Model-Based Supply Chain Management and Model-Based Work Planning

Commitment checking through material-based scanning

Commitment entering into field mobility software

Model-based supply chain management

CEE320
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Promise-Based Work Planning

Current Practice of Weekly Work Planning

• On a weekly basis, contractors create weekly work plan together on the wall
Promise-Based Work Planning

Current Practice of Weekly Work Planning

- Based upon the promises, daily/weekly/monthly work plans are created

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Duration</th>
<th>Performer</th>
<th>Delivery Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaffold</td>
<td>2 days</td>
<td>Jacob Sanchez</td>
<td>1/12/2010</td>
<td>InProgress</td>
</tr>
<tr>
<td>Overhead rough in</td>
<td>7 days</td>
<td>Brian Archer</td>
<td>1/19/2010</td>
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</tr>
<tr>
<td>Hang CAV</td>
<td>3 days</td>
<td>Kevin Mueller</td>
<td>1/20/2010</td>
<td>InProgress</td>
</tr>
<tr>
<td>Piping</td>
<td>1 days</td>
<td>Johnny Ringo</td>
<td>1/20/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>2nd floor door frame install</td>
<td>3 days</td>
<td>Jacob Sanchez</td>
<td>1/20/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Hang CAV</td>
<td>3 days</td>
<td>Kevin Mueller</td>
<td>1/20/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Piping of 2nd Fl CAV</td>
<td>10 days</td>
<td>Kevin Mueller</td>
<td>1/22/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Finishing</td>
<td>2 days</td>
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<td>1/22/2010</td>
<td>Complete</td>
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<tr>
<td>Duct Work</td>
<td>1 days</td>
<td>Kevin Mueller</td>
<td>1/20/2010</td>
<td>InProgress</td>
</tr>
<tr>
<td>Install backers for regrets</td>
<td>4 days</td>
<td>Jacob Sanchez</td>
<td>1/20/2010</td>
<td>InProgress</td>
</tr>
<tr>
<td>Flex Head Drops</td>
<td>5 days</td>
<td>Brian Archer</td>
<td>1/26/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Piping</td>
<td>10 days</td>
<td>Johnny Ringo</td>
<td>1/27/2010</td>
<td>InProgress</td>
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<tr>
<td>Install Regrets North Stair</td>
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<td>Jacob Sanchez</td>
<td>1/28/2010</td>
<td>InProgress</td>
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<tr>
<td>Electrical Work</td>
<td>4 days</td>
<td>David Pontious</td>
<td>1/28/2010</td>
<td>InProgress</td>
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<td>Frame and drywall main stairwell</td>
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<td>Sam Dugallando</td>
<td>1/28/2010</td>
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<tr>
<td>Complete install of duct in 3rd floor</td>
<td>5 days</td>
<td>Kevin Mueller</td>
<td>2/1/2010</td>
<td>InProgress</td>
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<td>In wall Rough in</td>
<td>9 days</td>
<td>David Pontious</td>
<td>2/1/2010</td>
<td>InProgress</td>
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<tr>
<td>In wall Rough in</td>
<td>10 days</td>
<td>David Pontious</td>
<td>2/1/2010</td>
<td>InProgress</td>
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<tr>
<td>In-wall Piping</td>
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<td>Johnny Ringo</td>
<td>2/1/2010</td>
<td>InProgress</td>
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<td>Johnny Ringo</td>
<td>2/1/2010</td>
<td>InProgress</td>
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<tr>
<td>Duct work</td>
<td>2 days</td>
<td>Kevin Mueller</td>
<td>2/2/2010</td>
<td>InProgress</td>
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<tr>
<td>Main Stair Flex Head Drops</td>
<td>3 days</td>
<td>Brian Archer</td>
<td>2/2/2010</td>
<td>InProgress</td>
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<tr>
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<td>5 days</td>
<td>Bill Sandberg</td>
<td>2/5/2010</td>
<td>InProgress</td>
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<tr>
<td>1st Floor Bathroom Counter Top Supports</td>
<td>5 days</td>
<td>Bill Sandberg</td>
<td>2/4/2010</td>
<td>InProgress</td>
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<tr>
<td>Piping of 1st Floor CAV</td>
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<td>Kevin Mueller</td>
<td>2/4/2010</td>
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</tr>
<tr>
<td>Install all door frames</td>
<td>5 days</td>
<td>Jacob Sanchez</td>
<td>2/11/2010</td>
<td>InProgress</td>
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</tbody>
</table>
Commitment Checking with Visual Inspection and Papers

Current Practice of Weekly Work Planning

- Daily commitment is reported and updates status of the promises

Foreman: “Where did these activities happen today?”

Foreman: “Ok, the activities were completed. I mark it.”

Foreman: “How much of quantities of the activities was completed?”

Foreman: “I fax my daily progress report.”

PE: “This is up-to-date progress of the project.”

PE: “I change the status of the activities to see if the activities have been completed according to the promises.”

