Agenda

1 The challenge of integrated Supply Chain Planning

2 Integrated Supply Chain Planning with SAP-APO

3 Selected planning scenarios

4 **The challenge of generic Optimizer**

5 Optimizer Architecture of SAP-APO

6 Selected benchmark results

Challenge: Generic Optimizer

SAP™

- **Generic Model**

- **Customization by activating a subset**

  - ■ **Reduction to customer problem**
    - ◆ **inactivate constraints**
    - ◆ **inactivate objectives**

  - ■ **However - No Enhancements**
    - ◆ **additional constraints**
    - ◆ **additional objectives**

- **Open Architecture**
  - ■ **most generic core model**
  - ■ **embedding of different special optimizer**

☺ **Optimal Solution ?**   ☹
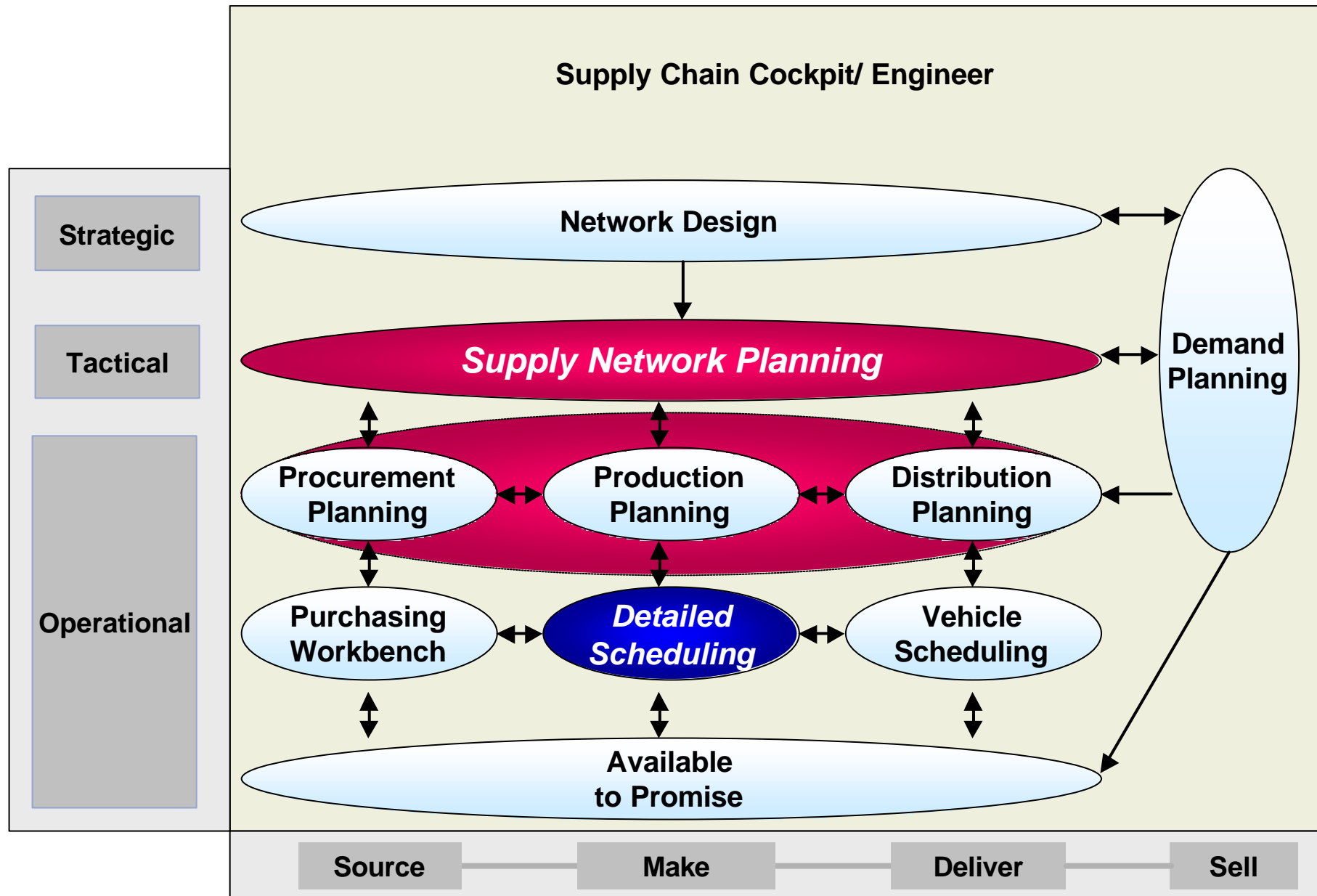
☺ **Better than 5% below optimum ?**   ☹

