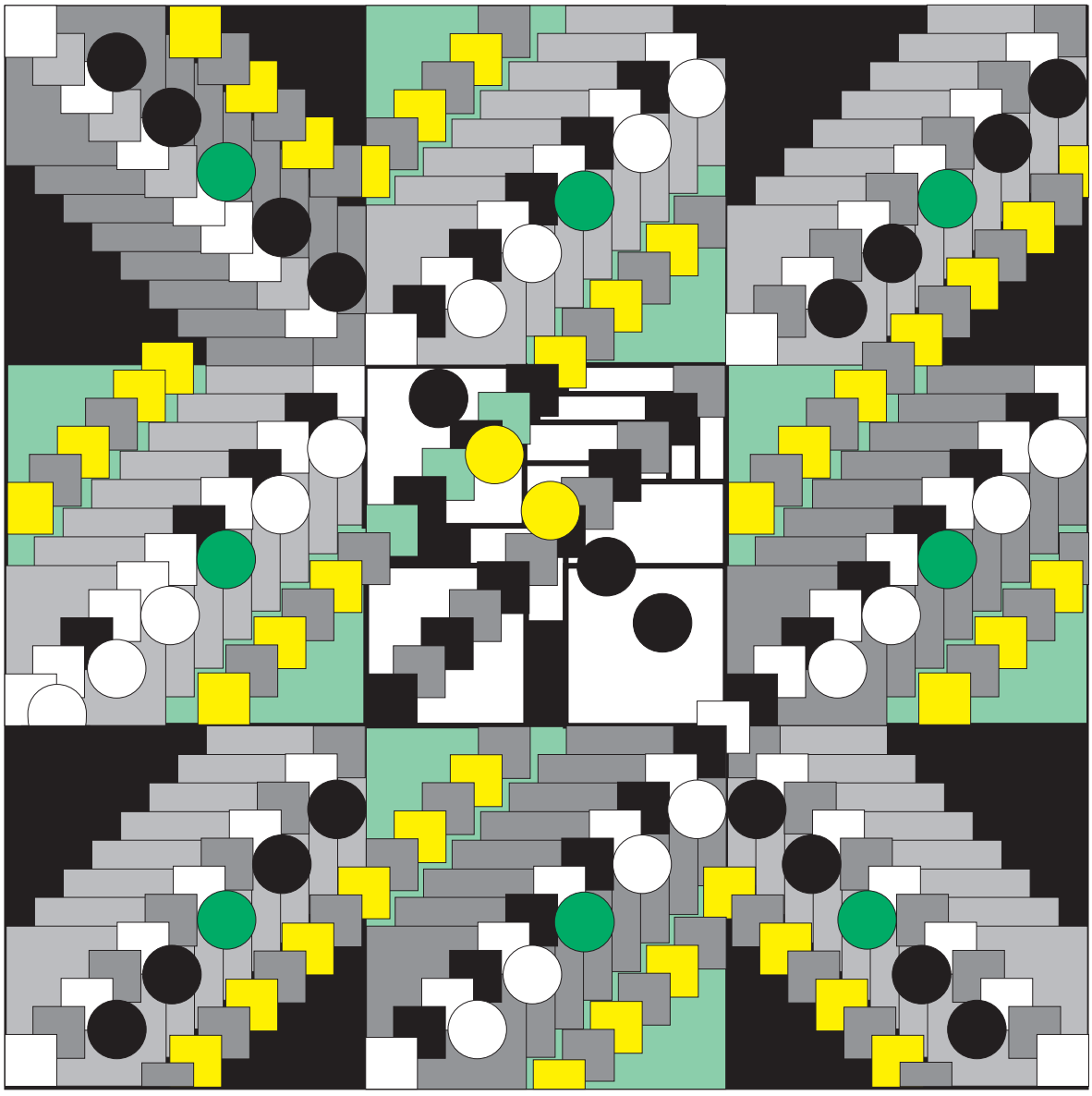
2220 Nways BroadBand Switch
Models 300, 500, and 501

IBM

Planning Series
HDLC Interface Specifications



GA33-0375-04

2220 Nways BroadBand Switch
Models 300, 500, and 501

Planning Series
HDLC Interface Specifications

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Note

Before using the information given in this document, be sure to read the general information and notices provided in the *2220 Nways BroadBand Switch Physical Lines Interface Specifications, External Cable References*, GA33-0379.

Fifth Edition (June 1998)

This edition applies to the following IBM licensed programs:

- Nways Switch Control Program Version 2 Release 2 (V2R2)
- Nways 2220 Switch Manager for AIX Version 1 replaces Nways Enterprise Manager Release 3.

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About This Document

Who Should Use This Document

Use this document if you are responsible for:

- Planning the installation of a network using IBM 2220 Nways BroadBand Switches (Nways Switches).
- Installing and configuring the network.

Purpose of This Document

This document describes:

- Functions provided by IBM Networking BroadBand Services (NBBS) architecture on high-level data link control (HDLC) interfaces of Nways Switches.
- Special features for bandwidth utilization, optimization, and automatic rerouting of connections.

How This Document Is Organized

The document is organized as follows:

- "Chapter 1. Nways Switch and High-Level Data Link Control" on page 1 gives an introduction to the HDLC access services provided by the Nways Switch.
- "Chapter 2. Configuring HDLC Resources" on page 5 provides recommendations for configuring HDLC resources.
- "Chapter 3. More Information on HDLC Options" on page 11 describes certain HDLC options.
- A Glossary is provided at the end.

Where To Find More Information

This document is a supplement to the *2220 Nways BroadBand Switch Planning Guide*, GA33-0293. For a complete list of customer information manuals, refer to "Bibliography" on page 33.

What's New in This Book

The following functions are new or have changed in Nways Switch Control Program since the last edition of this book:

- Non-disruptive path switching (NDPS) is enhanced with parallel NBBS trunks that ensure continued network availability in case of trunk failure.
- Non-reserved HDLC traffic is supported to optimize trunk usage.

Chapter 1. Nways Switch and High-Level Data Link Control

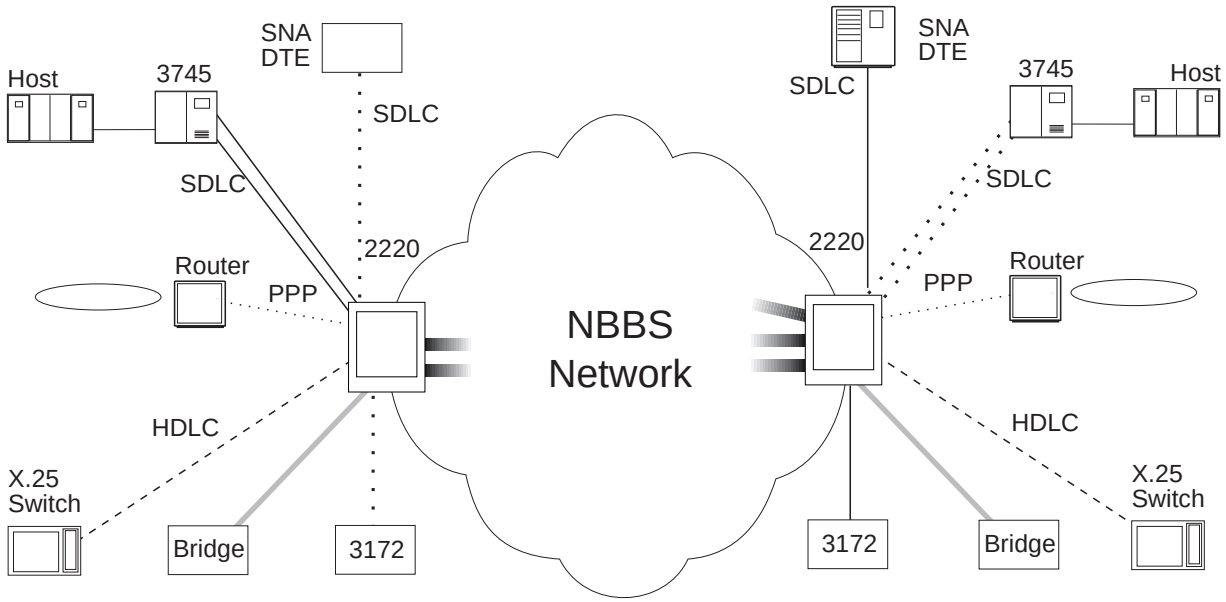
This document describes how the IBM 2220 Nways BroadBand Switch (*Nways Switch)* supports the high-level data link control (HDLC) protocol.

HDLC is used on data networks to connect devices that run protocols such as:

- Synchronous data link control (SDLC) in networks based on the IBM Systems Network Architecture (SNA)
- Link access procedures for D-channel (LAP-D) and for E-channel (LAP-E) in integrated services digital networks (ISDNs).

The Nways Switch supports non-real-time, real-time, and non-reserved HDLC traffic over permanent virtual circuits (PVCs). Devices that do not support the frame relay protocol can use the HDLC service to connect to a Networking BroadBand Services (NBBS) network.

Figure 1 shows the various types of HDLC traffic supported by Nways Switches communicating over an 2220 network.



Legend:

DTE Data terminal equipment

HDLC High-level data link control

PPP Point-to-point protocol

SDLC Synchronous data link control

SNA Systems Network Architecture

Figure 1. HDLC Traffic Supported by NBBS Network

Access Services

The Nways Switch provides the following HDLC services:

- Full duplex transfer of frames over HDLC connections. Frames are received in the same order as they are transmitted. No acknowledgment of the frames transferred across the network is provided to the user.
- Support of frame forwarding.
- Transport of variable-length frames (from 5 to 8192 bytes).
- Detection of errors in transmission, formats, and operation.
- Non-duplication of frames.
- To save bandwidth, removal of X'7E' flags and stuffed zero-bits. Interframe idle characters are detected but not transported through the 2220 network. Thus, the allocated bandwidth can be lower than the access rate. Dynamic bandwidth adaptation is supported on option.

