CAPPS: Collaborative Agents for Production Planning and Scheduling – A Challenge to Develop a new Software System Architecture for Manufacturing Management in Japan

Yasuyuki NISHIOKA
Hosei University
nishioka@k.hosei.ac.jp

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Outline

- Introduction
- Scheduling intensive manufacturing
- CAPPS architecture
- PSLX consortium’s recommendations
- Common schema of the domain (ontology)
- XML based messaging among agents
- New management models with CAPPS
- Summary

Market has changed

- Demand forecasting is frequently differ from the actual movement.
- Product life cycle (survival time) is shorten and unpredictable.
- Product customizations are strongly required almost one by one
- Demand deviation is huge because of the new type of supply chains

Current status of Japanese manufacturers

- Economical situation is very bad.
- Technologies are spread to new countries
- Quality/cost competitiveness decreases
- Conventional supply chains are confused
- Small sized firms get serious damage
- Vitality of young person has disappeared
- IT projects have not achieve their goals

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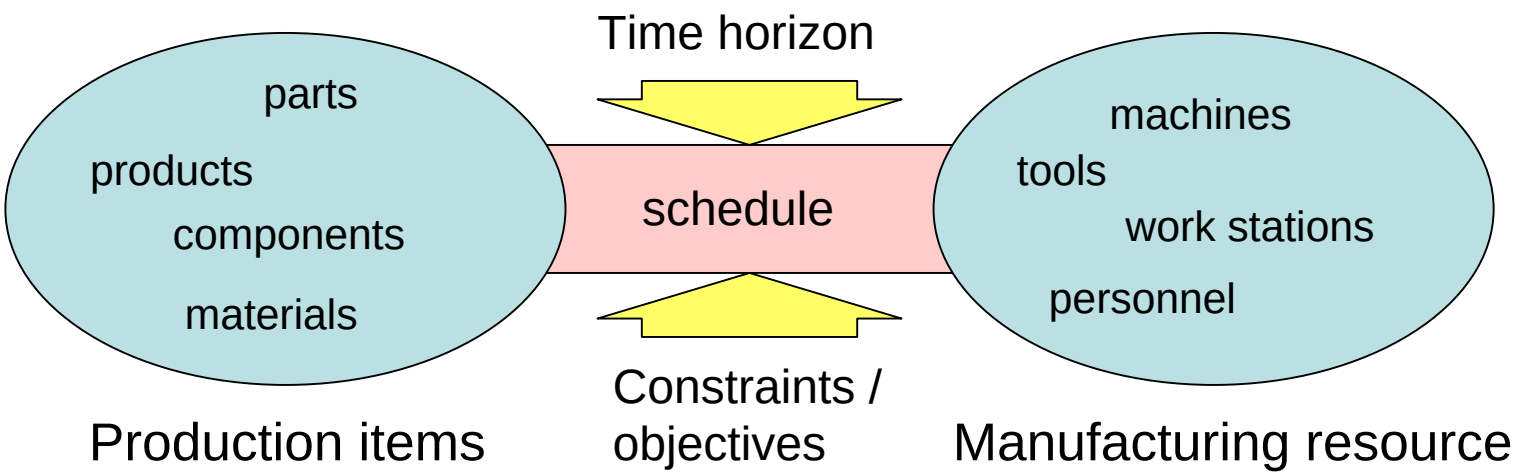
Why Japanese manufacturers should focus on scheduling

- Ship floor leaders make their own schedule autonomously
- Distributed decision and coordination have been successively performed
- Fixed production lead time is no longer met the customer’s requirements
- Backward scheduling (JIT scheduling) is effective for decreasing inventories

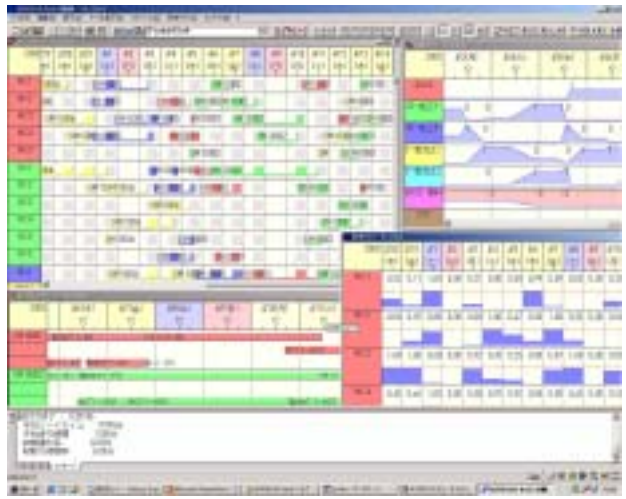
Definition of Production Scheduling

To clarify relationship among production items and manufacturing resources in the time horizon, concerning various constraints and objectives of production

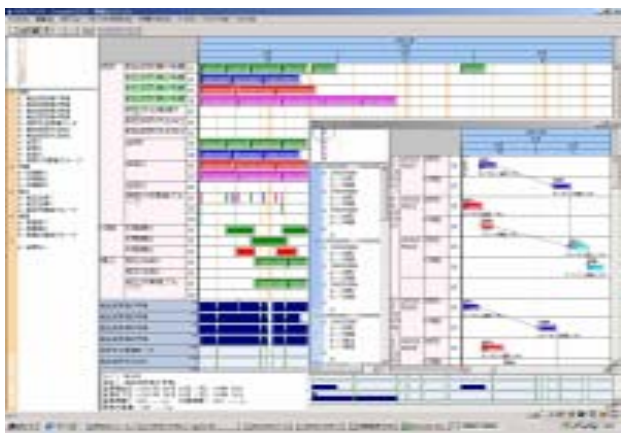


Production scheduling software

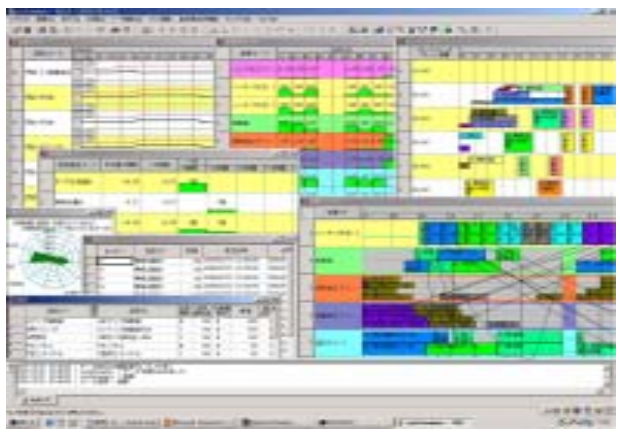
ACCROAD/Logics Japan, Co.,Ltd.



ASPROVA / ASPROVA Corporation



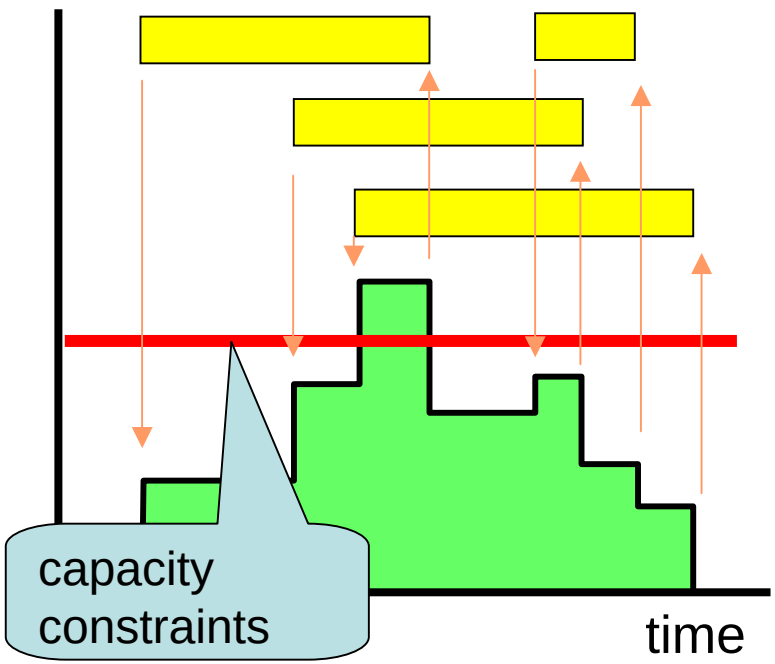
DIRECTOR / CIMTOPS Corporation

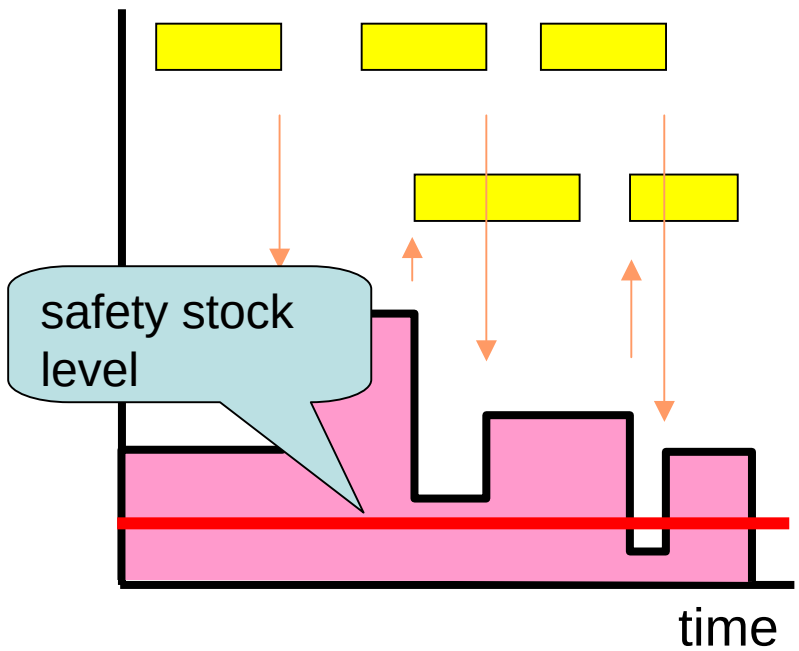


JoyScheduler / JT Engineering Inc.

Features of Schedulers (1/4)

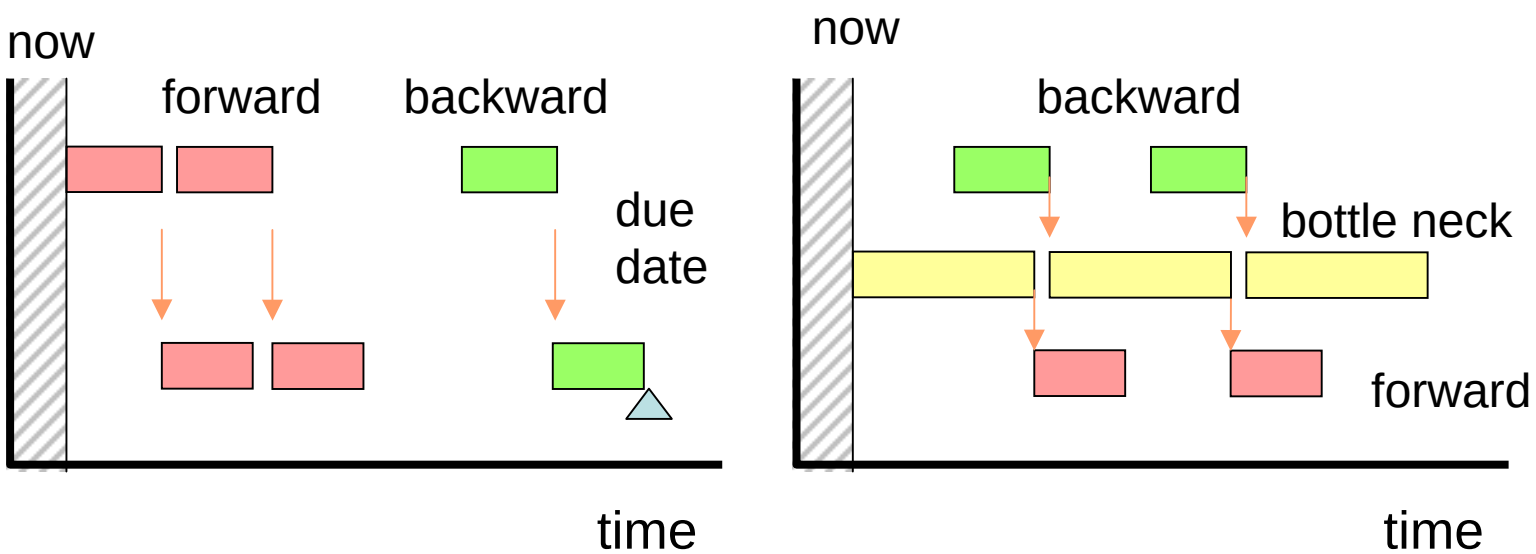
- Capacity constraints and material availability are simultaneously concerned





Features of Schedulers (2/4)

- Backward and forward scheduling are combined at the same time



Features of the schedulers

- Capacity constraints and material availability are simultaneously concerned
- Backward and forward scheduling are combined at the same time
- Changeover constraints among different operation can be precisely addressed
- Operations and inventories are pegged through the process flow

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Keys of Scheduling Intensive Manufacturing

- Visualizing correct schedule involving the real situation tackled by a shop floor managers using their local knowledge
- Dynamic rescheduling for shop floor disturbances such as emergency orders and machine broken downs
- Support tool for feed back cycles (order and report cycle) in performing rolling scheduling
- Short computational time without high optimization in order to use in interactive decision making for long scheduling horizon

