Construction Management Applications: Challenges in Developing Execution Plans

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Construction Management Domain

- To build ... under constraints
  - Time
  - Budget
  - Site location
  - Resources: equipment, labor, material

- To avoid or contain ... contingencies
  - Adverse weather
  - Accidents
  - Delivery problems
  - Labor strikes
Our objective

Provide automated project management support for

- Project execution
- What-if analysis
- Contingency planning
Stages of Steel Project Management

**Participants**
- Owner
- Architect
- Structural engineer
- General contractor
- Construction manager
- Design builder
- Steel contractor
- Steel fabricator
- Steel erector
- Lower tier subcontractors
- Steel suppliers
- Detailers
Participants
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Stages of Steel Project Management (cont’d)

Steel contract execution

Award lower tier subcontracts

Order steel

Prepare erection & shop drawings

Shop drawing approval

Deliver material

Fabricate steel

Deliver fabricated steel

Erect fabricated steel

Shop drawing approval

Deliver material

Fabricate steel

Deliver fabricated steel

Erect fabricated steel
Structural Framing Plan
Corner of the floor
The schedule

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Contingencies – Planning error
Contingencies – Productivity changes
Contingencies – Material not delivered
Contingencies – Space is a concern
The big picture

Regulatory Bodies (OSHA)
Plans
Budget
Site Conditions

Labor Crews
Equipment
Space Available, Weather
Productivity

Dispersed & Incomplete Knowledge

Resources
Project Specific Constraints

Operationalize to APS
Continuously Monitor and Update

Finished Product
Current Abilities & Future Needs

- **Current Abilities**
  - Gantt charts, critical path method (CPM)
  - Linear scheduling (Ioannou et al.)
  - Simulation of operations (AbouRizk et al.)
  - Virtual/Augmented reality (Martinez, Kamat et al.)

- **Resource/resource to human/resource interactions:**
  - Decision-making at a system-level
  - Constraint driven approaches
  - Contingency planning
Our system

- ICDMA (Interactive Construction Decision Making Aid)
- Can perform what-if analysis on As Planned Schedules (APSs) if provided with
  - Tasks and dependencies
  - Relevant constraints
  - External events
  - Relevant effects of events such as productivity
ICDMA interface
Temporal Network with Activities and Events (TONAE)
Monte Carlo Simulations
Extend ICMDA with contingency planning

- When the execution deviates from the as-planned schedule (APS), automatically suggest alternatives

- Assumptions of automated planners
  - The domain information is represented in PDDL format
  - There is a single plan
  - All planning activities are done “offline”
Challenge 1: knowledge representation

- Knowledge:
  - Dispersed, multi-format
  - Incomplete operationalization

- Need to represent:
  - The project plans and schedules
  - Constraints
  - Stochastic events
Challenge 2: execution time deviations

- Need to consider:
  - Effects on the cost and the duration
  - Constraints that are violated
  - Soft constraints

- Show:
  - Various levels of detail (HTN-style, macro-style)
  - Different views to stakeholders
Challenge 3: contingency responses

- Possible responses:
  - Do nothing (use contingency funds)
  - Reschedule, reallocate
  - Replan

- Available technologies
  - Plan generation
  - Planning under uncertainty
  - Planning with constraints
Conclusion

- Construction management: knowledge-rich domain
- Challenge 1: knowledge representation to aid contingency responses
- Challenge 2: Understanding the contingencies
- Challenge 3: Responding to contingencies
Thank You!

Acknowledgments
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Additional References