Bandwidth Modes

The Nways Switch supports HDLC in the following bandwidth modes:

- Fixed bandwidth (non-real-time)
- Bandwidth adaptation without limits (non-real-time)
- Bandwidth adaptation with limits (non-real-time)
- HDLC real-time
- HDLC non-reserved.

For details, see "Bandwidth Modes" on page 16.

Physical Lines

Table 1 lists the types of lines supported by HDLC and the associated line interface couplers (LICs).

Table 1. Physical Lines Supported by HDLC

Line Type	Line Interface Coupler
T1 or J1	514 (four interfaces)
	544 (eight interfaces)
E1	515 (four 75-Ohm interfaces)
	516 (four 120-Ohm interfaces)
	567 (four ISDN 120-Ohm interfaces)
	545 (eight 75-Ohm interfaces)
	546 (eight 120-Ohm interfaces)
E2, J2, E3	523 (four interfaces)
HSSI	530 (one interface)
T3	513 (one interface)
V.24, V.35, X.21	511 (sixty interfaces)
V.35, V.36, X.21	522 (four interfaces)

Each of the HDLC lines is a *port line.* It attaches an HDLC device to an Nways Switch and is a port to the 2220 network. HDLC port lines transport only HDLC traffic.

For cabling information, see the *2220 Nways BroadBand Switch Physical Lines Interface Specifications, External Cable References*, GA33-0379.

Channels

On E1, T1, or J1 line interfaces, you may define each 64 kbps slot as a dedicated HDLC link. For instance, using a LIC515 with four E1 interfaces, you may define up to 124 (31x4) HDLC links.

Note: *kbps* means 1000 bits per second.

It is also possible to define an HDLC link based on several 64 kbps slots (for example, 256 kbps). This is called *bonding*. The slots can be contiguous or not.

The maximum number of connections is defined at adapter level, not at port level. Despite the number of ports defined on an adapter, the maximum number of connections that an adapter can handle at the same time remains the same. In HDLC, only one connection is supported per logical port.

HDLC Logical Ports

HDLC logical ports (layer 2 of the OSI reference model) are called *HDLC ports*. They are generated by the Nways Switch Control Program to provide HDLC access services to physical HDLC port lines. An HDLC port sets up and maintains predefined HDLC connections.

HDLC Connections

In NBBS architecture, HDLC connections (called *HDLC potential connections*) are predefined between two HDLC devices attached to the network. HDLC connections are point-to-point and bidirectional. They operate in real-time and non-real-time over permanent virtual circuits (PVCs).

Chapter 2. Configuring HDLC Resources

This chapter provides recommendations for configuring HDLC resources (logical ports and connections) and NBBS traffic options.

Nways Switch Configuration Programs

HDLC resources (line attachments, logical ports, and potential connections) are configured using either:

- Nways Switch Configuration Tool Version 2 (NCT2) from a dedicated configuration station running under OS/2 or AIX
- Nways Switch Manager (component of the Nways Enterprise Manager) from a network management station.

For information on configuration parameters, see the online help. For guidelines on how to configure HDLC resources, refer to the *Nways Switch Configuration Overview* supplied with the NCT2.

Configuring HDLC Ports

In an 2220 network, you configure one HDLC port for each HDLC physical line. Using the 64 kbps time slots, you can create channels on port lines that work in time division multiplexing (E1, T1, or J1). You can create a channel for each time slot or group of time slots, and you configure one HDLC port on each channel.

The following physical interfaces support multiple HDLC ports:

- E1 line with LICs 515, 516, 545, 546, and 567
- T1 and J1 lines with LICs 514 and 544.

Before creating HDLC connections, you must create HDLC ports on both Nways Switches at the end-points of the connection. On one end, the port serves as *connection initiator*. On the other end, the port serves as the *connection completor*. A connection is always activated from the initiator logical port.

Some of the HDLC port parameters to configure are as follows:

- HDLC port name
- Attached resource identification
- Line attachment location (rack, slot, position, and channel, if any)
- Connection initiator, completor, or both
- Administrative state (locked or unlocked)
- Maximum bandwidth available (defaulted value: line speed).

Configuring HDLC Potential Connections

You configure one permanent HDLC potential connection for each HDLC port configured as a connection initiator. It is possible to define several non-permanent connections on the same HDLC port, but only one connection is active at a time. On port lines with channels, you configure one permanent connection per channel.

Some of the HDLC potential connection parameters to configure are as follows:

- Connection name
- Identification of initiator device (Nways Switch, port, and resource)
- Identification of completor device (Nways Switch, port, and resource)
- Quality of service (QoS) for both directions (for details, see “QoS Options”)
- Connection activation mode: permanent or none (for details, see “Activating Connections” on page 11)
- Accounting selection and bandwidth sensitivity over which accounting information is recorded
- Traffic definition in NBBS style (for details, see “NBBS Traffic Parameters”).

NBBS Traffic Parameters

When configuring HDLC potential connections, you must define the following NBBS traffic parameters:

Peak bit rate
Speed (in kbps) of the line that receives traffic from the user. This is the maximum throughput that the line can send to the access node. This value must be less than or equal to the link capacity. The default value is the link capacity.

Mean bit rate
Average traffic (in kbps) received from the user. This value must be less than or equal to the peak bit rate. Default value: 0.1 kbps.

Mean burst length
Maximum duration (in seconds) of a burst of traffic received from the user at peak rate. Range: 0 to 10 seconds. Default value: 0.01 s.

Adaptation limits
This option is configured when you select the bandwidth adaptation option (ADJ). Default values: 0.1 kbps for minimum limit and the link capacity for maximum limit for sending and receiving data.

If you change the adaptation limits for a connection, follow these rules:

- The minimum limit must be equal to or greater than its default value.
- The maximum limit must be equal to or lower than the peak bit rate.
- The mean bit rate must be within the adaptation limits.

QoS Options

Depending on the type of traffic and the way you want the connection to be managed by the 2220 network, you assign a quality of service (QoS) to each HDLC connection. The following QoS options define the possible characteristics of a potential connection:

- Bandwidth adaptation
- Bandwidth keeping
- Non-disruptive path switching
- Low-speed trunk line
- High priority

- Non-reserved.

Bandwidth Adaptation (ADJ)

Bandwidth adaptation (ADJ) allows Nways Switches along a connection to modify the required bandwidth depending on the current traffic and available resources. Bandwidth is adjusted within the limits configured for the connection. For details, see “Bandwidth Adaptation” on page 12. If there is not enough bandwidth, the connection is interrupted unless you selected the non-disruptive path switching (NDPS) option.

Bandwidth Keeping (KEEP)

When you select *bandwidth keeping* (KEEP) in addition to bandwidth adaptation (ADJ), if a bandwidth increase is requested and there is not enough bandwidth, the current bandwidth is kept and the connection is not terminated. Bandwidth keeping has no effect on connection activation and connection recovery after a link failure.

Non-Disruptive Path Switching (NDPS)

Non-disruptive path switching (NDPS) ensures that when a link fails in the 2220 network or if the current path is lacking resources, connections with the NDPS option are rerouted to another available path or to a parallel 2220 trunk. The Nways Switch that is the connection initiator reroutes the connections. When the NDPS option is not selected, connections are terminated and re-established by the Retry mechanism only when the path is available. See “Non-Disruptive Path Switching” on page 13 for more information.

Low-Speed (LS) Trunk Line

In data transmission, the low-speed trunk lines may have a wide end-to-end transfer delay because the transmitted data is buffered by the Nways Switch adapters along the path. For data traffic that does not need real-time transmission, these transfer delays have a minor impact on the data applications that are connected through the 2220 network.

When you select *low-speed* (LS) trunk line, although the allowed end-to-end delay is much greater, finding suitable paths is much easier. If low-speed lines are used and LS is not selected, connections can be rejected because the maximum end-to-end delay calculated on the path is wider than the delay required.

High Priority (HPRI)

If a path fails, it is possible that there is no longer sufficient bandwidth to support all existing connections. If you select *high priority* (HPRI), the bandwidth preemption function ensures that the connection is given first access to bandwidth. The other connections get only the remaining bandwidth.

Bandwidth preemption applies when one of the following events occurs:

- Connections are activated.
- A link fails.
- Bandwidth increase is requested.
- Connections with the NDPS option are rerouted.

For more information, see “Bandwidth Preemption” on page 13.

Non-Reserved (NR)

Non-reserved (NR) is a logical queue which is used for applications that do not require delay and bandwidth guarantee, only best-effort delivery. Non-reserved is also used for 2220 network control flow.

Non-reserved traffic is used to optimize trunk usage by filling up lines when reserved traffic does not use all of its reserved bandwidth. 2220 network connections may be defined as non-reserved for HDLC access services.

Using Predefined QoSs

The Nways Switch configuration programs provide predefined QoSs which you can assign to HDLC connections in relation with their types of traffic. You select a predefined QoS by clicking in a list. Following are the HDLC traffic types:

- Non-real-time
- Real-time
- Non-reserved.

QoS for HDLC Non-Real-Time Traffic

Table 2 shows the predefined QoS options for HDLC non-real-time traffic. Their names begin with QOSFRHDLC. For more information, see “Bandwidth Modes” on page 16 .

