Sensitivity Analysis for a Scenario Based Reliability Prediction Model

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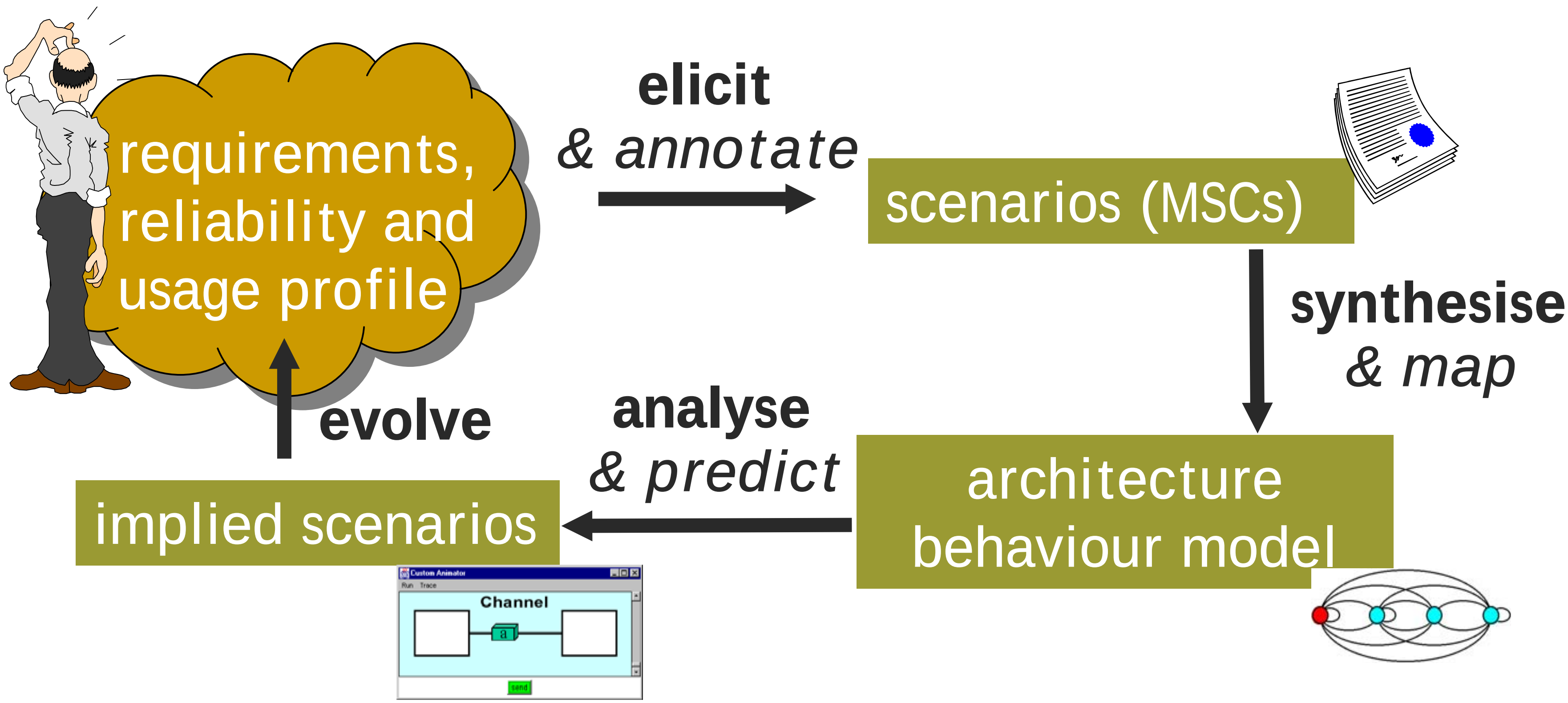
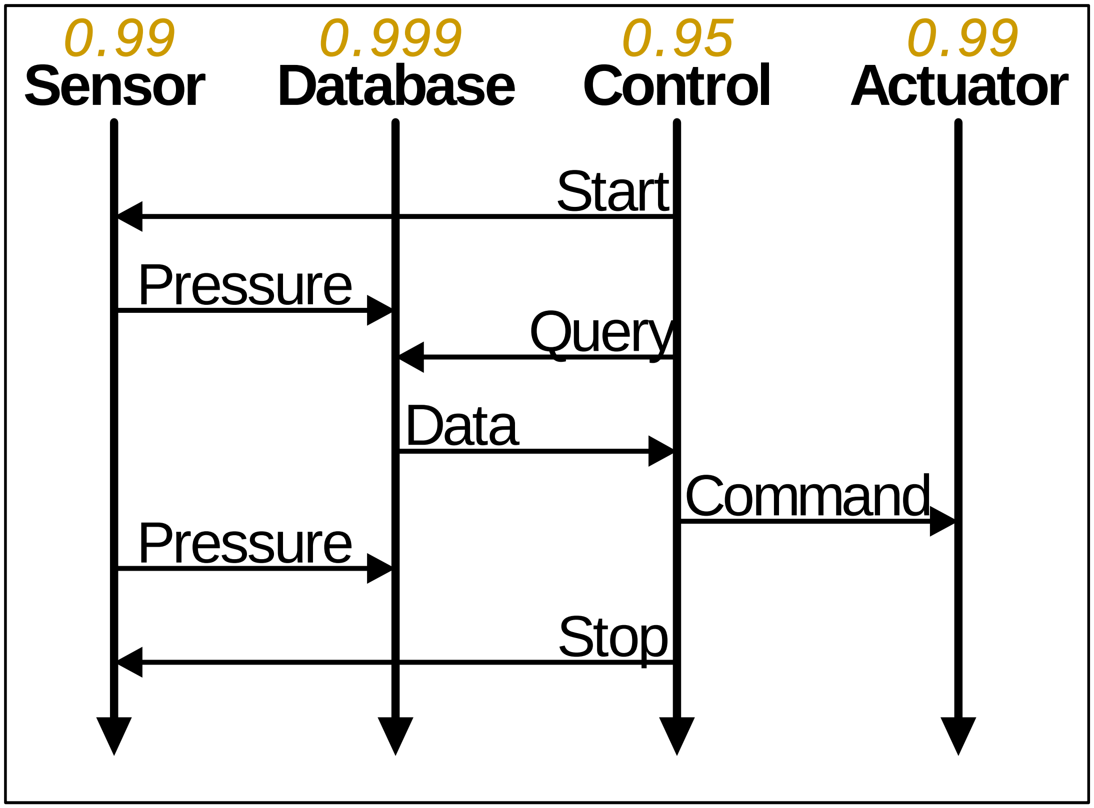
The Reliability Prediction Approach