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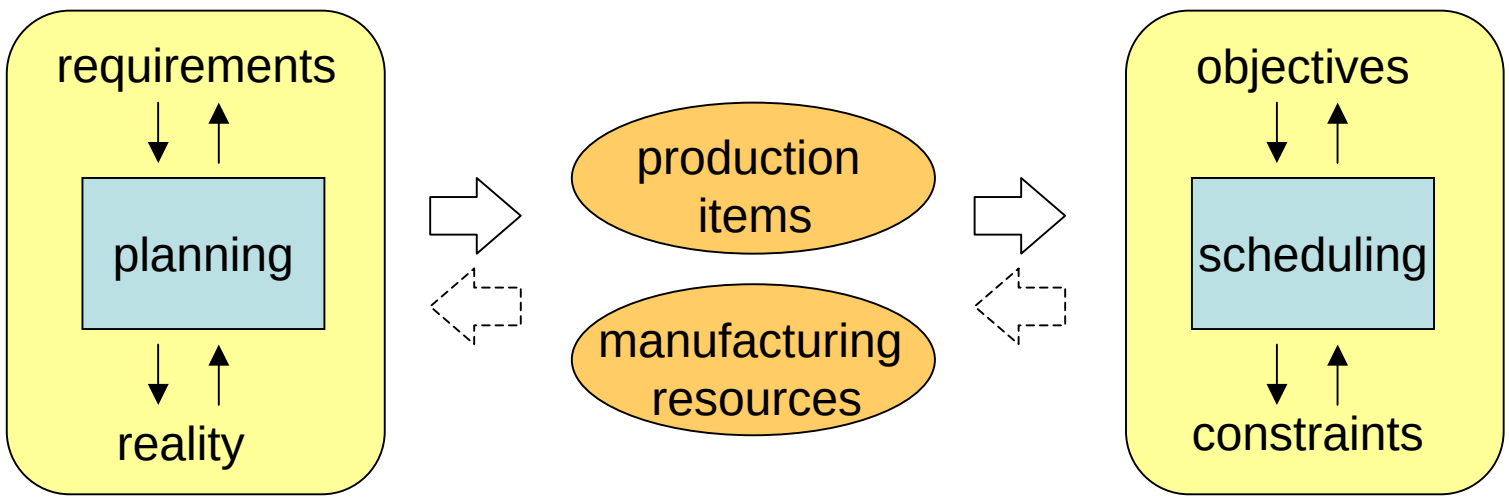
Toward Integration of planning and scheduling

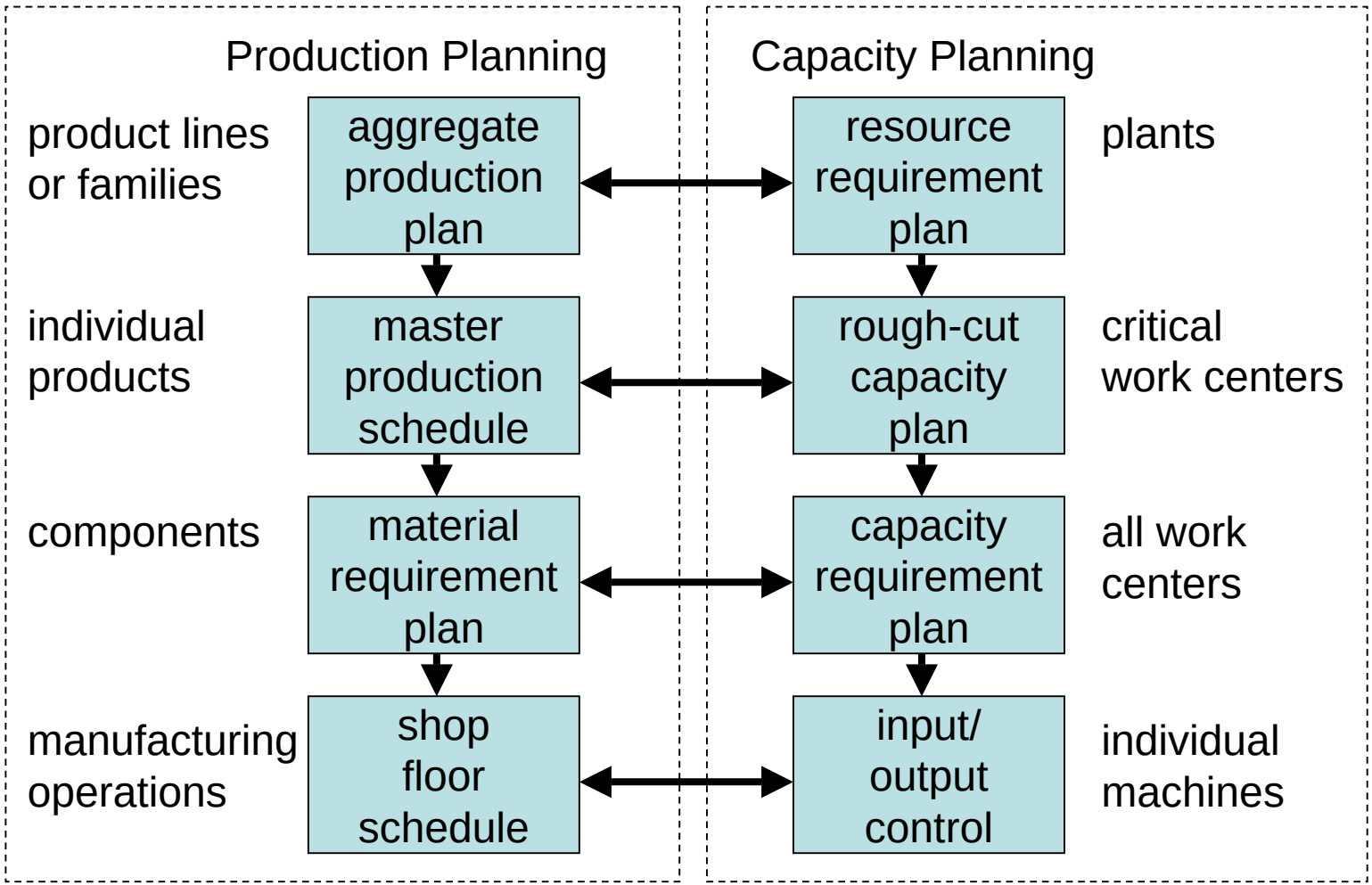
- Planning
  - To decide properties of production items and manufacturing resources in order to narrow the gap between requirements and reality
- Scheduling
  - To clarify relationship among production items and manufacturing resources in the time horizon, concerning various constraints and objectives of production

Advanced Planning and Scheduling

- a system architecture of planning and scheduling integration to dynamically and synchronously achieve the goal of manufacturing enterprises

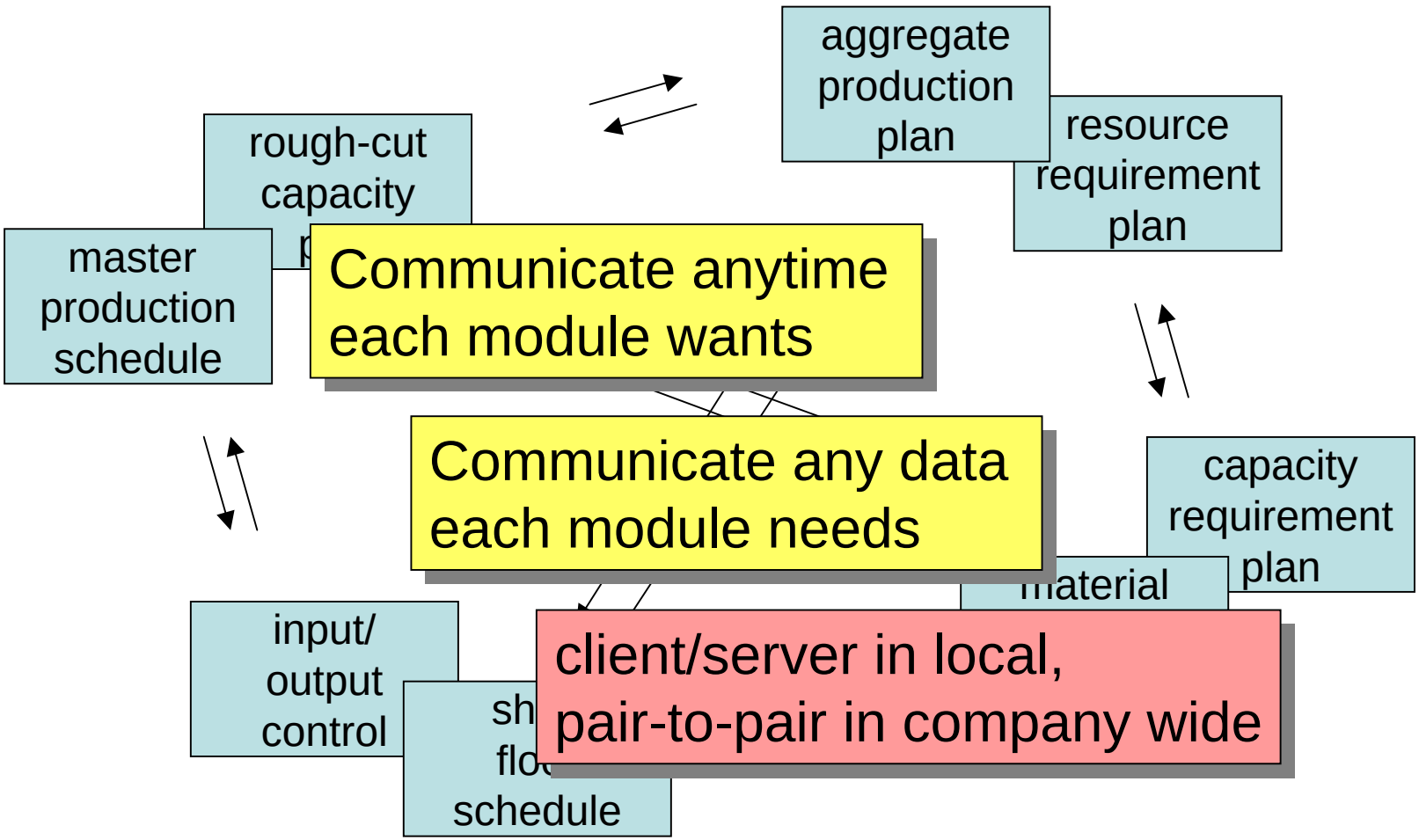


Typical planning modules



source Russell and Taylor, Operations Management

CAPPS architecture (image)

