Verifying the Adaptation Behavior of Embedded Systems

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Outline

Adaptation in Embedded Systems

Improve Quality and Functionality

- changing environment (car enters a tunnel, aquaplaning)
- reliability and dependability (get safely to next garage)
- personalization for specific needs (different drivers)

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Reduce Costs

- concurrent systems that consist of several parts
- depending on situation not all parts active at the same time
- dynamically adapt according to currently required needs
- share parts that are not used simultaneously

Adaptation in Embedded Systems

Challenges

- embedded systems are reactive real–time systems
  - verification of functional and temporal behavior
- hybrid systems (interacting analog and digital parts)
  - verification requires abstraction to discrete domains
- safety–critical systems (aviation, automotive industry)
  - legal aspects (“it wasn’t me who pushed the brakes”)

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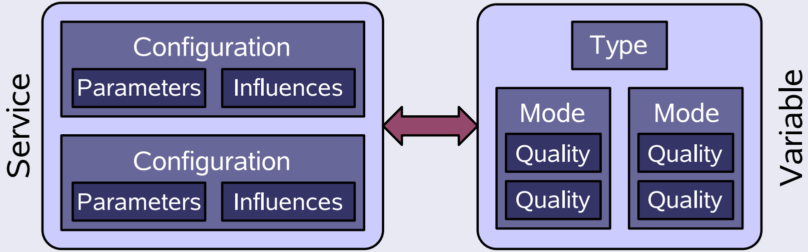
What about adaptation?

- adaptation has become increasingly complex part
- may trigger further adaptations in other components
- chain reaction of adaptations (up to 80% affected)
- can cause inconsistent and unstable configurations
- verification of adaptation behavior is a crucial concern

Modeling Adaptation Behavior

Services and Quality Descriptions



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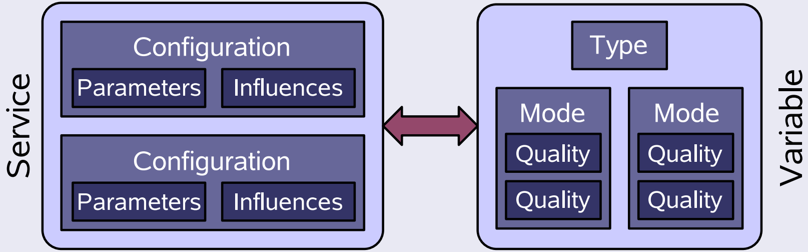
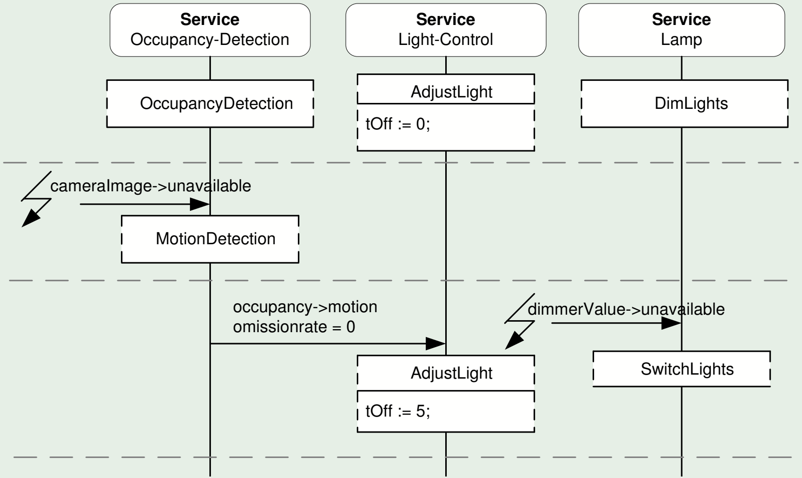


Configuration Rules

Configuration	Priority	Guard
OccupancyDetection	4	cameraImage[available]
TransponderDetection	3	transponderID[available]
MotionDetection	2	motion[available(r_point>0)]
Off	1	true

Modeling Adaptation Behavior

Example



Verifying Adaptation Behavior

Synchronous Languages (Quartz)

- precise notion of concurrency, communication, and time
- detailed formal semantics (structural operational semantics)
- specifications: temporal logics $\Rightarrow$ symbolic model checking

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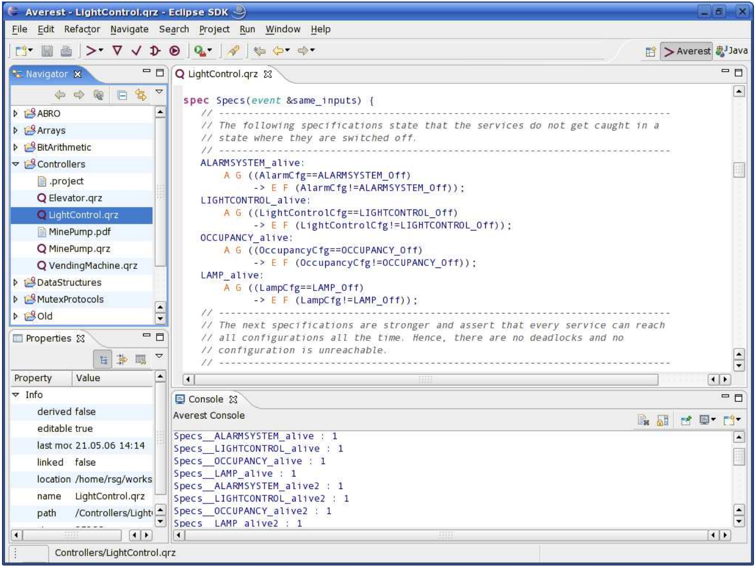
Example

```
module ABRO:
  input a,b,r: event;
  output o: event;
  loop
    [await a || await b];
    emit o;
  each r;
spec
  safe: A G (o -> a | b);
end
```

Tool Demonstration



Summary and Conclusion

Adaptation in Embedded Systems

- react on changes in the environment (failure of sensors)
- reduce costs and increase dependability (graceful degradation)
- can cause chain reaction of adaptations in other components

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Modeling and Verification

- modeling adaptation behavior at an abstract level
- augmenting data flow with quality descriptions
- configuration rules to describe potential adaptations
- translation to synch. languages $\Rightarrow$ symbolic model checking
  - can a certain configuration be reached at all?
  - can a system be caught in such a configuration?
  - can a certain configuration be reached infinitely often?
  - how long will it take to complete an adaptation?