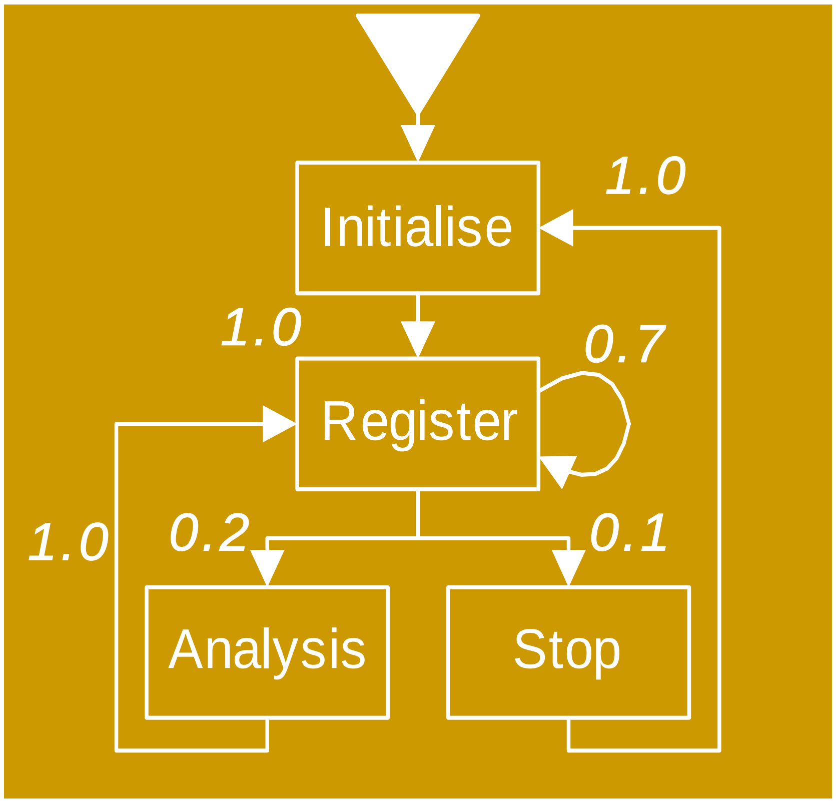


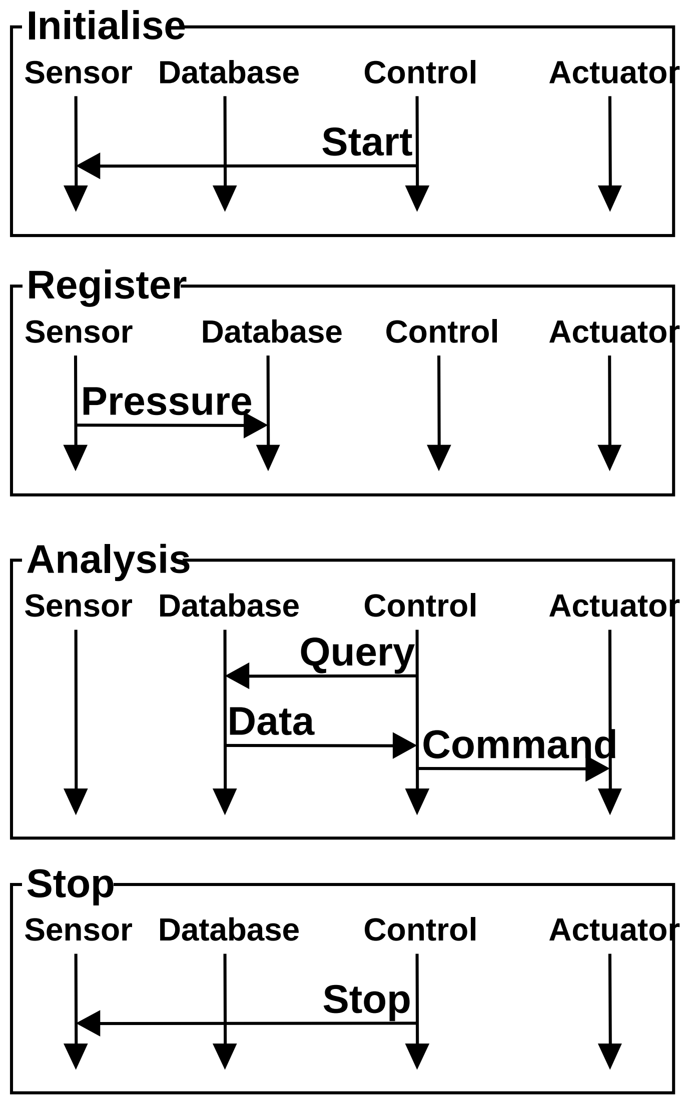
Annotated bMSC



- Annotate with *component reliabilities*
  - Could provide message- and timeline-level reliabilities instead
- Message interpreted as *invocation* of functionality in message *recipient* C
  - Assume P(success) = R_C
  - Assume success not dependent on time
  - Assume failures are independent across invocations

