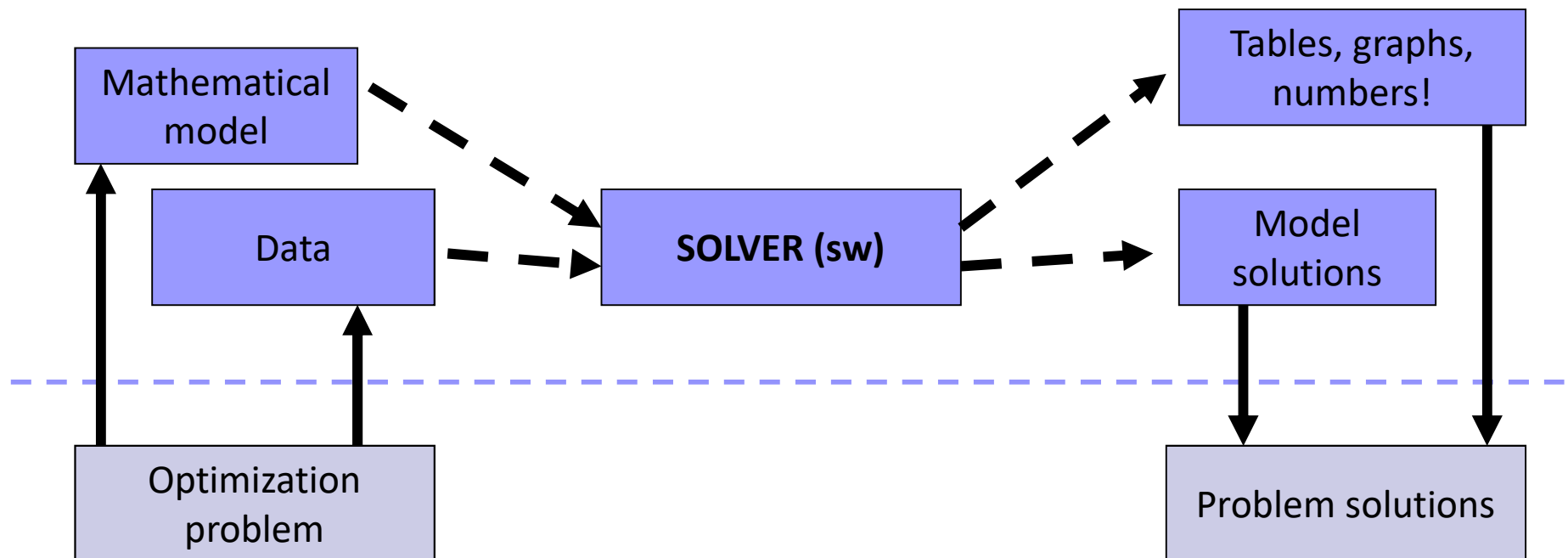


Solvers for Mathematical Programming

Solvers (optimizing engines)

A **solver** is a software application that takes the description of an optimization problem as **input** and provides the solution of the model (and related information) as **output**.



