time, unless non threadsafe EXEC CICS commands were issued. This is where you begin to see what threadsafe can offer with regard to potential savings in both CPU and response time.

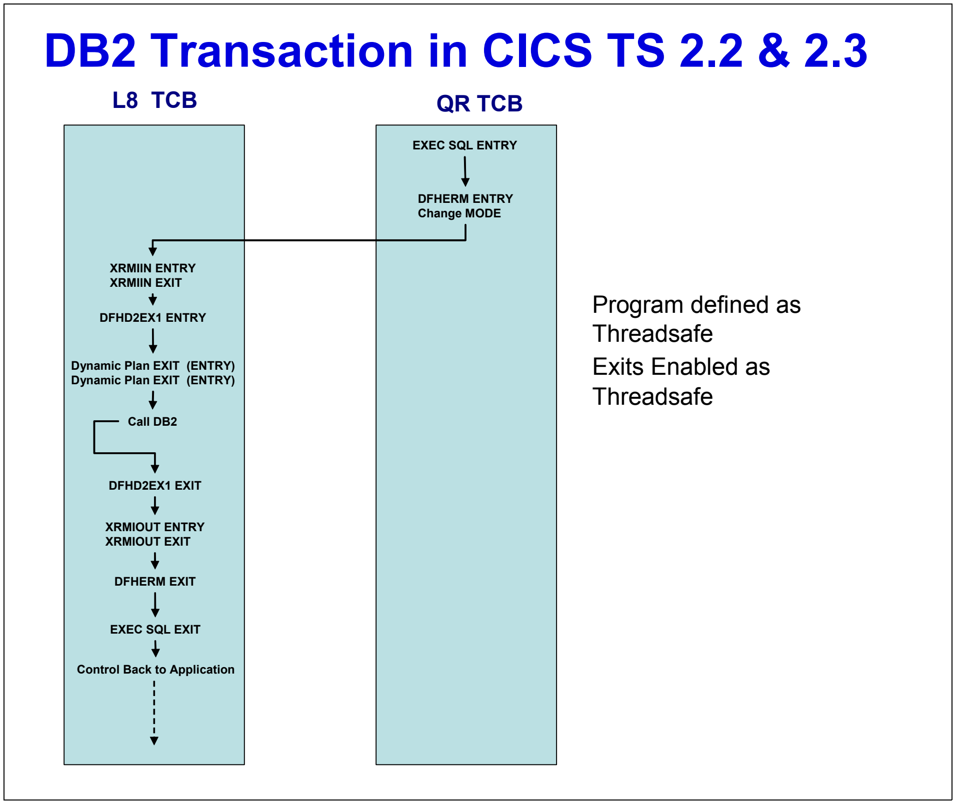

Figure 8-4 TCB switches with programs and exits running as threadsafe on CICS TS Version 2 or Version 3

Example 8-3 on page 210 is an example CICS trace showing the TCB switches described by Figure 8-4 after XRMIIN, XRMIOUT, the dynamic plan exit *and* the application program associated with transaction TRNA were written to threadsafe standards and then defined or enabled as THREADSAFE.

To be consistent, the diagram in Figure 8-4 only shows one DB2 call. However, the associated trace in Example 8-3 continues on to reflect a second DB2 call. You can see that the second DB2 call runs on the L8 TCB and no TCB switch was made.

Example 8-3 CICS trace of TCB switches with threadsafe program and exits

```
00772 QR    AP 2520 ERM   ENTRY ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                                 =000242=
00772 QR    US 0401 USXM  ENTRY INQUIRE_TRANSACTION_USER                                                                     =000243=
00772 QR    US 0402 USXM  EXIT  INQUIRE_TRANSACTION_USER/OK 00000000                                                         =000244=
00772 QR    RM 0301 RMLN  ENTRY ADD_LINK             RMI,24C57CE4 , 00000000 , 00000008,000949D0 , 00000000 , 00000008,24C =000245=
00772 QR    RM 0302 RMLN  EXIT  ADD_LINK/OK          0154000C,24C57CE4 , 00000000 , 00000008,000949D0 , 00000000 , 0000000 =000246=
00772 QR    DS 0002 DSAT  ENTRY CHANGE_MODE          0000000C                                                              =000247=
00772 L8001 DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                             =000255=
00772 L8001 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIIN                                      =000256=
00772 L8001 SM 0C01 SMMG  ENTRY GETMAIN              198,YES,00,TASK                                                       =000257=
00772 L8001 SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788                                                              =000258=
00772 L8001 SM 0D01 SMMF  ENTRY FREEMAIN             226E1788                                                              =000259=
00772 L8001 SM 0D02 SMMF  EXIT  FREEMAIN/OK          USER storage at 226E1788                                              =000260=
00772 L8001 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                                    =000261=
00772 L8001 AP 3180 D2EX1 ENTRY APPLICATION          REQUEST EXEC SQL SELECT                                               =000262=
00772 L8001 PG 0A01 PGLU  ENTRY LINK_URM             DB2PLAN,22C1E678 , 0000001C,NO,NO                                     =000263=
00772 L8001 DD 0301 DDLO  ENTRY LOCATE               21C27B70,22C1E574,PPT,DB2PLAN                                         =000264=
00772 L8001 DD 0302 DDLO  EXIT  LOCATE/OK            D7D7E3C5 , 22DA5B30                                                   =000265=
00772 L8001 LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM      22C871A0                                                              =000266=
00772 L8001 LD 0002 LDLD  EXIT  ACQUIRE_PROGRAM/OK   A43002D8,243002B0,D8,0,REUSABLE,ESDSA,OLD_COPY                        =000267=
00772 L8001 AP 1940 APLI  ENTRY START_PROGRAM        DB2PLAN,CEDF,FULLAPI,URM,NO,22F89A94,22C1E678 , 0000001C,3            =000268=
00772 L8001 SM 0C01 SMMG  ENTRY GETMAIN              190,YES,00,TASK                                                       =000269=
00772 L8001 SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788                                                              =000270=
00772 L8001 AP 00E1 EIP   ENTRY RETURN                                          0004,226E1798 .>.q,08000E08 ....           =000271=
00772 L8001 AP E160 EXEC  ENTRY RETURN               ASM                                                                   =000272=
00772 L8001 SM 0301 SMGF  ENTRY FREEMAIN             226E1788,TASK                                                         =000273=
00772 L8001 SM 0302 SMGF  EXIT  FREEMAIN/OK                                                                                =000274=
00772 L8001 AP 1941 APLI  EXIT  START_PROGRAM/OK     ....,NO,DB2PLAN                                                       =000275=
00772 L8001 LD 0001 LDLD  ENTRY RELEASE_PROGRAM      22C871A0,A43002D8                                                     =000276=
00772 L8001 LD 0002 LDLD  EXIT  RELEASE_PROGRAM/OK   243002B0,D8,ESDSA                                                     =000277=
00772 L8001 PG 0A02 PGLU  EXIT  LINK_URM/OK                                                                                =000278=
00772 L8001 AP 3250 D2D2  ENTRY DB2_API_CALL         230D7030                                                              =000279=
00772 L8001 AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                            =000285=
00772 L8001 AP 3181 D2EX1 EXIT  APPLICATION-REQUEST  SQLCODE 0 RETURNED ON EXEC SQL SELECT                                 =000286=
00772 L8001 MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME  DSNCSQL                                                               =000287=
00772 L8001 MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                                     =000288=
00772 L8001 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIOUT                                     =000289=
00772 L8001 SM 0C01 SMMG  ENTRY GETMAIN              198,YES,00,TASK                                                       =000290=
00772 L8001 SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788                                                              =000291=
00772 L8001 SM 0D01 SMMF  ENTRY FREEMAIN             226E1788                                                              =000292=
00772 L8001 SM 0D02 SMMF  EXIT  FREEMAIN/OK          USER storage at 226E1788                                              =000293=
00772 L8001 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                                    =000294=
00772 L8001 RM 0301 RMLN  ENTRY SET_LINK             0154000C,24C57CEC , 0000000C , 00000008,YES,NECESSARY                 =000295=
00772 L8001 RM 0302 RMLN  EXIT  SET_LINK/OK          24C57CEC , 0000000C , 00000008,                                       =000296=
00772 L8001 AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                               =000297=
00772 L8001 AP 2520 ERM   ENTRY ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                               =000298=
00772 L8001 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIIN                                      =000299=
00772 L8001 SM 0C01 SMMG  ENTRY GETMAIN              198,YES,00,TASK                                                       =000300=
00772 L8001 SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788                                                              =000301=
00772 L8001 SM 0D01 SMMF  ENTRY FREEMAIN             226E1788                                                              =000302=
00772 L8001 SM 0D02 SMMF  EXIT  FREEMAIN/OK          USER storage at 226E1788                                              =000303=
00772 L8001 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                                    =000304=
00772 L8001 AP 3180 D2EX1 ENTRY APPLICATION          REQUEST EXEC SQL SELECT                                               =000305=
00772 L8001 AP 3250 D2D2  ENTRY DB2_API_CALL         230D7030                                                              =000306=
00772 L8001 AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                            =000307=
00772 L8001 AP 3181 D2EX1 EXIT  APPLICATION-REQUEST  SQLCODE 0 RETURNED ON EXEC SQL SELECT                                 =000308=
00772 L8001 MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME  DSNCSQL                                                               =000309=
00772 L8001 MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                                     =000310=
00772 L8001 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIOUT                                     =000311=
00772 L8001 SM 0C01 SMMG  ENTRY GETMAIN              198,YES,00,TASK                                                       =000312=
00772 L8001 SM 0C02 SMMG  EXIT  GETMAIN/OK           226E1788                                                              =000313=
00772 L8001 SM 0D01 SMMF  ENTRY FREEMAIN             226E1788                                                              =000314=
00772 L8001 SM 0D02 SMMF  EXIT  FREEMAIN/OK          USER storage at 226E1788                                              =000315=
00772 L8001 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                                    =000316=
00772 L8001 AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                               =000317=
00772 L8001 AP 00E1 EIP   ENTRY RETURN                                          0004,226E1458 .>..,08000E08 ....           =000318=
```

8.2 Migrating WebSphere MQSeries regions

The WMQ adapter supplied with CICS Transaction Server Version 3.2 is now enabled as OPENAPI by CICS. Therefore the CICS-WMQ TRUE now uses L8 TCBs and not the eight private TCBs used by previous versions of the TRUE.

The potential for unnecessary TCB switches for WMQ applications is very similar to that for DB2 applications. As for DB2 calls, WMQ calls will invoke the RMI exits XRMIIN and XRMIOUT. In addition for WMQ there is also the API crossing exit which is executed before and after each WMQ call.

> **Note:** The definition for the API crossing exit (CSQCAPX) is supplied by CICS in CSD group DFHMQ. By default it is defined as THREADSAFE and should *not* be changed.

Figure 8-5 on page 212 shows the flow of a single WMQ call from CICS where the XRMIIN and XRMIOUT exits are defined as QUASIRENT and also the application program is defined as QUASIRENT.

We have not changed the definition of the API crossing exit from its default of THREADSAFE. If it were changed then both calls to the crossing exit would also be executed over on the QR TCB, thus adding four more TCB switches to the call.

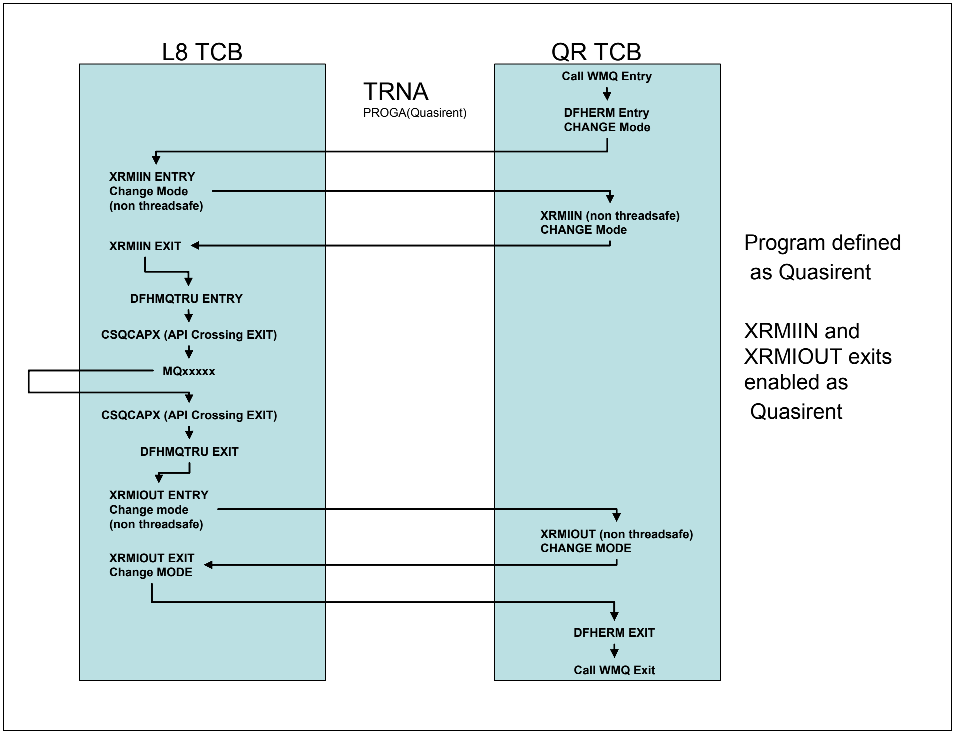

Figure 8-5 Call flow for a WMQ call with non threadsafe XRMIIN & XRMIOUT exits

If we enable the XRMI exits to be threadsafe there will be no switches back to the QR TCB when they are executed. This can be seen in Figure 8-6 on page 213.

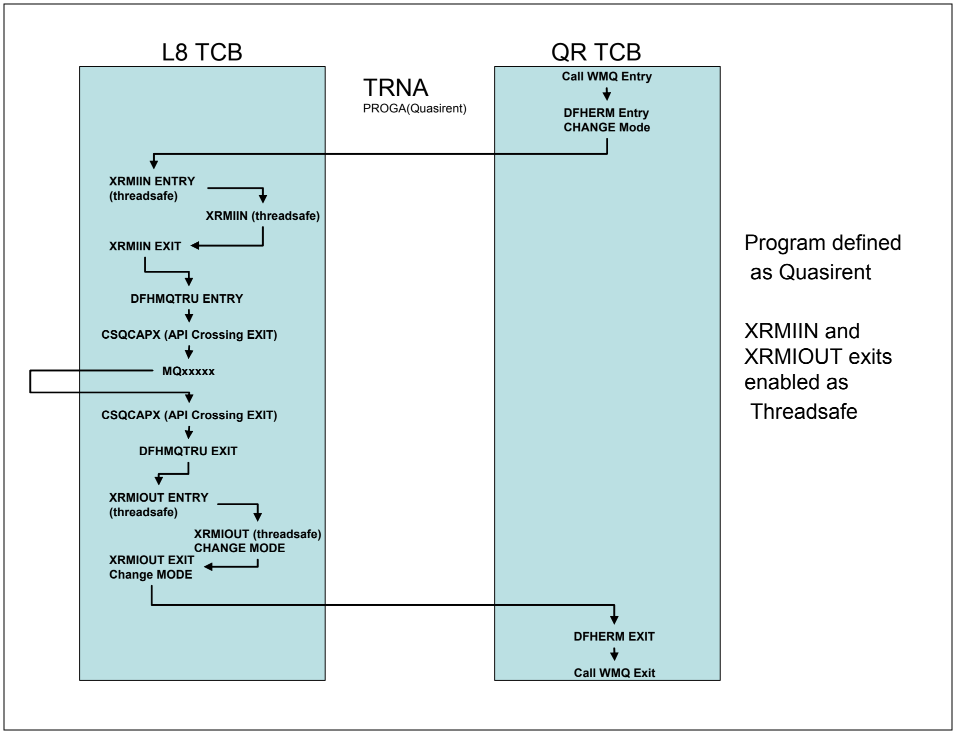

Figure 8-6 Call flow for a WMQ transaction with the XRMI exits enabled as threadsafe

Example 8-4 Example trace of an MQPUT operation.

```
***
       ***  MQPUT
       ***
 00052 L8001 AP 2520 ERM   ENTRY COBOL-APPLICATION-CALL-TO-TRUE(MQM     )                                                =001236=
 00052 L8001 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM GENGEXIT AT EXIT POINT XRMIIN                                  =001237=
 00052 L8001 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM GENGEXIT WITH RETURN CODE 790568                           =001238=
 00052 L8001 AP 2522 ERM   EVENT PASSING-CONTROL-TO-OPENAPI-TRUE(MQM     )                                               =001239=
 00052 L8001 AP A090 MQTRU ENTRY APPLICATION-REQUEST   MQPUT                                                              =001240=
 00052 L8001 AP A099 MQTRU EVENT CSQCPMGH              & CSQCPMGD ABOUT TO ISSUE MQPUT                                    =001241=


       ***
       ***  CSQCAPX
       ***
 00052 L8001 AP 00E1 EIP   ENTRY LINK                                         0004,266ADE6C ...%,08000E02 ....          =001242=
 00052 L8001 AP E110 EISR  ENTRY TRACE_ENTRY           266AD734                                                           =001243=
 00052 L8001 AP E160 EXEC  ENTRY LINK                  'CSQCAPX ' AT X'279F2A96','..Q........&...Y...............-y...' AT X =001244=
 00052 L8001 AP E111 EISR  EXIT  TRACE_ENTRY/OK                                                                           =001245=
 00052 L8001 PG 1101 PGLE  ENTRY LINK_EXEC             CSQCAPX,266AEB98 , 00000024,NO,NO                                  =001246=
 00052 L8001 DD 0301 DDLO  ENTRY LOCATE                2592AE60,26CD46AC,PPT,CSQCAPX                                      =001247=
 00052 L8001 DD 0302 DDLO  EXIT  LOCATE/OK             D7D7E3C5 , 26DF0108                                                =001248=
 00052 L8001 LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM       26DEF750                                                           =001249=
 00052 L8001 LD 0002 LDLD  EXIT  ACQUIRE_PROGRAM/OK    A6D84828,26D84800,550,REUSABLE,ECDSA,OLD_COPY,                     =001250=
 00052 L8001 AP 1940 APLI  ENTRY START_PROGRAM         CSQCAPX,NOCEDF,FULLAPI,EXEC,NO,2594C880,266AEB98 , 00000024,3,NO   =001251=
 00052 L8001 SM 0C01 SMMG  ENTRY GETMAIN               20C,YES,00,TASK                                                    =001252=
 00052 L8001 SM 0C02 SMMG  EXIT  GETMAIN/OK            266AEBD8                                                           =001253=
 00052 L8001 AP 00E1 EIP   ENTRY RETURN                                       0004,266AEBE8 ...Y,08000E08 ....          =001254=
 00052 L8001 AP E110 EISR  ENTRY TRACE_ENTRY           266AEC50                                                           =001255=
```

```
00052 L8001 AP E160 EXEC  ENTRY RETURN              ASM                                                            =001256=
00052 L8001 AP E111 EISR  EXIT  TRACE_ENTRY/OK                                                                     =001257=
00052 L8001 SM 0301 SMGF  ENTRY FREEMAIN            266AEBD8,TASK                                                  =001258=
00052 L8001 SM 0302 SMGF  EXIT  FREEMAIN/OK                                                                        =001259=
00052 L8001 AP 1941 APLI  EXIT  START_PROGRAM/OK    ,NO,CSQCAPX                                                    =001260=
00052 L8001 LD 0001 LDLD  ENTRY RELEASE_PROGRAM     26DEF750,A6D84828                                              =001261=
00052 L8001 LD 0002 LDLD  EXIT  RELEASE_PROGRAM/OK  26D84800,550,ECDSA                                             =001262=
00052 L8001 PG 1700 PGCH  ENTRY DELETE_OWNED_CHANNELS                                                              =001263=
00052 L8001 PG 1701 PGCH  EXIT  DELETE_OWNED_CHANNELS/OK                                                           =001264=
00052 L8001 PG 1102 PGLE  EXIT  LINK_EXEC/OK        ,,,                                                            =001265=
00052 L8001 AP E110 EISR  ENTRY TRACE_EXIT          266AD734                                                       =001266=
00052 L8001 AP E161 EXEC  EXIT  LINK                'CSQCAPX ' AT X'279F2A96','..Q........&...Y...............-y...' AT X =001267=
00052 L8001 AP E111 EISR  EXIT  TRACE_EXIT/OK                                                                      =001268=
00052 L8001 AP 00E1 EIP   EXIT  LINK                OK                            00F4,00000000 ....,00000E02 ....         =001269=


       ***
       ***  CSQCAPX
       ***
00052 L8001 AP 00E1 EIP   ENTRY LINK                                              0004,266ADE6C ...%,08000E02 ....         =001270=
00052 L8001 AP E110 EISR  ENTRY TRACE_ENTRY         266AD734                                                       =001271=
00052 L8001 AP E160 EXEC  ENTRY LINK                'CSQCAPX ' AT X'279F2A96','..Q........&...Y...............-y...' AT X =001272=
00052 L8001 AP E111 EISR  EXIT  TRACE_ENTRY/OK                                                                     =001273=
00052 L8001 PG 1101 PGLE  ENTRY LINK_EXEC           CSQCAPX,266AEB98 , 00000024,NO,NO                              =001274=
00052 L8001 DD 0301 DDLO  ENTRY LOCATE              2592AE60,26CD46AC,PPT,CSQCAPX                                  =001275=
00052 L8001 DD 0302 DDLO  EXIT  LOCATE/OK           D7D7E3C5 , 26DF0108                                            =001276=
00052 L8001 LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM     26DEF750                                                       =001277=
00052 L8001 LD 0002 LDLD  EXIT  ACQUIRE_PROGRAM/OK  A6D84828,26D84800,550,REUSABLE,ECDSA,OLD_COPY,                 =001278=
00052 L8001 AP 1940 APLI  ENTRY START_PROGRAM       CSQCAPX,NOCEDF,FULLAPI,EXEC,NO,2594C880,266AEB98 , 00000024,3,NO =001279=
00052 L8001 SM 0C01 SMMG  ENTRY GETMAIN             20C,YES,00,TASK                                                =001280=
00052 L8001 SM 0C02 SMMG  EXIT  GETMAIN/OK          266AEBD8                                                       =001281=
00052 L8001 AP 00E1 EIP   ENTRY RETURN                                            0004,266AEBE8 ...Y,08000E08 ....         =001282=
00052 L8001 AP E110 EISR  ENTRY TRACE_ENTRY         266AEC50                                                       =001283=
00052 L8001 AP E160 EXEC  ENTRY RETURN              ASM                                                            =001284=
00052 L8001 AP E111 EISR  EXIT  TRACE_ENTRY/OK                                                                     =001285=
00052 L8001 SM 0301 SMGF  ENTRY FREEMAIN            266AEBD8,TASK                                                  =001286=
00052 L8001 SM 0302 SMGF  EXIT  FREEMAIN/OK                                                                        =001287=
00052 L8001 AP 1941 APLI  EXIT  START_PROGRAM/OK    ,NO,CSQCAPX                                                    =001288=
00052 L8001 LD 0001 LDLD  ENTRY RELEASE_PROGRAM     26DEF750,A6D84828                                              =001289=
00052 L8001 LD 0002 LDLD  EXIT  RELEASE_PROGRAM/OK  26D84800,550,ECDSA                                             =001290=
00052 L8001 PG 1700 PGCH  ENTRY DELETE_OWNED_CHANNELS                                                              =001291=
00052 L8001 PG 1701 PGCH  EXIT  DELETE_OWNED_CHANNELS/OK                                                           =001292=
00052 L8001 PG 1102 PGLE  EXIT  LINK_EXEC/OK        ,,,                                                            =001293=
00052 L8001 AP E110 EISR  ENTRY TRACE_EXIT          266AD734                                                       =001294=
00052 L8001 AP E161 EXEC  EXIT  LINK                'CSQCAPX ' AT X'279F2A96','..Q........&...Y...............-y...' AT X =001295=
00052 L8001 AP E111 EISR  EXIT  TRACE_EXIT/OK                                                                      =001296=
00052 L8001 AP 00E1 EIP   EXIT  LINK                OK                            00F4,00000000 ....,00000E02 ....         =001297=


00052 L8001 AP A09A MQTRU EVENT CSQCPMGI            MESSAGE ID                                                     =001298=
00052 L8001 AP A091 MQTRU EXIT  APPLICATION-REQUEST  MQPUT 00000000,00000000                                       =001299=
00052 L8001 AP 2523 ERM   EVENT REGAINING-CONTROL-FROM-OPENAPI-TRUE(MQM      )                                     =001300=
00052 L8001 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM GENGEXIT AT EXIT POINT XRMIOUT                           =001301=
00052 L8001 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM GENGEXIT WITH RETURN CODE 790568                     =001302=
00052 L8001 RM 0301 RMLN  ENTRY SET_LINK            01000009,26FEC31C , 0000000C , 00000008,YES,NECESSARY          =001303=
00052 L8001 RM 0302 RMLN  EXIT  SET_LINK/OK         26FEC31C , 0000000C , 00000008,                                =001304=
00052 L8001 AP 2521 ERM   EXIT  COBOL-APPLICATION-CALL-TO-TRUE(MQM      )                                          =001305=
```

8.2.1 The API crossing exit (CSQCAPX)

Care should be taken when changing the WMQ API crossing exit (CSQCAPX). It is possible to execute CICS API commands. If you amend this exit to make calls to non threadsafe CICS API commands, be aware that this will cause a switch to the QR TCB in order to execute this command and then a switch back to the open TCB in order to continue with the WMQ call.

8.3 OPENAPI programs and additional TCB switching

CICS Transaction Server Version 3 allows programs to be defined with API(OPENAPI) and so run almost independently of the QR TCB. Such programs run on an L8 or L9 open TCB, depending upon their EXECKEY value. The OPENAPI definition is introduced in 2.2.5, "CICS Transaction Server 3.1" on page 21.

OPENAPI programs must be threadsafe and defined to CICS as such.

Because OPENAPI programs can potentially use non-CICS APIs, the key of the TCB is important and must match the execution key. This is unlike CICSAPI threadsafe programs that can execute in the CICS key or the user key irrespective of the TCB key. CICS services are implemented irrespective of the key of the TCB they are running under, unlike MVS services, which care about the TCB key.

Important note: Use of non-CICS APIs within CICS is entirely at the risk of the user. No testing of non-CICS APIs within CICS has been undertaken by IBM, and use of such APIs is not supported by IBM service.

The use of OPENAPI programs can increase TCB switching within CICS. If an OPENAPI program is defined to run with an execution key of user, it is given control under an L9 TCB rather than an L8 TCB. Should the program issue a call to an OPENAPI TRUE, the task is switched to an L8 TCB for the duration of the call. This is because OPENAPI TRUEs have to run in CICS key under an L8 TCB. Those IBM-supplied TRUES are:

DFHD2EX1	CICS DB2 Adapter
DFHMQTRU	CICS MQ Adapter
EZACIC01	IP CICS Sockets Adapter

On completion of the call, CICS returns control to the application program on its L9 TCB.

Likewise, an OPENAPI program that invokes non threadsafe EXEC CICS commands will be switched from its L8 or L9 TCB to the QR TCB for the duration of the CICS request, then switched back to the open TCB when returning control to the application program. This is because when a program is defined as being OPENAPI it means it *must* run its application logic under an open L8 or L9 TCB. This is different from a CICSAPI threadsafe program, which does not have affinity to any one TCB and executes under whatever TCB CICS deems appropriate to use.

To avoid such additional TCB switching, user key applications that make calls to OPENAPI enabled TRUEs are best left defined as CICSAPI threadsafe programs. Other good candidates for threadsafe programs defined with API(CICSAPI) are those that invoke non threadsafe CICS API requests.

Programs that are good candidates to be defined as API(OPENAPI) are:

- Those with an execution key of CICS that make calls to OPENAPI-enabled TRUEs
- Those that only invoke threadsafe CICS API requests
- CPU-intensive applications

A summary of good and bad candidates can be seen in “OPENAPI good and bad candidates” on page 53.

> **Note:** The EXECKEY program attribute will determine the mode of open TCB that is assigned for an OPENAPI program to run under. User key programs will run under an L9 TCB, CICS key programs under an L8 TCB. There is an exception to this behavior, however. If a CICS system does not have storage protection active (that is, STGPROT=NO is specified), all OPENAPI programs will run under L8 TCBs, regardless of their EXECKEY value. This is because STGPROT=NO makes CICS operate without any storage protection, and so run in a single storage key (key 8).

8.4 Function shipped commands

The temporary storage API commands (equally valid for function shipped transient data, interval control, file control, and DLI calls) are threadsafe. This is true when the commands are performed against locally defined resources or against shared temporary storage queues residing within a coupling facility. However, if these commands are performed against remote resources, they must be function shipped to the remote region to execute. This involves extra TCB switching due to Multi-Region Operation (MRO) and Intersystem Communication (ISC) CICS components not being threadsafe. The same is true for an EXEC CICS LINK command to a remote program (that is, a DPL call).

The following examples show these commands being performed in both local and remote scenarios.

Example 8-5 is a CICS trace of a threadsafe CICSAPI application program making a DB2 call on an open L8 TCB. It then does an EXEC CICS LINK to program DUMMY, which is defined as a local program. The LINK command is threadsafe, so there is no mode switch to the QR TCB and the request is processed on the L8 TCB.

Example 8-5 CICS trace of link command on local region

```
54728 L800I AP 3180 D2EX1 ENTRY APPLICATION          REQUEST EXEC SQL SELECT                                                  =000268=
54728 L800I AP 3250 D2D2  ENTRY DB2_API_CALL         22F76330                                                                 =000269=
54728 L800I AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                               =000270=
54728 L800I AP 3181 D2EX1 EXIT  APPLICATION-REQUEST  SQLCODE -805 RETURNED ON EXEC SQL SELECT                                 =000271=
54728 L800I MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME  DSNCSQL                                                                  =000272=
54728 L800I MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                                        =000273=
54728 L800I RM 0301 RMLN  ENTRY SET_LINK             01CF034D,22DE21EC , 0000000C , 00000008,YES,NECESSARY                    =000274=
54728 L800I RM 0302 RMLN  EXIT  SET_LINK/OK          22DE21EC , 0000000C , 00000008,                                          =000275=
54728 L800I AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                                  =000276=
54728 L800I AP 00E1 EIP   ENTRY LINK                                      0004,226D1458 ._..,08000E02 ....                    =000277=
54728 L800I AP E160 EXEC  ENTRY LINK                 'DUMMY    ' AT X'A43037D8',ASM                                           =000278=
54728 L800I PG 1101 PGLE  ENTRY LINK_EXEC            DUMMY,NO,NO                                                              =000279=
54728 L800I DD 0301 DDLO  ENTRY LOCATE               21C27B70,22B956DC,PPT,DUMMY                                              =000280=
54728 L800I DD 0302 DDLO  EXIT  LOCATE/OK            D7D7E3C5 , 2410F6B8                                                      =000281=
54728 L800I LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM      24199988                                                                 =000282=
54728 L800I AP 00E1 EIP   ENTRY LINK                                      0004,226D1458 ._..,08000E02 ....                    =000277=
54728 L800I AP E160 EXEC  ENTRY LINK                 'DUMMY    ' AT X'A43037D8',ASM                                           =000278=
54728 L800I PG 1101 PGLE  ENTRY LINK_EXEC            DUMMY,NO,NO                                                              =000279=
54728 L800I DD 0301 DDLO  ENTRY LOCATE               21C27B70,22B956DC,PPT,DUMMY                                              =000280=
54728 L800I DD 0302 DDLO  EXIT  LOCATE/OK            D7D7E3C5 , 2410F6B8                                                      =000281=
54728 L800I LD 0001 LDLD  ENTRY ACQUIRE_PROGRAM      24199988                                                                 =000282=
54728 L800I LD 0002 LDLD  EXIT  ACQUIRE_PROGRAM/OK   A4303C30,24303C30,138,0,REUSABLE,ESDSA,OLD_COPY                          =000283=
54728 L800I AP 1940 APLI  ENTRY START_PROGRAM        DUMMY,CEDF,FULLAPI,EXEC,NO,2410D6B8,00000000 , 00000000,2,NO             =000284=
54728 L800I SM 0C01 SMMG  ENTRY GETMAIN              190,YES,00,TASK                                                          =000285=
54728 L800I SM 0C02 SMMG  EXIT  GETMAIN/OK           226D1788                                                                 =000286=
54728 L800I AP 00E1 EIP   ENTRY RETURN                                    0004,226D1798 ._.q,08000E08 ....                    =000287=
54728 L800I AP E160 EXEC  ENTRY RETURN               ASM                                                                      =000288=
54728 L800I SM 0301 SMGF  ENTRY FREEMAIN             226D1788,TASK                                                            =000289=
54728 L800I SM 0302 SMGF  EXIT  FREEMAIN/OK                                                                                   =000290=
54728 L800I AP 1941 APLI  EXIT  START_PROGRAM/OK     ....,NO,DUMMY                                                            =000291=
54728 L800I LD 0001 LDLD  ENTRY RELEASE_PROGRAM      24199988,A4303C30                                                        =000292=
54728 L800I LD 0002 LDLD  EXIT  RELEASE_PROGRAM/OK   24303C30,138,ESDSA                                                       =000293=
54728 L800I PG 1102 PGLE  EXIT  LINK_EXEC/OK         ,,,                                                                      =000294=
54728 L800I AP E161 EXEC  EXIT  LINK                 'DUMMY    ' AT X'A43037D8',0,0,ASM                                       =000295=
54728 L800I AP 00E1 EIP   EXIT  LINK                 OK                   00F4,00000000 ....,00000E02 ....                    =000296=
```

Example 8-6 on page 218 is a CICS trace of a threadsafe CICSAPI application program making a DB2 call on an open L8 TCB. It then does a distributed program link (DPL) request to program DUMMY. Although the link command itself is threadsafe, there is a mode switch to the QR TCB in order to ship the request to the remote region. When the link to program DUMMY returns, notice that the application continues to run on the QR TCB and does not switch back to the L8 TCB. The application will not be switched to the L8 TCB until another DB2 request is made.