Annotated hMSC





- Annotate with *operational profile*

Synthesis of LTS for Architecture Model

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ArchitectureModel =
   (Database || Sensor || Control || Actuator).
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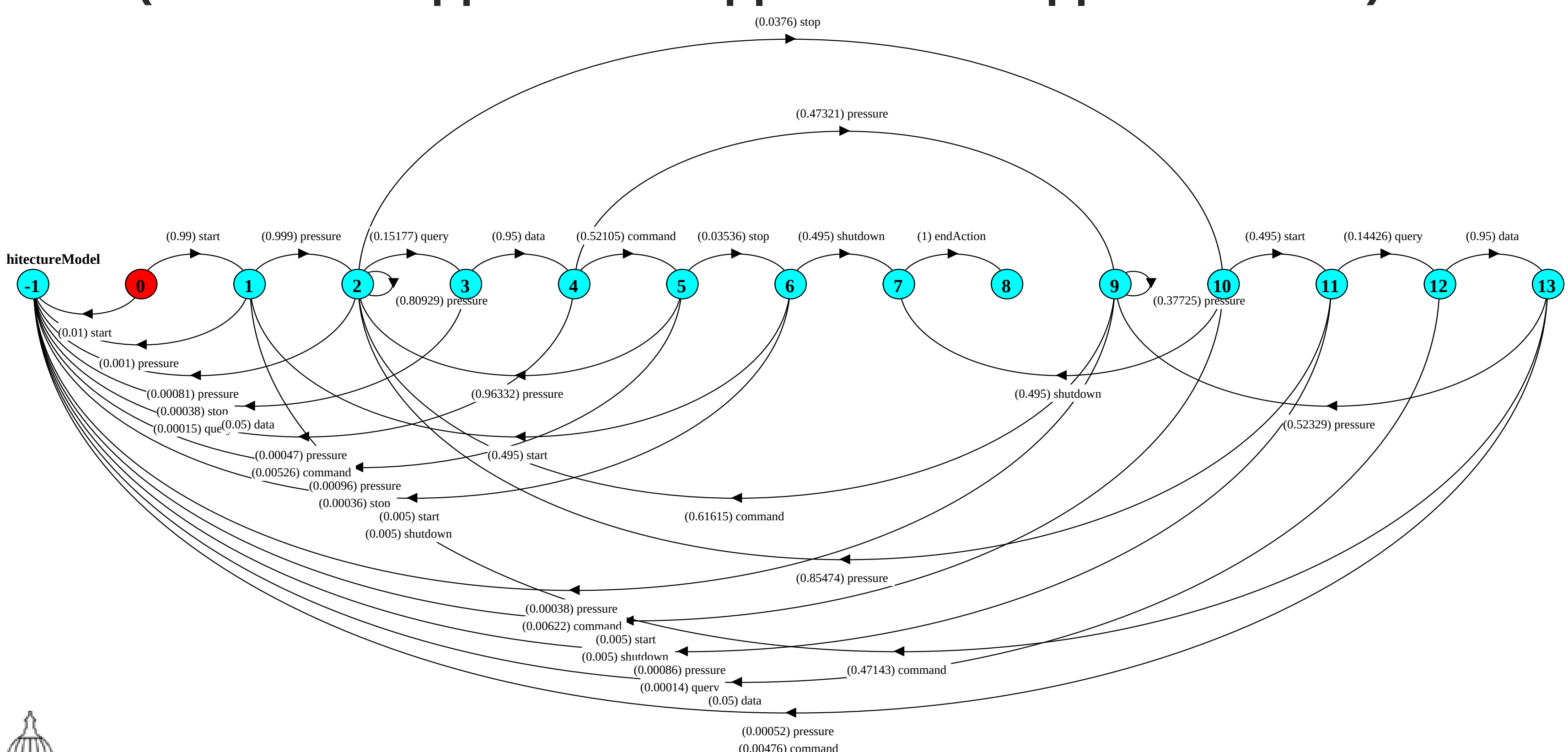

Implied Scenarios

- Traces exhibited by synthesised architecture but not by MSC specification
- Implied scenarios are "gaps" in the MSC specification and should be detected and validated
- Gap in the MSC specification: Positive Scenarios
- Gap in the synthesized architecture: Negative Scenarios
  1. Constraints built
  2. Compose with architecture model
  3. Re-calculate prediction

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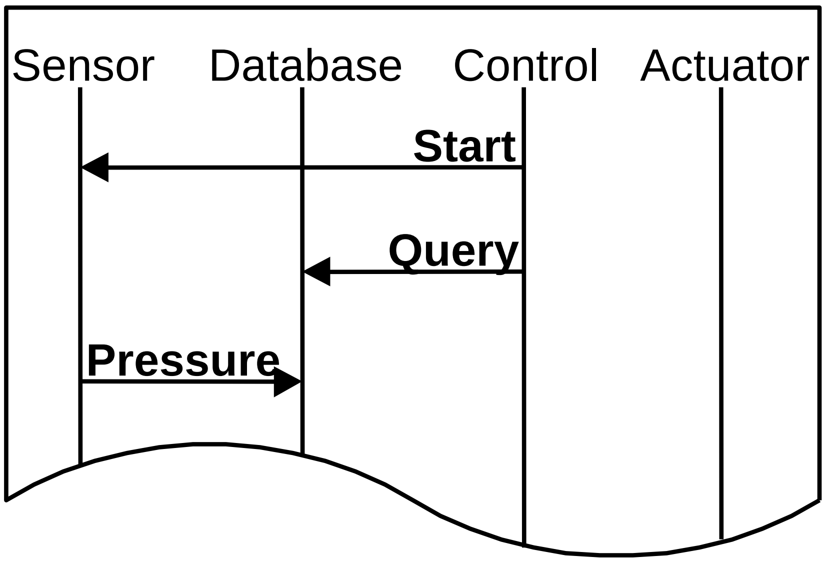
A Negative Scenario



