

IBM ILOG CPLEX Optimization Studio 12.2 – The Most Complete Optimization

Event: 244202

Moderator: Welcome to today's webcast, "IBM ILOG CPLEX Optimization Studio 12.2." This presentation will last approximately 30 minutes with a couple of polling questions at the end and time for Q and A. You can submit your questions at any time during the presentation and we will answer them at the end.

I would like to introduce our presenter today, Thomas Dong. Thomas Dong is the Senior Product Marketing Manager of the ILOG Optimization and Analytical Decision Support Solution. Tom has been with IBM since 2001 via the ILOG acquisition and currently leads the worldwide ILOG Optimization and Analytical Decision Support Solution's product marketing team.

Mr. Dong is also a volunteer on the INFORMS Science is Better PIC subcommittee and is a past member of the INFORMS Practice Conference Advisory Council. Mr. Dong holds an MSc in Operations Research from Princeton University. And at this time I would like to hand the presentation over to our presenter so we can get started. Tom?

Thomas Dong: Welcome to today's webcast titled "IBM ILOG CPLEX Optimization Studio 12.2 – The Most Complete Optimization Development Toolkit." In this presentation we will be discussing the latest enhancements to CPLEX Optimization Studio from streamlined packaging and licensing to major performance improvements in CPLEX Optimizer, the world's most trusted and widely deployed solver. For those of you new to our products, we will also be providing a brief overview of the product and its main features. Let me begin by introducing the ILOG Optimization Product Portfolio.

For long time users, depending on when you began using ILOG products, you will immediately notice that our offerings have been streamlined from close to 10 products and 5 bundles down to just 2. CPLEX Optimization Studio as depicted here on the left now completely supports the rapid development and deployment of both mathematical programming and constraint programming models for multiple development interfaces, a powerful IDE using the OPL modeling language, programmatic APIs via other third party modeling interfaces using supported CPLEX Optimizer connectors.

This single integrated offering features at its core industry-leading solvers for both mathematical programming and constraint programming. ILOG CPLEX Optimizer includes Simplex, Barrier and Mixed Integer algorithms for solving the full range of linear, quadratic and integer programming models.

Also including in CPLEX Optimizer is CP Optimizer for constraint programming and constraint-based scheduling. Note that CPLEX Optimization Studio through its Java API also supports the development of custom algorithms to work alongside your mathematical programming and constraint programming models.

Now to offer full flexibility during development, CPLEX Optimization Studio enables users to deploy CPLEX Optimizers into their own applications in a variety of ways. First, Concert Technology shown above the engines in the black bar is a unified object oriented modeling layer for all ILOG Optimization products, accessible in C++, Java and .NET. It allows users to represent optimization problems without the use of conventional matrixes, treating constraints as expressions that resemble all the right formulation.

Alternatively, the matrix-oriented access to the native C-language routine, the callable library provides the most direct interface to CPLEX Optimizer and offers an additional level of control over the most highly technical aspects of the solution algorithms.

Secondly, a key feature of CPLEX Optimization Studio is its graphical Integrated Development Environment or IDE shown at the top of the product diagram. The CPLEX Studio provides intuitive tools for model development, testing, profiling and tuning. It is built on the Optimization Programming Language or OPL as well as scripting language called OPL Script which is based on Java Script. Together, OPL and OPL Script offer declarative, rich and compact modeling and scripting language for mathematical programming with CPLEX Optimizer and Constraint Programming and Constraint-based scheduling with intuitive CPLEX CP Optimizer.

The IDE provides many productivity features to [code assist] the projects for organizing and managing optimization models and data with out-of-the-box access to major databases and Microsoft Excel. And for models defined in the OPL modeling language, users can directly deploy those models into production by embedding through Java, C++ or .NET.

Third and finally, connectors shown on the bottom left most side of the product diagram, the Microsoft Excel, MATLAB, AMPL, Python and Microsoft Software Foundation with engineers, scientists, mathematicians, statisticians, economists and software developers alike – the ability to tap into the power of CPLEX Optimizer within their familiar environment.