Example 8-6 CICS trace of distributed program link (DPL)

```
54734 L800I AP 3180 D2EX1 ENTRY APPLICATION          REQUEST EXEC SQL SELECT                                                 =000262=
54734 L800I AP 3250 D2D2  ENTRY DB2_API_CALL         22F76330                                                                =000263=
54734 L800I AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                              =000264=
54734 L800I AP 3181 D2EX1 EXIT  APPLICATION-REQUEST  SQLCODE -805 RETURNED ON EXEC SQL SELECT                                =000265=
54734 L800I MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME  DSNCSQL                                                                 =000266=
54734 L800I MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                                       =000267=
54734 L800I RM 0301 RMLN  ENTRY SET_LINK             01020035,22DE21EC , 0000000C , 00000008,YES,NECESSARY                   =000268=
54734 L800I RM 0302 RMLN  EXIT  SET_LINK/OK          22DE21EC , 0000000C , 00000008,                                         =000269=
54734 L800I AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                                 =000270=
54734 L800I AP 00E1 EIP   ENTRY LINK                                            0004,226D1458 ._..,08000E02 ....             =000271=
54734 L800I AP E160 EXEC  ENTRY LINK                 'DUMMY   ' AT X'A43037D8',ASM                                           =000272=
54734 L800I PG 1101 PGLE  ENTRY LINK_EXEC            DUMMY,NO,NO                                                             =000273=
54734 L800I DD 0301 DDLO  ENTRY LOCATE               21C27B70,22B956DC,PPT,DUMMY                                             =000274=
54734 L800I DD 0302 DDLO  EXIT  LOCATE/OK            D7D7E3C5 , 2410F6B8                                                     =000275=
54734 L800I PG 1102 PGLE  EXIT  LINK_EXEC/EXCEPTION  REMOTE_PROGRAM,PJA7,DUMMY,,                                             =000276=
54734 L800I DS 0002 DSAT  ENTRY CHANGE_MODE          QR                                                                      =000277=
54734 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                               =000278=
54734 QR    AP 00DF ISP   ENTRY CONVERSE                                    0003,04000000 ....,D7D1C1F7 PJA7                 =000279=
54734 QR    AP D900 XFP   ENTRY TRANSFORMER_1        226D14C0,0E0200000000000000000003C090000                                =000280=
54734 QR    PG 0500 PGIS  ENTRY INQUIRE_CURRENT_PROGRAM                                                                      =000281=
54734 QR    PG 0501 PGIS  EXIT  INQUIRE_CURRENT_PROGRAM/OK FUNCSHIP                                                          =000282=
54734 QR    AP D901 XFP   EXIT  TRANSFORMER_1        226D14C0,0E024C6E00580010FD016054734C00D5                               =000283=
54734 QR    AP FD01 ZARQ  ENTRY APPL_REQ             22F077F0,WRITE,READ,WAIT,FMH                                            =000284=
54734 QR    AP FD0D ZIS2  ENTRY IRC                  22F077F0,IOR,WRITE,WAIT,READ                                            =000285=
54734 QR    AP DD21 ZIS2  EVENT IRC                  SWITCH SUBSEQUENT TO SYSTEM (SCSCPJA7) RETURN CODE WAS 00000000         =000286=
54734 QR    AP DD22 ZIS2  EVENT IRC                  OUTBOUND REQUEST HEADER: FMH RQE CD , 12                                =000287=
54734 QR    DS 0004 DSSR  ENTRY WAIT_MVS             IRLINK,7F656CC0,YES,INHIBIT,YES,CONV,PJA7>ALA                           =000288=
54734 QR    DS 0005 DSSR  EXIT  WAIT_MVS/OK                                                                                  =000289=
54734 QR    AP DD24 ZIS2  EVENT IRC                  INBOUND REQUEST HEADER: FMH RQE CD , 12                                 =000290=
54734 QR    AP FD8D ZIS2  EXIT  IRC                  22F077F0,NORMAL                                                         =000291=
54734 QR    AP FC01 ZARQ  EVENT MRO/LU6.1            STATE SETTING TO SEND                                                   =000292=
54734 QR    AP FD81 ZARQ  EXIT  APPL_REQ                                                                                     =000293=
54734 QR    AP D900 XFP   ENTRY TRANSFORMER_4        226D14C0,0E024C6E00330010D9016054734C00D5                               =000294=
54734 QR    AP D901 XFP   EXIT  TRANSFORMER_4        226D14C0,0E024C6E003C001000DF6054734C00D5                               =000295=
54734 QR    AP 00DF ISP   EXIT  CONVERSE                                    0005,04000000 ....,D7D1C1F7 PJA7                 =000296=
54734 QR    AP E161 EXEC  EXIT  LINK                 'DUMMY   ' AT X'A43037D8',0,0,ASM                                       =000297=
54734 QR    AP 00E1 EIP   EXIT  LINK                 OK                         00F4,00000000 ....,00000E02 ....             =000298=
54734 QR    AP 00E1 EIP   ENTRY SEND-TEXT                                       0004,226D1458 ._..,08001806 ....             =000299=
54734 QR    AP E160 EXEC  ENTRY SEND                 TEXT 'TRANSACTION COMPLETE         ' AT X'24303714',30 AT X'A4303802 =000300=
54734 QR    SM 0C01 SMMG  ENTRY GETMAIN              22,YES,00,CICS24_SAA                                                    =000301=
54734 QR    SM 0C02 SMMG  EXIT  GETMAIN/OK           00041008                                                                =000302=
54734 QR    SM 0D01 SMMF  ENTRY FREEMAIN             22FA8020,22CBD6F0                                                       =000303=
54734 QR    SM 0D02 SMMF  EXIT  FREEMAIN/OK          TERMINAL storage at 22FA8020                                            =000304=
54734 QR    AP 00FA BMS   ENTRY SEND-OUT             CTRL                       0003,00000800 ....,04000020 ....             =000305=
54734 QR    SM 0301 SMGF  ENTRY GETMAIN              464,YES,00,MCPOSPWA,CICS                                                =000306=
54734 QR    SM 0302 SMGF  EXIT  GETMAIN/OK           22FA9008                                                                =000307=
54734 QR    PG 0500 PGIS  ENTRY INQUIRE_CURRENT_PROGRAM                                                                      =000308=
```

Example 8-7 on page 219 is a CICS trace of a threadsafe CICSAPI application program making a DB2 call on an open L8 TCB. It then issues a WRITEQ-TS request to temporary storage queue TCBTEST, which is defined as a local queue. The WRITEQ-TS command is threadsafe, so there is no mode switch to the QR TCB and the request is processed on the L8 TCB.

Example 8-7 CICS trace of WRITEQ-TS command on local region

```
54910 L800I AP 3250 D2D2  ENTRY DB2_API_CALL         22F76330                                                          =000257=
54910 L800I AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                        =000258=
54910 L800I AP 3181 D2EX1 EXIT  APPLICATION-REQUEST   SQLCODE -805 RETURNED ON EXEC SQL SELECT                         =000259=
54910 L800I MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME   DSNCSQL                                                          =000260=
54910 L800I MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                                 =000261=
54910 L800I RM 0301 RMLN  ENTRY SET_LINK             01020037,22DE21EC , 0000000C , 00000008,YES,NECESSARY             =000262=
54910 L800I RM 0302 RMLN  EXIT  SET_LINK/OK          22DE21EC , 0000000C , 00000008,                                   =000263=
54910 L800I AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                           =000264=
54910 L800I AP 00E1 EIP   ENTRY WRITEQ-TS                                     0004,23C41458 .D..,08000A02 ....         =000265=
54910 L800I AP E160 EXEC  ENTRY WRITEQ           TS 'TCBTEST ' AT X'24303850','THIS IS THE POST-SQL WRITEQ             =000266=
54910 L800I TS 0C01 TSMB  ENTRY MATCH            TCBTEST                                                               =000267=
54910 L800I TS 0C02 TSMB  EXIT  MATCH/OK         ,,,TCBTEST,,00000000,,ANY,NO,NO                                       =000268=
54910 L800I TS 0201 TSQR  ENTRY WRITE            TCBTEST,23C41660 , 00000050,YES,AUXILIARY,EXEC                        =000269=
54910 L800I TS 0901 TSAM  ENTRY WRITE_AUX_DATA   23C41660 , 00000050,TCBTEST,BB1A867EE0360C42,8,1,NO,NO,YES            =000270=
54910 L800I TS 0902 TSAM  EXIT  WRITE_AUX_DATA/OK    1,00000001                                                        =000271=
54910 L800I TS 0202 TSQR  EXIT  WRITE/OK         8                                                                     =000272=
54910 L800I AP E161 EXEC  EXIT  WRITEQ           TS 'TCBTEST ' AT X'24303850','THIS IS THE POST-SQL WRITEQ             =000273=
54910 L800I AP 00E1 EIP   EXIT  WRITEQ-TS        OK                            00F4,00000000 ....,00000A02 ....        =000274=
```

Example 8-8 on page 220 is a CICS trace of a threadsafe CICSAPI application program making a DB2 call on an open L8 TCB. It then issues a WRITEQ-TS request to temporary storage queue TCBTEST, which is defined as remote. Although the WRITEQ-TS command itself is threadsafe, there is a mode switch to the QR TCB in order to function ship the request to the remote region. When the WRITEQ-TS returns, notice that the application continues to run on the QR TCB and does not switch back to the L8 TCB. The application will not be switched to the L8 TCB until another DB2 request is made.

Example 8-8 CICS trace of WRITEQ-TS command being function shipped

```
54915 L800I AP 3180 D2EX1 ENTRY APPLICATION          REQUEST EXEC SQL SELECT                                              =000381=
54915 L800I AP 3250 D2D2  ENTRY DB2_API_CALL         22F76330                                                             =000382=
54915 L800I AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                           =000383=
54915 L800I AP 3181 D2EX1 EXIT  APPLICATION-REQUEST  SQLCODE -805 RETURNED ON EXEC SQL SELECT                             =000384=
54915 L800I MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME  DSNCSQL                                                              =000385=
54915 L800I MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                                    =000386=
54915 L800I RM 0301 RMLN  ENTRY SET_LINK             01CF034F,22DE21EC , 0000000C , 00000008,YES,NECESSARY               =000387=
54915 L800I RM 0302 RMLN  EXIT  SET_LINK/OK          22DE21EC , 0000000C , 00000008,                                      =000388=
54915 L800I AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                              =000389=
54915 L800I AP 00E1 EIP   ENTRY WRITEQ-TS                                           0004,23C41458 .D..,08000A02 ....      =000390=
54915 L800I AP E160 EXEC  ENTRY WRITEQ               TS 'TCBTEST ' AT X'24303850','THIS IS THE POST-SQL WRITEQ            =000391=
54915 L800I TS 0C01 TSMB  ENTRY MATCH                TCBTEST                                                              =000392=
54915 L800I TS 0C02 TSMB  EXIT  MATCH/OK             TCBTEST,TCBTEST,,TCBTEST,,00000000,PJA7,NO,NO,NO                     =000393=
54915 L800I DS 0002 DSAT  ENTRY CHANGE_MODE          QR                                                                   =000394=
54915 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                            =000395=
54915 QR    AP 00DF ISP   ENTRY CONVERSE                                            0003,04000000 ....,D7D1C1F7 PJA7      =000396=
54915 QR    AP D902 XFX   ENTRY TRANSFORMER_1        23C414C0,0A024C6E00330010D9036054915C00CD                            =000397=
54915 QR    AP D903 XFX   EXIT  TRANSFORMER_1        23C414C0,0A024C6E00580010FD016054915C00CD                            =000398=
54915 QR    AP FD01 ZARQ  ENTRY APPL_REQ             22F077F0,WRITE,READ,WAIT,FMH                                         =000399=
54915 QR    AP FD0D ZIS2  ENTRY IRC                  22F077F0,IOR,WRITE,WAIT,READ                                         =000400=
54915 QR    AP DD21 ZIS2  EVENT IRC                  SWITCH SUBSEQUENT TO SYSTEM (SCSCPJA7) RETURN CODE WAS 00000000      =000401=
54915 QR    AP DD22 ZIS2  EVENT IRC                  OUTBOUND REQUEST HEADER: FMH RQE CD , 15                             =000402=
54915 QR    DS 0004 DSSR  ENTRY WAIT_MVS             IRLINK,7F656CC0,YES,INHIBIT,YES,CONV,PJA7>ALA                        =000403=
54915 QR    DS 0005 DSSR  EXIT  WAIT_MVS/OK                                                                               =000404=
54915 QR    AP DD24 ZIS2  EVENT IRC                  INBOUND REQUEST HEADER: FMH RQE CD , 15                              =000405=
54915 QR    AP FD8D ZIS2  EXIT  IRC                  22F077F0,NORMAL                                                      =000406=
54915 QR    AP FC01 ZARQ  EVENT MRO/LU6.1            STATE SETTING TO SEND                                                =000407=
54915 QR    AP FD81 ZARQ  EXIT  APPL_REQ                                                                                  =000408=
54915 QR    AP D902 XFX   ENTRY TRANSFORMER_4        23C414C0,0A024C6E00330010D9036054915C00CD                            =000409=
54915 QR    AP D903 XFX   EXIT  TRANSFORMER_4        23C414C0,0A024C6E003C001000DF6054915C00CD                            =000410=
54915 QR    AP 00DF ISP   EXIT  CONVERSE                                            0005,04000000 ....,D7D1C1F7 PJA7      =000411=
54915 QR    AP E161 EXEC  EXIT  WRITEQ               TS 'TCBTEST ' AT X'24303850','THIS IS THE POST-SQL WRITEQ            =000412=
54915 QR    AP 00E1 EIP   EXIT  WRITEQ-TS            OK                             00F4,00000000 ....,00000A02 ....      =000413=
54915 QR    AP 00E1 EIP   ENTRY SEND-TEXT                                           0004,23C41458 .D..,08001806 ....      =000414=
54915 QR    AP E160 EXEC  ENTRY SEND                 TEXT 'TRANSACTION COMPLETE          ' AT X'24303738',30 AT X'A43038CC =000415=
54915 QR    SM 0C01 SMMG  ENTRY GETMAIN              22,YES,00,CICS24_SAA                                                 =000416=
54915 QR    SM 0C02 SMMG  EXIT  GETMAIN/OK           0004C008                                                             =000417=
54915 QR    SM 0D01 SMMF  ENTRY FREEMAIN             22FA88C0,22CBD6F0                                                    =000418=
54915 QR    SM 0D02 SMMF  EXIT  FREEMAIN/OK          TERMINAL storage at 22FA88C0                                         =000419=
54915 QR    AP 00FA BMS   ENTRY SEND-OUT             CTRL                           0003,00000800 ....,04000020 ....      =000420=
54915 QR    SM 0301 SMGF  ENTRY GETMAIN              464,YES,00,MCPOSPWA,CICS                                             =000421=
54915 QR    SM 0302 SMGF  EXIT  GETMAIN/OK           22FF3008                                                             =000422=
```

Example 8-9 on page 221 is a CICS trace of a threadsafe CICSAPI application program making a DB2 call on an open L8 TCB. It then issues a WRITEQ-TS request to a shared temporary storage queue TCBTEST, which resides within a coupling facility. In this scenario there is no need to function ship the WRITEQ-TS request. The application continues to run on the L8 TCB with no additional TCB switches to the QR TCB. Conversion of remote temporary storage queues to shared temporary storage queues within a coupling facility is a recommended solution within a threadsafe environment.

Note that the initial call to the shared temporary storage server is always issued from the QR TCB, regardless of which TCB the program is currently on.

Example 8-9 CICS trace of WRITEQ-TS request to shared temporary storage queue

```
00300 QR    AP 2520 ERM   ENTRY ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                       =000219=
00300 QR    US 0401 USXM  ENTRY INQUIRE_TRANSACTION_USER                                                           =000220=
00300 QR    US 0402 USXM  EXIT  INQUIRE_TRANSACTION_USER/OK 00000000                                               =000221=
00300 QR    RM 0301 RMLN  ENTRY ADD_LINK              RMI,22F914A4 , 22C1D640 , 00000008,000949D0 , 21B06F30 , 00000008,22F =000222=
00300 QR    RM 0302 RMLN  EXIT  ADD_LINK/OK           01C8000F,22F914A4 , 22C1D640 , 00000008,000949D0 , 21B06F30 , 0000000 =000223=
00300 QR    DS 0002 DSAT  ENTRY CHANGE_MODE           0000000C                                                     =000224=
00300 L8000 DS 0003 DSAT  EXIT  CHANGE_MODE/OK                                                                     =000225=
00300 L8000 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIIN                              =000226=
00300 L8000 SM 0C01 SMMG  ENTRY GETMAIN               198,YES,00,TASK                                              =000227=
00300 L8000 SM 0C02 SMMG  EXIT  GETMAIN/OK            22661788                                                     =000228=
CICS - AUXILIARY TRACE FROM 04/26/04 - APPLID SCSCPJA6 - TIME OF FIRST ENTRY ON THIS PAGE 09:58:10.4188565405        PAGE 00003

00300 L8000 SM 0D01 SMMF  ENTRY FREEMAIN              22661788                                                     =000229=
00300 L8000 SM 0D02 SMMF  EXIT  FREEMAIN/OK           USER storage at 22661788                                     =000230=
00300 L8000 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                            =000231=
00300 L8000 AP 3180 D2EX1 ENTRY APPLICATION           REQUEST EXEC SQL SELECT                                      =000232=
00300 L8000 AP 3250 D2D2  ENTRY DB2_API_CALL          230D7330                                                     =000233=
00300 L8000 AP 3251 D2D2  EXIT  DB2_API_CALL/OK                                                                    =000234=
00300 L8000 AP 3181 D2EX1 EXIT  APPLICATION-REQUEST   SQLCODE 0 RETURNED ON EXEC SQL SELECT                        =000235=
00300 L8000 MN 0201 MNMN  ENTRY ACCUMULATE_RMI_TIME   DSNCSQL                                                      =000236=
00300 L8000 MN 0202 MNMN  EXIT  ACCUMULATE_RMI_TIME/OK                                                             =000237=
00300 L8000 AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT XRMIOUT                             =000238=
00300 L8000 SM 0C01 SMMG  ENTRY GETMAIN               198,YES,00,TASK                                              =000239=
00300 L8000 SM 0C02 SMMG  EXIT  GETMAIN/OK            22661788                                                     =000240=
00300 L8000 SM 0D01 SMMF  ENTRY FREEMAIN              22661788                                                     =000241=
00300 L8000 SM 0D02 SMMF  EXIT  FREEMAIN/OK           USER storage at 22661788                                     =000242=
00300 L8000 AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETURN CODE 0                            =000243=
00300 L8000 RM 0301 RMLN  ENTRY SET_LINK              01C8000F,22F914AC , 0000000C , 00000008,YES,NECESSARY        =000244=
00300 L8000 RM 0302 RMLN  EXIT  SET_LINK/OK           22F914AC , 0000000C , 00000008,                              =000245=
00300 L8000 AP 2521 ERM   EXIT  ASSEMBLER-APPLICATION-CALL-TO-TRUE(DSNCSQL )                                       =000246=
00300 L8000 AP 00E1 EIP   ENTRY WRITEQ-TS                                     0004,22661458 ....,08000A02 ....     =000247=
00300 L8000 AP E160 EXEC  ENTRY WRITEQ                TS 'TCBTEST ' AT X'24300730','THIS IS THE POST-SQL WRITEQ    =000248=
00300 L8000 TS 0C01 TSMB  ENTRY MATCH                 TCBTEST                                                      =000249=
00300 L8000 TS 0C02 TSMB  EXIT  MATCH/OK              TCBTEST,TCBTEST,,TCBTEST,TSQSPQA1,22571FE0,,NO,NO,NO         =000250=
00300 L8000 TS 0A01 TSSH  ENTRY WRITE                 TCBTEST,22661660 , 00000050,22571FE0,YES,NO                  =000251=
00300 L8000 TS 0A0B TSSH  EVENT Before_server_request WRITE,TCBTEST,22661660 , 00000050,22571FE0,FUNC,YES,NO,0000300C =000252=
00300 L8000 TS 0A0C TSSH  EVENT After_server_request  WRITE,OK,4                                                   =000253=
00300 L8000 TS 0A02 TSSH  EXIT  WRITE/OK              4                                                            =000254=
00300 L8000 AP E161 EXEC  EXIT  WRITEQ                TS 'TCBTEST ' AT X'24300730','THIS IS THE POST-SQL WRITEQ    =000255=
00300 L8000 AP 00E1 EIP   EXIT  WRITEQ-TS             OK                      00F4,00000000 ....,00000A02 ....     =000256=
```

8.5 COBOL calls

If your application makes use of COBOL calls to invoke sub programs, you need to be aware that the concurrency value used will be the value set for the program at the calling level. So, if PROGA is defined as CONCURRENCY(QUASIRENT) and PROGB is defined as CONCURRENCY(THREADSAFE), the concurrency attribute that will be honored will be QUASIRENT when we call PROGB from PROGA. This can be demonstrated by looking at the following two trace examples.

This behavior can be seen when using dynamic COBOL calls or static COBOL calls or both.

8.5.1 PROGA (Quasirent) calls PROGB (threadsafe)

In Example 8-10 PROGA is defined as QUASIRENT and PROGB is defined as THREADSAFE. The trace shows that once all the DB2 calls have completed (including the call in PROGB, which is defined as THREADSAFE), the program returns to the QR TCB.

Example 8-10 PROGA - Quasirent and PROGB - threadsafe

```
11281 QR    AP 1940 APLI  ENTRY START_PROGRAM          PROGA ,CEDF,FULLAPI,EXE
11281 QR    AP 1948 APLI  EVENT CALL-TO-LE/370         Thread_Initialization CAL
11281 QR    AP 1949 APLI  EVENT RETURN-FROM-LE/370     Thread_Initialization OK
11281 QR    AP 1948 APLI  EVENT CALL-TO-LE/370         Rununit_Init_&_Begin_Invo
11281 QR    AP 00E1 EIP   ENTRY DELETEQ-TS
11281 QR    AP E160 EXEC  ENTRY DELETEQ                TS 'TONYQ   ' AT X'A266AB
11281 QR    AP E161 EXEC  EXIT  DELETEQ                TS 'TONYQ   ' AT X'A266AB
11281 QR    AP 00E1 EIP   EXIT  DELETEQ-TS             OK
11281 QR    AP 2520 ERM   ENTRY COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )
                ****
                **** First SQL Call in PROGA            *****
                ****
11281 L802I AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT
11281 L802I AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETUR
11281 L802I AP 3180 D2EX1 ENTRY APPLICATION            REQUEST EXEC SQL SELECT
11281 L802I AP 3250 D2D2  ENTRY DB2_API_CALL           230D7330
11281 L802I AP 3251 D2D2  EXIT  DB2_API_CALL/OK
11281 L802I AP 3181 D2EX1 EXIT  APPLICATION-REQUEST    SQLCODE 0 RETURNED ON EXE
11281 L802I AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT
11281 L802I AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETUR
                ****
                **** First SQL Complete - back to QR    *****
                ****
11281 QR    AP 2521 ERM   EXIT  COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )
11281 QR    AP 00E1 EIP   ENTRY WRITEQ-TS
11281 QR    AP E160 EXEC  ENTRY WRITEQ                 TS 'TONYQ   ' AT X'2266AB
11281 QR    AP E161 EXEC  EXIT  WRITEQ                 TS 'TONYQ   ' AT X'2266AB
11281 QR    AP 00E1 EIP   EXIT  WRITEQ-TS              OK
11281 QR    AP 00E1 EIP   ENTRY GETMAIN
11281 QR    AP E160 EXEC  ENTRY GETMAIN                AT X'226600F8',4080 AT X'
11281 QR    AP E161 EXEC  EXIT  GETMAIN                X'2266C948' AT X'226600F8
11281 QR    AP 00E1 EIP   EXIT  GETMAIN                OK
11281 QR    AP 00E1 EIP   ENTRY ADDRESS
11281 QR    AP E160 EXEC  ENTRY ADDRESS                AT X'A266D23C',SYSEIB,ASM
11281 QR    AP E161 EXEC  EXIT  ADDRESS                X'0005D494' AT X'A266D23C
11281 QR    AP 00E1 EIP   EXIT  ADDRESS                OK
                ****
                **** About to start PROGB               *****
                ****
11281 QR    AP 00E1 EIP   ENTRY LOAD
11281 QR    AP E160 EXEC  ENTRY LOAD                   'PROGB' AT X'2266D380'
11281 QR    AP E161 EXEC  EXIT  LOAD                   'PROGB' AT X'2266D380'
11281 QR    AP 00E1 EIP   EXIT  LOAD                   OK
11281 QR    AP 00E1 EIP   ENTRY PUSH
11281 QR    AP E160 EXEC  ENTRY PUSH                   HANDLE SYSEIB NOHANDLE AS
11281 QR    AP E161 EXEC  EXIT  PUSH                   HANDLE 0,0,SYSEIB,NOHANDL
11281 QR    AP 00E1 EIP   EXIT  PUSH                   OK
11281 QR    AP 2520 ERM   ENTRY COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )
                ****
                **** SQL Call in PROGB - switch to L8   *****
                ****
11281 L802I AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT
11281 L802I AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETUR
11281 L802I AP 3180 D2EX1 ENTRY APPLICATION            REQUEST EXEC SQL SELECT
11281 L802I AP 3250 D2D2  ENTRY DB2_API_CALL           230D7330
```

```
11281 L802I AP 3251 D2D2  EXIT  DB2_API_CALL/OK
11281 L802I AP 3181 D2EX1 EXIT  APPLICATION-REQUEST   SQLCODE 0 RETURNED ON EXE
11281 L802I AP D500 UEH   EVENT LINK-TO-USER-EXIT-PROGRAM XXXRMI AT EXIT POINT
11281 L802I AP D501 UEH   EVENT RETURN-FROM-USER-EXIT-PROGRAM XXXRMI WITH RETUR
                ****
                **** First SQL Complete - back to QR    *****
                ****
11281 QR    AP 2521 ERM   EXIT  COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )
11281 QR    AP 00E1 EIP   ENTRY WRITEQ-TS
11281 QR    AP E160 EXEC  ENTRY WRITEQ                TS 'TONYQ   ' AT X'2266AE
11281 QR    AP E161 EXEC  EXIT  WRITEQ                TS 'TONYQ   ' AT X'2266AE
11281 QR    AP 00E1 EIP   EXIT  WRITEQ-TS             OK
11281 QR    AP 00E1 EIP   ENTRY POP
11281 QR    AP E160 EXEC  ENTRY POP                   HANDLE SYSEIB NOHANDLE AS
11281 QR    AP E161 EXEC  EXIT  POP                   HANDLE 0,0,SYSEIB,NOHANDL
11281 QR    AP 00E1 EIP   EXIT  POP                   OK
11281 QR    AP 00E1 EIP   ENTRY WRITEQ-TS
11281 QR    AP E160 EXEC  ENTRY WRITEQ                TS 'TONYQ   ' AT X'2266AB
11281 QR    AP E161 EXEC  EXIT  WRITEQ                TS 'TONYQ   ' AT X'2266AB
11281 QR    AP 00E1 EIP   EXIT  WRITEQ-TS             OK
11281 QR    AP 00E1 EIP   ENTRY RETURN
11281 QR    AP E160 EXEC  ENTRY RETURN                COBOLII 00008
11281 QR    AP 1948 APLI  EVENT CALL-TO-LE/370        Rununit_End_Invocation CA
11281 QR    AP 1949 APLI  EVENT RETURN-FROM-LE/370    Rununit_End_Invocation OK
11281 QR    AP 1948 APLI  EVENT CALL-TO-LE/370        Rununit_Termination CALLP
11281 QR    AP 00E1 EIP   ENTRY ADDRESS
11281 QR    AP E160 EXEC  ENTRY ADDRESS               AT X'A2669800',SYSEIB,ASM
11281 QR    AP E161 EXEC  EXIT  ADDRESS               X'0005D494' AT X'A2669800
11281 QR    AP 00E1 EIP   EXIT  ADDRESS               OK
11281 QR    AP 00E1 EIP   ENTRY RELEASE
11281 QR    AP E160 EXEC  ENTRY RELEASE               'PROGB' AT X'A2669948'
11281 QR    AP E161 EXEC  EXIT  RELEASE               'PROGB' AT X'A2669948'
11281 QR    AP 00E1 EIP   EXIT  RELEASE               OK
11281 QR    AP 00E1 EIP   ENTRY FREEMAIN
11281 QR    AP E160 EXEC  ENTRY FREEMAIN              AT X'A266C948',SYSEIB,NOH
11281 QR    AP E161 EXEC  EXIT  FREEMAIN              AT X'A266C948',0,0,SYSEIB
11281 QR    AP 00E1 EIP   EXIT  FREEMAIN              OK
11281 QR    AP 1949 APLI  EVENT RETURN-FROM-LE/370    Rununit_Termination OK CA
11281 QR    AP 1948 APLI  EVENT CALL-TO-LE/370        Thread_Termination
11281 QR    AP 1949 APLI  EVENT RETURN-FROM-LE/370    Thread_Termination OK
11281 QR    AP 1941 APLI  EXIT  START_PROGRAM/OK      ....,NO,PROGA
11281 QR    AP 2500 ERMSP ENTRY PERFORM_PREPARE       NO,0005D264
11281 QR    AP 2501 ERMSP EXIT  PERFORM_PREPARE/OK    READ_ONLY
11281 QR    AP 1760 LTRC  ENTRY PERFORM_PREPARE       NO,22CD04B0
11281 QR    AP 1761 LTRC  EXIT  PERFORM_PREPARE/OK    READ_ONLY
11281 QR    AP 05A8 APRC  ENTRY PERFORM_PREPARE       NO,00000001
11281 QR    AP 05A9 APRC  EXIT  PERFORM_PREPARE/OK    READ_ONLY
11281 QR    AP 2500 ERMSP ENTRY SEND_DO_COMMIT        241FC030,NO,YES,01380036,
11281 QR    AP 2520 ERM   ENTRY SYNCPOINT-MANAGER-CALL-TO-TRUE(DSNCSQL )
                ****
                **** Return briefly to the L8 for commit processing  *****
                ****
11281 L802I AP 3180 D2EX1 ENTRY SYNCPOINT-MANAGER     REQUEST
11281 L802I AP 3250 D2D2  ENTRY SINGLE_PHASE_COMMIT   230D7330
11281 L802I AP 3251 D2D2  EXIT  SINGLE_PHASE_COMMIT/OK
11281 L802I AP 3181 D2EX1 EXIT  SYNCPOINT-MANAGER     REQUEST
11281 QR    AP 2521 ERM   EXIT  SYNCPOINT-MANAGER-CALL-TO-TRUE(DSNCSQL )
11281 QR    AP 2501 ERMSP EXIT  SEND_DO_COMMIT/OK     YES,YES,DSNCSQL
11281 QR    AP 2500 ERMSP ENTRY PERFORM_COMMIT        241FC030,NO,YES,YES,NO,NO
11281 QR    AP 2501 ERMSP EXIT  PERFORM_COMMIT/OK     YES,YES,YES,NO,UNNECESSAR
11281 QR    AP 2500 ERMSP ENTRY PERFORM_COMMIT        NO,FORWARD,0005D264
11281 QR    AP 2520 ERM   ENTRY CALL-TRUES-FOR-TASK-END
11281 QR    AP 2521 ERM   EXIT  CALL-TRUES-FOR-TASK-END
11281 QR    AP 2501 ERMSP EXIT  PERFORM_COMMIT/OK     YES
11281 QR    AP 1760 LTRC  ENTRY PERFORM_COMMIT        NO,FORWARD,22CD04B0
11281 QR    AP 1710 TFRF  ENTRY RELEASE_FACILITY      NO,NORMAL,22CD04B0,TC51
11281 QR    AP FD0B ZISP  ENTRY FACILITY_REQ          22CD04B0,FREE_DETACH,IMPL
```

```
11281 QR    AP FD03 ZDET  ENTRY DETACH              22CD04B0,TC51
11281 QR    AP FD18 ZSDS  ENTRY SEND_DFSYN          22CD04B0,TC51
11281 QR    AP FD1D ZSDR  ENTRY SEND_DFSYN_RESP     22CD04B0,TC51
11281 QR    AP FC90 VIO   EVENT TCTTE(22CD04B0)     SC38TC51,01CA,SEND,DATA,0
11281 QR    AP FD8B ZISP  EXIT  FACILITY_REQ
11281 QR    AP 1711 TFRF  EXIT  RELEASE_FACILITY/OK   TC51
11281 QR    AP 1761 LTRC  EXIT  PERFORM_COMMIT/OK     NO
11281 QR    AP 05A8 APRC  ENTRY PERFORM_COMMIT        NO,FORWARD,00000001
11281 QR    AP 05A9 APRC  EXIT  PERFORM_COMMIT/OK     NO
11281 QR    AP 0590 APXM  ENTRY RELEASE_XM_CLIENT     NORMAL
```

8.5.2 PROGA (threadsafe) calls PROGB (Quasirent)

If we swap over the definitions of PROGA and PROGB so that PROGA is now THREADSAFE and PROGB is QUASIRENT, we should see the opposite effect. That is, PROGB will remain on the L8 TCB after any DB2 calls due to the definition of PROGA are set to THREADSAFE. PROGB will start on the L8 TCB and continue there until completion. This can be seen in Example 8-11.

Example 8-11 PROGA - threadsafe and PROGB Quasirent

```
00108 QR    AP 1940 APLI  ENTRY START_PROGRAM       PROGA,CEDF,FULLAPI,EXE
00108 QR    AP 1948 APLI  EVENT CALL-TO-LE/370      Thread_Initialization CAL
00108 QR    AP 1949 APLI  EVENT RETURN-FROM-LE/370  Thread_Initialization OK
00108 QR    AP 1948 APLI  EVENT CALL-TO-LE/370      Rununit_Init_&_Begin_Invo
00108 QR    AP 00E1 EIP   ENTRY DELETEQ-TS
00108 QR    AP 00E1 EIP   EXIT  DELETEQ-TS          OK
00108 QR    AP 2520 ERM   ENTRY COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )
                ****
                **** First SQL Call in PROGA           *****
                ****
00108 L8000 AP 3180 D2EX1 ENTRY APPLICATION         REQUEST EXEC SQL SELECT
00108 L8000 AP 3250 D2D2  ENTRY DB2_API_CALL        22DDF030
00108 L8000 AP 3251 D2D2  EXIT  DB2_API_CALL/OK
00108 L8000 AP 3181 D2EX1 EXIT  APPLICATION-REQUEST   SQLCODE -805 RETURNED ON
00108 L8000 AP 2521 ERM   EXIT  COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )
                ****
                **** PROGA continues on L8 TCB         *****
                ****
00108 L8000 AP 00E1 EIP   ENTRY WRITEQ-TS
00108 L8000 AP 00E1 EIP   EXIT  WRITEQ-TS           OK
00108 L8000 AP 00E1 EIP   ENTRY GETMAIN
00108 L8000 AP 00E1 EIP   EXIT  GETMAIN             OK
00108 L8000 AP 00E1 EIP   ENTRY ADDRESS
00108 L8000 AP 00E1 EIP   EXIT  ADDRESS             OK
                ****
                **** Here we are about to call PROGB   *****
                ****   remaining on the L8 TCB         *****
                ****
00108 L8000 AP 00E1 EIP   ENTRY LOAD
00108 L8000 AP 00E1 EIP   EXIT  LOAD                OK
00108 L8000 AP 00E1 EIP   ENTRY PUSH
00108 L8000 AP 00E1 EIP   EXIT  PUSH                OK
00108 L8000 AP 2520 ERM   ENTRY COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )
00108 L8000 AP 3180 D2EX1 ENTRY APPLICATION         REQUEST EXEC SQL SELECT
00108 L8000 AP 3250 D2D2  ENTRY DB2_API_CALL        22DDF030
00108 L8000 AP 3251 D2D2  EXIT  DB2_API_CALL/OK
00108 L8000 AP 3181 D2EX1 EXIT  APPLICATION-REQUEST   SQLCODE -805 RETURNED ON
00108 L8000 AP 2521 ERM   EXIT  COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )
00108 L8000 AP 00E1 EIP   ENTRY WRITEQ-TS
00108 L8000 AP 00E1 EIP   EXIT  WRITEQ-TS           OK
00108 L8000 AP 00E1 EIP   ENTRY POP
```

```
00108 L8000 AP 00E1 EIP   EXIT  POP                    OK
00108 L8000 AP 00E1 EIP   ENTRY WRITEQ-TS
00108 L8000 AP 00E1 EIP   EXIT  WRITEQ-TS              OK
00108 L8000 AP 00E1 EIP   ENTRY RETURN
00108 L8000 AP 1948 APLI  EVENT CALL-TO-LE/370         Rununit_End_Invocation CA
00108 L8000 AP 1949 APLI  EVENT RETURN-FROM-LE/370     Rununit_End_Invocation OK
00108 L8000 AP 1948 APLI  EVENT CALL-TO-LE/370         Rununit_Termination CALLP
00108 L8000 AP 00E1 EIP   ENTRY ADDRESS
00108 L8000 AP 00E1 EIP   EXIT  ADDRESS                OK
00108 L8000 AP 00E1 EIP   ENTRY RELEASE
00108 L8000 AP 00E1 EIP   EXIT  RELEASE                OK
00108 L8000 AP 00E1 EIP   ENTRY FREEMAIN
00108 L8000 AP 00E1 EIP   EXIT  FREEMAIN               OK
00108 L8000 AP 1949 APLI  EVENT RETURN-FROM-LE/370     Rununit_Termination OK CA
00108 L8000 AP 1948 APLI  EVENT CALL-TO-LE/370         Thread_Termination
00108 L8000 AP 1949 APLI  EVENT RETURN-FROM-LE/370     Thread_Termination OK
00108 L8000 AP 1941 APLI  EXIT  START_PROGRAM/OK       ....,NO,PROGA
                ****
                **** Program End Return to QR TCB          *****
                ****

00108 QR    AP 2500 ERMSP ENTRY PERFORM_PREPARE        NO,0005B264
00108 QR    AP 2501 ERMSP EXIT  PERFORM_PREPARE/OK     READ_ONLY
00108 QR    AP 1760 LTRC  ENTRY PERFORM_PREPARE        NO,22CD04B0
00108 QR    AP 1761 LTRC  EXIT  PERFORM_PREPARE/OK     READ_ONLY
00108 QR    AP 05A8 APRC  ENTRY PERFORM_PREPARE        NO,00000001
00108 QR    AP 05A9 APRC  EXIT  PERFORM_PREPARE/OK     READ_ONLY
00108 QR    AP 2500 ERMSP ENTRY SEND_DO_COMMIT         22F91450,NO,YES,01030001,
00108 QR    AP 2520 ERM   ENTRY SYNCPOINT-MANAGER-CALL-TO-TRUE(DSNCSQL )
                ****
                **** Return briefly to the L8 for commit processing  *****
                ****
00108 L8000 AP 3180 D2EX1 ENTRY SYNCPOINT-MANAGER      REQUEST
00108 L8000 AP 3250 D2D2  ENTRY SINGLE_PHASE_COMMIT    22DDF030
00108 L8000 AP 3251 D2D2  EXIT  SINGLE_PHASE_COMMIT/OK
00108 L8000 AP 3181 D2EX1 EXIT  SYNCPOINT-MANAGER      REQUEST
00108 QR    AP 2521 ERM   EXIT  SYNCPOINT-MANAGER-CALL-TO-TRUE(DSNCSQL )
00108 QR    AP 2501 ERMSP EXIT  SEND_DO_COMMIT/OK      YES,YES,DSNCSQL
00108 QR    AP 2500 ERMSP ENTRY PERFORM_COMMIT         22F91450,NO,YES,YES,NO,NO
00108 QR    AP 2501 ERMSP EXIT  PERFORM_COMMIT/OK      YES,YES,YES,NO,UNNECESSAR
00108 QR    AP 2500 ERMSP ENTRY PERFORM_COMMIT         NO,FORWARD,0005B264
00108 QR    AP 2520 ERM   ENTRY CALL-TRUES-FOR-TASK-END
00108 QR    AP 2521 ERM   EXIT  CALL-TRUES-FOR-TASK-END
00108 QR    AP 2501 ERMSP EXIT  PERFORM_COMMIT/OK      YES
00108 QR    AP 1760 LTRC  ENTRY PERFORM_COMMIT         NO,FORWARD,22CD04B0
00108 QR    AP 1710 TFRF  ENTRY RELEASE_FACILITY       NO,NORMAL,22CD04B0,TC3F
00108 QR    AP 1711 TFRF  EXIT  RELEASE_FACILITY/OK    TC3F
00108 QR    AP 1761 LTRC  EXIT  PERFORM_COMMIT/OK      NO
00108 QR    AP 05A8 APRC  ENTRY PERFORM_COMMIT         NO,FORWARD,00000001
00108 QR    AP 05A9 APRC  EXIT  PERFORM_COMMIT/OK      NO
00108 QR    AP 0590 APXM  ENTRY RELEASE_XM_CLIENT      NORMAL
```

With CICS Transaction Server Version 3, the API attribute of the calling program is also inherited by the called program. If, for example, PROGA had been defined with API(OPENAPI) and EXECKEY(USER), it would have been invoked under an L9 TCB, and would have called PROGB under the L9 TCB also.