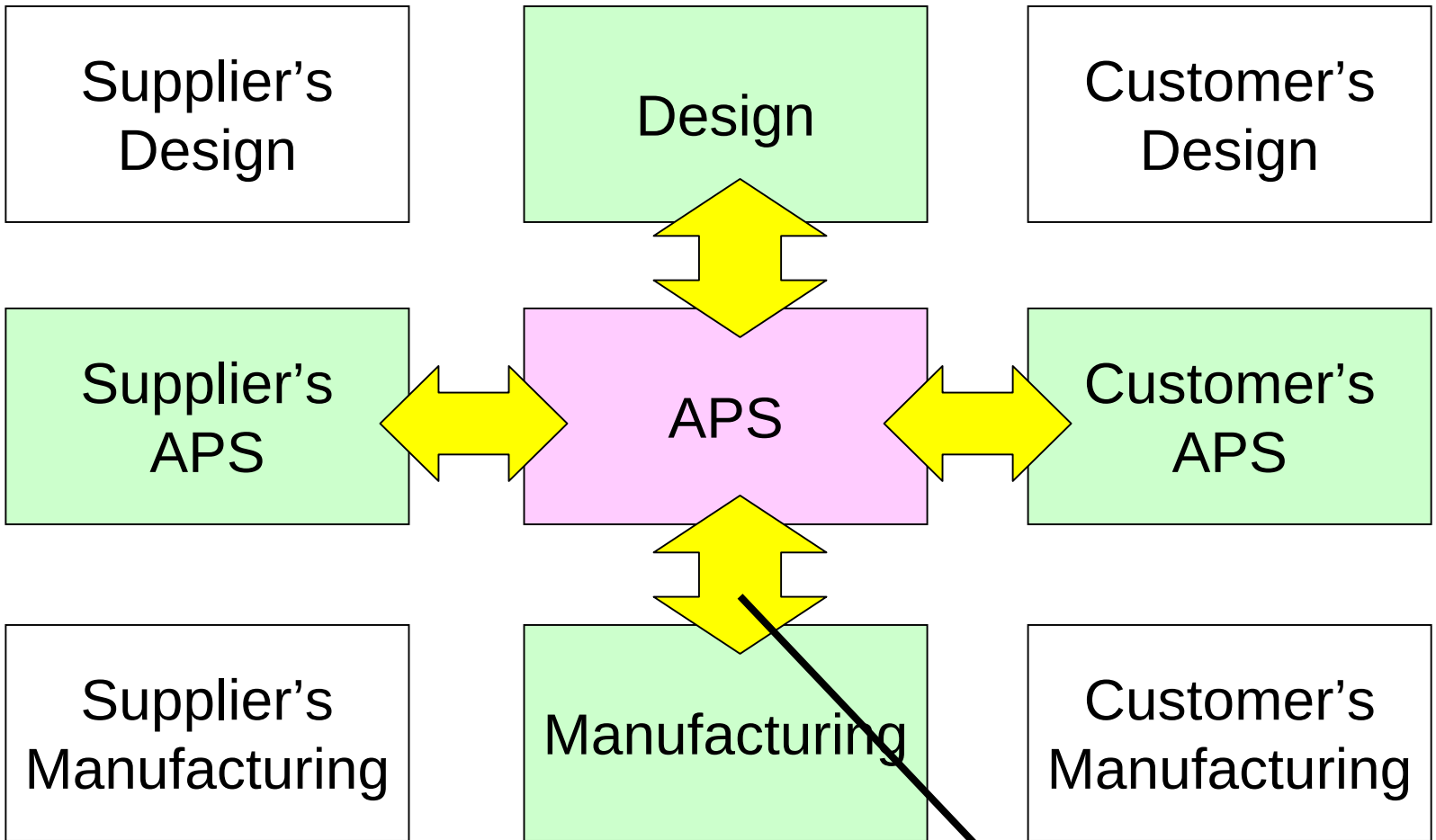


Agent based modeling

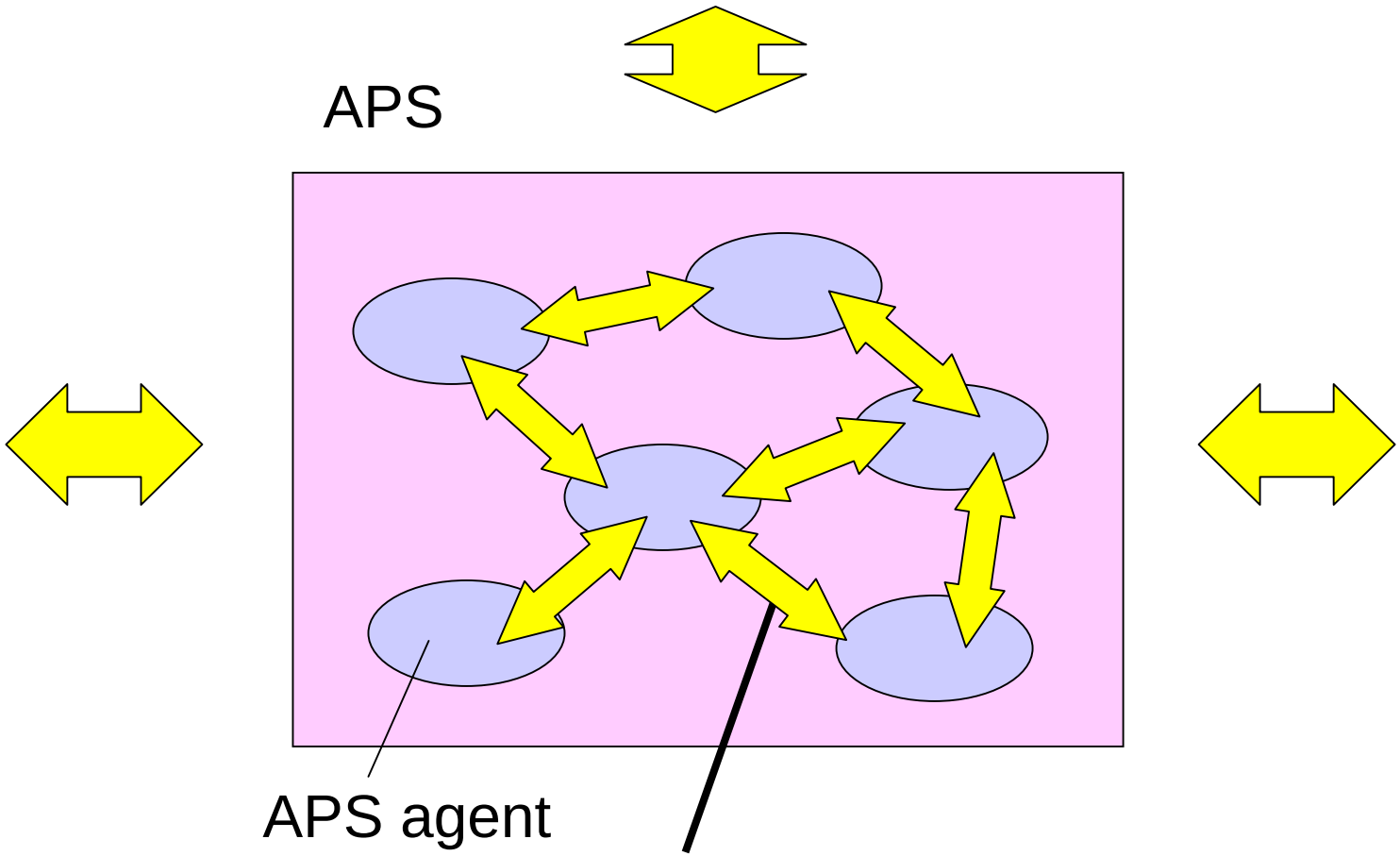
An autonomous subsystem which performs by itself in order to complete their missions received through their interface. In an encapsulated process, an agent can ask another agent to execute a part of its task.

In our definition, an agent should
(1) make decision autonomously,
(2) encapsulate its internal processes,
(3) have interfaces generally defined, and
(4) have capability to ask another agent

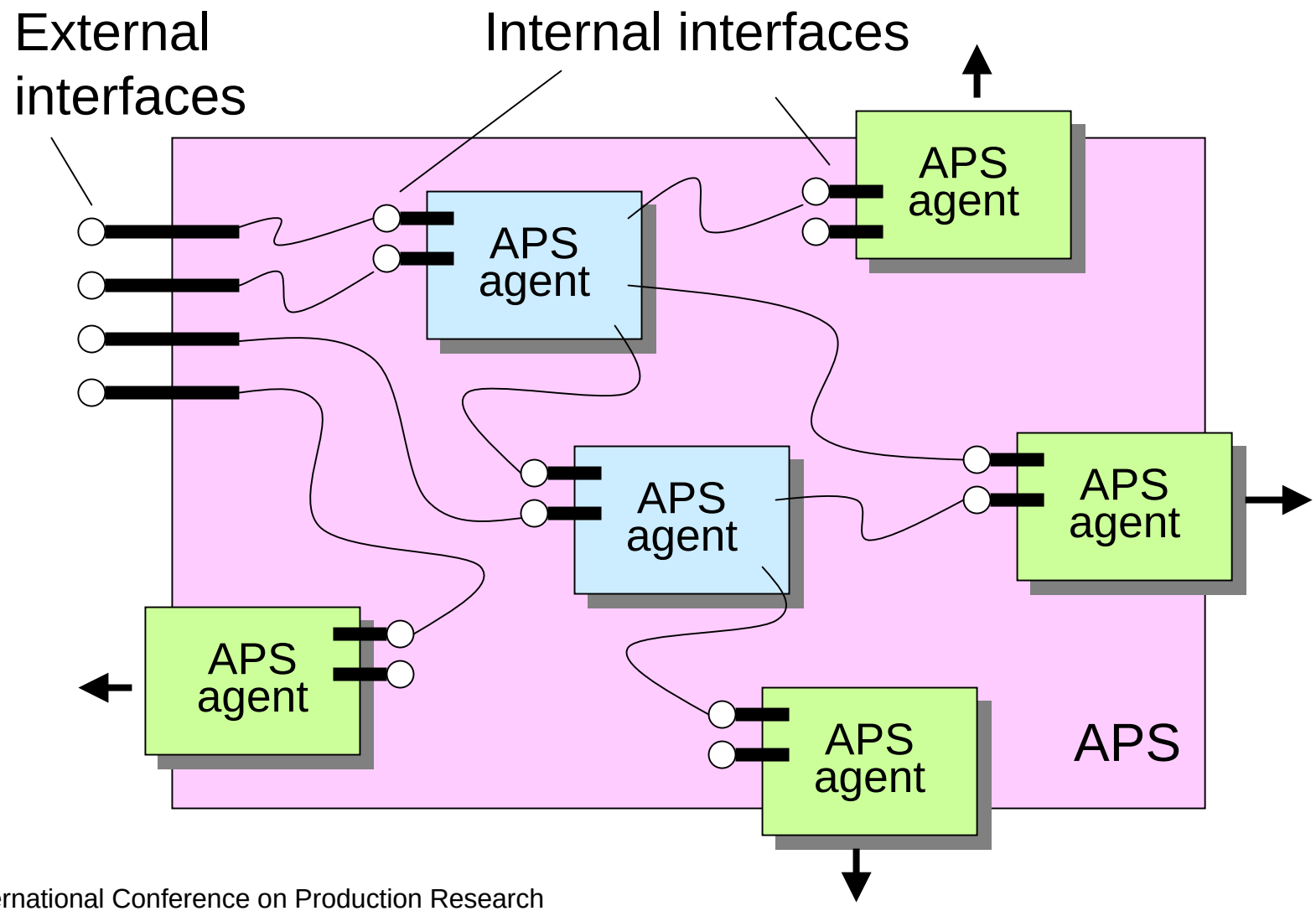
External interfaces



Internal interfaces



CAPPS architecture



Roles required for CAPPS

- Package makers
  - Develop software package as an agent according to the prescription of protocols and ontology
- System integrators
  - Design and develop relationship between agents or agents and external interfaces
- Manufacturers
  - Define external interface by clarifying requirements in their business models
- Standardization organization
  - Prescribe communication protocols and ontology for defining interfaces

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What is PSLX

- Reference architecture for APS software development
- Communication protocols and ontology among APS software
- XML schema for planning and scheduling problems
- Common terminology of planning and scheduling problems

PSLX (Planning and scheduling language on XML specification)

PSLX Consortium profile

- Founded in July 2001
- Chairman Prof. Kazuhiko Yasuda
- Board members (51)
  - IT vendor (16)
  - System integrator (18)
  - Consulting firm (5)
  - Manufacturer (4)
  - Research Institute (8)
- Recommendation specification was published in June 2003

Objective of PSLX Consortium

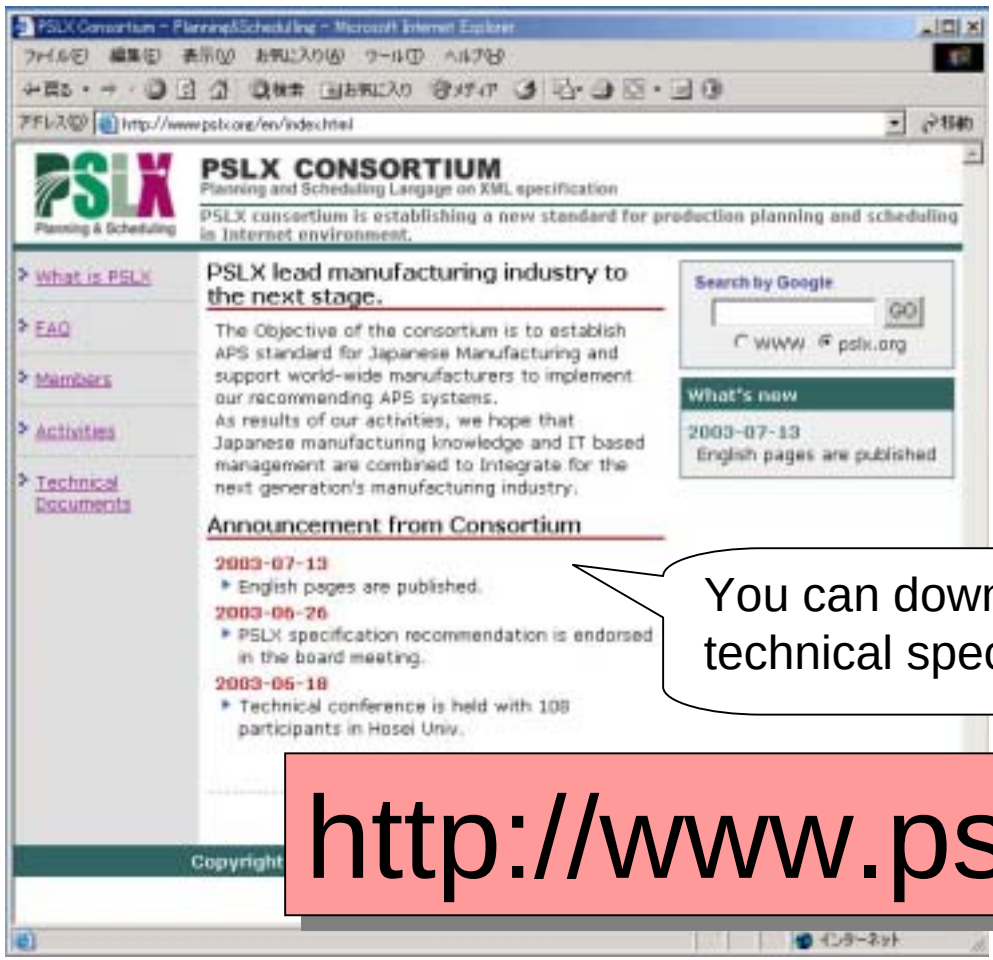
The objective of the consortium is to establish APS standard for collaborative manufacturing and support world-wide manufacturers to implement our recommending APS systems.
As results of our activities, we hope that elaborated manufacturing knowledge and IT based management are combined to integrate for the next generation's manufacturing industry.