Table 2. Predefined QoS for HDLC Non-Real-Time Traffic

Predefined QoS	Bandwidth Adaptation (ADJ)	Bandwidth Keeping (KEEP)	Non-Disruptive Path Switching (NDPS)	Low Speed Trunk Lines (LS)	High Priority (HPRI)
QOSFRHDLC					
QOSFRHDLCADJ	X				
QOSFRHDLCNDPS			X		
QOSFRHDLCADJNDPS	X		X		
QOSFRHDLCADJKEEP	X	X			
QOSFRHDLCADJKEEPNDPS	X	X	X		
QOSFRHDLCLS				X	
QOSFRHDLCADJLS	X			X	
QOSFRHDLCNDPSLS			X	X	
QOSFRHDLCADJNDPSLS	X		X	X	
QOSFRHDLCADJKEEPLS	X	X		X	
QOSFRHDLCADJKEEPNDPSLS	X	X	X	X	
QOSFRHDLCHPRI					X

Table 2. Predefined QoS for HDLC Non-Real-Time Traffic (continued)

Predefined QoS	Bandwidth Adaptation (ADJ)	Bandwidth Keeping (KEEP)	Non-Disruptive Path Switching (NDPS)	Low Speed Trunk Lines (LS)	High Priority (HPRI)
QOSFRHDLCADJHPRI	X				X
QOSFRHDLCNDPSHPRI			X		X
QOSFRHDLCADJNDPSHPRI	X		X		X
QOSFRHDLCADJKEEPHPRI	X	X			X
QOSFRHDLCADJKEEPNDPSHPRI	X	X	X		X
QOSFRHDLCLSHPRI				X	X
QOSFRHDLCADJLSHPRI	X			X	X
QOSFRHDLCNDPSLSHPRI			X	X	X
QOSFRHDLCADJNDPSLSHPRI	X		X	X	X
QOSFRHDLCADJKEEPLSHPRI	X	X		X	X
QOSFRHDLCADJKEEPNDPSLSHPRI	X	X	X	X	X

QoS for HDLC Real-Time Traffic

Table 3 shows the predefined QoS options for HDLC real-time traffic. Although these QoSs apply to FR and HDLC, they are taken from the CES QoS series and their names begin with QOSCESDATA. The QoSs for HDLC real-time traffic provide a real-time class 2 (RT2) connection. For more information, see“HDLC Real-Time” on page 20 .

Table 3. Predefined QoS for HDLC Real-Time Traffic

Predefined QoS	Real Time Class 2 (RT2)	Non-Disruptive Path Switching (NDPS)	High Priority (HPRI)
QOSCESDATAHPRI	X		X
QOSCESDATANDPSHPRI	X	X	X

QoS for HDLC Non-Reserved Traffic

Table 4 on page 10 shows the predefined QoS options for HDLC non-reserved traffic. The QoS names begin with QOSFRHDLCNR. For more information, see “HDLC Non-Reserved” on page 21.

Table 4. Predefined QoS for HDLC Non-Reserved Traffic

Predefined QoS	Non Reserved (NR)	Non-Disruptive Path Switching (NDPS)	High Priority (HPRI)
QOSFRHDLCNR	X		
QOSFRHDLCNRNDPS	X	X	
QOSFRHDLCNRHPRI	X		X
QOSFRHDLCNRNDPSHPRI	X	X	X

Chapter 3. More Information on HDLC Options

Default QoS Options

Table 5 displays the default settings in the Nways Switch Control Program for certain QoS options used in HDLC traffic.

Table 5. HDLC QoS: System Defaults

QoS Option	Without bandwidth adaptation	With bandwidth adaptation
Bandwidth adaptation (ADJ)	No	Yes
Bandwidth keeping (KEEP)	Not applicable	Yes
Logical queues	Real-time class 2, non-real-time, or non-reserved	
End-to-end delay	200 ms to 10 s	2 ms to 10 s
Maximum number of hops	10	10

When a connection is established, the Path Selection function minimizes the number of hops and the trunk load to guarantee the required end-to-end delay.

Activating Connections

Activating a connection means starting its set up over the network. The required Nways Switch resources (adapter, line interface coupler, and line attachments) must be available, the line must be unlocked, and the remote equipment must be ready. Otherwise, the connection set up will fail.

In an 2220 network, the Nways Switch that is the connection initiator activates the connection in one of the following modes depending on the Permanent Mode option:

- When you select Permanent Mode, the connection is activated when the Nways Switch resources, the line, and the remote equipment are ready.
- When you *do not* select Permanent Mode, the connection is activated only when a network operator enters a Start Connection command from the Nways 2220 Switch Manager.

HDLC Frame Format

An HDLC frame consists of the following:

- Opening flag (1 byte) containing a `01111110` bit pattern.
- Address field (2 bytes) consisting of:

  Address field extension bits (2 bits).

  Address Field Extension is not supported but is defined as follows:

  – Bit one of the first address byte is set to 0.

  – Bit one of the second address byte is set to 1.

C/R bit (1 bit)
The C/R bit is user-application specific and is passed transparently through the network.

- Frame length (5 to 8192 bytes) including address, information, and CRC fields
- Information field (1 to 8188 bytes)
- Frame check sequence (FCS) (2 bytes)

  The Nways Switch at the network entry point performs cycle redundancy checking (CRC) on incoming frames and discards frames with errors by using the abend sequence process. Frames are not checked when they leave the 2220 network.
- Closing flag (1 byte) containing a `01111110` bit pattern

The network discards **invalid frames** without notifying the sending terminal. A frame is invalid if:

- It is not properly bounded by the opening and closing flags.
- It has an improper length (less than five bytes or more than 8192 bytes) between flags.
- It is not made of an integral number of bytes before the insertion or after the extraction of the zero-bits.
- It contains a frame-check sequence error.

Reception of seven or more contiguous 1-bits is interpreted as an **abend** and is ignored.

Idle periods between frames are filled by `01111110` bit patterns.

Bandwidth Adaptation

When you select the bandwidth adaptation option (ADJ), the required bandwidth is adjusted depending on the current traffic and available resources. The option takes into account peak hours and empty hours, and modifications on connection requirements, such as interactive file transfer.

Bandwidth adaptation is performed as follows:

1. The connection input traffic is regularly measured to see if there are changes to make in bandwidth requirements.
2. Changes in bandwidth requirements are confirmed over a certain period of time (several seconds).
3. A request is sent over the network to increase or decrease bandwidth. In case of bandwidth increase, the network answer must be received before changing policing parameters.

Bandwidth adaptation guarantees a QoS while providing flexibility in reservation. On the contrary, the non-reserved service takes advantage of idle periods on trunks, but does not guarantee a QoS. You use bandwidth adaptation to take into account long term variations in traffic rather than short-term bursts. For more information on selecting a QoS with bandwidth adaptation, see“Bandwidth Adaptation (ADJ)” on page 7 .

Non-Disruptive Path Switching

Non-disruptive path switching (NDPS) restores a connection over another network path or a parallel trunk if the current trunk fails or if there is insufficient bandwidth when bandwidth adaptation (see “Bandwidth Adaptation” on page 12) is performed.

When a trunk fails or when bandwidth adaptation cannot be successfully performed, the connections with the NDPS attribute are rerouted on another trunk (when possible). The rerouting order depends on connection priority: high priority (HPRI), real-time class 2 (RT2), non-real-time (NRT), and non-reserved (NR). At the same priority level, the connection with the widest bandwidth is rerouted first. If necessary, low-priority connections are preempted on the trunk used for rerouting (see “Bandwidth Preemption”).

When a trunk with a parallel trunk configuration fails, the bandwidth used by the connections of the parallel trunk is reduced to its initial value so that the parallel trunk can transport the connections of the failing trunk.

When many connections require NDPS at the same time, a large amount of traffic control is created in the 2220 network. This can result in long rerouting delays. (For more information on selecting a QoS with the NDPS option, see “Non-Disruptive Path Switching (NDPS)” on page 7.)

Bandwidth Preemption

Bandwidth preemption is a function that stops a low priority connection so that a higher priority connection can use its resources. Bandwidth preemption is used:

- At connection setup
- On link failure
- On bandwidth increase request.

For more information on selecting a QoS with bandwidth preemption, see “High Priority (HPRI)” on page 7.

At Connection Setup

Preemption at connection setup is performed as follows:

1. A low-priority connection, without the non-disruptive path selection (NDPS) option, is established.
2. A request occurs to establish a new connection with a higher priority and there is not enough trunk capacity to support both connections at the same time.
3. The high-priority connection is established.
4. The low-priority connection is terminated and its resources (bandwidth and label) are released.

   If the low-priority connection has the NDPS option, it is immediately rerouted with its initial mean bit rate. The connection is not terminated.

   If the low-priority connection has the bandwidth adaptation (ADJ) option, it is rerouted with its initial mean bit rate, if possible.

If the new connection has the same priority as an established connection, and if there is not enough bandwidth available, the new connection is rejected.

After Link Failure

Preemption after link failure is performed as follows:

1. A low-priority connection without NDPS is established on a trunk. A connection with a higher priority is also established on the trunk.
2. The bandwidth capacity of the trunk becomes insufficient.
3. The high-priority connection is rerouted.
4. The low-priority connection is terminated and its resources are released.

   If the low-priority connection has the NDPS option, it is immediately rerouted with its initial mean bit rate. The connection is not terminated.

   If the low-priority connection has the bandwidth adaptation (ADJ) option, it is rerouted with its initial mean bit rate, if possible.

If there is not enough bandwidth available to reroute the high-priority connection, even when the low-priority connections are preempted, the high-priority connection is terminated and the low-priority connections are kept.

