



ProSim

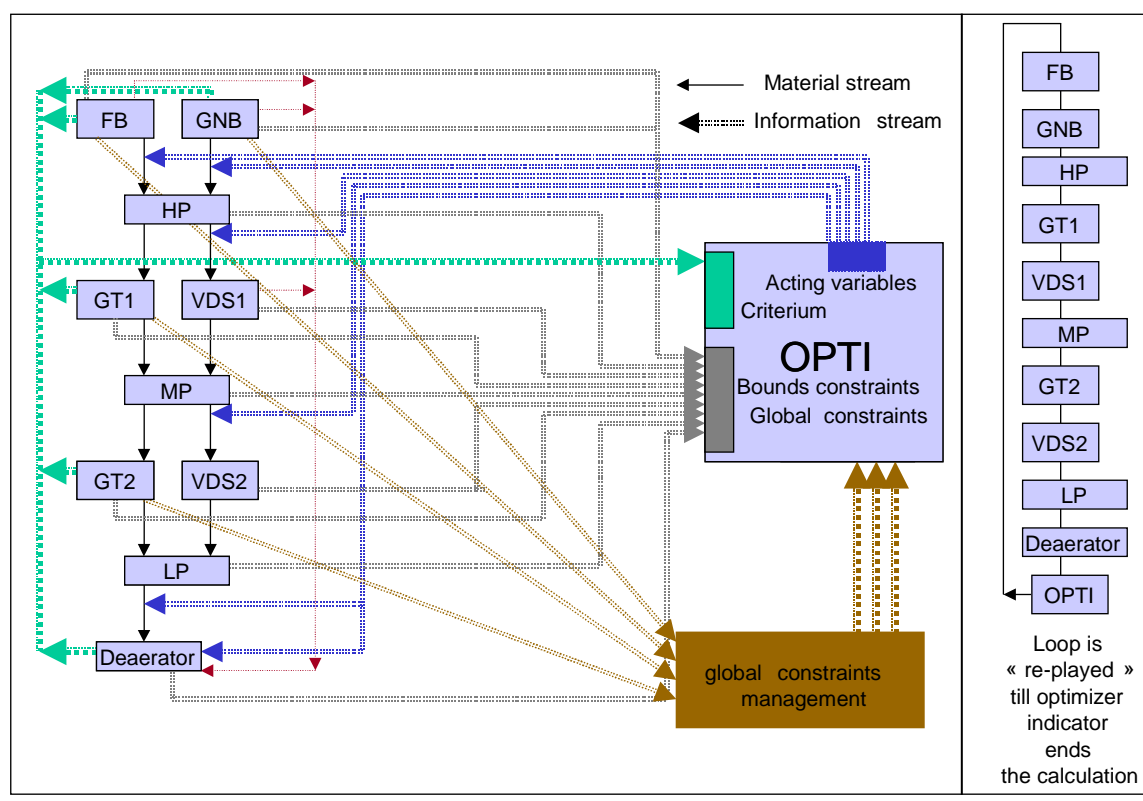
Ariane

Process Simulation & Optimization: Sequential modular approach or global approach? Why not both?

ESCAPE18 June 1 - 4, 2008 Lyon (FRANCE)

Philippe BAUDET, Pierre CASTELAIN, Olivier BAUDOIN

1 Sequential modular approach & global approach: the two categories



Major difficulty: computation time due to numerous runs of the calculation loop

Sequential modular approach

- Advantages:
- Ariane historical approach
 - Easy initialization

Power Plant

- 3 headers
- 2 boilers
- 2 turboalternators
- 2 desuperheating valves
- 1 deaerator

Optimization problem

- Minimize operating cost
- Maximize the production of electricity
- Minimize fuel consumption
- While respecting all constraints (technical, environmental)

Global approach

Generate and solve a global mathematical problem

Objective function

$$F_{obj} = 1.0 \times Q_{obj} + 0.05 \times (5000 + P_{elec1} - P_{tur1} - P_{tur2}) + 76.0 \times (Q_{des1} + Q_{des2}) + 216.851 \times (Q_{gas2})$$

Equality constraints (linear or not)

- (1) $Q_{d1} = Q_{d1} + Q_{d1} + Q_{d1} = Q_{d1}$
- (2) $Q_{t1} = Q_{t1} + Q_{t1} + Q_{t1} = Q_{t1}$
- (3) $Q_{t1} = Q_{t1} + Q_{des1} = Q_{t1}$
- (4) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (5) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (6) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (7) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (8) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (9) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (10) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (11) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (12) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (13) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (14) $Q_{t2} = Q_{t2} + Q_{t2} = Q_{t2}$
- (15) $H_{t1} - H_{t1} = D_{t1} + H_{t1} - P_{t1} = H_{t1}$
- (16) $H_{t1} - H_{t1} = D_{t1} + H_{t1} - P_{t1} = H_{t1}$
- (17) $H_{t1} - H_{t1} = D_{t1} + H_{t1} - P_{t1} = H_{t1}$
- (18) $H_{t1} - H_{t1} = D_{t1} + H_{t1} - P_{t1} = H_{t1}$
- (19) $H_{t1} - H_{t1} = D_{t1} + H_{t1} - P_{t1} = H_{t1}$
- (20) $H_{t1} - H_{t1} = D_{t1} + H_{t1} - P_{t1} = H_{t1}$
- (21) $H_{t1} - H_{t1} = D_{t1} + H_{t1} - P_{t1} = H_{t1}$
- (22) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$
- (23) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$
- (24) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$
- (25) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$
- (26) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$
- (27) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$
- (28) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$
- (29) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$
- (30) $Q_{t1} = Q_{t1} + Q_{t1} = Q_{t1}$

