Research Challenges in Supervisory Control Theory

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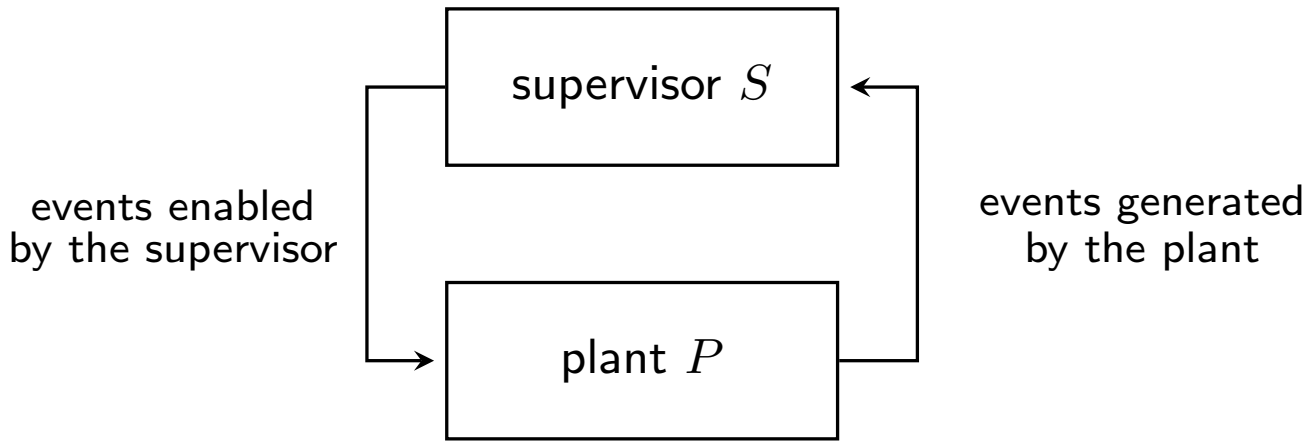
Supervisory Control (Theory)

Supervisory control is a general term for control of many individual controllers, such as within a distributed control system. It refers to a high level of overall monitoring of individual process controllers, and allows integration of operation between controllers.



Supervisory control theory (SCT) is a method for automatically synthesizing supervisors that restrict the behavior of a plant such that as much as possible of the given specifications are fulfilled. The plant is assumed to spontaneously generate controllable or uncontrollable events. The supervisor observes the string of events generated by the plant and might prevent the plant from generating some of the controllable events.

Core challenges in SCT

1. *scalability* of supervisory controller synthesis
2. *expressivity of requirements*
3. development of *synthesis techniques for networked supervisors*
4. integration of *performance optimization* techniques and supervisory controller synthesis
5. development of a *discipline of modelling* that facilitates use of the model-based engineering approach towards supervisory control synthesis

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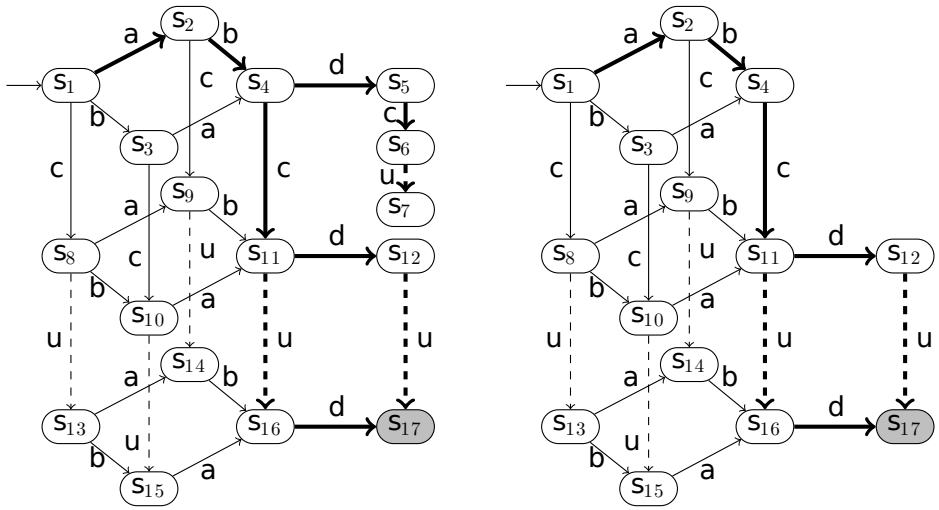
Scalability