On Bandwidth Request

Preemption on bandwidth request is performed as follows:

1. A low-priority connection without NDPS is established on a trunk. A connection with a higher priority is also established on the trunk.
2. The high-priority connection requests more bandwidth and there is not enough bandwidth.
3. The high-priority connection gets the bandwidth.
4. The low-priority connection is terminated and its resources are released.

   If the low-priority connection has the NDPS option, it is immediately rerouted with its initial mean bit rate. The connection is not terminated.

   If the low-priority connection has the options bandwidth adaptation (ADJ) and bandwidth keeping (KEEP), it is rerouted with its initial mean bit rate, if possible.

If there is not enough bandwidth for the high-priority connection (even when adding the bandwidth of the low-priority connections):

- The high-priority connection is terminated while the low-priority connection continues to operate.
- If the high-priority connection has the KEEP option, its bandwidth remains unchanged and the bandwidth increase is rejected.

Bandwidth Management

Bandwidth management allocates a bandwidth that corresponds to users' needs. It is based on the connection parameters that define traffic characteristics and requested quality of service.

Allocating Bandwidth

The Nways Switch enforces fairness among users and provides low delay across the network. Accepting a request for a connection is a contract based on the connection parameters. This contract is a credit of network resources (mainly buffers) guaranteed for the duration of the connection.

When no data is transmitted on a given connection, it accumulates transmission credit, allowing the network to accept bursts of data at the port speed rather than at the assigned rate.

Network resources are reserved depending on the initial connection parameters. The 2220 network finds the best path to set the connection, then accepts the new connection by:

- Allocating the bandwidth needed to meet the terms of the contract, thus guaranteeing the requested QoS
- Smoothing this traffic flow, which may be bursty, by buffering data for each connection at the entry point to the network.

The combination of these two operations gives the *equivalent capacity* (Ec), which is the final amount of bandwidth reserved for each connection.

Leaky Bucket Policing

Once the allocated bandwidth is reserved, a policing process based on a *leaky bucket* algorithm ensures that the contract is respected. The leaky bucket behaves in the following way. Traffic bursts conforming to the contract are accepted using the transmission credit (*green traffic*) accumulated by the connection. When the transmission credit is exhausted, the traffic is considered as non-conforming, and one of the following process may occur:

- It is bufferized with a short delay.
- It becomes *red traffic* and enters the 2220 network where it is transmitted on a best effort basis.
- It is discarded.

Traffic Descriptors

Table 6 shows the traffic descriptors used in HDLC.

Table 6. HDLC Traffic Descriptors

NBBS Fixed Bandwidth	**NBBS Bandwidth Adaptation**	
	Without Limits	**With Limits**
R m b	R m (initial) b (initial)	R m (initial) b (initial) Minimum bandwidth Maximum bandwidth
QoS without ADJ option	QoS with ADJ option	
Legend: **R** Peak bit rate (kbps) **m** Mean bit rate (kbps) **b** Mean burst length (seconds)		

Bandwidth Modes

This section describes bandwidth modes for HDLC traffic:

- Fixed bandwidth (non-real-time)
- Bandwidth adaptation without limits (non-real-time)
- Bandwidth adaptation with limits (non-real-time)
- HDLC real-time
- HDLC non-reserved.

Fixed Bandwidth

The parameters that define fixed bandwidth are as follows:

Peak bit rate (R)
Speed (in kbps) of the line that receives traffic from the user. This is the maximum throughput that the line can send to the access node.

Mean bit rate (m)
Average traffic (in kbps) received from the user.

Mean burst length (b)
Maximum duration (in seconds) of a burst of traffic received from the user at peak rate.

Quality of service (QoS)
In this mode, you select a predefined QoS without the bandwidth adaptation (ADJ) option.

These parameters define the amount of traffic expected. This value is used as the contract between the user and the 2220 network.

Allocated Bandwidth

Based on the contract, an equivalent capacity is computed depending on the QoS defined for the connection. When you select a QoS with FRHDLC option for a connection, the equivalent capacity is reserved as non-real-time traffic. All the trunks along the path as well as on the other side of the connection (also called *egress* port) are involved in this reservation. A first check is performed to ensure that the capacity is available. Other connections are prevented from using the bandwidth. Once the reservation is made, the leaky bucket algorithm starts.

Traffic That Conforms

Received traffic that conforms to the contract is accepted and sent through the 2220 network as green. Under normal conditions, green traffic is never discarded.

Traffic That Exceeds

Received traffic that exceeds the contract is handled by the leaky bucket algorithm in the following ways:

- Traffic that is 20% over the allocated bandwidth is accepted, marked in red, and sent to the 2220 network. Red traffic is never guaranteed and is transported if the trunks are not overloaded. When congestion occurs, red traffic is discarded.
- Traffic over the 20% mentioned above is discarded without entering the 2220 network.

Example

R = 64 kbps

m = 10 kbps

b = 0.01 second

QoS = QOSFRHDLCNDPS.

The allocated bandwidth in the example is 10.04 kbps. This corresponds to the accepted green traffic if the burstiness does not exceed 0.01 second at 64 kbps. Two kbps of exceeding traffic is accepted as red. Traffic exceeding 12 kbps is discarded.

Bandwidth Adaptation Without Limits

The parameters that define bandwidth adaptation without limits are as follows:

Peak bit rate (R)
Speed of the line (in kbps) that receives traffic from the user. This is the maximum throughput that the line can send to the access node.

Initial mean bit rate (m)
Initial bandwidth (in kbps) to be allocated a connection setup. The bandwidth is reserved for the connection.

Initial mean burst length (b)
Maximum duration (in seconds) of a burst of traffic that is received at peak rate. In this mode, you configure an initial value of 4÷R. The value changes as the adapter dynamically changes the allocated bandwidth.

Quality of service (QoS)
In this mode, you configure a predefined QoS with the bandwidth adaptation (ADJ) option, and with or without the bandwidth keeping (KEEP) option.

Allocated Bandwidth

The initial mean bit rate is allocated first. As soon as the connection is set up, an adapter mechanism periodically:

- Analyzes the traffic received over a certain period of time.
- Compares received traffic to the configured QoS.
- Decides if the allocated bandwidth must be changed to fit the traffic received. The value of the reserved bandwidth varies from a few bits per second to the peak bit rate.

Bandwidth Increase/Decrease Granted by the Network

When the 2220 network grants a new contract that is dynamically computed by the adapter, all the received traffic should be accepted.

If some traffic exceeds the current contract, it is marked as red, and a new bandwidth is computed within the next seconds. During the bandwidth adaptation period, a wide bandwidth is assigned to the connection to accept red traffic.

Bandwidth Increase Not Granted by the Network

When the 2220 network cannot increase bandwidth for some reason (for example, because there is no more available bandwidth along the path), the non-disruptive

path switching (NDPS) mechanism is attempted, if enabled by the QoS. If the required bandwidth still cannot be allocated at this time:

- If the bandwidth keeping option (KEEP) has not been selected, the connection is deactivated.
- If the KEEP option has been selected, the connection is kept active with the previously allocated bandwidth in a mode called *HDLC slow adaptation mode*. In this mode, to protect the 2220 network only 20% of red traffic is allowed. The connection returns to normal mode as soon as bandwidth adaptation has been successfully granted.

Example

R = 64 kbps

Initial m = 10 kbps

Initial b = 4÷64 = 1÷16 second

QoS = QOSFRHDLCADJKEEPNDPS.

The initial allocated bandwidth in this example is 10 kbps. It dynamically varies from 100 bps to 64 kbps depending on the traffic received. It also depends on the 2220 network ability to allocate newly requested bandwidth.

Bandwidth Adaptation With Limits

The parameters that define bandwidth adaptation with limits are as follows:

Peak bit rate (R)
Speed (in kbps) of the line that receives traffic from the user. This is the maximum throughput that the line can send to the access node.

Initial mean bit rate (m)
Initial bandwidth (in kbps) to be allocated at connection setup. You define a value between the minimum bandwidth and the maximum bandwidth. The bandwidth is reserved for the connection along the link.

Initial mean burst length (b)
Maximum duration (in seconds) of a burst of traffic that is received from the user at peak rate. In this mode, you configure an initial value of 4÷R. The value changes as the adapter dynamically changes the allocated bandwidth.

Minimum bandwidth
Minimum bandwidth (in kbps) reserved even when no traffic is received. You must configure a minimum bandwidth smaller that the maximum bandwidth.

Maximum bandwidth
Maximum bandwidth (in kbps) that can be allocated to the connection. You must configure a maximum bandwidth smaller than or equal to the peak bit rate.

Quality of service (QoS)
In this mode, you select a predefined QoS with the bandwidth adaptation (ADJ) option, and with or without the bandwidth keeping (KEEP) option.

The maximum bandwidth and minimum bandwidth parameters are the limits for the bandwidth adaptation algorithm.

Allocated Bandwidth

The initial mean bit rate is allocated first. As soon as the connection is set up, an adapter mechanism periodically:

- Analyzes the traffic received over a certain period of time.
- Compares the received traffic to the configured QoS.
- Decides if the allocated bandwidth must be changed to fit the traffic received.

  The value of the reserved bandwidth varies from minimum bandwidth to maximum bandwidth.

Figure 2 displays parameters and bandwidth variations.