Major difficulty: Initialization

- Advantage:
- Computation time

2 Ariane Software

Making the best of power plants with Ariane

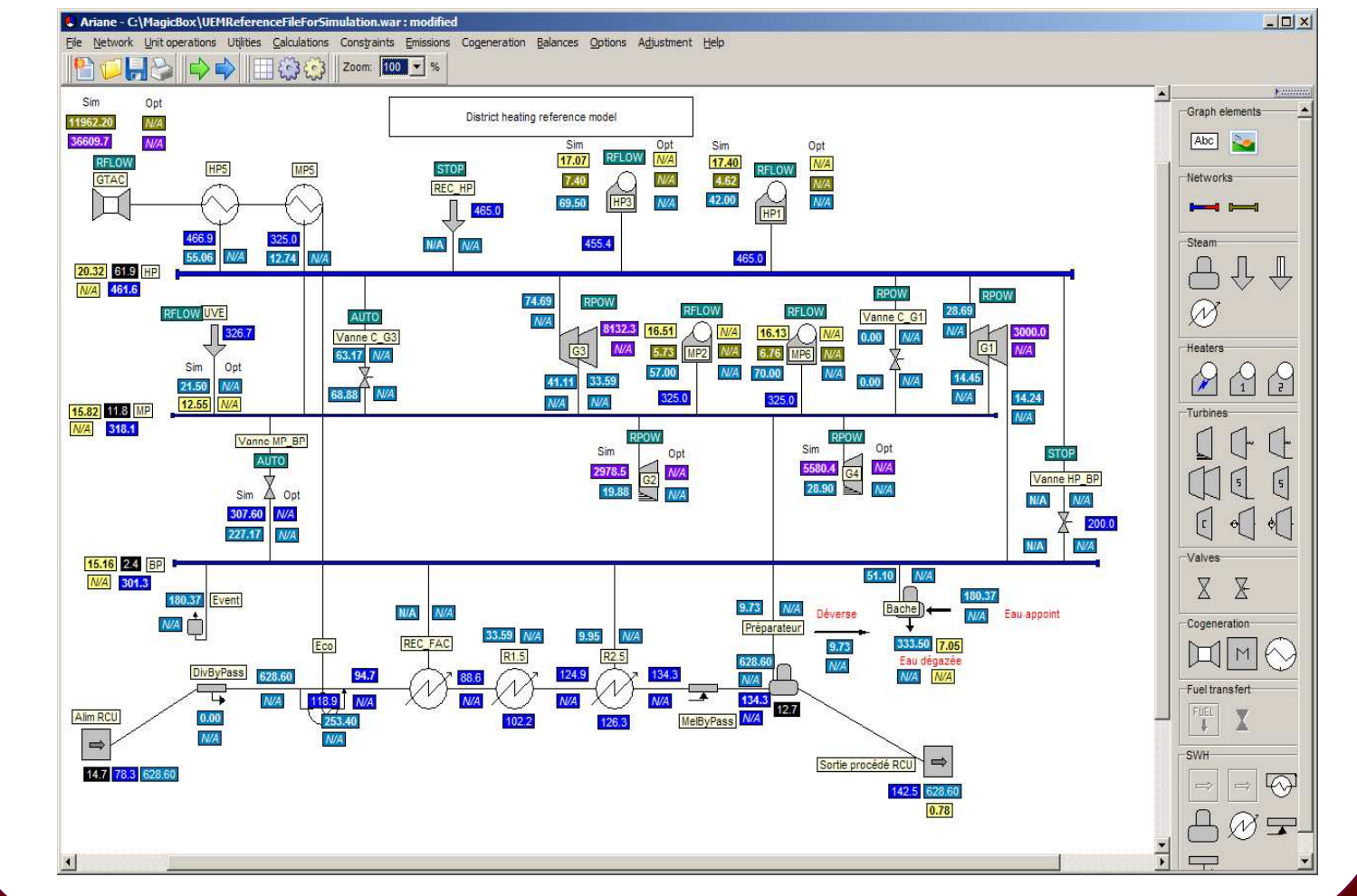


Ariane is a software suite dedicated to the management of power plants that produce utilities (steam, hot water, electricity, compressed air...) from a variety of fuels.

It helps identifying and reaching the optimal operating configuration while taking into account the full complexity of both technological and economical aspects of utilities production:

- Plant operation constraints (demand, sourcing, technical, regulations...)
- Polluting emission constraints (NOx, SOx, CO2, CO...)
- Technical characteristics of each equipment.

