H.-O. Günther
Dept. of Production Management
Technical University of Berlin

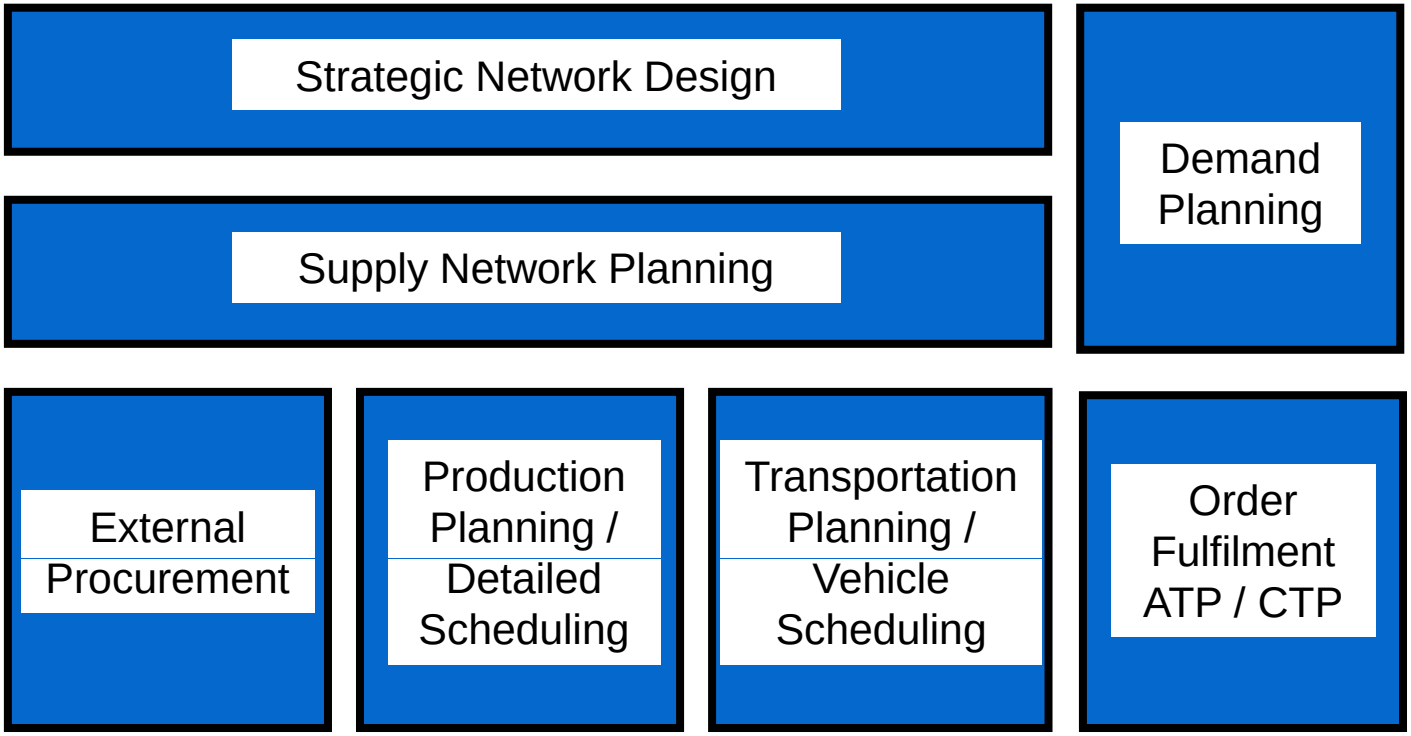
Supply Chain Management and Advanced Planning Systems

A Tutorial

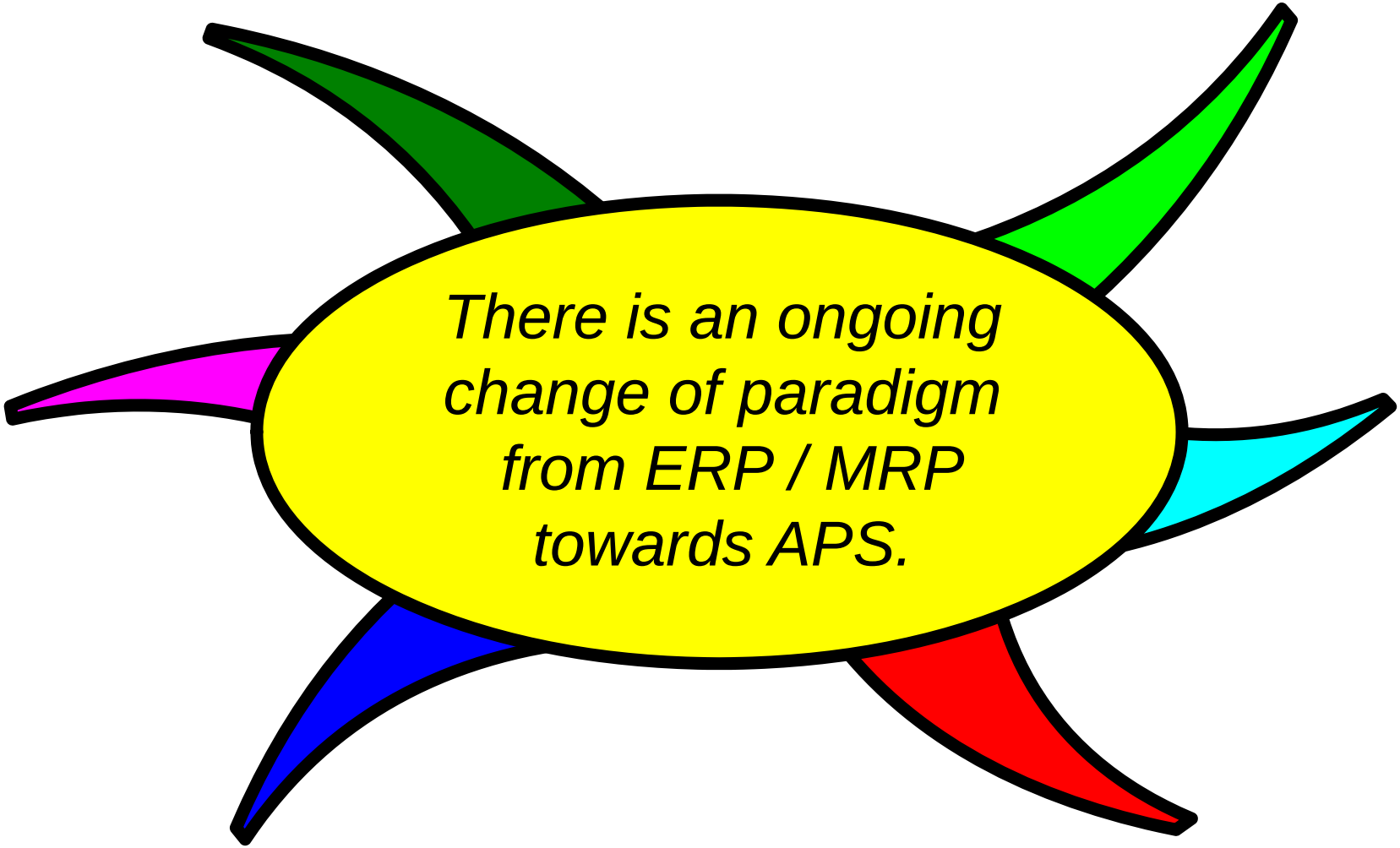
SCM Workshop, TU Berlin, October 17-18, 2005

Outline

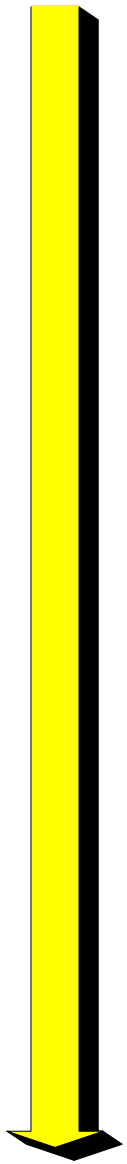
- **Introduction: The concept of SCM and APS**
- **APS modules**



Lesson 1


There is an ongoing
change of paradigm
from ERP / MRP
towards APS.

Generations of PPC software



1960s

- **Predecessors of PPC systems**
  - Focus on inventory control
  - Basic order processing

1970s

- **Material requirements planning (MRP)**
  - Bill of material files
  - Calculation of net requirements

1980s

- **Manufacturing resources planning (MRP II)**
  - Enhanced planning functions
  - Integration of financial accounting and management functions

1990s

- **Integrated systems**
  - CIM: Integration of manufacturing
  - ERP systems covering the whole enterprise

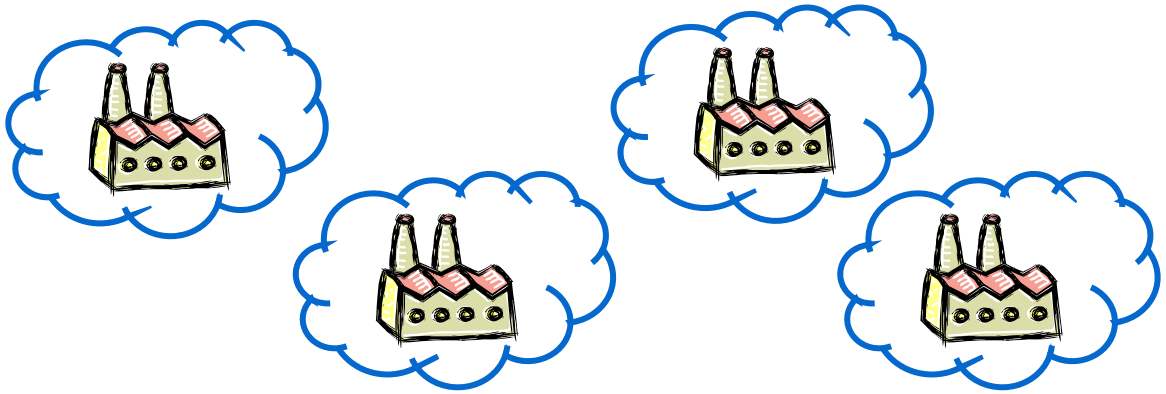
2000s

- **Advanced Planning and Scheduling systems**
  - Integration into Supply chain management concept
  - Use of true optimization techniques