- monolithic synthesis suffers from state space explosion
- manual decompositions exist
- decomposition techniques using Design Structure Matrices [1]
- compositional synthesis [2]
- partial-order reduction techniques for use with SCT [3]



[1] Martijn Goorden, Joanna M. van de Mortel-Fronczak, Michel A. Reniers, and Jacobus E. Rooda. Structuring multilevel discrete-event systems with dependency structure matrices. CDC 2017.

[2] Hugo Flordal, Robi Malik, Martin Fabian, and Knut kesson. Compositional synthesis of maximally permissive supervisors using supervision equivalence. DEDS 17, 4 (2007), 475-504.

[3] Bram van der Sanden, Marc Geilen, Michel Reniers, and Twan Basten. 2018. Partial-Order Reduction for Supervisory Controllers. (2018). In submission.

Expressivity of requirements

- traditionally requirements are (extended) finite automata
- state-based expressions
- requirements in fragments of temporal logics such as LTL and modal μ-calculus [1]
- formulating such properties is hard for engineers: formulation of properties in terms of scenarios-based formalisms such as life sequence charts. Validation of complex requirements is hardly supported by tool sets in the domain of supervisory control.

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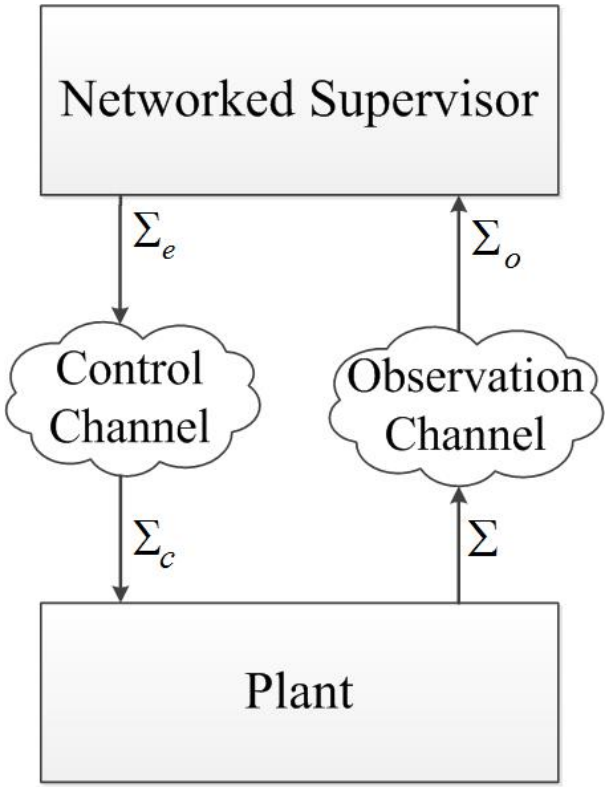
[1] A.C. van Hulst, Michel A. Reniers, and Wan J. Fokkink. Maximally permissive controlled system synthesis for non-determinism and modal logic. Discrete Event Dynamic Systems 27, 1 (2017), 109-142.