Draft Recommendation

- PSLX-01 : Grand Design for Manufacturing Enterprises
- PSLX-02 : APS Agent models
- PSLX-03 : PSLX Domain Objects
- PSLX-04 : XML Specification and Data Exchange
- PSLX-05 : PSLX Common Dictionary

This document is being proposed to ISO TC184/SC5

PSLX Consortium web site



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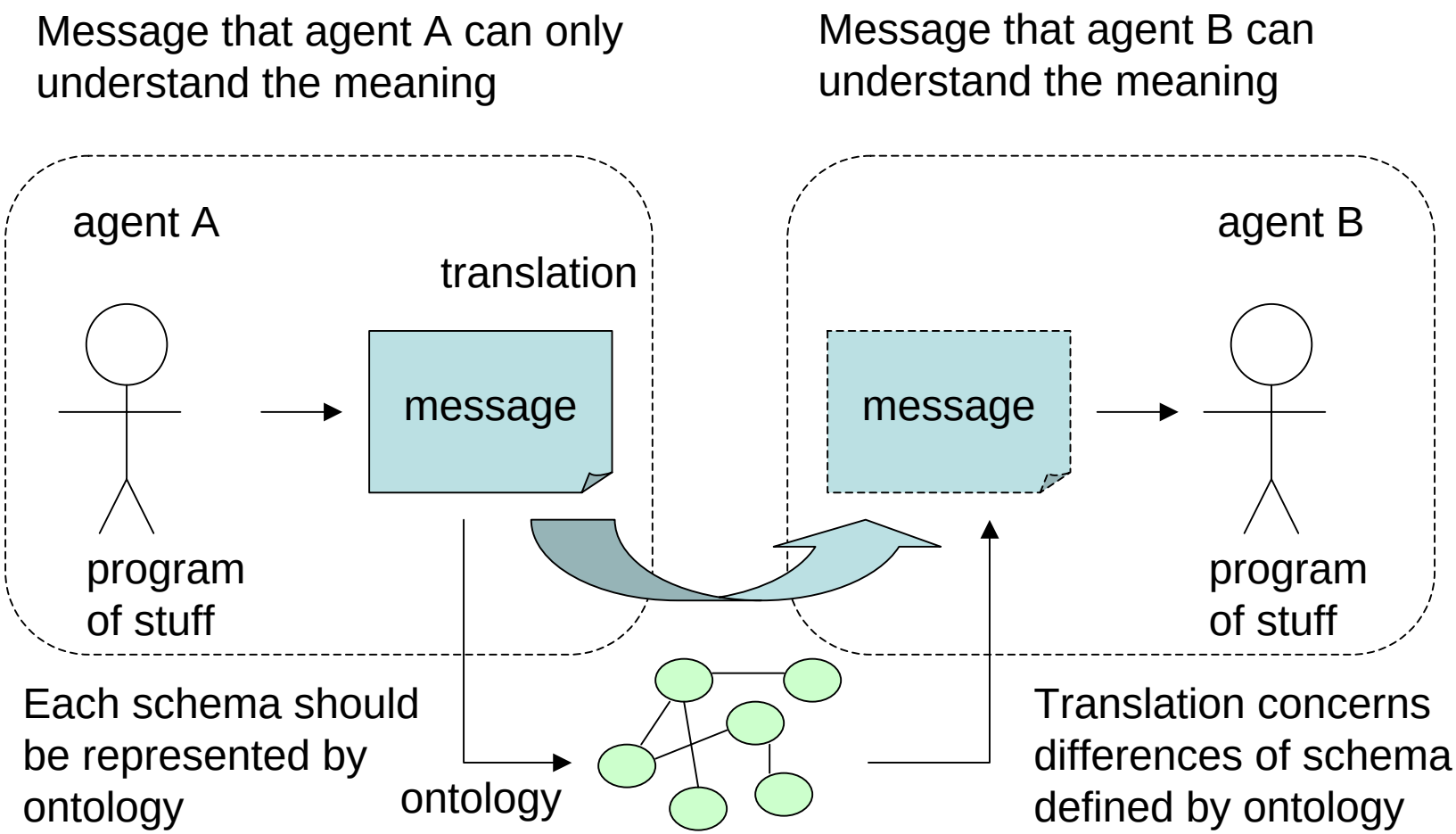
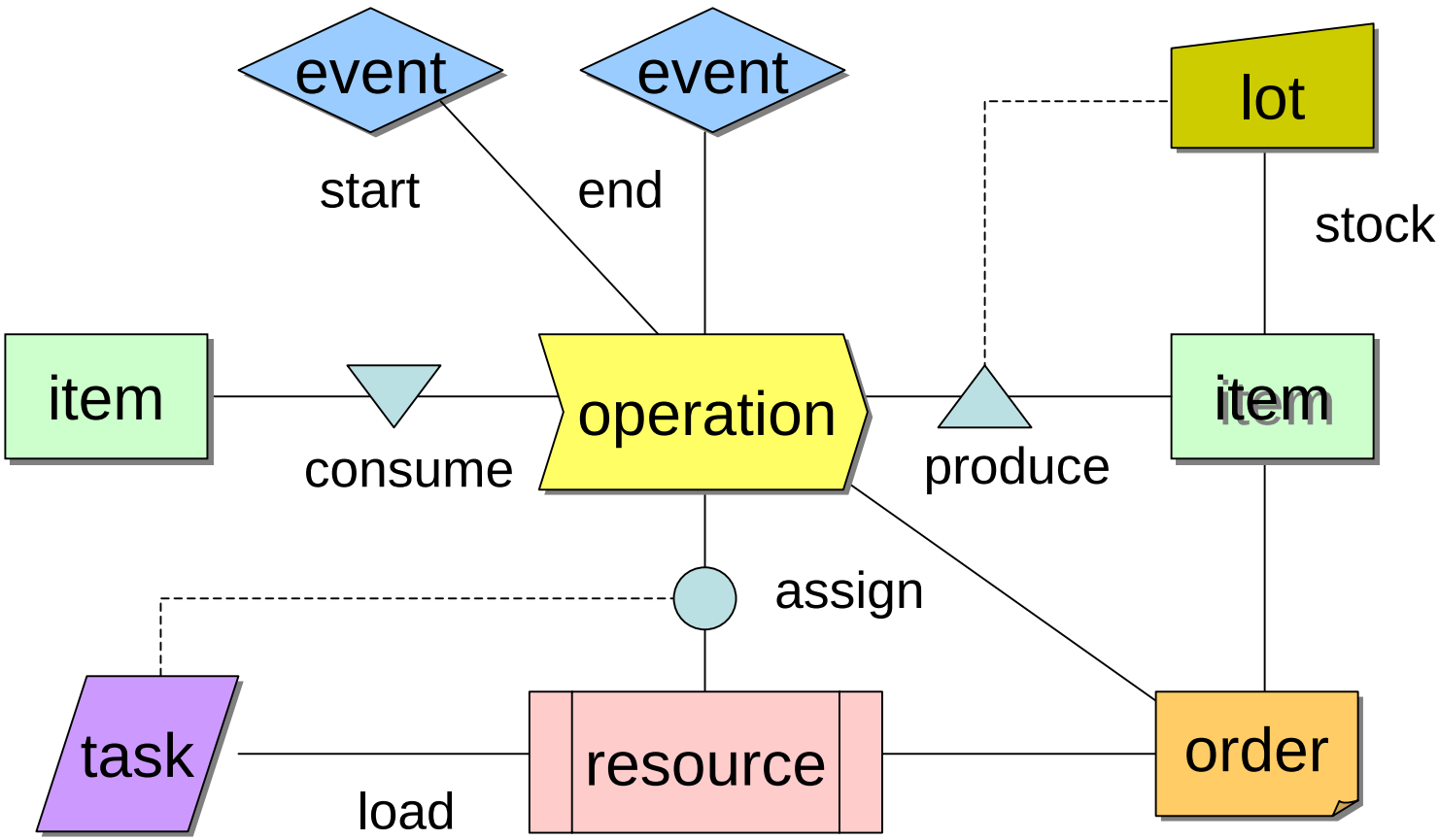
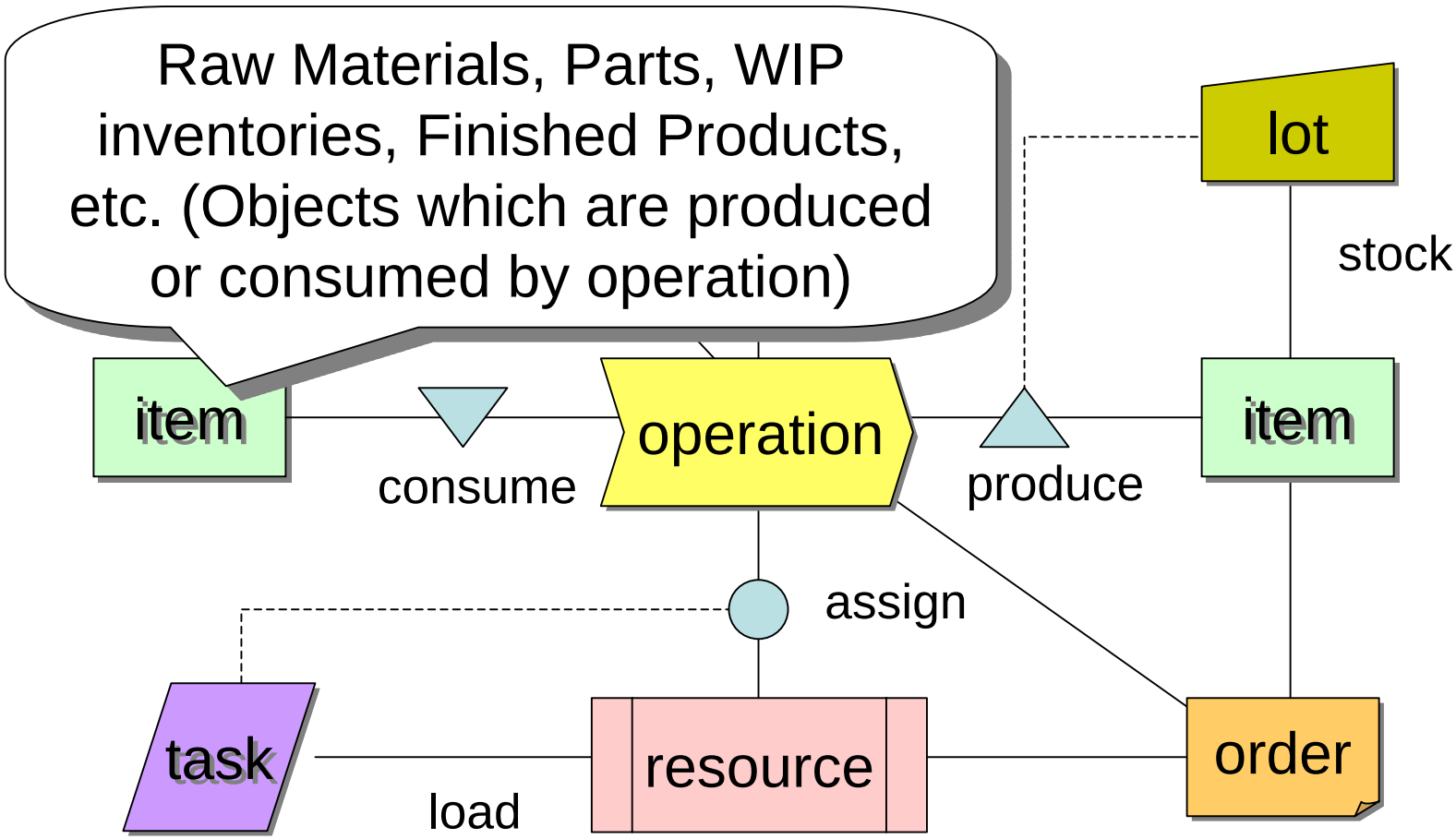
Communication between two agents