So in summary, CPLEX Optimization Studio packages together best-of-breed solvers and modeling tools and as such is the most complete OR toolkit available on the market. It includes multiple development interfaces but is designed ultimately with the deployment of your models to production in mind. You can directly embed component libraries for your OPL models into your Java, .NET, or C++ application. Alternatively, IBM also offers ODM Enterprise, an enterprise class platform for generating complete software application directly from CPLEX Optimization Studio. Leveraging decades of implementation experience, IBM has packaged best practices and optimization-based planning and scheduling to offer multi-user collaboration, what-if analysis, scenario management, data analytics and integration with Microsoft Office Tools out-of-the-box.

For more information on ODM Enterprise, please visit our website where you will find data sheets, white papers and a recording of a webcast from the same series titled, “ODM Enterprise: A Platform for Business Centric Planning and Scheduling Applications.”

For those of you familiar with ILOG’s products, especially for those of you with existing entitlement, you may be wondering how CPLEX Optimization Studio relates to you. It is important to note that CPLEX Optimization Studio is now IBM’s single OR tools offering and individual development components are no longer available. The good news is that all active entitlements for development licenses of earlier versions of CPLEX and CPL Optimizer plus all former OPL CPLEX development bundles now all equally entitle you to CPLEX Optimization Studio.

Moreover, deployment licenses for CPLEX Optimizer will now entitle you to use both math programming and constraint programming. Plus you will no longer be required to choose between MP and CP in either development or deployment.

The other major change in the latest release, built on our integration to IBM and adoption of IBM values, mainly trust in every relationship. Licensing does little to exemplify trust with our paying commercial customers who have already entered a legally binding contract with access to our products. And as such, we are delighted to announce the burdensome process of licensing has been eliminated.

In addition to these packaging and licensing changes, CPLEX Optimization Studio 12.2 has major release level feature enhancements which we will cover next beginning with what's new in the IDE, followed by the connectors and finally the engine.

Let's begin first with the CPLEX Studio IDE. With a focus on modern usability standards, the CPLEX Studio IDE provides powerful, easy-to-use productivity tools for model development, testing, profiling and tuning [for each] deployment. This screenshot highlights the main development view of models where you define and debug your optimization model.

In the latest release, support for testing and solution analysis in particular has been enhanced for the class of problems related to scheduling. For solution results are best viewed in a Gantt chart. Therefore in addition to being able to view data and engine results in tabular form, engine problems can now be viewed in both resource and activity Gantt chart views. Using these views, you can quickly validate your input data and scheduling models alike.

While the IDE is the premier development interface for math programming and constraint programming models, CPLEX Optimizer as a best-of-breed solver often reaches markets already served by other modeling interfaces. And that is why roughly two years ago IBM embarked on an interoperability strategy to better support our engines for third party product.

In the latest release we have continued to evolve and improve the connectors for Microsoft Excel, MATLAB and Python. And we have also added two more supported connectors to the product. We now support the latest release of Microsoft Software Foundation 2.0 and we now include a connector for AMPL allowing you to connect the latest releases of CPLEX and AMPL, regardless if you have purchased AMPL from IBM or another AMPL reseller.

In terms of improvement to our existing solver connectors, our first connector for Excel 2003 and 2007 brings the speed, robustness and reliability of CPLEX Optimizer to spreadsheet optimization, providing direct access from the Excel user interfaces along with all of the features CPLEX users expect, including support for all CPLEX problem types, solution analysis and algorithmic parameter setting.

You can use Excel functions to create the linear and quadratic expressions in the model or alternatively invoke a macro. For those of you familiar with the connectors from the last release, in the latest Excel Add-in you will notice various performance improvements in the interface for building the model.

The second connector for MATLAB has been designed to offer CPLEX Optimizer functions with similar or identical arguments to corresponding MATLAB toolkit functions, making it easy to test a CPLEX from an existing MATLAB application and bringing an industry-leading mixed integer and quadratic solver to the leading numerical computing environment. For the MATLAB toolbox, support has been added in the latest release for the [stream] binary integer [least-squares] problem, non-negative quadratically constrained least-squares problem and quadratically constrained least-squares problem.

Additionally solution quality functions for MATLAB expanded to cover the same functionality as in the APIs as well as various performance improvements and interface for building a model.

Finally, the Python connector brings expressiveness of Python to object-oriented features for the math programming community. The space in the sparse matrix data structures of the [C-API] and offers the flexibility and controls of the C-API all with potentially faster development time. It also offers additional interactive functionality not available in CPLEX Interactive Optimizer. For example, users can request concepts of work criteria, (inaudible), [faces] inverse rules directly without writing a program in C or C+ .This can ultimately result in more efficient debugging and troubleshooting.