- Control should never Query before Sensor supplies Pressure
- Constrain the architecture (with an LTS) to prevent the scenario from occuring

The Sensitivity Analysis

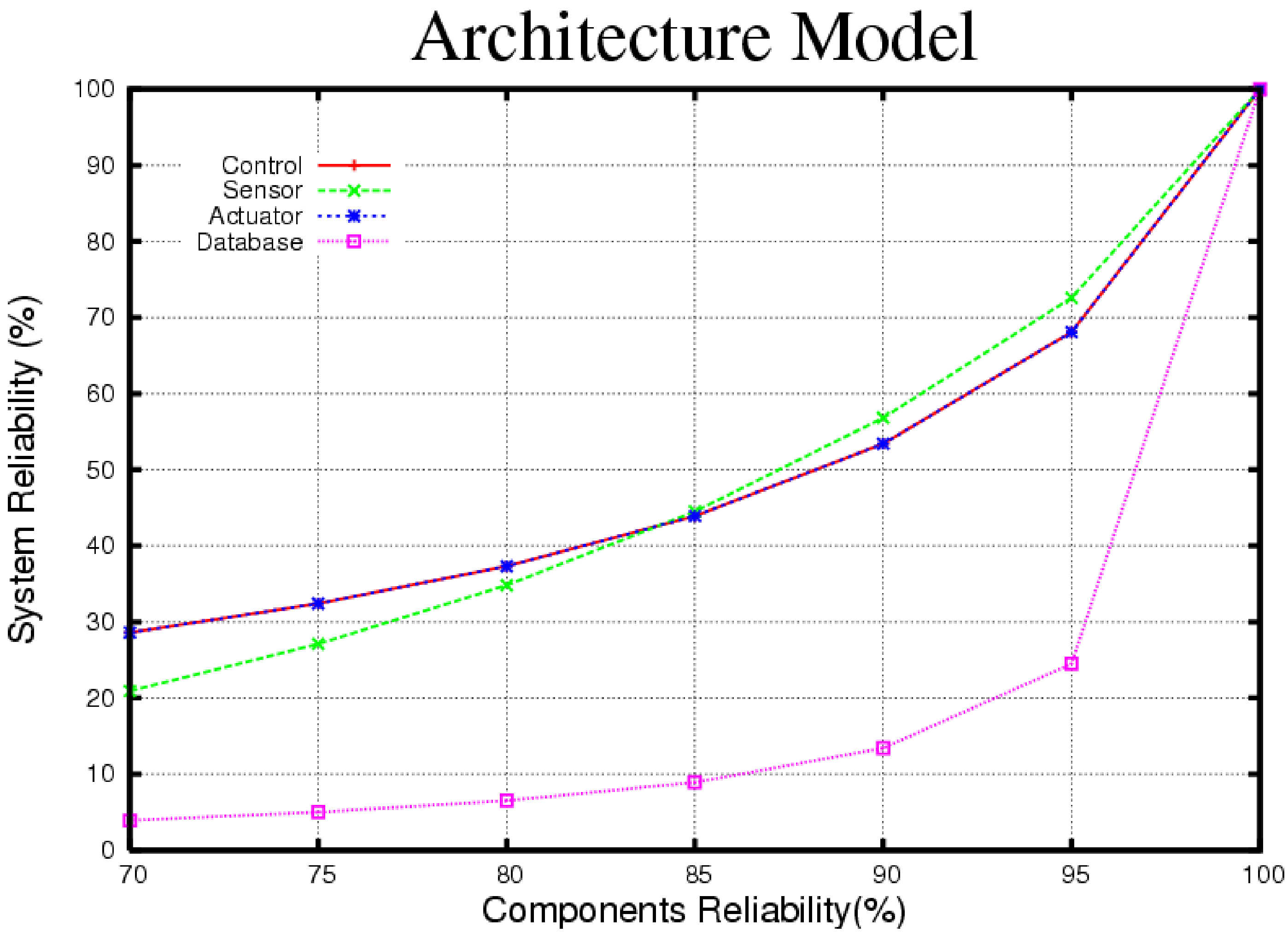
Sensitivity Analysis of the System Reliability

- As a function of:
  - Component reliability
  - Transition probability
- Implied scenario impact
- As a function of scenario executions