The programs used to create these examples can be found in Appendix B, “COBOL call program listings” on page 333.

8.6 The CSACDTA field

Historically, the CSACDTA field provided the address of the task control area (TCA) for the currently dispatched task running within CICS. Before OTE was introduced, all tasks ran under the control of the QR TCB, and this provided a guarantee that a running task would retrieve the address of its own TCA if it accessed the CSACDTA field.

With the introduction of OTE, it is *no longer safe* to assume that the TCA address held within CSACDTA is the TCA of the task that is accessing the CSA. CSACDTA contains the address of the task currently dispatched on the *QR* TCB. The program that is referencing CSACDTA may be running under an open TCB. In this case the wrong TCA address will be used by the program, leading to unpredictable results.

Since CICS/ESA Version 4.1, direct access to CICS control blocks is not supported. The CICS system programming interface (SPI) should be used for programs wishing to access state information about a task.

Prior to CICS TS 3.1

In the releases of CICS prior to CICS Transaction Server 3.1 the CSACDTA field will return the address of the currently dispatched task executing under the QR TCB.

CICS TS 3.1

In CICS Transaction Server Version 3.1, CSACDTA is renamed CSAQRTCA to further discourage its use.

CICS TS 3.2

In CICS Transaction Server Version 3.2 IBM has *withdrawn* the ability to reference a TCA using this field. This has been done by loading CSAQRTCA with the address of an area of fetch-protected storage. This will result in an abend ASRD with message DFHSR0618 if it is referenced.

9

Migration scenario

This chapter describes a threadsafe migration from beginning to end using a sample application. Using a migration plan based on the concepts that are developed and detailed in Chapter 4, “Threadsafe tasks” on page 57, the authors of this book took a CICS-DB2 application running as quasi-reentrant under CICS Transaction Server Version 1.3 and converted it to threadsafe running under CICS Transaction Server Version 2.3. Each step of the migration process is illustrated with displays of the required system and application changes.

DB2 is one example of a user of the CICS Resource Manager Interface (RMI) which has been enhanced to exploit OTE. In addition, the z/OS Communications Server IP CICS Sockets Version 1 Release 7 and later can be configured to use OTE and also, from CICS Transaction Server 3.2, the WebSphere MQseries CICS adapter will now also exploit OTE.

While in this exercise CICS Transaction Server Version 2.3 is the target release, the migration process described is the same if we take any quasi-reentrant program and convert it to be a threadsafe program. However, note that additional considerations apply when migrating the program to be an OPENAPI program in CICS Transaction Server Version V3. We discuss at the end of the chapter why this is not recommended for RMI users that exploit OTE (CICS-DB2 applications, IP CICS Sockets applications, or WebSphere MQSeries applications).

The chapter is organized into the following sections:

- 9.1, “Application overview” on page 229

This section describes the sample application that we used in the migration.

- 9.2, “Migration plan” on page 229

  This section provides an overview of our migration plan.

- 9.3, “Migration part 1” on page 230

  This section details each of the steps taken to ensure that the application does not incur the overhead of extra TCB switches under CICS Transaction Server Version 2.3 compared to Version 1.3, without fully converting it from quasi-reentrant to threadsafe.

- 9.4, “Migration part 2” on page 246

  This section details each of the steps taken to fully convert the application from quasi-reentrant to threadsafe, in order to achieve a performance improvement.

- 9.5, “Performance measurement” on page 264

  This section details the actions taken to measure the application performance post-migration, and compares the threadsafe results with the quasi-reentrant results.

- 9.6, “Additional considerations for OPENAPI programs” on page 270

  This section details additional considerations involved should an application be migrated to run as OPENAPI under CICS Transaction Server Version 3.1 rather than threadsafe.

9.1 Application overview

This section describes the sample application that we used in the migration.

It should be noted that although the application is not realistic (it is designed to generate a large volume of CICS DB2 tasks rather than to serve any useful business purpose), the profile of the individual tasks are not dissimilar to some of the typical CICS transactions in large DB2 applications.

9.1.1 Description of the application

The application is designed to generate a large volume of CICS DB2 transactions. It consists of a driver transaction, which asynchronously starts 10 daughter transactions. Each of the daughter transactions, on completion, restarts itself a finite number of times.

There are 11 application programs, corresponding to the 11 transactions described previously. Each program issues a large number of EXEC SQL requests. The 10 daughter programs are similar, but not identical. In addition to the EXEC SQL requests, a variety of EXEC CICS commands are issued, and there are some updates to shared resources.

In addition to the 11 application programs, there are 3 global user exit programs, a PLTPI program, and a dynamic plan exit program.

Full source code listings of the application programs are provided in Appendix C, “Assembler routines” on page 339.

9.2 Migration plan

This section provides an overview of the plan we used to migrate the application from running as quasi-reentrant under CICS Transaction Server Version 1.3, to running as threadsafe under CICS Transaction Server Version 2.3.

A key decision we made at the outset was that we did not want to implement simultaneously what for most organizations would be two major changes. They are:

- Migrating the application from a CICS Transaction Server Version 1.3 region to a CICS Transaction Server Version 2.3 region
- Migrating the application to be fully threadsafe

At first glance, the first of the two changes above may not appear to have any relevance to a threadsafe migration. However, we have already discussed in this book that this is not the case. Chapter 8, "Migration pitfalls" on page 201, explains in detail why user exit programs must be considered when migrating a DB2 application to CICS Transaction Server Version 2 or later.

We therefore split our migration plan into two major parts to reflect the fact that most organizations will migrate to threadsafe in two stages. Table 9-1 outlines our migration plan.

Table 9-1 Migration plan

Threadsafe migration plan	
	Part 1 - Migrate application from CICS TS V1.3 to V2.3
Step 1	Identify exits in scope for part 1.
Step 2	Convert in-scope exits to be threadsafe.
Step 3	Address non threadsafe commands within in-scope exits.
Step 4	Confirm performance after migration to CICS TS 2.3.
	Part 2 - Migrate application to be fully threadsafe
Step 1	Identify programs in scope for part 2.
Step 2	Convert user exits to be threadsafe.
Step 3	Convert application programs to be threadsafe.
Step 4	Address non threadsafe commands.
Step 5	CICS system changes.

9.3 Migration part 1

As outlined in 9.2, "Migration plan" on page 229, the migration plan is split into two major parts:

- Upgrading to CICS Transaction Server Version 2.3 without incurring extra TCB switches
- Convert application to be fully threadsafe

This section covers part 1 of the migration, converting a quasi-reentrant DB2 application running under CICS Transaction Server Version 1.3, to run as largely quasi-reentrant under CICS Transaction Server Version 2.3, with the minimum of threadsafe-related changes.

Note: Upgrading a CICS region from one release to another is not what this book is about, and therefore this particular aspect of the migration is not covered. The focus of this section is on ensuring that the sample application can run as quasi-reentrant under CICS Transaction Server Version 2.3 and incur the same number of TCB switches as it did running under CICS Transaction Server Version 1.3. (The circumstances under which a quasi-reentrant application will incur additional TCB switches under CICS Transaction Server Version or later is discussed in detail in Chapter 8, “Migration pitfalls” on page 201.)

9.3.1 Step 1: Identify exits in scope for part 1

For the purposes of part 1 of the migration, we are only interested in programs, user exits, and commands that can be invoked on the call path of an EXEC SQL statement. These are the entities that can cause an increase in TCB switches under CICS Transaction Server Version 2 or later.

We know there are only two exit points invoked directly as a result of an EXEC SQL statement, XRMIIN and XRMIOUT, and that there is one user-replaceable module (URM) that can be invoked directly on the first SQL call of each unit of work—the dynamic plan exit program. The following sections cover each of these in turn.

XRMIIN and XRMIOUT

To determine whether this CICS region has programs running at the XRMIIN and XRMIOUT exit points, we ran the CICS-supplied sample statistics program, DFH0STAT, requesting a global user exit report.

Global User Exits

Exit Name	Program Name	Entry Name	<------- Global Area -------> Entry Name	Length	Use Count	Number of Exits	Program Status
XTSQRIN	XXXTS	XXXTS	XXXTS	64	1	1	Started
XEIIN	XXXEI	XXXEI		0	0	2	Started
XEIOUT	XXXEI	XXXEI		0	0	2	Started
XRMIIN	XXXRMI	XXXRMI		0	0	2	Started
XRMIOUT	XXXRMI	XXXRMI		0	0	2	Started

Figure 9-1 GLUE section of DFH0STAT report

As can be seen from Figure 9-1, program XXXRMI is enabled at both exit points. Therefore we now know that we have at least one program in scope for part 1. Next we need to determine whether it is possible for any of the other enabled exit points (XEIIN, XEIOUT, or XTSQRIN) to be invoked via XXXRMI, and the only accurate method of doing this is by examining the source code.

An examination of the XXXRMI source code in Appendix C, “Assembler routines” on page 339, shows that it does *not* contain any code that will cause the other exit points to be invoked, so the scope of this step is limited to XXXRMI itself.

Dynamic plan exit program

To determine whether any dynamic plan exit (DPE) programs exist, we again ran the CICS-supplied sample statistics program, DFH0STAT, this time requesting reports for DB2 connection and DB2 entries.

As can be seen in Figure 9-2, there is a single DPE program in use named PLANEXIT, so this can be added to the list of in-scope programs. We also need to determine whether PLANEXIT calls any other programs or invokes any user exits. The best method of achieving this is by examining the source code.

```
DB2 Connection
______________
  DB2 Connection Name. . . . . . . . . . . . :  DB2CON
  DB2 Group Id . . . . . . . . . . . . . . . :
  DB2 Sysid. . . . . . . . . . . . . . . . . :  D7Q2
  DB2 Release. . . . . . . . . . . . . . . . :   7.1.0
  DB2 Connection Status. . . . . . . . . . . :  CONNECTED
  DB2 Connection Error . . . . . . . . . . . :  SQLCODE
  DB2 Standby Mode . . . . . . . . . . . . . :  RECONNECT
  DB2 Pool Thread Plan Name. . . . . . . . . :
  DB2 Pool Thread Dynamic Plan Exit Name . . :  PLANEXIT
  Pool Thread Authtype . . . . . . . . . . . :  SIGNID

DB2 Entries
___________
  DB2Entry Name. . . . . . . . . . . . . . . :  MIG
  DB2Entry Static Plan Name. . . . . . . . . :
  DB2Entry Dynamic Plan Exit Name. . . . . . :  PLANEXIT
  DB2Entry Authtype. . . . . . . . . . . . . :  SIGNID
  DB2Entry Authid. . . . . . . . . . . . . . :
```

Figure 9-2 DB2 section of DFH0STAT report

We can see from the PLANEXIT source code in Appendix C, “Assembler routines” on page 339, that it does *not* call any other programs, but that it does issue an EXEC CICS ASSIGN command. We have already established the list of active exit points (see Figure 9-1 on page 231), so we can therefore conclude that PLANEXIT will cause program XXXEI to be invoked at the XEIIN and XEIOUT exit points.

We now know the full scope of the programs that need to be addressed in part 1 of the migration:

- User exit program XXXRMI, which is invoked twice (at XRMIIN and XRMIOUT) on every SQL call
- URM PLANEXIT, which is invoked on the first SQL call each unit of work,
- User exit program XXXEI, which is invoked twice (at XEIIN and XEIOUT) every time PLANEXIT executes

9.3.2 Step 2: Convert in-scope exits to threadsafe

Having established the list of in-scope exit programs for part 1, we now need to determine whether they can be redefined as threadsafe. This means identifying any instances of updates to shared resources, and removing or serializing access if they exist. Once completed, it is then safe to redefine the programs as threadsafe.

The actions taken to achieve this are listed here and described in the subsequent sections:

1. Run DFH0STAT to find shared program storage.
2. Run DFH0STAT to find GWAs.
3. Run DFHEISUP to find other potential shared resources.
4. Examine source code.
5. Redefine programs as threadsafe.

Run DFH0STAT to find shared program storage

The supplied sample statistics program, DFH0STAT, can provide useful information about the use of shared storage. First of all, the System Status section shows us whether reentrant programs reside in read-only storage (Figure 9-3).

```
System Status
_____________
  MVS Product Name. . . . . . . :  MVS/SP7.0.4
  CICS Startup. . . . . . . . . :  INITIAL
  CICS Status . . . . . . . . . :  ACTIVE
Storage Protection. . . . . . :  INACTIVE
Transaction Isolation . . . . :  INACTIVE
Reentrant Programs. . . . . . : PROTECT
```

Figure 9-3 System Status section of DFH0STAT report

Moreover, the Programs section shows us where each program resides.

```
Programs
________
  Program   Data   Exec                          Program    Program
    Name     Loc   Key    Times Used   ...        Size      Location
  ___________________________________________________________________
  DB2MANY    Any   USER            1              1,536      ERDSA
  DB2PROGA   Any   USER           12              1,312      ERDSA
  DB2PROG1   Any   USER           12              1,256      ERDSA
  DB2PROG2   Any   USER           12              1,256      ERDSA
  DB2PROG3   Any   USER           12              1,256      ERDSA
  DB2PROG4   Any   USER           12              1,216      ERDSA
  DB2PROG5   Any   USER           12              1,216      ERDSA
  DB2PROG6   Any   USER           12              1,216      ERDSA
  DB2PROG7   Any   USER           12              1,216      ERDSA
  DB2PROG8   Any   USER           12              1,304      ERDSA
  DB2PROG9   Any   USER           12              1,304      ERDSA
  EXITENBL   Any   USER            1                432      ERDSA
  PLANEXIT   Any   USER          121                208      ERDSA
  XXXEI      Any   USER            1                184      ERDSA
  XXXRMI     Any   USER            1                184      ERDSA
  XXXTS      Any   USER            1                104      ERDSA
```

Figure 9-4 Programs section of DFH0STAT report

Figure 9-3 on page 233 and Figure 9-4 together allow us to conclude that all application programs and exits are reentrant, reside in protected ERDSA storage, and therefore cannot use the program itself as a form of shared storage.

Run DFH0STAT to find GWAs

We have already run the supplied sample statistics program DFH0STAT to determine which user exit programs are enabled for the application. In addition to listing the exit programs, DFH0STAT also displays whether each one has a global work area (GWA).

```
Exit Programs
_____________
                              <---- Global Area ---->    No.
  Program     Entry       Entry               Use     of     Program
    Name       Name        Name      Length   Count   Exits  Status
  ____________________________________________________________________
  DFHEDP     DLI                          0       0       0  Started
  DFHD2EX1   DSNCSQL     DSNCSQL         16       1       0  Started
  XXXEI      XXXEI                        0       0       2  Started
  XXXRMI     XXXRMI                       0       0       2  Started
  XXXTS      XXXTS       XXXTS           64       1       1  Started
```

Figure 9-5 Exit Programs section of DFH0STAT report

By referring to Figure 9-5, we can see that both of the user exit programs in scope for part 1 of the migration, XXXRMI and XXXEI, have a GWA length of zero. We can also rule out the possibility that they share a GWA that is owned by another exit program, because the Entry Name column is blank for these programs, and the programs that do own a GWA have a use count of 1.

Run DFHEISUP to find potential shared resources

As a next step, we ran the CICS-supplied load module scanner DFHEISUP against *all* of the programs and exits, using our own modified version of the supplied threadsafe inhibitors table, DFHEIDTH.

> **Attention:** It is important to note that scanning the in-scope programs alone might not be sufficient, as the commands to create or address a shared resource may not necessarily be confined to the programs that access or update it.

The changes we made to DFHEIDTH are shown in Figure 9-6, and the output from DFHEISUP is shown in Figure 9-7 on page 236.

```
EXTRACT EXIT GASET *
GETMAIN SHARED *
ADDRESS CWA *
LOAD SET *            LOAD SET * command added to the supplied list
```

Figure 9-6 Modified DFHEIDTH threadsafe inhibitors table

```
Module Name        'CICSRS4.MIG.LOAD(DB2PROG4)'
Module Language    Assembler
Offset/EDF         Command
-----------------  ------------------------------------------
00001387/no-edf    ADDRESS CWA

Module Name        'CICSRS4.MIG.LOAD(DB2PROG5)'
Module Language    Assembler
Offset/EDF         Command
-----------------  ------------------------------------------
00001387/no-edf    ADDRESS CWA

Module Name        'CICSRS4.MIG.LOAD(DB2PROG6)'
Module Language    Assembler
Offset/EDF         Command
-----------------  ------------------------------------------
00001387/no-edf    ADDRESS CWA

Module Name        'CICSRS4.MIG.LOAD(DB2PROG7)'
Module Language    Assembler
Offset/EDF         Command
-----------------  ------------------------------------------
00001387/no-edf    ADDRESS CWA

Total possible commands located = 4
```

Figure 9-7 DFHEISUP detailed report using DFHEIDTH filter table

Figure 9-7 shows that XXXRMI, XXXEI, and PLANEXIT are not mentioned in the DFHEISUP report, which means that none of them issue any of the threadsafe inhibitor commands. Also significant is that there is no instance anywhere in the application of the LOAD, GETMAIN SHARED, and EXTRACT EXIT commands. However, it is important to note that the application does make use of the common work area (CWA). It is possible for the CWA address to be passed to other programs as a parameter.

Examine source code

Although running utilities such as DFH0STAT and DFHEISUP can help determine whether a program is likely to be threadsafe, ultimately this is no substitute for a full understanding of the application.

However, we are off to a good start. The previous steps have already allowed us to conclude that:

- All programs are reentrant and reside in read-only storage.
- XXXRMI and XXXEI do not use GWAs.

- There is no use of EXEC CICS SHARED GETMAIN within the application.
- There is no use of EXEC CICS EXTRACT EXIT within the application.
- There is no use of EXEC CICS LOAD within the application.
- The application uses the CWA, but not necessarily in the in-scope programs.

All that remains is to examine the source code of the in-scope programs for evidence of CWA access, and any nonstandard programming techniques that could result in access to a shared resource. The source code for XXXRMI, PLANEXIT, and XXXEI is listed in Appendix C, “Assembler routines” on page 339, and it is clear from this that there is nothing to cause us any concern in this regard.

Redefine programs as threadsafe

Now that we have established that XXXRMI, PLANEXIT, and XXXEI are all truly threadsafe, we can redefine them as such.

Figure 9-8 shows the program definition for PLANEXIT after it has been redefined as threadsafe. The same change was made to the XXXRMI and XXXEI definitions. Figure 9-9 on page 238 shows how CEMT can be used to confirm this.

```
CEDA  View PROGram( PLANEXIT )
 PROGram        : PLANEXIT
 Group          : THDSAFE
 DEscription    :
 Language       :
 RELoad         : No
 RESident       : No
 USAge          : Normal
 USElpacopy     : No
 Status         : Enabled
 RSl            : 00
 CEdf           : Yes
 DAtalocation   : Any
 EXECKey        : User
 COncurrency    : Threadsafe
REMOTE ATTRIBUTES
```

Figure 9-8 CEDA VIEW PROGRAM display

```
I PROG(XXX*)
STATUS:  RESULTS - OVERTYPE TO MODIFY
 Prog(XXXEI   ) Leng(0000000184) Ass Pro Ena Pri     Ced
    Res(001) Use(0000000001) Any Uex Ful Thr           Nat
 Prog(XXXRMI  ) Leng(0000000184) Ass Pro Ena Pri     Ced
    Res(001) Use(0000000001) Any Uex Ful Thr           Nat
 Prog(XXXTS   ) Leng(0000000104) Ass Pro Ena Pri     Ced
    Res(001) Use(0000000001) Any Uex Ful Qua           Nat
```

Figure 9-9 CEMT INQUIRE PROGRAM display

9.3.3 Step 3: Address non threadsafe commands

Having successfully converted each of the programs in scope for part 1 to be threadsafe, the final step is to determine whether any of these programs issues non threadsafe commands. These programs are invoked on the SQL call path, and are therefore critical to performance. Any non threadsafe commands issued within an SQL flow will cause a TCB switch from L8 to QR and back again. Refer to chapter Chapter 2, “OTE and threadsafe overview” on page 11, for a full discussion on this topic.

To determine which commands are issued by XXXRMI, PLANEXIT, and XXXEI, we ran the load module scanner utility, DFHEISUP, with the supplied non threadsafe command table, DFHEIDNT.

```
CICS LOAD MODULE SCANNER UTILITY
SCAN PERFORMED ON Fri May  7 11:21:25 2004 USING TABLE RSTABLE2.3

SUMMARY LISTING OF CICSRS4.MIG.LOAD.PART1
=====================================
Module Name   Commands Found  Language

LOAD LIBRARY STATISTICS
=======================
Total modules in library                          =      3
Total modules Scanned                             =      3
Total CICS modules/tables not scanned             =      0
Total modules possibly containing requested commands =      0
```

Figure 9-10 DFHEISUP summary report using DFHEIDNT filter table

Figure 9-10 on page 238 shows the DFHEISUP summary report when run against XXXRMI, PLANEXIT, and XXXEI, and shows that the number of non threadsafe commands in these three programs is zero.

We can conclude therefore that we have no further work to do to address non threadsafe commands in part 1 of the migration.

9.3.4 Step 4: Confirm performance after migration to CICS TS 2.3

Important: The results shown in this section are specific to the sample application and the system it was running on at the time. The purpose is to illustrate the importance of converting user exits on the SQL call path to be threadsafe when upgrading to CICS Transaction Server Version 2 or later. However, these specific results should not be used as a benchmark for other applications or any other system.

We have now completed part 1 of the migration, that is, migrated the application from CICS Transaction Server Version 1.3 to CICS Transaction Server Version 2.3, and converted the user exit programs on the SQL call path to be threadsafe.

To confirm that the application is not incurring extra TCB switches under CICS Transaction Server Version 2.3, and therefore has comparable performance with CICS Transaction Server Version 1.3, we used CICS Performance Analyzer Version 1 Release 3 to interrogate the SMF type 110 records. Figure 9-11 on page 240 shows the selection criteria we used to generate the reports. We used 5-minute intervals (that is, the difference between SMFSTART and SMFSTOP) in each of the reports

For more information about CICS Performance Analyzer (CICS PA) see the IBM Redbooks publication *CICS Performance Analyzer*, SG24-6063.

```
CICSPA IN(SMFIN001),
       SMFSTART(yyyy/mm/dd,hh:mm:ss.00),
       SMFSTOP(yyyy/mm/dd,hh:mm:ss.00),
       APPLID(cicsapplid),
       LINECNT(60),
       FORMAT(':','/'),
   SUMMARY(OUTPUT(TESTSUM),
       BY(TRAN),
       SELECT(PERFORMANCE(
       INC(TRAN(DB21,DB22,DB23,DB24,DB25,
       DB26,DB27,DB28,DB29,DB2A)))),
       FIELDS(TRAN,
              TASKCNT,
              DB2REQCT(TOTAL),
              CHMODECT(TOTAL)))
```

Figure 9-11 Selection criteria for CICS PA report

First, we measured our baseline. Figure 9-12 shows the result of running CICS PA prior to part 1 of the migration, when the application was running under CICS Transaction Server Version 1.3.

```
 V1R3M0      CICS Performance Analyzer
                Performance Summary
 ___________________________________________________
 Data from 02:44:58  5/13/2004 to 02:49:59  5/13/200


                        Total    Total
Tran       #Tasks    DB2 Reqs ChngMode

DB2A          482      482000        0
DB21          470      470000        0
DB22          479      479000        0
DB23          483      483000        0
DB24          484      484000        0
DB25          461      461000        0
DB26          481      481000        0
DB27          494      494000        0
DB28          482      482000        0
DB29          490      490000        0
```

Figure 9-12 CICS PA report showing SQL calls in CICS TS 1.3

> **Note:** The number of switches between the QR TCB and DB2 subtask thread TCBs is not captured in SMF type 110 records for CICS Transaction Server Version 1.3. However, it is possible to calculate this value from the number of SQL calls. The formula is:
>
> ```
> TCB switches = (SQL calls * 2) + (syncpoints * 4) - (read-only syncpoints * 2)
> ```
>
> (Units of work with no DB2 updates will perform single-phase commit rather than two-phase commit, and therefore two switches will occur during sync point instead of four.)

As expected, the ChngMode field is zero for our CICS Transaction Server Version 1.3 transactions (see Figure 9-12 on page 240). However, the number of TCB switches can be calculated using the formula defined above. From our knowledge of the sample application, we know we have a read-only workload with only one syncpoint per task, so the total TCB switches for each transaction shown in Figure 9-12 on page 240 can be calculated using the following modified formula:

```
TCB switches = (2 * DB2 Reqs) + (2 * #tasks)
```

Now that we know our baseline, we measured application performance under CICS Transaction Server Version 2.3. Figure 9-13 on page 242 shows the result of running the same CICS PA report after part 1 of the migration was completed.

```
 V1R3M0     CICS Performance Analyzer
               Performance Summary
__________________________________________________
Data from 15:09:58  5/13/2004 to 15:14:59  5/13/2004


                           Total    Total
Tran        #Tasks   DB2 Reqs ChngMode

DB2A           498     498000   996996
DB21           499     499000   998998
DB22           500     500000   1001E3
DB23           498     498000   996996
DB24           498     498000   996996
DB25           498     498000   996996
DB26           499     499000   998998
DB27           499     499000   998998
DB28           498     498000   996996
DB29           498     498000   996996
```

Figure 9-13 CICS PA report showing TCB switches in CICS TS 2.3

To compare the figures from CICS Transaction Server Version 1.3 and CICS Transaction Server Version 2.3, we calculated the averages across all transactions and tabulated the results (Table 9-2).

Table 9-2 CICSTS 1.3 versus CICS TS 2.3

	CICS TS 1.3	**CICS TS 2.3**
Avg. SQL calls per task	1000	1000
Avg. TCB switches per task	2002	2002
Transaction throughput	15.97 tps	16.56 tps

The figures in Table 9-2 confirm that we have achieved the goal of part 1 of the migration plan. The application is now running as quasi-reentrant under CICS Transaction Server Version 2.3, without extra TCB switches, and with a transaction throughput that is similar to CICS Transaction Server Version 1.3. In fact, we measured a slight improvement in throughput.

What will happen if

Throughout this book we have continually highlighted the benefit of converting all user exit programs on the SQL call path to threadsafe when upgrading to CICS

Transaction Server Version 2 or later, even if the initial intention is to leave application code as quasi-reentrant. This is why we split the migration plan into two parts in this chapter.

To further illustrate this point, we decided to measure what the sample application performance *would have been* had we simply upgraded to CICS Transaction Server Version 2.3 without converting the user exit programs on the SQL call path to threadsafe.

We therefore redefined XXXRMI, PLANEXIT, and XXXEI as quasi-reentrant under CICS Transaction Server Version 2.3, and generated the same CICS PA report that we produced with the programs defined as threadsafe. To differentiate this from what we actually did in part 1 of the migration, we have called this approach the *simplistic conversion* to CICS Transaction Server Version 2.3. The results are shown in Figure 9-14.

```
 V1R3M0     CICS Performance Analyzer
               Performance Summary
__________________________________________________
Data from 16:39:58  5/13/2004 to 16:44:59  5/13/2004


                      Total    Total
Tran       #Tasks   DB2 Reqs ChngMode

DB2A          368     368000   2209E3
DB21          368     368000   2209E3
DB22          368     368000   2209E3
DB23          367     367000   2203E3
DB24          368     368000   2209E3
DB25          368     368000   2209E3
DB26          367     367000   2203E3
DB27          367     367000   2203E3
DB28          368     368000   2209E3
DB29          369     369000   2215E3
```

Figure 9-14 CICS PA report showing TCB switches after simplistic conversion

To compare the simplistic conversion figures with both CICS Transaction Server Version 1.3 and our actual CICS Transaction Server Version 2.3 migration, we again calculated the averages across all transactions and added the results to our table. See Table 9-3.

Table 9-3 CICS TS 1.3 vs. CICS TS 2.3 actual conversion vs. simplistic conversion

	CICS TS 1.3	**CICS TS 2.3 (actual conversion)**	**CICS TS 2.3 (simplistic conversion)**
Avg. SQL calls per task	1000	1000	1000
Avg. TCB switches per task	2002	2002	**6003**
Transaction throughput	15.97 tps	16.56 tps	**12.26tps**

As can be seen in Table 9-3, failure to define all the user exit programs on the SQL call path within the sample application as threadsafe would have resulted in a significant increase in TCB switches after the upgrade from CICS Transaction

Server Version 1.3 to CICS Transaction Server Version 2.3 and a corresponding decline in transaction throughput. This point is reinforced by the two charts shown in Figure 9-15 and Figure 9-16 on page 246.

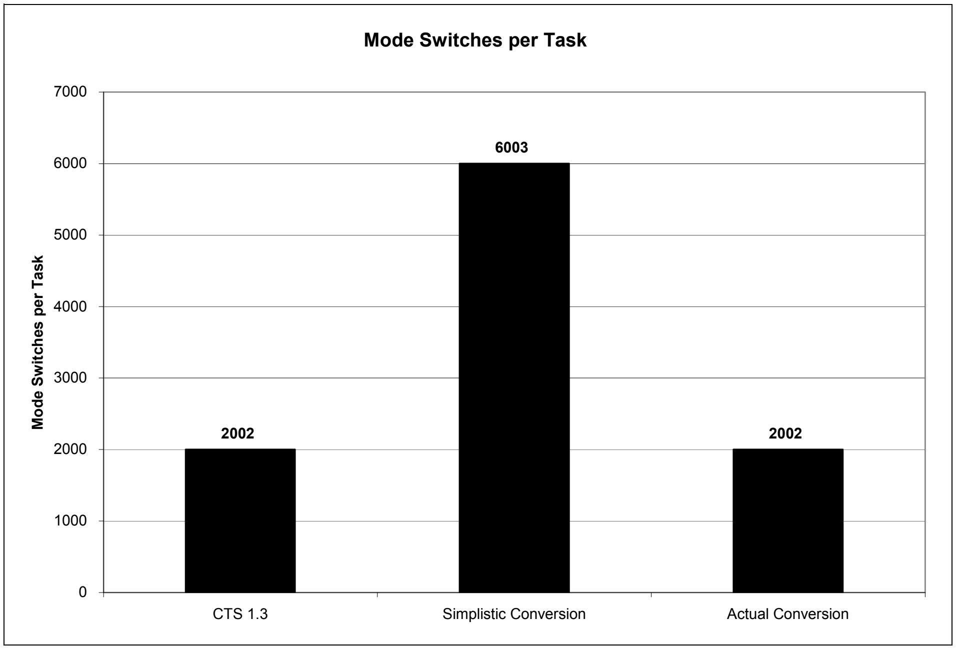

Figure 9-15 Mode switches per task

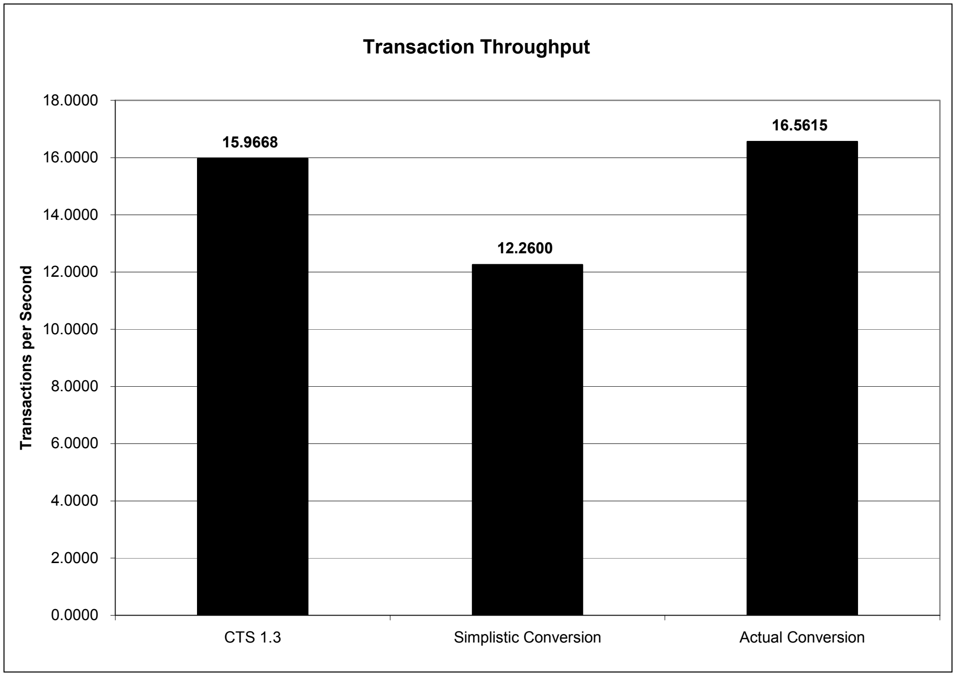

Figure 9-16 Transaction throughput

9.4 Migration part 2

As outlined in 9.2, “Migration plan” on page 229, the migration plan is split into two major parts:

- Upgrading to CICS Transaction Server Version 2.3 without incurring extra TCB switches
- Converting application to be fully threadsafe

This section covers part 2 of the migration, which converts the application to be threadsafe.

