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**MIPIII** optimizes mathematical programs that contain variables that can take on only discrete or integer values, that is, Mixed-Integer Programming models.

Many models have an integer component - whether to build a facility at A or at B, whether to make the purchase from vendor X or Y, which single distribution center is used for each market, which mode of transportation is used, how are products sequenced on a line - the list of examples is endless. A mixed-integer model is no longer linear and requires additional algorithmic logic for optimization. The mixed-integer optimizer supplies that logic; it works with a linear optimizer (C-WHIZ or WHIZARD) to solve a controlled sequence of models to find the integer values for the discrete variables that results in the optimal all integer solution.

MIPIII enhances the reality of the mixed-integer model with a variety of variable types and discrete control structures: zero/one variables, bivalent variables, semicontinuous variables, general integer variables, type 1 and type 2 special ordered sets, special unordered sets, and logical constraints.

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Input of the matrix and specification of the integer variables can be done in several ways:

**STANDARD MPS INPUT** - Markers in the standard MPS input file denote which variables are integers or belong to special ordered sets.

**DATAFORM or OML** - In addition to creating the matrix these programs create lists of variable names to identify the integer variables and specify their types.

**MIPIII DRIVER** - The menu and dialogue screens include the facility to supply the list of integer variables and special ordered sets.

## INTEGER VARIABLE TYPES

**ZERO/ONE** - These variables may have only one of two values: zero or one.

**BIVALENT** - These variables may have only one of two values: zero or a specified value.

**SEMICONTINUOUS** - These variables must either be zero or have a value in a specified continuous range.

**GENERAL INTEGER** - These variables must have a whole number value within a specified acceptable range.

**SPECIAL ORDERED SET, TYPE 1** - From a specified list of variables, one and only one can have a nonzero value. Each set is ordered by a set of reference values associated with the variables. (Multiple choice)

**SPECIAL ORDERED SET, TYPE 2** - From a specified set of variables, one or two can be nonzero; if two they must be adjacent; the set sums to 1.0. (Piecewise linearization)

**SPECIAL UNORDERED SET** - From a specified set of variables one and only one is selected to be nonzero. There are no reference values to order the set.

**LOGICAL CONSTRAINTS** - A model can contain constraints that are honored conditionally, e.g., constraint B is in effect only if constraint A is met.

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A C-coded version of MIPIII has replaced the original DATAFORM-coded version. This was done to improve performance and to permit imbedding MIPIII in C- or FORTRAN-coded application programs via OML. The new MIPIII can also be invoked from within a DATAFORM program.

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# MIPIII, BRANCH AND BOUND MIXED-INTEGER OPTIMIZER

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## SIMPLIFIED EXECUTION CONTROL

MIPIII is controlled without having to code an execution control program. A control file supplies the information in tabular form.

One set of information tells MIPIII what to do and the names of model parameters, e.g., where is the matrix, what is the name of the objective function, bound and range sets, and the right-hand-side, the direction of optimization, the name of advanced basis to insert, where to write the solution, is this a resume of an earlier run, etc.

A second set of information tells MIPIII how to do it, e.g., maximum number of branch and bound nodes, the integer bound limit, forced first solution switch, various tolerances, node history save frequency, etc.

## GUIDANCE FROM THE USER

Often the user has additional information that might help find the best integer solution. MIPIII benefits from the following assistance:

**FORCED FIRST SOLUTION** - The FFS table suggests a good starting point for some or all integer variables, e.g., whether a variable is at zero or at its upper bound, which variable in an SOS is nonzero, and the value of a general integer variable.

**PRIORITIES** - The PRIOR table tells MIPIII which are the important integer variables and sets. In many cases it is helpful to make the strategic decisions first and then settle the less important matters. This table gives a numeric priority to any or all integer variables and sets.

**INTEGER BOUND** - If you can supply a good guess for the global optimal objective function value, the search time is shortened since MIPIII ignores all branches that are worse than your guess.

**BLASTOFF** - This optional starting mode is selected if it is perceived that a good strategy is to push integer variables to their nearest integer bound when they are relatively close in the continuous solution.

## MULTIPLE STOPPING CRITERIA

An exhaustive search for the global optimum may take prohibitively long. MIPIII honors the following premature stopping criteria:

**FIRSTINT** - As soon as MIPIII finds the first all integer solution node it terminates the search.

**NODE LIMIT** - After evaluating the specified number of branch and bound nodes MIPIII terminates the search.

**PERCENT OF OPTIMAL** - The first all integer node that is within the specified percentage of the theoretical best solution terminates the search.

After examining the results of a run that was terminated prematurely, you might want to resume the search. Resumption is extremely easy. Simply remove from the run control file instructions for input of the matrix and add the single keyword parameter, RESUME.

## SUPPORT

Technical assistance, training, and consulting services are available. Bionetics analysts have extensive experience formulating and implementing mixed-integer models using the sophisticated discrete variable constructs provided by MIPIII.

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