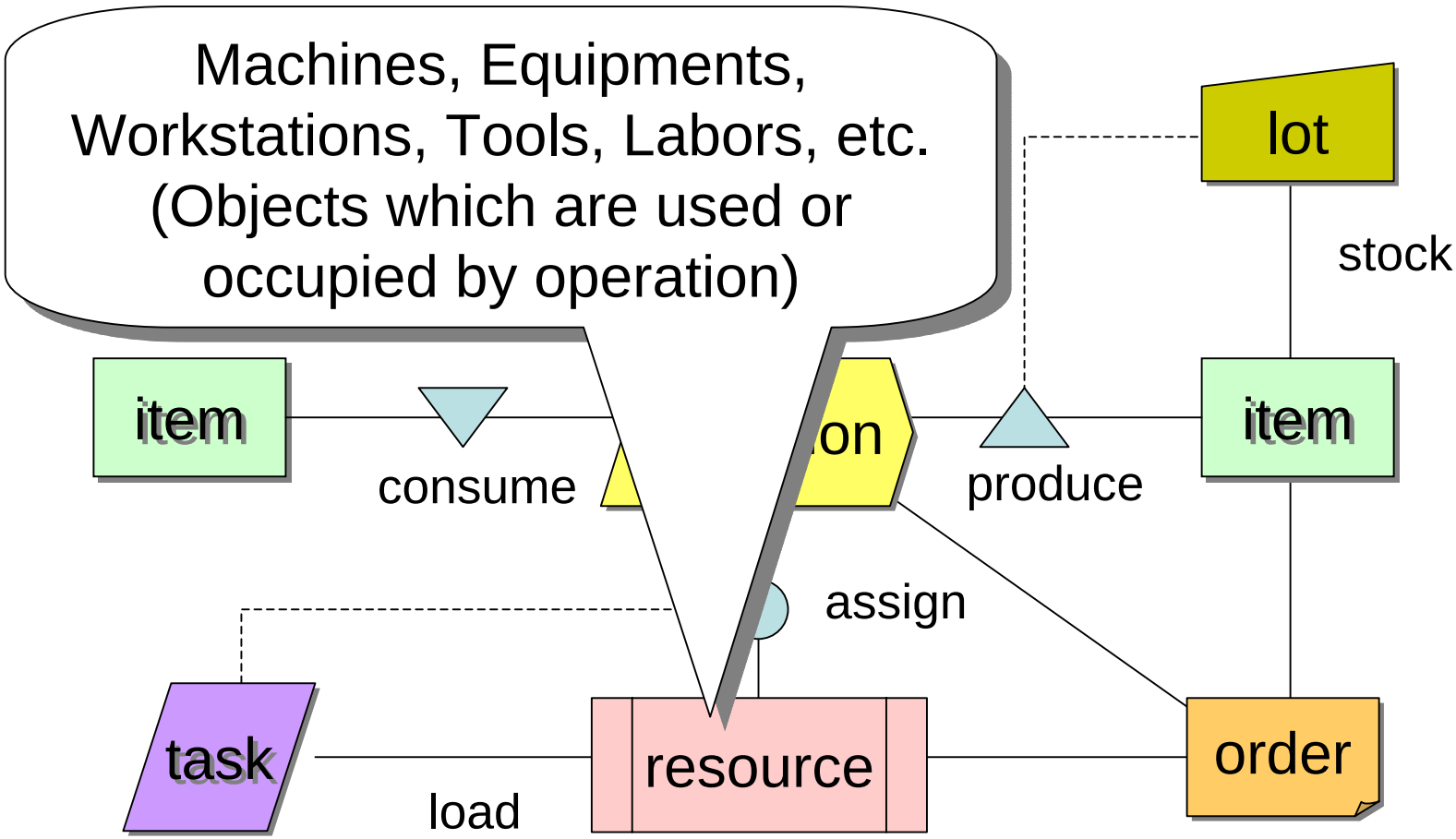
Primitive objects in production



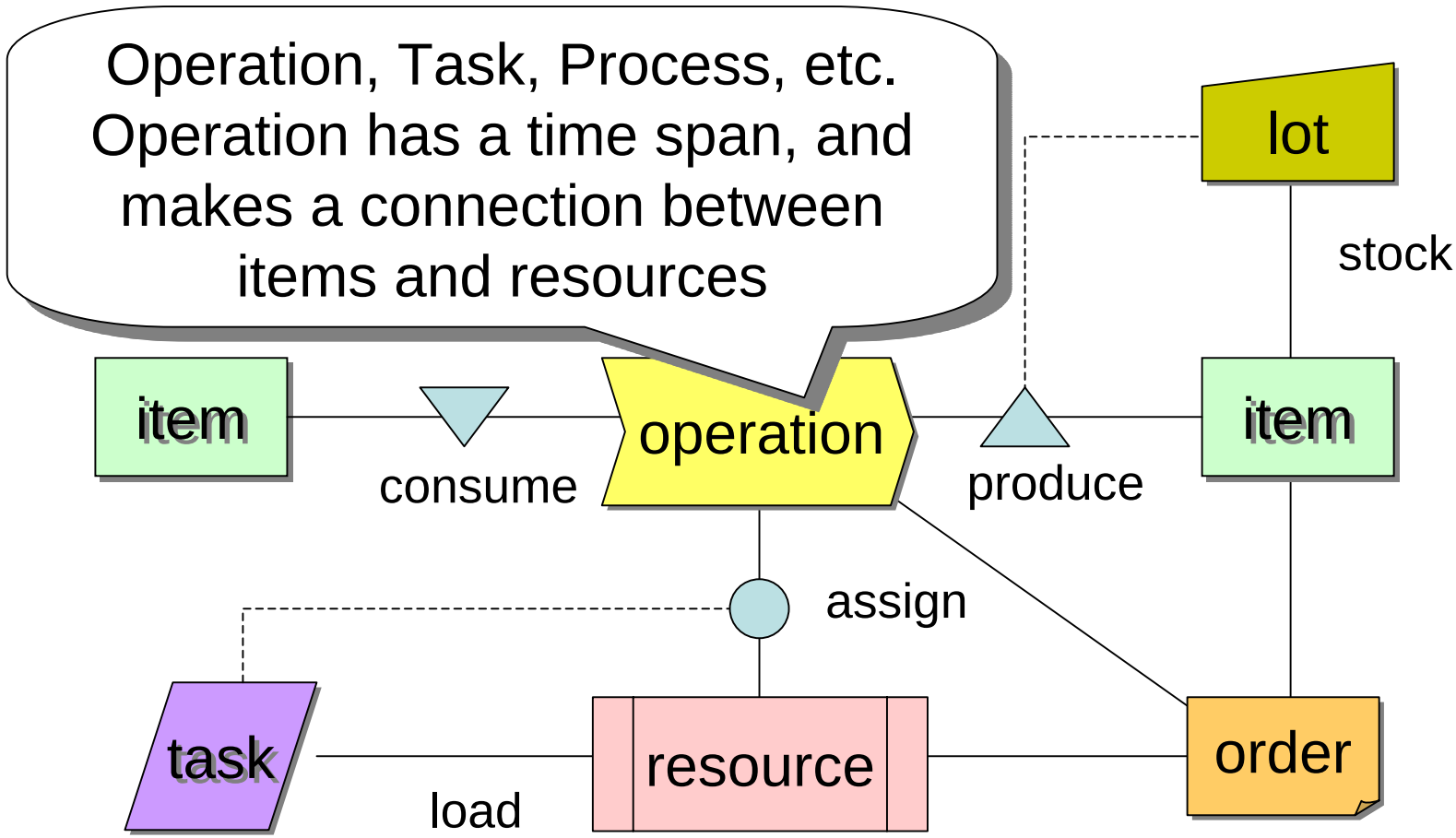
Primitive objects in production



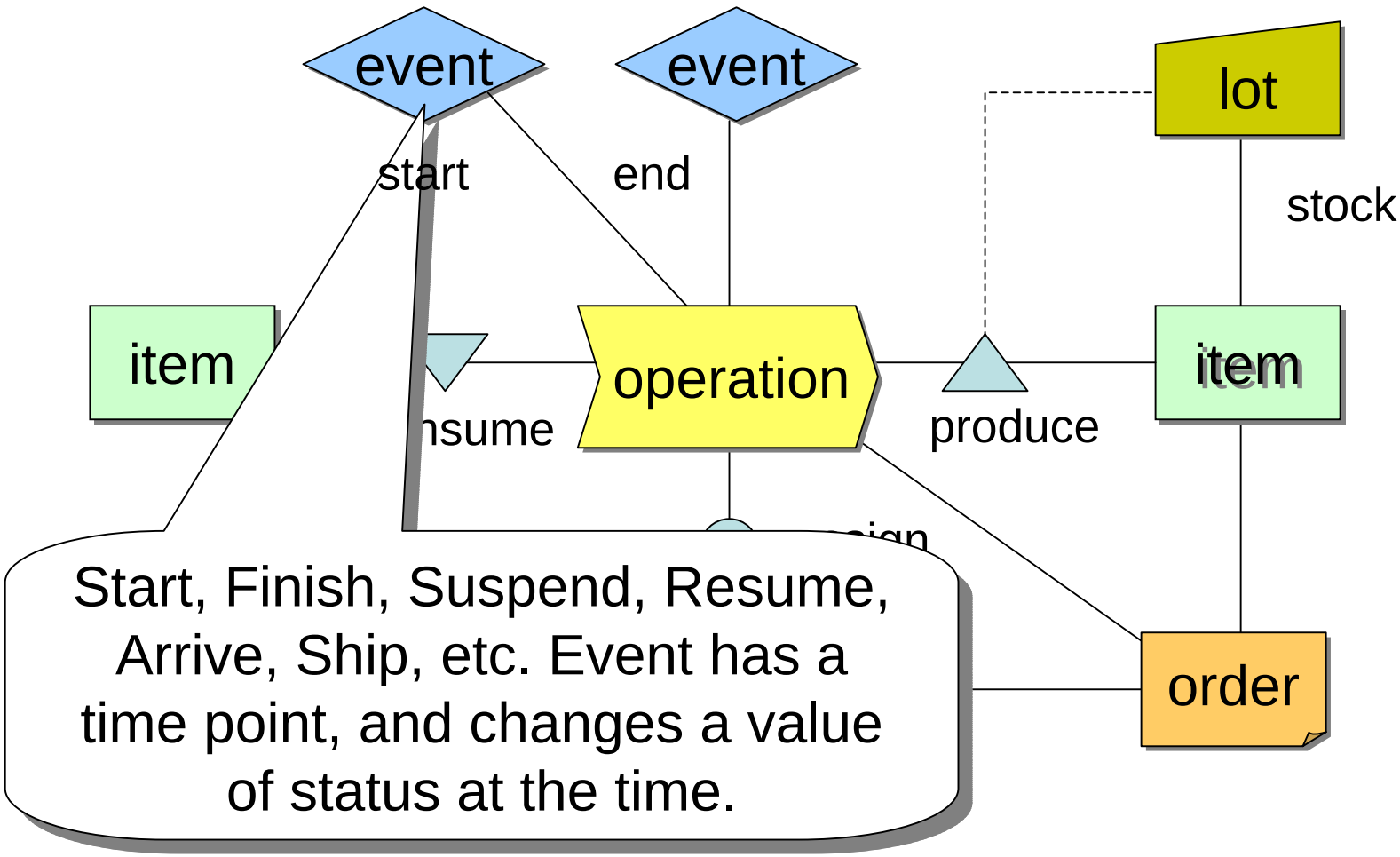
Primitive objects in production



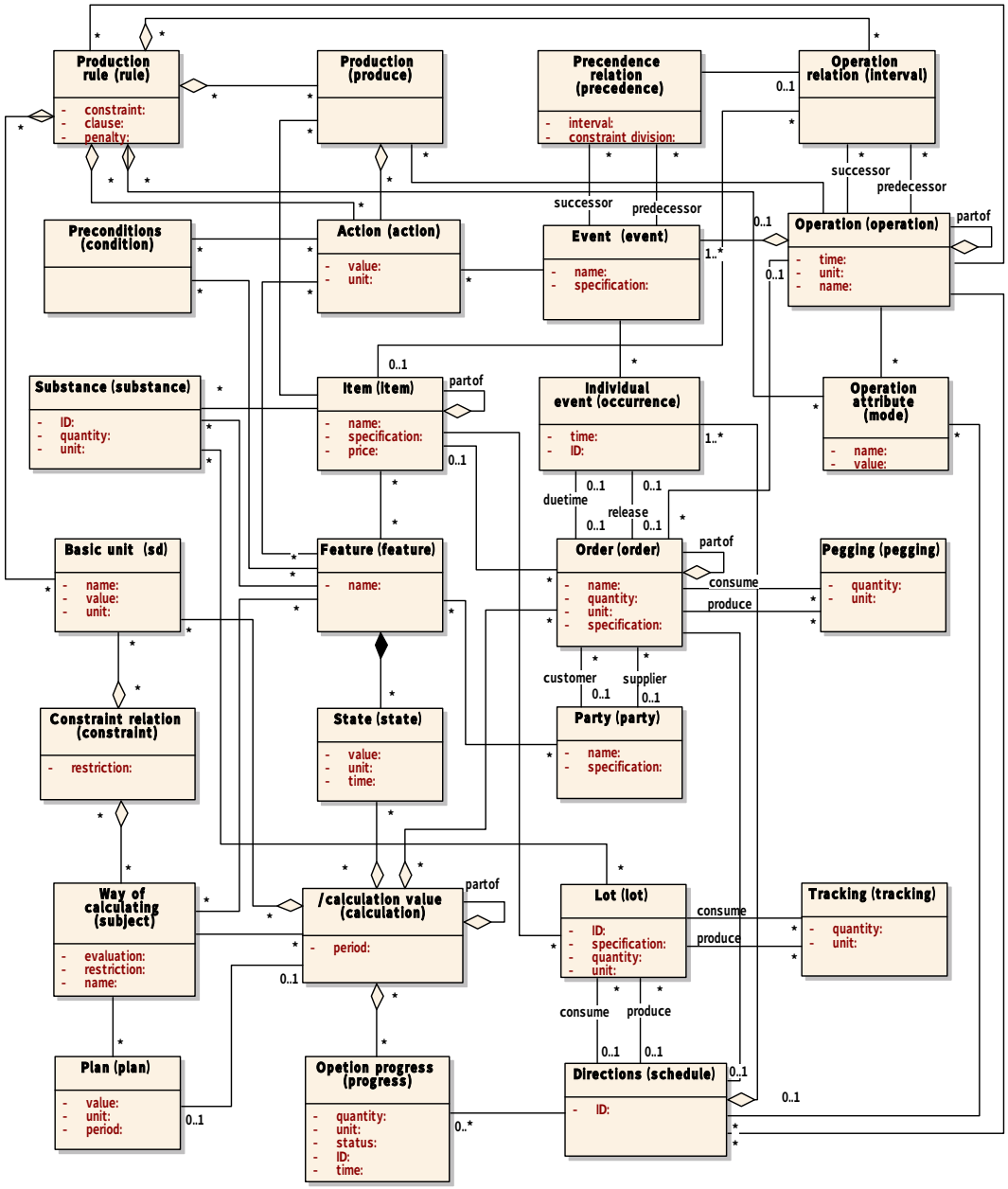
Primitive objects in production



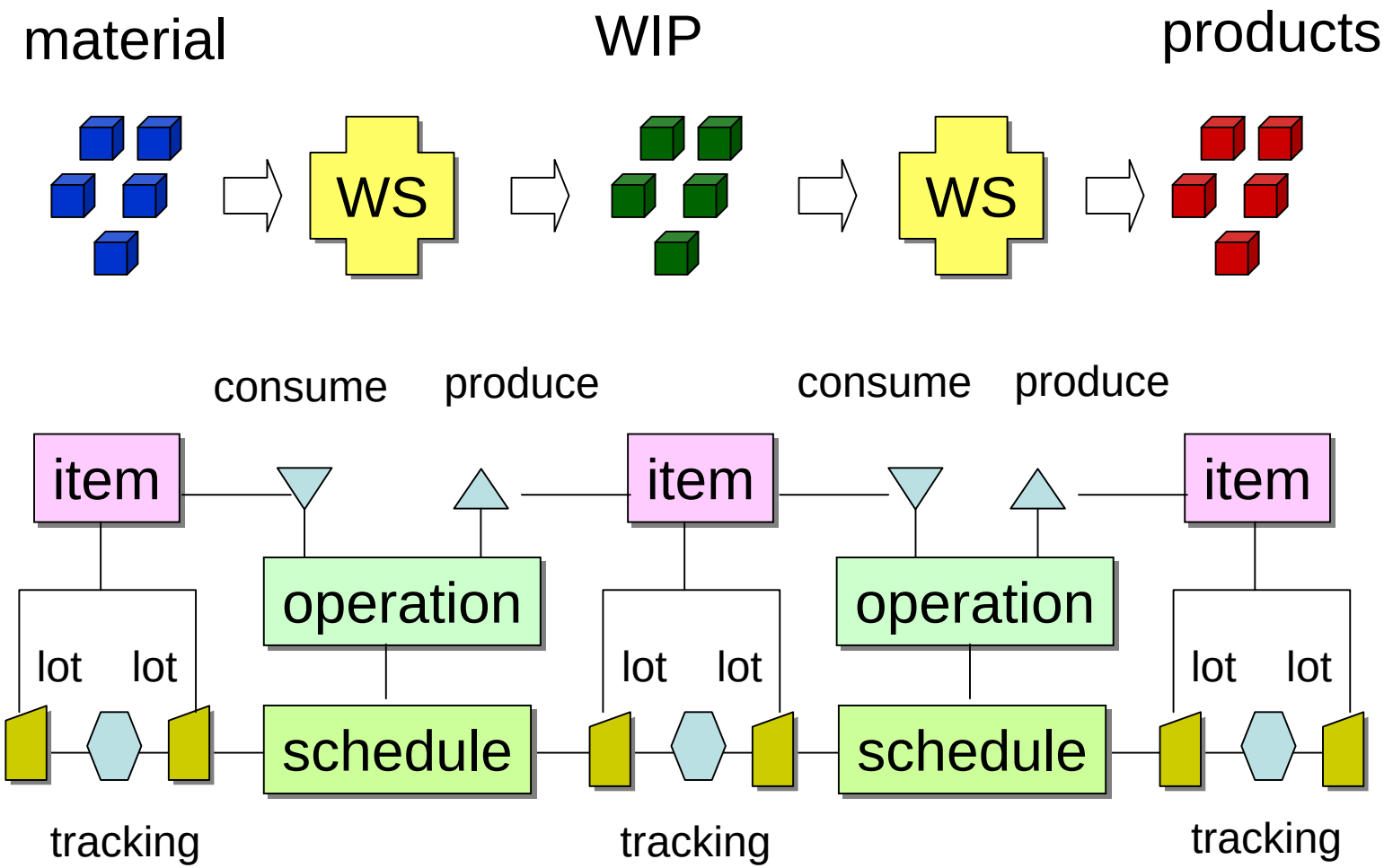
Primitive objects in production



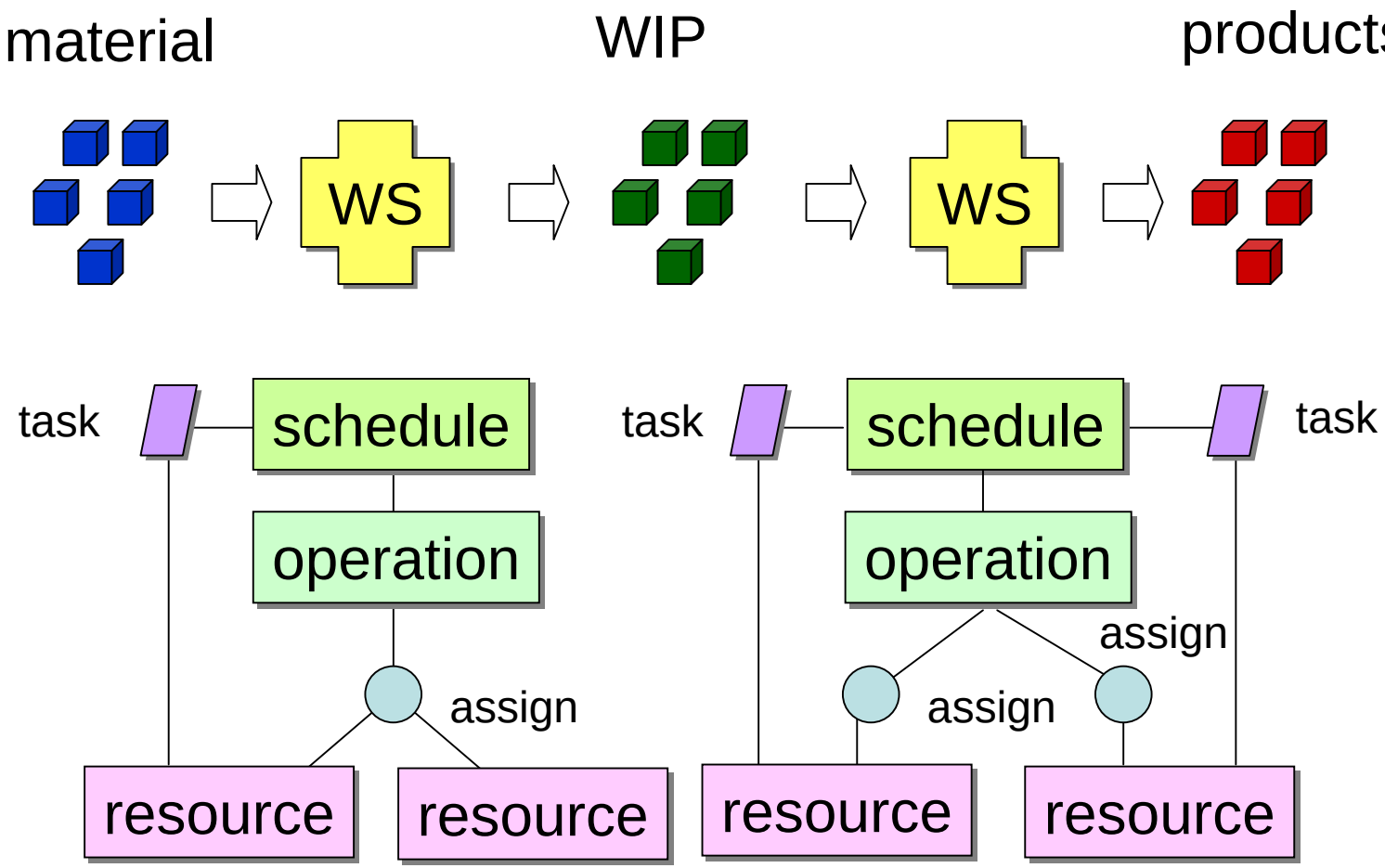
Top level objects



Sample representation (1)

