Controller Synthesis for Hierarchical Agent Interactions

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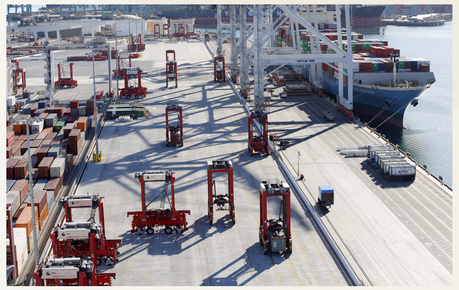
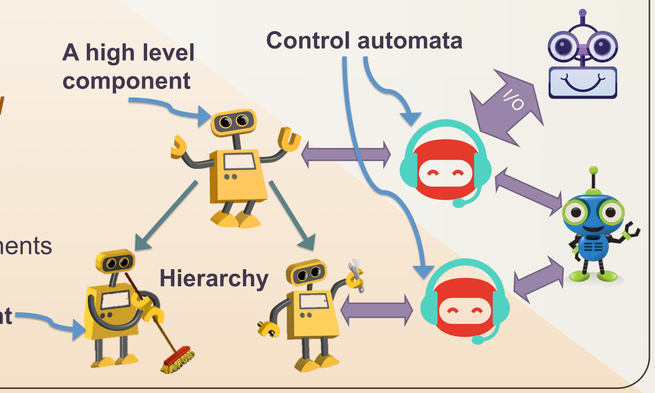
Motivation

- Need for a controller to coordinate several components to reach a desired goal
- Components may have hierarchy
- Complex systems are made up of several communicating components
- Examples: Warehouse, harbor management facility, helper robots in hospital, web services

