CS²

Construction Supply Chain Simulator

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Agenda

- **Supply Chain Management**
  - Need for Coordination
  - Construction Supply Chain

- **CS$^2$, Construction Supply Chain Simulator**
  - System Architecture
  - Simulation Scenario Overview

- **Simulation Demonstration and Discussion**

- **Future Work**
  - Web Services
  - Web Services Integration
  - SCVisualizer
Road Map

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Supply Chain

Financial Flow
Payments, Credits, Credit terms, Payment schedule, etc

Material Flow
Goods, Products, Raw material, etc

Information Flow
Product info, Delivery LT, P.O., Invoice, Forecast, etc

Sources
Suppliers
Converters
Distributors
Retailers
Need for Coordination

- Numerous participants
- Conflicting goal and objective
- Performance improvement
- Cost, Quality, and Efficiency issue
Why bother?

- Excessive inventory
- Insufficient or excessive capacities
- Long backlogs
- Uncertain production planning
- High costs for correction (Expediting)
Bullwhip effect in Construction

- **No-Disturbance**
  - Web services SCM Model, Original Schedule
  - Current SCM Model, Original Schedule

- **With-Disturbance**
  - Web services SCM Model, Delayed Schedule
  - Current SCM Model, Delayed Schedule

< Legend>
- 1 -- Order from GC to Sub
- 2 -- Order from Sub to Supplier

Source: Min, J., Bjornsson, H., 2002
## Alternative approaches in SCM

<table>
<thead>
<tr>
<th>Approach</th>
<th>Principle</th>
<th>Applicability in construction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long-term relationships</strong> (Buzzell et al. 1995)</td>
<td>Develop strong and long-term relationships with supply chain members to improve products, reduce costs, and develop more efficient processes and procedures.</td>
<td>It can be applied to negotiated jobs. Difficult in case of competitive bid jobs.</td>
</tr>
<tr>
<td>Working with fewer suppliers (Davis 1994)</td>
<td>Dealing with fewer suppliers and carriers to encourage closer working relationships and allow greater use of supplier and carrier expertise.</td>
<td>Construction by itself requires supplier’s expertise</td>
</tr>
<tr>
<td>Inv. and cycle time management with suppliers (Inger et al. 1995)</td>
<td>Working with supply chain members to reduce channel-wide inventory levels and cycle times, so as to reduce overall costs.</td>
<td>It requires interactive communication and collaboration</td>
</tr>
<tr>
<td>Strong commitment (Christopher 1994)</td>
<td>Building commitment at all levels of the organization to encourage implementation and continued use of SCM techniques.</td>
<td>It depends on managerial decision</td>
</tr>
<tr>
<td>Internet-based Information sharing (Sandelands 1994, Lee 2000, Rosenbaum 2001)</td>
<td>Regularly sharing information with supply chain members, allowing quicker response to changes and better short-term and long-term planning.</td>
<td>Technology driven approach. It fits well into the requirements of construction SCM.</td>
</tr>
</tbody>
</table>
Motivation for Simulation

- Illustrate the value of sharing information
- Investigate the applicability of information technology in construction supply chain management
  - Web services
  - Computer Agent
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CS² - System Architecture

TCP/IP Connection

JATLite (Java Agent Template Lite)

Agent Router

Administrator

GC
Steel
Drywall
Floor
Elevator
Door

User Interface
Computer Agent
Database
Simulation Scenario Overview

- **Project Description**
  - Hamilton Landing Project, Novato, CA
  - Convert decommissioned air force hangars to commercial buildings
  - GMP contract ($15M)
Project Members

- General Contractor
- 5 Subcontractors
  - Structural Steel subcontractor
  - Drywall subcontractor
  - Elevator subcontractor
  - Access Floor subcontractor
  - Door and HW subcontractor
This part is what you have to play with.

This part will be assumed to be done without any problem.
User Interface - Login

Select your role

Type your name

Type IP address

Click start to begin

Welcome to CS²!
- CIFE Flight Simulator

Your Name: Hans Bjornsson
Your Position: General Contractor
Router location: 171.66.38.194
Password (only for Admin): 
Start!
You can record any updated information to these 3 columns.

Write messages to subcontractors.

Read messages from subcontractors.

Review construction progress and send delivery request.

Click run.
User Interface - Subcontractors

- View production progress
- Decide current production and next week’s production schedule
- Deliver to the site
- Read a message from GC
- Write a message to GC
- Click run
## Comparing simulations