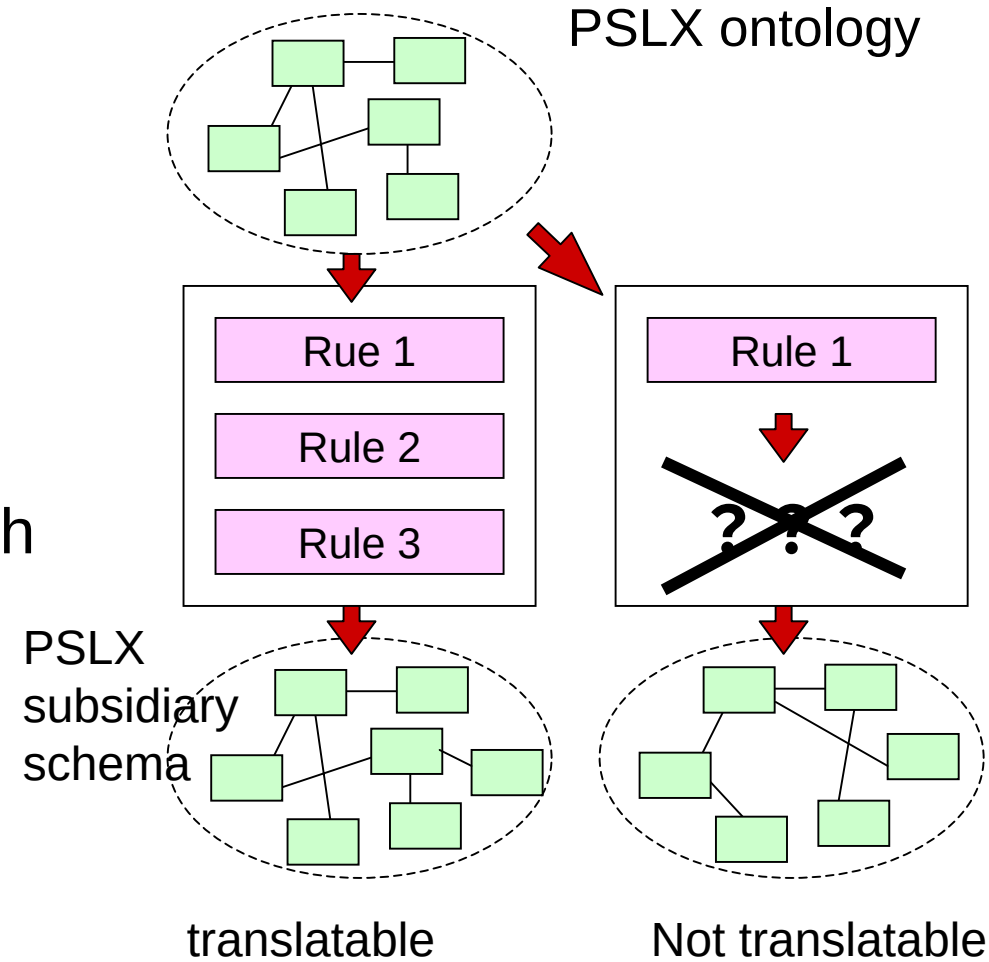


Sample representation (2)



Rules of schema translation

- create subclass
- divide class
- merge class
- create attribute class
- create relation class
- add/delete attribute
- move attribute through class relation
- add/delete relation
- add constraints
- change class name



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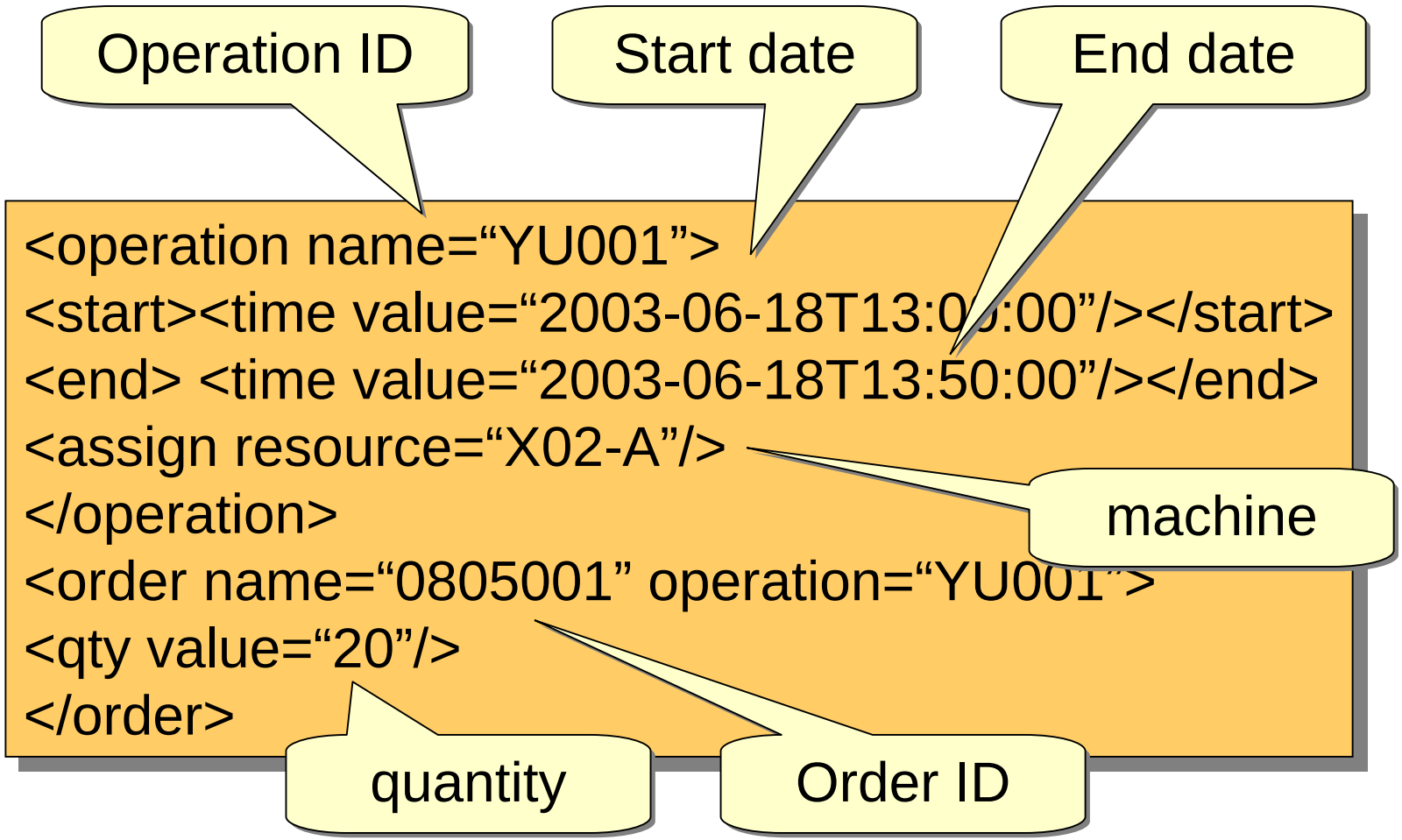
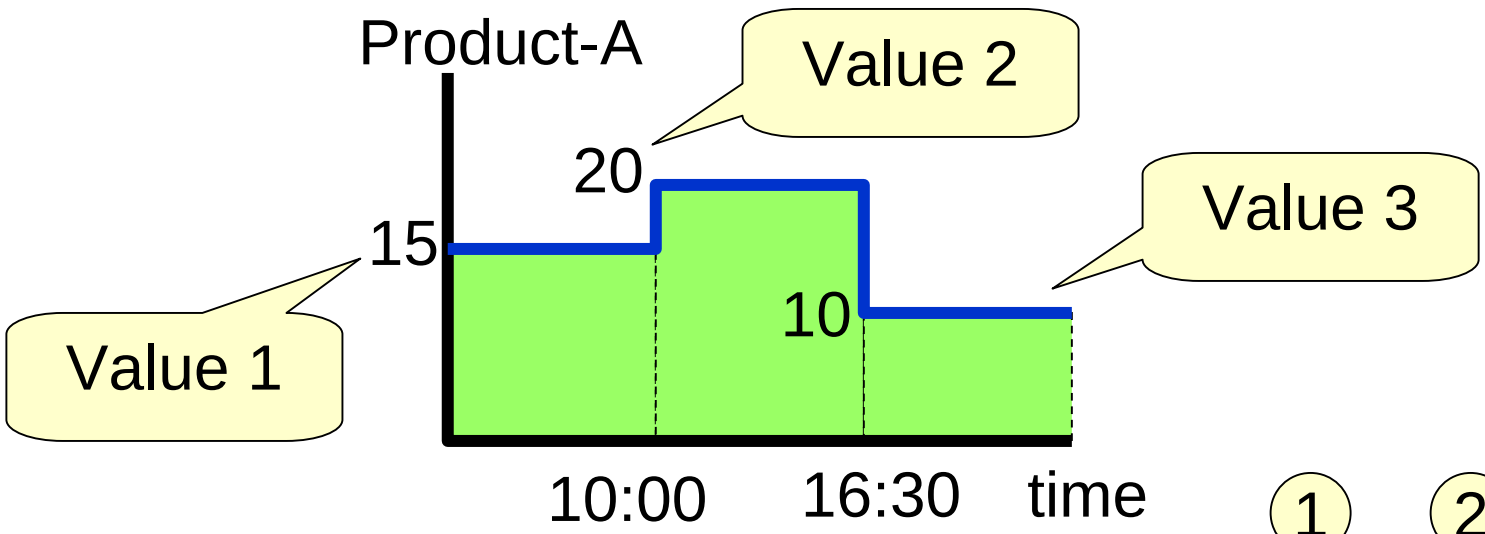
PSLX tag set