😐 **Best-of-Breed Solution !**

◆ **Depends on Problem Complexity (Model, Size)**

◆ **Computation time**

Solution: Scalability ?!

- **Parallelization**

  - **3-tier Client Server**

    - **Separation Application, LiveCache and Optimizer server**
    - **Several Optimizer server**

  - **Multi Processor**

    - **Multi user: parallel optimization runs**
    - **Multi optimizer agents in one optimization run**

- **Tradeoff: generalization vs computation time**

  - **Two Optimization Models**
    - ◆ **Linear Optimization vs Scheduling**

  - **Several optimization algorithms**
    - ◆ **e.g. 4 different scheduling optimizer**
    - ◆ **e.g. 3 different LP optimizer**

- **Tradeoff: algorithmic complexity vs computation time**
  - **Cubic computation time acceptable for small problems**
  - **Linear computation time required for large problems**
  - → **Solution: Metaheuristics / Decomposition**

Integrated SC Planning with APO

SAP

Supply Chain Cockpit/ Engineer

Strategic

Tactical

Operational

Network Design

Supply Network Planning

Demand Planning

Procurement Planning ↔ Production Planning ↔ Distribution Planning

Purchasing Workbench ↔ *Detailed Scheduling* ↔ Vehicle Scheduling

Available to Promise

| Source | Make | Deliver | Sell |

Decision Variables

SAP™

- **Detailed Scheduling**

  - ■ **starting time**

  - ■ **resource selection**

- **Supply Network Planning**

  - ■ **Production quantity**

  - ■ **Transportation quantity**

  - ■ **Additional Capacities**

  - ■ **External supplies**

Objective function

SAP

- **Detailed Scheduling**

  - **Delay costs**

  - **Setup costs**

  - **Makespan (compactness)**

  - **Production Costs (Priorities)**

  - **Inventory Costs (Earliness)**

- **Supply Network Planning**

  - **Delay costs**

  - **Nondelivery Costs (Maxim. Profit)**

  - **Production costs**

  - **Transportation costs**

  - **Inventory costs**