9.4.1 Step 1: Identify programs in scope for part 2

The first step is to identify the application programs (including PLT programs), user exits, and user-replaceable modules that are defined as quasi-reentrant. If program autoinstall is in operation, it is not sufficient to use a list of programs defined to CICS—we need to start with the application load libraries concatenated within DFHRPL.

The list of modules in the sample application load library is shown in Figure 9-17, while Figure 9-18 on page 248 shows the corresponding entries from the Programs by DSA section of a DFH0STAT print.

```
Name            Size       TTR     AC   AM   RM   Attributes
DB2MANY        00000558   001D46   00    31  ANY      RN RU
DB2PROGA       00000480   001E06   00    31  ANY      RN RU
DB2PROG1       00000448   001E0F   00    31  ANY      RN RU
DB2PROG2       00000448   001E18   00    31  ANY      RN RU
DB2PROG3       00000448   001E21   00    31  ANY      RN RU
DB2PROG4       00000420   001E2A   00    31  ANY      RN RU
DB2PROG5       00000420   001E33   00    31  ANY      RN RU
DB2PROG6       00000420   001E3C   00    31  ANY      RN RU
DB2PROG7       00000420   001F02   00    31  ANY      RN RU
DB2PROG8       00000478   001F0B   00    31  ANY      RN RU
DB2PROG9       00000478   001F14   00    31  ANY      RN RU
EXITENBL       000001B0   001D1A   00    31  ANY      RN RU
PLANEXIT       000000D0   001D23   00    31  ANY      RN RU
XXXEI          000000B8   001D2C   00    31  ANY      RN RU
XXXRMI         000000B8   001D35   00    31  ANY      RN RU
XXXTS          00000068   001D3E   00    31  ANY      RN RU
```

Figure 9-17 Application load library member list

Programs by DSA and LPA

Program Name	Concurrency Status	Times Used ...	Program Size	Program Location
DB2MANY	Quasi Rent	3	1,368	ERDSA
DB2PROGA	Quasi Rent	36	1,152	ERDSA
DB2PROG1	Quasi Rent	36	1,096	ERDSA
DB2PROG2	Quasi Rent	36	1,096	ERDSA
DB2PROG3	Quasi Rent	36	1,096	ERDSA
DB2PROG4	Quasi Rent	36	1,056	ERDSA
DB2PROG5	Quasi Rent	36	1,056	ERDSA
DB2PROG6	Quasi Rent	36	1,056	ERDSA
DB2PROG7	Quasi Rent	36	1,056	ERDSA
DB2PROG8	Quasi Rent	36	1,144	ERDSA
DB2PROG9	Quasi Rent	36	1,144	ERDSA
EXITENBL	Quasi Rent	1	432	ERDSA
PLANEXIT	Thread Safe	363	208	ERDSA
XXXEI	Thread Safe	1	184	ERDSA
XXXRMI	Thread Safe	1	184	ERDSA
XXXTS	Quasi Rent	1	104	ERDSA

Figure 9-18 Programs by DSA section of DFH0STAT report

Taking the information displayed in Figure 9-17 on page 247 and Figure 9-18 together, we now have a definitive list of the application programs and exits that are defined as quasi-reentrant:

- DB2MANY
- DB2PROG1
- DB2PROG2
- DB2PROG3
- DB2PROG4
- DB2PROG5
- DB2PROG6
- DB2PROG7
- DB2PROG8
- DB2PROG9
- DB2PROGA
- EXITENBL
- XXXTS

These programs constitute the full scope of part 2 of the migration.

9.4.2 Step 2: Convert user exits to be threadsafe

This step has a variety of tasks, such as gathering information and examining code, as well as other tasks.

Gather information using DFH0STAT

To determine whether any user exits are in scope for part 2, we again look at the Exit Programs section of the DFH0STAT print.

Figure 9-19 shows that we have one global user exit in scope for migration. Program XXXTS is enabled at the XTSQRIN exit point. (The CICS Customization Guide tells us that XTSQRIN is invoked prior to each user temporary storage request.)

```
User Exit Programs
__________________
                      <---- Global Area ---->   No.
  Program    Entry     Entry           Use     of    Program    Program
    Name      Name      Name    Length  Count  Exits  Status   Concurrency
  ____________________________________________________________________________
  XXXEI      XXXEI                   0      0      2  Started  Thread Safe
  XXXRMI     XXXRMI                  0      0      2  Started  Thread Safe
  XXXTS      XXXTS      XXXTS       64      1      1  Started  Quasi Rent

Global User Exits
_________________
    Exit     Program    Entry    <------- Global Area ------->  Number    Program
    Name      Name      Name     Entry Name  Length  Use Count  of Exits  Status
  ______________________________________________________________________________
  XTSQRIN    XXXTS      XXXTS     XXXTS         64          1         1   Started
  XEIIN      XXXEI      XXXEI                    0          0         2   Started
  XEIOUT     XXXEI      XXXEI                    0          0         2   Started
  XRMIIN     XXXRMI     XXXRMI                   0          0         2   Started
  XRMIOUT    XXXRMI     XXXRMI                   0          0         2   Started
```

Figure 9-19 User Exits section of DFH0STAT report

Highly significant is the fact that DFH0STAT also shows that XXXTS owns a global work area (see Figure 9-19). A GWA is, by definition, a shared resource, and we now must determine which programs access it. As owner of the GWA, it is probable that the XXXTS code is not threadsafe, but we will need to look at the source code to confirm this.

Examine source code

The source code for XXXTS is listed in Appendix C, “Assembler routines” on page 339. An examination of this code confirms that this program is not threadsafe, because it updates a counter field in the GWA without serialization.

Gather information using DFHEISUP

Having discovered a shared resource (that is, the XXXTS GWA) we now need to determine which other programs access this resource. DFH0STAT has already told us that no other user exits programs share this GWA (see Figure 9-19 on page 249). However, we also need to look for programs that address it via an EXEC CICS EXTRACT EXIT command.

DFHEISUP is designed for this purpose, and we ran it against the entire application using a single filter table entry: EXEC CICS EXTRACT EXIT GASET *. Figure 9-20 shows the output from DFHEISUP.

```
CICS LOAD MODULE SCANNER UTILITY
SCAN PERFORMED ON Fri May  7 16:35:42 2004 USING TABLE RSTABLE2.3

SUMMARY LISTING OF CICSRS4.MIG.LOAD
=====================================
Module Name   Commands Found  Language

LOAD LIBRARY STATISTICS
=======================
Total modules in library                             =     16
Total modules Scanned                                =     16
Total CICS modules/tables not scanned                =      0
Total modules possibly containing requested commands =      0
```

*Figure 9-20 DFHEISUP summary report for EXTRACT EXIT * command*

DFHEISUP tells us that no program issues the EXEC CICS EXTRACT EXIT command, so it is safe for us to conclude that access to this GWA is limited to program XXXTS.

Important: We were able to reach this conclusion because we know the sample application always uses standard CICS interfaces to address GWAs. Applications using other methods to address GWAs would need further investigation before this conclusion could be reached.

Serialize access to GWAs

Having established that XXXTS is the only program to update the GWA, we now need to ensure that this update is serialized. Figure 9-21 shows the appropriate extract from the source code.

```
GWAUPDT  EQU    *
         L      R6,GWACOUNT           GET THE COUNTER
         LA     R6,1(R6)              INCREMENT
         ST     R6,GWACOUNT             AND STORE
         B      RETURN                EXIT
```

Figure 9-21 XXXTS source code (quasi-reentrant)

We can see in Figure 9-21 that the update is performed with a store (ST) instruction. Using XPI enqueue and dequeue commands to serialize this update would be perfectly valid, but since a single field is being updated, we decided to replace the store with a Compare and Swap (CS) routine. Figure 9-22 shows the changed code.

```
GWAUPDT  EQU    *
         L      R6,GWACOUNT           PUT ORIGINAL COUNTER IN R6
LOOP     LR     R7,R6                 CREATE A COPY IN R7 TO MODIFY
         LA     R7,1(R7)              INCREMENT THE COPY IN R7
         CS     R6,R7,GWACOUNT        USE COMPARE & SWAP TO UPDATE
         BC     4,LOOP                 AND REPEAT IF UNSUCCESFUL
         B      RETURN                EXIT
```

Figure 9-22 XXXTS source code (threadsafe)

Having serialized access to the GWA, XXXTS now contains threadsafe code.

Redefine exits as threadsafe

Having completed an analysis of all user exits, identified and serialized access to their shared resources (from all application programs, not just user exit programs), it is now safe to redefine all exits as threadsafe.

Figure 9-23 shows XXXTS redefined as threadsafe.

```
 OBJECT CHARACTERISTICS
  CEDA  View PROGram( XXXTS    )
   PROGram        : XXXTS
   Group          : MIGAPPL3
   DEscription    :
   Language       :
   RELoad         : No
   RESident       : No
   USAge          : Normal
   USElpacopy     : No
   Status         : Enabled
   RSl            : 00
   CEdf           : Yes
   DAtalocation   : Any
   EXECKey        : User
   COncurrency    : Threadsafe
  REMOTE ATTRIBUTES
   DYnamic        : No
 + REMOTESystem   :
```

Figure 9-23 CEDA view program display

9.4.3 Step 3: Convert application programs to be threadsafe

For most applications, this is likely to be the single biggest step in a threadsafe migration, and the step most dependent on user application knowledge. The migration process described in this section is valid for the sample application because we know that this application uses standard CICS interfaces to create and address shared resources.

Run DFH0STAT to find shared program storage

This is a step we have already performed in part 1 of the migration, but it must be repeated now if the application has changed in the meantime. (In a real-life scenario, months may have elapsed between the implementation of parts 1 and 2 of the migration plan.) This is not the case for the sample, and therefore the conclusion reached in part 1 is still valid—program storage is not used as a shared resource within the application.

Refer to "Run DFH0STAT to find shared program storage" on page 233 for a full discussion of the results of this step.

Run DFHEISUP to find potential shared resources

This is also a step that has already been performed in part 1 of the migration, and would only need to be repeated if the application had changed in the meantime. The details are discussed in “Run DFHEISUP to find potential shared resources” on page 235, but since the results are more relevant to this part of the migration, they are repeated here in Figure 9-24.

```
Module Name        'CICSRS4.MIG.LOAD(DB2PROG4)'
Module Language    Assembler
Offset/EDF         Command
-----------------  ------------------------------------------
00001387/no-edf    ADDRESS CWA

Module Name        'CICSRS4.MIG.LOAD(DB2PROG5)'
Module Language    Assembler
Offset/EDF         Command
-----------------  ------------------------------------------
00001387/no-edf    ADDRESS CWA

Module Name        'CICSRS4.MIG.LOAD(DB2PROG6)'
Module Language    Assembler
Offset/EDF         Command
-----------------  ------------------------------------------
00001387/no-edf    ADDRESS CWA

Module Name        'CICSRS4.MIG.LOAD(DB2PROG7)'
Module Language    Assembler
Offset/EDF         Command
-----------------  ------------------------------------------
00001387/no-edf    ADDRESS CWA

Total possible commands located = 4
```

Figure 9-24 DFHEISUP detailed report using DFHEIDTH filter table

Running DFHEISUP with the threadsafe inhibitors table DFHEIDTH reveals that the programs listed here all address the CWA (Figure 9-24):

- DB2PROG4
- DB2PROG5
- DB2PROG6
- DB2PROG7

The absence within the application of the GETMAIN SHARED, EXTRACT EXIT, and LOAD SET commands is confirmed by DFHEISUP, and therefore since we know that *the sample always uses standard CICS interfaces*, we can conclude that the CWA is the only remaining shared resource we need to address.

Examine source code

We have reached the point in the migration where we know we have one remaining shared resource—the CWA—to investigate, and we have also identified the programs that access it: DB2PROG4, DB2PROG5, DB2PROG6, and DB2PROG7.

An examination of the source code (listed in Appendix C, “Assembler routines” on page 339) shows us that each of the four programs access and update the data in the CWA using the same sequence of instructions. An appropriate extract is shown in Figure 9-25.

```
*****************************************************************
*                                    INCREMENT COUNTER IN CWA
         EXEC CICS ADDRESS CWA(R10)
         USING CWASTG,R10
         L     R9,CWACOUNT
         LA    R9,1(R9)
         ST    R9,CWACOUNT
*****************************************************************
```

Figure 9-25 DB2PROG4-7 source code (quasi-reentrant)

Figure 9-25 shows that all four programs take a counter from the CWA, increment it by 1, and then store it back. This code is not threadsafe, and unless changed, all four programs must remain defined as quasi-reentrant.

Note: For the purposes of our test we decided to use enqueue/dequeue to serialize access. It should be noted though that Compare and Swap is less costly than using enqueue/dequeue.

Serialize access to shared resources

We have identified that we have non threadsafe code in the application. Programs DB2PROG4, DB2PROG5, DB2PROG6, and DB2PROG7 all update a counter field in the CWA. To convert this code to be threadsafe, we decided to serialize access to the CWA.

To achieve this, all four programs must be changed to use an identical serialization technique. The option we chose was an enqueue/dequeue on the address of the CWA. Figure 9-26 shows the appropriate extract of code after the EXEC CICS ENQ and DEQ commands have been added. (The code prior to the change was shown previously in Figure 9-25 on page 254.)

```
*****************************************************************
*                                    INCREMENT COUNTER IN CWA
         EXEC CICS ADDRESS CWA(R10)
         USING CWASTG,R10
         EXEC  CICS ENQ RESOURCE(CWASTG)
         L     R9,CWACOUNT           UPDATE CWA WHILE
         LA    R9,1(R9)               OWNING ENQ ON
         ST    R9,CWACOUNT             CWA ADDRESS
         EXEC  CICS DEQ RESOURCE(CWASTG)
*****************************************************************
```

Figure 9-26 DB2PROG4-7 source code (threadsafe)

The code illustrated in Figure 9-26 is threadsafe and enables programs DB2PROG4, DB2PROG5, DB2PROG6, and DB2PROG7 to be redefined as such.

Redefine application programs as threadsafe

Having completed an analysis of all application programs, identified and serialized access to their shared resources, it is now safe to redefine all programs as threadsafe.

Figure 9-27 shows a CEMT display of the application programs after they have been redefined as threadsafe.

```
I PROG(DB2*)
STATUS:  RESULTS - OVERTYPE TO MODIFY
 Prog(DB2MANY ) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
 Prog(DB2PROGA) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
 Prog(DB2PROG1) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
 Prog(DB2PROG2) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
 Prog(DB2PROG3) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
 Prog(DB2PROG4) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
 Prog(DB2PROG5) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
 Prog(DB2PROG6) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
 Prog(DB2PROG7) Leng(0000000000)     Pro Ena Pri     Ced
    Res(000) Use(0000000000) Any Uex Ful Thr
Prog(DB2PROG8) Leng(0000000000)     Pro Ena Pri     Ced
   Res(000) Use(0000000000) Any Uex Ful Thr
Prog(DB2PROG9) Leng(0000000000)     Pro Ena Pri     Ced
   Res(000) Use(0000000000) Any Uex Ful Thr
```

Figure 9-27 CEMT INQUIRE PROGRAM display

9.4.4 Step 4: Address non threadsafe commands

Having successfully converted and redefined all application programs and exits as threadsafe, our one remaining migration task is to investigate the extent to which non threadsafe commands are used within the application. In particular, we are looking for commands that can be issued between the first and last SQL call within a CICS task. Non threadsafe commands that are issued either prior to the first SQL call or after the last SQL call will not have a detrimental impact on performance.

Note: In CICS Transaction Server Version 3.1 if the application is an OPENAPI application then all non threadsafe commands, wherever they are in the program, are an issue. They would cause two TCB switches per command.

To determine which commands are issued within the application, we ran the load module scanner utility, DFHEISUP, with the supplied non threadsafe command table, DFHEIDNT, against the whole application.

```
SUMMARY LISTING OF CICSRS4.MIG.LOAD
=====================================
Module Name                  Commands Found  Language
'CICSRS4.MIG.LOAD(DB2MANY)'               2  Assembler
'CICSRS4.MIG.LOAD(DB2PROGA)'              3  Assembler
'CICSRS4.MIG.LOAD(DB2PROG1)'              4  Assembler
'CICSRS4.MIG.LOAD(DB2PROG2)'              4  Assembler
'CICSRS4.MIG.LOAD(DB2PROG3)'              4  Assembler
'CICSRS4.MIG.LOAD(DB2PROG4)'              2  Assembler
'CICSRS4.MIG.LOAD(DB2PROG5)'              2  Assembler
'CICSRS4.MIG.LOAD(DB2PROG6)'              2  Assembler
'CICSRS4.MIG.LOAD(DB2PROG7)'              2  Assembler
'CICSRS4.MIG.LOAD(DB2PROG8)'              3  Assembler
'CICSRS4.MIG.LOAD(DB2PROG9)'              3  Assembler
'CICSRS4.MIG.LOAD(EXITENBL)'              2  Assembler

LOAD LIBRARY STATISTICS
=======================
Total modules in library                           =     16
Total modules Scanned                              =     16
Total CICS modules/tables not scanned              =      0
Total modules possibly containing requested commands =   12
```

Figure 9-28 DFHEISUP summary report using DFHEIDNT filter table

Figure 9-28 shows the summary output from DFHEISUP and highlights the programs that will need further investigation. From our knowledge of the sample application, we know that each application program listed in the report is a self-contained CICS transaction, so we can examine the use of commands on a program-by-program basis.

The source code for the programs discussed in the following sections is listed in Appendix C, “Assembler routines” on page 339.

Program DB2MANY

Figure 9-29 details the two non threadsafe commands discovered by DFHEISUP in program DB2MANY: EXEC CICS START and EXEC CICS SEND.

```
Module Name         'CICSRS4.MIG.LOAD(DB2MANY)'
Module Language     Assembler
Offset/EDF          Command
-----------------   ------------------------------------------
00001650/no-edf     START TRANSID FROM LENGTH INTERVAL
00001659/no-edf     SEND TEXT FROM LENGTH FREEKB TERMINAL
```

Figure 9-29 DFHEISUP detailed report for program DB2MANY

We can see from the source code in Appendix C, “Assembler routines” on page 339, that DB2MANY contains EXEC SQL calls, but both the START and SEND commands will always be executed after the last call, and so will not impact performance. No action is therefore required.

(The ASKTIME command, which will be executed between SQL calls, was made threadsafe in CICS Transaction Server Version 2.3).

Programs DB2PROG1, DB2PROG2, and DB2PROG3

Figure 9-30 details the four non threadsafe commands discovered by DFHEISUP in programs DB2PROG1, 2, and 3:

- EXEC CICS RETRIEVE
- EXEC CICS POST
- EXEC CICS WAITCICS
- EXEC CICS START

```
Module Name          'CICSRS4.MIG.LOAD(DB2PROG1)'
Module Language      Assembler
Offset/EDF           Command
-----------------    -----------------------------------------
00001435/no-edf      RETRIEVE LENGTH SET
00001444/no-edf      POST SET INTERVAL
00001453/no-edf      WAITCICS ECBLIST NUMEVENTS PURGEABILITY NAME
00001466/no-edf      START TRANSID FROM LENGTH INTERVAL

Module Name          'CICSRS4.MIG.LOAD(DB2PROG2)'
Module Language      Assembler
Offset/EDF           Command
-----------------    -----------------------------------------
00001435/no-edf      RETRIEVE LENGTH SET
00001444/no-edf      POST SET INTERVAL
00001453/no-edf      WAITCICS ECBLIST NUMEVENTS PURGEABILITY NAME
00001466/no-edf      START TRANSID FROM LENGTH INTERVAL

Module Name          'CICSRS4.MIG.LOAD(DB2PROG3)'
Module Language      Assembler
Offset/EDF           Command
-----------------    -----------------------------------------
00001435/no-edf      RETRIEVE LENGTH SET
00001444/no-edf      POST SET INTERVAL
00001453/no-edf      WAITCICS ECBLIST NUMEVENTS PURGEABILITY NAME
00001466/no-edf      START TRANSID FROM LENGTH INTERVAL
```

Figure 9-30 DFHEISUP detailed report for programs DB2PROG1, 2, and 3

We can see from the source code in Appendix C, "Assembler routines" on page 339, that these three programs contain EXEC SQL calls, but both the RETRIEVE and POST will always be executed before the first call, and the START will always be executed after the last call, and so these commands will not impact performance.

However, the WAITCICS command presents a problem, because it is non threadsafe and it will always be executed between SQL calls. Our options are:

- Leave the code unchanged and not gain the performance benefit from defining the programs as threadsafe.
- Redesign the code so that the WAITCICS does not execute between SQL calls.
- Change the code so that the WAITCICS is no longer required.

In actual fact, there is a simple solution in this particular case that makes the last option viable. The EXEC CICS WAIT EXTERNAL command *is* threadsafe, and can be substituted in our application for the WAITCICS command. Figure 9-31 and Figure 9-32 show the code change that we implemented.

```
         LA    R9,ECB1              WAIT UNTIL ECB POSTED
         EXEC  CICS WAITCICS                                           X
                    ECBLIST(R9)                                        X
                    NUMEVENTS(=F'1')                                   X
                    NAME(=C'APPLWAIT')                                 X
                    PURGEABLE
```

Figure 9-31 Unchanged code contains a non threadsafe command

```
         LA    R9,ECB1              WAIT UNTIL ECB POSTED
         EXEC  CICS WAIT EXTERNAL                                      X
                    ECBLIST(R9)                                        X
                    NUMEVENTS(=F'1')                                   X
                    NAME(=C'APPLWAIT')                                 X
                    PURGEABLE
```

Figure 9-32 Code changed to use a threadsafe command

Programs DB2PROG4, DB2PROG5, DB2PROG6, and DB2PROG7

Figure 9-33 details the two non threadsafe commands discovered by DFHEISUP in programs DB2PROG4, 5, 6, and 7:

- EXEC CICS RETRIEVE
- EXEC CICS START

```
Module Name          'CICSRS4.MIG.LOAD(DB2PROG4)'
Module Language      Assembler
Offset/EDF           Command
------------------   --------------------------------------------
00001409/no-edf      RETRIEVE LENGTH SET
00001427/no-edf      START TRANSID FROM LENGTH INTERVAL

Module Name          'CICSRS4.MIG.LOAD(DB2PROG5)'
Module Language      Assembler
Offset/EDF           Command
------------------   --------------------------------------------
00001409/no-edf      RETRIEVE LENGTH SET
00001427/no-edf      START TRANSID FROM LENGTH INTERVAL

Module Name          'CICSRS4.MIG.LOAD(DB2PROG6)'
Module Language      Assembler
Offset/EDF           Command
------------------   --------------------------------------------
00001409/no-edf      RETRIEVE LENGTH SET
00001427/no-edf      START TRANSID FROM LENGTH INTERVAL

Module Name          'CICSRS4.MIG.LOAD(DB2PROG7)'
Module Language      Assembler
Offset/EDF           Command
------------------   --------------------------------------------
00001409/no-edf      RETRIEVE LENGTH SET
00001427/no-edf      START TRANSID FROM LENGTH INTERVAL
```

Figure 9-33 DFHEISUP detailed report for programs DB2PROG4, 5, 6, and 7

We can see from the source code in Appendix C, “Assembler routines” on page 339, that these four programs contain EXEC SQL calls, but the RETRIEVE will always be executed before the first call, and the START will always be executed after the last call, and so neither will impact performance. No action is therefore required.

The ASKTIME command, which will be executed between SQL calls, was made threadsafe in CICS Transaction Server Version 2.3.

Programs DB2PROG8, DB2PROG9, and DB2PROGA

Figure 9-34 details the three non threadsafe commands discovered by DFHEISUP in programs DB2PROG8, 9, and A:

- EXEC CICS RETRIEVE
- EXEC CICS WRITEQ TD
- EXEC CICS START

```
Module Name          'CICSRS4.MIG.LOAD(DB2PROG8)'
Module Language      Assembler
Offset/EDF           Command
-----------------    ----------------------------------------
00001489/no-edf      RETRIEVE LENGTH SET
00001507/no-edf      WRITEQ TD QUEUE FROM LENGTH
00001516/no-edf      START TRANSID FROM LENGTH INTERVAL

Module Name          'CICSRS4.MIG.LOAD(DB2PROG9)'
Module Language      Assembler
Offset/EDF           Command
-----------------    ----------------------------------------
00001489/no-edf      RETRIEVE LENGTH SET
00001507/no-edf      WRITEQ TD QUEUE FROM LENGTH
00001516/no-edf      START TRANSID FROM LENGTH INTERVAL

Module Name          'CICSRS4.MIG.LOAD(DB2PROGA)'
Module Language      Assembler
Offset/EDF           Command
-----------------    ----------------------------------------
00001497/no-edf      RETRIEVE LENGTH SET
00001515/no-edf      WRITEQ TD QUEUE FROM LENGTH
00001524/no-edf      START TRANSID FROM LENGTH INTERVAL
```

Figure 9-34 DFHEISUP detailed report for programs DB2PROG8, 9 and A

We can see from the source code in Appendix C, "Assembler routines" on page 339, that these three programs contain EXEC SQL calls, but the RETRIEVE will always be executed before the first call, and both the WRITEQ TD and START will always be executed after the last call, and so will not impact performance. No action is therefore required.

(The READQ TS command, which will be executed between SQL calls, was made threadsafe in CICS Transaction Server Version 2.2.)

Program EXITENBL

Figure 9-35 details the two non threadsafe commands discovered by DFHEISUP in program EXITENBL—both were EXEC CICS ENABLE.

```
Module Name          'CICSRS4.MIG.LOAD(EXITENBL)'
Module Language      Assembler
Offset/EDF           Command
-----------------    --------------------------------------------
00000824/no-edf      ENABLE PROGRAM EXIT START
00000833/no-edf      ENABLE PROGRAM GALENGTH EXIT START
```

Figure 9-35 DFHEISUP detailed report for program EXITENBL

We can see from the source code (listed in Example C-6 on page 354) that this program does not contain EXEC SQL calls and, from our knowledge of the application, we know is executed via the PLTPI. No action is therefore required.

This completes our investigation of EXEC CICS commands within the application. We were able to confirm, with one exception, that all non threadsafe commands are executed either prior to the first SQL call or after the last SQL call in every CICS program. Moreover, we were able to address the one instance of a non threadsafe command executing between SQL calls by substituting it with a similar command that is threadsafe.

9.4.5 Step 5: CICS system changes

We are now in a good position. We have an application we know is fully threadsafe, and does not issue non threadsafe commands between SQL calls. The final step in the migration is to make appropriate changes to the CICS region in order to let the application exploit the open transaction environment.

Table 9-4 shows the parameter values we implemented in the CICS Transaction Server Version 2.3 region. The CICS Transaction Server Version 1.3 region values are shown for comparison.

Table 9-4 CICS system parameters pre- and post-migration

Parameter	Pre-migration (CICS TS 1.3)	Post-migration (CICS TS 2.3)
SIT		
MXT	110	110
DSA	4M	4M
MAXOPENTCBS	N/A to application	130

Parameter	Pre-migration (CICS TS 1.3)	Post-migration (CICS TS 2.3)
FORCEQR	N/A to application	NO
DB2CONN		
TCBLIMIT	130	130
DB2ENTRY		
THREADLIMIT	120	120
PRIORITY	LOW	LOW

As illustrated by Table 9-4 on page 263, the only changes required in our CICS Transaction Server Version 2.3 region was to set FORCEQR to NO (this is the default in any case) and MAXOPENTCBS to be the same value as TCBLIMIT. The key thing to note is that MAXOPENTCBS, TCBLIMIT, and THREADLIMIT are all higher than MXT; that is, MXT is the parameter we chose to throttle the CICS workload in the event that throttling is ever required.

The CICS system changes complete our migration of the application to threadsafe. The final step in the plan is to confirm that we have achieved what we set out to achieve: improved application performance.

9.5 Performance measurement

This section describes what we did to measure the performance of the sample application after it was fully converted to threadsafe. The results are shown and compared with the corresponding figures measured when the application was quasi-reentrant.

Important: The results shown in this chapter are specific to the sample application and the system it was running on at the time. The purpose is to show that threadsafe migrations will improve application performance, but these specific results should not be used as a benchmark for any other application or system.

9.5.1 Reports

We used SMF type 110 records to gather the following key measurements for each transaction:

- The number of SQL calls
- The number of TCB switches
- The response time
- The CPU time
- The throughput (tasks per second)

We used CICS Performance Analyzer Version 1 Release 3 (CICS PA) to report against the SMF data. Figure 9-36 shows the selection criteria we used to generate the reports. We used 5-minute intervals (that is, the difference between SMFSTART and SMFSTOP) in all our reports.

```
CICSPA IN(SMFIN001),
       SMFSTART(yyyy/mm/dd,hh:mm:ss.nn),
       SMFSTOP(yyyy/mm/dd,hh:mm:ss.nn),
       APPLID(cicsapplid),
       LINECNT(60),
       FORMAT(':','/'),
   SUMMARY(OUTPUT(TESTSUM),
       BY(TRAN),
       SELECT(PERFORMANCE(
       INC(TRAN(DB21,DB22,DB23,DB24,DB25,
       DB26,DB27,DB28,DB29,DB2A)))),
       FIELDS(TRAN,
              TASKCNT,
              RESPONSE(TOTAL),
              DB2REQCT(TOTAL),
              CHMODECT(TOTAL),
              CPU(TIME(TOT)),
              QRCPU(TIME(TOT)),
              L8CPU(TIME(TOT))))
```

Figure 9-36 CICS PA report - selection criteria

Figure 9-37 shows the report generated for the application after part 1 of the migration was completed (that is, quasi-reentrant application, with threadsafe exits on the SQL call path), and Figure 9-38 on page 267 shows the corresponding report after part 2 was completed (that is, the is application fully threadsafe).

Note: In the next few CICS PA performance reports we decided to use totals, not averages. If averages are required you must divide the number of tasks by the whichever total you are interested in.

```
 V1R3M0                   CICS Performance Analyzer
                             Performance Summary
             ________________________________________________
             Data from 15:09:58  5/13/2004 to 15:14:59  5/13/2004


                      Total     Total    Total    Total    Total    Total
Tran       #Tasks Response DB2 Reqs ChngMode User CPU   QR CPU   L8 CPU
                      Time                          Time     Time     Time
DB2A          498  300.471   498000   996996  37.8468   8.2547  29.5920
DB21          499  301.155   499000   998998  37.0994   7.4055  29.6939
DB22          500  301.048   500000   1001E3  36.6220   7.3962  29.2258
DB23          498  300.426   498000   996996  36.7766   7.3603  29.4164
DB24          498  300.475   498000   996996  37.4116   7.8154  29.5961
DB25          498  300.414   498000   996996  37.1906   7.8236  29.3670
DB26          499  300.977   499000   998998  37.6047   7.9280  29.6767
DB27          499  301.023   499000   998998  37.4565   7.8656  29.5908
DB28          498  300.599   498000   996996  37.8501   8.2476  29.6025
DB29          498  300.456   498000   996996  37.7188   8.2497  29.4691
```

Figure 9-37 Performance report before full migration to threadsafe

```
 V1R3M0                     CICS Performance Analyzer
                                Performance Summary
                 ________________________________________________
                 Data from 17:19:59  5/13/2004 to 17:24:59  5/13/2004


                       Total     Total    Total    Total     Total     Total
Tran        #Tasks Response DB2 Reqs ChngMode User CPU    QR CPU    L8 CPU
                       Time                          Time      Time      Time
DB2A           813  303.524   813000     3252  49.1480    .2283   48.9198
DB21           959  304.113   959000     3836  54.2789    .2374   54.0415
DB22           967  303.960   967000     3868  53.7371    .2400   53.4971
DB23           959  304.398   959000     3836  54.1888    .2366   53.9522
DB24           951  303.937   951000     3804  53.9875    .2169   53.7706
DB25           955  303.988   955000     3820  53.9665    .2187   53.7478
DB26           951  303.723   951000     3804  54.0771    .2176   53.8595
DB27           956  303.770   956000     3824  54.1474    .2174   53.9300
DB28           813  303.917   813000     3252  49.1606    .2285   48.9321
DB29           817  303.342   817000     3268  49.0784    .2247   48.8537
```

Figure 9-38 Performance report after full migration to threadsafe

Looking at the data in Figure 9-37 on page 266 and Figure 9-38 together, we can see that our threadsafe migration has delivered the reduction in TCB switches we set out to achieve, and this in turn has resulted in substantial improvements in all of our key performance indicators (KPIs):

- Transaction CPU time
- Transaction response time
- Transaction throughput (tasks per second)

We used the figures in the CICS PA reports to calculate our KPIs and tabulated the results (Table 9-5).

Table 9-5 KPIs: quasi-reentrant versus threadsafe

	Quasi-reentrant	**Threadsafe**	**Improvement**
Avg. SQL calls per task	1000	1000	
Avg. TCB switches per task	2002	4	
Avg. cpu time per task	0.0749 sec	0.0575 sec	**23%**
Avg. response time	0.6032 sec	0.3324 sec	**45%**
Transaction throughput	16.62 tps	30.47 tps	**83%**

To illustrate this more clearly, we created charts for each of the KPIs, and these are shown in 9.5.2, “Charts” on page 268.

9.5.2 Charts

In this section we provide charts for each of the KPIs.