Power plant example



3 New solving method

The sequential modular sequence is executed only three times (count, encoding and final simulation)

4 major steps:

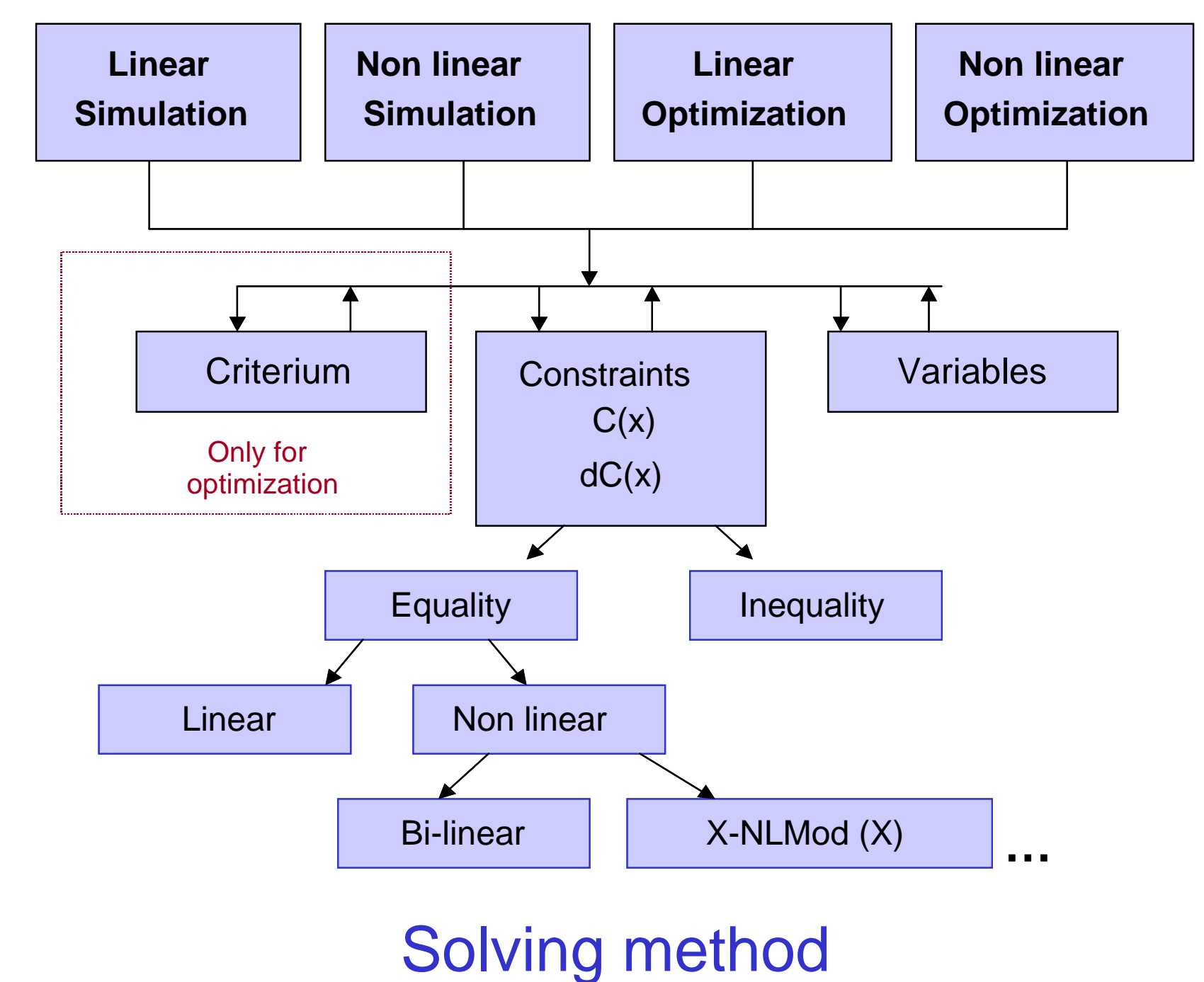
- 1) **Count** of all variables and constraints and memory allocation
- 2) **Encoding** of the mathematical system and variables initialization
- 3) **Analysis** of the generated mathematical problem, choice of the most appropriate solver and **problem solution**
- 4) **Final simulation** and edition of all results (including secondary interest results calculated only during the final simulation)

Initialization is made using a modular sequential approach during mathematical problem formulation

Solving method is an externalized process that makes use of a global approach

4 Advantages of both approaches are combined

- Computation time reduction (global solution with analytical derivatives)
- Re-use of validated code
- Benefits of the modular sequential initialization
- Automatic analysis of the resulting mathematical problem
- Selection of the most suitable solver depending on the resulting problem
- Library of solvers, easy to enrich



A quick, robust and precise method to solve continuous problem and that is able to evolve

5 And now...

Manage a mixed optimization problem

Real Time Structure Optimization

- Start / Stop of equipment (boolean part): GA, SA or other boolean methods
- Operating conditions (continuous part): LP or NLP

Example: switchable turbine start/stop management

