Alert Generation in Execution Monitoring Using Resource Envelopes

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Executive Summary

Execution monitoring is an important aspect of AI. We apply the idea of resource envelope to alert generation in execution monitoring. We study three applications in details.
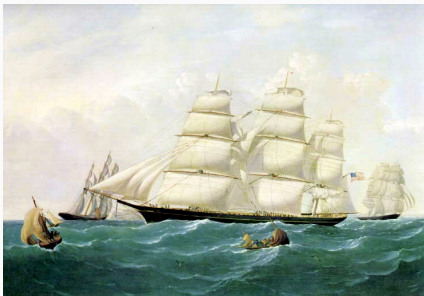
Agenda

- Alert Generation in Execution Monitoring

- Simple Temporal Network with Resources (STNR) and Resource Envelope

- Applying Resource Envelopes for Alert Generation in Execution Monitoring

- Conclusion

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Alert Generation in Execution Monitoring

For a given execution plan, adaptation are often required in response to a changing environment. Alerts for such adaption are important.

Ships need to adapt their routes in response to unexpected hurricane. (Image: (Skillet n.d.))

A team needs to adapt its plan in response to unexpected illness of its members. (Image: (U.S. Department of Defense Current Photos 2013))

Potential Future Resource Depletion as Alerts

- One important type of alert relates to potential future resource depletion.
- Examples include depletion of fuel in transportation applications, labor hours in human resource management applications, supplies in manufacturing applications, and so on.
- We apply the idea of resource envelope to generate this type of alert under the framework of Simple Temporal Network with Resources (STNR), a temporal reasoning framework.
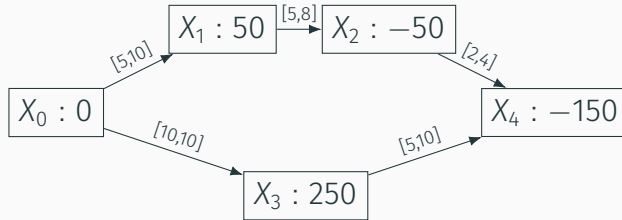
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Simple Temporal Network (STN)

- A graphical representation of a collection of simple temporal constraints between the execution times of various events.
- First proposed in (Dechter et al. 1991).
- Formally, it is defined on a directed graph $G = \langle \mathcal{X}, \mathcal{E} \rangle$, where
  - $\mathcal{X}$ is a set of events, and
  - each edge $e_{ij} = (X_i, X_j) \in \mathcal{E}$ represents a simple temporal constraint $LB(e_{ij}) \leq X_j - X_i \leq UB(e_{ij})$.
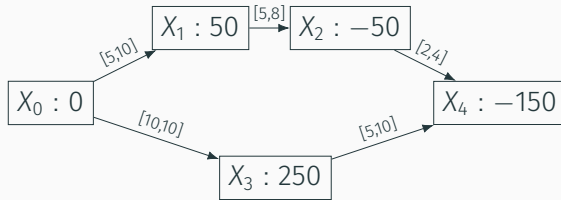
Simple Temporal Network with Resources (STNR)

Each event in an STN is also associated with a resource level. A resource level is positive/negative if this event produces/consumes resources. Example:

Resource Envelope

The largest and smallest possible total resource levels at each time instant (Kumar 2003). Can be computed using a maxflow procedure.
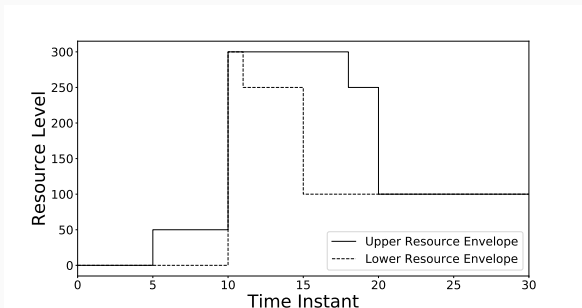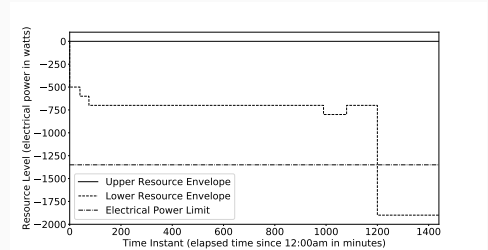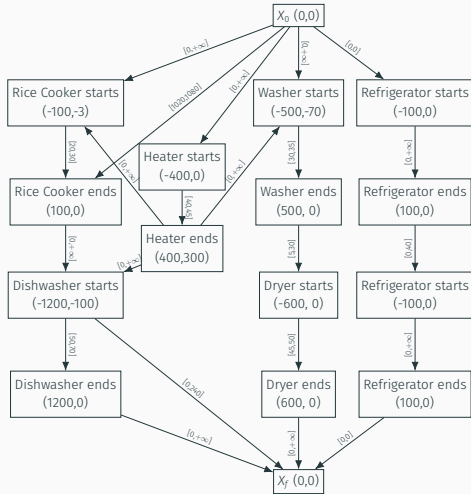
Agenda