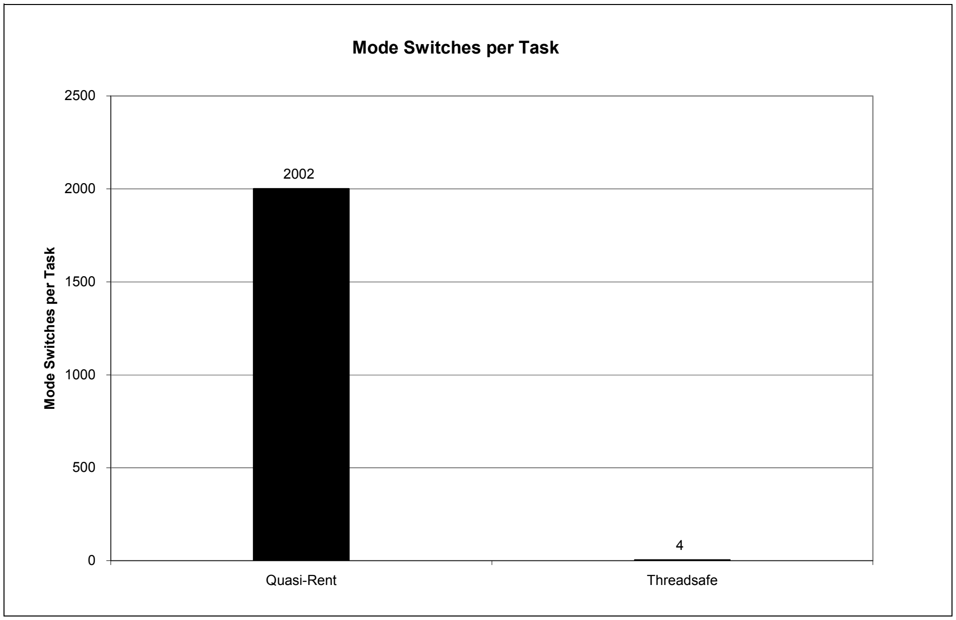

Figure 9-39 Mode switches per task CICS TS 2.3

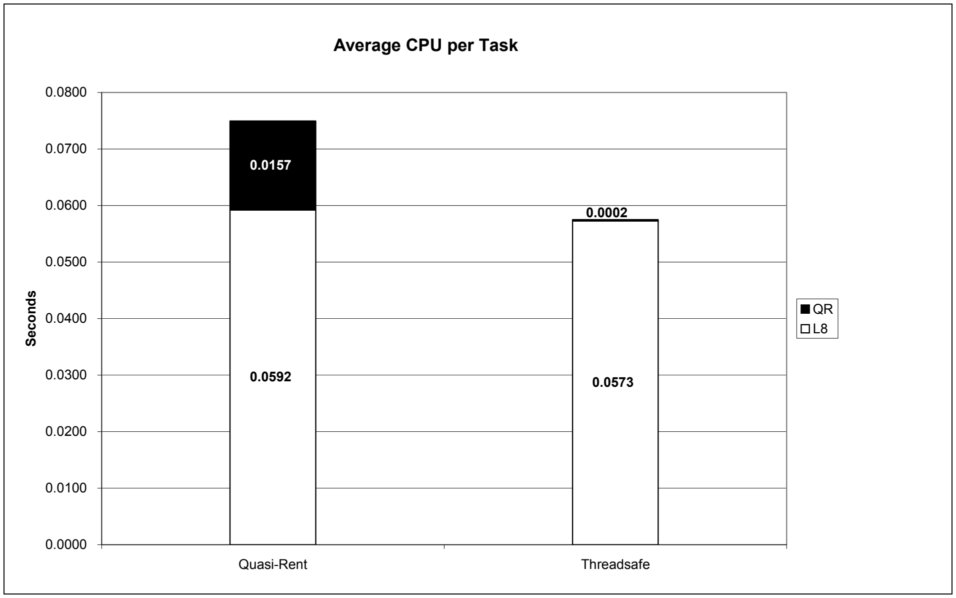

Figure 9-40 Average CPU per task

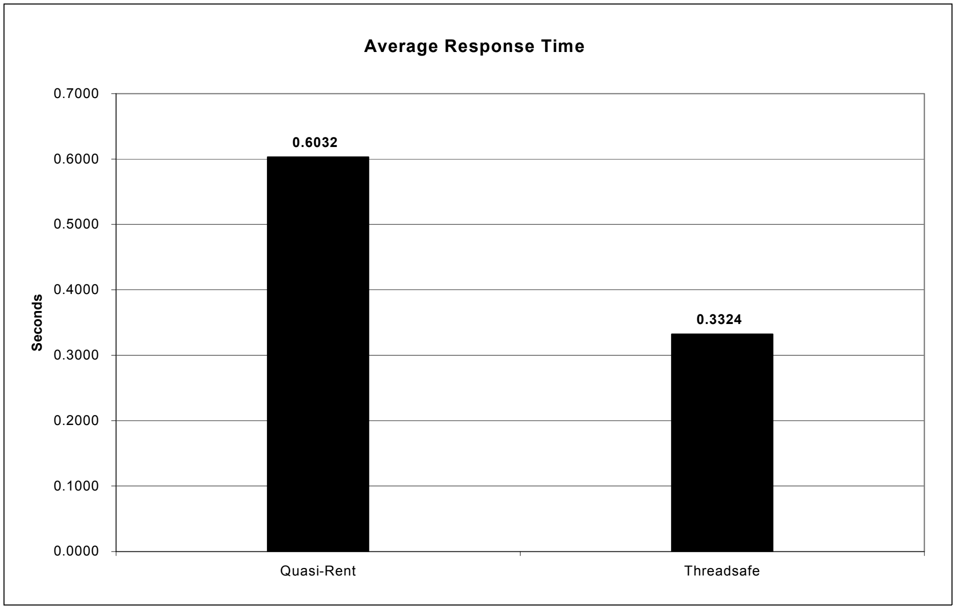

Figure 9-41 Average response time

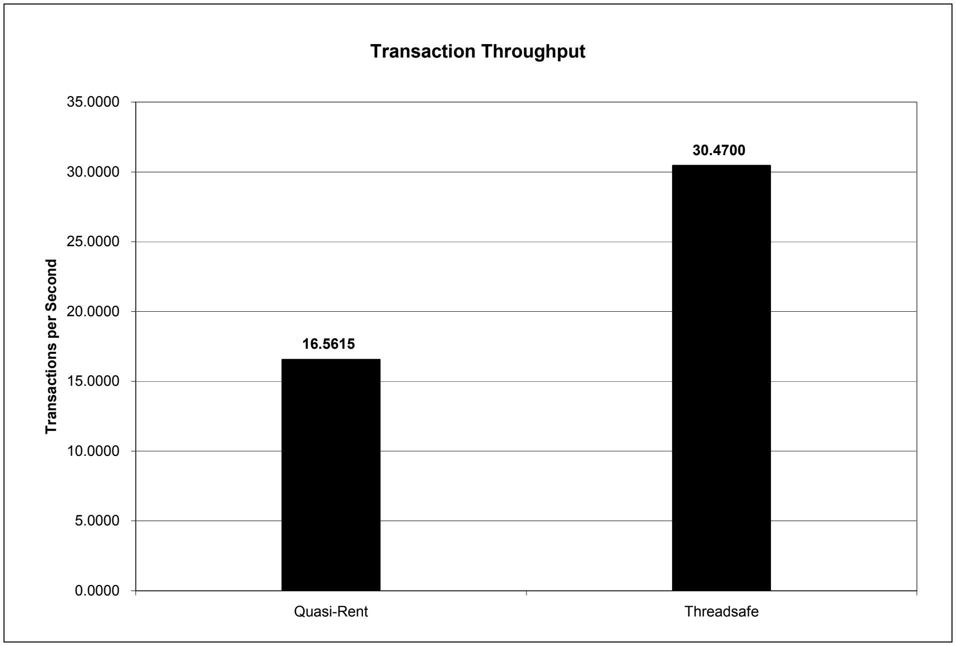

Figure 9-42 Transaction throughput

9.5.3 Conclusions

The performance measurements complete the migration of the sample application from quasi-reentrant to threadsafe. The reports and charts shown in 9.5.1, "Reports" on page 265, and 9.5.2, "Charts" on page 268, illustrate that we have achieved our goal. By migrating the entire application to threadsafe, we delivered substantial improvements in each of our key performance indicators:

- 23% improvement in transaction CPU time
- 45% improvement in transaction response times
- 83% improvement in transaction throughput

9.6 Additional considerations for OPENAPI programs

CICS Transaction Server Version 3.1 extends OTE and allows applications to be defined not only as THREADSAFE, but also with an API attribute that takes values of CICSAPI or OPENAPI (CICSAPI being the default). Hence, a threadsafe application in CICS Transaction Server Version 2 is a threadsafe, CICSAPI program in CICS Transaction Server Version 3.1.

The OPENAPI attribute mandates that the application also be defined as THREADSAFE because it must be coded to threadsafe standards, as it will execute on an open TCB. Hence, an OPENAPI application is one that is defined as THREADSAFE and OPENAPI.

THREADSAFE, OPENAPI applications differ from THREADSAFE, CICSAPI applications programs in that they *always* execute on an open TCB, whereas THREADSAFE, CICSAPI applications execute on *either* QR TCB or an open TCB, whichever is being used at the time. This allows THREADSAFE, OPENAPI programs to safely use non-CICS APIs because they are guaranteed not to be running on the QR TCB. Any non-CICS API command that halts the TCB will halt just that open TCB and not the whole of CICS.

For non-CICS APIs to function correctly the key of the TCB is important, and it must match the execution key. For example, an MVS getmain determines the key of storage required by examining the key of the TCB rather than the PSW execution key. (For CICSAPI programs, the TCB key is irrelevant, as the CICS API works independently of the TCB key.) This means that THREADSAFE, OPENAPI, EXECKEY(USER) programs *always* run on an L9 TCB, and THREADSAFE, OPENAPI, EXECKEY(CICS) applications *always* run on an L8 TCB (assuming storage protection is active).

Task-related user exits (TRUEs) always run in EXECKEY(CICS). OPENAPI TRUEs such as the CICS-DB2 TRUE, or the IP CICS Sockets TRUE in z/OS Communications Server Version 1 Release 7 (if configured), therefore always run on an L8 TCB. Hence a conflict exists between a EXECKEY(USER) application that is defined as OPENAPI that must run on an L9 TCB, and an OPENAPI TRUE that must run on an L8 TCB. Two TCB switches will occur for *every* call to an OPENAPI TRUE, L9 to L8 and L8 to L9 afterwards.

Note: We strongly recommend that EXECKEY(USER) CICS-DB2 applications that have previously been made threadsafe, and defined to CICS as such, remain as THREADSAFE, CICSAPI PROGRAMS, unless storage protection is not being used. The applications should not be defined as OPENAPI.

The same recommendation applies to EXECKEY(USER) IP CICS Sockets applications.

10

Performance case studies

This chapter documents the results obtained by some benchmark comparisons performed by IBM for applications running on CICS Transaction Server Version 3.2, and utilizing DB2, WMQ, and EXEC CICS file control calls. It is intended to provide a comparison of the benefits obtained when redefining such applications from quasi-reentrant to threadsafe. In these benchmarked examples, it is taken as a given that the applications are already analyzed and written to threadsafe standards, so there are no issues such as shared storage areas or serialization techniques to consider.

10.1 CICS DB2 and file control application

The test involved driving a transaction that carried out the following work. An initial (quasi-reentrant) COBOL program EXEC CICS LINKed to another COBOL application program. This second application then performed a variety of DB2 and CICS commands. The sequence followed was:

EXEC CICS READ

EXEC SQL OPEN

EXEC SQL FETCH

EXEC CICS ASKTIME

EXEC SQL UPDATE

EXEC SQL CLOSE

Note: The application logic involves EXEC CICS commands that are threadsafe in CICS Transaction Server Version 3.2, and so can execute under an open TCB or QR TCB. In the same way, EXEC SQL calls to DB2 also execute under open (L8) TCBs.

This application looped internally 100 times when linked to, so this series of commands was issued 100 times per task.

Testing involved defining the second program as CONCURRENCY(QUASIRENT), API(CICSAPI) and then redefining it as CONCURRENCY(THREADSAFE), API(OPENAPI). In both cases, performance and diagnostic data was gathered to provide metrics for the comparative results. This included CICS Performance Analyzer reports, CICS statistics, RMF data and CICS auxiliary trace.

The CICS system was not using storage protection for these tests: STGPROT=NO was specified.

Note: This is not an example intended to demonstrate issues with serialization of shared data; nor is it intended to demonstrate performance problems with TCB switching due to interleaved threadsafe and non threadsafe EXEC CICS commands. It is provided to quantify benefits when taking such a program that is or has been made a good threadsafe candidate application, and redefining if as threadsafe to CICS. In a similar vein, it is not intended to reveal performance issues when having to switch between L9 and L8 TCBs for OPENAPI programs that are defined with EXECKEY(USER) and that issue calls to DB2.

The application can be considered a good candidate for being redefined threadsafe in CICS Transaction Server Version 3.2 since it:

- Includes EXEC SQL calls to DB2, which require an L8 TCB
- Has EXEC CICS commands that are threadsafe and so have no affinity to a given TCB environment
- Does not interleave threadsafe and non-threadsafe commands

In fact, this sort of application would be a good model for one that had been prepared for threadsafe use prior to migrating to CICS Transaction Server Version 3.2, because prior to that release EXEC CICS READ commands were non threadsafe, while EXEC CICS ASKTIME commands were threadsafe. Hence the application has already been well structured to separate its non threadsafe and threadsafe work, and so avoid TCB switching where possible. It has good construction with regard to threadsafety.

10.1.1 Environment

Performance testing was carried out on a dedicated IBM test system to provide comparable results. The hardware and software environment was as follows:

- Z990 2084-303 with 3 dedicated CPs
- z/OS Version 1.7
- CICS Transaction Server Version 3.2
- CICS Performance Analyzer 2.1
- DB2 Version 7.1

10.1.2 Results

Two sets of results were obtained, first when the application was defined as CONCURRENCY(QUASIRENT), API(CICSAPI) and then after it was redefined as CONCURRENCY(THREADSAFE), API(OPENAPI).

CICS Performance Analyzer was used to investigate the CPU usage and response times for the application, and compare the number of invocations of the transaction (that is, CICS tasks) that executed for the tests.

RMF workload activity was used to review the total CPU usage, transaction rates and internal response time for the comparison tests.

In addition, a review of the CICS auxiliary trace taken during the tests could be used (if so desired) to verify the TCB switching activity taking place during the execution of the transactions.

```
CICS Performance Analyzer
Performance Summary

                          Avg         Avg                  Avg       Avg        Avg        Avg
               Tran       User CPU    Dispatch   #Tasks    L8 CPU    L9 CPU     Response   DSCHMDLY
                          Time        Time                 Time      Time       Time       Count
Results when
quasirent:     FCDB       .010710     .020827     2313     .007678   .000000    .031925    9050757

Results when
threadsafe:    FCDB       .008057     .013630     3452     .007944   .000000    .014356    1806209
```

Figure 10-1 Comparison of transaction performance between quasirent and threadsafe

Figure 10-1 shows the results from CICS Performance Analyzer when comparing the transaction's characteristics for both a quasirent and a threadsafe definition of the main application. As can be seen, the average user CPU time and average dispatch time were reduced after the program was redefined. This can be explained by the reduction in TCB switches that took place when the program was redefined as threadsafe. Prior to that, each EXEC SQL command required a switch from QR to L8 for the duration of the call to DB2, followed by a switch from L8 back to QR upon return to CICS. With 100 iterations of the loop within the application, this resulted in 800 switches for the EXEC SQL calls and 2 switches for the end-of-task syncpoint flows to DB2. When the program was redefined as CONCURRENCY(THREADSAFE), API(OPENAPI), there were 2 switches for the EXEC CICS LINK to the second program, and 2 switches for the syncpoint flows to DB2. The switch from QR to L8 on the link to the second program was because it was defined as API(OPENAPI) and so had to execute under an open TCB. Likewise, the switch back from L8 to QR on the return from the link was because the top level linking program was still defined as quasirent.

The results also show that the comparison is even more favorable when the program was redefined as threadsafe, since more than 1000 additional tasks were able to be executed within the test time frame.

Note that the average L8 CPU time did increase when the application was redefined as threadsafe; however, this was more than countered by the reduction in QR TCB CPU usage, as reflected in the total value shown by the average user CPU time.

L9 TCB CPU usage was 0 since storage protection was not active, and the application's execution key was therefore not pertinent. An L8 TCB could be used instead.

Also note that the average response time for using the threadsafe application was less than half that of the quasirent version.

Finally, the DSCHMDLY value (redispatch wait time caused by a change mode to switch TCBs) was reduced by eighty percent, a direct reflection of the fact that far fewer TCB switches were having to take place.

```
CICS Performance Analyzer
DB2 - Long Summary

                                         Avg       Max       Avg      Max       Avg      Max
         Tran/   Program/  #Tasks/   DB2Rqst   DB2Rqst   UserCPU  UserCPU  Response Response
         SSID    Planname  #Threads    Count     Count      Time     Time      Time     Time

Results when quasirent:
         FCDB   FCDB2001   2313        400.0      400   .010710   .012918     .0319    .1539

         DF2A   DB9A       2313       Thread Utilization      Entry=    0     Pool=   2313
                                      Class1: Thread Time Avg: Elapsed=  .0312   CPU= .008933
                                                          Max: Elapsed=  .1533   CPU= .011068

Results when threadsafe:
         FCDB   FCDB2001   3452        400.0      400   .008056   .018088     .0144    .0546

         DF2A   DB9A         3452      Thread Utilization     Entry=    0     Pool=   3452
                                       Class1: Thread Time Avg: Elapsed= .0126  CPU= .007693
                                                           Max: Elapsed= .0462  CPU= .017703
```

Figure 10-2 Comparison of DB2 performance activity between quasirent and threadsafe

Figure 10-2 shows the results from CICS Performance Analyzer when comparing the transaction's DB2 performance characteristics for both a quasirent and a threadsafe definition of the main application. As before, the response time can be seen to have reduced when redefining the application as threadsafe. The same is true for the average user CPU time.

```
W O R K L O A D   A C T I V I T Y

z/OS V1R7     SYSPLEX PLEX3      DATE 07/10/2007      INTERVAL 00.45.546      MODE = GOAL
RPT VERSION V1R7 RMF             TIME 11.51.14

Results when quasirent:

REPORT BY: POLICY=POLICY

   TRANSACTIONS   TRANS-TIME HHH.MM.SS.TTT    ---SERVICE----   SERVICE TIMES   ---APPL %---
   AVG      1.00  ACTUAL              36.024    IOC        160   CPU      30.9    CP     68.19
   MPL      1.00  EXECUTION           36.024    CPU       6209K  SRB       0.1    AAPCP   0.00
   ENDED       2  QUEUED                   0    MSO       2663M  RCT       0.0    IIPCP   0.00
   END/S    0.04  R/S AFFIN                0    SRB      26214   IIT       0.0

   TRANSACTIONS   TRANS-TIME HHH.MM.SS.TTT
   AVG      0.00  ACTUAL                  49
   ENDED    2250
   END/S   49.40



Results when threadsafe:

REPORT BY: POLICY=POLICY

   TRANSACTIONS   TRANS-TIME HHH.MM.SS.TTT    ---SERVICE----   SERVICE TIMES   ---APPL %---
   AVG      1.00  ACTUAL              38.026    IOC          0   CPU      28.4    CP     62.73
   MPL      1.00  EXECUTION           38.026    CPU       5696K  SRB       0.2    AAPCP   0.00
   ENDED       2  QUEUED                   0    MSO       2444M  RCT       0.0    IIPCP   0.00
   END/S    0.04  R/S AFFIN                0    SRB      38026   IIT       0.0


   TRANSACTIONS   TRANS-TIME HHH.MM.SS.TTT
   AVG      0.00  ACTUAL                  13
   ENDED    3506
   END/S   76.99
```

Figure 10-3 Comparison of RMF workload activity between quasirent and threadsafe

Figure 10-3 shows the results from RMF workload activity when comparing the transaction's CPU and throughput characteristics for both a quasirent and a threadsafe definition of the main application. The transaction rate can be seen to have increased from 49.40 per second up to 76.99 per second. This is because the use of L8 TCBs has allowed for parallel processing to exploit multiple CPs in the hardware, and increased the transaction throughput as a result. Likewise, the transaction time has reduced from 49 to 13 seconds. The CPU time has reduced, reflecting the reduction in TCB switches when redefining the program as threadsafe.

```
CICS TCB Mode Statistics
________________________


TCB    < TCBs Attached >    TCB    Attach       MVS     Accumulated         Accumulated         Accumulated
Mode   Current      Peak  Attaches  Failures    Waits   Time in MVS wait    Time Dispatched      Time / TCB
_______________________________________________________________________________________________________________

Results when quasirent:

 QR          1         1         0         0   538040    00:00:35.590807    00:00:10.394348    00:00:10.552730
 L8         81        81        71         0   916768    00:14:08.888409    00:01:19.872928    00:00:20.877639


Results when threadsafe:

 QR          1         1         0         0     7474    00:00:44.388717    00:00:01.596551    00:00:00.637270
 L8         10        10         0         0     7333    00:06:58.286155    00:00:45.715037    00:00:28.074048


TRANSACTION MANAGER STATISTICS
______________________________


Results when quasirent:

Peak number of active user transactions       :          82
Total number of active user transactions      :        2287


Results when threadsafe:

Peak number of active user transactions       :          12
Total number of active user transactions      :        3547
```

Figure 10-4 Comparison of CICS statistics data between quasirent and threadsafe

Figure 10-4 shows the output from the DFHSTUP CICS statistics utility program for the comparison between TCB activity when the application was defined first as quasi-reentrant and then as threadsafe.

In the quasi-reentrant case, both the QR and L8 TCBs entered many more MVS waits than in the threadsafe case. For the L8 TCBs, the accumulated time spent in MVS waits was over twice as long as for the threadsafe case. Note too that the quasirent workload required a peak of 81 L8 TCBs to accommodate the transactions, whereas the threadsafe workload peaked at 10 L8 TCBs. This is because (in the quasi-reentrant case), work built up in the CICS system as tasks were attached and competing for subdispatch processing under the QR TCB. This led to a higher peak of user transactions in the system (82 as opposed to 12). Since L8 TCBs can only be reused once their owning task has completed, there was the resultant need to attach more L8 TCBs in this case to accommodate these additional concurrently attached tasks as they issued their interleaving EXEC SQL calls to DB2. The higher number of L8 TCBs, coupled with the greater number of TCB switches between them and the QR TCB in the quasi-reentrant case, led to the L8 TCBs experiencing more MVS waits than in the threadsafe case because there were more occasions when they had no further work to perform and so relinquished control back to the operating system.

The total accumulated time for the TCBs was lower in the threadsafe case, which reflects the fewer TCB switches that were required.

Since fewer peak L8 TCBs were required in the threadsafe case, the need for below the line storage was reduced as a result, thereby assisting with virtual storage constraint relief for this given workload.

10.2 CICS WMQ and file control application

The test involved driving a transaction that carried out the following work. An initial (quasi-reentrant) COBOL program EXEC CICS LINKed to another COBOL application program. This second application then performed a variety of WMQ and CICS commands. The sequence followed was:

EXEC CICS READ

WMQ PUT

WMQ GET

This application looped internally 100 times when linked to, so this series of commands was issued 100 times per task. In addition, an MQOPEN was issued before the loop, and an MQCLOSE was issued after the loop had completed.

Testing involved defining this second program first as CONCURRENCY(QUASIRENT), API(CICSAPI) and then redefining it as CONCURRENCY(THREADSAFE), API(OPENAPI). In both cases, performance and diagnostic data was gathered to provide metrics for the comparative results. This included CICS Performance Analyzer reports, CICS statistics, RMF data and CICS auxiliary trace.

As before, the CICS system was not using storage protection for these tests: STGPROT=NO was specified.

Once again, this was not a test designed to demonstrate serialization issues.

10.2.1 Environment

Performance testing was carried out on a dedicated IBM test system to provide comparable results. The hardware and software environment was as follows:

- Z990 2084-303 with 3 dedicated CPs

- z/OS Version 1.7
- CICS Transaction Server Version 3.2
- CICS Performance Analyzer 2.1
- WMQ Version 6.1

10.2.2 Results

Two sets of results were obtained, first when the application was defined as CONCURRENCY(QUASIRENT), API(CICSAPI) and then after it was redefined as CONCURRENCY(THREADSAFE), API(OPENAPI).

CICS Performance Analyzer was used to investigate the CPU usage and response times for the application, and to compare the number of invocations of the transaction (that is, CICS tasks) that executed for the tests.

RMF workload activity was used to review the total CPU usage, transaction rates, and internal response time for the comparison tests.

In addition, a review of the CICS auxiliary trace taken during the tests could be used (if so desired) to verify the TCB switching activity taking place during the execution of the transactions.

The following results are a summary from these various sources.

```
CICS Performance Analyzer
Performance Summary

                  Avg       Avg                 Avg      Avg      Avg       Avg      Avg
            Tran  User CPU  Dispatch   #Tasks   L8 CPU   L9 CPU   Response  DSCHMDLY DSCHMDLY
                  Time      Time                Time     Time     Time      Time     Count
Results when
quasirent:  FCMQ  .011992   .014209    1500    .009574  .000000  .019020  .004250   7141728

Results when
threadsafe: FCMQ  .011003   .013148    1500    .010866  .000000  .015339  .000076    312592
```

Figure 10-5 Comparison of transaction performance between quasirent and threadsafe

Figure 10-5 shows the results from CICS Performance Analyzer when comparing the transaction's characteristics for both a quasirent and a threadsafe definition of the main application. As can be seen, the average user CPU time and average dispatch time were reduced after the program was redefined. This can be explained by the reduction in TCB switches that took place when the program was redefined as threadsafe. Prior to that, each WMQ call required a switch from QR to L8 for the duration of the call to WMQ, followed by a switch from L8 back to QR upon return to CICS. With 100 iterations of the loop within the application, this resulted in 400 switches for the WMQ calls and 2 switches for the end-of-task syncpoint flows to WMQ. When the program was redefined as CONCURRENCY(THREADSAFE), API(OPENAPI), there were 2 switches for the EXEC CICS LINK to the second program, and 2 switches for the syncpoint flows to WMQ. The switch from QR to L8 on the link to the second program was because it was defined as API(OPENAPI) and so had to execute under an open TCB. Likewise, the switch back from L8 to QR on the return from the link was because the top level linking program was still defined as quasirent.

The reduction in the average user CPU time and average dispatch time was less marked than in the case of the file control/DB2 application. This can be explained by the fact that the WMQ application only issued two WMQ calls (the WMQ PUT and WMQ GET) within the scope of its loop. There were four EXEC SQL calls in the file control/DB2 example program. So, the CPU benefits of remaining on an L8 TCB, and the reduction in TCB switching, is less marked in the WMQ example than in the DB2 example. This is another indication of the scaleability of benefits that threadsafe exploitation brings: the more an application has the need to drive an OTE-enabled TRUE such as for DB2 or WMQ calls, the more the savings can be if that application is suitable for redefining as a threadsafe program.

Note that the average L8 CPU time did increase when the application was redefined as threadsafe. As with the DB2 tests earlier, L9 TCB CPU usage was 0 since storage protection was not active, and the application's execution key was therefore not pertinent. An L8 TCB could be used instead.

Also note that the average response time for using the threadsafe application was reduced compared with that of the quasi-reentrant version.

Finally, the DSCHMDLY value (redispatch wait time caused by a change mode to switch TCBs) and DSCHMDLY count (number of TCB switches) was reduced by orders of magnitude, a direct reflection of the fact that far fewer TCB switches were having to take place once the application was redefined as CONCURRENCY(THREADSAFE), API(OPENAPI).

```
CICS Performance Analyzer
WebSphere MQ Class 1 Summary
                                                 ----- Average -----
                     SSID  APPLID    TRAN    Count    CPU        Calls

Results when
quasirent:           VICC  IYCUZC19  FCMQ    15282    0.007768   200.0

Results when
threadsafe:          VICC  IYCUZC19  FCMQ     6088    0.007634   200.0
```

Figure 10-6 Comparison of WMQ performance activity between quasirent and threadsafe

Figure 10-6 shows the results from CICS Performance Analyzer when comparing the transaction's WMQ performance characteristics for both a quasirent and a threadsafe definition of the main application. As before, the CPU usage can be seen to have reduced when redefining the application as threadsafe.

```
CICS TCB Mode Statistics
________________________

TCB   < TCBs Attached >  TCB     Attach     MVS      Accumulated        Accumulated        Accumulated
Mode  Current      Peak  Attaches Failures  Waits  Time in MVS wait   Time Dispatched      Time / TCB
___________________________________________________________________________________________________

Results when quasirent:

 QR         1         1        0        0  264838   00:00:40.827822   00:00:05.157484   00:00:05.228039
 L8        81        81       71        0  312696   00:01:13.668300   00:00:18.511194   00:00:15.920050


Results when threadsafe:

 QR         1         1        0        0    5305   00:00:45.505023   00:00:00.480204   00:00:00.340059
 L8        10        10        0        0    4651   00:01:12.057051   00:00:19.912177   00:00:16.667971


TRANSACTION MANAGER STATISTICS
______________________________

Results when quasirent:

Peak number of active user transactions       :         6
Total number of active user transactions      :      1535


Results when threadsafe:

Peak number of active user transactions       :         8
Total number of active user transactions      :      1535
```

Figure 10-7 Comparison of CICS statistics data between quasirent and threadsafe

Figure 10-7 shows the output from the DFHSTUP CICS statistics utility program for the comparison between TCB activity when the application was defined first as quasi-reentrant and then as threadsafe.

In the quasi-reentrant case, both the QR and L8 TCBs entered many more MVS waits than in the threadsafe case. The total accumulated time for the TCBs was lower in the threadsafe case, which reflects the fewer TCB switches that were required.

Note too that the quasi-reentrant workload required a peak of 81 L8 TCBs to accommodate the transactions, whereas the threadsafe workload peaked at 10 L8 TCBs. As in the DB2 tests, this is because (in the quasi-reentrant case) work built up in the CICS system as tasks were attached and competing for subdispatch processing under the QR TCB. Since L8 TCBs can only be reused once their owning task has completed, there was the resultant need to attach more L8 TCBs, in this case to accommodate these additional concurrently attached tasks as they issued their interleaving WMQ calls. The higher number of L8 TCBs, coupled with the greater number of TCB switches between them and the QR TCB in the quasi-reentrant case, led to the L8 TCBs experiencing more MVS waits than in the threadsafe case because there were more occasions when they had no further work to perform and so relinquished control back to the operating system.

The total accumulated time for the TCBs was lower in the threadsafe case, which reflects the fewer TCB switches that were required.

As with the DB2 example, since fewer peak L8 TCBs were required in the threadsafe case, the resultant need for below the line storage was reduced when the application was redefined as threadsafe.

Part 3

Customer examples and general questions

This part explains performance indicators, describes an actual threadsafe conversion project, presents the results from a real customer's benchmark tests for a threadsafe conversion, and answers a few frequently asked questions of a general nature about threadsafe.

11

Danske Bank threadsafe conversion

This chapter shows the results obtained during a customer threadsafe conversion of intensive CICS/DB2 applications.

This chapter covers the following topics:

- Hardware and software configuration
- Online application infrastructure
- Threadsafe project definition
- Threadsafe analysis and resolution
- The autoinstall process
- Threadsafe conversion results
- Summary and conclusions

11.1 Hardware and software configuration

Danske Bank is the second largest bank in Scandinavia and is an integrated banking solution, providing continuous real-time processing in a CICS/DB2 environment.

The Danske Bank online systems are characterized by:

- High transaction volume. This is approximately 66 million transactions on an average day for all production CICS systems and 77 million transactions including all CICS systems, production, test, and development.
- High transaction rate in a peak hour. This is approximately 6.5 million transactions on an average day for all production CICS systems and 7.5 million transactions including all CICS systems, production, test, and development.
- Continuous use. CICS systems run 24/7.

The Danske Bank threadsafe conversion project involved all applications, with a few exceptions that are described later. The implication of this was that thousands of programs were made threadsafe overnight.

Hardware configuration

During the time of conversion the hardware configuration was:

- 6 CECs on two physical sites consisting of 2 Z9 and 4 Z900 machines. A CEC is a physical CPU including memory, engines, OSA adapters, and Coupling Facility (CF) links.
- Usage of CF for each environment: production, test, and so forth.
- M800 as the storage system.

Software configuration

The software details and levels are:

- z/OS 1.8
- CICS Transaction Server for z/OS V3.1
- DB2 UDB for z/OS V8
- IBM Websphere MQ for z/OS V6

11.2 Online application infrastructure

Figure 11-1 and Figure 11-2 show the overall online application-related topology for Danske Bank.

The application infrastructure consists of a CISCO router where data arrives from the network. The transactions are then routed as follows:

- The CISCO router selects a CEC with an LPAR with a z/OS system. In the z/OS selection process, the CISCO router uses a round robin algorithm. In a round robin algorithm, the different z/OS systems are selected one at a time in a sequence. When the last system is selected, the iteration starts all over again
- On the z/OS system, the front-end CICS initiates the transactions.

CICSPlex SM is not used for routing purposes, but only for monitoring purposes.

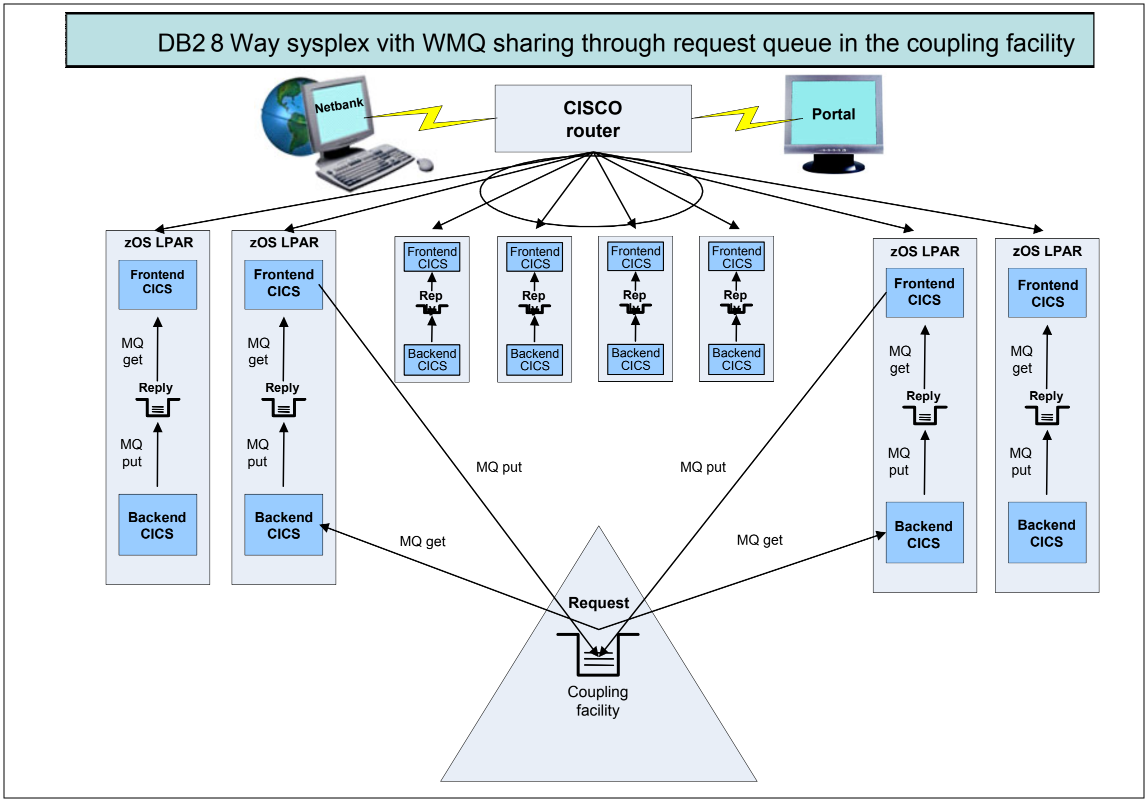

Figure 11-1 Danske Bank 8-way sysplex with WMQ shared queues

Figure 11-1 shows that transactions are routed dynamically from the front-end CICS to a back-end CICS using WMQ shared queues.

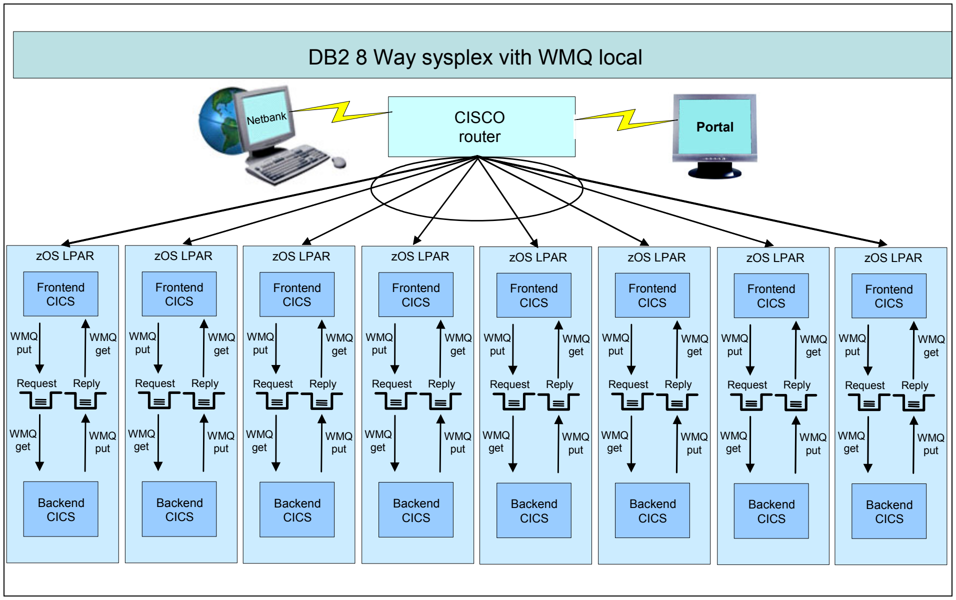

Figure 11-2 Danske Bank with 8 way sysplex showing static routing

The result of the Danske Bank threadsafe conversion was a MIPS saving of a little below 300 MIPS during the peak processing one hour period.

Figure 11-2 shows that transactions are statically routed from the front-end CICS system to a back-end CICS system.

The routing mechanism (static or dynamic) is managed by the CISCO router and is decided on a individual transaction basis.

11.3 Threadsafe project definition

Danske Bank had eight primary objectives for the threadsafe project:

- Maximizing throughput and increasing concurrency by exploiting the CICS Open Transaction Environment.
- Decreasing capacity needs by reducing the MIPS usage during peak hours.
- Exploiting the use of non-CICS API in the future.
- Minimizing resources required during the change of applications to threadsafe standard.