So for users of the Python connector, the latest release adds formatted reports and histograms for the problem statistics, new methods for reporting solution quality for the incumbent or members of the solution pool, and finally support for Python 2.6.

Our interoperability story is based on the best-of-class performance of our engine. And with the latest release another round of ground-breaking performance improvements have been achieved, firmly establishing CPLEX Optimizer not only as the most robust and reliable solver on the market, but also the fastest.

That has been the theme of the latest release. What the development team focused on further boosting the speed of the MIP solver. In MIPs they achieved the remarkable 2.7x speedup on difficult models which makes it typically a strong release. For the barrier solver they achieved a smaller but welcomed 16% speedup nearly across the board. In both of these cases the improvement comes

always form enhancements and the fundamental algorithms and the implementation for parallel processing. But as always the CPLEX team has also added some other goodies that our users should like. For MIP users a feature was added that provides an assessment of the numerical stability of the [sum] problem during Branch & Cut. This is analogous to the so-called (inaudible) value, the condition number for continuous LP and QP matrixes. And so we call this new feature MIP Kappa. The MIP Kappa feature lets you judge how reliable the final solution is in terms of the stability of the model itself.

Finally new ports are included in the standard release for Solaris on a 32-bit x86 platform and for Linux on IBM z series and p series hardware.

Now let me talk a little more in a little detail about the performance improvements on mixed integer models. Here we have a chart in the style that the CPLEX uses for assessing performance using the previous release CPLEX 12.1 as a reference I will refer to in comparison.

The team uses a set of real world models, contributed from a variety of sources included the largest user base in the world. We divide the full test set according to the slower of the two versions being compared and group all models taking under one second in both versions in the first line, models taking more than one second but less than 10 seconds in the second line, and so on.

This way of grouping is a conservative one to do performance testing and removes a former bias that favors the new version. Simple notable points here. First, as is typically the case for MIP, the benefit of the advanced features in this new release increases rapidly if the model difficulty increases. The speedup factor shown here are geometric means which also is a conservative form of measurement compared to just say normal averages.

Not shown are models taking greater than 10,000 seconds since that was the time limit used for those [room].

The second point to mention is performance on MIP models remains highly variable inherently so and users should be aware that on any given model it is possible for there to be some aggression as demonstrated in the wins/losses column.

If you are concerned with measuring performance you should always use more than just one model for the comparison. However, when slowdowns occur they can appear much smaller in size than the speedups on other models. Otherwise impressive overall speedup could not have been achieved.

The bottom line summarizes for all of the models except the trivial ones taking under a second, an overall speedup of 50% is reached. And focusing on just the difficult models, taking at least 1,000 seconds and assuming a conservative speedup of models taking longer than 10,000 seconds, the speedups seen was at least 2.7 times.

Turning now to the barrier solver for linear program, the performance story is much simpler to tell. The same comparison methodology was used. You can see that there is much less variability as shown in the win/losses column. And once you get beyond trivial models taking less than a second, a fairly stable double digit percentage speedup is witnessed.

Indeed the speedup peaks slightly on the easier models, like 1 to 10 seconds because one part of the speedup was due to the removal of certain parallel processing bottlenecks that affected all models equally. And thus on a percentage basis is a bit larger on easier models. There is not much more to say about this, but if you use barrier for you LP models, look for this speedup in your run. So CPLEX continually sets the standard for itself.

Let's take a quick historical look at the market-leading performance of CPLEX and how it stacks up against prior releases. For fun we dug up some marketing messages for releases of the past decade or so. As explained earlier, a single speedup number doesn't usually give good insight on what to expect. But we generally provide two numbers. As you can see, version 12.2 stacks up very favorably to these other release, all except for CPLEX 11, which remains a once in a decade event. This new release is quite an achievement for the team considering that each time they have to beat the previous state of the art.

People who wonder what CPLEX will be like under IBM now have two releases to judge us by. It is hard work but the team (inaudible) the details and came through once again. We think users should be pleased with the results.