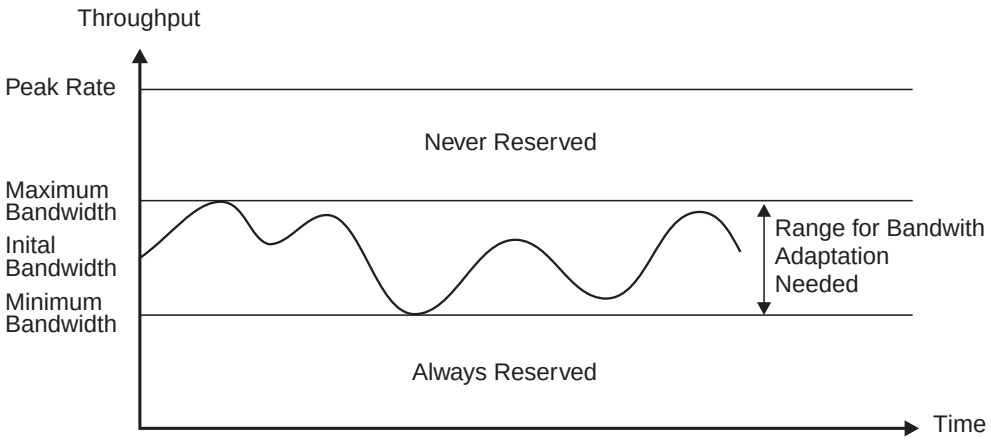


Figure 2. Bandwidth Adaptation

You can use the maximum bandwidth and minimum bandwidth parameters separately.

- Example 1:

  ```
  minimum bandwidth = 10 kbps
  maximum bandwidth = peak rate
  ```

  This ensures minimum bandwidth reservation and bandwidth adaptation for traffic that exceeds the reserved bandwidth.
- Example 2:

  ```
  minimum bandwidth = 0
  maximum bandwidth = 20 kbps
  peak rate  = 45 kbps
  ```

  This ensures that the connection will never occupy all the available bandwidth. 25 kbps remain for the other connections.

When a bandwidth increase is not granted by the 2220 network, the connection enters slow adaptation mode as described in “Bandwidth Increase Not Granted by the Network” on page 17.

If the received traffic exceeds the maximum bandwidth, the adapter forces the new reservation to the maximum bandwidth and goes in *maximum bandwidth reached mode*. Since no more bandwidth can be allocated, the network must be protected against receiving more traffic.

In HDLC maximum bandwidth reached mode, only 20% of red traffic is allowed. This protects the network from having too much red traffic.

Maximum bandwidth reached mode is similar to slow adaptation mode except that:

- In maximum bandwidth reached mode, no more bandwidth can be allocated by a network operator.
- In slow adaptation mode, the bandwidth limitation originates with the 2220 network. Since new bandwidth can become available at any time (for example, due to bandwidth release by other connections, or new trunks activated), attempts to increase bandwidth are periodically performed.

The connection returns to normal mode as soon as a significant bandwidth decrease is performed.

Example

R = 64 Kbps

Initial m = 10 kbps

Initial b = 4÷64 = 1÷16 second

QoS = QOSFRHDLCADJKEEPNDPS

Maximum bandwidth = 20 kbps

Minimum bandwidth = 5 kbps

In this example, the initial allocated bandwidth is 10 kbps. It dynamically varies from 5 kbps to 20 kbps depending on the traffic received and depending on the ability of the 2220 network to allocate the newly requested bandwidth.

HDLC Real-Time

The Nways Switch supports real-time traffic over HDLC (and frame-relay) connections in real-time class 2 (RT2). Voice is transported in real-time with a low transport delay.

Real-time traffic in HDLC allows assigning priorities among different types of traffic. RT2 packets have a higher priority than non-real-time traffic (NRT) and non-reserved (NR) in the whole transport process (policing, input queues, and output queues). Real-time and non-real-time connections can be mixed over the same HDLC port line. Real-time in HDLC also improves the quality of voice communications.

When configuring a connection for real-time traffic, you select a predefined quality of service (QoS) from “HDLC Real-Time” depending on the desired options. Although these QoSs apply to HDLC, they are taken from the CES QoS series and their names begin with QOSCESDATA. They provide a real-time class 2 (RT2) connection.

- On every low-speed connection, an outbound queue handles the traffic classes.
- On high-speed connections (associated with an high-speed adapter), there is a single outbound queue that handles the traffic. The bandwidth usage must be 50% of the link capacity. Also it is recommended that you set an undersubscription of 50%.

The following constraints are related to HDLC real-time traffic:

Jitters induced on RT1 queue

Large equivalent capacity.

Jitters Induced On RT1 Queue

Non-real-time flow is preempted by real-time traffic in order to limit jitters and delays. However, a real-time class 1 (RT1) packet may wait until the end of the transmission of an RT2 packet. To minimize the delay induced on RT1 packets, limit RT2 packets to a size of **128 bytes**.

On 128 kbps links, the maximum jitter per Nways Switchis 8 ms. Real-time HDLC packets longer than 128 bytes are discarded by input port adapters.

Wide Equivalent Capacity

The equivalent capacity assigned to a connection is highly dependent on buffer size and loss priority. The smaller the buffers are, the wider the equivalent capacity is. This limits the number of connections and reduces the probability to congest output buffers. RT2 buffers are very small while NRT buffers are 256 KB.

To limit packet loss on HDLC real-time connections, reserve a wide bandwidth even when traffic is small. Also configure the equivalent capacity parameters with precision. With small buffers, the equivalent capacity is very sensitive. A small difference in the initial mean burst length (b) may cause important changes in bandwidth reservation. Also remember that the initial burstiness (b) is a mean value and that wider bursts (for example, ten times wider) are likely to happen.

HDLC Non-Reserved

The Nways Switch supports non-real-time HDLC flow in non-reserved (NR) mode. For information on how to select QoS options and use the traffic options described in “NBBS Traffic Parameters” on page 6, see “QoS for HDLC Non-Reserved Traffic” on page 9.

The non-reserved flow uses the non-reserved (NR) queue which has the lowest priority. Non-reserved traffic is sent only when no traffic is present on the other queues (RT2 and NRT).

While red traffic is limited to a few bytes in the adapter queues, non-reserved traffic use 256 KB queues to absorb larger bursts. Non-reserved is the preferred choice for router traffic. It also guarantees that non-real-time flows always has priority.

Congestion Management

In an 2220 network you deal with congestion at two levels. One is the connection level (policing), the other is the physical adapter level (severe adapter congestion).

Policing Connection

Each connection is subject to a contract between the user and the network in terms of traffic characteristics. The traffic is checked when entering the 2220 network and is declared either:

- Conforming (green) for the traffic that stays within the allocated bandwidth
- Non-conforming (red) for the traffic in excess.

Red traffic is allowed to enter the 2220 network if there are enough resources to handle it, but it may be discarded at any intermediate stage if there are not enough resources.

The bandwidth adaptation option is used to set the minimum and maximum values of the bandwidth for each connection (the minimum bandwidth can be set to 0). Use of this option depends on the choice of QoS defined at connection level.

After a bandwidth increase request, if the bandwidth increase is not granted or if the maximum bandwidth is reached, the connection is terminated and the frames are discarded. If the maximum bandwidth is not reached, the network takes one of the following actions depending on the QoS option that you configured:

- If the ADJ option has been configured, the network tries to obtain the bandwidth on the existing path.
- If the KEEP option has been configured, the network keeps the connection and discards part of the traffic until the bandwidth can be successfully increased. The last bandwidth value allocated is kept.
- If the NDPS option has been configured, the network tries non-disruptive path switching.
- If none of the actions above can be done, the network terminates the connection and discards the frames.

Severe Adapter Congestion

Severe adapter congestion occurs when there are no more resources available on the adapter. All incoming frames are discarded. This can occur when a significant amount of red traffic is sent over the network.

Glossary

The following are the abbreviations and technical terms used in the 2220 Nways Switch library.

2220. The IBM 2220 Nways BroadBand Switch (also called Nways Switch) is a fast packet switch enabling high-speed communications over a broadband network. It implements the functions of the IBM Networking BroadBand Services (NBBS) architecture.

2220-300. 2220 Nways Switch Model 300.

2220-500. 2220 Nways Switch Model 500.

2220-501. 2220 Nways Switch Model 501.

2220 NSM. 2220 Nways Switch Manager

AAL. ATM adaptation layer.

ABR. Availability bit rate. A best effort service with a minimum bit rate and a maximum cell loss value.

ac. Alternating current.

access services. Functions that are performed by a port adapter of the IBM 2220 Nways BroadBand Switch to:

- Support the attachment of external user devices through port lines
- Prepare user data packets
- Control the input traffic on port lines
- Manage line protocols.

active remote connector (ARC). A connector that supplies the electrical and physical interfaces between a line interface coupler type 511 (LIC511) in an Nways Switch subrack and data circuit-terminating equipment (DCE) or data terminal equipment (DTE). ARCs are housed in line connection boxes (LCBs).

adapter. An Nways Switch module that can be used, depending on its hardware type and the code that it runs, as:

Control point adapter

Port adapter

Trunk adapter

Voice server adapter.

A trunk or port adapter is associated with a line interface coupler (LIC). A voice server adapter can be associated with a voice server extension (VSE).

ADPCM. Adaptive differential pulse code modulation.

AIS. Alarm indicator signal.

AIX. Advanced Interactive Executive.

alarm and power control (APC). In an Nways Switch, a module that connects the NAS, reports alarms, and controls the power supplies.

Alert Manager. An application that processes the SNA alerts received from IBM 3746s operating in IP mode.

AMI. Alternate mark inversion.

ANSI. American National Standards Institute.

APC. Alarm and power control (module).

AR. Access rate.

ARC. Active remote connector.

asynchronous transfer mode (ATM). A high-speed, connection-oriented switching and multiplexing protocol that transmits different types of traffic (voice, video, and data) simultaneously.

ATM. Asynchronous transfer mode.

ATMAn. ATM adapter type n (module).