  - **Costs for additional capacities**

    - **Transportation (Outsourcing)**

    - **Production (over time)**

    - **Product (Outsourcing)**
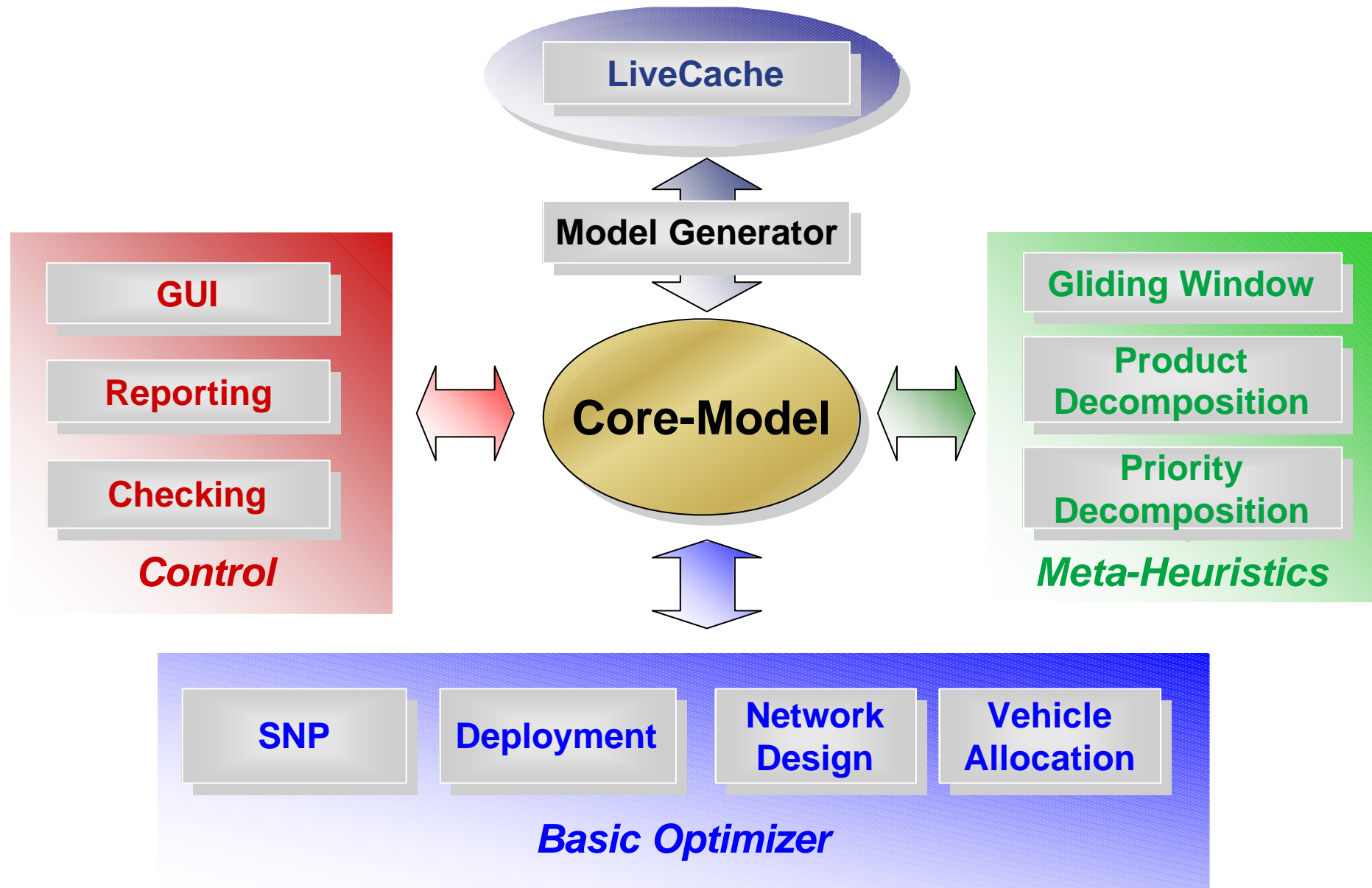
Constraints

SAP

- **Detailed Scheduling**
  - delivery time
  - setup activities
  - time constraints
    - minimal (sequencing)
    - maximal (shelf life)
  - capacities
    - production
    - storage
  - calendar
    - capacities
    - breaks / shifts
    - productivity
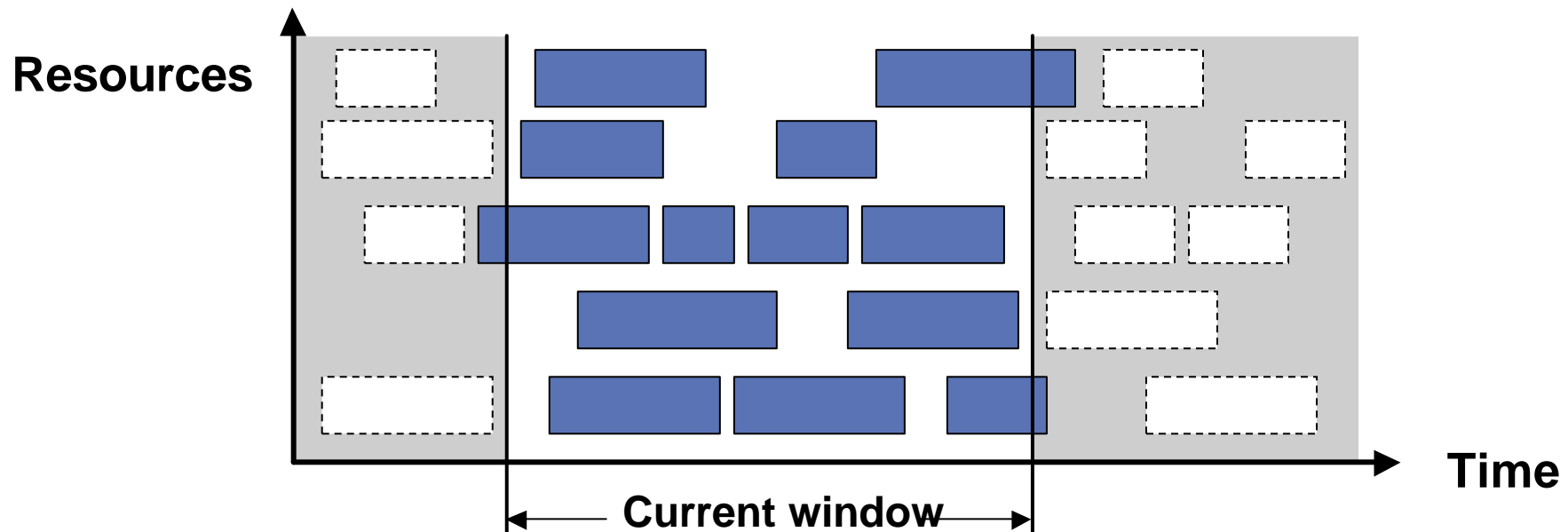
- **Supply Network Planning**
  - delivery time
  - shelflife
  - capacities
    - storage
    - production
    - transport
    - handling
  - calendar
    - capacities
    - breaks (weekends)
  - discretization
    - lot sizes
    - minimal lot sizes
    - additional shifts
    - piecewise linear cost functions

SAP

1. The challenge of integrated Supply Chain Planning

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5. **Optimizer Architecture of SAP-APO**