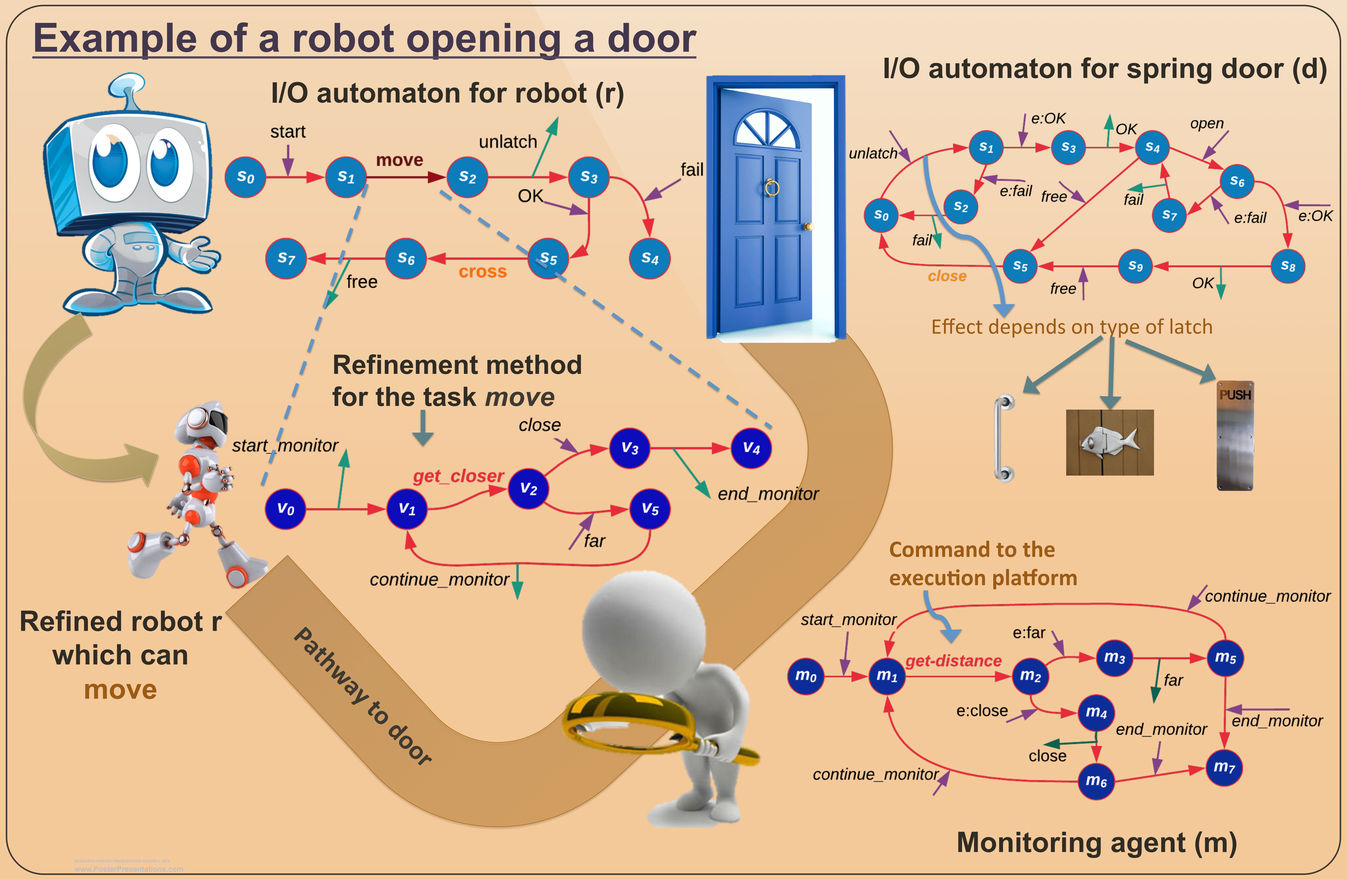


Our Contribution

- A framework modeling a system as a set of ***hierarchical*** input/output automata (**IOA**)
  - Good for systems with inherent hierarchy
  - Inputs and outputs model communication
- Synthesis of control ***automata*** to coordinate the components
  - Makes decision based on environment



Example of a robot opening a door



The Distributivity Theorem

The operations of parallel composition and refinement are **distributive**, a critical feature needed for handling this representation and the planning algorithm.

$$\Re(\sigma_1, s, \mu_t) \parallel \sigma_2 = \Re(\sigma_1 \parallel \sigma_2, s^*, \mu_t)$$

Current state

Refinement method for task t

Refinement IOAs Parallel Composition

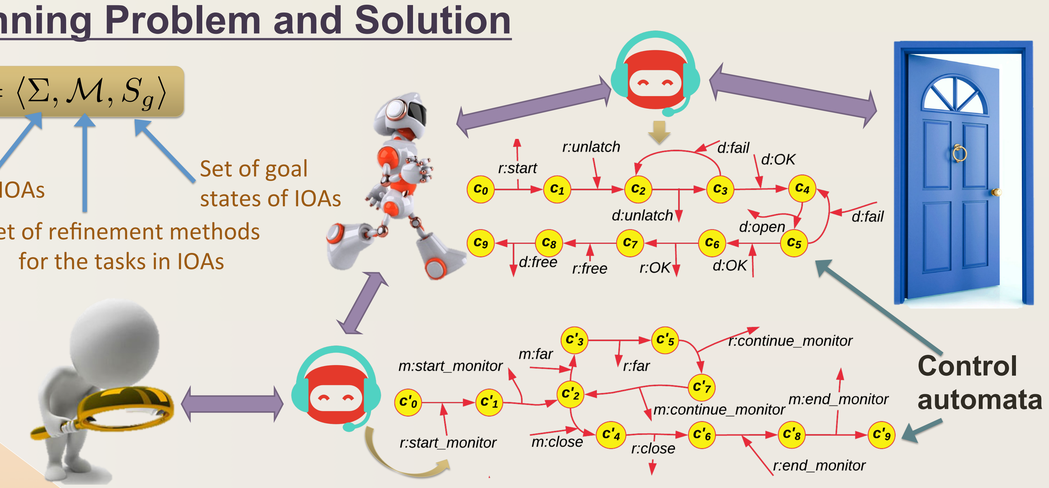
Planning Problem and Solution

$P = \langle \Sigma, \mathcal{M}, S_g \rangle$

Set of IOAs

Set of refinement methods for the tasks in IOAs

Set of goal states of IOAs



The solution consists of two control automata:

- One control automaton for robot(r) and spring door (d)
- One control automaton for robot(r) and monitor (m)

Both of them together forms the control structure that drives the refined robot, door and monitoring agent towards desired goal states via I/O interactions. We proposed a new algorithm for solving this problem.

Conclusion

- We modeled complex communicating systems as a set of hierarchical input/output automata (IOA)
- We formalized parallel and hierarchical composition of IOAs and the distributivity theorem.
- Our planning algorithm synthesizes a hierarchical control structure
- Our framework is very useful in a nondeterministic environment where continuous monitoring is required.
- It allows smooth integration of acting and planning.

Contact

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