Explaining Complex Scheduling Decisions

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AURORA

- General-purpose scheduling framework
- Successfully applied in aerospace, manufacturing, defense, and service industries
- Minimizes the time and cost associated with large and complex projects
- Combines graph analysis with heuristic scheduling to quickly produce an effective schedule

SCHEDULING MODEL

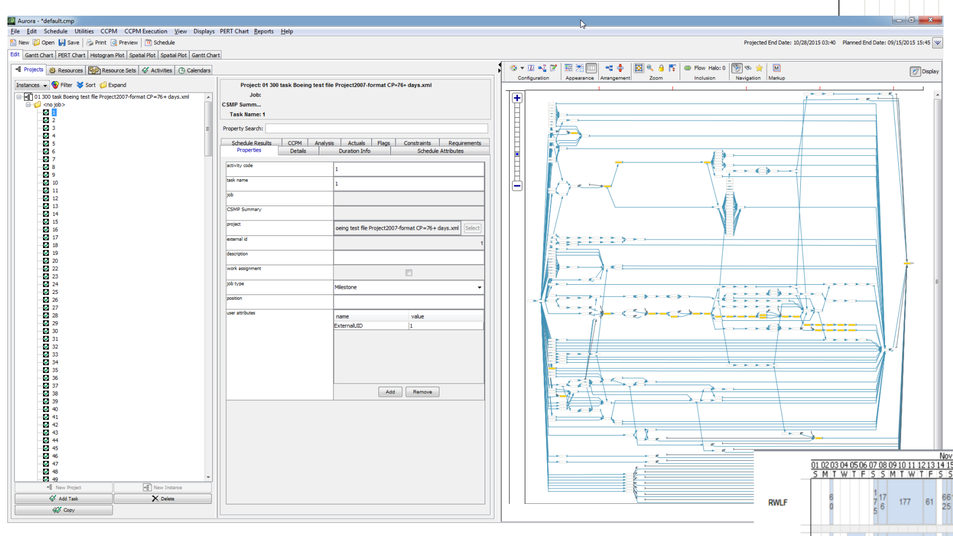
- **Tasks***:* Jobs that need to be completed, e.g. *InstallCockpitDoor*.
- **Constraints:** Limitations on when a task can be completed. E.g.:
  - **Temporal:** *InstallCockpitDoor* must be completed by 5:00 PM on March 1, 2018.
  - **Ordering:** *PaintCockpitDoor* must happen before *InstallCockpitDoor* with a lag of at least 48 hours in between to allow the paint to cure.
  - **Resource:** *InstallCockpitDoor* requires a specific resource (*CockpitArea*) three mechanics from the *Mechanics* resource set.
  - **Calendar:** Individual *Mechanics* work one of two shifts M-F, while the *CockpitArea* is generally available at any time.

SCHEDULING ENGINE

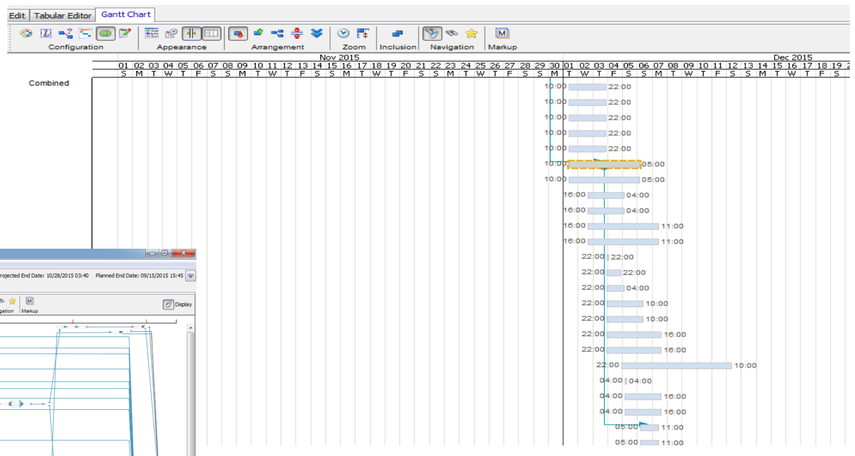
- Initialization Phase
  - Preprocessor
  - Prioritizer
- Scheduling Phase
  - Scheduler
  - Conflict Manager
  - Prioritizer
- Finalization Phase
  - Conflict Manager
  - Postprocessor