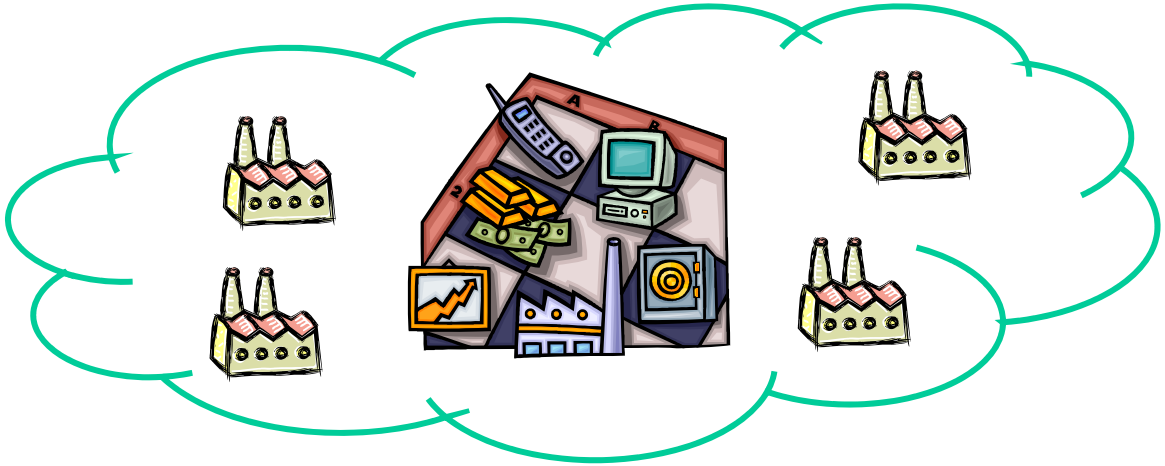
Lesson 2

Change of view

Plant specific view



Holistic view



More efficient network-wide planning needed

↳ ↳ ↳ Development of APS

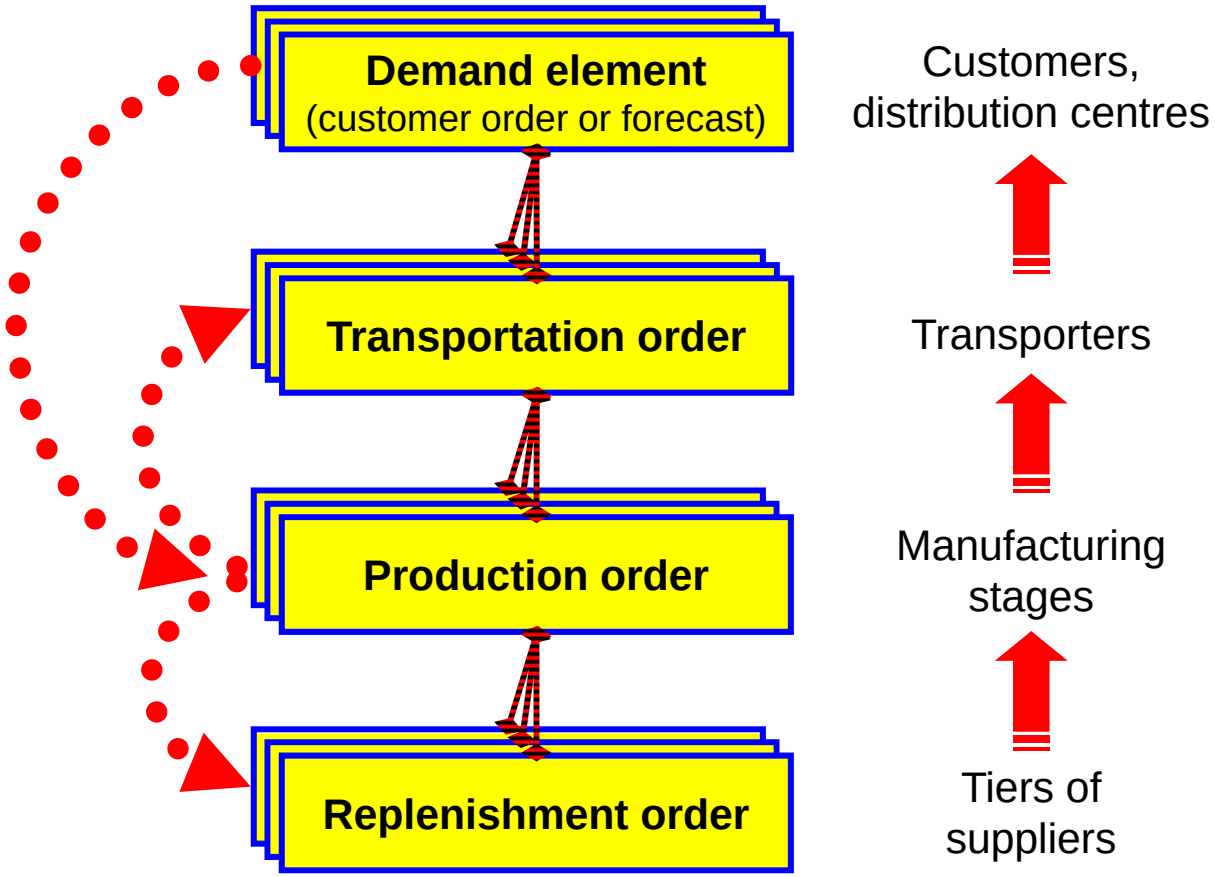
Supply chain management

Definition

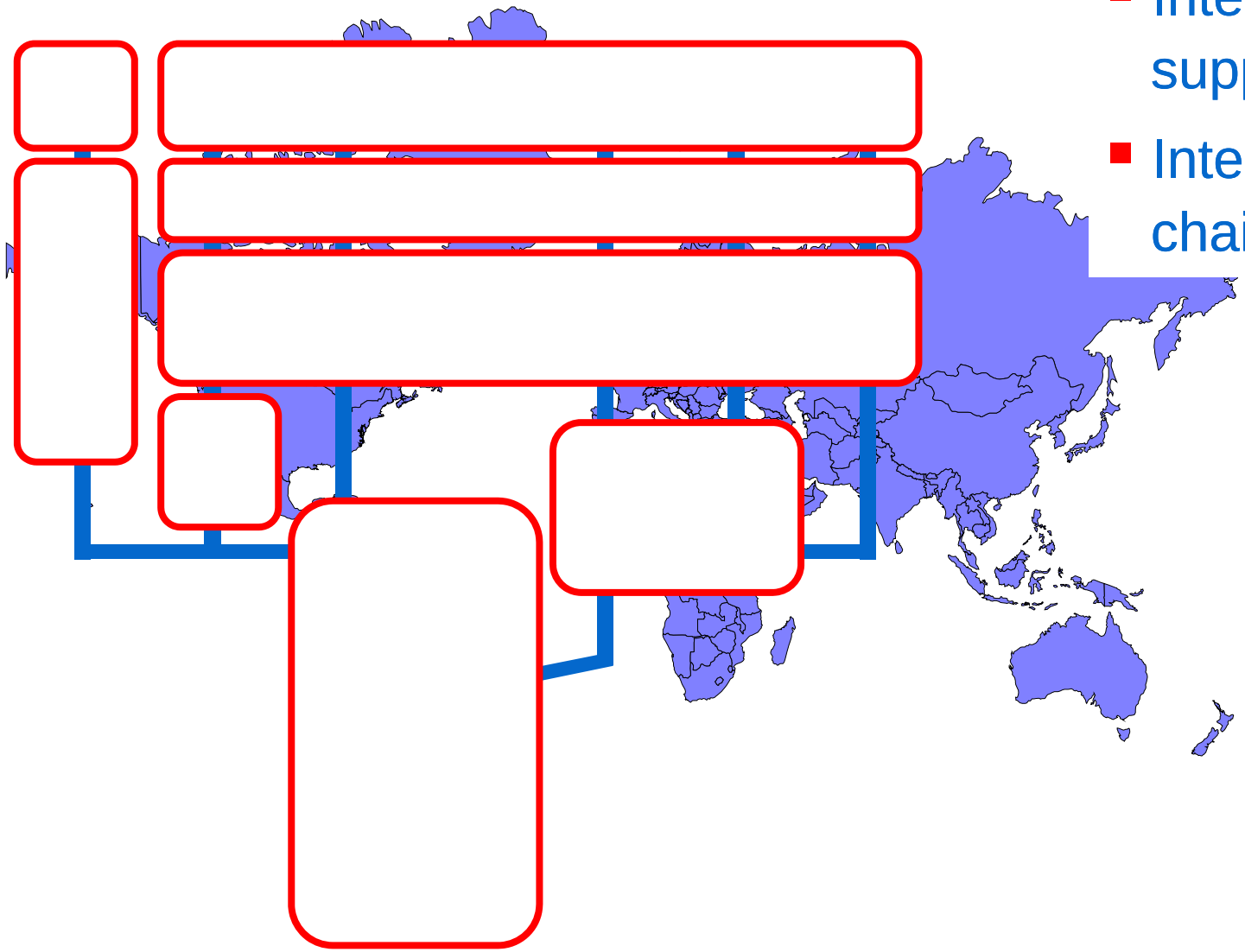
"A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request….

… the supply chain includes all functions involved in receiving and filling a customer request."

(Chopra and Meindl, 2004)

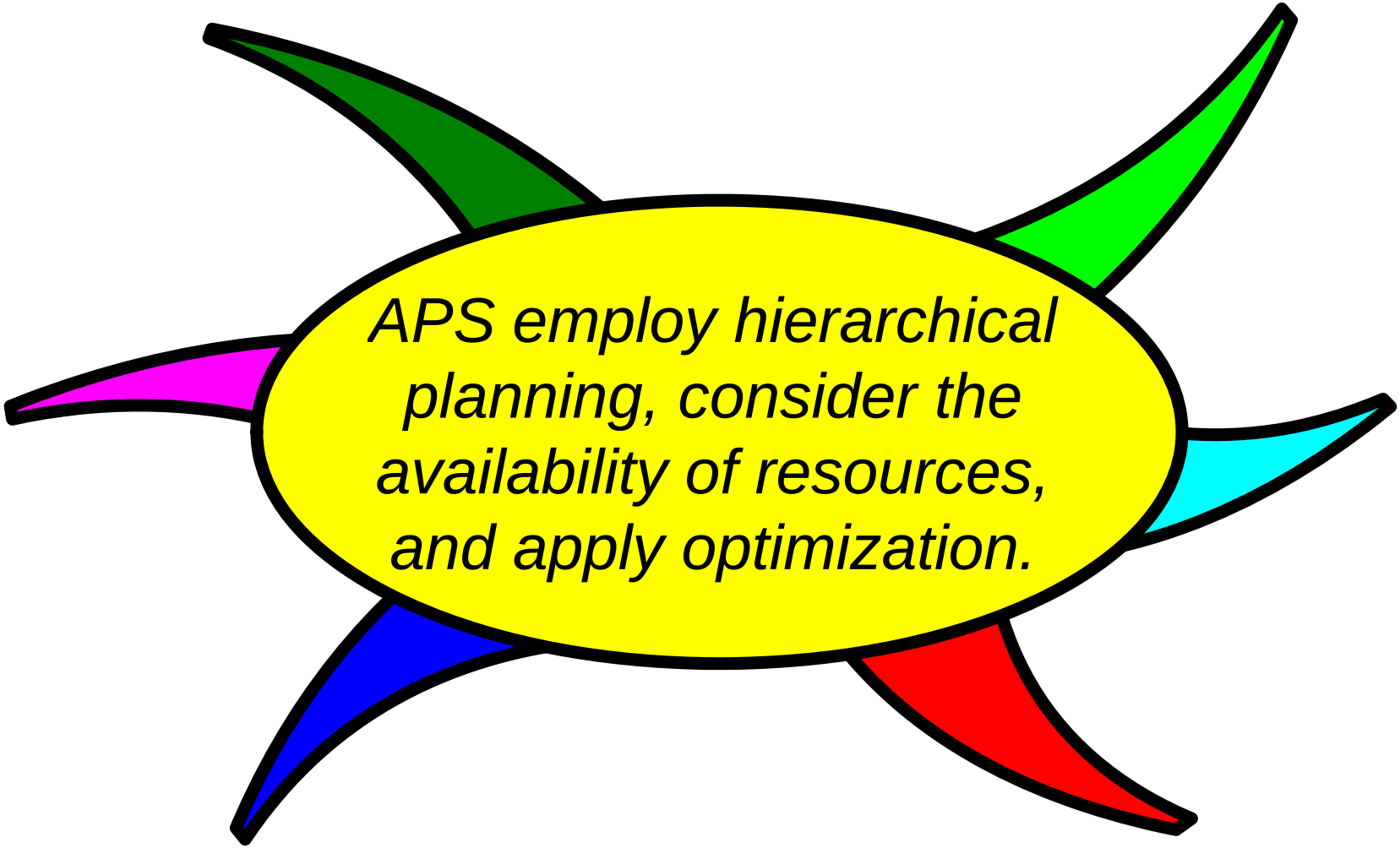


Types of supply chains (networks)

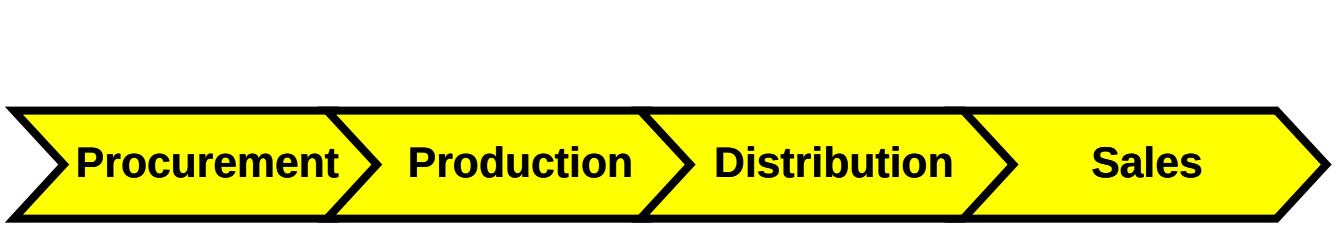


- Inter-company supply chains
- Internal supply chains

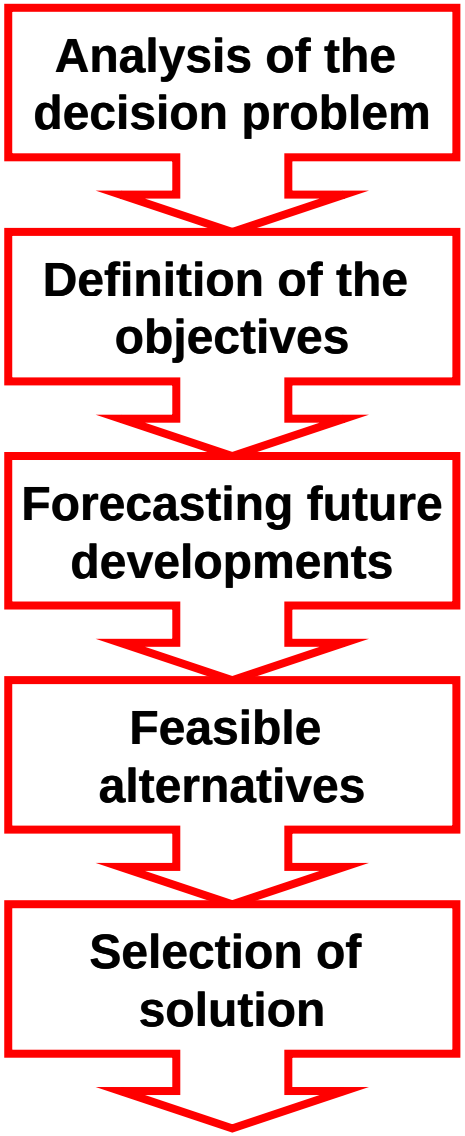
Lesson 3


APS employ hierarchical planning, consider the availability of resources, and apply optimization.

Characteristics of Advanced Planning

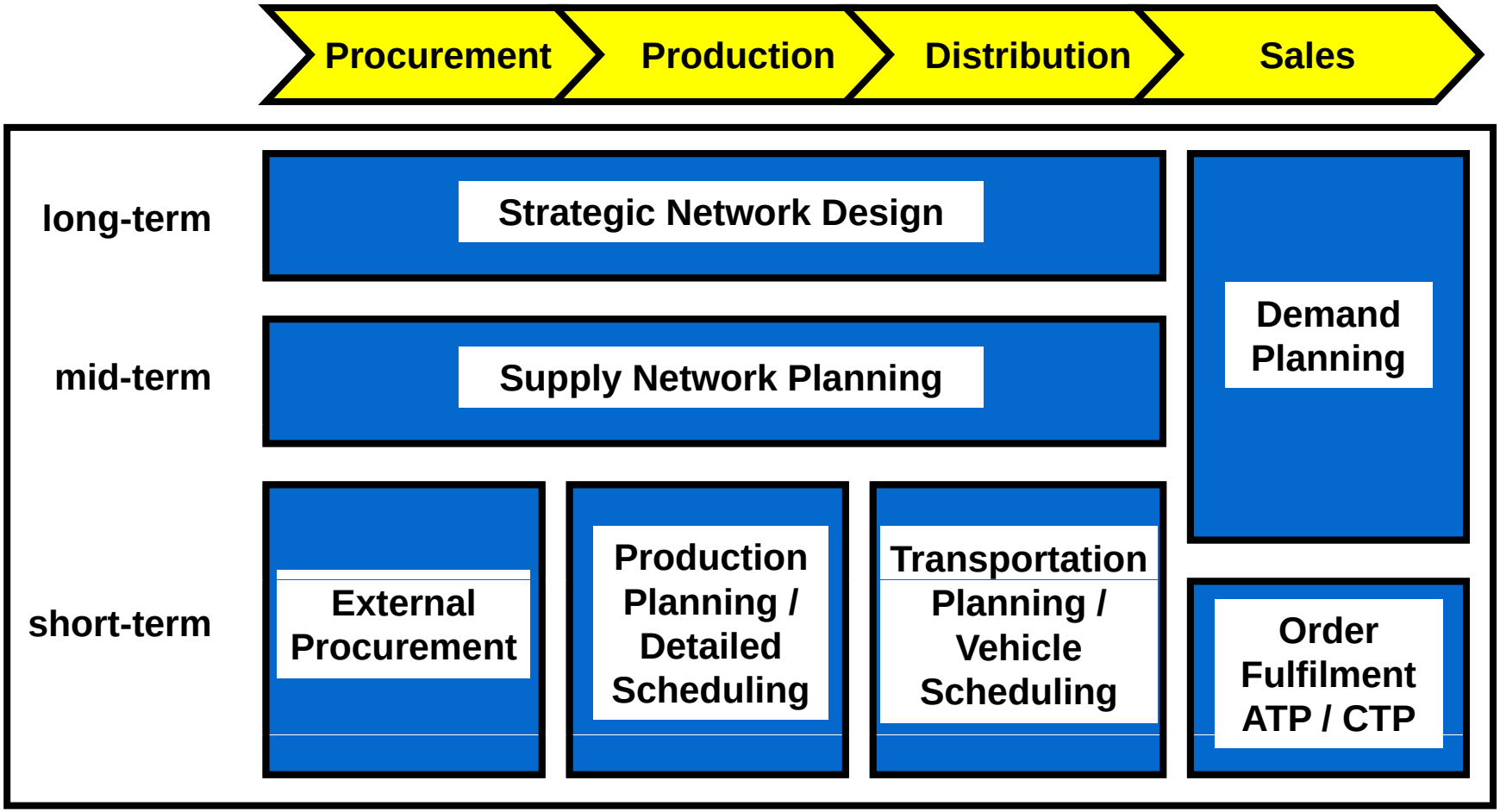


- Integral planning of the entire supply chain
- True optimization
- Hierarchical planning
- e.g. APS from SAP, i2 technologies, Manugistics, Oracle, Aspen Tech