Component Reliability Sensitivity I

- Identify components with greatest impact on the software reliability
- Method:
  - Vary one component reliability and fix the others
  - Transition probabilities remain unchanged

Component Reliability Sensitivity II



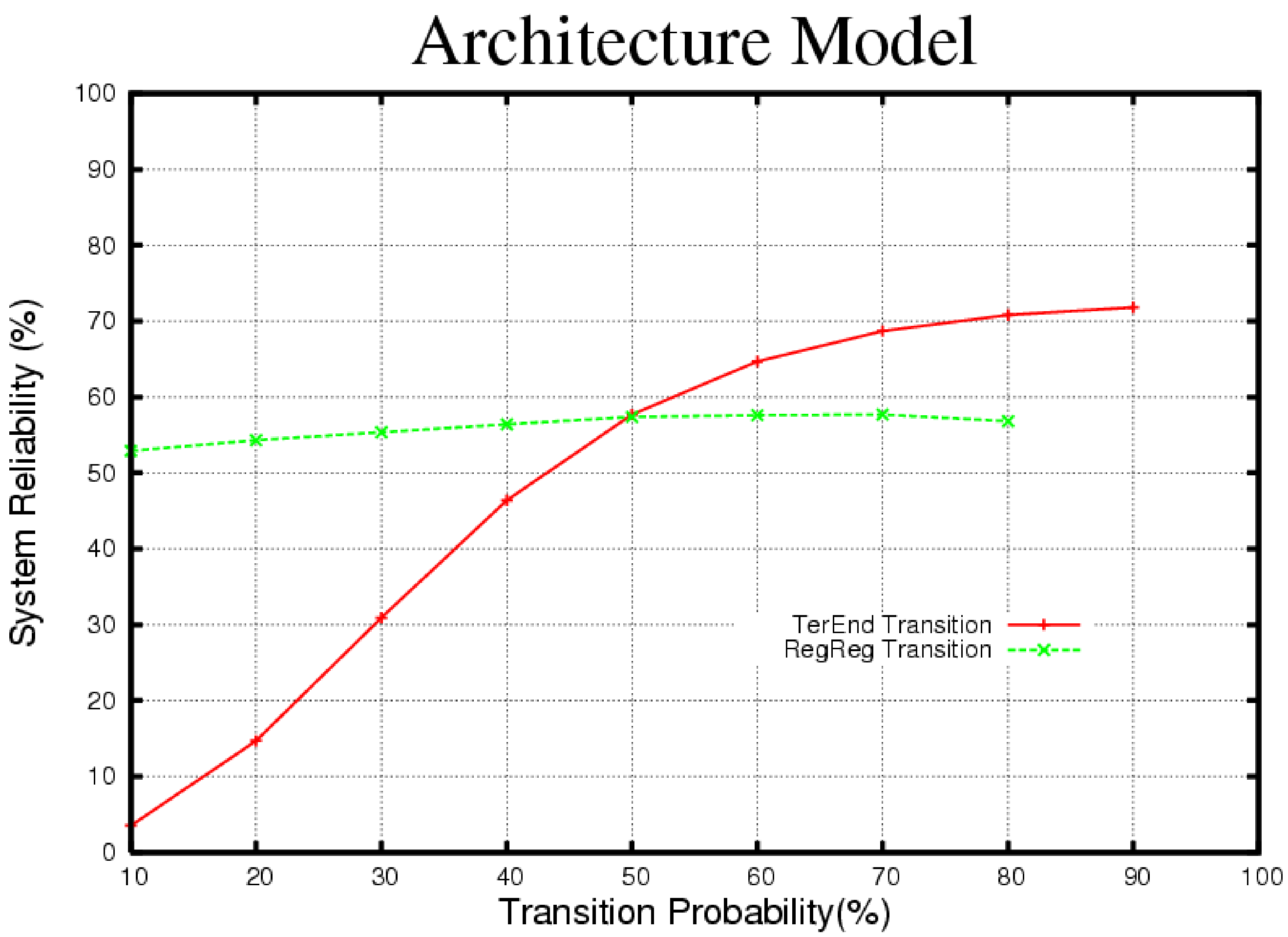
Component Reliability Sensitivity III

- Analysis:
  - Database has greatest impact on the system reliability. Why?
    - Number of requests the component processes?
    - What about Sensor?
  - Higher probability of transition to a scenario has a higher influence on the components' sensitivity of the reliability