<pslx>	<char>	<produce>	<event>	<expression>
<profile>	<address>	<consume>	<ev>	<op>
<error>	<description>	<assign>	<start>	<parameter>
<color>	<time>	<predecessor>	<end>	<query>
<display>	<duration>	<successor>	<release>	<min>
<unit>	<spec>	<partof>	<duetime>	<max>
<translate>	<location>	<pegging>	<customer>	<earliest>
<scale>	<progress>	<tracking>	<supplier>	<latest>
<qty>	<capacity>	<lotsize>	<item>	<shortest>
<price>	<load>	<tasksize>	<resource>	<longest>
<base>	<stock>	<condition>	<lot>	<enumerate>
<priority>	<shift>	<action>	<task>	
	<calendar>	<changeover>	<operation>	
		<interval>	<order>	

Work order representation



Stock level representation



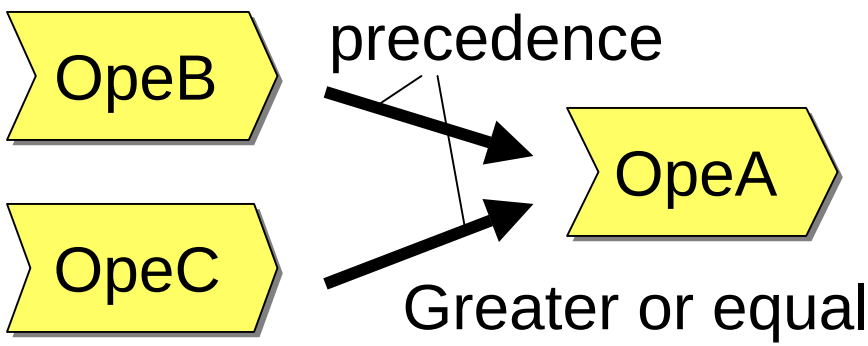
1 2

```
<item name="Product-A">
<stock><time ref="init"/><qty value="15"/></stock>
<stock><time value="2003-06-18T10:00:00"/><qty value="20"/></stock>
<stock><time value="2003-06-18T16:30:00"/><qty value="10"/></stock>
</item>
```

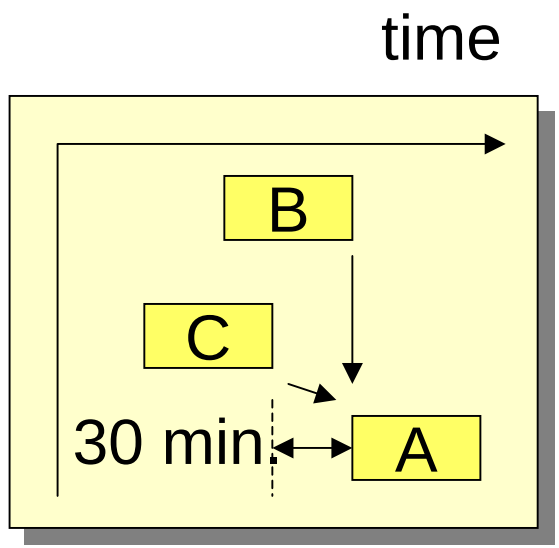
3

Precedence relations

```
<operation name="OpeA">
<predecessor operation="OpeB"/>
<predecessor operation="OpeC">
   <duration value="PT30M"/>
</predecessor>
</operation>
```



Greater or equal than 30 min.

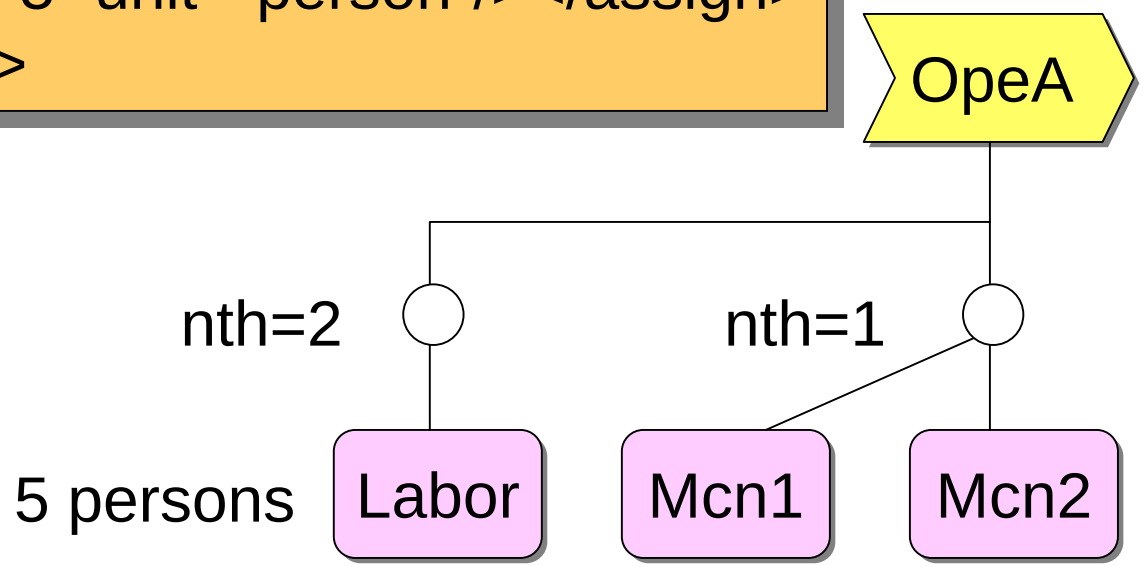


Schedule sample

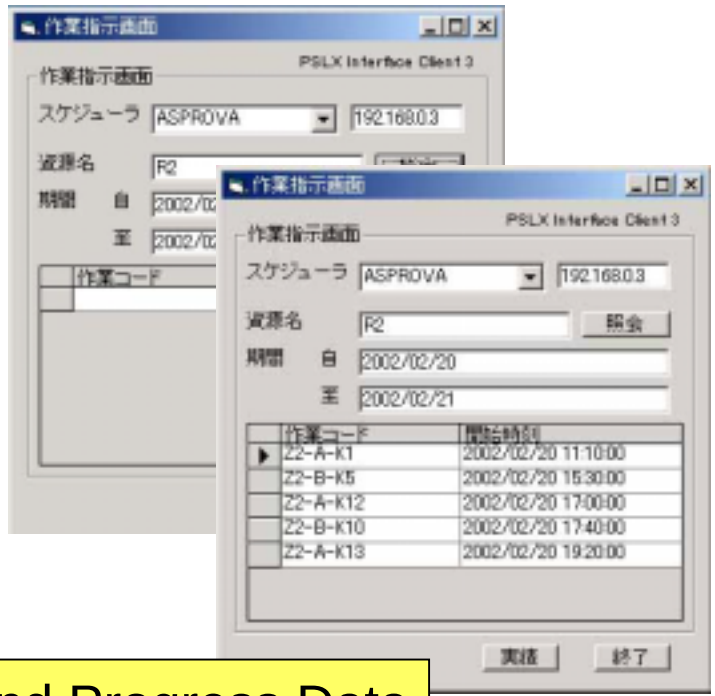
Resource assignment

```
<operation name="OpeA">
<assign resource="Mcn1" nth="1"/>
<assign resource="Mcn2" nth="1"/>
<assign resource="Labor" nth="2">
<qty value="5" unit="person"/></assign>
</operation>
```

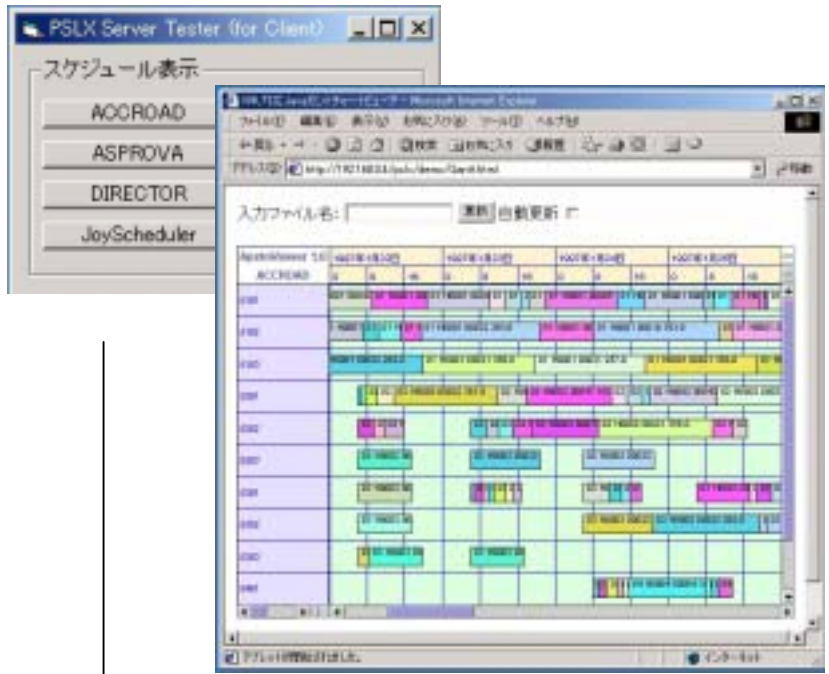
alternative resources



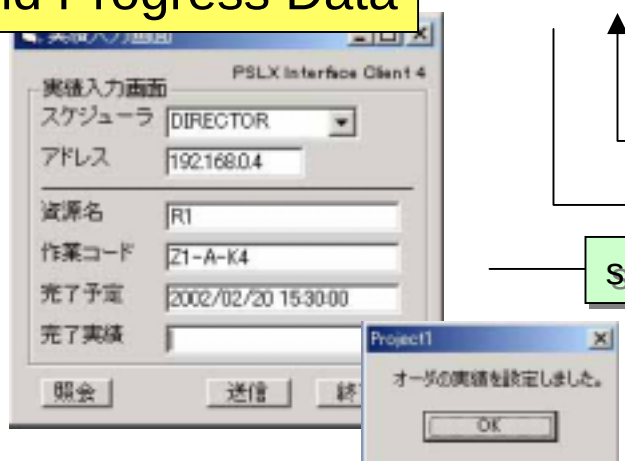
Show Dispatching Order



Rescheduling/Display Gantt Chart



Send Progress Data



getSchedule

getOrder

setProgress

WWW Server

Scheduler

PSLX support Scheduler

Industrial Applications

- Project 1-A (started in Aug 2002)
  - Resource booking system for a mechanical fabrication manufacture
- Project 1-B (started in Aug 2002)
  - Stock information sharing with a 3rd tire automotive parts supplier
- Project 3 (started in Sep 2002)
  - Web based supply chain planning for one of a kind production
- Project 2 (started in Nov 2002)
  - Remote maintenance using MES and scheduler integration