ATM adaptation layer (AAL). In ATM devices, a set of protocols that adapt non-ATM devices to an ATM network. There are several classes of ATM adaptation layers which represent the main traffic types (for example, data, voice, and video).

ATM network interface. A logical resource generated by the Nways Switch Control Program to provide access services to a physical ATM port or trunk line. An ATM network interface sets up and maintains predefined ATM virtual connections.

AT&T. American Telephone & Telegraph (Company).

B8ZS. Bipolar eight-zero substitution.

Bc. Burst committed.

Be. Burst in excess.

bearer service profile (BSP). A set of parameters that defines a type of ISDN traffic (speech, audio, data, or video). One BSP is associated with each ISDN numbering plan table.

BECN. Backward explicit congestion notification.

B-ICI. Broadband inter-carrier interface.

BMI. Byte multiplexer interface.

BNC. Bayonet Niell-Concelman.

bps. Bit per second.

bridge. A functional unit that interconnects two local area networks. A bridge works at the data link level (layer 2) of the OSI reference model.

broadband network. A network that uses a large frequency band to transport different kinds of traffic (such as coded voice, video, and data) at the same time.

BS. Bearer services.

BSC. Binary synchronous communication.

BSP. Bearer service profile.

BT. Burst tolerance.

bursty. Refers to transmission at variable bit rate where the time between data transmissions is not always the same.

CAC. Connection admission control.

CAS. Channel associated signaling.

CBR. Constant bit rate.

CCS. (1) Common channel signaling (2) Change control server (also called CC server).

CDB. Configuration database.

CDV. Cell delay variation.

CDVT. Cell delay variation tolerance.

cell loss priority (CLP). A priority bit in the ATM cell header. When set, it indicates that the cell can be discarded during traffic congestion.

centralized configuration database. A database prepared with the Nways Switch Configuration Tool Version 2 (NCT2) on a configuration station. It stores the parameters of a 2220 network.

CES. Circuit emulation services.

change control server (CCS or CC server). A station that runs the IBM NetView Distribution Manager for AIX to store the Nways Switch Control Program and to manage code changes.

CIR. Committed information rate.

circuit emulation services (CES). An access service that emulates a leased line. It transports information with a constant bit rate at the source and destination. The traffic can be PCM voice, video, fax, multimedia, or real-time synchronous data (such as BSC).

CLIP. Calling line identification presentation.

CLIR. Calling line identification restriction.

CLK. Clock (module).

CLKRD. Clock redrive (module).

clock module (CLK). A module of the 2220 Model 300 or 500 that transmits clock signals to the line interface couplers (LICs). It is optional and can have a backup.

clock redrive (CLKRD). A module of the 2220 Model 501 that drives the signals from the Model 500 clock module to the adapters of the Model 501. The clock redrive is optional and can have a backup.

clock references. In an Nways Switch, the software function that controls the transmission of clock signals to the LICs where they are used for bit synchronization.

CLP. Cell loss priority.

CMIP. Common management information protocol.

CMIS. Common management information services.

CMOT. CMIP over TCP/IP.

CNM. Communication network management.

code file. A named set of records stored as a unit in a change control server. An Nways Switch code file can include data or internal code.

COLP. Connected line identification presentation.

COLR. Connected line identification restriction.

configuration station. See Nways Switch configuration station.

control point (CP). In an Nways Switch, a logical resource that provides network control functions. It can have a backup.

CP. Control point.

CPA. Control point adapter (module).

CPE. Customer premises equipment.

CP spanning tree. In a 2220 network, a distribution tree that connects the Nways Switch control points through trunk lines. The CP spanning tree supplies a very fast and efficient way to multicast control messages such as network topology data.

CRC. Cyclic redundancy check.

CSU. Channel access unit.

CTD. Cell transfer delay.

data circuit-terminating equipment (DCE). An equipment installed on a user premises that provides all the functions required to establish, maintain, and terminate a connection, and to do the signal conversion

and coding between a data terminal equipment (DTE) and a line. A DCE can be separate piece of equipment or part of other equipment.

data terminal equipment (DTE). That part of a data station that serves as data source, data sink, or both, and provides the data communication control function depending on the type of protocol used.

dB. Decibel.

dBm. Decibel based on 1 milliwatt.

DC48. Dc power input type -48V

dc. Direct current.

DCD. Dc distribution (module).

DCE. Data circuit-terminating equipment.

DDI. Direct dialing-in.

DE. Discard eligibility.

decibel (dB). (1) One tenth of a bel. (2) A unit that expresses the ratio of two power levels on a logarithmic scale. (3) A unit for measuring relative power. The number of decibels is 10 times the logarithm (base 10) of the ratio of the measured power levels; if the measured levels are voltages (across the same or equal resistance), the number of decibels is 20 times the log of the ratio.

decibel based on 1 milliwatt (dBm). A unit of absolute power measurement that is scaled such that 0 dBm equals 1 milliwatt.

dialog box. On the screen of a station, an area with entry fields and push buttons. (Also called dialog.)

DLCI. Data link connection identifier.

DNPT. Destination numbering plan table.

DSP. Digital service processor.

DSU. Data service unit.

DTE. Data terminal equipment.

DTMF. Dual-tone modulation frequency.

DTR. Data terminal ready.

dummy module. In an Nways Switch, a cover inserted in the place of a module to ensure correct air cooling inside a logic subrack. During normal operation, the dummy modules must not be removed.

E1 standard. A European standard for TDM digital transmission service at 2.048 Mbps.

E3 standard. A European standard for TDM digital transmission service at 34.368 Mbps. An E3 line can transport up to 16 E1 circuits.

E&M. Earth & mark.

ECMA. European Computers Manufacturers Association.

EIA. Electronics Industries Association.

equivalent capacity. The minimum amount of bandwidth needed by a connection to ensure that the packet loss ratio is below a specified threshold.

ESF. Extended status flags.

ETS. European telecommunication standard.

FANB. Fan box.

FAT. File allocation table.

fax. Document received from a facsimile machine. Synonym for telecopy.

FCS. Frame check sequence.

FDDI. Fiber Distributed Data Interface.

FE1. Fractional E1.

FECN. Forward explicit congestion notification.

FEP. Front-end processor.

fiber. Synonym for optical fiber.

fiber budget. The optical power loss as result of the number of connections in the optical fiber link subtracted from the working budget. The loss as a result of connections includes connector loss and splice loss. The fiber budget is expressed in decibels.

Fiber Distributed Data Interface (FDDI). A U.S. standard for 100 Mbps token-ring LANs using optical fiber cables over distances of several kilometers.

fiber optic cable. Synonym for optical fiber.

FR. Frame relay.

FRAD. Frame-relay access device.

frame relay (FR). A connection-oriented protocol to transport data frames over a fast packet-network with guaranteed end-to-end quality of service.

FRFH. Frame-relay frame handler.

front-end processor (FEP). A processor, such as the IBM 3745, 3746 Model 900 or 950, or 3174, that relieves a main frame from communication control tasks.

FRTE. Frame-relay terminal equipment.

FRU. Field replaceable unit.

FT1. Fractional T1.

FTP. File transfer protocol.

Gbps. Gigabit per second (10 to the power of 9 bits per second).

GCRA. Generic cell rate algorithm.

GFP. Generic function protocol.

GFT. Generic function transport.

GSM. Group special mobile.

GUI. Graphical user interface.

HDB3. High-density bipolar 3.

HDLC. High-level data link control.

high-level data link control (HDLC). A data network protocol.

hot pluggable. Refers to a hardware component that can be installed or removed without disturbing the operation of any other resource that is not connected to, or dependent, on this component.

HPFS. High-performance file system.

HPRI. High priority.

HSAn. High-speed adapter type n (module).

HSDS. High-speed digital services.

HSSI. High-speed serial interface.

hub (intelligent). A wiring concentrator, such as the IBM 8260, that supplies bridging and routing functions for LANs with different cables and protocols.

hunt group. See X.25 hunt group.

IDNX. Integrated Digital Network Exchange.

IE. Information element.

ILMI. Interim local management interface.

IMU. Inverse multiplexing unit

Integrated Digital Network Exchange (IDNX). A processor integrating voice, data, and image applications. It also manages transmission resources and connects to multiplexers and network management support systems. It permits integration of equipment from different vendors.

integrated services digital network (ISDN). A digital end-to-end public or private network that supports multiple services including, but not limited to, voice and data.

IP. Internet Protocol.

IP gateway adapter. In an Nways Switch, a port adapter that routes the IP control between the NAS and the network management station.

ISDN. Integrated services digital network.

ISDN network interface. A logical resource generated by the Nways Switch Control Program to provide access services to a physical ISDN or QSIG port line. An ISDN network interface sets up and maintains connections between calling ISDN terminal equipments and called terminal equipments attached through other Nways Switches.

ISO. International Organization for Standardization.

isochronous. Refers to transmission at a constant bit rate where there is a clock relationship between source and destination. The bit rates are the same on the destination and source.

ITU-T. International Telecommunication Union - Telecommunication (replaces CCITT).

jitter. Undesirable variations in the transmission delay of a digital signal. Also called cell delay variation (CDV).

KB. Kilobyte (storage capacity, 1024 bytes).

kbps. Kilobit per second (1000 bits per second).

LAN. Local area network.

LAPB. Link access procedure for B-channel.

LAPD. Link access procedure for D-channel.

LCB. Line connection box.

LCBB. Line connection box, base (LCEB and LCPB).

LCBE. Line connection box, expansion (LCEE and LCPE).

LCEB. Line connection enclosure, base.

LCEE. Line connection enclosure, expansion.

LCPB. Line connection power, base.

LCPE. Line connection power, expansion.