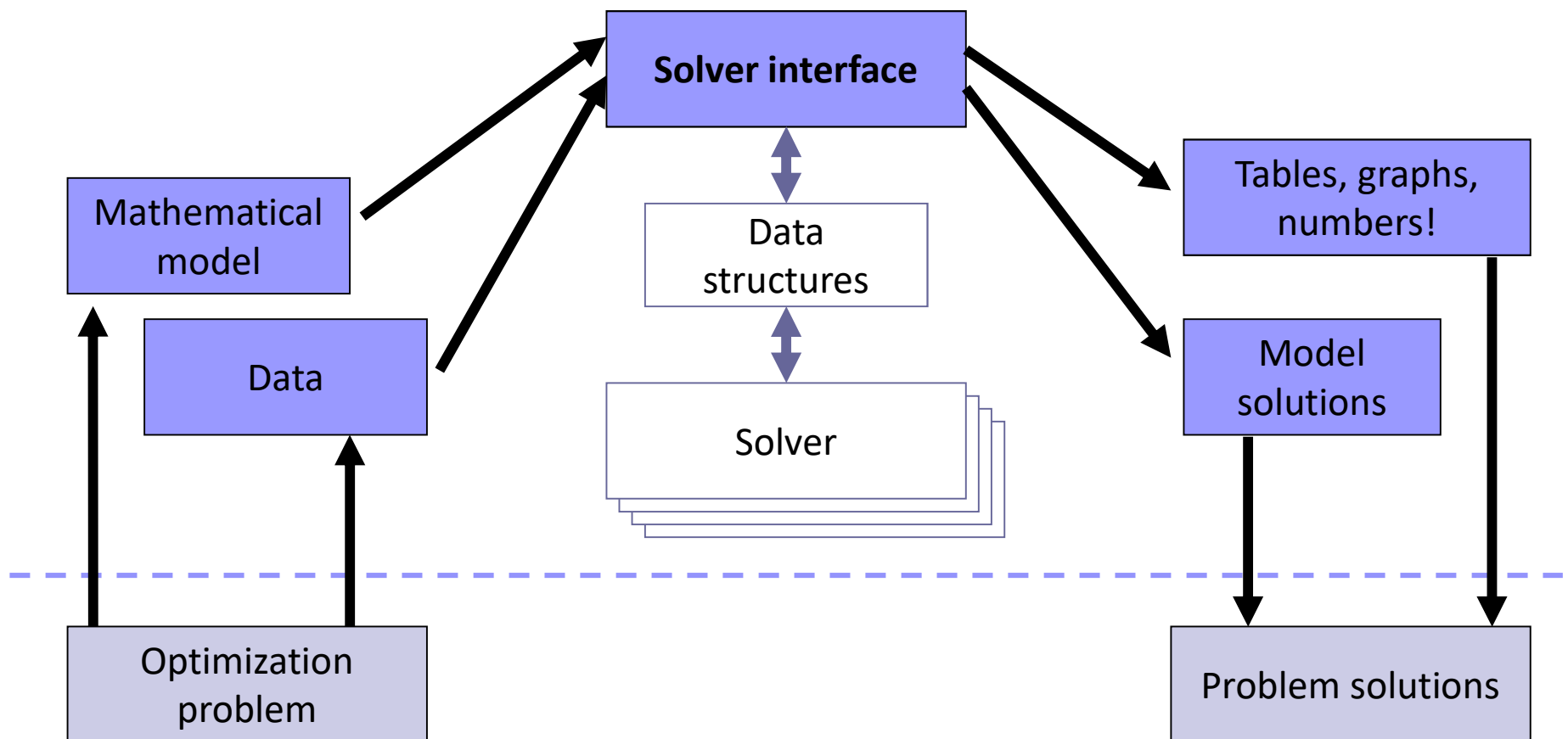


MILP solvers

- Most used in practice:
 - ☐ very efficient
 - ☐ numerical stability
 - ☐ easy to use or embed
- 1 000 000 000 speed-up in the last 15 years
 - ☐ hardware speed-up: x 1000
 - ☐ simplex improvements: x 1000
 - ☐ branch-and-cut improvement: x 1000
- e.g. Cplex, Gurobi, Xpress, Scip, Lindo, GLPK etc.

Solver interfaces

A solver can be accessed via modelling languages or **general-purpose-language libraries**





IBM Ilog Cplex

- One of the first MILP solvers
- Includes **state-of-the-art** technology
- (One of) the best solvers available (Gurobi, Xpress)
- Possible interfaces
 - Interactive optimizer
 - **C – API libraries (Callable libraries)**
 - C++ libraries (Concert technologies)
 - Python / Java / .Net wrapper libraries
 - Matlab / Excel plugins
 - OPL / AMPL / ZIMPL ... algebraic modelling language



Cplex Callable Libraries

- C API towards *LP/QP/MIP/MIQP* algorithms
- Basic objects: **Environment** and **Problem**
- **Environment**: license, optimization parameters ...
- **Problem**: contains problem information: variables, constraints ...)
- (at least one) environment and problem must be created

CPXENVptr **CPXopenCPLEX** / **CPXcloseCPLEX**

CPXLPptr **CPXcreateprob** / **CPXfreeprob**

Cplex API functions

- The two objects can be accessed (e.g. to add variables or constraints, or to solve a problem) via the functions provided by the API
- (Almost) all the API functions can be called as

```
int CPXfuncName (environment[,problem] ,... ) ;
```

Error code (0=ok)
CPXgeterrorstring returns a
description of the error

Basic objects

Parameters

Sparse matrix representation

- Sparse matrix: many zero entries
- Compact representation:
 - Explicit representation of “nonzeroes”
 - Linearization into indexes (**idx**) and values (**val**) vectors
 - A third vector to indicate where rows begins (**beg**)