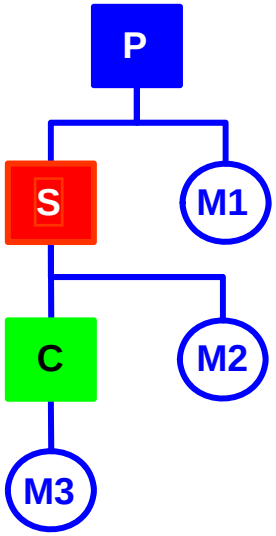
(Fleischmann et al. 2002)

Architecture of Advanced Planning Systems

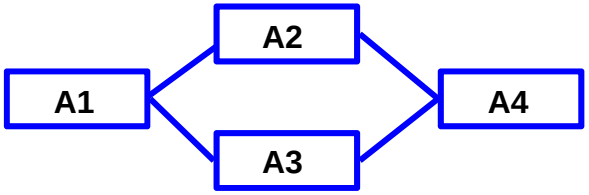


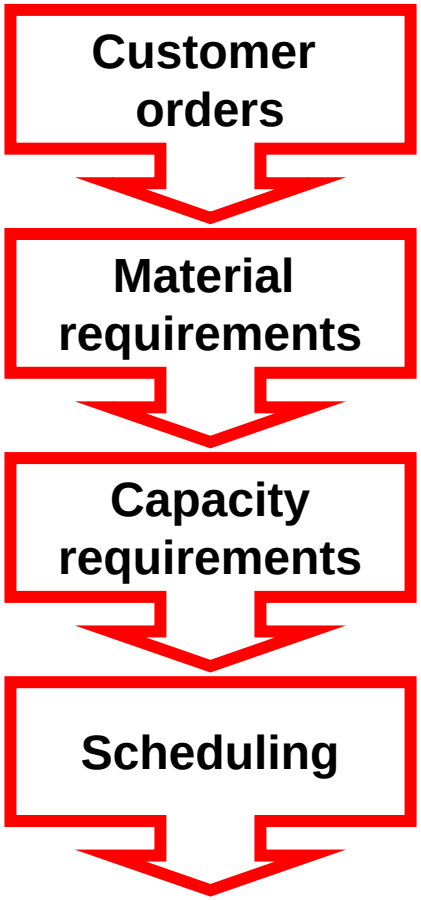
- Companies rarely use the entire suite of modules.
- Even APS from different software vendors are used in a company.
- Various industry specific solutions offered

Classical MRP systems

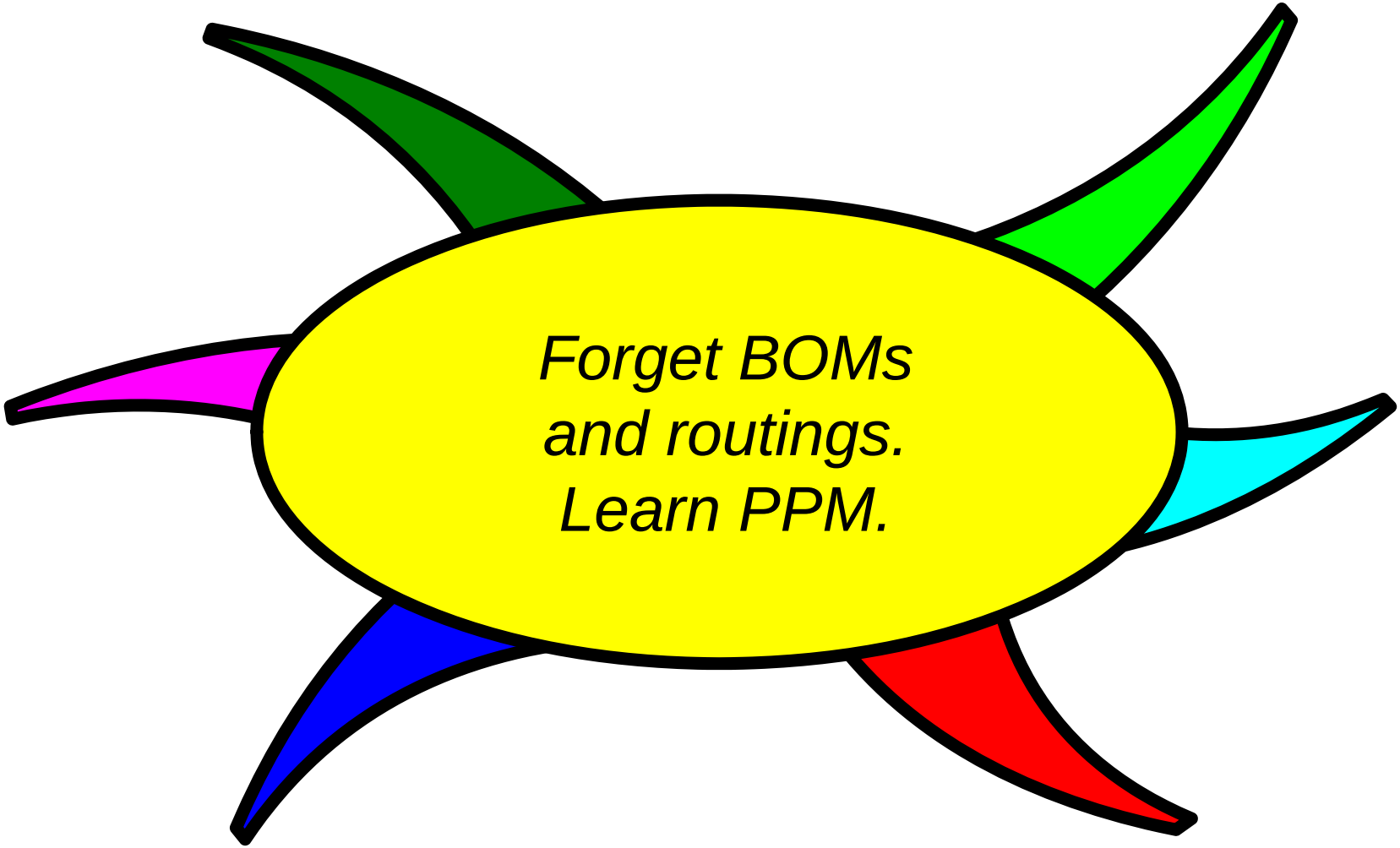


Routing

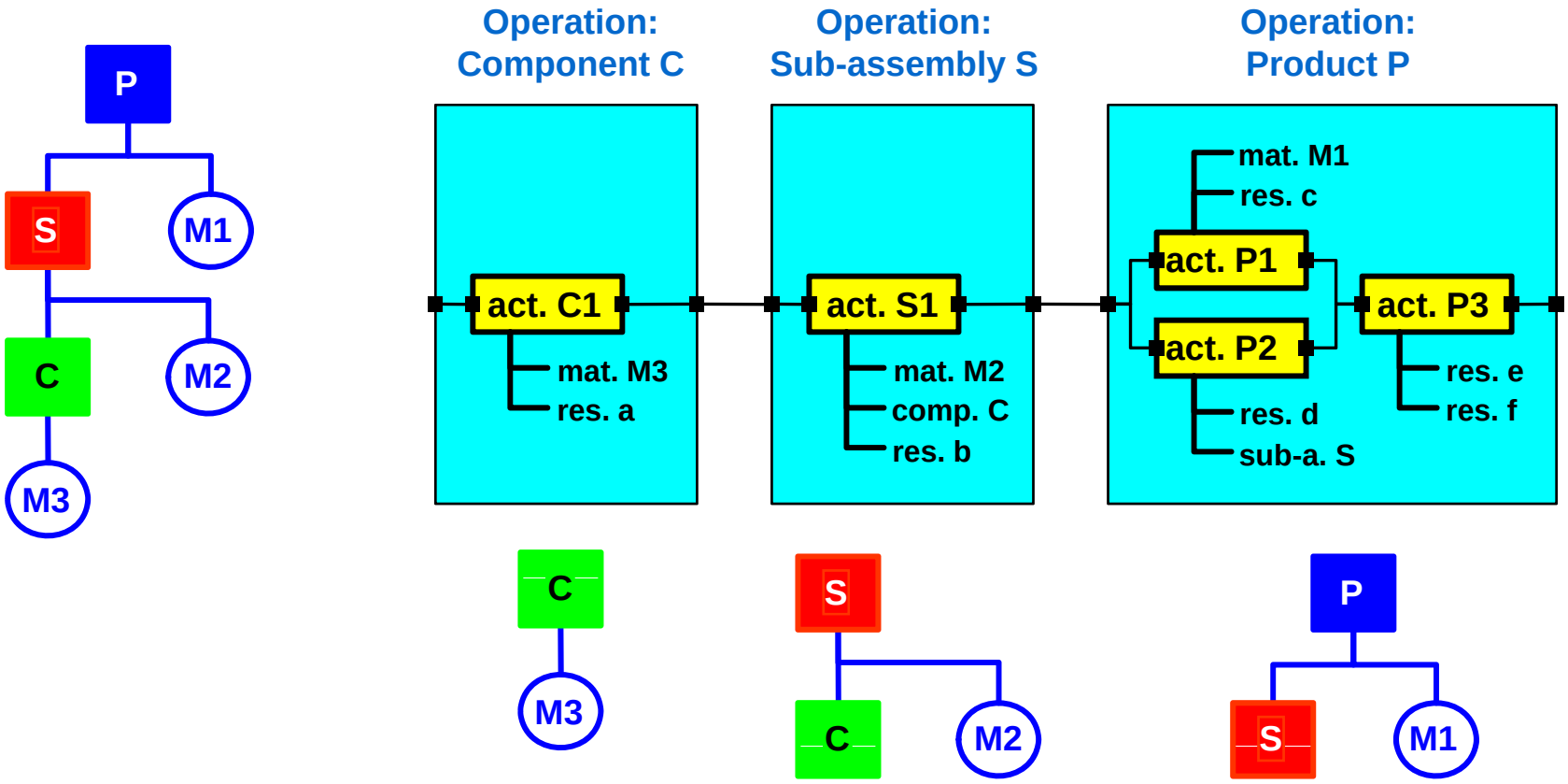




Lesson 4

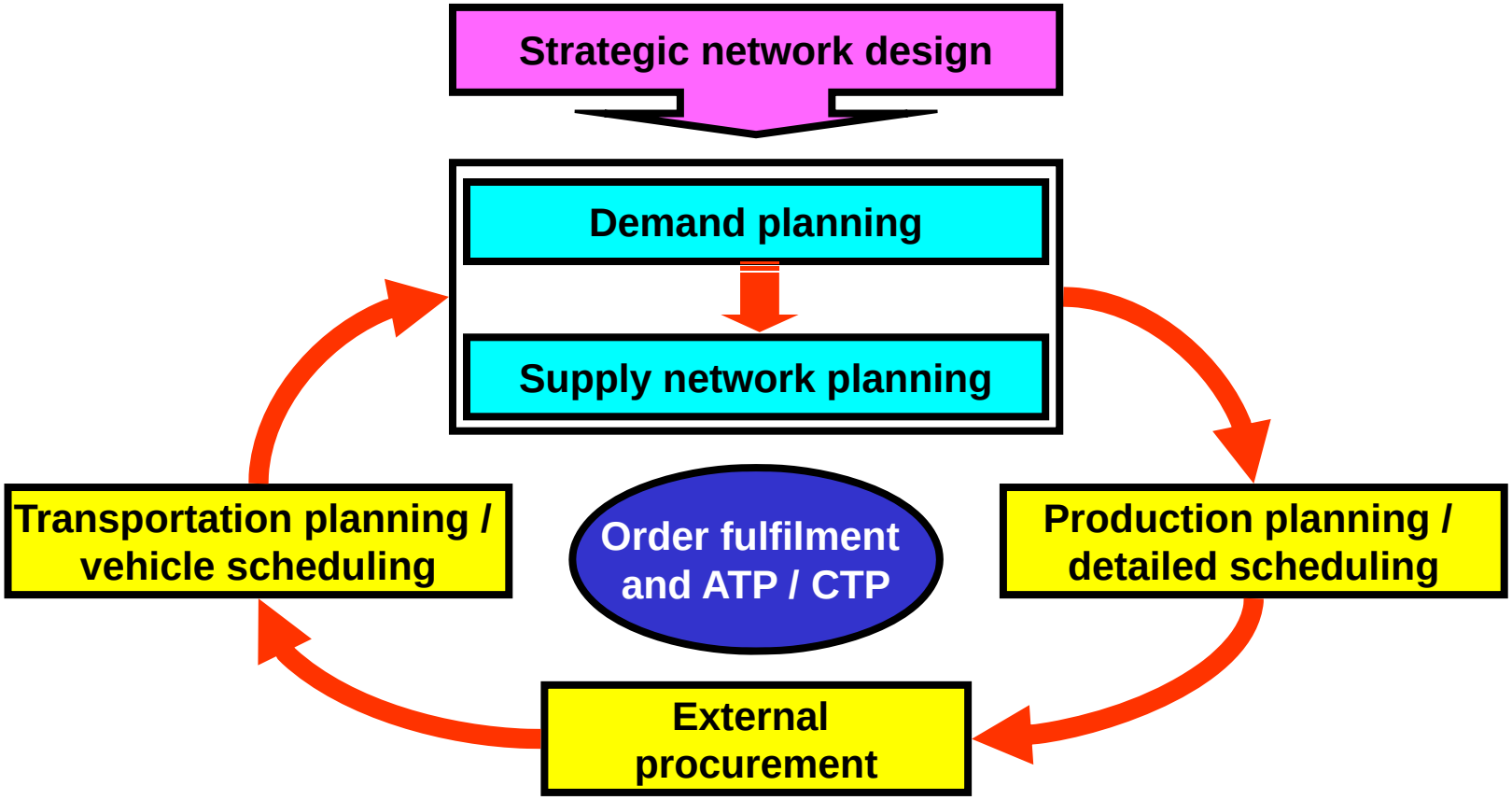


Production-process-model



- Assign resources and materials to each activity.
- Alternative modes (resources, routings) can be defined for an activity.