- **Non-Sharing vs. Information Sharing**

<table>
<thead>
<tr>
<th></th>
<th>Non-Sharing Simulation</th>
<th>Info.-Sharing Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shared Info.</strong></td>
<td>- Original Schedule</td>
<td>- Original Schedule</td>
</tr>
<tr>
<td></td>
<td>- Disturbance information</td>
<td>- Disturbance information</td>
</tr>
<tr>
<td><strong>Expediting</strong></td>
<td>- Manual information update</td>
<td>- Automated information update</td>
</tr>
<tr>
<td><strong>Use of agent</strong></td>
<td>- User message passing</td>
<td>- User message passing</td>
</tr>
<tr>
<td></td>
<td>- Information propagation</td>
<td>- Information propagation</td>
</tr>
<tr>
<td></td>
<td>- Project status monitoring</td>
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</tr>
<tr>
<td><strong>Assumptions</strong></td>
<td>- Simulation cycle starts on every Mon.</td>
<td>- Communication and Delivery lead-time.</td>
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<td>- Communication and Delivery lead-time.</td>
<td>- Inventory holding cost</td>
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Simulation Demonstration
Simulation Result Discussion

- Project Duration
- Inventory Holding Cost
- Weekly Production
- Cumulative Finished Goods Inventory
Project Duration

Comparison of Project Duration

- General Contractor: 24 weeks (Base Case), 23 weeks (Non-Info. Sharing), 17 weeks (Info. Sharing)
- Steel Subcontractor: 9 weeks (Base Case), 8 weeks (Non-Info. Sharing), 11 weeks (Info. Sharing)
- Drywall Subcontractor: 16 weeks (Base Case), 14 weeks (Non-Info. Sharing), 17 weeks (Info. Sharing)
- Elevator Subcontractor: 17 weeks (Base Case), 17 weeks (Non-Info. Sharing), 16 weeks (Info. Sharing)
- Floor Subcontractor: 16 weeks (Base Case), 16 weeks (Non-Info. Sharing), 13 weeks (Info. Sharing)
- Door Subcontractor: 17 weeks (Base Case), 17 weeks (Non-Info. Sharing), 16 weeks (Info. Sharing)
Inventory Holding Cost

Comparison of Inventory Holding Cost for Subcontractors

- Base Case
- Non-Info Sharing
- Info. Sharing

Subs. Inventory Holding Cost

Steel Subcontractor
Drywall Subcontractor
Elevator Subcontractor
Floor Subcontractor
Door Subcontractor
Weekly Production, Drywall

1st disturbance from Steel fabrication

2nd disturbance from Steel installation

Estimated Delivery date for you is week 16.

Reminder: delivery date is week 16.

Steel is delayed at least 2 weeks.

Please deliver by week 18.
Weekly Production, Other subs

Elevator sub

Floor sub

Door sub
Finished Goods Inventory, Drywall

1st disturbance from Steel fabrication
2nd disturbance from Steel installation
Finished Goods Inventory, Other subs

Elevator sub

Floor sub

Door sub
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## Commercial SCM Applications

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<th>Manufacturing SCM applications</th>
<th>Characteristics of Construction industry</th>
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<tr>
<td>Targeted for large manufacturers and retailers</td>
<td>Medium to small firms</td>
</tr>
<tr>
<td>Configuration takes long</td>
<td>Quick configuration is critical in a project</td>
</tr>
<tr>
<td>Suitable for Stable supply chains</td>
<td>Temporary and Dynamic supply chains</td>
</tr>
<tr>
<td>High cost</td>
<td></td>
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</tbody>
</table>
Web services

- **Definition**
  - Web services are encapsulated, loosely coupled contracted functions offered via standard protocols
    
    (Source: WebServices.org)

- We're seeing that basic connectivity isn't enough. The most interesting uses of connectivity require a platform that doesn't just show things to people on a screen, but which also allow them to exchange information.

  (Bill Gates, 2002)
A Web Service is...

- Programmable application logic accessible using standard Internet protocols.
- Accessed via Web protocols (e.g., HTTP) and data formats (e.g., XML).
- Not via object-model-specific protocols (e.g., DCOM, RMI, IIOP)
Architecture for Web Services

Service Broker

Service Requester

Service Provider

Inquire WSDL (Service) Using SOAP

Publish WSDL (Service) Using SOAP

Bind to Service Using SOAP
EAI vs. Web services

- **Enterprise Application Integration**
  - Specific to a particular business process
  - Designed as tighter bound implementation of connecting systems.
  - E.g., Connecting an order processing application to an inventory control application.

- **Web Services**
  - Loose bound collection of services
  - Discover and bind dynamically.
Web Service Integration

- Integrate Web services to perform encapsulated business functions
- Enable dynamic integration with decreased human intervention
- Automate app-to-app / org-to-org cooperation using open standards
- Web Service Integration requires service engines
  - Computer Agent
Computer Agent

- Capability to accomplish task on behalf of user
- Flexibility in creating it
- Self-Initializing / Message-Initializing Action
- Message passing
Beyond $CS^2 \ldots$ SCVVisualizer

- $CS^2$ is more than a simulator
- Supply Chain Management service engine in Construction
- Deploy the service engine on top of Web services environment
- Enhance information transparency
SCVisualizer: System Architecture

Supply Chain Management Web Service

SOAP Router (e.g., AXIS)
HTTP Server (e.g., APACHE)
JATLite (Java Agent Template Lite)
TCP/IP Connection
Agent Router

Internet Web Services

Financial Web Service
Tracking Web Service
Other Web Service