LINGO10:

Introduction

LINGO provides a completely integrated package that includes a powerful language for expressing optimization models, a full featured environment for building and editing problems, and a set of fast built-in solvers. Convenient Data Options

LINGO takes the time and hassle out of managing your data. It allows you to build models that pull information directly from databases and spreadsheets. Similarly, LINGO can output solution information right into a database or spreadsheet making it easier for you to generate reports in the application of your choice. Optimization Modeling with LINGO, a comprehensive modeling text discussing all major classes of linear, integer and nonlinear optimization problems.

Easy model expression

One of LINGO’s most powerful features is its mathematical modeling language. LINGO’s modeling language lets you express your problems in a natural manner very similar to standard mathematical notation. LINGO allows you to do things such as quickly express a series of similar constraints in a single compact statement.

When building models, you typically find there are one or more sets of related objects (e.g., sets of factories, customers, vehicles, or employees). Often if a constraint applies to one member of a set, then a constraint of the same form also applies to each of the other set members. Rather than requiring that you express an individual constraint for each set member, LINGO allows you to express the entire group of constraints in one concise statement. Taking advantage of sets is the foundation of LINGO’s modeling language, the fundamental building block of the program’s most powerful capabilities. LINGO even allows you to express common sets implicitly, such as days of the week or months of the year. LINGO’s modeling language can help you drastically cut your model development time. Very large models can often be efficiently expressed with LINGO in less than a single page. The modeling language’s similarity to standard mathematical notation makes it very easy to read.

Using LINGO, you can easily make your model "scalable". This means the dimensions of your model can change without requiring changes to your expression of the problem. For example, suppose you are finding the cheapest way to supply a product from several different warehouses to several different customers. If the number of warehouses or customers change, many modeling packages would require significant changes to the problem’s formulation. However, with LINGO, your problem formulation needs no modification. You can simply change the size of your data files and LINGO takes care of the rest.

LINGO’s modeling language includes an extensive library of mathematical, probability and financial functions. You can also create user defined functions for LINGO to use. LINGO accepts generalized expressions including those with parentheses and variables on the right-hand side.
manage data in a variety of forms

Gathering the model's data and getting it in an appropriate format can be a frustrating and time-consuming task, but with LINGO you can manage your data in a variety of convenient forms. LINGO lets you keep your data:

- In an Excel or Lotus spreadsheet file.
- In a database such as Access, Oracle, DB/2, Paradox, SQL Server etc.
- In a separate text file in list or table form.
- Stored with the model expression.
- Entered by the user when the model is run.

By providing a wide variety of data options, LINGO provides you with maximum flexibility and convenience. By allowing you to separate your expression of the problem from the data, LINGO models are easier to read and modify, and there is less chance of errors. It also makes prototyping problems on a smaller data set easy. Once you are comfortable with the model, you can easily swap in a larger set of data or several different data sets to investigate different scenarios. LINGO's flexibility even makes creating reports easy. In addition to being able to read data from spreadsheets and databases, LINGO can also write solution information to these formats. This means that, rather than forcing you to learn some built-in report generator, you can simply output the solution to your application of choice for building reports and analyzing the output.

Powerful solvers

Linear Solvers

LINGO is available with three state of the art solvers for linear models.

- **Primal and Dual Simplex Solvers**

  The base version includes the Primal and Dual Simplex solvers, which incorporate numerous enhancements for maximum speed and robustness. Pricing options, for instance, include partial pricing and Devex. You have the option to choose the best pricing strategy based upon problem characteristics.

- **Barrier Solver**

  The optional Barrier solver provides an alternative means of solving linear models. The Barrier option utilises a barrier or interior point method to solve linear models. Unlike the Simplex solvers that move along the exterior of the feasible region, the Barrier solver moves through the interior space to find the optimum. Depending upon the size and structure of a particular model, the Barrier solver may be significantly faster than the Simplex solvers and can provide exceptional speed on large linear models, particularly on sparse models with more than 5,000 constraints or highly degenerate models. The Barrier licence option is required to utilise the Barrier solver.
Integer Solver

For models with general and binary integer restrictions, LINGO includes an integer solver that works in conjunction with the linear, nonlinear and quadratic solver. For linear models, you have the ability to tailor the solution strategy and apply different classes of cuts to ensure maximum speed on particular problem structures.

Nonlinear Solvers

LINGO includes a number of ways to find locally or globally optimal solutions to nonlinear models.

- **General Nonlinear Solver**

For nonlinear programming models, the primary underlying technique used by LINGO's optional nonlinear solver is based upon a Generalised Reduced Gradient (GRG) algorithm. However, to help get to a good feasible solution quickly, LINGO also incorporates Successive Linear Programming (SLP). The nonlinear solver takes advantage of sparsity for improved speed and more efficient memory usage. The Nonlinear licence option is required to solve nonlinear models.

- **Global Solver**

Local search solvers are generally designed to search only until they have identified a local optimum. If the model is non-convex, other local optima may exist that yield significantly better solutions. Rather than stopping after the first local optimum is found, the Global solver will search until the global optimum is confirmed. The Global solver converts the original non-convex, nonlinear problem into several convex, linear subproblems. Then, it uses the branch-and-bound technique to exhaustively search over these subproblems for the global solution. The Nonlinear and Global licence options are required to utilise the global optimisation capabilities.