APS planning cycle

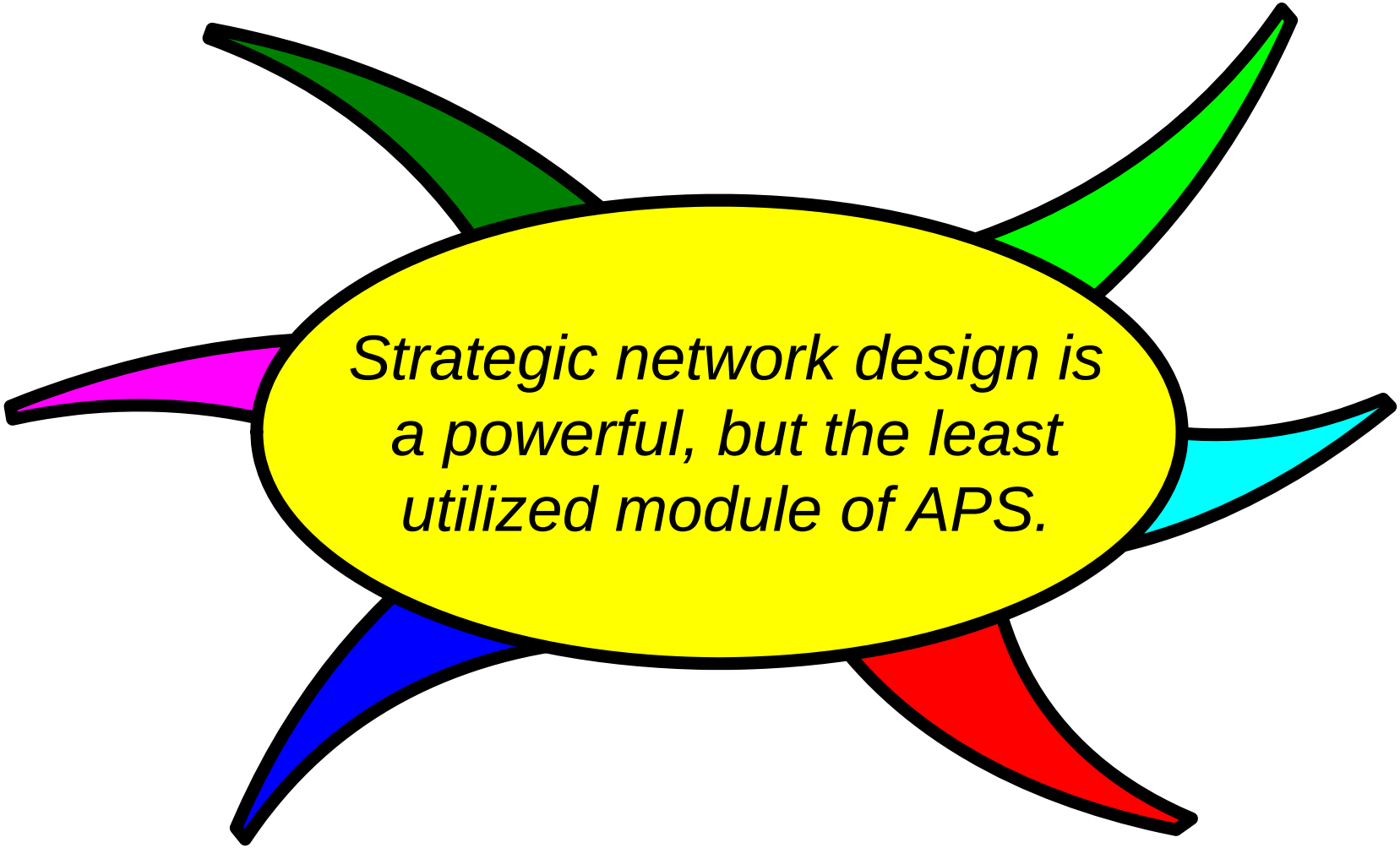


- The APS planning cycle represents the logical order of planning tasks.
- Planning tasks differ by the frequency by which they are called up.

Outline

- **Introduction: The concept of SCM and APS**
- **APS modules**
  - Strategic network design
  - Supply network planning
  - Demand planning
  - External procurement
  - Production Planning / Detailed Scheduling
  - Transportation Planning / Vehicle Scheduling
  - Order Fulfilment and ATP / CTP

Lesson 5


Strategic network design is
a powerful, but the least
utilized module of APS.

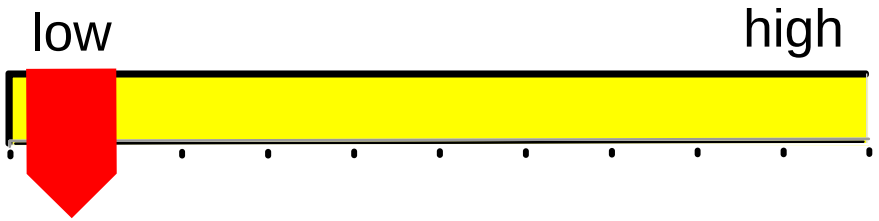
Strategic network design

Strategic Network Design

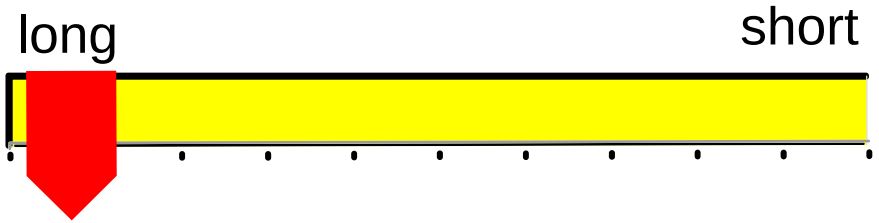
- **Decisions**
  - Number of plants and DCs
  - Locations and capacities
  - Assignment of products to plants
  - Assignment of locations to each other
    e.g. customers to DCs
  - Determination of transportation links
- **Mathematical methods**
  - Heuristics, MILP, Clustering techniques

Strategic network design

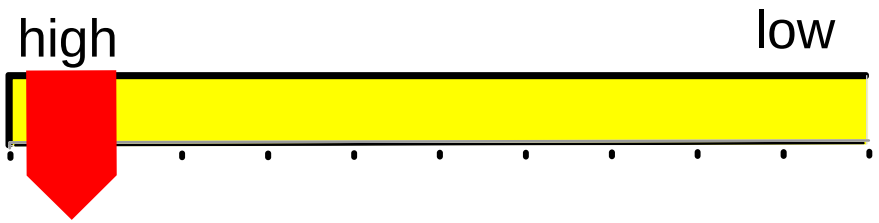
Planning frequency



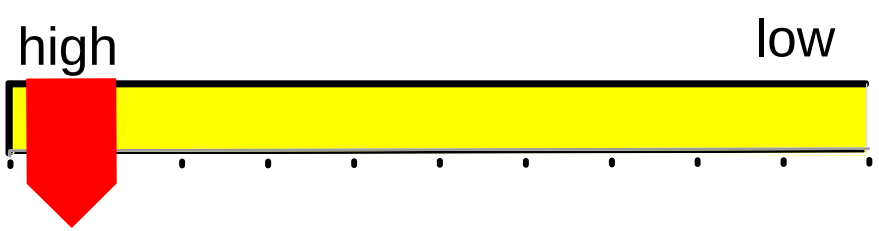
Planning horizon



Degree of aggregation

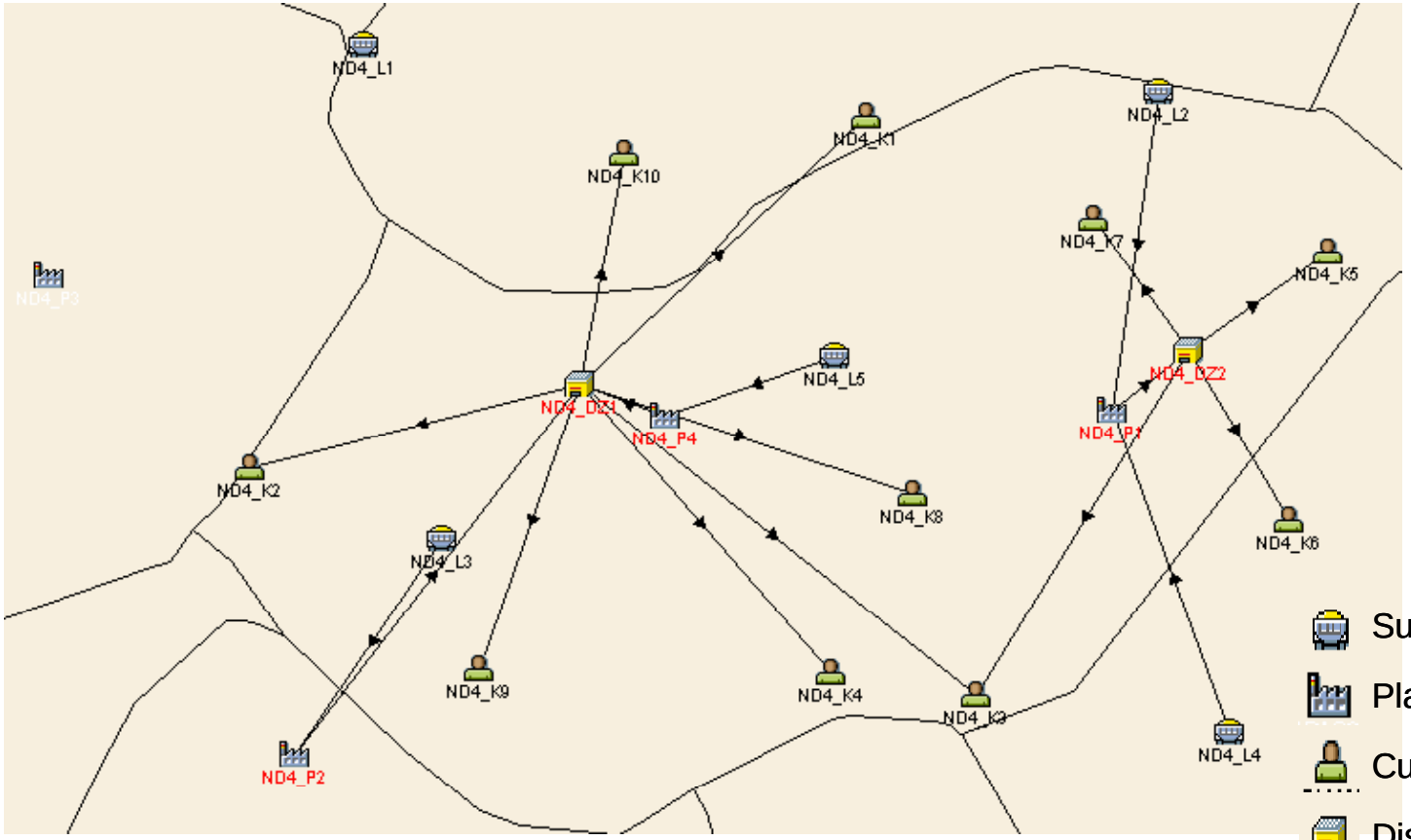


Management level



Strategic network design

- Exercise: Modelling Nutricia's supply network design by use of SAP APO 3.1 (based on Wouda et al., 2003)



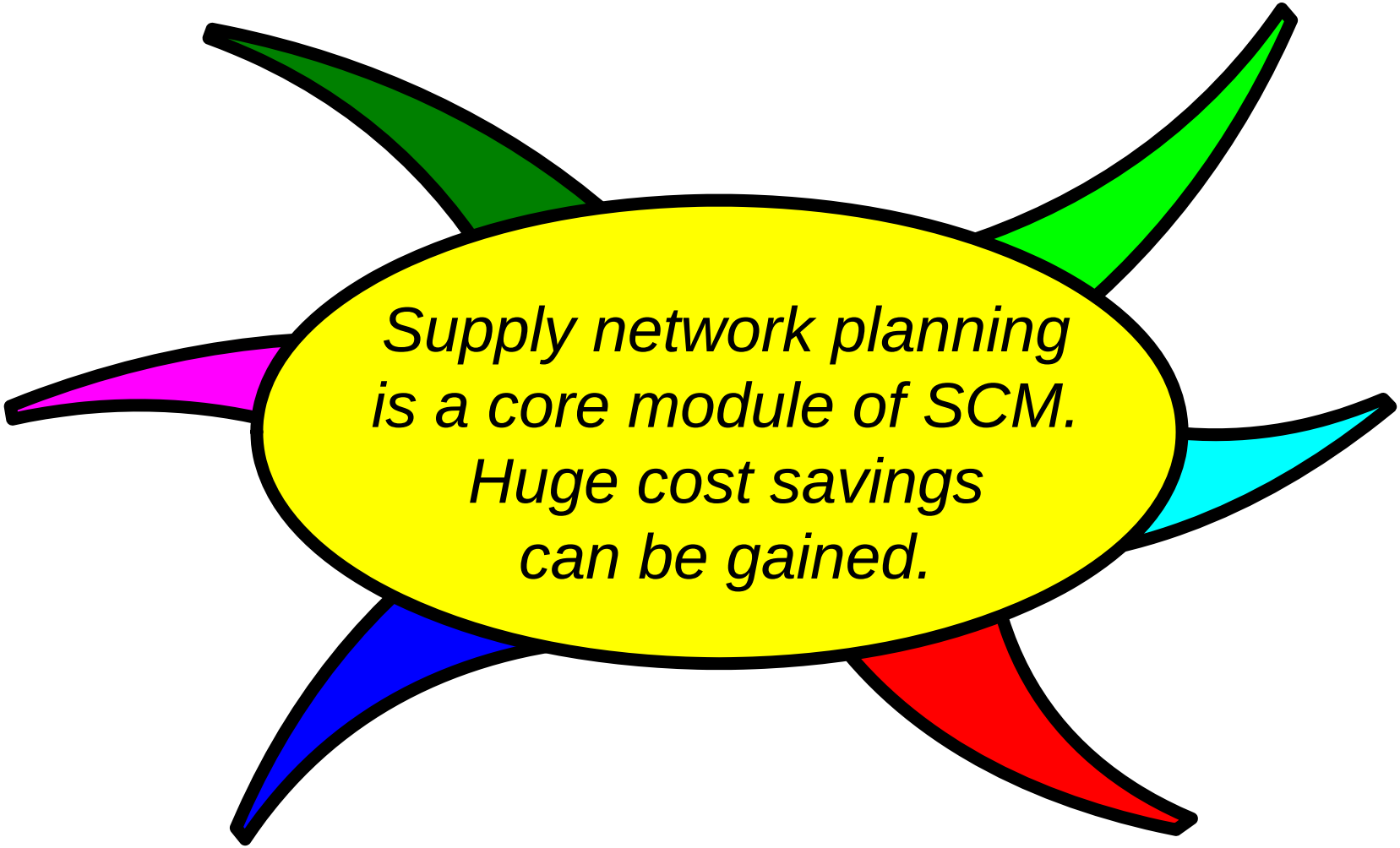
Lesson 6


Forecasting is essential at all planning levels. Pure forecasts can cause ampli-fication of demand.

Demand planning

- **Use of forecast**
  - Strategic level: design of the supply network
  - Operational level: production, distribution, and procurement decisions
  - Short-term: update of production orders
- **Demand planning**
  - Most essential in make-to-stock environment, e.g. in the consumer goods industry
  - Collaborative forecasting between partners in the supply chain
- **Mathematical methods**
  - Statistical forecasting techniques
  - Tools for incorporating human judgement

Lesson 7


Supply network planning
is a core module of SCM.
Huge cost savings
can be gained.

