Product design / development / engineering | Energy | Work allocation optimization | Deterministic / Stochastic

Short Duration Job Scheduling and Assignment using Staged Mixed Integer Programs

Atlantic Utility

BUSINESS PROBLEM

Atlantic Utility's electric field force transitioned to a work dispatch solution that allows supervisors to assign service jobs under 6 hours to field crews and for crews to self-select jobs. However, the solution does not include uniform criteria with which to assign or select high-priority jobs; users manually identify jobs based on proximity, due date, and other factors. The absence of uniform criteria may lead to variability in job prioritization, increasing the risk that jobs that should have had a higher priority become overdue, potentially resulting in missing service level commitments or providing less efficient customer service.

APPROACH

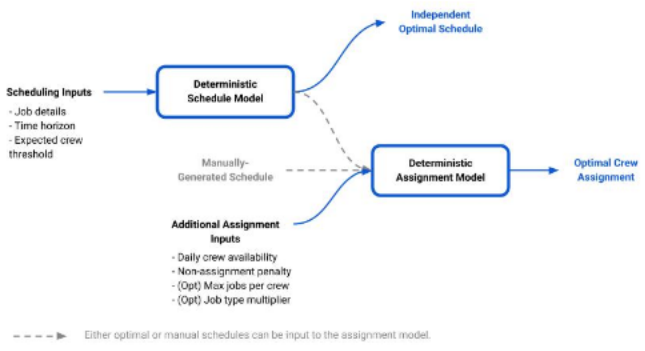
1) Perform field interviews and reference historical data contained in a SQL database and legacy databases to define a set of job prioritization criteria. 2) Design staged, proof-of-concept algorithms to prioritize jobs for scheduling and assignment with flexibility to include additional criteria in future iterations. 3) Develop operationalization recommendations for the algorithm.

DATA SOURCES

This research relies on 1) legacy on-prem work management systems containing job design details 2) the application SQL database (e.g. user job metadata) and 3) daily crew assignment spreadsheets and service job reports. Additional sources including data from past field interviews and a performance management tool that tracks user behavior may be used, if available.

Data Types and Format

Available data is a collection of timestamp, real-time longitude and latitude feeds, and numerical fields like distance. Categorical data and variable-length character sequences may also be used.



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IMPACT

Efficient and consistent electric service job assignment and completion is core to field force operations and a requisite to providing a high standard of safe and reliable customer service across the electric grid. However daily job assignment is inherently challenging given the need to consider multiple factors including service priority level, due date, distance to crews, estimated man hours, and crew availability. This is further complicated by the lack of a standardized set of criteria by which to aggregate those factors into a clear set of prioritized jobs. The introduction of a job prioritization engine alleviates the burden placed on supervisors to balance multiple criteria coming from disparate data sources, reduces the variability in job prioritization across barns, and further lessens the risk that high-priority, jobs, with SLAs imposed by regulators, become overdue. Use of the algorithm as a fast, automatic aid for supervisors and field crews to claim jobs also allows for a more predictable job execution process that can enable improved resource planning and customer service. Strategic recommendations detailing how to deploy and operationalize this engine ensure adherence to industry best practices related to pipeline orchestration, testing, and deployment. The opportunity to scale the model both in terms of the set of input jobs and the inclusion of uniform criteria also allows for its use as a foundation for future work and resource planning initiatives.

DRIVERS

Utility companies across North America are increasingly investing in new technologies and software as part of the larger "smart grid" transition in which new software applications, sensors, meters, and data management technologies are used to reduce operational costs and improve customer experience. Atlantic Utility has similarly increased investment in internal tools and external solutions to expand their digital ways of working.

BARRIERS

At times it was challenging to identify common goals among different service barns, each with unique operating characteristics. Creating staged optimization programs to prioritize service jobs required some level of standardization which can be difficult to introduce over a varied network of operating units.

ENABLERS

The Digital team was extremely supportive and knowledgeable; they organized field visits to allow for in-person data gathering and provided easy access to required data and relevant resources in the company. In addition, the creation of an internal advisory panel composed of director-level members gave me instructive guidance and support throughout my internship.

ACTIONS

A qualitative data gathering effort was conducted which included over 30 interviews with supervisors, field workers, and resource coordinators across 8 service barns in New England and New York. In addition, over 25% of service barns in the network were analyzed in terms of their backlog and job requirements to inform the development of the staged optimization formulations.

INNOVATION

This thesis presents an application of staged mixed integer optimization formulations to the scheduling and assignment processes of daily electric utility service work with use cases that are generalizable outside the utilities industry. Specifically, a standardized metric was formulated and used to assess localized service jobs; it demonstrates an effective approach to backlog management that considers relevant capacity trade-offs.

IMPROVEMENT

Results from the scheduling stage show that optimal scheduling outperforms naive strategies and over increasing time horizons, demonstrates a greater ability to balance overdue and coming due jobs. Combining scheduling and assignment stages also shows significant improvement in barn backlog reduction over multiple simulated months. These formulations reduce job accumulations with the dual benefit of ensuring uniformity across the network.

BEST PRACTICES

1) Take the time to identify or create a relevant metric that can be reasonably expected to reflect business improvement and that allows for direct computation of cost savings. 2) Ensure relevant data is available and accessible; if not, consider the feasibility of simulated results. 3) Leverage existing Python libraries and if possible, use open-source optimization solvers like Google OR-tools to avoid licensing fees.

OTHER APPLICATIONS

Outside of the utilities industry, applications of the staged formulations can be considered in logistics and delivery settings. This environment can share similar short-term delivery expectations with the need to weigh trade-offs between on-time and overdue deliveries. We could envision similar planning scenarios in which deliveries have specific due dates and that are of variable distance and have minimum crew availability requirements.