CPLEX has come to be known, obviously, as the leading commercial math programming solver on the market. The company behind CPLEX is equally known for leading advances in the area of constraint

programming. And now you will find the CPLEX name backing IBM's leadership in all aspects of mathematical optimization, offering a collection of algorithms for both math programming and constraint programming. CPLEX Optimizer now provides the greatest flexibility in both development and deployment, giving access to Simplex, barrier, mixed integer and constraint programming optimizers from a single development or deployment license.

In the latest release a number of enhancements have been made to the Constraint Programming Optimizer. CPLEX Studio Version 12.2 provides new integer expressions and constraints that allow for easier modeling of problems that involve constraints and costs related to transitions between activities executed on a unary resource.

For instance, it is now possible to model transition costs or transition times that hold between immediate successors in a sequence. Furthermore, constraints between sequence variables such as in permutation [floor shop] problems are now easier to handle. Also new in 12.2 are the new CP Search API. While the modeling objects provided by Concert Technology and the automatic search procedures provided by CP Optimizer will generally perform well to solve your model, in some situations you may need full flexibility of writing and maintaining the solution process in various ways such as writing custom constraints for custom constructive search by [means pool].

With this release the number of new classes and functions are provided in the CP Optimizer Engine Extension for implementing custom scheduling constraints in search. Documentation and samples are provided with [advised] help. Users decide whether custom algorithmic developments are necessary and if so to provide search procedure characteristic principles, design implementation, and source code for building block.

With that, I have covered the highlights of the latest release of CPLEX Optimization Studio which once again sets the bar for product leadership in terms of both completeness of offering and performance on three distinct but equally important elements – speed, robustness and reliability.

For existing customers, we hope you upgrade as soon as possible to leverage the latest features and for many of you the opportunity to take advantage of your new entitlement under the new packaging.

For those evaluating and considering CPLEX Optimization Studio, let me now point you to our free 90-day trial. The trial is of the full featured product for solving instructional or prototype size problems.

Those limits are 500 variables by 500 constraints for math programming problems and for constraint programming the search space is limited to 20,000 discrete decision variables. You can find this trial directly on the CPLEX Optimization Studio product page at www.ibm.com, or the link provided here.

Now for more advanced purchase decisions, you can also work directly with your IBM account executive to evaluate the full product with no limits on problem size. Please note that the trial is for CPLEX Optimization Studio for all third party connectors, all the APIs and well the IDE are available in the trial.

Finally, for our academic customers, a quick word on IBM Academic Initiative which has been offering no-charge access to ILOG Optimization product and related coursework to qualified members since February of 2010. To qualify you must be a faculty member or research professional at an accredited institution or qualifying member of a standards organization. Membership is granted on an individual basis and must be renewed annually. Please note that there is no limit on the number of members from an institution that can join and since membership is granted on an individual basis, each member of your department will need to personally qualify to download and access the software.

The question is why does IBM offer free software to academics? Well, for decades IBM has relied on its strong ties with academia. In fact, computer science came into its own as a discipline in the 1960s with IBM's involvement with universities. Under the Academic Initiative we hope to achieve the same for Operations Research and Management Science as an academic discipline.

So what is the Academic Initiative? Well at the turn of the century IBM's university ambassadors were noting a dramatic drop in the enrollment of STEM disciplines which are Science, Technology, Engineering and Math programs. As an IT company, IBM was very concerned about technical skills inhibiting industry growth, especially as demand for IT and technology related jobs continued to grow. So in 2004, IBM Academic Initiative was formed as a partnership between IBM and academia. Today the program impacts over 1 million students each academic year with over 4,000 faculty at some 3,000 institutions teaching nearly 10,000 courses using IBM technology.

IBM's Academic Initiative is specifically focused on promoting skills around standards-based software, together with new skills for the 21st Century, notably now in business analytics and optimization-related skills. The benefits to academic institutions and students are many, from easy access to open standards-based technologies and supporting resources, on-going staff development, increases in the placement and finally it ensures that academia and students have the most current relevant curriculum

that maps for the kinds of jobs that are expected so schools can be attractive for enrollment, funding and growth.

AI does not generate revenues for IBM, obviously, so it is important to acknowledge the worldwide community of IBM volunteers. There are over 2,200 volunteer IBM university ambassadors who regularly visit and maintain relationships with universities, colleges and even high schools of all sizes. There is also an on-demand community of over 40,000 IBMers and 5,000 retirees who make themselves available for speaking engagements or specials of each project.