Supply network planning

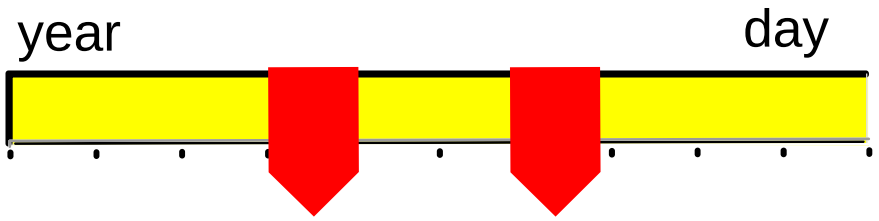
- **Mathematical methods**
  - LP and MILP, heuristics

Supply Network Planning

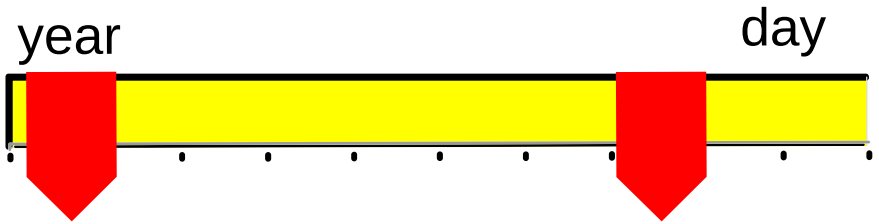
- **Decisions**
  - Allocation of production quantities between plants
  - Supply from the plants to DCs and from the DCs to customers
  - Smoothing out seasonal cycles in demand
  - Consideration of production, transportation, and handling capacities as *hard constraints*
  - Consideration of demand, due dates, and safety stocks as *soft constraints*

Supply network planning

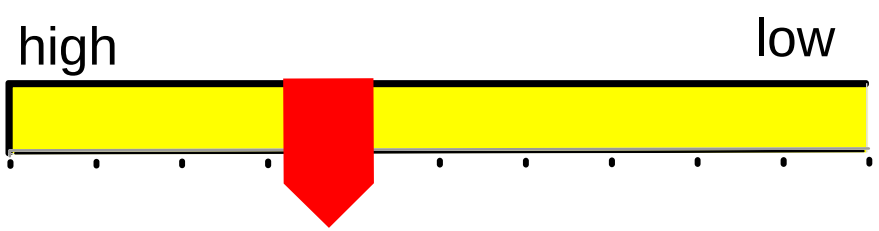
Planning frequency



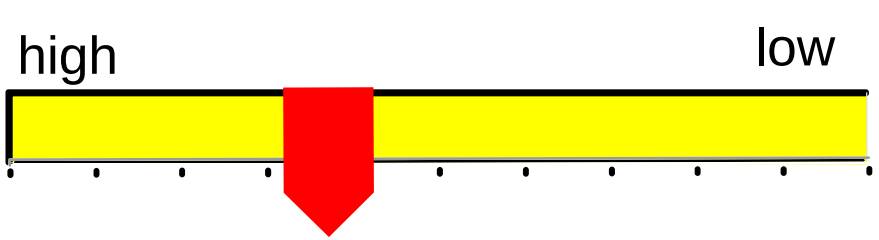
Planning horizon



Degree of aggregation

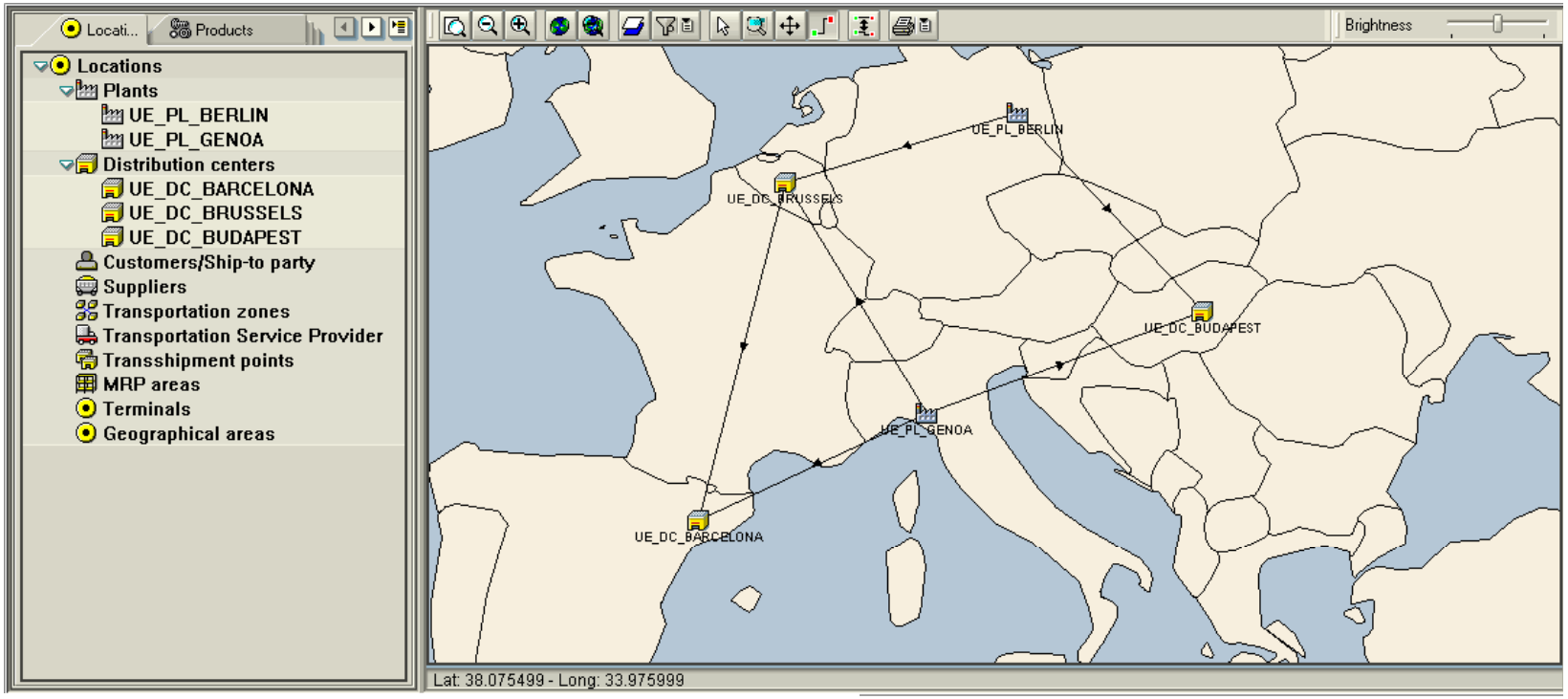


Management level



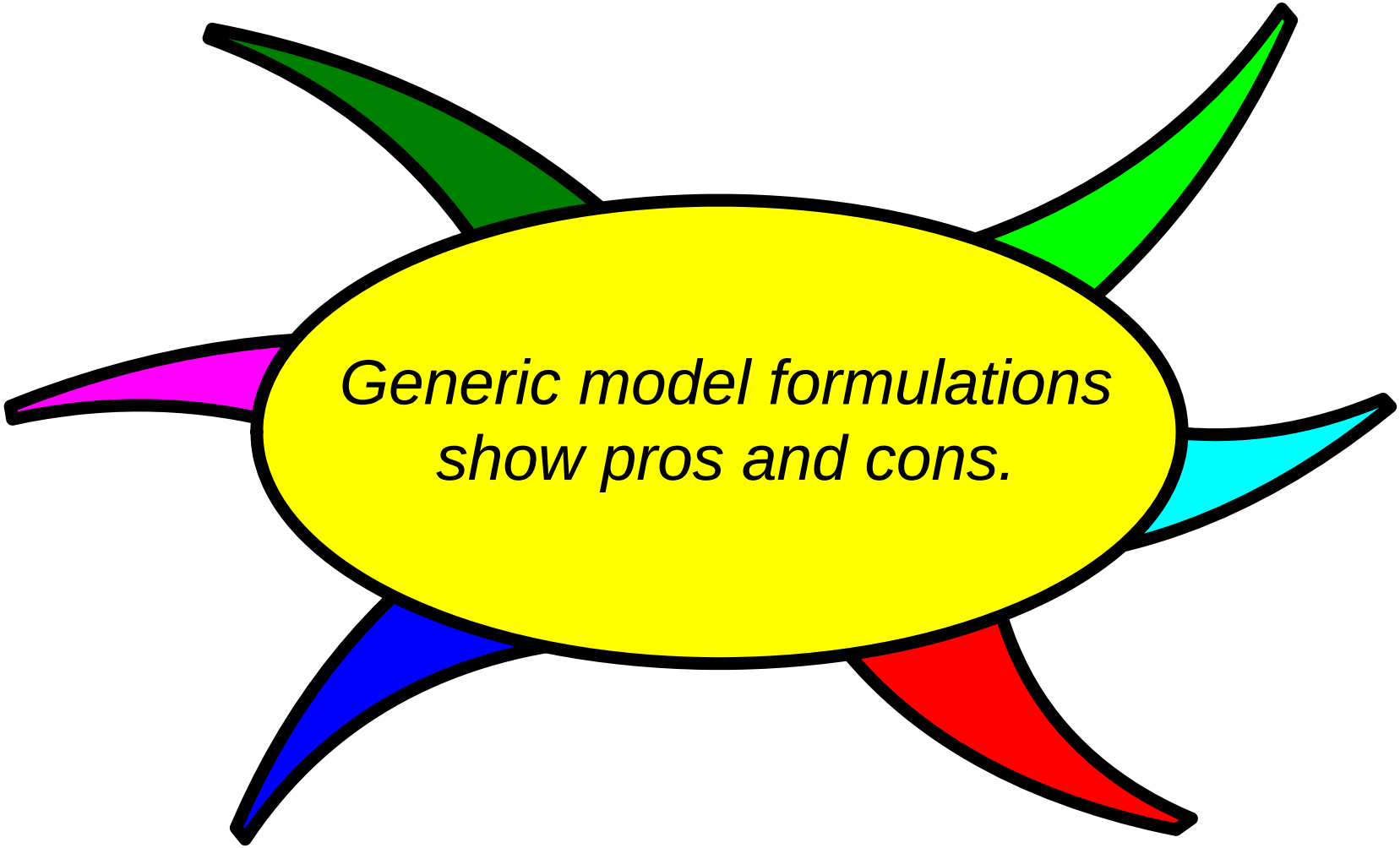
Supply network planning

Supply chain engineer in SAP APO 3.1



- Set-up of the network configuration
- Integration of suppliers and transporters
- Assign and modify master data, e.g. product portfolio and capacities, costs, safety stocks, demand figures, modes of transportation etc

Lesson 8



Supply network planning

Generic model formulation

Storage and handling capacity at DCs

$$\sum_{p \in P(i)} \alpha_p \cdot y_{pjt} \leq SC_j$$

Production capacity at plants

$$\sum_{p \in P(i)} \sum_{j \in J(i)} a_{pi} \cdot x_{pijt} \leq PC_{it}$$

$$\sum_{p \in P(i)} \sum_{i \in I(j)} \alpha_p \cdot x_{pijt} + \sum_{p \in P(i)} \sum_{k \in K(j)} \alpha_p \cdot z_{pjkt} \leq HC_j$$

Storage and handling costs per DC

Transportation capacity per link

$$\sum_{p \in P(i)} \alpha_p \cdot x_{pijt} \leq TC_{ijt}$$

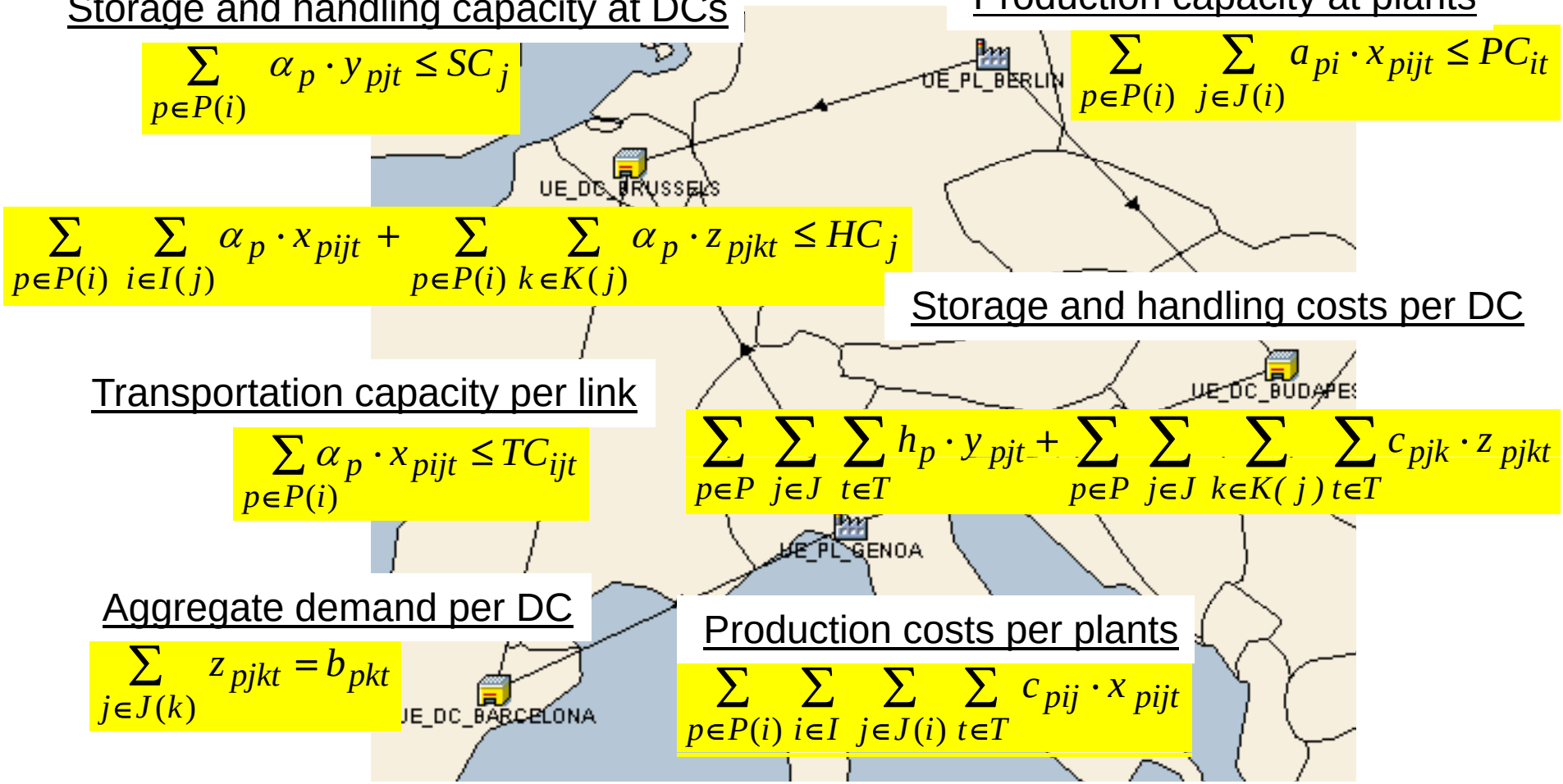
$$\sum_{p \in P} \sum_{j \in J} \sum_{t \in T} h_p \cdot y_{pjt} + \sum_{p \in P} \sum_{j \in J} \sum_{k \in K(j)} \sum_{t \in T} c_{pjk} \cdot z_{pjkt}$$