6. Selected benchmark results

SAP™

LiveCache

Model Generator

GUI

Reporting

Checking

Control

Core-Model

Gliding Window

Bottleneck

Multi Agents

Meta-Heuristics

Constraint Propagation

Genetic Algorithmen

Repair Optimizer

Campaign Optimizer

Basic Optimizer

LiveCache

Model Generator

GUI

Reporting

Checking

Control

Core-Model

Gliding Window

Product Decomposition

Priority Decomposition

Meta-Heuristics

SNP

Deployment

Network Design

Vehicle Allocation

Basic Optimizer

Resources

Time

Current window

Gliding window script

1. **Optimize only in current window**

2. **Move window by a time delta**

3. **Go to first step**

Metaheuristics - Bottleneck

Resources

Bottleneck

Time
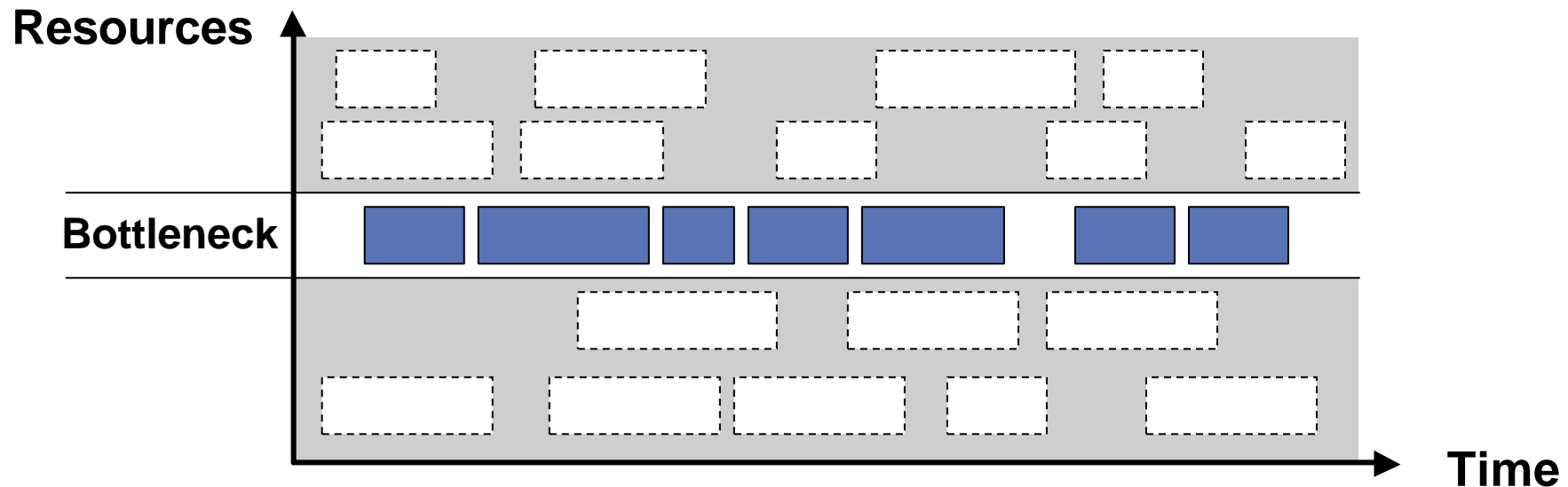
Bottleneck Script

1. Determine bottleneck

2. Schedule bottleneck resources only

3. Fix sequence on bottleneck resource

4. Schedule all resources

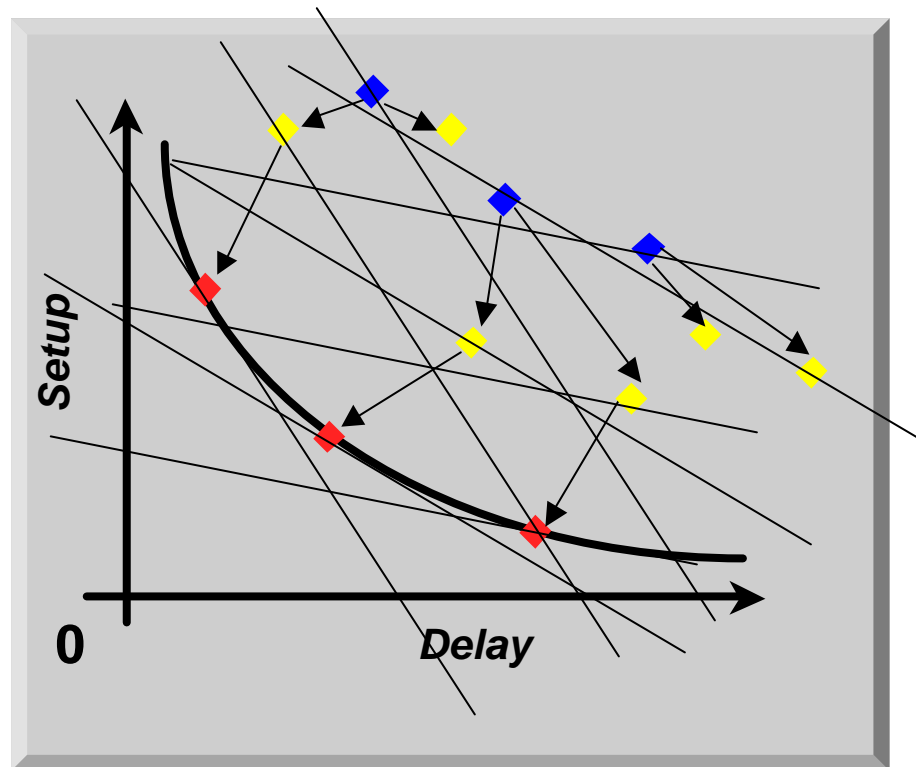# Multi Agent Optimization
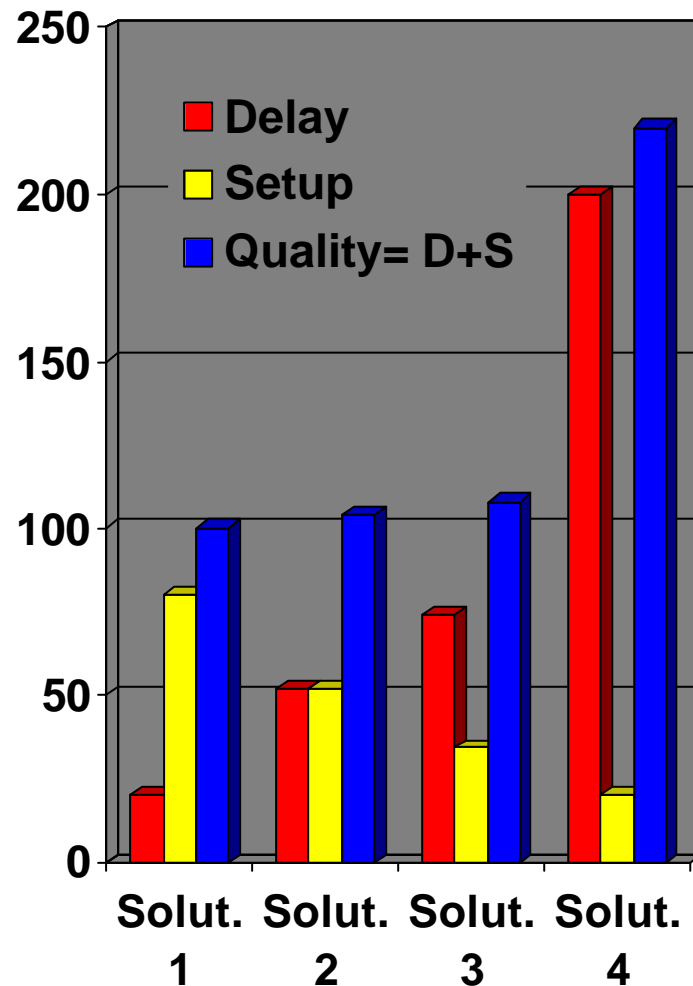
- **Objective**
  - **Multi Criteria Optimization**
  - **user selects out of solutions with**
    - ◆ **similar overall quality**
    - ◆ **different components**
  - **Use power of Parallelization**

- **Multi Agent Strategy**
  - **Different AGENTS focusing on Setup or Delay or Makespan**
  - **New solutions by local improvement**
  - **Integrated in Optimizer Architecture (independent of basic optimizer)**

- **Performance**
  - **Speedup » available processors**

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SNP Optimizer - Customer Problems

SAP™

- **Kimberley Clark**

  - **Model:** 30 Buckets, 19.000 Locations-Products, 23.000 Arc-Materials, 8.500 PPMs

  - **LP:** 2.600.000 Variables, 600.000 Constraints

  - **Solution:** optimal after 30 minutes

- **Johnson&Johnson**

  - **Model:** 22 Buckets, 916 Location-Products, 333 Arc-Materials, 741 PPMs

  - **MIP:** 104.000 Variables (14.000 discrete), 46.000 Constraints

  - **Solution:**
    - ◆ < 5% optimality-gap after 5 minutes
    - ◆ < 3% optimality-gap after 80 minutes