LCR. Least cost routing.

LED. Light-emitting diode.

LICn. Line interface coupler type n (module).

line. In a 2220 network, any physical medium, such as a telephone wire, microwave beam, or optical fiber, that transmits information. A line can be a trunk line or a port line.

line connection box (LCB). A metallic box that:

- Multiplexes up to 15 low-speed lines. There can be up to four LCBs per LIC type 511 for a total of 60 lines (two LCBs and 30 lines per LIC connector).
- Reduces cable lengths between Nways Switch and DCE or DTE locations.

An LCB fits in a standard 19-inch rack. Each one houses up to 15 active remote connectors (ARCs).

line interface coupler (LIC). In an Nways Switch, a module that physically attaches trunk or port lines. Each line interface coupler is associated with a trunk or port adapter, and supports specific line interfaces.

LIV. Link integrity verification.

LMI. Local management interface.

local area network (LAN). A computer network located on a user premises in a limited geographical area.

logical port. (Also called NBBS port.) A logical resource generated by the Nways Switch Control Program to provide access services to a physical port line (or channel of a TDM port line) using HDLC, FR, or CES protocol. A logical port sets up and maintains its predefined connections.

logical trunk. (Also called NBBS trunk.) A logical resource generated by the Nways Switch Control Program to provide transport services to a physical trunk line (or channel of a TDM trunk line). A logical trunk is mainly responsible for optimizing bandwidth and maintaining the CP spanning tree.

LSAn. Low-speed adapter type n (module).

MA/SR. Multi-access/sub-rate.

management access. Refers to an Nways Switch that connects a network management station or a change control server to a 2220 network through its service bus, which is a dedicated Ethernet LAN.

MB. Megabyte (storage capacity, 1 048 576 bytes).

Mbps. Megabit per second (10 to the power of 6 bits per second).

MBS. Maximum burst size.

MLT. Multiple logical trunks.

module. In an Nways Switch, a hardware unit plugged in a slot of the logic subrack. It houses, for example, an adapter, a line interface coupler, or a voice server extension. All modules are hot pluggable.

ms. Millisecond (1/1000 second).

NAS. Nways Switch administration station.

NBBS. Networking BroadBand Services (architecture).

NBBS architecture. See Networking BroadBand Services.

NBBS connection. See potential connection and virtual connection.

NBBS network. A network built with IBM 2220 Nways BroadBand Switches and conforming to the IBM Networking BroadBand Services (NBBS) architecture.

NBBS port. See logical port.

NBBS trunk. See logical trunk.

NCT2. Nways Switch Configuration Tool Version 2.

NDPS. Non-disruptive path switching.

NEM. Nways Enterprise Manager (see 2220 Nways Switch Manager).

network control. Functions that are performed by an Nways Switch control point to:

- Allocate and control the Nways Switch resources
- Provide topology and directory services
- Select routes
- Control congestion.

network management station (NMS). A station that runs IBM NetView for AIX and the 2220 Nways Switch Manager. It is used to manage network topology, accounting, performance, configuration, and error reporting.

network node interface (NNI). An interface between nodes in a communication network.

Network Support Center (NSC). A location from which IBM remotely supports 2220 networks.

Networking BroadBand Services (NBBS). An IBM architecture for high-speed networking that complements ATM standards and provides access services, transport services, and network control to user traffic.

NIC. Network Information Center.

NMS. Network management station.

NNI. Network node interface.

NPT. Numbering plan table.

NR. Non-reserved.

NRT. Non-real-time.

NRZI. Non-return-to-zero inverted recording.

NRZ-1. Non-return-to-zero change-on-ones recording.

NSAP. Network service address point.

NSC. Network Support Center.

NSM. (See 2220 Nways Switch Manager)

NVDM. NetView Distribution Manager for AIX.

NTT. Nippon Telegraph & Telephone (Corporation).

numbering plan table (NPT). A set of parameters, organized in origin NPT and destination NPT, that defines a type of called ISDN numbers. A numbering plan table is associated with each ISDN network interface.

Nways 2220 Switch Manager (2220 Switch Manager). An IBM licensed program that runs under NetView for AIX to manage the 2220 Nways Switch operation and configuration from a network management station. It replaces the Nways Enterprise Manager (NEM) which is no longer available.

Nways BroadBand Switch. Synonym for 2220 Nways BroadBand Switch.

Nways Enterprise Manager (NEM). An IBM licensed program that was used under NetView for AIX in a network management station to manage Nways Switches, routers, and bridges in a 2220 network (see 2220 Nways Switch Manager).

Nways Switch. Synonym for 2220 Nways BroadBand Switch.

Nways Switch administration station (NAS). A station attached to each 2220 to run the Control Program, and control and service the Nways Switch locally.

Nways Switch configuration station. A mandatory OS/2 or AIX station that runs a stand-alone version of the Nways Switch Configuration Tool Version 2 (NCT2) and stores the centralized configuration database of the NBBS network. An OS/2 station can be used as a remote user console.

Nways Switch Configuration Tool Version 2 (NCT2). A component of the Nways Switch Control Program that is used to configure physical and logical resources. It is also used in stand-alone version under OS/2 or AIX .

Nways Switch Control Program. The IBM licensed program that runs in the NAS and adapters of the 2220 Nways Switch. It includes a CMIP agent to work with the 2220 Switch Manager.

Nways 2220 Switch Manager for AIX. (See Nways 2220 Switch Manager)

Nways Switch Resource Control. A component of the Nways Switch Control Program. It is used from the NAS of an Nways Switch or from a remote user console to control resources and configuration files.

OAM. Operation, administration, and maintenance.

OC3. Optical carrier level 3.

ONPT. Origin numbering plan table.

operation, administration, and maintenance (OAM). A group of functions coded in specific ATM cells to handle alarms and loopback tests on ATM connections.

optical fiber. In fiber optics technology, a wave guide that propagates optical signals from light-generating transmitters to light-detecting receivers.

OSI. Open systems interconnection.

packet loss ratio. The probability that a packet will not reach its destination or not reach it in a specified time. It is obtained by dividing the number of packets lost in transmission by the total number transmitted.

packet transfer mode (PTM). The native transfer mode of the NBBS architecture. PTM divides the traffic into packets of variable length.

PBX. Private branch exchange.

PCM. Pulse code modulation.

PCR. Peak cell rate.

PDH. Plesiochronous digital hierarchy.

permanent virtual circuit (PVC). A virtual circuit that has a logical channel permanently assigned to it at each item of data terminal equipment. It is activated by a program or by a network operator request.

plesiochronous. Refers to transmission at a nominal bit rate where the source and destination are controlled by different clocks. The bit rates are nearly the same.

PLP. Packet layer protocol.

PNP. Private numbering plan.

port. See logical port.

port adapter. In an Nways Switch, a module that provides access services to one or more port lines. Each port adapter is associated with a line interface coupler (LIC).

port line. A communication line that connects a device on user premises to an Nways Switch and serves as a port to the 2220 network. Port lines have different protocols and interfaces.

position. When configuring an Nways Switch, the position parameter indicates the line attachment number on the LIC module (1 to 8, depending on the LIC type).

potential connection. A predefined connection through a 2220 network between two HDLC, CES, or frame-relay devices.

PPP. Point-to-point protocol.

PRA. Primary Rate Access.

private branch exchange (PBX). A switching system located on a user premises that relays inside lines (extensions) and provides access to the public telephone network.

PRS. Primary reference source.

PSDN. Packet switched data network.

PSN. Public switched network.

PSTN. Public switched telephone network.

PTF. Program temporary fix.

PTM. Packet transfer mode.

PTNX. Private telecommunications network exchange.

pulse code modulation (PCM). A standard adopted for the digitalization of analog voice signals. In PCM, voice is sampled at a rate of 8 kHz and each sample is coded in an 8-bit frame.

PVC. Permanent virtual circuit.

Q signaling (QSIG). An international standard for signaling procedures in private telecommunication networks. It applies to the PBX-to-Nways Switch interface, which is called the Q reference point.

QoS. Quality of service.

QSIG. Q signaling.

quality of service (QoS). In a 2220 network, a set of parameters that guarantees the characteristics of a connection, mainly its end-to-end delay, delay variation, and packet loss tolerance.

RABM. Router and Bridge Manager.

rack. A metallic structure, with a standard 19-inch width, that houses the hardware elements of an Nways Switch, that is, logic subrack with modules, fan boxes, and power units. When configuring an Nways Switch, the rack parameter indicates the 2220 Model (rack A is the Model 300 or 500, and rack B is the Model 501).

RDI. Remote defect indication.

real-time processing. Refers to the manipulations of data that are required, or generated, by certain process while the process is in operation. Usually, the results influence the process and, perhaps, related processes.

remote user console. A station running OS/2, TCP/IP, and Nways Switch Resource Control. It can be connected to the NAS of an Nways Switch to remotely control and service it.

resource. In an Nways Switch, a hardware element or a logical entity created by the Control Program. Adapters, modules, and line attachments are examples of physical resources. Control points, logical trunks, logical ports, and network interfaces are examples of logical resources.

resource profile. A record of the characteristics of an Nways Switch resource. It includes (for example) the part number or module name, the change level, and the name and phone number of the person to contact when a problem occurs.

RETAIN. Remote Technical Assistance Information Network

RIP. Route Information Protocol.

router. An attaching device that connects two LAN segments of the same or different architectures. It can also be connected to a wide area network. A router works at the network level (layer 3) of the OSI reference model by determining the best paths for network traffic flows.

Router And Bridge Manager. An application that provides distributed management for routers such as the IBM 2210 or 2216, bridges such as the IBM 8229, and communication controllers such as the IBM 3746 in IP mode.