Aggregate demand per DC

$$\sum_{j \in J(k)} z_{pjkt} = b_{pkt}$$

Production costs per plants

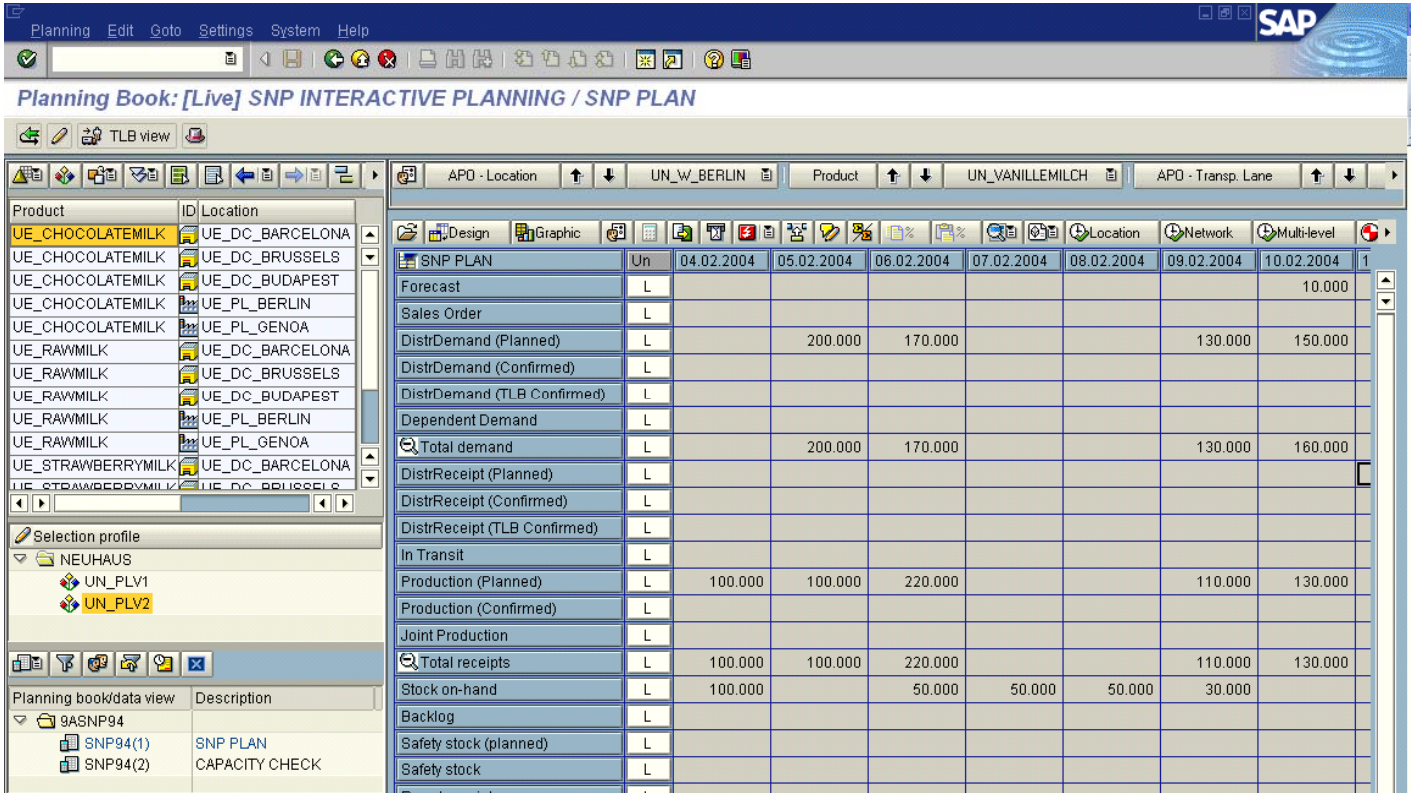
$$\sum_{p \in P(i)} \sum_{i \in I} \sum_{j \in J(i)} \sum_{t \in T} c_{pij} \cdot x_{pijt}$$



Assigning attributes to pre-defined entities

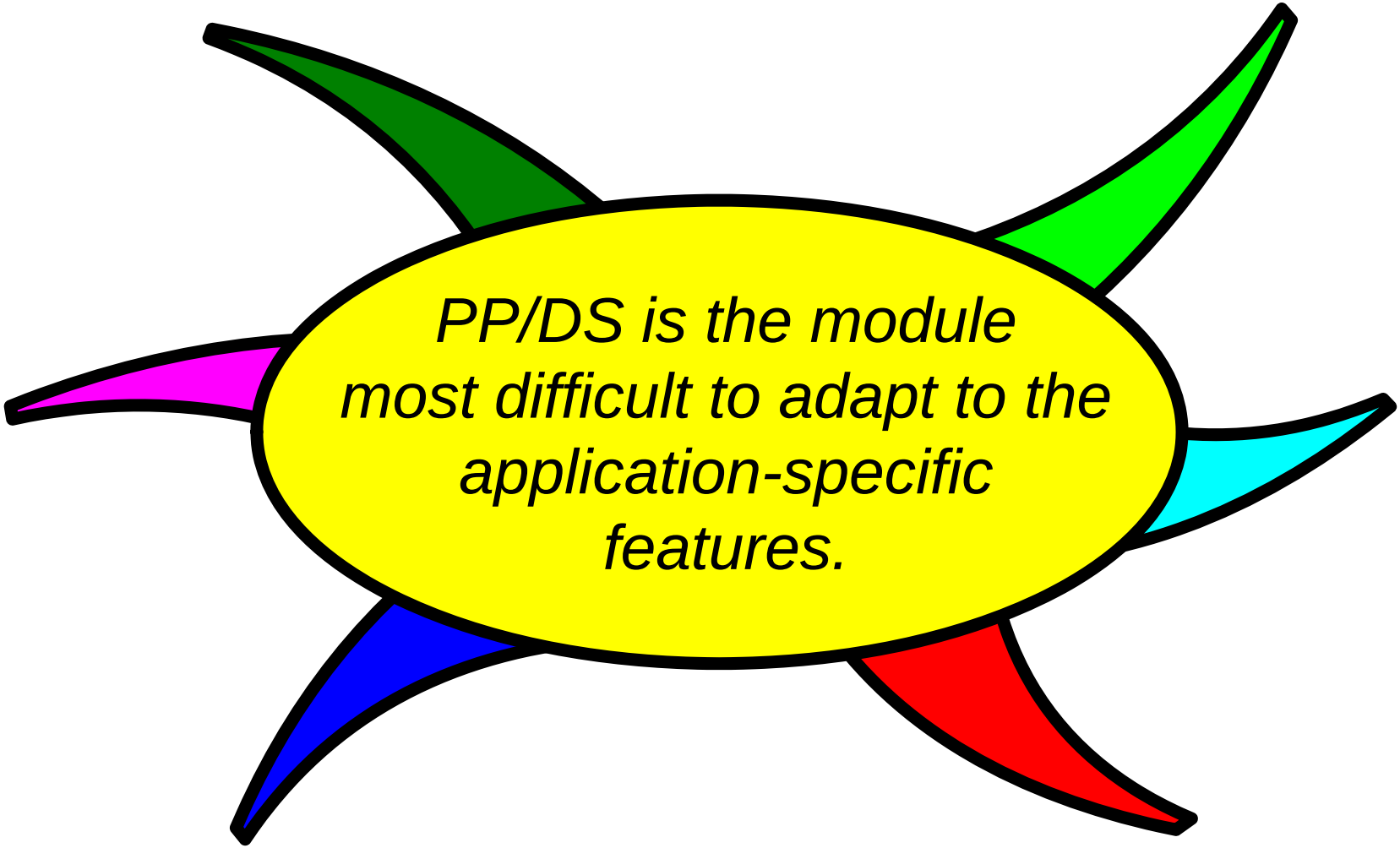
Supply network planning

- **Planning books offer user-defined views of the solution**



- **Additional features of SAP APO 3.1**
  - Safety stock planning
  - Lot-sizing and production campaign planning

Lesson 9


PP/DS is the module
most difficult to adapt to the
application-specific
features.

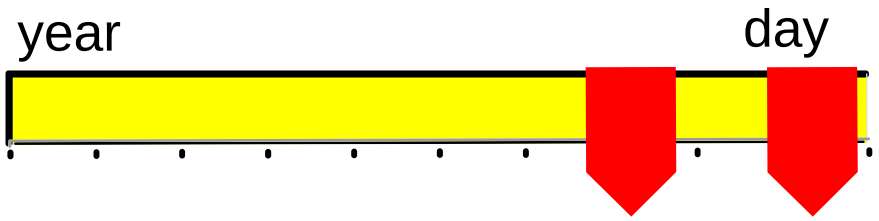
Production Planning / Detailed Scheduling

- **Decisions**
  - Generation of production orders
  - Allocation of resources according to a finite scheduling policy
- **Mathematical methods**
  - Genetic algorithms
  - Constraint programming
  - Rules and heuristics
  - Application specific algorithms

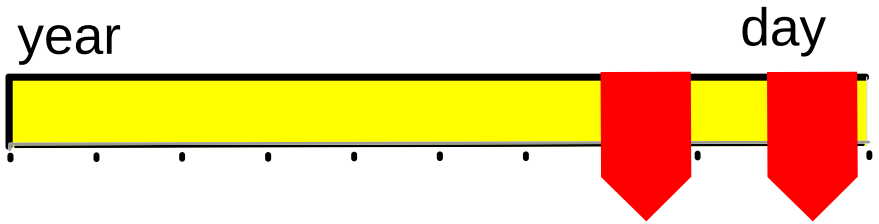
- Lot-sizing, sequencing, and procurement proposals
- Consideration of the availability of resources as *hard constraints*
- Consideration of due dates, time windows etc. as *soft constraints*