SAP™

- **Wacker**

  - **Model:** 124 resources, maximal time constraint, alternatives modes

  - **Problem Size:** 30 000 activities

  - **Objective:** makespan, delay

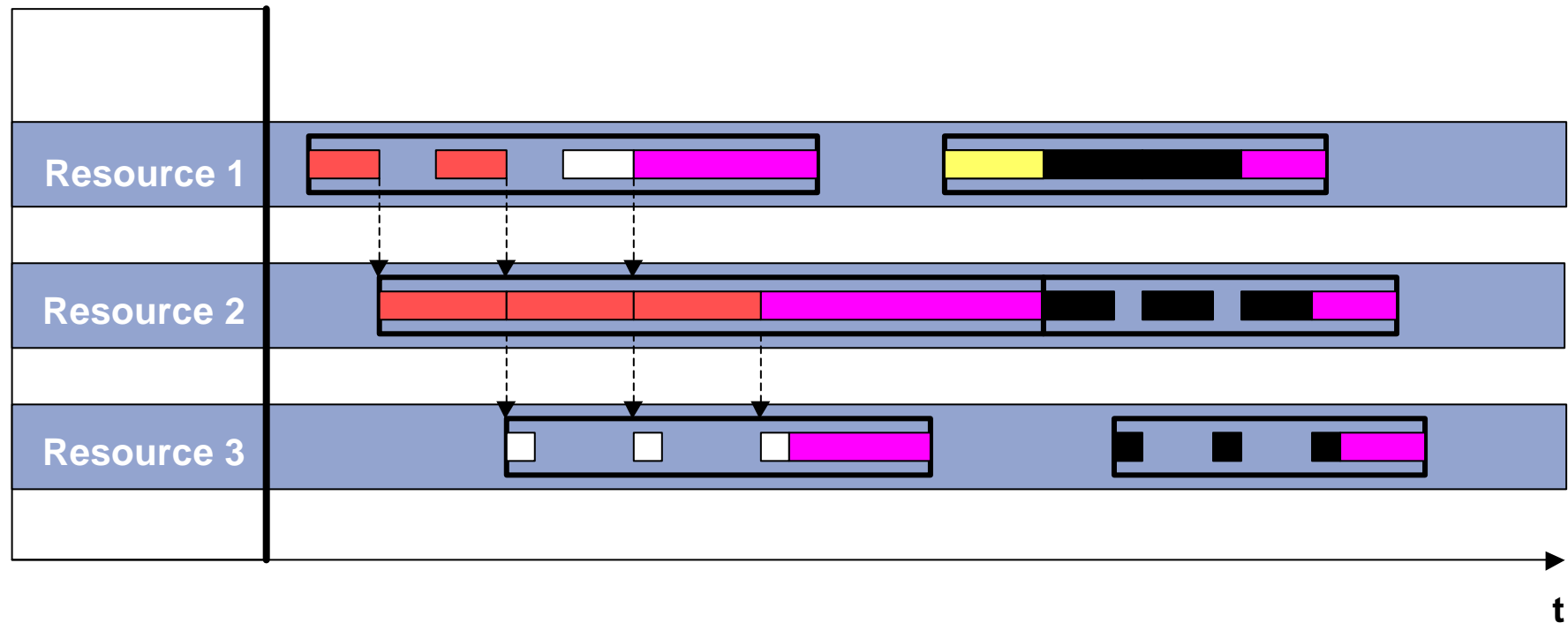 - **Run Time:** 20 minutes   (periodically every 2 hours)

- **Vicaima**

  - **Model:** 30 resources, maximal time constraint, setup activities

  - **Problem Size:** 12 500 activities, 2 000 setup activities

  - **Objective:** makespan, delay, setup

  - **Run Time:** 3 hours   (periodically every night)