EXAMPLE RESULTS

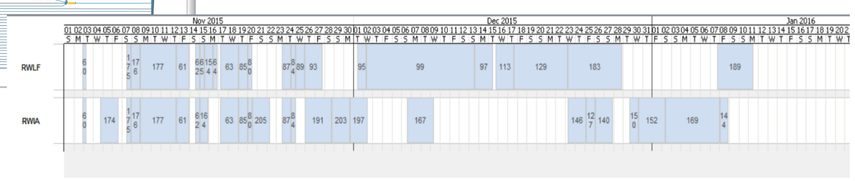
- Final aircraft assembly subset:
  - 300 tasks (40,000 tasks in real-world)
  - 250+ resources
  - 800+ days of work



The 300-task model viewed in Aurora. The model display includes tasks (left), task details (center), and network diagram (right).



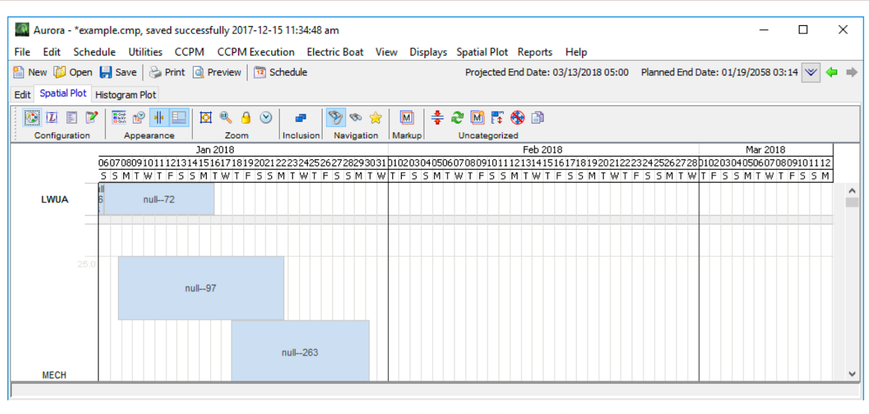
A Gantt chart view of the created schedule. The arrows leading into and out of the highlighted task show the temporal dependencies between tasks.



A resource specific plot that shows the tasks assigned to resources RWLF and RWIA over time.

GENERATING EXPLANATIONS

- Explanations are generated for each task:
  - Constructed from decisions made in each of the scheduling phases
  - Impacted by the order in which tasks are scheduled



A plot of tasks scheduled before the explained task. The x-axis is time; the y-axis are resource constraints.

scheduled order	110
explanation	The start date was affected by the flow start time, which set it to 12/01/2017 00:00 The end date was affected by the maximum flow time of 7300.00 days, which set it to 11/26/2037 00:00 The start date was affected by null--66, which set it to 12/27/2017 11:00 The end date was affected by null--108, which set it to 10/29/2037 12:00 The start date was affected by null--66, which set it to 01/06/2018 11:00 The start date was affected by ForwardSchedule, restricted by availability of LWUA; waiting for null--72, which set it to 01/16/2018 11:00 The end date was affected by ForwardSchedule, based on duration and start time, which set it to 01/17/2018 17:00

A scheduling explanation for a task in Aurora. Task and resource names are obfuscated.

TYPICAL USER

- Scheduling expert
  - Primary responsibility is creating and maintaining schedule
- Objectives for Aurora
  - Create a valid schedule
  - **Carry out what-if analysis to improve schedule**
  - Negotiate changes to the scheduling model based on what-if analysis
  - Respond to changing circumstances

FUTURE WORK

- Improve reporting on delays caused by multiple resources
- Add simple way to visualize explanation
- Improve visual representation of text-based explanation
- Provide a graphics-based explanation

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