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

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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 different from the actual movement.
- Product life cycle (survival time) is shortened 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.

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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

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- 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

Production Planning
- Aggregate production plan
- Master production schedule
- Material requirement plan
- Shop floor schedule

Capacity Planning
- Resource requirement plan
- Rough-cut capacity plan
- Capacity requirement plan
- Input/output control

Product lines or families
- Individual products
- Components
- Manufacturing operations

Plants
- Critical work centers
- All work centers
- Individual machines

Source: Russell and Taylor, Operations Management
Communicate anytime each module wants

Communicate any data each module needs

client/server in local, pair-to-pair in company wide
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

Supplier’s Design → Design → APS → Manufacturing → Customer’s APS

Supplier’s APS → Design → APS → Manufacturing → Customer’s APS

Supplier’s Manufacturing → Design → APS → Manufacturing → Customer’s Manufacturing

Interfaces (external)
Internal interfaces

Interfaces (internal)

APS agent

APS
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

You can download the technical specification!

http://www.pslx.org
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Communication between two agents

Message that agent A can only understand the meaning

agent A
program of stuff
message
translation
ontology
Each schema should be represented by ontology

Message that agent B can understand the meaning

agent B
program of stuff
message
Translation concerns differences of schema defined by ontology
ontology
Primitive objects in production

- **event**
  - start
  - end

- **lot**
  - stock

- **item**
  - consume
  - produce

- **task**
  - load

- **resource**
  - assign

- **order**
Primitive objects in production

Raw Materials, Parts, WIP inventories, Finished Products, etc. (Objects which are produced or consumed by operation)
Primitive objects in production

Machines, Equipments, Workstations, Tools, Labors, etc. (Objects which are used or occupied by operation)

- **item**: consume
- **on**: produce
- **assign**: order

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Operation, Task, Process, etc. Operation has a time span, and makes a connection between items and resources.
Primitive objects in production

Start, Finish, Suspend, Resume, Arrive, Ship, etc. Event has a time point, and changes a value of status at the time.
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

PSLX subsidiary schema

translatable

Not translatable

PSLX ontology
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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

<operation name="YU001">
  <start><time value="2003-06-18T13:00:00"/></start>
  <end> <time value="2003-06-18T13:50:00"/></end>
  <assign resource="X02-A"/>
</operation>

<order name="0805001" operation="YU001">
  <qty value="20"/>
</order>
<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>
Precedence relations

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

OpeB  precedence  OpeA

OpeC  Greater or equal than 30 min.  OpeA

Schedule sample

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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>
Show Dispatching Order

Rescheduling/Display Gantt Chart

Send Progress Data

getOrder

getSchedule

setProgress

WWW Server

PSLX support

Scheduler

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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

plant

Booking chart

capacity

work
dorders

Marketing office A

book / cancel

Marketing office B

book / cancel

Marketing office C

book / cancel

Generating booking chart

APS

Modifying booking chart

6月 2 3 4 5 6
A
B
C
D

Line 1
Line 2
Line 3
Pegging system in stockless production

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Concurrent manufacturing with a customer negotiation process

Customer negotiation

<table>
<thead>
<tr>
<th>Initial order definition with uncertain data</th>
</tr>
</thead>
<tbody>
<tr>
<td>order lead time</td>
</tr>
<tr>
<td>Product option decision support</td>
</tr>
<tr>
<td>final due</td>
</tr>
<tr>
<td>preliminary production</td>
</tr>
<tr>
<td>OpeA</td>
</tr>
<tr>
<td>OpeD</td>
</tr>
<tr>
<td>OpeF</td>
</tr>
<tr>
<td>OpeB</td>
</tr>
<tr>
<td>OpeC</td>
</tr>
<tr>
<td>OpeE</td>
</tr>
<tr>
<td>Calculate latest decision point</td>
</tr>
</tbody>
</table>

Initial order definition with uncertain data

Concurrent manufacturing with a customer negotiation process.
Project based mass production

Long term production planning

Decision of Model change date

Model change

Product A1 ↔ Product A2

Model change operation scheduling

Planning of company profit

Opportunity loss

Sales amount

Detail scheduling

2003

4 5 6 7 8 9 10 11 12

2003

2 4 5 6 7 8 9 10 11 12
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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Summary

• 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!

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http://www.pslx.org