- Minimizing resources required for the threadsafe conversion process.
- Not allowing the size of the CSD to grow.
- Automating the decision of threadsafe or non-threadsafe at program execution, thus reducing the likelihood of human error. For this reason the CICS auto-install program was used.
- Delaying the threadsafe execution until the next weekly run to give the Danske Bank development team a week to analyze the program for threadsafe execution problems.

To help validate the outcome of the conversion project, the following measurement milestones were defined:

- Establish a *before* and *after* threadsafe conversion measurement of the number of TCB switches in the transactions. The number of changes in TCB switches should then be used to calculate the changes in the MIPS capacity requirements during peak hours.
- To validate the threadsafe conversion before and after measurements, MIPS changes in peak hour were compared to actual MIPS used in the production systems before and after threadsafe conversion.

11.4 Threadsafe analysis and results

Danske Bank separated their programs into the following categories:

- **Completely threadsafe programs**
  Whether making SQL calls or not, these programs could all in general be defined as threadsafe.
- **Completely non-threadsafe programs that would not endanger data integrity by updating shared resources (like CWA and so forth)**
  An analysis of the different programs would show whether or not they should be made threadsafe.
- **Non-threadsafe programs that would endanger data integrity by updating shared resources (like CWA and others)**
  An analysis of the different programs would show whether these programs are important enough to be changed. Importance here is defined as the relative execution frequency related to the amount of effort to change the program. We also made the decision here on whether or not they should be made threadsafe.
- **Programs not being linked reentrant**
  An analysis must be done to see if this is just a matter of changing the linkage option or not.

- **Threadsafe or non-threadsafe programs linked together with a non-threadsafe run-time module**
  For Danske Bank this meant that all VAGen (Visual Age Generator) programs were defined as non-threadsafe because the Language Environment run-time module was non-threadsafe.

11.4.1 Programs used in threadsafe analysis

Danske Bank used the CICS Transaction Affinities Utility load module scanner to identify threadsafe/non-threadsafe programs.

11.4.2 Resolution

The result of the threadsafe analysis was:

- Libraries that contain only threadsafe programs.
- Libraries that contain non-threadsafe programs only.
- Libraries that contain a mixture of threadsafe and non-threadsafe programs.
- Programs that should be defined as non-threadsafe for different reasons, for example not reetrant.
- Programs that should be defined as threadsafe but that come from a mixed library.

All of the this information was used in the autoinstall threadsafe conversion process described in next.

11.5 The autoinstall process

The Danske Bank changed the existing autoinstall program exit to correctly install programs as threadsafe or not. This was done for the following reasons:

- Ease of maintenance to an ongoing automated process.
- The decision whether a program should be defined threadsafe or not must be determined at autoinstall time. The CICS autoinstall program only knows program type and name; some additional information needs to be supplied.

Because Danske Bank has more than 100,000 programs, the reasons for defining the programs threadsafe or non-threadsafe at autoinstall time was:

- Cold start: Time to add 100,000 programs
- Warm start: Time to reinstall 100,000 programs
- Maintenance: CEDA definitions of 100,000 programs

- CICS storage: Avoid having unused program definitions filling up CICS storage

11.5.1 Data extract process for the CICS CFDT information

The question was how to supply the additional information apart from program name and type.

It must be remembered that the CICS autoinstall program executes on the QR TCB. No MVS API can be used without blocking the QR TCB, which in turn would block the complete CICS address space if this function resulted in an MVS wait. For these reasons Danske Bank decided to supply the additional information from a batch job and store the information in a CFDT that could be accessed from all CICS systems' autoinstall programs. A CFDT is a CICS-defined data table that resides in the CF.

To supply the necessary data the following processes were implemented as a series of batch programs. To control this, the information from 11.4.2, "Resolution" on page 292 was used:

- All relevant PDS/PDSE directories were read and controlled by a parameter list.
  - The information supplied here was linkage conventions (reentrant, addressing-mode).
  - Special checks were added for duplicates, large programs, and so forth.
  - Another parameter was used to determine whether certain programs required special treatment. This could, for example, be linkage relations to other programs like the inheritance of threadsafe from main programs to sub programs. If the main program is threadsafe, all subsequent programs must be threadsafe because of the inheritance rules.
- The output generated several lists showing all the information just identified, and a dataset with all the necessary threadsafe information covering all the relevant programs.
- The threadsafe information dataset was used as input to another program. This program copied the information to a CICS CFDT.

It was decided to execute this process once a week for the three different environments:

- Production systems
- Test systems
- Development systems

11.5.2 Data information structure in CICS CFDT

The key to the CFDT was the program name, which could be defined generically to avoid having too many entries.

The data information structure for the CICS CFDT is described in Table 11-1. Only the most important information related to the threadsafe determination is showed. Danske Bank also kept other kinds of information but these are irrelevant in understanding the general concept.

Table 11-1 CICS CFDT data structure

Name	Type	Description
CMDT_NRN	B'00000001'	Non-reentrant
CMDT_FOR	B'00000100'	DSN non-threadsafe
CMDT_EXT	B'00100000'	Exception = threadsafe
CMDT_EXN	B'01000000'	Exception = non-threadsafe

11.5.3 Danske Bank CICS autoinstall program

The following functionality was added to the standard CICS autoinstall program to use the information in Table 11-1:

- A prerequisite is that the definition to be installed is of type program.
- If autoinstall mask is '*' for a given program, a default autoinstall model is used that defines programs as threadsafe, unless the program is:
  - Not found
  - Non rentrant
  - Non threadsafe library
  - Special non threadsafe action

Programs used during CICS startup, like PLT programs, are always CEDA defined.

11.6 Threadsafe results

The results were generated based on CICS SMF 110 record analysis.

The following CICS SMF 110 records were collected.

1. A point in time *before* converting to threadsafe for the Danske Bank applications. This was further subdivided into those applications that were issuing SQL calls and all other applications.

2. A point in time *after* conversion to threadsafe for the Danske Bank applications. This was further subdivided into those applications that were issuing SQL calls and to all other applications.

The basis for the measurement was the peak hour between 10-11 AM, during which Danske Bank expects a high transaction rate. The transaction rate per peak hour is shown in Table 11-2.

Table 11-2 Transaction measurements

Date	Description	# Transactions	# TCB switches
10-02-2006 Before	Before converting, including those transactions issuing SQL calls.	3,179,639	250,820,638
11-27-2006 After	After converting, including those transactions issuing SQL calls.	2,678,469	104,224,554
10-02-2006 Before	Before converting, including all transactions.	7,859,741	280,879,869
11-27-2006 After	After converting, including all transactions.	6,462,891	128,826,384

Figure 11-3 on page 296 shows the average number of TCB switches before and after threadsafe conversion for all eight z/OS systems, and a total. This figure includes all transactions.

As seen from Figure 11-3, the average number of TCB switches for the total transactions doing SQL calls was reduced from 79 (before threadsafe conversion) to 39 (after threadsafe conversion). This is a reduction to approximately half of the TCB switches after threadsafe conversion.

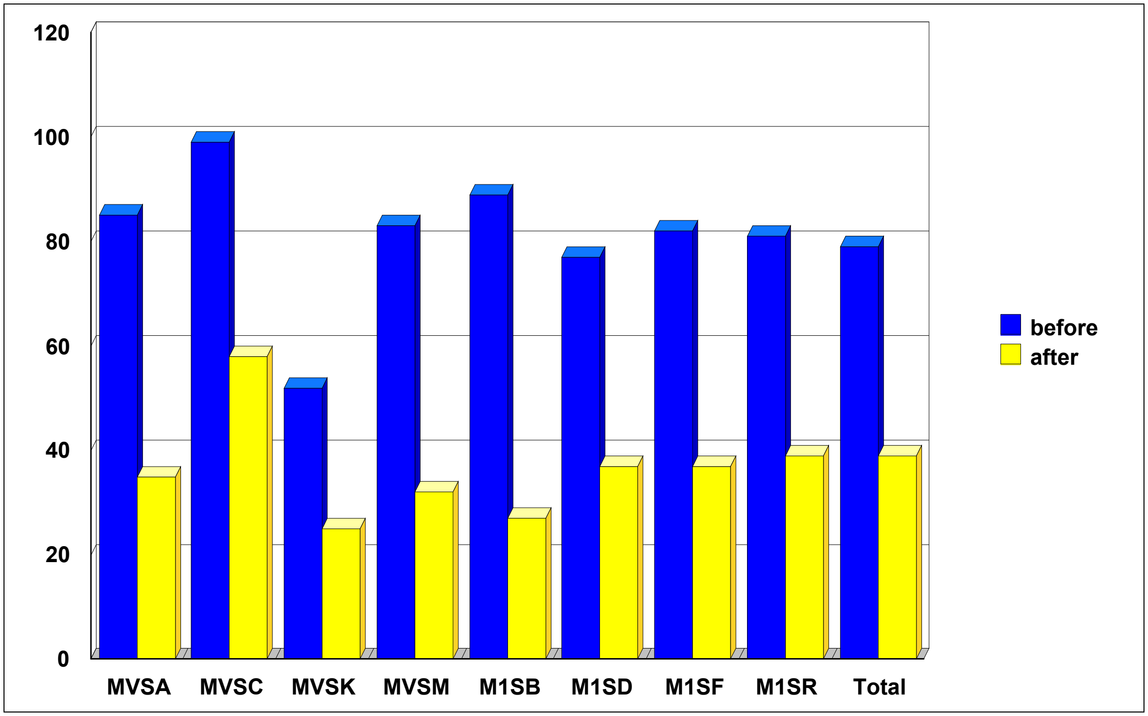

Figure 11-3 TCB switches average per transaction, DB2

Figure 11-4 on page 297 shows the average number of TCB switches before and after threadsafe conversion for all eight z/OS systems (MVSA, MVSC, and so forth) and a total. This figure only includes transactions performing SQL calls.

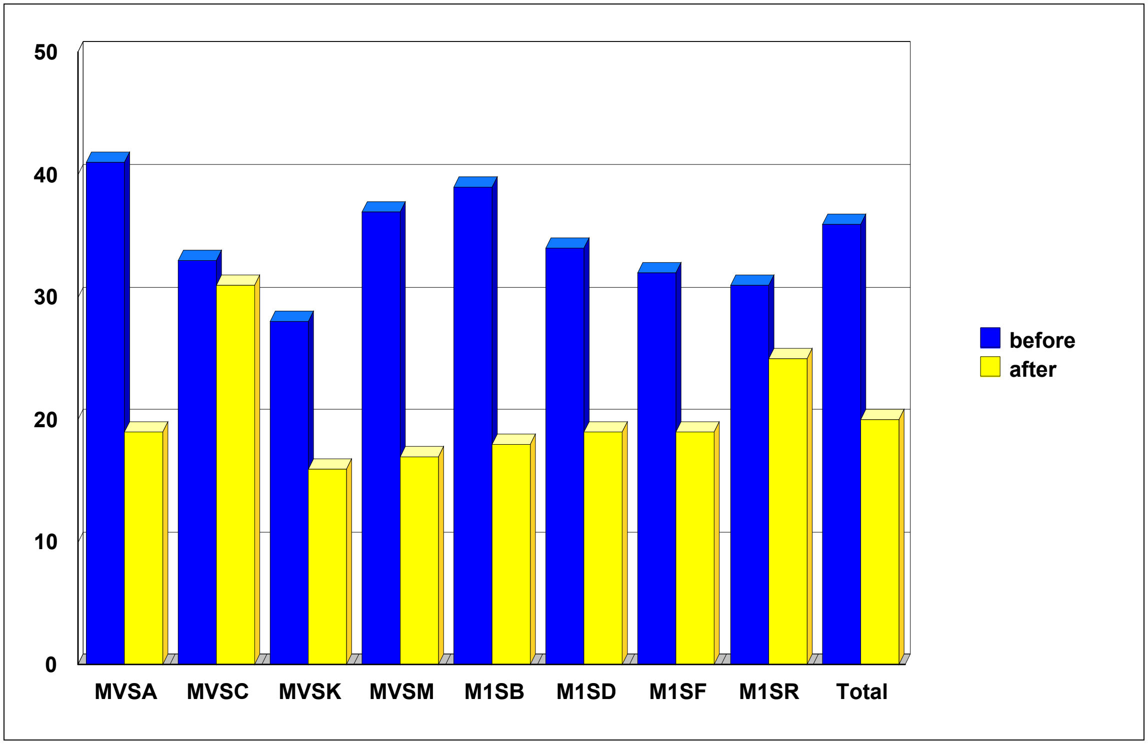

Figure 11-4 TCB switches average per transaction

As seen from Figure 11-4, the average number of TCB switches for all transactions was reduced from 36 (before threadsafe conversion) to 20 (after threadsafe conversion). This is a reduction of 44% in TCB switches after threadsafe conversion.

11.7 Threadsafe summary and conclusion

The decision to make the threadsafe or non-threadsafe definitions for CICS programs an automated process at CICS autoinstall time had several major advantages:

- Elimination of human errors
- Fast converting process overnight
- Optimizing CICS start up time
- Limiting the reliance on program definition changes via the CEDA transaction
- Minimizing CICS storage usage by only installing active program definitions

Note: The automated process was specific to the autoinstall phase. Human expertise and analysis were very much required prior to this.

The result of the Danske Bank threadsafe conversion was a MIPS saving of a little below 300 MIPS during the peak processing period. This can be directly attributed to reduced TCB switching.

Danske Bank is looking forward to CICS Transaction Server Version 3.2 since WMQ, local File Control, and VSAM RLS are threadsafe. They have many WMQ applications and want to use VSAM RLS for application tracing.

In general, if you design and write application code to threadsafe standards, you can define the CICS program as threadsafe. It then has the benefit of being able to run on its own dedicated L8 open TCB, and avoids two TCB switches per DB2 request.

12

Diagnosing performance problems

This chapter provides an overview of diagnosing performance problems using the following data sources:

- Message IEF374I
- SMF Type 30
- RMF workload activity reports
- CICS statistics
- CICS monitoring

12.1 Introduction

Here we look at two types of performance problem, which are:

- Increased response time
- CPU increase

We also need to review the following areas:

- What is the scope?
- When did it start?
- What changed?
  - Applications
  - Other software
  - Maintenance applied
  - Hardware

12.2 Define the problem

Usually, performance problems fall into two major categories: poor response time or increased CPU consumption. Each of these problems requires slightly different approaches, and often different data to diagnose the cause and resolve the problem:

- Poor response time

  Users have begun to complain that their response time has increased. This is usually an indication of resource constraint somewhere in the system: waits of various types (enqueues, locks, slow I/O, string, or buffer waits), file, journal or logger bottlenecks, slowdowns in DB2, DBCTL or another subsystem, and of course, not enough CPU cycles to support the workload.

  - The bottleneck could be within the CICS region. For example, applications are doing many more GETMAINs/FREEMAINs after implementing new functionality in the Language Environment.
  - Applications might be spending much more time in DB2, IMS, or another database product after implementing a new release.
  - The bottleneck could be outside the region. For example, DASD contention is slowing writes and causing applications to wait.

- Increased CPU time

  Either the end user paying the bill is complaining that his CPU costs have gone up, or someone has noticed that she is using more CPU than before. First, determine how the CPU increase is being measured: is it from SMF records or perhaps a report from a vendor product?

  – If the reported increase is from a vendor product, how is the CPU usage determined? Is it calculated from a formula based on the hardware type, or is it calculated from data reported by SMF or RMF?

  – If the increase is reported following a change in hardware, was the formula used in the vendor product updated to reflect the new hardware? In other words, is there a real increase, or are we being misled by erroneous reports?

A few more questions are:

- What is the scope?

  Identify the scope of the problem. Is it an overall slowdown—that is, are all transactions affected, or are only a few transactions affected, perhaps a single application? The scope of the symptoms will help determine where to look next. Since you are trying to identify the resources that are adversely affecting response time, you will need to look at information that tells you about resource usage in the system: either system-wide resource usage (CICS statistics) or usage by individual transactions (CICS monitoring data), or even MVS-wide data in RMF reports.

- When did the problem start?

  Can you associate the onset of the problem with a change of any kind, or with a specific time?

- What changed?

  – Was maintenance applied (*any* maintenance, not just CICS but also MVS, VTAM, LE, OEM products, and so on)?

  – Were there application changes? Hardware changes? (Processor, DASD, LPAR configuration, new NCP or I/O configuration, and so on?) Were there any new releases of software?

12.3 Performance hierarchy

Performance problems represent a class of problems that are often difficult and time consuming to resolve. Like learning to diagnose an 0C1 program check, we must learn to use and understand the tools and methodologies that can assist in problem resolution.

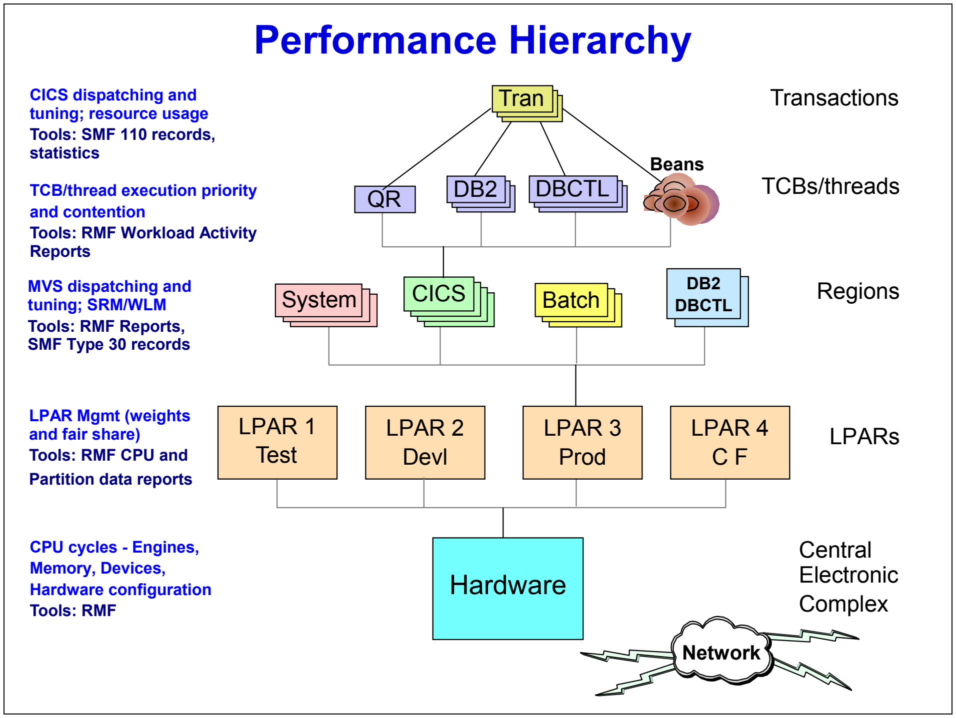

Figure 12-1 Performance hierarchy diagram

The Central Electronic Complex (CEC) is a physical collection of hardware that consists of central storage, one or more central processors (CP), timers, and channels.

The hardware resources of a CEC (central processors, central storage, expanded storage, and channel paths) can be divided into logical partitions (LPARs). Each LPAR executes a separate copy of an operating system (z/OS, MVS, VM, VSE, Linux®, and so on).

Each layer shown in Figure 12-1 builds on the resources of the lower levels. For example, in order for CICS to dispatch a task, an engine (CP, central processor) must have been made available (allocated) to the z/OS image. This in turn dispatches the CICS region (that is, assigns a CP to the CICS region). The CICS region can then dispatch CICS tasks using the CP allocated by z/OS.

Difficulty in solving a performance problem is reduced by a better understanding of the layers that provide the execution environment. The underlying resources allocated to CICS are provided by the hardware. If there are insufficient or poorly configured hardware resources, CICS performance will be affected. Tuning and application changes can reduce resource demand.

The MVS (z/OS) dispatcher, with assistance from Workload Manager (WLM), allocates the available LPAR resources between regions (address spaces). MVS tuning can be performed to increase a region's share of these resources, within the scope of the resources available to the LPAR. If it is felt that an LPAR has insufficient resources, consider investigating the reports produced that detail the LPAR management data.

Important: A basic premise to remember is that a lack of underlying hardware resources is nearly impossible to tune away with software.

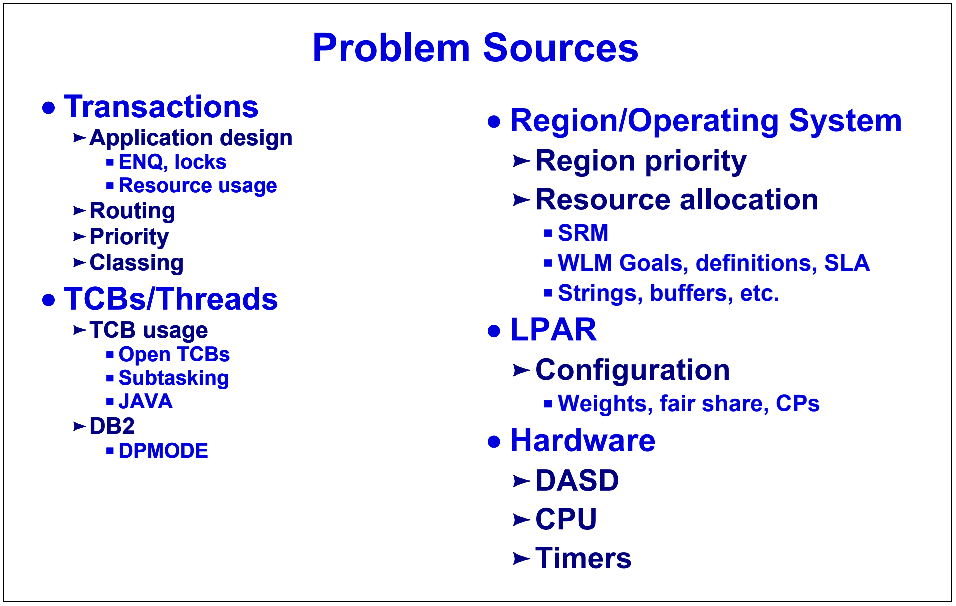

Figure 12-2 Problem sources

12.4 Key performance indicators

In this section we discuss key performance indicators.

12.4.1 Indicators from System Management Facilities (SMF)

Here are performance indicators for CICS performance records (SMF 110 subtype 1):

- Wait for redispatch time (DISPWAIT) is a measure of the length of time following the posting of the ECB until CICS redispatches the task.
- Wait for QR Mode TCB time (QRMODDLY) is the elapsed time a task waited for redispatch on the CICS QR TCB.
  - QRMODDLY is a subset of DISPWAIT time.
- Average CPU per task.
- Average response time.
- Wait times associated with resources, for example:
  - File wait
  - MRO link wait time
  - RMI time
  - RMI suspend time
  - TCLASS delay
  - First dispatch delay
- QR TCB CPU to dispatch ratio.
- Transaction rate.
- Logwrites per second.

12.4.2 Indicators from Resource Management Facility (RMF)

Here are the key performance indicators that can be obtained from RMF:

- Workload activity reports
  - TCB CPU seconds in the interval
  - APPL% (the percent an engine (CP) used in the interval)
  - Average CPU per task
  - Divide APPL% by RMF transaction rate
  - MVS busy
- RMF transaction level report classes
  - Average response time
  - Transaction rate

- Partition data report
  - LPAR logical and physical busy
  - CEC busy

12.5 Performance data sources

The following performance data sources are discussed in more detail in the following sections.

- Message IEF374I
  - Written at step termination
  - Contains TCB and SRB accumulated time for the address space
  - Some of the information contained in SMF 30 records
  - Job/address space
- SMF type 30 records
  - Subtype 2 and 3 (interval records):
    - Written every SMF interval - similar to CICS interval statistics
    - Information such as *CPU seconds used* is available at the end of the SMF interval
- RMF workload activity reports, SMF interval information
  - SMF 70–78 records
  - TCB and SRB times
  - DASD I/O counts and response times
  - Indication of CP usage (APPL%)
  - Region level statistics
- CICS monitoring records
  - SMF 110 subtype 1 records
  - CICS task level data - performance and exception
- CICS statistics
  - SMF 110 subtype 2 records
  - Information collected on an interval basis and/or end of day
  - Information is similar to RMF data but CICS-based
  - CICS resource based

12.5.1 Message IEF374I

This is written to the JESYSMSG log for the job during step termination. It shows you the virtual storage above and below the 16-MB line.

- The sample in Figure 12-3 shows a one-step CICS job.

  Job and step numbers are the same.

- Includes all TCB and SRB time in the region.

```
IEF373I STEP/CICS/START 2002349.1112
IEF374I STEP/CICS/STOP  2002349.1310 CPU 62MIN 37.76SEC SRB 10MIN 28SEC VIRT 5420K SYS 344K EXT 116612K SYS 16896K

IEF375I  JOB/IYOT122/START 2002349.1112
IEF376I  JOB/IYOT122/STOP  2002349.1310 CPU   62MIN 37.76SEC SRB   10MIN 28.05SEC
```

Figure 12-3 IEF374I message

12.5.2 SMF records

Performance data is captured in many places within a z/OS system. During step termination, information is collected as SMF type 30 records. The processor time used by the collective TCBs and SRBs in the address space is written to the JES log (JESYSMSG) during step termination, as message IEF374I.

This data can be used to define the overall CPU time associated with an address space. From a CICS perspective, these numbers include all time that is not associated with the actual transactions processed. Simply dividing the total CPU time by the number of transactions processed does not give a true representation of resources used.

For example, suppose 50% of the transactions simply read a record from a VSAM file and display a message on the terminal and 50% of the transactions issue 100 EXEC SQL calls. Dividing the processor time by the total transactions does not provide a true picture of resource usage. In the case where the CPU per transaction suddenly increases, it is quite difficult to understand the root cause.

z/OS collects statistical information about an System Management Facilities interval. The interval is defined using the INTVAL(tt) option in the SMFPRMxx member of SYS1.PARMLIB. To display the status of the SMF datasets, use the command D SMF. The SMF options in use can be displayed using a D SMF,O command (Figure 12-4).

```
COMMAND INPUT ===> /d smf,o
 IEE967I 13.10.10 SMF PARAMETERS 330
    MEMBER = SMFPRMZI    <------------------------------------- SYS1.PARMLIB member
        MULCFUNC -- DEFAULT
         . . . . .
        SUBSYS(OMVS,TYPE(0,30,70:79,90,88,89,99,101,110,245)) -- PARMLIB
        SUBSYS(OMVS,INTERVAL(SMF,SYNC)) -- PARMLIB
        SUBSYS(OMVS,NOEXITS) -- PARMLIB
        SUBSYS(STC,NODETAIL) -- SYS
        SUBSYS(STC,TYPE(0,30,70:79,88,89,90,99,101,110,245)) -- PARMLIB <- Record types collected
        SUBSYS(STC,INTERVAL(SMF,SYNC)) -- PARMLIB
        SUBSYS(STC,EXITS(IEFACTRT)) -- PARMLIB
      INTVAL(05) -- PARMLIB    <---------------------------------- SMF Interval
        NOPROMPT -- PARMLIB
        LISTDSN -- PARMLIB
        DSNAME(SYSD.MAN4) -- PARMLIB
        DSNAME(SYSD.MAN3) -- PARMLIB                                  SMF dataset names
        DSNAME(SYSD.MAN2) -- PARMLIB
        DSNAME(SYSD.MAN1) -- PARMLIB
```

Figure 12-4 d smf, o command

The Resource Measurement Facility (RMF) function of z/OS gathers a large amount of information regarding resource usage, which is written to SMF as record types 70 to 78. The information includes TCB and SRB times, DASD I/O counts, along with a breakdown of the response times, Central Processor (CP) usage, and more.

It is also possible to obtain the number and rate of CICS transactions completed during the SMF interval. However, as in the case of the contents of IEF374I, this information is presented at a region level. For example, in order to calculate the CPU time per transaction, the total CPU consumed in the interval is divided amongst the number of transactions completing in the interval.

RMF reports are generated using the RMF post processor (ERBRMFPP). For maximum granularity, each CICS region should be assigned to a separate reporting class. In addition, we strongly recommend that report classes be defined to display the CICS transactions that complete during the interval. For example, a report class might be generated for all transactions that begin with JOR (JOR1, JOR2, JOR3, and so on) with a second report class defined for transactions beginning with DB2 (DB21, DB22, and so on). This would allow transaction rates and response times to be reported for individual sets of transactions rather than the region as a whole. There can be up to 999 report classes in a sysplex. Report classes are defined using the Work Load Manager facilities (=WLM in ISPF).

SMF Type 110 subtype 1 records

CICS collects performance data at the task level (activated via the MNPER SIT parm, CEMT SET MONITOR, or EXEC CICS SET MONITOR). Three classes of performance monitoring may be selected: performance class data (MNPER), exception class data (MNEXE), and a new transaction resource class data (MNRES), with the addition of CICS Transaction Server 2.2 APAR PQ63143. This class data is present at the base code level in later releases of CICS.

Performance class data is detailed at the transaction level. It provides information such as response time, time spent waiting for a resource or I/O, and CPU time. At least one performance record is written for each transaction at task termination time. For long-running tasks, the MNFREQ option can be used to cause periodic records to be written.

Exception class monitoring data provides information about CICS resource shortages at the transaction level. This data can be used to identify system constraints that affect transaction performance. An exception record is written to SMF when the shortage has been resolved. Refer to the *CICS Performance Guide* for a detailed description of exception records.

With the addition of PQ63143, transaction resource class data provides additional transaction level information about file resources. To activate transaction resource collection for files, an Monitor Control Table (MCT) must be assembled with FILE=parm.

SMF Type 110 subtype 2 records

CICS interval statistics are collected for CICS resource usage at the expiration of each statistics recording interval and written to SMF as type 110 subtype 2 records. The interval can be specified using the STATINT SIT (System Initialization Table) parameter, and STATRCD=ON must also be specified. Otherwise, as is the case with older releases of CICS, the interval is set using the CICS master terminal function CEMT SET STATISTICS, or EXEC CICS SET STATISTICS command.

The the interval statistics can be considered as CICS region level data, but at a more granular level than RMF data (for example, dataset level statistics versus the actual DASD activity in RMF).

SMF Type 30 records

The SMF 30 records contain *region level* statistics. There are a number of methods that can be used to view the records. The record shown in Figure 12-5 was selected by using a SORT with the control cards shown in Example 12-1 on page 310.

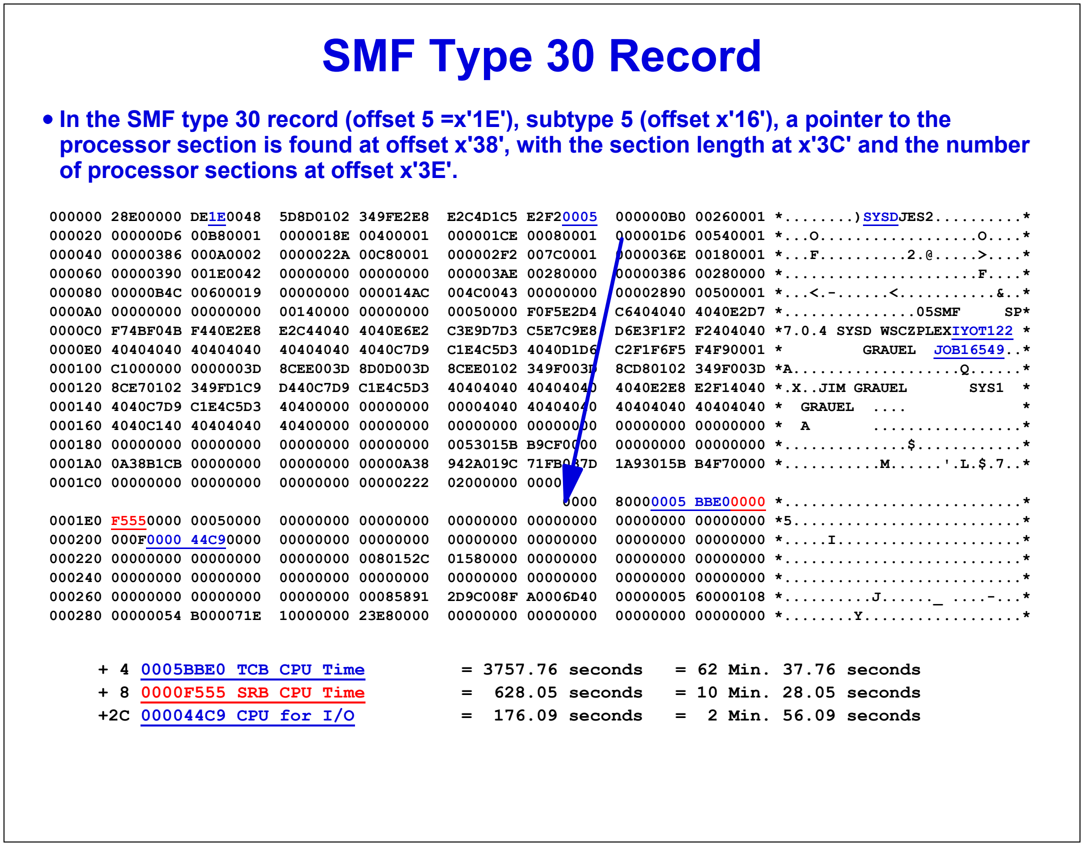

Figure 12-5 An example of an SMF type 30 record

SMF Type 30 Record: Notes

Processor Section:

Offsets		Name	Length	Format	Description
0	0	SMF30PTY	2	binary	Address space dispatching priority (note this field is not valid in goal mode)
4	4	SMF30CPT	4	binary	Step CPU time under the task control block (TCB), in hundredths of a second (including enclave time, preemptable class SRB time, and client SRB time).
8	8	SMF30CPS	4	binary	Step CPU time under the service request block (SRB), in hundredths of a second.
44	2C	SMF30IIP	4	binary	Amount of CPU time used to process I/O interrupts, in hundredths of a second.
52	34	SMF30HPT	4	binary	CPU time consumed for the step, in hundredths of a second, to support requests for data to be transferred between a hiperspace and an address space, when the hiperspace is backed by expanded storage. The CPU time may vary depending on the availability of expanded storage.
68	44	SMF30ASR	4	binary	Additional CPU time accumulated by the preemptable SRBs and client SRBs for this job, in hundredths of a second. This value is also included in the value in SMF30CPT.

Refer to OS/390 V2R4.0 MVS System Management Facilities (SMF) - SMF30COF

Figure 12-6 SMF Type 30 record layout

Example 12-1 Sort example

```
//SYSIN    DD *
      SORT FIELDS=(47,8,CH,A,11,4,PD,A,7,4,BI,A)
       INCLUDE COND=(6,1,FI,EQ,30)
```

DFHJUP was then used to print the records in hex.

SMF 30 records consist of a header plus a number of sections, that is, processor, performance, I/O, and so on.

The processor section contains information such as the TCB (+4) and SRB (+8) times, which are reported in the IEF374I message.

- An SMF 30 subtype 2 record is written at the completion of each SMF interval.
- A subtype 5 record is written at job termination.

Refer to z/OS V1R7.0 MVS System Management Facilities (SMF) -Record Type 30 (1E)

12.5.3 RMF Workload Activity reports

RMF provides a wealth of information that is invaluable in the resolution of performance problems. This information can be used to understand how changes affect CPU, storage, and DASD usage.

Figure 12-8 on page 312 contains a WLM Workload Activity Report that presents data collected for report classes RIYOT122 and RJORIY1. Report class RIYOT122 provides RMF information about a CICS region called IYOT122. Report class RJORIY1 was defined to show the number of transactions beginning with JOR, which ended in the given SMF interval.