RS. Recommended specification.

RSF. Remote support facility.

RSN. Receive sequence number.

RT. Real-time.

RVX. RS/EIA-232, V.24/V.35, X.21.

s. Second.

SCR. Sustainable cell rate.

SDH. Synchronous digital hierarchy.

SDLC. Synchronous data link control.

SDT. Structured data transfer.

serial line internet protocol (SLIP). A TCP/IP protocol used on a point-to-point connection between two IP hosts over a serial line (for example, an RS/EIA-232 connection to a modem over a telephone line).

SLA. Serial link architecture.

SLIP. Serial line internet protocol.

slot. When configuring an Nways Switch, the slot parameter indicates the module location (1 to 12) in the logic subrack.

SNA. Systems Network Architecture.

SNMP. Simple Network Management Protocol.

SONET. Synchronous optical network.

spanning tree. See CP spanning tree.

SRC. System reference code.

SSN. Send sequence number.

station. A microcomputer that is connected to a host or a network and at which a user can run applications.

STM-1. Synchronous transport module type 1.

STS-3c. Synchronous transport signal type 3 concatenated.

SUB. Subaddress.

subrack. A metallic structure installed in an Nways Switch rack. A logic subrack holds modules. A power subrack holds power supply components.

SVC. Switched virtual circuit.

SW. Switch (module).

switch module (SW). A module of the 2220 Model 300 or 500 that interconnects the adapters through an ATM cell switch. It can have a backup.

switch redrive (SWRD). A module of the 2220 Model 501 that drives the signals from the switch module in the Model 500 to the adapters of the Model 501. It can have a backup.

SWRD. switch redrive (module)

switched virtual circuit (SVC). A connection set up from a calling address to a called address following a call establishment protocol. It is released when a clear request signal is received.

synchronous digital hierarchy (SDH). A international recommendation for the internal operation of carrier optical networks.

synchronous optical network (SONET). A U.S. standard for transmitting digital information over optical interfaces. It is closely related to the international recommendation for synchronous digital hierarchy (SDH).

T1 standard. A TDM digital transmission service with a basic rate of 1.544 Mbps. Also called DS-1.

T3 standard. A TDM digital transmission service with a basic rate of 44.736 Mbps. A T3 line can transport up to 28 T1 circuits. Also called DS-3.

TCPA. Trunk and control point adapter.

TCP/IP. Transmission Control Protocol/ Internet Protocol.

TDM. Time division multiplexing.

TE. Terminal equipment.

Telnet. In TCP/IP, an application protocol that allows a user at one site to access a remote system as if the display station were locally attached. Telnet uses the Transmission Control Protocol (TCP) as the underlying protocol.

time division multiplexing (TDM). The process of breaking the bandwidth on a communication line into a number of channels, possibly of different size.

TME. Tivoli Management Environment.

TMN. Telecommunication Management Network.

TPA. Trunk or port adapter.

Transmission Control Protocol/ Internet Protocol (TCP/IP). A set of communication protocols that support peer-to-peer connections over both local and wide area networks.

transport services. Functions that are performed by a trunk adapter of an Nways Switch to:

- Support the attachment of trunk lines
- Maximize bandwidth utilization
- Guarantee the quality of service of a connection
- Transfer packets between Nways Switches
- Manage logical queues and schedule transmission.

trunk. See logical trunk.

trunk adapter. In an Nways Switch, a module that provides transport services to one or more trunk lines. Each trunk adapter is associated with a line interface coupler (LIC).

trunk line. In a 2220 network, a high-speed line connecting two Nways Switches. It can be, for example, a copper cable, optical fiber, or radio wave guide and can be leased from telecommunication companies.

UBR. Unspecified bit rate. A best effort service with no quality commitment.

UNI. User network interface.

UPC. Usage parameter control.

URL. Uniform resource locator.

user network interface (UNI). A standardized interface between a user and a communication network.

UTC. Universal time, coordinated.

UUS. User-user signaling.

VBR. Variable bit rate.

VC. Virtual channel.

VCC. Virtual channel connection.

VCI. Virtual channel identifier.

VCN. Virtual circuit number.

virtual channel (VC). In ATM, a unidirectional route between two ATM devices. Virtual channels always come in pairs, one in each direction. They follow virtual paths.

virtual channel connection (VCC). In ATM, a unidirectional connection established over a virtual channel. Virtual channel connections always come in pairs, one VCC in each direction.

virtual channel identifier (VCI). In ATM, the unique numeric tag that identifies every channel. It is defined by a 16-bit field in the ATM cell header.

virtual connection. In frame relay, the return path of an FR potential connection.

virtual path (VP). In ATM, a group of virtual channels that are switched together as one unit. (Also called VC service.)

virtual path connection (VPC). In ATM, a connection established over a virtual path. Virtual path connections always come in pairs, one VPC in each direction. (Also called VP service.)

virtual path identifier (VPI). In ATM, an 8-bit field in the ATM cell header that indicates the virtual path over which the cell is to be routed.

voice server adapter (VSA). In an Nways Switch, a module that supplies additional voice functions to voice connections operating in pulse code modulation at 64 kbps. It can attach a voice server extension (VSE).

voice server extension (VSE). In an Nways Switch, a module associated with a voice server adapter (VSA) to supply voice functions to an extended number of PCM voice connections.

VP. Virtual path.

VPC. Virtual path connection.

VPD. Vital product data.

VPI. Virtual path identifier.

VPN. Virtual private network.

VSA. Voice server adapter (module).

VSEn. Voice server extension type n (module).

WAN. Wide area network.

wide area network (WAN). A network that provides communication services to a large geographic area. It can use or provide public communication facilities.

window. On the screen of a station, an area with a title bar, a menu bar, and scroll bars.

X.25 hunt group. A group of X.25 network interfaces associated with one common subscriber address. If an interface is busy, the connection searches (hunts) for the other interfaces of the group until a free one is found.

X.25 network interface. A logical resource generated by the Nways Switch Control Program to provide access services to a physical X.25 port line. An X.25 network interface sets up and maintains connections between calling X.25 subscribers and called subscribers attached to other Nways Switches.

X.25 Recommendation. An international standard for the interface between data terminal equipments and packet-switched networks.

X.25 subscriber. An X.25 end-user connected to an X.25 network interface through a DTE. A subscriber is defined by an address and a logical name.

Bibliography

This section lists prerequisite and related publications.

Nways Switch Publications

- *2220 Nways BroadBand Switch At a Glance, an Overview*, GA33-0292
- *2220 Nways BroadBand Switch Planning Guide*, GA33-0293
- *2220 Nways BroadBand Switch Configuration Guide*, GA33-0474
- *2220 Nways BroadBand Switch Physical Lines Interface Specifications, External Cable References*, GA33-0379
- *2220 Nways BroadBand Switch Frame Relay Interface Specifications*, GA33-0374
- *2220 Nways BroadBand Switch HDLC Interface Specifications*, GA33-0375
- *2220 Nways BroadBand Switch CES Interface Specifications*, GA33-0376
- *2220 Nways BroadBand Switch ATM Interface Specifications*, GA33-0378
- *2220 Nways BroadBand Switch X.25 Interface Specifications*, GA33-0413
- *2220 Nways BroadBand Switch ISDN Interface Specifications*, GA33-0447
- *How to use the NAS*, online tutorial[1]

Nways 2220 Switch Manager Publications

- *IBM Nways 2220 Switch Manager for AIX Installation Guide*, SH11-3088
- *IBM Nways 2220 Switch Manager for AIX: Performance Monitoring and Accounting*, GA33-0366
- *IBM Nways 2220 Switch Manager User's Guide*, online manual[2]

TME 10 NetView for AIX Version 5 Publications

- *NetView for AIX Installation and Configuration* , SC31-8163
- *NetView for AIX V4R1 User's Guide* , SC31-8158

TMN 2.2 Publications

- *TMN 2.2 General Information* , GT01-0458
- *TMN 2.2 Agent User's Guide* SC31-8157

TME 10 Software Distribution Publications

- *Software Distribution for AIX Concepts* , GH19-4161
- *Software Distribution for AIX Getting Started* , GH19-4162
- *Software Distribution for AIX User's Guide* , GH19-4163
- *Software Distribution for AIX Installation and Customization* , GH19-4164
- *NetView Distribution Management Agent/2 User's Guide* , SH19-4084

OSI System Management Standards for CMIP

OSI stands for Open Systems Interconnection

OSI Management Framework and Overview

- *OSI Basic Reference Model Part 4: Management Framework* ISO 7498-4
- *Systems Management Overview* ISO 10040

CMIP/CMIS

- *Common Management Information Service Definition* ISO 9595

Systems-Management Functions

- *Part 1: Object Management Function* , ISO 10164-1
- *Part 2: State Management Function* , ISO 10164-2
- *Part 3: Attributes for Representing Relationships* ISO 10164-3
- *Part 4: Alarm Reporting Function* , ISO 10164-4
- *Part 5: Event Report Management Function* , ISO 10164-5

1. Online documentation delivered with the 2220 Nways Switch Control Program.
2. Online documentation delivered with the Nways 2220 Switch Manager product.

- *Part 9: Objects and Attributes for Access Control* ISO 10164-9
- *Accounting Management* , SC 21 N 4971
- *OSI Software Management* , SC 21 N 6040
- *General Relationship Model* , SC 21 N 6041
- *Performance Management* , SC 21 N 6306

Management Information Model

- *Part 1: Management Information Model* , ISO 10165-1
- *Part 2: Definition of Management Information* , ISO 10165-2
- *Part 5: Generic Managed Information* , ISO 10165-5

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