Production Planning / Detailed Scheduling

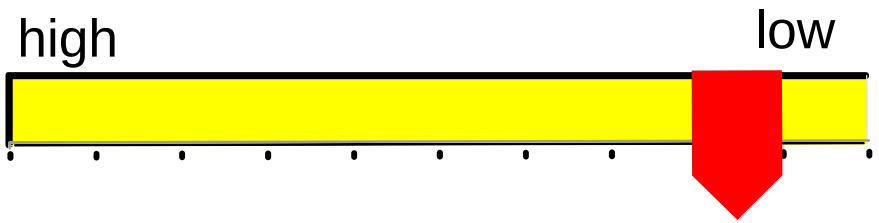
Planning frequency



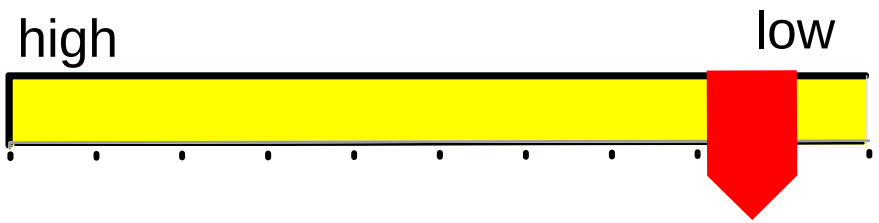
Planning horizon



Degree of aggregation

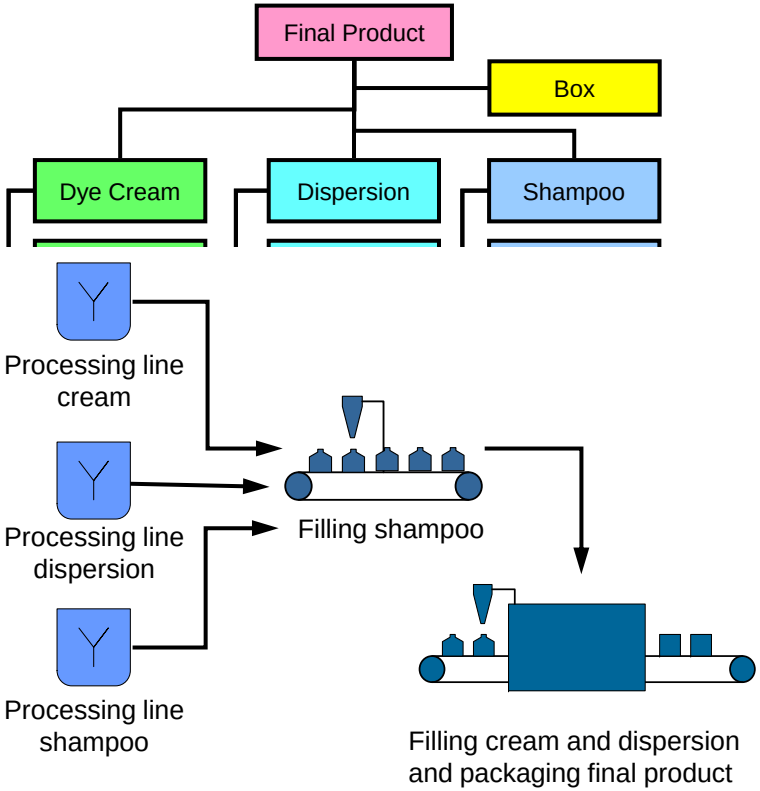


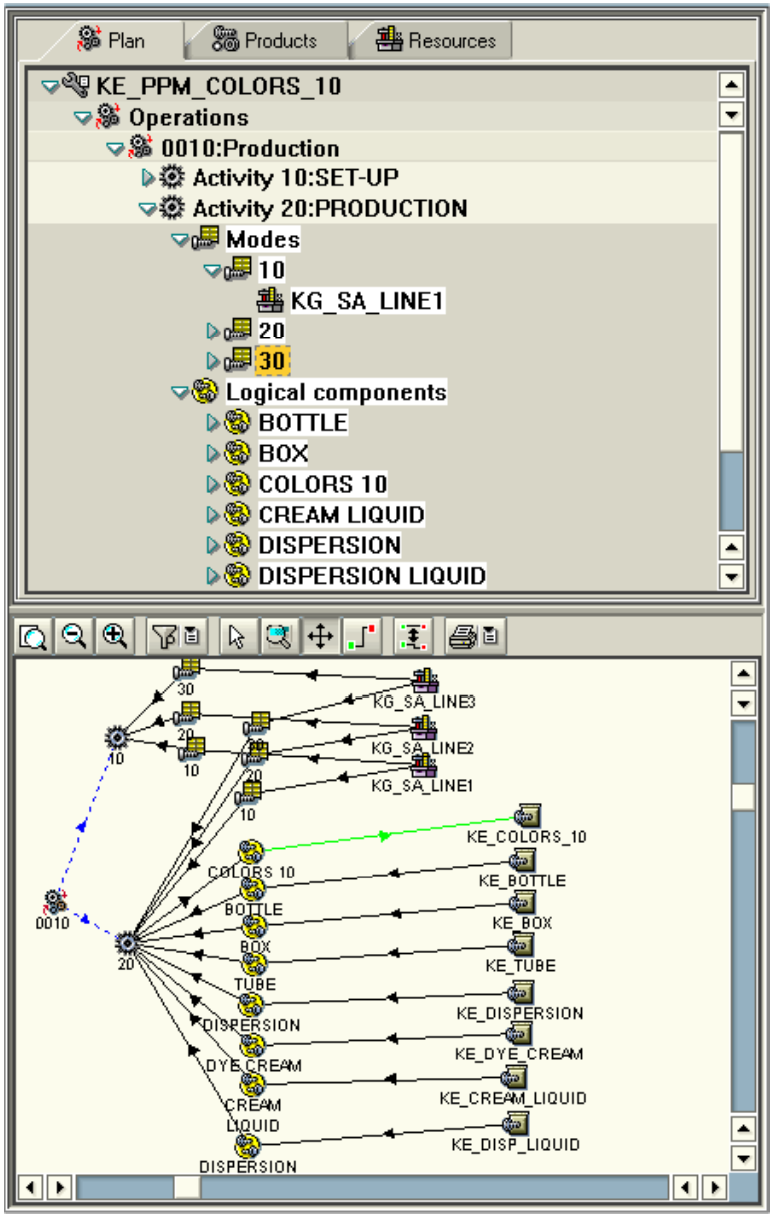
Management level



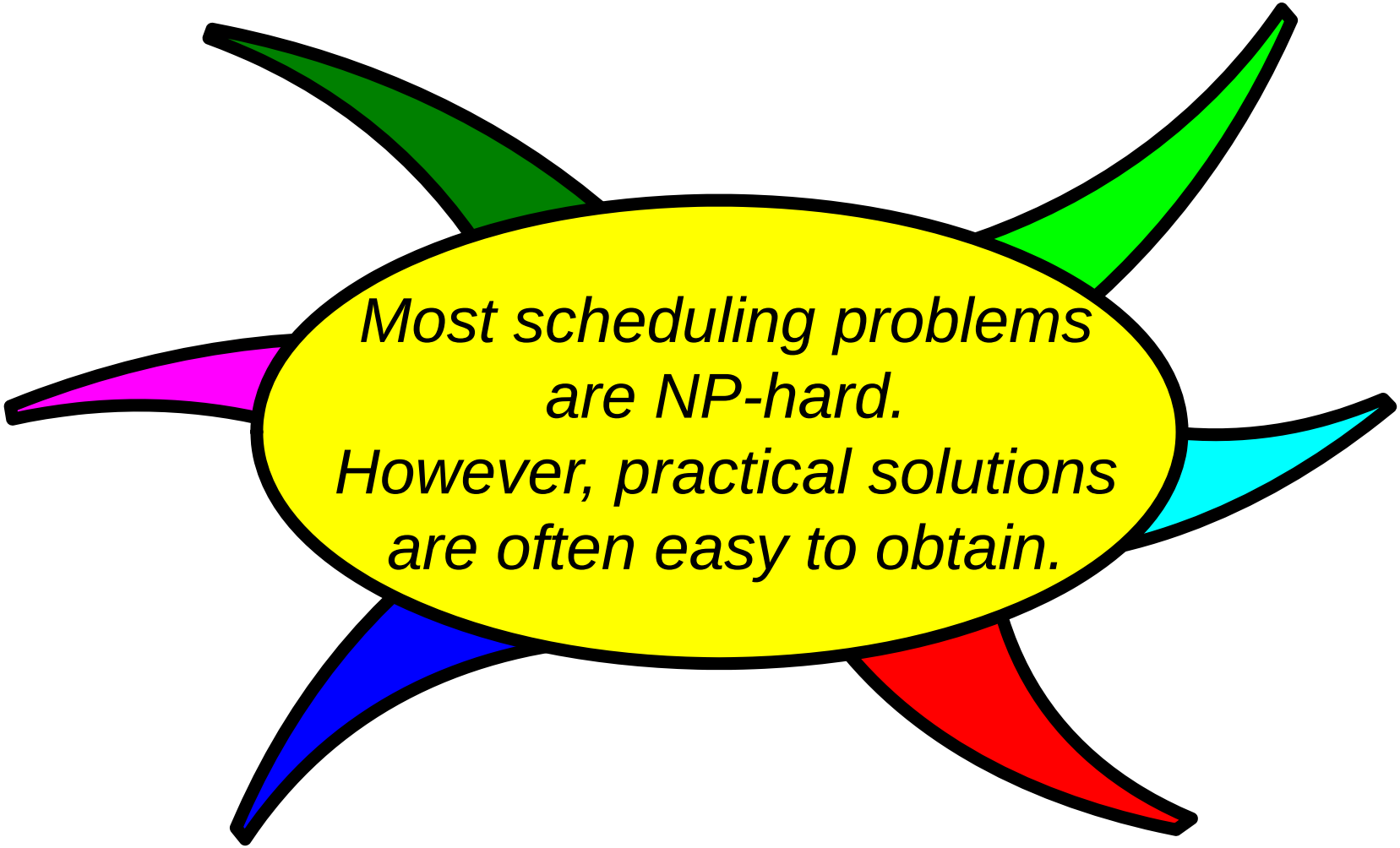
Production Planning / Detailed Scheduling

- Case study: Production of hair dyes



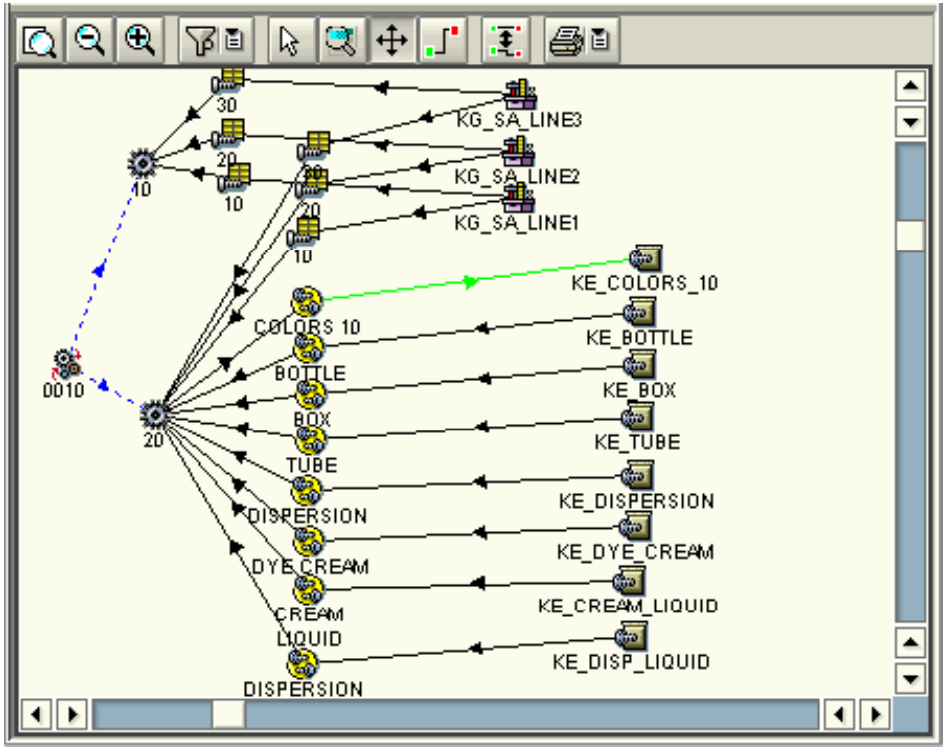


Lesson 10


Most scheduling problems
are NP-hard.
However, practical solutions
are often easy to obtain.

Production Planning / Detailed Scheduling

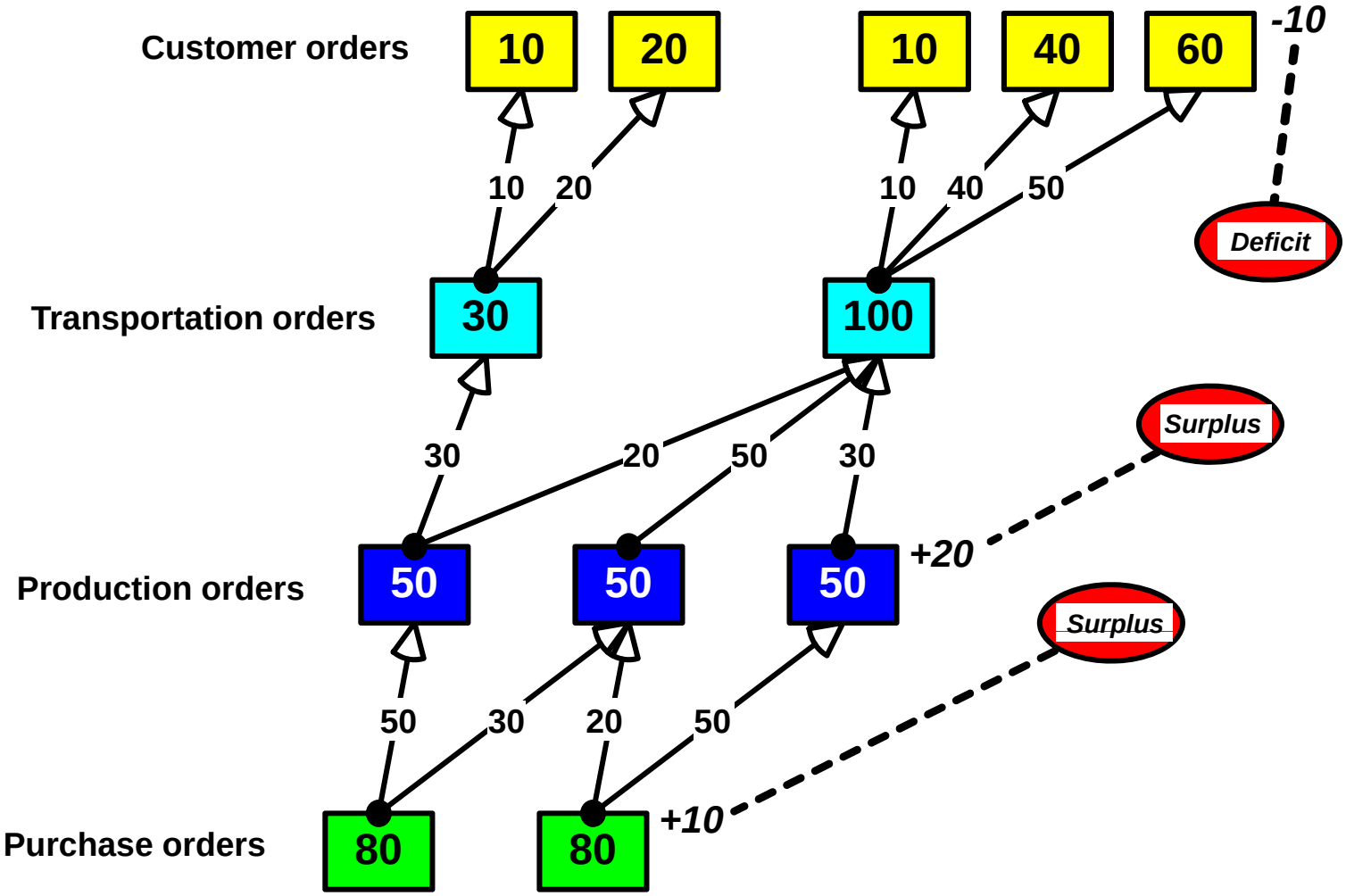
- Case study: Production of hair dyes
  - Solutions obtained from the PP/DS module of SAP APO 3.1 within 2 minutes
  - GA superior to CP
  - Alternative solvers can be integrated via “Optimization extended workbench”

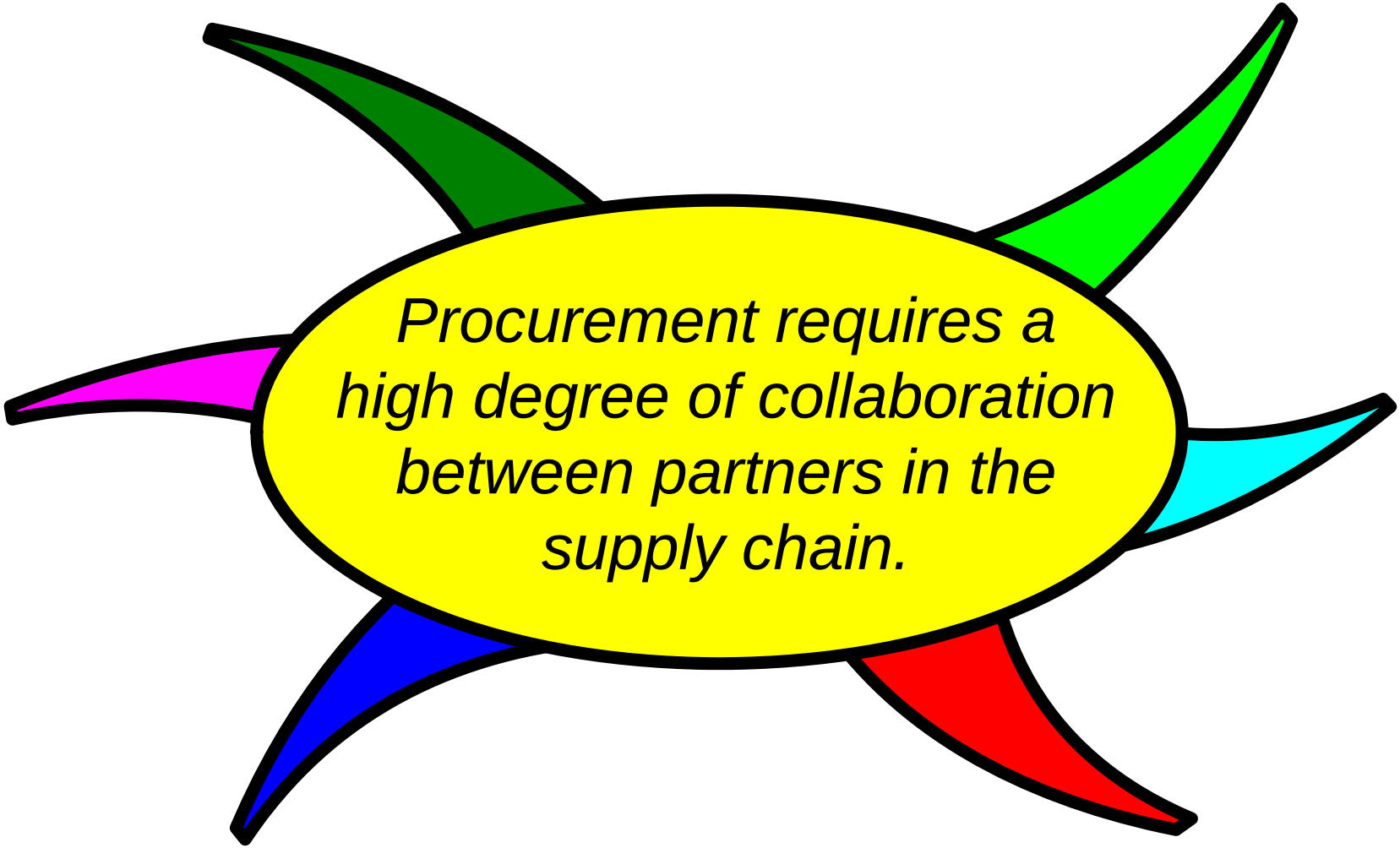


- Additional features of SAP APO 3.1
  - Characteristics based planning
  - Shelf-life consideration
  - Model mix planning

