Dynamic Repositioning of Condition-Based Maintenance Resources

Lisa M. Maillart, University of Pittsburgh,
Department of Industrial Engineering

Motivation

- Recent advances in sensor technologies facilitate the implementation of adaptive, condition-based maintenance (CBM) policies
- In many CBM applications, the assets being maintained are geographically dispersed and the maintenance resources are limited; e.g.,
  - swimming robots used for maintaining subsea infrastructures
  - locomotive industry with assets distributed on a railroad network
  - large computer server centers maintained by robots
- Requires a novel maintenance optimization framework that integrates
  - condition monitoring
  - repositioning of maintenance resources

Project Description

- Establish a Markov decision process framework to explore this novel class of problems
  - resulting models will determine optimal actions (e.g., reposition, perform a repair, idle) for the maintenance resources to minimize total expected cost (e.g., downtime, travel, maintenance)
  - resulting policies prescribe actions as a function of the
    - conditions of the assets
    - locations of the maintenance resources
- Analyze the resulting policies numerically, analytically, and via simulation to answer open questions, e.g.,
  - How can the proximity of a maintenance resource to an asset location be exploited to perform opportunistic maintenance?
  - How can maintenance resources be repositioned in anticipation of asset degradation and maintenance needs?
  - Under what conditions is the optimal policy well-structured?
- Consider a suite of extensions to the base model
- Develop implementation-friendly heuristic policies

Context

- Existing work that considers mobile maintenance resources is limited by
  - considering only reactive or preventive maintenance
  - not allowing resources to idle at intermediate locations
- Our approach combines CBM, i.e., *predictive* maintenance, and more flexible control of mobile maintenance resources
- Promising preliminary results

University of Pittsburgh

Minimize cost by jointly optimizing the positions of maintenance resources and the timing of condition-based maintenance actions.

Project Deliverables

- Efficient and scalable coding of the base model that facilitates preliminary numerical results, e.g.,

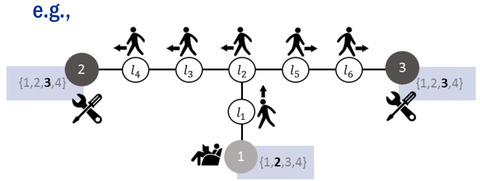

Figure 1. Policy schematic for *a* single maintenance resource on a graph with three assets denoted by and six auxiliary locations. Each asset has four possible degradation levels ranging from (1) as-good-as-new to (4) down or failed. The optimal actions are depicted by : travelling towards the indicated direction, : replacement, and, : idling.

- Submission of a 3-year NSF proposal by end of the funding period
- If funded, this grant will result in multiple peer-reviewed publications and conference presentations

Potential Impact

- Contribution of a novel class of problems to the maintenance optimization literature
- Generation of new managerial insights on the cost-effective use of mobile maintenance resources
- Reductions in maintenance expenditures
- Improvements in the safety and reliability of critical networks