Resource Envelopes for Alert Generation

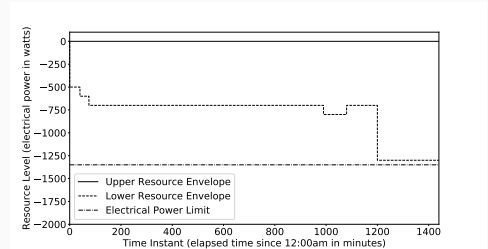Basic Principle: If the minimum resource level is too low at some time instants, an alert should be generated.
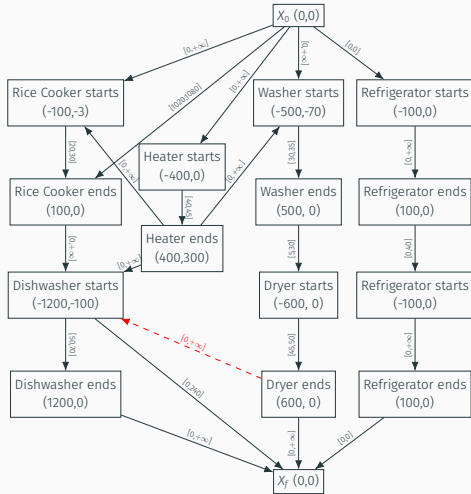
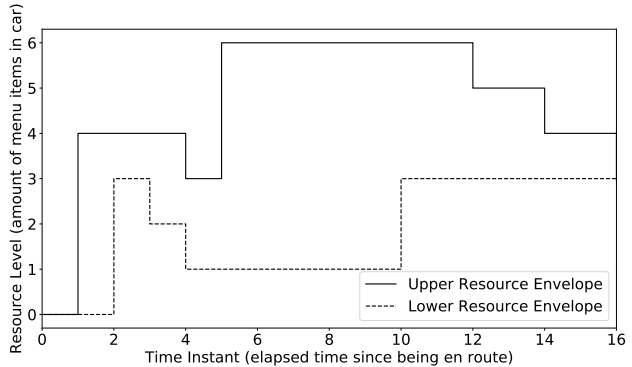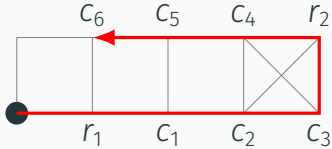Example: If resource level below 110 is dangerous at time instant 17, an alert will be generated.
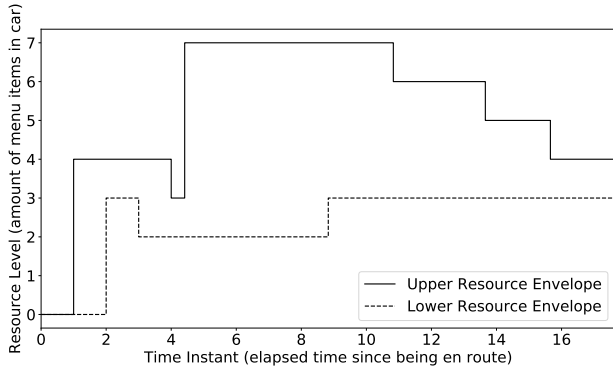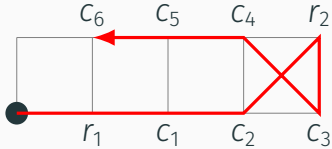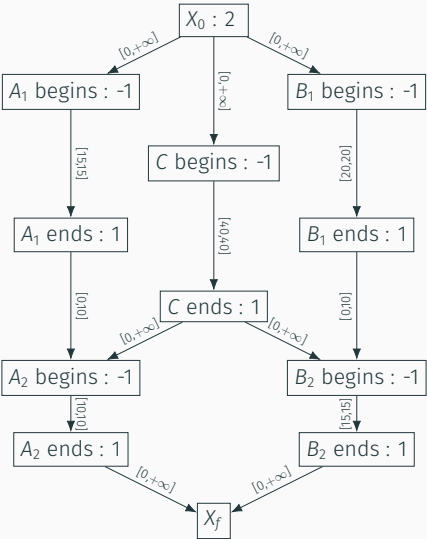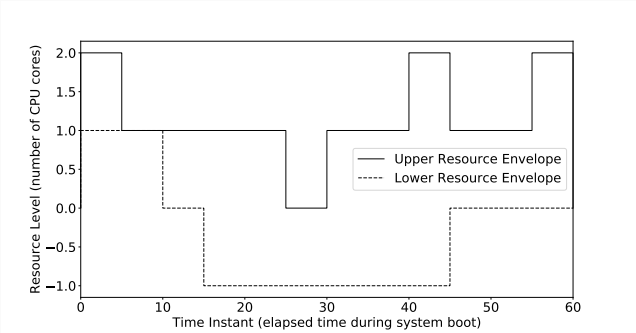
Smart Home

Smart Home

Service Management (System Boot)

- During system boot, services are being started.
- Traditionally, a service cannot start before all its dependencies have started.
- A modern system service management system, such as systemd, can start a service and its dependencies at the same time.
- For example, the web service depends on the database management system (DBMS). The web service
  - begins starting up without the DBMS (A_1 begins),
  - then gets interrupted when it needs to connect to the DBMS (A_1 ends),
  - continues starting up once the DBMS is ready (A_2 begins), and
  - finishes starting up (A_2 ends).

Service Management (System Boot)

Resource: CPU cores

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Conclusion

- Generating alerts for resource depletion in execution monitoring is important.
- We apply the idea of resource envelope to generate this type of alert under the framework of Simple Temporal Network with Resources (STNR).
- We demonstrate on three application domains: smart home, food delivery, and service management.
- (Future work) Make use of more features in resource envelopes.

References I

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T. K. S. Kumar. "Incremental Computation of Resource-Envelopes in Producer-Consumer Models". In: *the International Conference on Principles and Practice of Constraint Programming*. 2003, pp. 664–678.

S. D. Skillet. *Clipper Ship HURRICANE in the English Channel*. URL: https://commons.wikimedia.org/wiki/File:S._D._Skillet_-_Clipper_Ship_HURRICANE_in_the_English_Channel.jpg.

U.S. Department of Defense Current Photos. Jan. 2013. URL: https://commons.wikimedia.org/wiki/File:130105-A-GX635-442_(8364697465).jpg.