IBM and its people are truly committed to the early adoption of our products and technologies in academia and why we are so excited by the inclusion of ILOG Optimization products in AI, especially as IBM funds its own investments in business analytics and optimization, a major growth market opportunity IBM sees as companies move beyond data modernization projects and seek to leverage the wealth of data and information to make better and smarter decisions.

To date, IBM has organized a service line and global business services dedicated to business analytics and optimization while IBM Software Group has formed a business analytics division and continues to make a number of acquisitions in addition to the recent launch for Cognos, ILOG and SPSS.

Aligning ILOG's past academic programs with IBM Academic Initiative was rather obvious given the reach ILOG Optimization products had in academia prior to our acquisition by IBM. In 2009, CPLEX and OPL Studio were first made available but were restricted versions suitable only for teaching introductory courses. We received very positive feedback following our official launch at INFORMS in San Diego in October of 2009 and decided to fast track our full move into AI.

Since February 15 of 2010, full versions of our products covering the entire IBM ILOG Optimization Product Portfolio are available targeting the full range of teaching and non-commercial research and academia.

For the full range of mathematical programming problems, academics have full access to CPLEX Optimization Studio for both teaching and research. Users can access CPLEX Optimizer through the OPL-based IDE, the programmatic APIs or via third party tools using the supported connectors.

For constraint programming/constraint-based scheduling, access to CPLEX CP Optimizer is available from CPLEX Optimization Studio. Alternatively, for solving complex routing and scheduling problems with constraint programming, IBM ILOG CP, our first generation constraint programming engine is also available through AI.

Please note that academic research editions of all ILOG Optimization products are available on all commercially supported platforms.

And with that I have covered the major new features of the latest release of CPLEX Optimization Studio and touched on a number of programs and initiatives that will allow you to quickly assess the latest release. As you prepare to submit your questions, let me summarize again for you some possible next steps.

First, if you are an existing customer and haven't already upgraded to 12.2, please do. If you are considering CPLEX Optimization Studio, please download the trial and contact an IBM account executive to discuss your needs. And finally if you are an academic and haven't yet registered for IBM Academic Initiative, please do so now. You will gain immediate access to the latest versions of all ILOG Optimization Software, free of charge, for use in your research and teaching.

Moderator: Okay, thank you Tom. And thank you to the audience for attending and we now have just two quick polling questions that we would like to ask before moving on to the Q and A. And we do have some good questions to answer. So, our first polling question is: How many years have you been using ILOG Optimization products? (A) less than 1 year; (B) more than one year and less than or equal to 5 years; (C) more than five years and less than or equal to 10 years; and (D) greater than or more than 10 years. So please go ahead and answer.

And the question again is how many years have you been using ILOG Optimization products.

Okay, looks like everybody has answered. Let's take a look at that. Thank you. And our next question: What is the most exciting feature for you in the latest release? (A) CPLEX MIP Optimizer performance improvements; (B) MIP Kappa; (C) MIP Barrier Optimizer performance improvements; (D) CPLEX CP Optimizer transition-based scheduling; (E) CPLEX Studio IDE Gantt charts; or (F) removal of license key enforcement.

So give everybody a moment to answer. And the question again was: What is the most exciting feature for you in the latest release?

Let's take a look. Great, it looks like everybody has answered. And there are the results. Okay.

Let's move on to the Q and A. A moment, just takes a second for my screen to refresh. Okay, first question. Does CPLEX support any non-linear optimization? It says: I recall that it used to support quadratic optimization to some extent. [Yana]?

Yana: Yes, the answer is that CPLEX does support some types of non-linear programs, more specifically CPLEX support quadratic programs, problems with the objective function which is quadratic. Certain kinds of quadratically constrained programs. As well as mixed integer quadratically constrained programs. And you will find more details and examples in documentation that is distributed with the IBM ILOG CPLEX Optimization Studio 12.2

Thomas Dong: Wendy, there was also a similar question from [Tao Zui] from UC who asked another question whether CPLEX sells any general non-linear optimization problems. So just let me address that as well. So as Yana said, we do solve a certain subset of non-linear optimization problems as she just listed. Currently we do not have any general non-linear solving capabilities but this is something that we have been considering for many years now and certainly remains on our roadmap now.