PE: “I enter the quantities completed into system.”
Unreliable Planned Durations

Limitation #1 in Current Practice

- The planned durations of the activities are derived without accurate quantities
- To achieve a higher PPC (percentage of plan completion), the planned durations tend to be longer

Is this 4-day duration reliable?
Lack of Constraints Analysis

Limitation #2 in Current Practice

• The activities are planned without constraint analysis of area, crew, and material flow.

<table>
<thead>
<tr>
<th>Task</th>
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<th>Planner</th>
<th>Start Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping of 2nd fl CAV</td>
<td>10 days</td>
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<td>1/21/2010</td>
<td>Complete</td>
</tr>
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<td>Wall Rough In</td>
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<td>Sam Digiannonado</td>
<td>1/26/2010</td>
<td>InProgress</td>
</tr>
<tr>
<td>Duct Work</td>
<td>1 day</td>
<td>Kevin Mueller</td>
<td>1/26/2010</td>
<td>InProgress</td>
</tr>
<tr>
<td>Install backing for regrets</td>
<td>4 days</td>
<td>Jacob Sanchez</td>
<td>1/26/2010</td>
<td>InProgress</td>
</tr>
</tbody>
</table>

When planning, did you do constraint analysis of area/crew/material flow? NO

Then, do you think these planned activities are still reliable?
Commitment Checking with Visual Inspection and Papers

Limitation #3 in Current Practice

• The commitment checking to see if the promises (i.e., planned activities) have been completed according to the plans is through the unreliable, time-consuming process.

• It is likely to report manipulated commitment in order to pretend to say “My work is going OK!”

• Unreliable promises are created when planned

• Unreliable commitment checking are performed when completed

Visual inspection?  
Measuring tape?  
Paper report?  
Manual entering/updating?  
→ 2 hours every day!
Intuition #1: Model-Based Quantity-Derived Duration Creation

- To support contractors to derive reliable durations when creating work plans, VDC models can give them accurate model-based quantities
- Duration = productivity rate x quantities
Intuition #2: Visualization of Work Plan Activities

- To analyze constraints of area, crew, and material flows, VDC can give contractors 3D visualization of planned activities
Intuition #3: Reliable, Fast Checking of Commitment (1 of 3)

- Field mobility software enables material-based commitment checking and fast recording, documenting, reporting, and sharing.

1. **RFID Barcode**
   - Manufactured
   - Shipped
   - Received
   - Installed
   - Punch list

2. **VDC**
   - Attach/Scan tags
   - Scan tags
   - Scan tags
   - Scan tags
   - Click punch lists

3. **Website**
   - Real-time status reports
   - Color-coded 4D visualization
   - QA/QC and punch list reports
   - Last Planner System for updating daily/weekly work plans
   - Supply chain members have access to the website for real-time, two-way collaboration
Intuition #3: Reliable, Fast Checking of Commitment (2 of 3)

- Material-based commitment checking enables improvement in alignment between demand and supply to reduce amounts of inventory and work-in-process

Date of delivery/receiving = Date of installation → Continuous work flow in a supply chain

This mismatch (i.e., average 7 days of inventory turnaround) between demand and supply was due to supplier’s late response to demand variability such as:

- Change orders
- QA/QC issues
- Delay/acceleration of works
- Late sharing of updated work plans
Intuition #3: Reliable, Fast Checking of Commitment (3 of 3)

• Misalignment between demand and supply requires additional costs associated with (Arbulu and Ballard, 2004; Walsh et al., 2004):
  √ Storage
  √ Maintaining and re-handling
  √ Damage/lost of inventory

The project site in SF’s China Town was very tight and had little space for inventory storage
### Stepping Stones of Research

#### What are Missing?

- Work planning needs to:
  - Create work plans with model-based quantities to increase reliability of durations
  - Switch commitment checking from activity-based to material-based
  - Increase speed of status updating for fast status sharing to reduce latency of decision making and batch sizes of materials to be ordered for improvement in alignment between demand and supply

- VDC tools need to:
  - Offer visualization of planned activities to conduct constraints analysis
  - Offer model-based quantities to increase reliability of durations
  - Link as-built quantities from VDC models and as-built time logs from field to Last Planner System to accurately monitor mismatch between as-planned (i.e., supply) and as-built (i.e., demand)

- Field mobility software needs to:
  - Enable material-based commitment checking
  - Increase speed of status updating
This Research Will Address the Question

How much can the integration methodology of VDC, lean methods, and field mobility software improve:

1. Reliability of planned durations
2. Constraints analysis to best perform planned activities
3. Alignment between demand and supply
4. Distortion of demand information
5. Time savings in recording, documenting, reporting, and sharing
On-Going Development

- Currently working with Tekla, Scenario VPD, and Autodesk
  - to develop Model-Based Work Planning
- Currently developing field mobility software, DPR Mobile
  - to develop Model-Based Supply Chain Management
- Currently documenting a standard execution plan
  - to institutionalize this new process
Q&A