A Schedule Optimization Tool for Destructive and Non-Destructive Vehicle Tests

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Overview

• Inspirational Video
• Introduction
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• Scheduling UI
• Domain Customization
  • UI
  • Scheduler
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Inspirational Video

Testing Conducted by Vehicle Research and Test Center at Transportation Research Center Inc.

Improved Restraints in Rollovers

CONTRACT NO. DTNH22-07-D-00060

April 20, 2010
Introduction

• Create a schedule for testing new and refreshed vehicles
  • Test vehicles hand-built
  • Project end date defined externally
  • Limited personnel and facility resources
Aurora Scheduling Framework

Given a list of tasks (or jobs or activities) each with a set of required resources and constraints, assign resources to tasks (for specific time windows)

- Heuristic-based scheduling framework
- Customized for domain
- E.g. Minimize the number of vehicles required while still completing project on time
Boeing Airplane Assembly Scheduling

- Very large, complex models
  - Large numbers of resource contentions, constraints
- Widely distributed users working on different projects
- Part of integrated management system
  - Accepts inputs from modeling system, sends outputs to shop floor management system
Medical Resident Scheduling

- Allocating residents for hospital staffing and educational purposes
- 150+ residents must be scheduled for a full year
- Extensive rules provide flexible constraints for an acceptable schedule
At NASA’s Kennedy Space Center, Aurora schedules the use of floor space and other resources at the Space Station Processing Facility, the world’s largest low-particle clean room where Int'l Space Station components are prepared for flight.
Managed Intelligent Deconfliction And Scheduling (MIDAS)

Performs automated resource assignment, scheduling, and deconfliction for Defensive Space Control and Space Situational Awareness operations.
Scheduling UI
Initial Schedule by Resource
Scheduling Framework

• Schedule Initialization
  • Preprocessor
  • Queue Initializer
  • Prioritizer

• Scheduling Loop
  • Scheduler
  • Quality Criterion
  • Conflict Manager

• Schedule Finalization
  • Postprocessor
Domain Specific Customization

- User Interface
  - Build Pitch
  - Manage Vehicles
  - Optimization Dashboard
- Scheduling Components
Build Pitch

The image shows a window titled "Build Pitch Configuration". The window contains a table with the following columns:

- **Vehicle Type**
- **Number**

The table lists various vehicle types and their corresponding numbers:

- EIGHT: 4
- ELEVEN: 4
- FIVE: 4
- FOUR: 4
- NINE: 4
- ONE: 4
- SEVEN: 4
- SIX: 4
- TEN: 4
- THREE: 4
- TWELVE: 4
- TWO: 4
- W/B 1: 4
- W/B 2: 4

There are two buttons at the bottom of the window: "OK" and "Cancel".
Manage Vehicles

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Build Order</th>
<th>Build Date</th>
<th>End Date</th>
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<td>01/19/2058 06:00</td>
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<tr>
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<td>2</td>
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<td>01/19/2058 06:00</td>
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<td>08/09/2012 07:30</td>
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<tr>
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<td>08/10/2012 07:30</td>
<td>01/19/2058 06:00</td>
</tr>
<tr>
<td>TWO-001</td>
<td>6</td>
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<td>FOUR-007</td>
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<td>01/19/2058 06:00</td>
</tr>
<tr>
<td>FOUR-004</td>
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<td>01/19/2058 06:00</td>
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<tr>
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<td>01/19/2058 06:00</td>
</tr>
</tbody>
</table>
Optimization Dashboard

Current Results
- Vehicles: 19
- WB: 4
- Total Vehicles: 23
- Destructive Tasks: 19
- Exclusive Tasks: 1
- Utilization: 68%

Optimization Remaining
- Scheduling Runs: 1
- Current Scheduling Run:
- Approximate Time: 0

Progress
- Set Backward Schedule
- Date Optimizer
- Meta Disabler Optimizer
- Set Forward Schedule

Buttons:
- Start
- Stop
- Pause
- Resume
- Export Utilization
- Close
Scheduling Component Customization

- Schedule direction management
  - Preprocessor, Postprocessor
- Support for exclusive tasks, destructive tasks, and task series
  - Preprocessor, Prioritizer, Scheduler, Postprocessor
- Heuristic Tuning
  - Preprocessor, Prioritizer, Quality Criterion, Postprocessor
Methods

• Test Model
  • 60 tasks
    • 18 destructive, 1 destructive and exclusive
  • 680 days work over 55 calendar days
  • Fixed build pitch with 1105 possible work days

• Lower Bound
  • 22 vehicles
    • 19 destructive tasks, 3 specific vehicles required that do not match destructive tasks

• Manual Solution
  • 25 vehicles
Results

• Aurora Solution
  • Round 1: 22 Vehicles
    • Too good!
  • Round 2: 23 Vehicles
    • 8% reduction in vehicles
    • Withstood scrutiny

• Schedule created in 2 minutes from model vs. days of labor
  • Spend this time using ‘What-if’ capability to try and further improve the schedule
Optimized Schedule
Comparing Schedule Snapshots
Conclusion

• Complex, real-world, scheduling problem
• Added domain-specific heuristics to a general intelligent scheduling framework
• Generated schedule for vehicle testing
  • with a significant reduction in the number of vehicles required
  • that still completed in the given timeframe
Ongoing Work

- Testing on more complex models that require over 100 vehicles
- Utilizing facility and personnel constraints when creating a schedule
- Supporting the transition of the software into the hands of the actual planners