Networked Supervisory Control



- facilitate asynchronous interaction between supervisor and plant
- message delays
- message ordering disturbances
- message loss
- initial work is reported [1]

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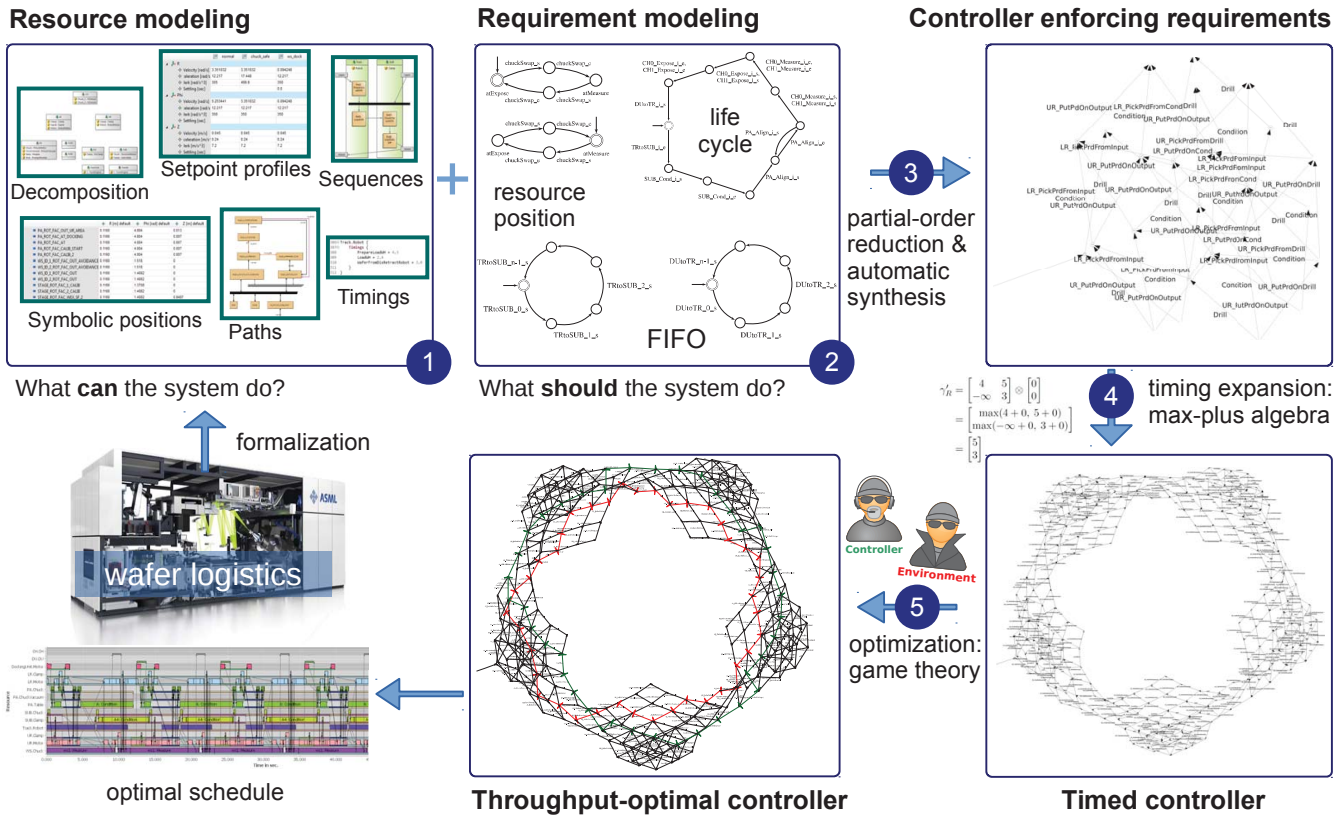
[1] Aida Rashidinejad, Michel Reniers, and Lei Feng. Supervisory Control of Timed Discrete Event Systems Subject to Communication Delays and Non-FIFO Observations. WODES 2018.

Performance optimization



- combine SCT and performance optimization [1]
- true integration of techniques is still sought for

[1] Bram v.d. Sanden, João Bastos, Jeroen Voeten, Marc Geilen, Michel Reniers, Twan Basten, Johan Jacobs, and Ramon Schiffelers. Compositional Specification of Functionality and Timing of Manufacturing Systems. FDL 2016.

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