- **Multistart Solver**

When limited time makes searching for the global optimum prohibitive, the Multistart solver can be a powerful tool for finding good solutions more quickly. This intelligently generates a set of candidate starting points in the solution space. Then, the general nonlinear solver intelligently selects a subset of these to initialise a series of local optimisations. For non-convex nonlinear models, the quality of the solution returned by the multistart solver will be superior to that of the general nonlinear solver. The Nonlinear and Global licence options are required to utilise the multistart capabilities.

Quadratic Solver

In addition to solving linear and mixed integer models, with the Barrier option LINGO can automatically detect and solve models in which the objective function and/or some constraints include quadratic terms. By taking advantage of the quadratic structure, LINGO can solve these models much more quickly than using the general nonlinear solver. LINGO can even handle quadratic models with binary and general integer restrictions. These quadratic capabilities make LINGO suitable for applications such as portfolio optimization problems, constrained
regression problems, and certain classes of difficult logistics problems (e.g., layout problems, fixed-charge-network problems with quadratic objectives). The Quadratic solver is included in the Nonlinear licence option.

**Preprocessing and User Control**

Preprocessing routines are included in all solvers. The Linear and Nonlinear solvers include scaling and model reduction techniques. Scaling procedures can improve speed and robustness on numerically difficult models. Model reduction techniques can often make models solve faster by analysing the original formulation and mathematically condensing it into a smaller problem. The Integer solver includes extensive preprocessing and cut generation routines.

LINGO is designed so the user has as much control over the input to the solvers as possible. When the Solve routine is initiated, LINGO analyses the problem and considers internal parameters set by the user to achieve optimal performance for your particular problem.

**Linearisation**

LINGO's linearisation capabilities can dramatically improve performance on models with common nonsmooth functions. The feature can automatically convert many nonsmooth functions and operators (e.g., max and absolute value) to a series of linear, mathematically equivalent expressions. Many nonsmooth models may be entirely linearised. This allows the linear solver to quickly find a global solution to what would have otherwise been an intractable problem.

**What's New in version 10.0**

**New Programming Capabilities Support Looping, if/then/else, and more**

An extension to LINGO's modeling language allows users to easily solve a series of related models. You can solve one or more models in a loop, with model solutions being fed to subsequent models as input. LINGO includes examples of using this capability to find the efficient frontier of a portfolio model, solve a cutting stock model using column generation, and solving a traveling salesman problem.

**Faster Linear Solver**

Enhancements have made the Dual Simplex solver 40% faster on linear models than previous releases.

**Improved Integer Solver**

Broad classes of integer programming models solve significantly faster. Improvements in the Integer solver include a faster presolver, enhancements to exploit Special Ordered Sets and Semi-continuous variables, and improvements in the cut generation strategies to reduce the branch-and-bound size.

**Improved Global Solver**

The Global Solver, for non-convex nonlinear models, includes a number of enhancements that make it faster and more robust. The branching strategies used by the Global Solver have been improved - especially on mixed integer nonlinear models. The algebraic reformulation has been
improved to tighten the convex relaxation and improve tractability. The presolver for the Global Solver has been enhanced to more quickly find good, feasible solutions. The Global Solver supports several new mathematical functions.

**Improved Nonlinear Solver**

The Nonlinear solver includes a new option to compute second-order derivatives analytically, and first order derivative calculations are now done faster.

**Expanded Analytical Tools for Infeasible Models**

LINGO 9.0 included tools for helping pinpoint portions of a linear model that cause it to be infeasible. For release 10.0, this infeasibility analysis has been expanded to also support the full range of model classes, including mixed integer linear, quadratic, nonlinear and mixed integer nonlinear models.

**New Function for Table Output**

The Table function provides greater control over how multidimensional objects get displayed. The function displays either an attribute's values or a set's members in tabular format. It can also display sets and attributes of more than two dimensions.

**Improved Error Tracking**

LINGO has always had the ability to pinpoint compiler errors in the model source. LINGO can now trace runtime errors back to a single source line of the model, greatly facilitating model development and debugging.

**Windows Version Can Address 50% More Memory**

The standard Windows (Win32) version of LINGO can now access more memory allowing it to handle large, more complex models without running out of memory.

**New JNI Interface**

A Java JNI interface is now available for the LINGO callable DLL.

**New 64-bit Versions Available**

64-bit versions of LINGO are now available for the AMD Athlon and Intel Xeon processors running Windows XP64. These versions take full advantage of the 64-bit address space, allowing access to virtually unlimited memory.

**Support for Inverse of the Standard Normal Cumulative Distribution Function**

LINGO now supports the @NORMSINV() function for computing the inverse of the standard normal cumulative distribution.

**Additional Options**

- Priority of unary minus
- Linear generation mode for reduced memory consumption
- Linear optimality tolerance
- Second order derivatives
- Default lower variable bound
- BigM coefficient threshold
Terms related to Flow Chart are given as below:

NO is no. of decision variables
NS is no. of slack variables.

a is the array containing basis Matrix, Unit Matrix and basis.

c is an array containing values of Cj's.

d is an array containing values of b; e is an array containing values of b; f is an array containing values of b;