SAP™

- **Open Optimization Architecture**
  - embedding of new optimizer
  - embedding of new metaheuristics

- **Scalability / Flexibility**
  - generic modeling (customizing by activating a subset)
  - special optimizer
  - special metaheuristics
  - parallelization

- **Open to external solutions**
  - BAPI: Certificated Interface
  - Heuristic Framework: User defined heuristics
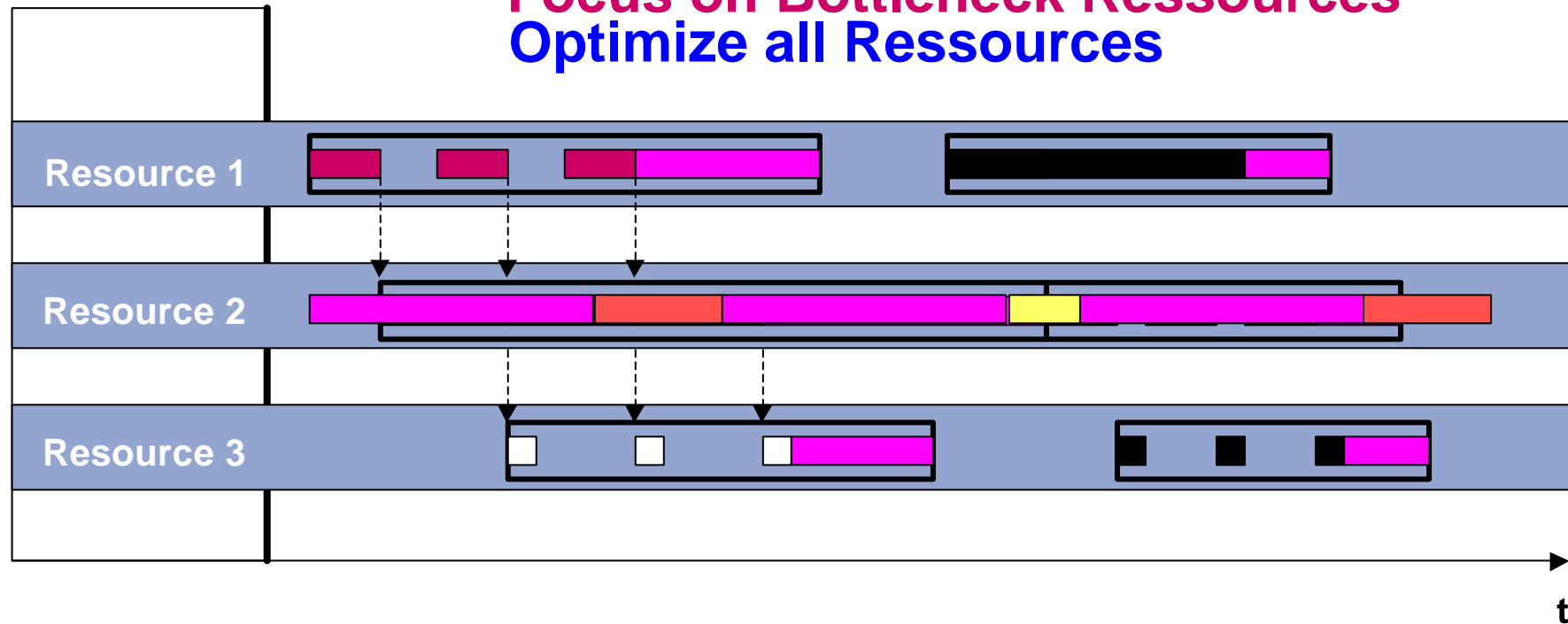 - Optimizer extension workbench: Partner Solutions

Campaigns

Campaign Optimization

Optimize Campaigns
Focus on Bottleneck Ressources
Optimize all Ressources

Resource 1

Resource 2

Resource 3

t

Batches

Setup

Campaign A

Campaign B