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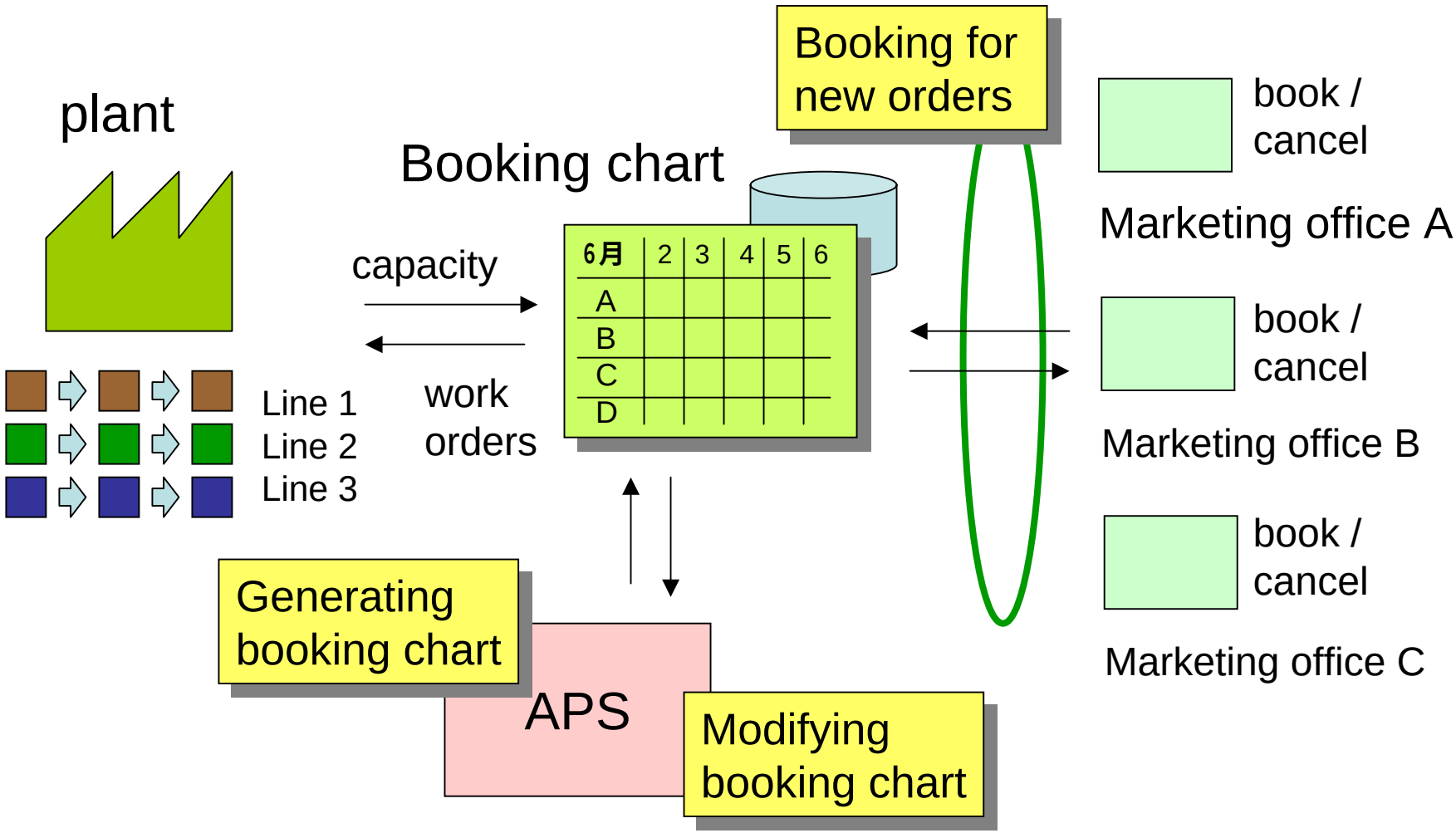
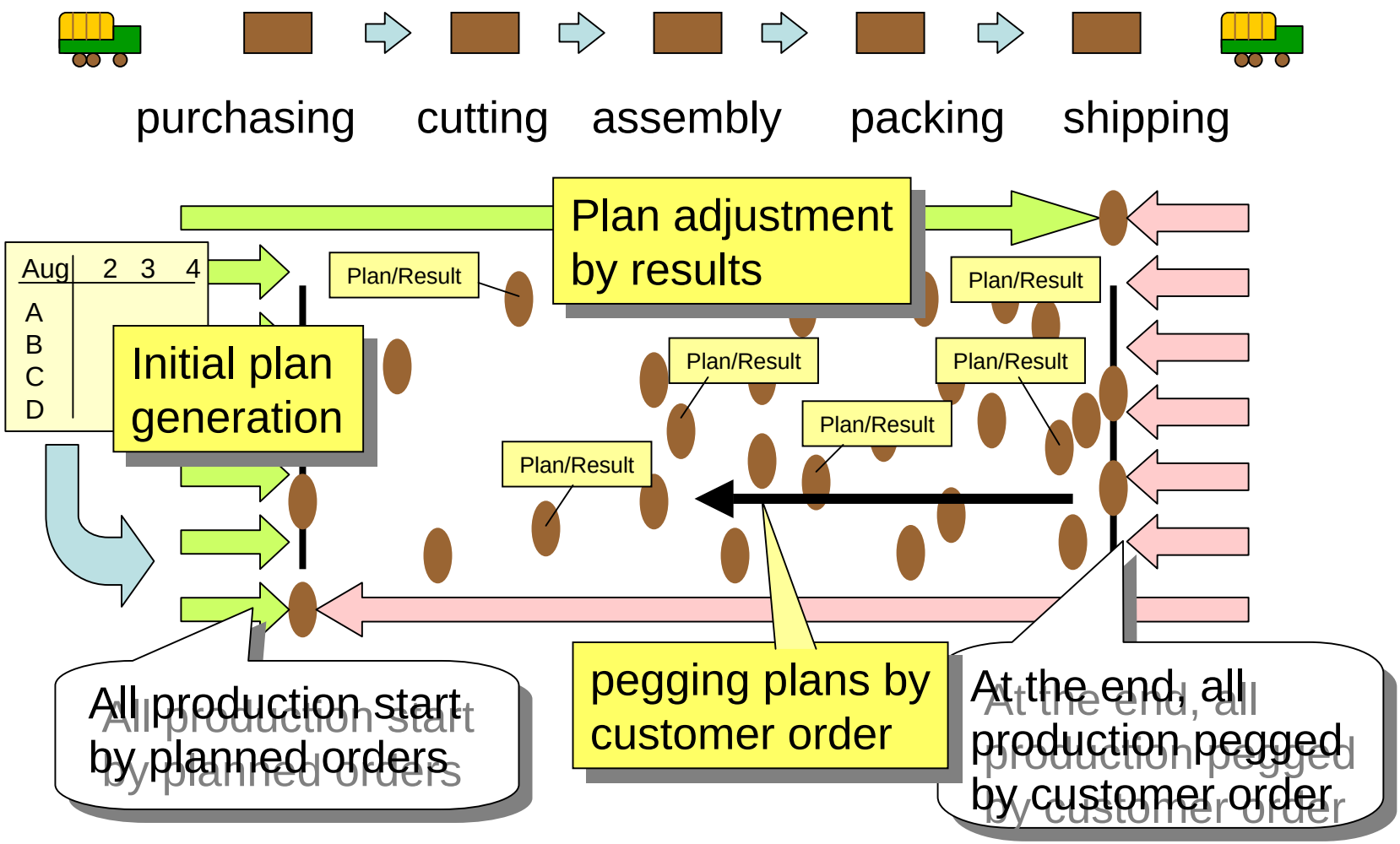
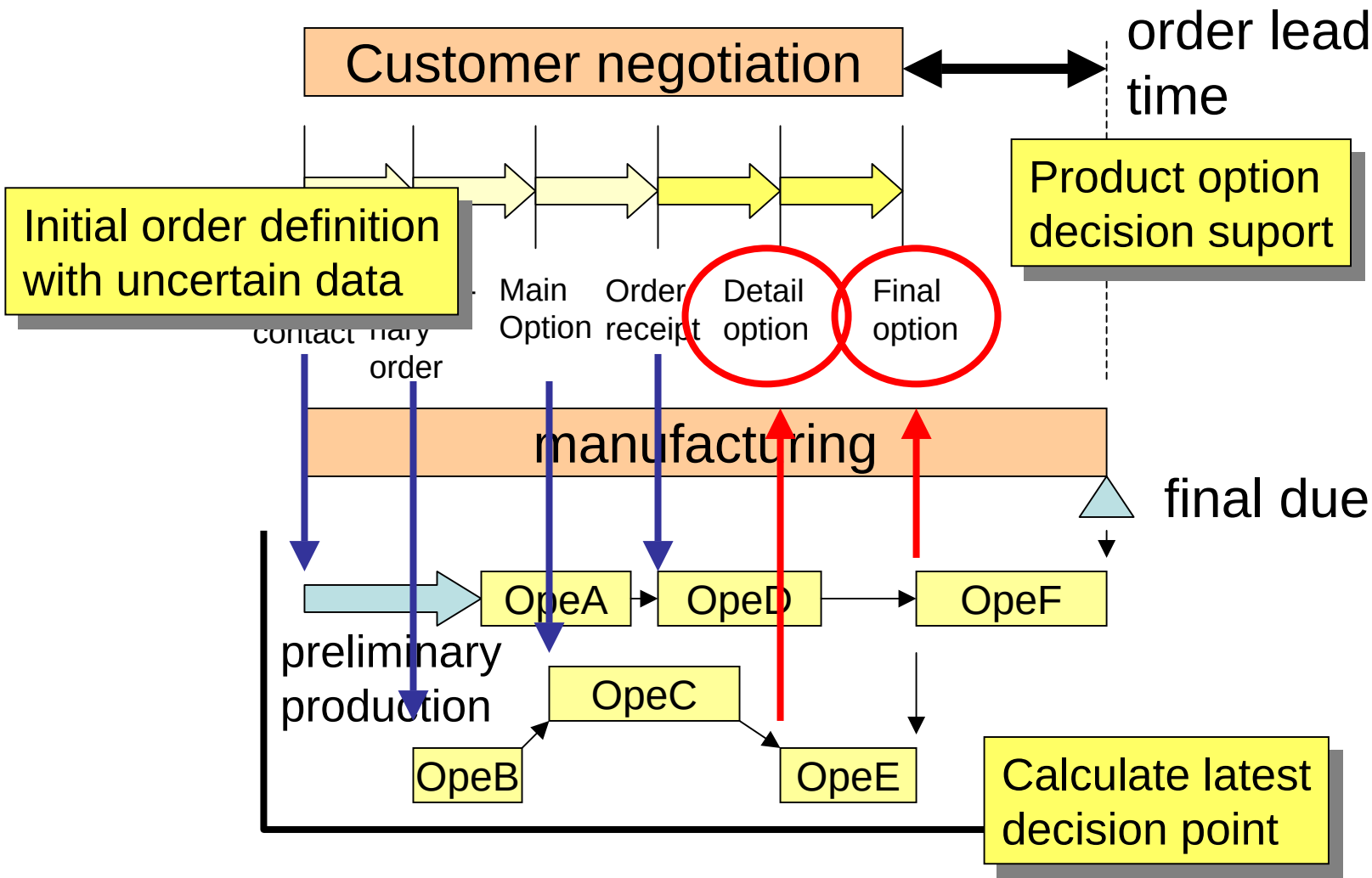
Booking-type production system



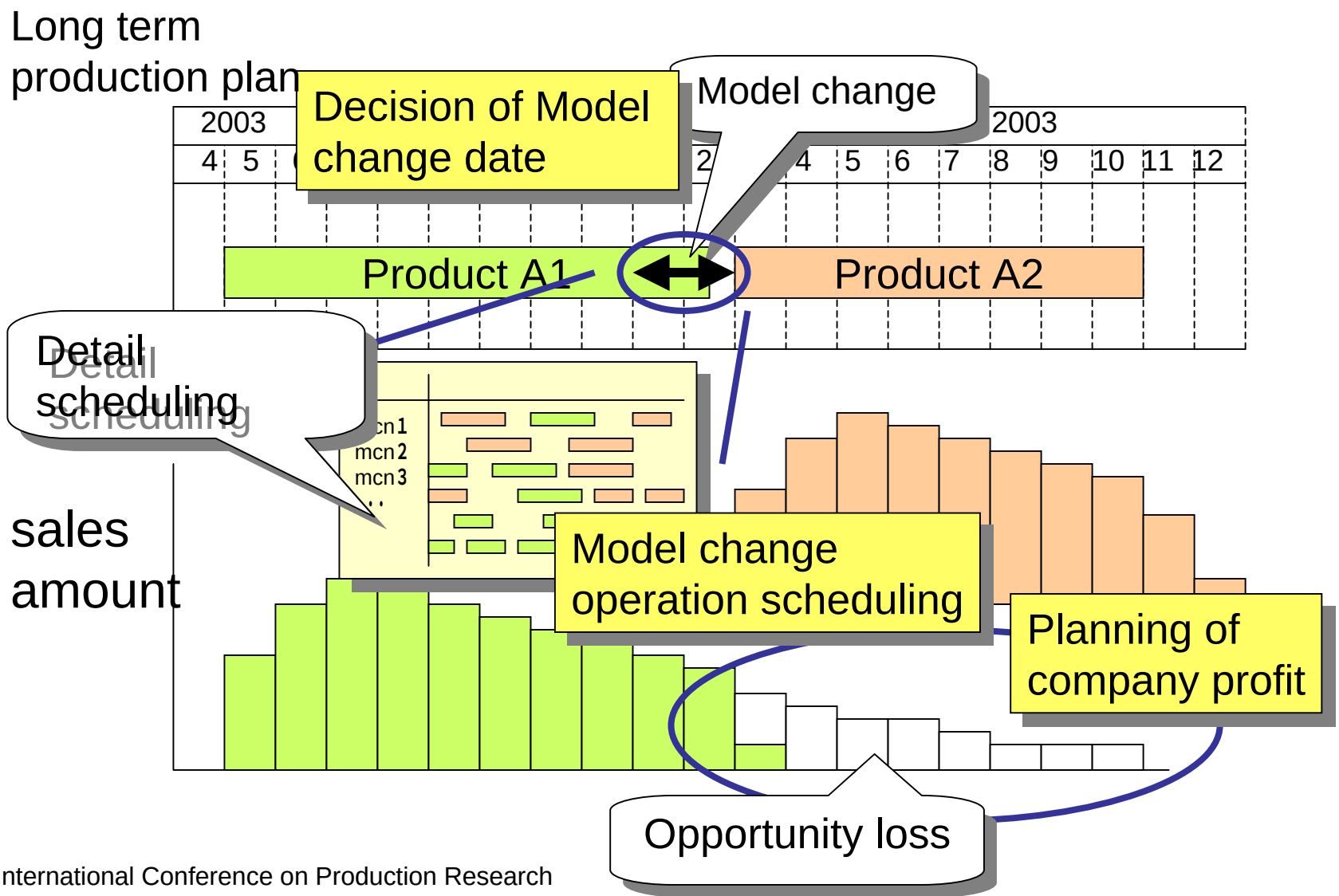
Pegging system in stockless production



Concurrent manufacturing with a customer negotiation process



Project based mass production



Collaboration on SCM

- Sharing resource capacity or stock information → Transaction level
- Sharing aggregate production plan or forecasting information → Forecasting level
- Sharing production orders or master production schedule → Planning level
- Sharing detail production schedule and its progress → Scheduling level

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- Scheduling is a key technology in next generation manufacturing
- Agent based architecture in CAPPS is important approach to implement a system
- XML based specification for application collaboration is demonstrated
- Integration of planning and scheduling in practice is the great challenge in the future

Thank you!!
Comments and suggestions
are welcome !

nishioka@k.hosei.ac.jp

http://www.pslx.org