Report classes are defined using the WLM ISPF panels (=WLM option 2.6, then enter a 3 beside CICS). shows report classes for TRANIDs starting with JOR (report class RJORIY1), and a second report class (RCICSIY1) for all transactions starting with C.

```
 Subsystem-Type  Xref  Notes  Options  Help
--------------------------------------------------------------------------
                 Modify Rules for the Subsystem Type      Row 1 to 8 of 10
Command ===> ____________________________________________ SCROLL ===> PAGE

Subsystem Type . : CICS        Fold qualifier names?   Y  (Y or N)
Description  . . . CICS transaction level rules

Action codes:   A=After     C=Copy        M=Move     I=Insert rule
                B=Before    D=Delete row  R=Repeat   IS=Insert Sub-rule
                                                             More ===>
          --------Qualifier--------                -------Class--------
Action    Type        Name     Start                Service     Report
                                          DEFAULTS: ________    ________
 ____   1  SI         IYOT1    ___                  ________    ________
 ____   2    TN         JOR*     ___                ________    RJORIY1
 ____   2    TN         C*       ___                ________    RCICSIY1
```

Figure 12-7 RMF report classes

The report interval is listed in the start and end times at the top of the page. A word of caution: T Figure 12-8 on page 312 he minimum interval is defined by the INTVAL() parm in the SMFPRMxx member of SYS1.PARMLIB. In the samples collected, the interval was set to 5 minutes:

```
INTVAL(05)                    /* SMF GLOBAL RECORDING INTERVAL */
```

It is also important to ensure that the SMF 70 to 79 records are being collected, along with the CICS 110 records. The records to be collected are also defined in the SMFPRMxx member:

```
SUBSYS(STC,EXITS(IEFACTRT),INTERVAL(SMF,SYNC),
                              TYPE(0,30,70:79,88,89,90,99,110,245))
         SUBSYS(OMVS,NOEXITS,INTERVAL(SMF,SYNC),
                              TYPE(0,30,70:79,90,88,89,99,110,245))
```

When the reports are formatted, it is possible to report a larger interval than was specified in the SMFPRMxx member, via the DINTV parm. However, do not forget that the length of the minimum interval is the value specified for INTVAL. One word of caution: SMF88 data that is formatted using IXGRPT1 does not have the ability to summarize at a larger interval than the interval used for data collection (the INTVAL value specified in the current SMFPRMxx).

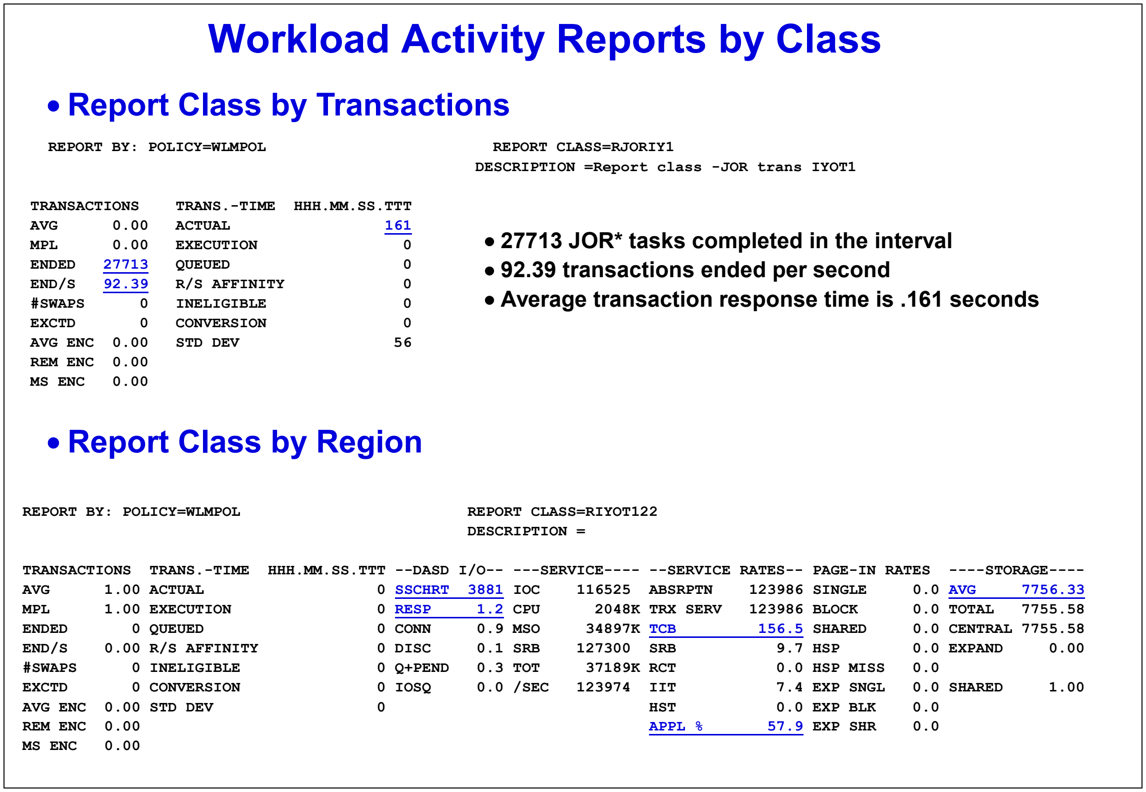

Figure 12-8 Workload Activity Reports by class

Referring to Figure 12-8:

- The following fields should be noted in the reports:
  - MPL: Multiprogramming level. Number of address spaces active in this service/report class during the interval

   - TCB: provides the CPU seconds accumulated in TCB mode during the collection interval
   - SRB: provides the CPU seconds accumulated in SRB mode during the collection interval
   - APPL%: percentage of an engine (CP) used during the collection interval
- The following field should be noted under STORAGE:
   - AVG: average number of central and expanded storage frames allocated to ASIDs in the report class
- The following field should be noted under PAGE-IN RATES:
   - SINGLE: average rate at which pages are read into central storage from aux (DASD)
- The following fields should be noted under DASD I/O:
   - SSCHRT: number of start subchannels (SSCHs) per second in the reported interval
   - RESP: average DASD response time (in milliseconds).
- The following fields should be noted in the transaction report:
   - ENDED: reports the number of CICS transactions that ended during the SMF interval
   - END/S: provides the transaction rate for those transactions reported, as defined in the report class
   - TRANS. TIME: transaction response time

12.5.4 CICS PA reports

CICS PA can provide a report on transaction response time as reported by WLM. It provides a slightly different perspective. Notice in Figure 12-9 on page 314 that it reports by both service class (which is not being used) and report class. In addition to the information provided in the RMF report, CICS PA provides data showing the standard deviation and 90% peak.

CICS PA Workload Report

```
V1R2M0                              CICS Performance Analyzer
                               Workload Manager Activity Summary by Service Class

WKLD0001 Printed at 12:21:12 10/06/2003 Data from 16:44:59 10/02/2003 to 16:49:59 10/02/2003

Service                              -------------- Response Time --------------
Class     APPLID     Phase     #Tasks     Average     Std Dev     90% Peak     Maximum

*Other*   IYOT1      BTE       29051      .1566       .0671       .2426        .6043

V1R2M0                              CICS Performance Analyzer
                               Workload Manager Activity Summary by Report Class

WKLD0001 Printed at 12:21:12 10/06/2003 Data from 16:44:59 10/02/2003 to 16:49:59 10/02/2003

Report                               -------------- Response Time --------------
Class     APPLID     Phase     #Tasks     Average     Std Dev     90% Peak     Maximum

RCICSIY1  IYOT1      BTE       1330       .0320       .0177       .0547        .1138
RJORIY1   IYOT1      BTE       27721      .1625       .0627       .2429        .6043
```

Figure 12-9 CICS PA workload report

CICS PA provides extensive reports and analysis of the CICS performance monitoring record. CICS writes a performance monitoring record to SMF as 110 record subtype 1 when each task completes. The records contain an extensive amount of information about the task showing everything from response time, CPU used, to suspend/wait times. Each segment of response time is reported. For example, if the task issues 100 file control calls, the calls will be detailed as to the type (read, read/update, rewrite, and so on). The total file I/O wait time is recorded. An example CICS PA report is shown in Figure 12-10.

```
V1R2M0                                              CICS Performance Analyzer
                                                       Performance Summary

SUMM0001 Printed at  7:53:10 10/05/2003      Data from 01:00:00 10/03/2003 to 01:04:59 10/03/2003
Summary of DB2* and JOR* task records in the SMF dataset

                  Avg        Avg       Avg     Avg     Avg     Avg     Avg       Avg       Avg     Avg      Avg      Avg
Tran   #Tasks Response Dispatch User CPU QR CPU L8 CPU Suspend DispWait ChngMode QRModDly FCAMRq  FC Wait DB2 Reqs
                 Time       Time      Time    Time    Time    Time    Time                Time              Time
DB2A     2506   .1204      .0110     .0065   .0004   .0061   .1094   .0464       404     .0288       0    .0000      200
JORB     1806   .1660      .0079     .0056   .0056   .0000   .1581   .0483         0     .0483     168    .0983        0
```

Figure 12-10 CICS PA performance summary

12.5.5 DFH0STAT

DFH0STAT is supplied as a compiled sample program. The source continues to be available as a sample COBOL program in SDFHSAMP. You need to install CSD group DFH$STAT. It is run as the STAT transaction to collect CICS statistics and write them to the JES spool. The output can then be viewed under TSO. The SIT parm SPOOL=YES is required.

The information provided via DFH0STAT is also available in the CICS shutdown statistics.

Note: DFH0STAT must not be used in place of the shutdown statistics. It will only report information provided in the current statistics interval. In addition, the unsolicited records will be lost.

```
Applid IYOT1     Sysid IYO1  Jobname IYOT122     Date 12/15/2002  Time 11:57:13              CICS 6.2.0
____________________________________________________________________________________________________________
System Status
_____________
  MVS Product Name. . . . . . . :  MVS/SP7.0.4                CICS Transaction Server Level . . :  02.02.00
  CICS Startup. . . . . . . . . :  INITIAL
  CICS Status . . . . . . . . . :  ACTIVE                     RLS Status. . . . . . . . . . . . :  RLS=NO
  Storage Protection. . . . . . :  ACTIVE                     RRMS/MVS Status . . . . . . . . . :  OPEN
  Transaction Isolation . . . . :  ACTIVE
  Reentrant Programs. . . . . . :  NOPROTECT                  VTAM Open Status. . . . . . . . . :  OPEN
                                                              IRC Status. . . . . . . . . . . . :  OPEN
  Force Quasi-Reentrant . . . . :  No                         TCP/IP Status . . . . . . . . . . :  OPEN

  Program Autoinstall . . . . . :  ACTIVE                     Max IP Sockets. . . . . . . . . . :    255
  Terminal Autoinstall. . . . . :  ENABLED                    Active IP Sockets.. . . . . . . . :      0

  Activity Keypoint Frequency. . . . . . . :    1,000         WEB Garbage Collection Interval . :     60
  Logstream Deferred Force Interval. . . . :        0         Terminal Input Timeout Interval . :      5

  DB2 Connection Name . . . . . :  SYSD
```

Figure 12-11 DFH0STAT sample output

The dispatcher summary is used to track information such as the TCB and SRB time accumulated in the address space since the start of the CICS region or the beginning of the last statistics interval. For the QR TCB, the CPU-to-dispatch ratio is calculated. CPU and dispatch time information is provided for all TCB modes, but the ratio is only calculated for the QR TCB. For open TCB modes like J8 and L8, the TCBs are not necessarily permanent, that is, they can be attached and detached during the CICS run or within a statistics interval.

```
Dispatcher
  Current ICV time . . . . . . . . . . . . . . :          3,000ms
  Current ICVR time. . . . . . . . . . . . . . :         20,000ms
  Current ICVTSD time. . . . . . . . . . . . . :            100ms
  Current PRTYAGING time . . . . . . . . . . . :            500ms
  MRO (QR) Batching (MROBTCH) value. . . . . . :              1
  Concurrent Subtasking (SUBTSKS) value. . . . :              1
  Current number of CICS Dispatcher tasks. . . :             27
  Peak number of CICS Dispatcher tasks . . . . :             29
  Current number of TCBs attached. . . . . . . :              7
  Current number of TCBs in use. . . . . . . . :              7
  Number of Excess TCB Scans . . . . . . . . . :              0
  Excess TCB Scans - No TCB Detached . . . . . :              0
  Number of Excess TCBs Detached . . . . . . . :              0
  Average Excess TCBs Detached per Scan. . . . :              0
  Number of CICS TCB MODEs . . . . . . . . . . :             18
  Number of CICS TCB POOLs . . . . . . . . . . :              4
 Dispatcher TCB Modes
  Dispatcher Start Time and Date . . . . . . . :  13:10:00.00569  05/05/2006
  Address Space Accumulated CPU Time . . . . . :  00:17:53.38121  (Not Reset)
  Address Space Accumulated SRB Time . . . . . :  00:02:31.70997  (Not Reset)
  Address Space CPU Time (Since Reset) . . . . :  00:00:55.93860
  Address Space SRB Time (Since Reset) . . . . :  00:00:07.58986

   TCB   TCBs Attached    Op. System    Op. System     Total TCB       Total TCB        DS TCB      TCB CPU/Disp
   Mode  Current    Peak    Waits        Wait Time    Dispatch Time     CPU Time       CPU Time        Ratio
    QR       1        1       90,525  00:00:41.30698  00:01:31.49197  00:00:55.93948  00:00:01.49983     61.1%
    RO       1        1            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    CO       1        1            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    SZ       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    RP       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    FO       1        1            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    SL       1        1            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    SO       1        1            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    SP       1        1            1  00:00:00.00000  00:00:00.00996  00:00:00.00000  00:00:00.00000
    D2       1        1            4  00:02:00.00270  00:00:00.00010  00:00:00.00008  00:00:00.00003
    JM       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    S8       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    L8       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    L9       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    J8       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    J9       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    X8       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
    X9       0        0            0  00:00:00.00000  00:00:00.00000  00:00:00.00000  00:00:00.00000
____________________________________________________________________________________________________
  Totals     8                                                        00:00:55.93957  00:00:01.49987
```

Figure 12-12 DFH0STAT dispatcher report

CICS Transaction Server Version 2.2 APAR PQ76702 introduced the ability to collect additional TCB information for the CICS address space. This function is present at the base code level in later releases of CICS. DFH0STAT has been changed to display the TCB structure along with CPU and storage information for each TCB.

It is very important to remember that this display, like all DFH0STAT displays, is a snapshot captured at a particular point in time. It shows the TCBs and their status as they were when the STAT transaction was run. The number of TCBs can and will change over the course of a CICS run. It is very important to understand that open TCBs (S8, L8, L9, J8, J9, X8, and X9) can be detached and a new TCB attached at a later time, which might be located at the exact same address. Therefore the CPU values may seem incorrect over an extended period of time, because there is actually more than a single TCB being reported. Multiple displays provide a trend but they should not be used as a substitute for the dispatcher shutdown statistics and RMF data produced for the region.

The address space accumulated TCB and SRB CPU time is displayed. Storage allocated information is provided at both address space and TCB levels.

```
Dispatcher - MVS TCBs
 Dispatcher Start Time and Date . . . . . . :  10:22:47.81766  01/16/2004
 Address Space Accumulated CPU Time . . . . :  00:20:14.25838  (Not Reset)
 Address Space Accumulated SRB Time . . . . :  00:00:00.44907  (Not Reset)
 Address Space CPU Time (Since Reset) . . . :  00:20:15.00231
 Address Space SRB Time (Since Reset) . . . :  00:00:00.44711

 Current number of CICS TCBs . . . . . . . . . . . . . :              36
 Current CICS TCB CPU time . . . . . . . . . . . . . . :  00:20:15.04754
 Current CICS TCB Private Storage below 16MB . . . . . :           5,368K
 Current CICS TCB Private Storage above 16MB . . . . . :         121,860K
 Current number of non-CICS TCBs . . . . . . . . . . . :               1
 Current non-CICS TCB CPU time . . . . . . . . . . . . :  00:00:00.75399
 Current non-CICS TCB Private Storage below 16MB . . . :             104K
 Current non-CICS TCB Private Storage above 16MB . . . :           1,248K

  TCB              CICS       Current TCB      Current TCB Private Stg  Task  Tran   Task   Mother    Sister   Daughter
Address  TCB Name  TCB   <--- TCB CPU Time---> Below 16MB   Above 16MB Number  ID   Status   TCB       TCB       TCB
009F0860 IEFIIC    No    00:00:00.75399 100.0%       104K       1,248K   None               009FFD90          009F0A40
009F0A40 DFHSIP    Yes   00:00:00.03861   0.0%     5,312K     121,340K   None               009F0860          009DD9C0
009DD9C0 FO        Yes   00:00:00.02274   0.0%        12K          32K   None               009F0A40 009F0058 009DD610
009DD610 RO        Yes   00:00:00.29527   0.0%        16K          32K   None               009DD9C0          009DD260
009F0058 DFHTRTCB Yes    00:00:00.00002   0.0%         0K           0K   None               009F0A40
009DD260 QR        Yes   00:05:21.69479  26.4%        16K         260K     35 STAT   Run    009DD610          009A65F0
009A65F0 L800Q     Yes   00:00:38.52774   3.1%         0K           0K   None               009DD260 009A6AE8
009A6AE8 L800P     Yes   00:01:21.47988   6.7%         0K           4K   None               009DD260 009A6D90

009B2868 L800A     Yes   00:01:12.86450   5.9%         0K           4K   None               009DD260 009B2B10
009B2B10 L8009     Yes   00:01:10.83851   5.8%         0K           4K   None               009DD260 009B5308

009B4348 L8001     Yes   00:00:00.34601   0.0%         0K           4K   None               009DD260 009B4C00
009B4C00 L8000     Yes   00:00:00.00545   0.0%         0K           4K   None               009DD260 009B4E88
009B4E88 DFHSKTSK Yes    00:00:00.01054   0.0%         8K           4K   None               009DD260 009B9418
009B9418 D2000     Yes   00:00:00.00061   0.0%         0K           0K   None               009DD260 009B9A68
009B9A68 SO        Yes   00:00:00.00187   0.0%         4K         116K   None               009DD260 009B9D90
009B9D90 SL        Yes   00:00:00.00025   0.0%         0K           8K   None               009DD260
```

Figure 12-13 DFH0STAT Dispatcher MVS TCBs report

Each TCB entry in the display shows the TCB address, the TCB name, and the current TCB accumulated CPU time, and storage allocation is given. The TCB name is taken from the PRB CDE (Contents Directory Entry) for non-CICS TCBs or the CICS name found in the KTCB (in the Kernel Domain). Additional information displayed includes the active task (if the TCB is executing when the inquiry is issued), the mother (attaching) TCB, sister (attached by the same mother) TCB, and daughter (attached by this TCB) TCBs.

If we look at the QR TCB in Figure 12-13 we can see the TCB located at 009DD260. It was attached by the TCB located at 009DD610 (the RO), and it has attached a number of daughter TCBs. The daughter TCBs are listed in reverse order starting with L800Q at location 009A65F0. Following the sister TCB chain, it is observed that the L8, a DFHSKTSK, the D2000, SO, and SL TCBs are all daughters of the QR TCB. (Note that due to space limitations, not all TCBs have been displayed.)

Also notice that the QR TCB has accumulated 26.4% of the address space CPU time: 5 minutes and 21.69479 seconds of the 20 minutes—15.04754 seconds of the TCB time in the address space.

The QR TCB has allocated 16-K bytes of storage below the 16 MB line and 260 K above the line. The current task is task number 35 (a STAT transaction).

12.6 Conclusions

You must consider many different areas when reviewing performance. There are many tools out there to help. However, no one tool can be used alone to get a picture of your overall performance. The steps and guidelines listed here provide you with a clearer picture of the performance of your systems.

You must:

- Define the problem.
- Understand the workload.
- Understand the physical configuration.
- If CPU has increased:
  - Establish a baseline before a new function is implemented
    - CICS Performance data (SMF 110 records)
    - SMF 70-78, SMF 30
    - CICS trace
    - CPU to Dispatch ratio
    - Measure with the following three data collectors:

      - DFH0STAT
      - Shutdown statistics
      - CICS PA
- If response time has increased:
  - Establish a baseline using
    - CICS Performance data (SMF 110 records)
    - SMF 70-78, SMF 30
- Remember that capacity problems usually manifest themselves as response time problems.

13

Common threadsafe questions

In this chapter we answer some of the most frequently asked questions about threadsafe.

13.1 General threadsafe questions

Can I go ahead and define all my applications as threadsafe?

Answer: No. A full analysis of each of your applications must be performed before making the definition change. Otherwise you could compromise your application's shared data and also see a performance degradation due to excessive TCB switches caused by non threadsafe CICS commands and non threadsafe user exits. Just changing a program's definition is not enough.

If my application is reentrant can I define it as threadsafe?

Answer: No. Reentrancy is just one aspect of being threadsafe. You need to check whether the application accesses any shared resources, and if so does it have the necessary serialization logic in place. An application can be reentrant, link-edited with RENT, and reside in a CICS read-only DSA, but if it incorrectly accesses shared data without serialization logic, then it is non threadsafe.

Are there automatic tools I can run to tell me if my application code is threadsafe or to convert my application automatically?

Answer: No, there is no automatic way of making your programs threadsafe. CICS provides the load module scanner to help you identify those commands that could cause your application code to be non threadsafe and to identify those CICS commands that are non threadsafe and will cause a switchback to the QR TCB. However, the load module scanner is an aid to be used as a starting point in analyzing your application.

What happens if I define an application program as threadsafe to CICS when it is not threadsafe?

Answer: CICS cannot protect you from the consequences, and the results are unpredictable. You risk the integrity of the shared data as multiple instances of the program each running on its own TCB can access the data at the same time. There is no protection provided via quasi-reentrancy because the application is not running on the QR TCB. The loss of data integrity may not be instantly detected and may become apparent later. This is similar to the victim of a storage overwrite finding out long after the storage overwrite occurred.

What is a non threadsafe CICS command, and do such commands have a data integrity exposure?

Answer: A non threadsafe CICS command is a CICS command that insists on running on QR TCB. The CICS code that implements the command relies on quasi-reentrancy, that is, serialization provided by running on the QR TCB. No, there is no data integrity exposure, as serialization of shared resources is provided by QR TCB. On the other hand, a threadsafe CICS command is one in which the CICS code does not rely on running on QR TCB and can execute safely on open TCBs concurrently.

Can I define a program as threadsafe if it contains non threadsafe CICS commands?

Answer: Yes. By defining a program as threadsafe you are telling CICS the application code (for example, the COBOL source code) is threadsafe, you are not telling CICS about what API commands the program uses. (CICS manages the threadsafety issues of its own code.) Non threadsafe EXEC CICS commands will cause a switch back to the QR TCB. This affects the performance of the application, but it does not affect the integrity of your data.

For a program defined as CONCURRENCY(THREADSAFE) API(CICSAPI), following execution of a non threadsafe CICS command, the program remains on the QR TCB until the next request to an OPENAPI TRUE (for example, a DB2 or WMQ request). For a program defined as CONCURRENCY(THREADSAFE) API(OPENAPI), following execution of a non threadsafe EXEC CICS command, the program receives control back on the open TCB (either L8 or L9).

Will a program defined with CONCURRENCY(QUASIRENT) calling DB2 V6 or later use L8 TCBs?

Answer: Yes, CICS always uses L8 TCBs with DB2 V6 and later irrespective of whether the application is threadsafe or not. For every DB2 call the DB2 work will be done on the L8 TCB and, once complete, CICS will switch back to the QR TCB before returning to the non threadsafe application. This will happen for every DB2 call.

Will an application running on CICS Transaction Server Version 3.2 that calls WMQ use L8 TCBs?

Answer: Yes, CICS Transaction Server Version 3.2 uses an OTE-enabled TRUE for handling CICS-WMQ calls. L8 TCBs are used for the requests to WMQ. If the application is defined as threadsafe, control will remain on the open TCB upon return from WMQ. If the application is defined as quasi-reentrant, control will switch back to the QR TCB upon return from WMQ.

Can I stop using L8 TCBs by specifying FORCEQR=YES in the SIT?

Answer: No, DB2 calls for DB2 V6 and later will always switch to an L8 TCB. FORCEQR=YES will override the CONCURRENCY(THREADSAFE) API(CICSAPI) setting for any program defined as such, forcing a switchback to the QR TCB following the DB2 call. FORCEQR=YES has no affect on a program defined as CONCURRENCY(THREADSAFE) API(OPENAPI) that must run on an open TCB.

Prior to CICS Transaction Server Version 2.2, did TCB switching occur for DB2 requests?

Answer: Yes, for each DB2 request two TCB switches occurred. One switch from QR TCB to a DB2 thread TCB before calling DB2, and then one switchback to QR TCB after the DB2 call has completed. Activity on the DB2 thread TCB was not visible in a CICS trace.

Prior to CICS Transaction Server Version 3.2, did TCB switching occur for WMQ requests?

Answer: Yes, for each WMQ request two TCB switches occurred: one switch to a WMQ thread TCB before calling WMQ, and then one switch back to the original TCB after the WMQ call has completed. Activity on the WMQ thread TCB was not visible in a CICS trace.

Can I stop using L8 TCBs by specifying FCQRONLY=YES in the SIT?

Answer: It depends what you mean. CICS Transaction Server Version 3.2 will allow EXEC CICS file control requests to be processed under an open TCB. If your application were running under an L8 or L9 TCB when it issued a file control command, CICS would execute this threadsafe API request under the open TCB. This is the same as for other threadsafe EXEC CICS commands. However, the file control threadsafety implementation also provides the option of disabling threadsafe support for EXEC CICS file control API commands by means of the FCQRONLY SIT parameter. If this is set to YES, file control commands are processed under the QR TCB within CICS, as per earlier releases. However, this will not remove support for and use of L8 TCBs for, for instance, WMQ or DB2 calls, nor for programs defined with CONCURRENCY(THREADSAFE) API(OPENAPI), which have to execute their application logic under an L8 or L9 open TCB. FCQRONLY is specific to the execution path within CICS for EXEC CICS file control commands only.

Can I still address a task’s TCA by using the CSACDTA field?

Answer: No. With the introduction of OTE it is no longer safe to assume the TCA address held within CSACDTA is the TCA of the task that is accessing the CSA. CSACDTA contains the address of the task currently dispatched *under the QR TCB*. The task that is looking at the value in CSACDTA may be running under an open TCB. This can lead to the wrong TCA address being used by the program, with unpredictable results. The CICS system programming interface (SPI) should be used whenever possible for programs wishing to access state information about a task.

Note also that CSACDTA was renamed CSAQRTCA in CICS Transaction Server Version 3.1, to further discourage using the CSA to address the running task's TCA. In CICS Transaction Server Version 3.2, IBM has now withdrawn the ability to reference a TCA using this field, by loading CSAQRTCA with the address of an area of fetch-protected storage. This will result in an abend ASRD with message DFHSR0618 if it is referenced.

What is the difference between a THREADSAFE program and an OPENAPI program in CICS Transaction Server Version 3?

Answer: A threadsafe program is a program defined as CONCURRENCY(THREADSAFE) and API(CICSAPI). It can run on QR TCB or an open TCB. Part of it may run on QR TCB, and then after a DB2 or WMQ request, part of it can run on an open TCB. A threadsafe program has no TCB affinity, and no affinity to the key of the TCB. Use of non-CICS APIs is not allowed, as they may execute on QR TCB and so damage the CICS environment.

An OPENAPI program is a program defined as CONCURRENCY(THREADSAFE) and API(OPENAPI). It always runs on an open TCB. It starts on an open TCB, and all application code runs on an open TCB. If CICS has to switch to QR TCB to execute a non threadsafe CICS command, then CICS will switch back to the open TCB when it returns control to the program. An OPENAPI program runs on an open TCB whose key matches the program's execution key, that is, an L8 TCB for EXECKEY(CICS) or an L9 TCB for EXECKEY(USER). Use of non-CICS APIs is allowed at the user's own risk, as they will not run on QR TCB and will not block main CICS processing.

If STGPROT=NO is specified, does CICS still need to use L9 TCBs for EXECKEY(USER) programs?

Answer: No. If CICS is not utilizing storage protection, there is no need for open TCBs that match user key storage and execution. L9 TCBs do not have to be used for CONCURRENCY(THREADSAFE) API(OPENAPI) EXECKEY(USER) programs. L8 TCBs can be used instead.

If SUBTSKS is specified, to allow CICS to utilize the CO TCB for concurrent VSAM calls on busy systems, is this still honored for those file control requests that are issued under an open TCB?

Answer: No. If a CICS Transaction Server Version 3.2 application were running under an open TCB, and issued an EXEC CICS file control command, it would not be sensible to then switch to another TCB in order to process the request. The SUBTSKS SIT parameter is only honored by CICS if the application were running on the QR TCB when the file control command was issued.

What differences will be seen when tasks are running in CICS Transaction Server Version 3.2 and issue file control commands?

Answer: CICS Transaction Server Version 3.2 supports threadsafe file control. Applications that are running on an open TCB can therefore call VSAM under the open TCB as part of a file control request.

Prior to CICS Transaction Server Version 3.2, file control was a non-threadsafe EXEC CICS API, and so all file control commands were processed under the QR TCB. If VSAM had to suspend a task during its execution of a request to an LSR file, it drove the supplied UPAD exit in CICS and the task was suspended by the CICS dispatcher. If the request was NSR, CICS issued the request to VSAM asynchronously and could then suspend the task if needed. For example, tasks would be suspended on FCIOWAITs or FCXCWAITs. The reason a task was suspended could be analyzed, for example by using CEMT online, or by investigating a CICS system dump offline. The IPCS system dump formatter could be run against a system dump and return, for example, the task environment (using the KE VERBEXIT) or the dispatcher environment (using the DS VERBEXIT). Since non-threadsafe commands have to run under the serialized QR TCB, only one task would be seen to be running on this TCB at any one time, and the KE VERBEXIT data would clearly identify the running task at the time of the dump.

With CICS Transaction Server Version 3.2, VSAM requests can be executed under an open TCB. If they are, any suspends due to VSAM do not require calling the UPAD exit since there is no danger that blocking the TCB will affect other tasks within CICS (unlike the effect that a blocking operation on the QR TCB would have). This means that such requests will not result in the CICS dispatcher being invoked to suspend the task. Tasks will still appear to be running when investigated using techniques such as CEMT or IPCS. This may affect the analysis of task activity when using performance monitors or equivalent pieces of software.

13.2 Questions about CICS exits

How do I find out what exits I use, and whether they are defined as threadsafe?

Answer: Use the CICS-supplied sample DFH0STAT to look at user exits. It will report what exit programs are active and what the concurrency setting of the exit program is. The report will include any exits supplied by third-party vendors in support of their products.

If my exits are for a vendor product, can I just define them as threadsafe and improve my performance?

Answer: No, you must contact the vendor and have them tell you whether it is safe to change the concurrency attribute of the exit's program definition.

13.3 Performance questions

I am planning on migrating to CICS Transaction Server Version 3 and am worried about the potential performance impacts. Can I do the migration and then set FORCEQR to FORCE to allow the system to run like my current CICS system?

Answer: No, you must review and set your exits to threadsafe before you perform the migration to be safe. You cannot turn off the use of L8 open TCBs.

What is the cost of a TCB switch?

Answer: The pathlength of a single TCB switch (say from QR to L8) is approximately 2000 instructions. So, a non-threadsafe application issuing an EXEC SQL call to DB2 would incur 4000 additional instructions (half when switching from the QR TCB onto an L8 TCB in order to call DB2, and half when switching back to the QR TCB upon return to CICS).

The benefits of being threadsafe can be seen when such additional pathlength is scaled up by the number of calls to OPENAPI TRUEs such as DB2 and WMQ from within busy quasi-reentrant applications. In addition to the execution time required to execute the TCB switches, there is also the corresponding CPU cost, together with the increased contention of having to use the QR TCB for non-threadsafe application work.

13.4 Load module scanner questions

Are the commands listed in table DFHEIDTH non threadsafe?

Answer: Some of the commands in DFHEIDTH are non threadsafe, but that is not its purpose. The commands listed in DFHEIDTH give the application programmer access to shared storage. There is potential for the application program code being non threadsafe unless it has implemented serialization logic around updates to the shared storage. Therefore the purpose of DFHEIDTH is to report programs that may contain non threadsafe code.

I ran the load module scanner DFHEISUP with table DFHEIDTH against my programs and found they were using EXEC CICS ADDRESS CWA, but when searching the code I could not find any reference to the CWA. Are these programs therefore threadsafe?

Answer: If the report from DFHEISUP flags use of a command that gives you access to shared storage, if you never reference the storage in question, then there is no threadsafety issue. Perhaps someone changed the code years ago but never removed the reference to the shared storage. If that is the only potential shared storage issue reported, then your program is threadsafe.

Is there a table that lists all non threadsafe CICS commands?

Answer: Yes, table DFHEIDNT lists all non threadsafe CICS commands. Note that use of this table tells you whether you may experience excessive TCB switching due to having to return to QR TCB to execute the non threadsafe CICS command. It does not tell you anything about the application code and whether it is threadsafe. How much TCB switching will occur depends upon how many CICS commands there are and their relative position in the code to DB2 or WMQ calls, or both.

Part 4

Appendixes

A

CICS, DB2, and WMQ maintenance

This appendix provides a list of the recommended maintenance to be applied to CICS, DB2, and WMQ.

CICS TS 2.3 APARs

- PQ78987

  CPU increase in regions connecting to DB2 when migrating to CICS Transaction Server V2
- PQ93953 and PK04677

  Purge and forcepurge of task using OPENAPI True fails
- PK05932

  Sqlcode -922 after COBOL program precompiled in DB2 V8 new function mode
- PK12632

  Task stuck in resumed early state
- PK18498

RMI 0C4 abend

- PK26061

  Abend AD3K and AEXZ on a task purge of a DB2 threadsafe transaction

CICS TS 3.1 APARs

- PQ05771

  Purge and forcepurge of task using OPENAPI True fails

- PK05933

  Sqlcode -922 after COBOL program precompiled in DB2 V8 new function mode

- PK14003

  Task stuck in resumed early state

- PK20040

  RMI 0C4 abend

- PK21134

  Abend AD3K due to recovery backout failure after a task is purged

- PK31859

  Abend AD3K and AEXZ on a task purge of a DB2 threadsafe transaction

CICS TS 3.2 APARs

- PK45354

  File control threadsafety modifications

  Change default for FCQRONLY parameter to YES

DB2 7.1 APARs

- PQ44614

  Subsystem init changes for group attach

- PQ45691

  Group attach fixes

- PQ45692

  Group attach fixes
- PQ46501

  ERLY code changes for OTE
- PQ50703

  Incorrect accounting class 1 TCB time reported when threads switch TCB
- PQ65357

  CICS-DB2 thread is not released properly at sync point if the package is bound with OPTHHINT

Note: Some of the above DB2 maintenance affects DB2 ERLY code that resides in the LPA, and so having applied the maintenance, an MVS IPL is required for it to become active. For this reason, for DB2 V7.1 we also list those apars that hit ERLY code pertaining to group attach as well as that required to support OTE.

DB2 8.1 APARs

- PK21892

  Excessive stack storage for identified signed on connections

WMQ 5.3.1 APARs

- PK39200

  Checks CICS release and alias changes

WMQ 6.1 APARs

- PK42616

  Checks CICS release
- PK38772

  Bridge code does not provide a reason code for signon failures after migrating to Version 6.0

DFHEISUP APARs

- PQ73890

  DFHEISUP does not list the EXEC CICS SEND MAP command when the command contains the option MAPONLY.

- PQ76545

  Abend 0C4 in module DFHEISUP scanning application load libraries.

- PQ77185

  CEE3204S THE SYSTEM DETECTED A PROTECTION EXCEPTION (SYSTEM COMPLETION CODE=0C4).

- PQ78531

  DFHEISUP Library problem. Runs short on storage.

- PQ82603

  Running the DFHEISUP utility returns an undocumented error message when certain commands are encountered.

- PQ87863 (CICS TS 2.3 only)

  ASKTIME ABSTIME is listed as non threadsafe in DFHEIDNT.

B

COBOL call program listings

This appendix contains the COBOL programs used to demonstrate the effect of using COBOL calls as described in 8.5, “COBOL calls” on page 221.

