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Cost Savings and Capacity Factor Improvements via Outage Optimization

Diego Mandelli (INL) Mohammad Movassat (OPG)



Context: Plant Outage Planning

- **Plant outage:** About 13K–18K performed activities condensed into a 2–3 weeks time window
- **Issue:** Outage delays have a significant economic impact
 - Delays in completing an activity
 - Unexpected (emergent) activities
- This talk: Methods and tools to <u>co-pilot</u> outage managers in the outage planning and execution phases
 - Measuring the resilience of an outage schedule
 - Identifying critical points in the outage schedule
 - Proactively allocating resources to reduce the risk of delays



Issue 1: Delays in Completing an Activity

- Context: Outage schedule planning methods are based on point estimates of activity completion times
 - Such values may not reflect actual operational experience
 - Internal and external factors may affect actual completion times
- Our work: Estimate activity duration variance through artificial intelligence and machine learning (AI/ML) methods, based on historic outage data

Outcome

- Statistical prediction of completion time
- Identification of internal and external factors that affect the completion time

Completion time for activity "calibration of pressure transmitter"



Issue 2: Emergent Activities

- Approach based on NLP methods
 - Assess the nature of the emergent activity
 - Identify the planned activity that triggered emergent one
 - Assess the occurrence likelihood of the emergent activity
- **Knowledge graph**: Structured database of an historic outage that captures relations between
 - Outage planned and unexpected activities
 - Condition reports observed during the outage
- Data analytics
 - Flag planned activities that might trigger emergent ones
 - Based on type of activity or type of SSC
 - Pre-allocate resources to address unexpected activities
- **Benefits:** Improved data understanding
 - Capture and integrate data from various sources
 - Enhanced query capabilities: Explore relationships between events and infer new knowledge





Merging Outcomes of the Two Analyses

- Goal: Assess outage schedule resilience
 - The ability to counteract unexpected events (delays, or emergent activities)
- **Develop optimization methods** that account for all resources (i.e., time, crews, equipment, space) in the outage schedule calculation
 - The outage schedule is not altered!
- Analysis benefits
 - Outage planning
 - Evaluate the risk of outage delays
 - Identify opportunities to reduce the impact of delays
 - · Identify the impact of crew availability
 - Flag emergence of potential unexcepted activities
 - Outage execution
 - Automatically allocate jobs to available crews if delays, or emergent activities are encountered
 - Constantly monitor near critical paths



Final Remarks

- **Goal:** Decreased risk of power plant outage delays
- Scope: Deployment of AI/ML and optimization methods designed to assist outage staff to create a resilient outage schedule
 - Identifying critical points in the outage schedule
 - Delays in completing an activity
 - Unexpected (emergent) activities
 - Proactively allocating resources to reduce the risk of delays
- Industry collaborator: Ontario Power Generation (OPG)
- Open-source tools
 - Risk Analysis and Virtual Environment (RAVEN)
 - Digital Analytics, Causal Knowledge Acquisition and Reasoning (DACKAR)
 - LOGOS