I will mention without making any particular commitments that now that we are part of IBM we do have the reach of IBM research and the contributions that that team has made in that field to potentially leverage moving forward. And this is certainly one of the synergies in IBM that we are hoping to leverage moving forward.

Wendy, would you ask the next question?

Moderator: The next question is for you, Tom. It says: I have one development and three runtime licenses. I have never been able to use OPL before. Are you saying that not only can I develop using

OPL, (a) can I also use the resulting model with my three runtime licenses? If so, that is wonderful, exciting and I can't wait.

Thomas Dong: Okay, yes. So let me just handle this in two separate parts. So yes, on the development side, absolutely – your entitlements that you had previously I presume were just on CPLEX. Yes, now your development entitlements are for the CPLEX Optimization Studio which provides you access to the OPL-based IDE. So, yes, please upgrade to CPLEX Optimization Studio and you will now by all means have access to OPL.

The second part of your question I just want to be more careful on this one and that is with your runtime licenses or deployment licenses. If you had past entitlements, just keep in mind that those were application specific. So you can deploy still those runtime licenses but keep in mind that you did have a contractual limitation on the application area that you could use. But then again, as I noted, this covers both math programming and constraint programming now in a single deployment license.

Jack, if you are on the line, let me know if I did or didn't answer your question specifically or not. And if there are others on the line, I looked at the attendee list, we do have a lot of existing customers who might have similar questions as well.

Moderator: Great, thank you. Our next question says: I have a significant investment in my research and teaching that depends upon using Access data bases and Excel spreadsheets to import data and export solutions. This does not work in my Version 6.3. Does the current version of the IDE support these two products? Yana?

Yana: Yes, the current version of the IDE does support the Access database and Excel spreadsheets. This should also work in our last version of the IDE 6.3. So if there is any problem that you are running into, please feel free to contact the IBM ILOG technical support and we will be happy to assist you.

Moderator: Okay, let's see. Next question. Have you tested CPLEX 12.2 on problems for which another solver performs better than CPLEX 12.1 or older?

Thomas Dong: The benchmarks that I refer to here are on ILOG's test bench. And version over version and in continuous testing we always test against this test bed. And it is something that we are actually very proud of. It is confidential, it is a proprietary test that we have accumulated from all of our users who have been willing to provide us their more complex problems for which they have always wanted us to tune our engines against, in addition to obviously all of the public benchmarks that are out there.

Since CPLEX has always led in performance by comparing CPLEX to CPLEX, that has always been the only really relevant measure for us to improve the performance of our engine. So to answer your question then the answer is yes, we are continually tuning our engines to problems and continuing to make sure that release over release over this entire test bed which is several thousand test sets, that we are improving performance.

Moderator: Is there a plan to incorporate simulation optimization?

Thomas Dong: Let me answer this in two parts. So the first part is, obviously as IBM moves into the advanced analytics field and works at defining a software category around advanced analytics, this actually is a very relevant question that we are dealing with right now. And with the acquisition of SPSS for statistics and predictive modeling combined with ILOG Optimization, there are certainly a lot of synergies that we can exploit, especially as businesses become more comfortable with using advanced analytics techniques.

So simulation does come up quite often. Naturally we have seen a natural progression of our customers or IBM's customers moving from stats to simulation to optimization. And manufacturing is a very good example of that where simulation has been very effective and the next step in simulation has typically been to optimization.

So from a simulation perspective, IBM has looked at this a bit. I can't really say much more in terms of strategy around simulation other than that there are some basic Monte Carlo simulation capabilities in one of the WebSphere products called WebSphere Business Modeler. That is something that we could potentially exploit.

So, that is just, again, one of these forward looking statements that I can share just in terms of vision. It is not a commitment to anything but IBM obviously has a very large portfolio that we can leverage and over time we will be looking to exploit this.

And I think [Ram] also clarified here in his question that he is looking for Monte Carlo to handle uncertainty. So, again, stochastic programming, robust optimization and the like. These again are also very interesting areas of innovation that we are currently exploring, again with IBM research on things that we can do in these areas.

Moderator: That's our time. And so thank you Tom and thank you Yana. And thank you to the attendees. Today we know everybody has busy schedules and we appreciate you spending some time with us. And that concludes our presentation for today.