Program listings for COBOL call examples

Program PROGA

Example: B-1 PROGA

```
IDENTIFICATION DIVISION.
       PROGRAM-ID. PROGA .
       ENVIRONMENT DIVISION.
       DATA DIVISION.
       WORKING-STORAGE SECTION.

       01 ws-PROGB                         pic x(08)
              VALUE 'PROGB'.
       01 ws-queue                         pic x(08)
              VALUE 'TONYQ'.
       01 WS-MSG.
          03 ws-before-after               pic x(12).
          03 filler                        pic x(10)
              value 'PROGA : '.
          03 filler                        pic x(17)
              value 'Counter value :- '.
          03 ws-counter                    pic 9(8).

       01 ws-counter-s9                    pic s9(8) comp.

           EXEC SQL INCLUDE SQLCA END-EXEC.

           EXEC SQL
                 DECLARE DSN8710.EMP TABLE (
                 EMPNO                        CHAR(6),
                 FIRSTNME                     CHAR(12),
                 MIDINIT                      CHAR(1),
                 LASTNAME                     CHAR(15),
                 WORKDEPT                     CHAR(3),
                 PHONENO                      CHAR(4),
                 HIREDATE                     DATE,
                 JOB                          CHAR(8),
                 EDLEVEL                      SMALLINT,
                 SEX                          CHAR(1),
                 BIRTHDATE                    DATE,
                 SALARY                       DECIMAL,
                 BONUS                        DECIMAL,
                 COMM                         DECIMAL )
           END-EXEC.

       PROCEDURE DIVISION.
```

```
EXEC CICS DELETEQ TS QUEUE(WS-QUEUE) NOHANDLE END-EXEC.

EXEC SQL
    SELECT count(*)
    INTO :WS-COUNTER-S9
    FROM DSN8710.EMP
    WHERE EMPNO = "000990"
END-EXEC.

MOVE ZEROES TO WS-COUNTER.

MOVE 'Before CALL' to ws-before-after.

EXEC CICS
  WRITEQ TS MAIN
  QUEUE(WS-QUEUE) FROM(WS-msg)
END-EXEC.

Call ws-PROGB using dfheiblk
                    ws-counter.

MOVE 'After CALL ' to ws-before-after.

EXEC CICS
  WRITEQ TS MAIN
  QUEUE(WS-QUEUE) FROM(WS-msg)
END-EXEC.

EXEC CICS RETURN END-EXEC.
```

Program PROGB

Example: B-2 PROGB

```
IDENTIFICATION DIVISION.
       PROGRAM-ID. PROGB.
       ENVIRONMENT DIVISION.
       DATA DIVISION.
       WORKING-STORAGE SECTION.

       01 WS-COUNTER-S9                     PIC S9(8) COMP.
       01 WS-QUEUE                          PIC X(08)
              VALUE 'TONYQ'.
       01 WS-MSG.
          03 filler                         pic x(10)
              value 'PROGB: '.
          03 filler                         pic x(17)
              value "Counter value :- ".
          03 filler                         pic x(12)
              value spaces.
          03 ws-counter                     pic 9(8).

           EXEC SQL INCLUDE SQLCA END-EXEC.

           EXEC SQL
                DECLARE DSN8710.EMP TABLE (
                EMPNO                       CHAR(6),
                FIRSTNME                    CHAR(12),
                MIDINIT                     CHAR(1),
                LASTNAME                    CHAR(15),
                WORKDEPT                    CHAR(3),
                PHONENO                     CHAR(4),
                HIREDATE                    DATE,
                JOB                         CHAR(8),
                EDLEVEL                     SMALLINT,
                SEX                         CHAR(1),
                BIRTHDATE                   DATE,
                SALARY                      DECIMAL,
                BONUS                       DECIMAL,
                COMM                        DECIMAL )
           END-EXEC.

       Linkage section.
       01 dfhcommarea.
          03 ls-count                        pic 9(8).

       PROCEDURE DIVISION.
           move 99999 to ls-count
                         ws-counter.
```

```
    EXEC SQL
        SELECT count(*)
        INTO :WS-COUNTER-S9
        FROM DSN8710.EMP
        WHERE EMPNO = "000990"
    END-EXEC.

    EXEC CICS WRITEQ TS MAIN
      QUEUE(WS-QUEUE) FROM(WS-MSG) END-EXEC.

AA-EXIT.
    EXIT.
    GOBACK.
```

C

Assembler routines

This appendix lists the assembler routines we used in our migration.

DB2MANY

Example C-1 is a list of code for the DB2MANY program.

Example: C-1 iDB2MANY example

```
***********************************************************************
 DFHEISTG DSECT
          EXEC SQL INCLUDE SQLCA
 *
 **********************************************
 DFHEISTG DSECT
 **********************************************
 VVEMP     DS   CL80
 EMPNO     DS   CL6
 FIRSTNME  DS   CL12
 MIDINIT   DS   CL1
 LASTNAME  DS   CL15
 WORKDEPT  DS   CL3
 PHONENO   DS   CL4
 HIREDATE  DS   CL10
 JOB       DS   CL8
 EDLEVEL   DS   HL2
 SEX       DS   CL1
 BIRTHDATE DS   CL10
 SALARY    DS   PL3
 BONUS     DS   PL3
 COMM      DS   PL3
 **********************************************
 TERMNL         DC    F'0'
DATALEN        DS    F'0'
               DS    0D
               DC    C'EISTG   '
MESSAGES DS    CL80                TEMP STORE
KEYNUM   DS    CL9                 TEMP STORE
COMLEN   DS    1H                  LENGTH OF C
         DS   0F
SQDWSTOR DS   (SQLDLEN)C     RESERVE STORAGE TO BE USED FOR SQLDSECT
SDARGDATA      DC    50F'0'
               DC    C'EISTG END'
SDARG          DSECT
SDREPEAT       DC    X'00000000'  NUMBER OF TIMES TO REPEAT DB2 CALL
SDTERMID       DS    CL4       TERMINAL ID
SDREPCNT       DC    F'0'      CURRENT NUMBER TO BE ATTACHED
SDPASSCT       DC    F'0'      NUMBER OF START TASK PASSES
SDTRAN         DS    F'0'
SDASKTIM       DS    CL4
SDEMPNO        DS    CL6       EMPLOYEE NUMBER TO USE
INPUT          DC    20F'0'    INPUT DATA
```

```
INMSGLEN       DS    OH        MESSAGE LENGTH
*
*********************************************************
SQDWSREG EQU   7
RETREG   EQU   2                    SET UP REGISTER USAGE
COUNTER  EQU   5
R06      EQU   6
R08      EQU   8
R9       EQU   9
COMPTR   EQU   4                    POINTER TO COMMAREA
SDPASSR  EQU   11                   PASS COUNT REG
*********************************************************
DB2MANY  CSECT
DB2MANY  AMODE 31
DB2MANY  RMODE ANY
*****************************************************************
* OBTAIN INPUT DATA
         LA    R08,SDARGDATA
         USING SDARG,R08
         MVC   SDREPEAT,REPEAT  SET TO THE NUMBER OF DB2 CALLS
*****************************************************************
*
* SQL WORKING STORAGE
         LA    SQDWSREG,SQDWSTOR   GET ADDRESS OF SQLDSECT
         USING SQLDSECT,SQDWSREG   AND TELL ASSEMBLER ABOUT IT
*
         EXEC SQL
               DECLARE DSN8710.EMP TABLE (
               EMPNO                       CHAR(6),
               FIRSTNME                    CHAR(12),
               MIDINIT                     CHAR(1),
LASTNAME                    CHAR(15),                 *
               WORKDEPT                    CHAR(3),                *
               PHONENO                     CHAR(4),                *
               HIREDATE                    DATE,                   *
               JOB                         CHAR(8),                *
               EDLEVEL                     SMALLINT,               *
               SEX                         CHAR(1),                *
               BIRTHDATE                   DATE,                   *
               SALARY                      DECIMAL,                *
               BONUS                       DECIMAL,                *
               COMM                        DECIMAL )
*
*
RESET    L     COUNTER,COUNT
*
READLOOP DS    OH
         EXEC  CICS ASKTIME
*
```

```
 EXEC SQL SELECT * INTO :VVEMP FROM DSN8710.EMP WHERE EMPNO='000140'
         LA    COUNTER,1(COUNTER)
         C     COUNTER,MAXREAD
         BNH   READLOOP
*
*****************************************************************
**  NOW START THE NEXT TASK                                  ****
**                                                           ****
         L     SDPASSR,SDPASSCT     LOAD THE WORK REG
         C     SDPASSR,NUMPASS
         BE    NOSTART
STARTLP  DS    0H
         LA    R08,SDARGDATA
         USING SDARG,R08
         MVC   SDTERMID,EIBTRMID
         MVC   SDREPEAT,REPEAT SET THE NUMBER OF DB2 CALLS PER TRAN
         MVC   SDREPCNT,NUMTRAN  PASS THE NUMBER OF TIMES TO RESTART
         MVC   SDTRAN,=CL4'DB21'
         MVC   TERMNL,EIBTRMID
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)
                    FROM(SDARG) LENGTH(SDLENG)
********************************************************************
         MVC   SDTRAN,=CL4'DB22'
         MVC   TERMNL,EIBTRMID
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)
                    FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         MVC   SDTRAN,=CL4'DB23'
         MVC   TERMNL,EIBTRMID
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)
                    FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         MVC   SDTRAN,=CL4'DB24'
MVC   TERMNL,EIBTRMID
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)
                    FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         MVC   SDTRAN,=CL4'DB25'
         MVC   TERMNL,EIBTRMID
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)
                    FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         MVC   SDTRAN,=CL4'DB26'
         MVC   TERMNL,EIBTRMID
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)
                    FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         MVC   SDTRAN,=CL4'DB27'
         MVC   TERMNL,EIBTRMID
```

```
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)
                   FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         MVC   SDTRAN,=CL4'DB28'
         MVC   TERMNL,EIBTRMID
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)
                   FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         MVC   SDTRAN,=CL4'DB29'
         MVC   TERMNL,EIBTRMID
EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)                *
                   FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         MVC   SDTRAN,=CL4'DB2A'
         MVC   TERMNL,EIBTRMID
         EXEC CICS START TRANSID(SDTRAN) INTERVAL(0)                *
                   FROM(SDARG) LENGTH(SDLENG)
*****************************************************************
         LA    SDPASSR,1(SDPASSR)  INCREMENT THE COUNTER
         C     SDPASSR,NUMPASS
         BNL   NOSTART
         B     STARTLP
NOSTART  DS OH
         EXEC CICS SEND TEXT FROM(AREA) FREEKB
         EXEC CICS RETURN
         DS    OF
AREA     DC    CL40'TRANSACTION COMPLETE'
***************************************************************
          DC F'0'
REPEAT    DC    X'000000C8'     TEST NUMBER OF TIMES TO REPEAT
COUNT     DC    X'00000000'
MAXREAD   DC    X'000000C8'    NUMBER OF DB2 CALLS FOR DB2M XACTION
SDEND     DC    X'00000001'    LAST ONE
NUMTRAN   DC    F'01000000'  NUMBER OF TIMES A TASK IS TO RESTART
NUMPASS   DC    F'00000001'  THE NUMBER OF PASSES AT STARTING TASKS
***************************************************************
SDLENG   DC    X'0030'    LENGTH OF TS RECORD
 ***************************************************************
          END
```

DB2PROG1

Programs DB2PROG1, 2, and 3 (EXEC CICS RETRIEVE, EXEC CICS POST, EXEC CICS WAITCICS and EXEC CICS START).

We show a list of the DB2PROG1 code in Example C-2.

Example: C-2 DB2PROG1 example (same as DB2PROG2 and DB2PROG3)

```
DFHEISTG DSECT
          EXEC SQL INCLUDE SQLCA
 *
 ***********************************************
 DFHEISTG DSECT
 ***********************************************
 VVEMP     DS   CL80
 EMPNO     DS   CL6
 FIRSTNME  DS   CL12
 MIDINIT   DS   CL1
 LASTNAME  DS   CL15
 WORKDEPT  DS   CL3
 PHONENO   DS   CL4
 HIREDATE  DS   CL10
 JOB       DS   CL8
 EDLEVEL   DS   HL2
 SEX       DS   CL1
 BIRTHDATE DS   CL10
 SALARY    DS   PL3
 BONUS     DS   PL3
 COMM      DS   PL3
 ***********************************************
 TERMNL         DC    F'0'
DATALEN        DS    F'0'
               DS    0D
ECB1           DS    1F
***********************************************
* THE FORMAT OF THE TS QUEUE RECORD PASSED TO
***********************************************
               DC    C'EISTG   '
MESSAGES DS    CL80                TEMP STORE
KEYNUM   DS    CL9                 TEMP STORE
COMLEN   DS    1H                  LENGTH OF C
         DS   0F
SQDWSTOR DS   (SQLDLEN)C     RESERVE STORAGE TO BE USED FOR SQLDSECT
SDARGDATA      DC    20F'0'
               DC    C'EISTG END'
SDARG          DSECT
SDREPEAT       DC    X'00000000'  NUMBER OF TIMES TO MAKE THE DB2 CALL
SDTERMID       DS    CL4       TERMINAL ID
```

```
SDREPCNT       DC    F'0'       CURRENT NUMBER TO BE ATTACHED
SDTRAN         DS    F'0'
SDASKTIM       DS    CL4       YES ISSUE ASKTIME,NO SKIP ASKTIMES
SDEMPNO        DC    2F'0'      EMPLOYEE NUMBER TO USE
*
*********************************************************
R1       EQU   1
SQDWSREG EQU   7
RETREG   EQU   2                   SET UP REGISTER USAGE
R06      EQU   6
R08      EQU   8
R9       EQU   9
SDREPCTR EQU   5
COMPTR   EQU   4                   POINTER TO COMMAREA
*********************************************************
DB2PROG1 CSECT
DB2PROG1 AMODE 31
DB2PROG1 RMODE ANY
*****************************************************************
         MVC   TERMNL,EIBTRMID
* OBTAIN START DATA
         EXEC CICS RETRIEVE SET(R08) LENGTH(DATALEN)
         USING SDARG,R08
*****************************************************************
*
* SQL WORKING STORAGE
         LA    SQDWSREG,SQDWSTOR   GET ADDRESS OF SQLDSECT
         USING SQLDSECT,SQDWSREG   AND TELL ASSEMBLER ABOUT IT
*
         EXEC SQL                                                      *
               DECLARE DSN8710.EMP TABLE (                             *
               EMPNO                       CHAR(6),                    *
               FIRSTNME                    CHAR(12),                   *
               MIDINIT                     CHAR(1),                    *
               LASTNAME                    CHAR(15),                   *
WORKDEPT                    CHAR(3),
               PHONENO                     CHAR(4),
               HIREDATE                    DATE,
               JOB                         CHAR(8),
               EDLEVEL                     SMALLINT,
               SEX                         CHAR(1),
               BIRTHDATE                   DATE,
               SALARY                      DECIMAL,
               BONUS                       DECIMAL,
               COMM                        DECIMAL )
*
******************************************************************
         L     6,SDREPEAT
         EXEC  CICS POST SET(R9)
```

```
         ST    R9,ECB1              POST EVENT & STORE ADDRESS
*
AGAIN    DS    0H
         LA    R9,ECB1              WAIT UNTIL ECB POSTED
         EXEC  CICS WAITCICS
                    ECBLIST(R9)
                    NUMEVENTS(=F'1')
                    NAME(=C'APPLWAIT')
                    PURGEABLE
*
 EXEC SQL SELECT EMPNO INTO :EMPNO FROM DSN8710.EMP
                  WHERE EMPNO='000070'
BCT  6,AGAIN
*
*****************************************************************
**  NOW START THE NEXT TASK                                  ****
**                                                           ****
         L     SDREPCTR,SDREPCNT     LOAD THE WORK REG
         LTR   SDREPCTR,SDREPCTR
         BZ    NOSTART
         S     SDREPCTR,SDEND        DECREMENT THE COUNTER
         ST    SDREPCTR,SDREPCNT     SAVE IT BACK FOR NEXT START
         EXEC CICS START TRANSID('DB21') INTERVAL(0)
                   FROM(SDARG) LENGTH(DATALEN)
*****************************************************************
*        EXEC CICS PERFORM STATISTICS RECORD DISPATCHER
NOSTART  DS 0H
*        EXEC CICS SEND TEXT FROM(AREA) FREEKB
         EXEC CICS RETURN
         DS    0F
BIG_NUMBER DC  X'00000500'     XXX,XXX  1280 TIMES
AREA     DC    CL30'TRANSACTION COMPLETE'
***************************************************************
          DC F'0'
REPEAT    DC    X'00007500'         NUMBER OF TIMES TO REPEAT
MAXREAD   DC    X'00000600'         MAX READ COUNT
MAXREAD2  DC    X'00000005'         MAX READ COUNT
SDEND     DC    X'00000001'    LAST ONE
***************************************************************
SDLENG   DC    X'0030'    LENGTH OF TS RECORD
***************************************************************
         END
```

DB2PROG4

Programs DB2PROG4, 5, 6, and 7 (EXEC CICS RETRIEVE and EXEC CICS START).

Example C-3 is a list of the source code for the DB2PROG4.

Example: C-3 DB2PROG4 example (same as DB2PROG5, 6, and 7)

```
DFHEISTG DSECT
         EXEC SQL INCLUDE SQLCA
*
**********************************************
DFHEISTG DSECT
**********************************************
VVEMP     DS   CL80
EMPNO     DS   CL6
FIRSTNME  DS   CL12
MIDINIT   DS   CL1
LASTNAME  DS   CL15
WORKDEPT  DS   CL3
PHONENO   DS   CL4
HIREDATE  DS   CL10
JOB       DS   CL8
EDLEVEL   DS   HL2
SEX       DS   CL1
BIRTHDATE DS   CL10
SALARY    DS   PL3
BONUS     DS   PL3
COMM      DS   PL3
**********************************************
TERMNL         DC    F'0'
DATALEN        DS    F'0'
**********************************************
* THE FORMAT OF THE TS QUEUE RECORD PASSED TO
**********************************************
               DC    C'EISTG   '
MESSAGES DS    CL80              TEMP STORE
KEYNUM   DS    CL9               TEMP STORE
COMLEN   DS    1H                LENGTH OF C
         DS   0F
SQDWSTOR DS   (SQLDLEN)C     RESERVE STORAGE TO BE USED FOR SQLDSECT
SDARGDATA      DC    20F'0'
               DC    C'EISTG END'
SDARG          DSECT
SDREPEAT       DC    X'00000000'  NUMBER OF TIMES TO MAKE THE DB2 CALL
SDTERMID       DS    CL4       TERMINAL ID
SDREPCNT       DC    F'0'      CURRENT NUMBER TO BE ATTACHED
SDTRAN         DS    F'0'
```

```
SDASKTIM       DS    CL4      YES ISSUE ASKTIME,NO SKIP ASKTIMES
SDEMPNO        DC    2F'0'     EMPLOYEE NUMBER TO USE
*********************************************************
CWASTG         DSECT
CWACOUNT       DS    F             COUNTER TO UPDATE
*********************************************************
SQDWSREG EQU  7
RETREG   EQU   2                   SET UP REGISTER USAGE
R08      EQU   8
R9       EQU   9
R10      EQU   10
COUNT2   EQU   9
SDREPCTR EQU   5
COMPTR   EQU   4                   POINTER TO COMMAREA
*********************************************************
DB2PROG4 CSECT
DB2PROG4 AMODE 31
DB2PROG4 RMODE ANY
*****************************************************************
         MVC   TERMNL,EIBTRMID
* OBTAIN START DATA
         EXEC CICS RETRIEVE SET(R08) LENGTH(DATALEN)
         USING SDARG,R08
*****************************************************************
*        EXEC CICS PERFORM STATISTICS RECORD DISPATCHER
*
* SQL WORKING STORAGE
         LA    SQDWSREG,SQDWSTOR   GET ADDRESS OF SQLDSECT
         USING SQLDSECT,SQDWSREG   AND TELL ASSEMBLER ABOUT IT
*
         EXEC SQL                                                      *
               DECLARE DSN8710.EMP TABLE (                             *
               EMPNO                       CHAR(6),                    *
               FIRSTNME                    CHAR(12),                   *
               MIDINIT                     CHAR(1),                    *
               LASTNAME                    CHAR(15),                   *
               WORKDEPT                    CHAR(3),                    *
               PHONENO                     CHAR(4),                    *
HIREDATE                    DATE,
               JOB                         CHAR(8),
               EDLEVEL                     SMALLINT,
               SEX                         CHAR(1),
               BIRTHDATE                   DATE,
               SALARY                      DECIMAL,
               BONUS                       DECIMAL,
               COMM                        DECIMAL )
*
******************************************************************
         L    6,SDREPEAT
```

```
AGAIN    DS   OH
         EXEC CICS ASKTIME
NOASKT   DS   OH
***************************************************************
 EXEC SQL SELECT EMPNO INTO :EMPNO FROM DSN8710.EMP
                  WHERE EMPNO='000100'
         BCT  6,AGAIN
*****************************************************************
*                                    INCREMENT COUNTER IN CWA
         EXEC CICS ADDRESS CWA(R10)
         USING CWASTG,R10
         L     R9,CWACOUNT
         LA    R9,1(R9)
         ST    R9,CWACOUNT
*****************************************************************
**  NOW START THE NEXT TASK                                  ****
**                                                           ****
         L     SDREPCTR,SDREPCNT     LOAD THE WORK REG
         LTR   SDREPCTR,SDREPCTR
         BZ    NOSTART
         S     SDREPCTR,SDEND        DECREMENT THE COUNTER
         ST    SDREPCTR,SDREPCNT     SAVE IT BACK FOR NEXT START
         EXEC CICS START TRANSID('DB24') INTERVAL(0)
                   FROM(SDARG) LENGTH(DATALEN)
*****************************************************************
*        EXEC CICS PERFORM STATISTICS RECORD DISPATCHER
NOSTART  DS OH
*        EXEC CICS SEND TEXT FROM(AREA) FREEKB
         EXEC CICS RETURN
         DS    OF
BIG_NUMBER DC  X'00000500'      XXX,XXX  1280 TIMES
AREA     DC    CL30'TRANSACTION COMPLETE'
***************************************************************
          DC F'0'
REPEAT    DC    X'00007500'         NUMBER OF TIMES TO REPEAT
MAXREAD   DC    X'00000600'         MAX READ COUNT
MAXREAD2  DC    X'00000005'         MAX READ COUNT
SDEND     DC    X'00000001'    LAST ONE
***************************************************************
SDLENG   DC    X'0030'    LENGTH OF TS RECORD
***************************************************************
END
```

DB2PROG8

Programs DB2PROG8, 9, and A (EXEC CICS RETRIEVE, EXEC CICS WRITEQ TD and EXEC CICS START).

Example C-4 is a list of the source code for program DB2PROG8.

Example: C-4 (DB2PROG8 example (same as DB2PROG9 and DB2PROGA)

```
************************************************************************
DFHEISTG DSECT
         EXEC SQL INCLUDE SQLCA
*
**********************************************
DFHEISTG DSECT
**********************************************
VVEMP     DS   CL80
EMPNO     DS   CL6
FIRSTNME  DS   CL12
MIDINIT   DS   CL1
LASTNAME  DS   CL15
WORKDEPT  DS   CL3
PHONENO   DS   CL4
HIREDATE  DS   CL10
JOB       DS   CL8
EDLEVEL   DS   HL2
SEX       DS   CL1
BIRTHDATE DS   CL10
SALARY    DS   PL3
BONUS     DS   PL3
COMM      DS   PL3
**********************************************
TERMNL         DC    F'0'
DATALEN        DS    F'0'
**********************************************
* THE FORMAT OF THE TS QUEUE RECORD PASSED TO
**********************************************
               DC    C'EISTG   '
MSG      DS    CL80
KEYNUM   DS    CL9                 TEMP STORE
COMLEN   DS    1H                  LENGTH OF C
QTEST    DS    CL8
         DS   0F
SQDWSTOR DS   (SQLDLEN)C     RESERVE STORAGE TO BE USED FOR SQLDSECT
SDARGDATA      DC    20F'0'
               DC    C'EISTG END'
SDARG          DSECT
SDREPEAT       DC    X'00000000'  NUMBER OF TIMES TO MAKE THE DB2 CALL
SDTERMID       DS    CL4       TERMINAL ID
```

```
SDREPCNT       DC    F'0'      CURRENT NUMBER TO BE ATTACHED
SDTRAN         DS    F'0'
SDASKTIM       DS    CL4      YES ISSUE ASKTIME,NO SKIP ASKTIMES
SDEMPNO        DC    2F'0'     EMPLOYEE NUMBER TO USE
*
*********************************************************
SQDWSREG EQU  7
RETREG   EQU   2                   SET UP REGISTER USAGE
R06      EQU   6
R08      EQU   8
RA       EQU   10
COUNT2   EQU   9
SDREPCTR EQU   5
COMPTR   EQU   4                   POINTER TO COMMAREA
*********************************************************
DB2PROG8 CSECT
DB2PROG8 AMODE 31
DB2PROG8 RMODE ANY
*****************************************************************
         MVC   TERMNL,EIBTRMID
* OBTAIN START DATA
         EXEC CICS RETRIEVE SET(R08) LENGTH(DATALEN)
         USING SDARG,R08
*****************************************************************
*        EXEC CICS PERFORM STATISTICS RECORD DISPATCHER
*
* SQL WORKING STORAGE
         LA    SQDWSREG,SQDWSTOR   GET ADDRESS OF SQLDSECT
         USING SQLDSECT,SQDWSREG   AND TELL ASSEMBLER ABOUT IT
*
         EXEC SQL                                                      *
               DECLARE DSN8710.EMP TABLE (                             *
               EMPNO                       CHAR(6),                    *
               FIRSTNME                    CHAR(12),                   *
               MIDINIT                     CHAR(1),                    *
               LASTNAME                    CHAR(15),                   *
               WORKDEPT                    CHAR(3),
               PHONENO                     CHAR(4),
               HIREDATE                    DATE,
               JOB                         CHAR(8),
               EDLEVEL                     SMALLINT,
               SEX                         CHAR(1),
               BIRTHDATE                   DATE,
               SALARY                      DECIMAL,
               BONUS                       DECIMAL,
               COMM                        DECIMAL )
*
******************************************************************
         L    6,SDREPEAT
```

```
AGAIN    DS   0H
*****************************************************************
         EXEC CICS READQ TS QUEUE(QTEST) SET(RA) LENGTH(COMLEN)
                   NOHANDLE
*****************************************************************
NOASKT   DS   0H
 EXEC SQL SELECT EMPNO INTO :EMPNO FROM DSN8710.EMP
                  WHERE EMPNO='000140'
*
         BCT  6,AGAIN
*
*****************************************************************
         MVC   MSG,=CL80'DB2PROG8 ENDED'
EXEC  CICS WRITEQ TD QUEUE(=C'THDS') FROM(MSG) NOHANDLE
*****************************************************************
**  NOW START THE NEXT TASK                                  ****
**                                                           ****
         L     SDREPCTR,SDREPCNT     LOAD THE WORK REG
         LTR   SDREPCTR,SDREPCTR
         BZ    NOSTART
         S     SDREPCTR,SDEND        DECREMENT THE COUNTER
         ST    SDREPCTR,SDREPCNT     SAVE IT BACK FOR NEXT START
         EXEC CICS START TRANSID('DB28') INTERVAL(0)               *
                   FROM(SDARG) LENGTH(DATALEN)
*****************************************************************
NOSTART  DS 0H
*****************************************************************
         EXEC  CICS RETURN
         DS    0F
BIG_NUMBER DC  X'00000500'     XXX,XXX  1280 TIMES
AREA     DC    CL30'TRANSACTION COMPLETE'
***************************************************************
          DC F'0'
REPEAT    DC    X'00007500'         NUMBER OF TIMES TO REPEAT
MAXREAD   DC    X'00000600'         MAX READ COUNT
MAXREAD2  DC    X'00000005'         MAX READ COUNT
SDEND     DC    X'00000001'    LAST ONE
***************************************************************
SDLENG   DC    X'0030'    LENGTH OF TS RECORD
***************************************************************
         END
```

Planexit

Example C-5 shows the example code used for our Planexit.

Example: C-5 Planexit

```
TITLE 'PLANEXIT - DB2 CICS ATTACH, DYNAMIC PLAN ALLOCATION EXIT'
*
PLANEXIT AMODE 31                      CAN ADDR STORAGE ABOVE THE LINE
PLANEXIT RMODE ANY                     CAN RUN ABOVE THE LINE
PLANEXIT DFHEIENT CODEREG=(3),EIBREG=(11),DATAREG=(13)
*
A100     EQU   *                      ADDRESS COMMAREA
         USING CPRMPARM,R2
         L     R2,DFHEICAP
         EXEC  CICS ASSIGN USERID(USERID) NOHANDLE
*
RETURN   EQU   *                      RETURN TO CALLER
         EXEC  CICS RETURN
*
*
         LTORG
*
*                                     WORKING STORAGE
         DFHEISTG
USERID   DS    1CL8
         DFHEIEND
*
*
               DSNCPRMA               COMMAREA
*
*
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
```

```
R13      EQU   13
R14      EQU   14
R15      EQU   15
*
         END   PLANEXIT
```

EXITENBL

Example C-6 shows the example code used to enable all exits.

Example: C-6 Program to enable all exits

```
TITLE 'ENABLE - ENABLE EXITS FOR SAMPLE APPLICATION'
*
EXITENBL AMODE 31                         CAN ADDR STORAGE ABOVE THE LINE
EXITENBL RMODE ANY                        CAN RUN ABOVE THE LINE
EXITENBL DFHEIENT CODEREG=(3),EIBREG=(11),DATAREG=(13)
*
A100     EQU   *
         EXEC  CICS ENABLE PROGRAM(=CL8'XXXEI')                      X
                           EXIT(=CL8'XEIIN')                         X
                           START
*
         EXEC  CICS ENABLE PROGRAM(=CL8'XXXEI')                      X
                           EXIT(=CL8'XEIOUT')                        X
                           START
*
         EXEC  CICS ENABLE PROGRAM(=CL8'XXXRMI')                     X
                           EXIT(=CL8'XRMIIN')                        X
                           START
*
         EXEC  CICS ENABLE PROGRAM(=CL8'XXXRMI')                     X
                           EXIT(=CL8'XRMIOUT')                       X
                           START
*
         EXEC  CICS ENABLE PROGRAM(=CL8'XXXTS')                      X
                           EXIT(=CL8'XTSQRIN')                       X
                           GALENGTH(=H'64')                          X
                           START
*
RETURN   EQU   *                         RETURN TO CALLER
         EXEC  CICS RETURN
*
         LTORG
*                                        WORKING STORAGE
```

```
         DFHEISTG
         DFHEIEND
*
         END   EXITENBL
```

XXXEI exit

Example C-7 shows the example source code for our XXXEI exit.

Example: C-7 Example XXXEI

```
DFHUEXIT TYPE=EP,ID=(XEIIN,XEIOUT)
          COPY  DFHTSUED            COMMAND LEVEL PLIST DEFINITIONS
 *
 DFHEISTG DSECT                     WORKING STORAGE
 RETCODE      DS XL4
 RESPONSE     DS F
 *
 XXXEI    DFHEIENT
 XXXEI    AMODE 31
 XXXEI    RMODE ANY
          LR    R2,R1               DFHUEPAR PLIST PROVIDED BY CALLER
          USING DFHUEPAR,R2         ADDRESS UEPAR PLIST
 *
          LA    R15,UERCNORM        SET OK RESPONSE
          ST    R15,RETCODE           IN WORKING STORAGE
 *
 RETURN   EQU   *
          L     R15,RETCODE         FETCH RETURN CODE
          DFHEIRET RCREG=15         RETURN TO CICS
 *
 R0       EQU   0
 R1       EQU   1
 R2       EQU   2
 R3       EQU   3
 R4       EQU   4
R5       EQU   5
 R6       EQU   6
 R7       EQU   7
 R8       EQU   8
 R9       EQU   9
 R10      EQU   10
 R11      EQU   11
 R12      EQU   12
 R13      EQU   13
```

```
R14      EQU   14
R15      EQU   15
         END   XXXEI
```

XXXRMI exit

Example C-8 shows the source code for our example XXXRMi exit.

Example: C-8 Example XXXRMI

```
DFHUEXIT TYPE=EP,ID=(XRMIIN,XRMIOUT)
          COPY  DFHTSUED              COMMAND LEVEL PLIST DEFINITIONS
 *
 DFHEISTG DSECT                       WORKING STORAGE
 RETCODE      DS XL4
 RESPONSE     DS F
 *
 XXXRMI   DFHEIENT
 XXXRMI   AMODE 31
 XXXRMI   RMODE ANY
          LR    R2,R1                 DFHUEPAR PLIST PROVIDED BY CALLER
          USING DFHUEPAR,R2           ADDRESS UEPAR PLIST
 *
          LA    R15,UERCNORM          SET OK RESPONSE
          ST    R15,RETCODE             IN WORKING STORAGE
 *
 RETURN   EQU   *
          L     R15,RETCODE           FETCH RETURN CODE
          DFHEIRET RCREG=15           RETURN TO CICS
 *
 R0       EQU   0
 R1       EQU   1
 R2       EQU   2
 R3       EQU   3
 R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
```

```
R13      EQU   13
R14      EQU   14
R15      EQU   15
         END   XXXRMI
```

XXXTS exit

Example C-9 shows the source code used for XXXTS exit.

Example: C-9 Example XXXTS

```
DFHUEXIT TYPE=EP,ID=(XTSQRIN)
*
GWA      DSECT                      GLOBAL WORK AREA
GWACOUNT DS    F
GWAL     EQU   *-GWA
*
XXXTS    CSECT
XXXTS    AMODE 31
XXXTS    RMODE ANY
         SAVE  (14,12)              SAVE REGS
         LR    R12,R15              SET-UP BASE REGISTER
         USING XXXTS,R12            ADDRESSABILITY
         LR    R2,R1                DFHUEPAR PLIST PROVIDED BY CAL
         USING DFHUEPAR,R2          ADDRESS UEPAR PLIST
         L     R8,UEPGAA            GET GWA ADDRESS
         USING GWA,R8               ADDRESSABILITY
*
GWA_CHECK_LENGTH EQU *
         L     R10,UEPGAL           LOAD ADDRESS OF LENGTH OF GWA
         LH    R9,0(,R10)           LOAD LENGTH OF GWA
         LA    R10,GWAL             LOAD EXPECTED LENGTH OF GWA
         CLR   R9,R10               IS IT BIG ENOUGH?
         BNL   GWAUPDT              YES, CAN UPDATE DATA IN GWA
GWAERROR EQU   *
         B     RETURN               GWA NOT BIG ENOUGH, EXIT
*
GWAUPDT  EQU   *
         L     R6,GWACOUNT          GET THE COUNTER
         LA    R6,1(R6)             INCREMENT
         ST    R6,GWACOUNT            AND STORE
         B     RETURN               EXIT
*
RETURN   EQU   *
         L     R13,UEPEPSA          ADDRESS OF EXIT SAVE AREA
         RETURN (14,12),RC=UERCNORM RESTORE REGS AND RETURN
*
```

```
         LTORG
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         END   XXXTS
```

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

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Threadsafe considerations for CICS

This IBM Redbooks document is a comprehensive guide to threadsafe concepts and implementation in the context of CICS. In addition to providing detailed instructions for implementing threadsafe in your environment, it describes the real world experiences of users migrating applications to be threadsafe, along with our own experiences. It also presents a discussion of the two most critical aspects of threadsafe, system performance and integrity.

Originally, CICS employed a single TCB to process everything (such as application code, task dispatching, terminal control, file control, and so on) executed on what today is known as the application or Quasi-reentrant (QR) TCB. Over time, CICS added specialized TCBs to help offload management tasks from the overcrowded QR TCB. VSAM subtasking, the VTAM High Performance Option, and asynchronous journaling were all implemented on separate TCBs. Of course, the DB2 and MQ Series attachment facilities also employ TCBs apart from the application TCB. Distributing processing among multiple TCBs in a single CICS address space is not new, but customers and ISVs had little control over which TCB CICS is selected to dispatch a given function.

Beginning with CICS Version 2, all of that has changed. Applications can execute on TCBs apart from the QR TCB. This has positive implications for improving system throughput and for implementing new technologies inside of

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