Production Planning / Detailed Scheduling

- Complete pegging (dynamic or fixed)



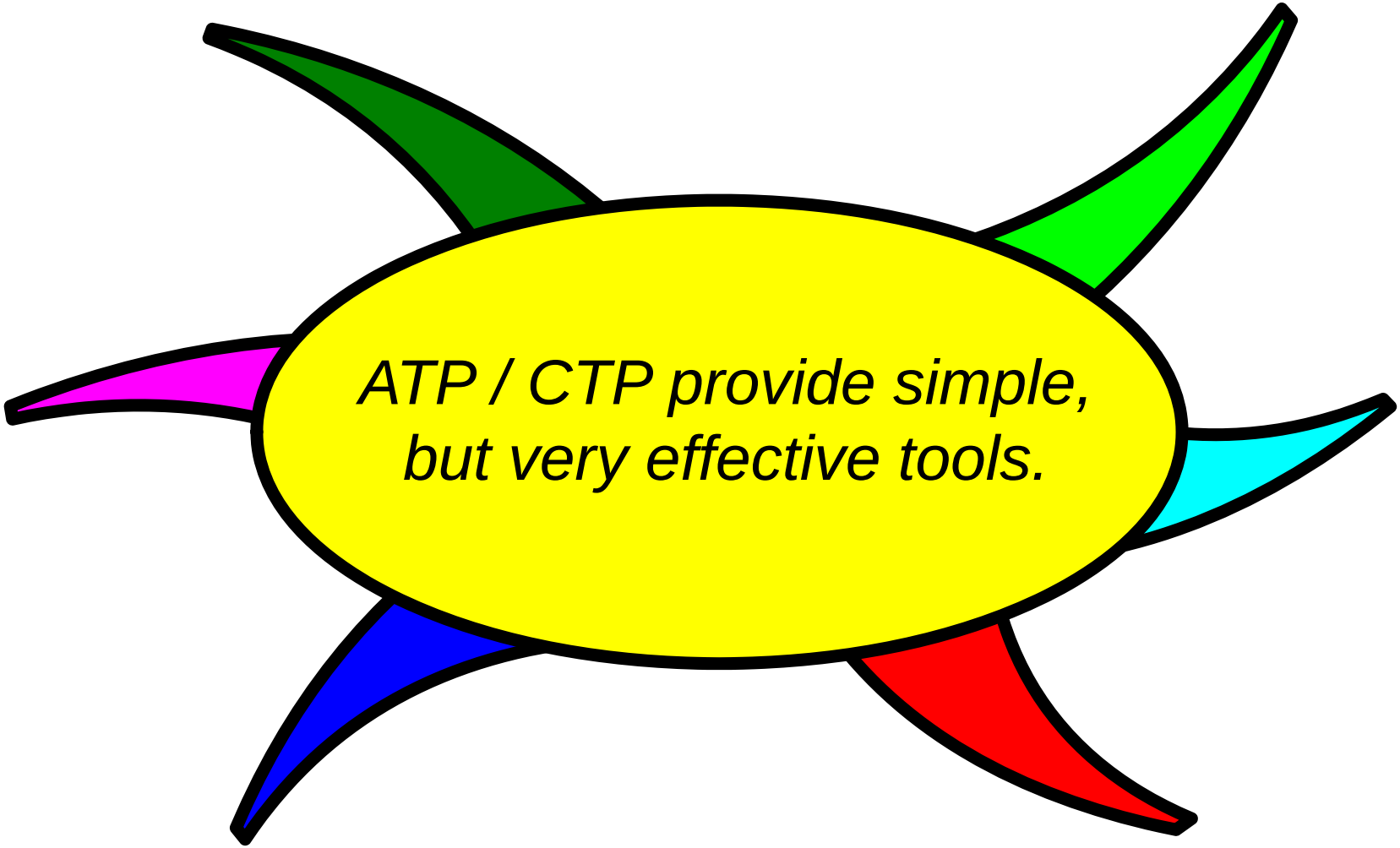

Procurement requires a high degree of collaboration between partners in the supply chain.

External procurement

- **Decisions**
  - Determination of the purchase quantity
  - Selection of the supplier
  - In-house or external supply?
  - Release of deliveries for JIT goods

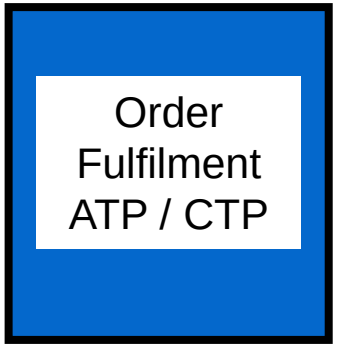
- **Mathematical methods**
  - Rule-based and heuristic procedures
  - MILP

Lesson 12



Order fulfilment and ATP / CTP

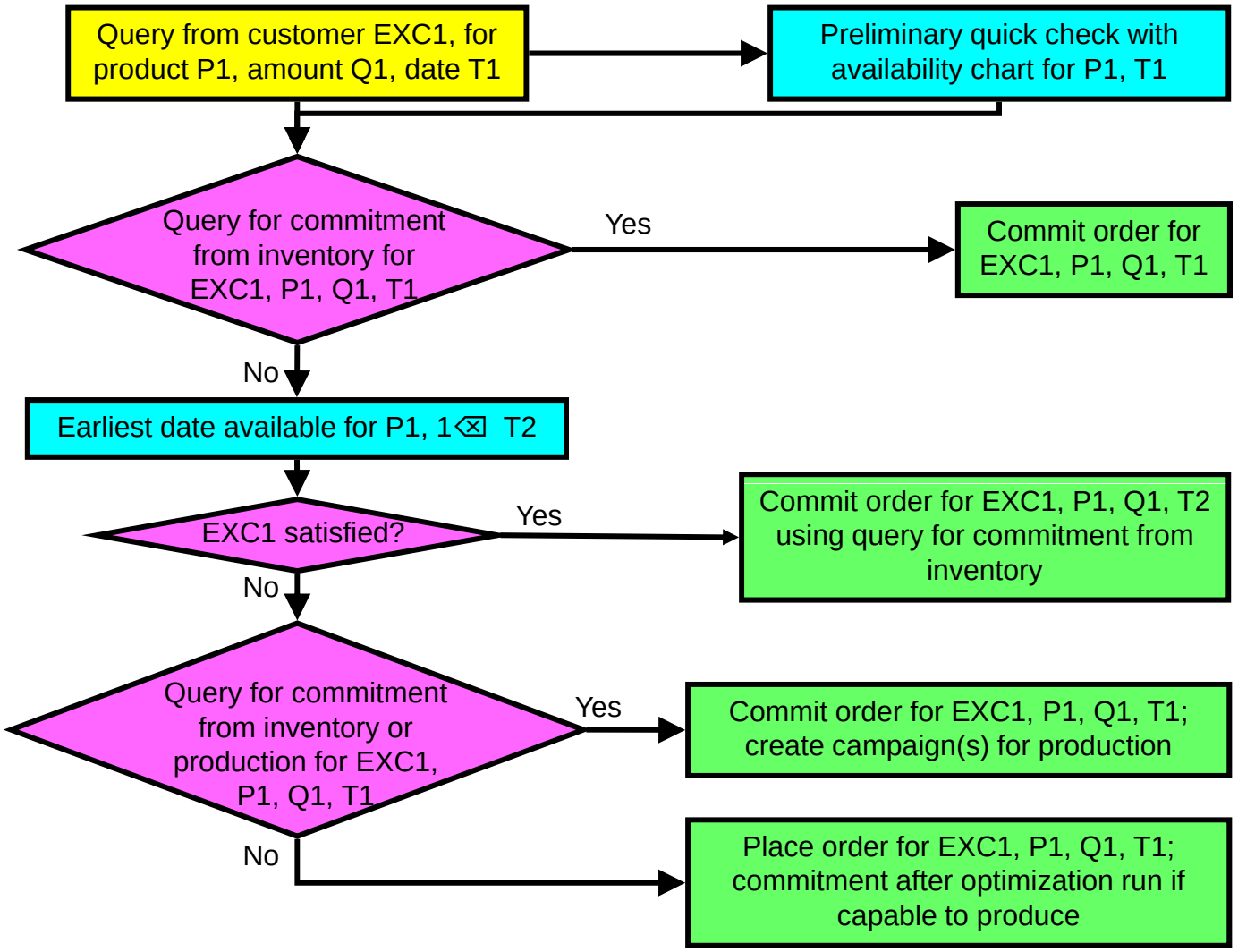
- **Decisions**
  - Matching customer orders against available quantities
  - Quick response to customer requests (*Available to Promise*: ATP)
  - Capacity check for new or enhanced production orders in response to customer requests (*Capable to Promise*: CTP)



- **Mathematical methods**
  - Rule-based ATP
  - Batch mode ATP (MILP)

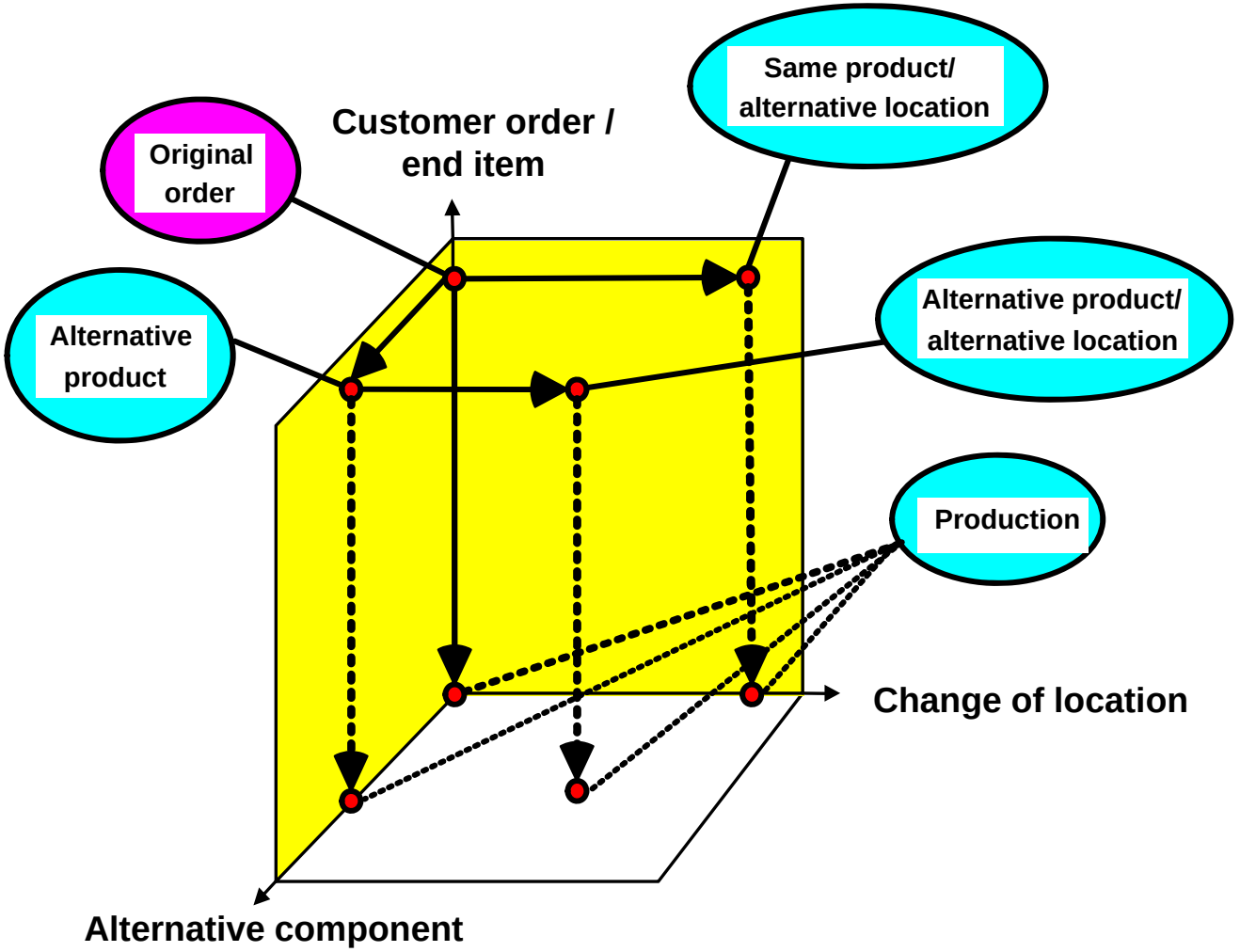
Order fulfilment and ATP / CTP

- Rule-based ATP: Bayer AG, Germany



Order fulfilment and ATP / CTP

- ATP decision cube of SAP APO 3.1



Lesson 13


Customer satisfaction finally depends on the timely execution of transportation activities.

Transportation planning and vehicle scheduling

- **Decisions**
  - Choice of the transportation mode (e.g. truck or rail)
  - Integration of external logistics service providers and offering of own logistics services (e.g. VMI)
  - Determination of regular freight frequencies between locations and of the unit transportation size
  - Vehicle loading and scheduling considering time windows for delivery
  - Collaboration between locations and with external logistics service providers

- **Mathematical methods**
  - Heuristics
  - Local Search

Concluding remarks

Huge cost savings can be gained through efficient use of APS.

APS have been adopted in many industries.

Collaboration between partners in the supply chain including share of information and transparency of business processes is seen as a major driver of SCM performance.

No global “optimize SCM” button provided by APS.
Expertise needed.

Optimization models often require large computational effort.

APS, especially at the detailed scheduling level, do not sufficiently consider application specific features.

APS are most successful for intra-company supply chains with centralized logistics control.