Transition Probability Sensitivity I

- Find out if scenario transitions significantly influence our prediction technique. If so, which?
- Method:
  - Take splitting transitions, vary one of them and normalize the others
  - Components reliability remain unchanged

Transition Probability Sensitivity II



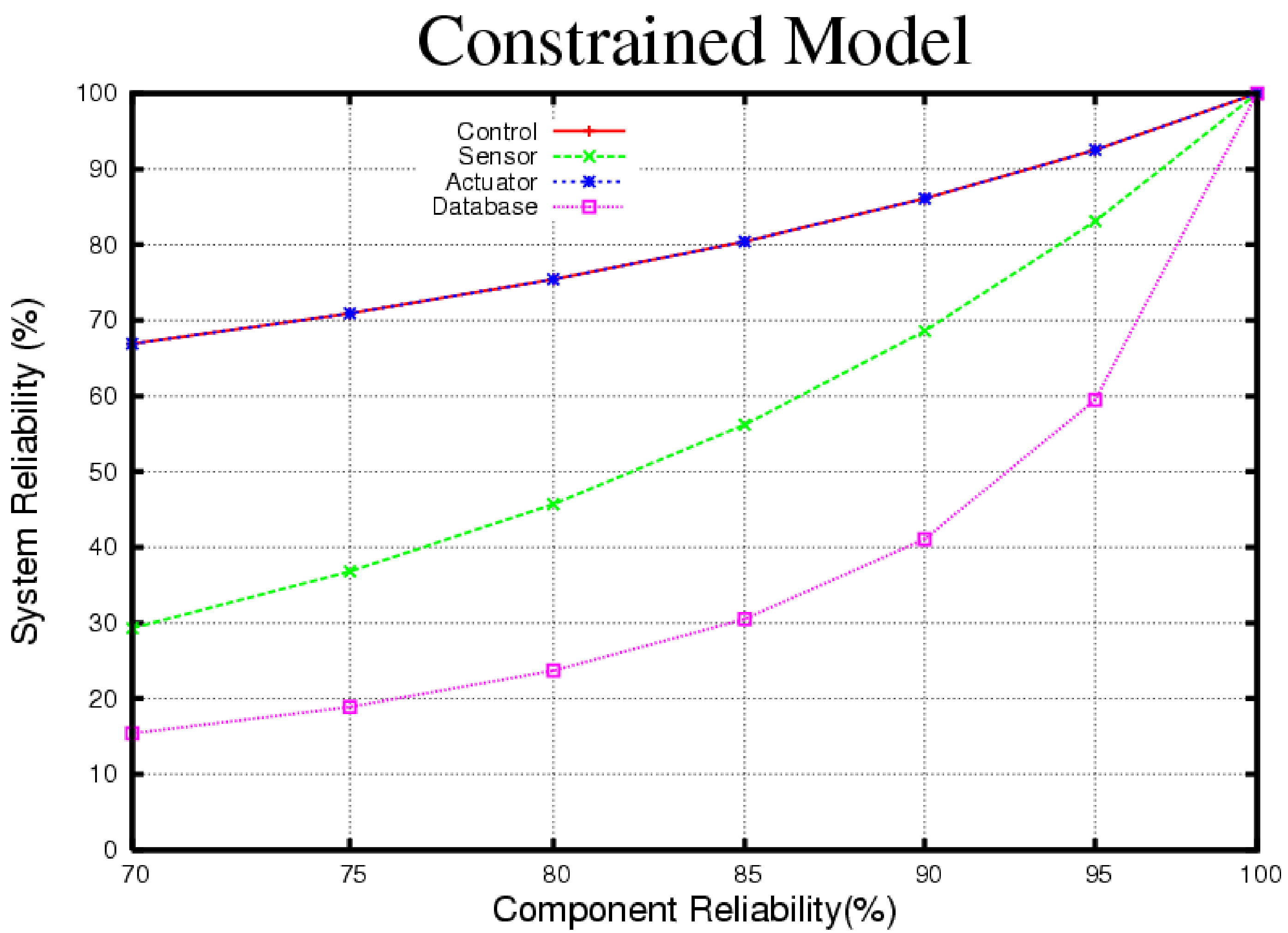
Transition Probability Sensitivity III

- Analysis:
  - Outgoing transitions of scenario *Terminate* have higher impact on the system reliability
  - Higher chances to reach *End* scenario:
    - Lower probability of returning to *Initialize*
    - Fewer chances for the system failure

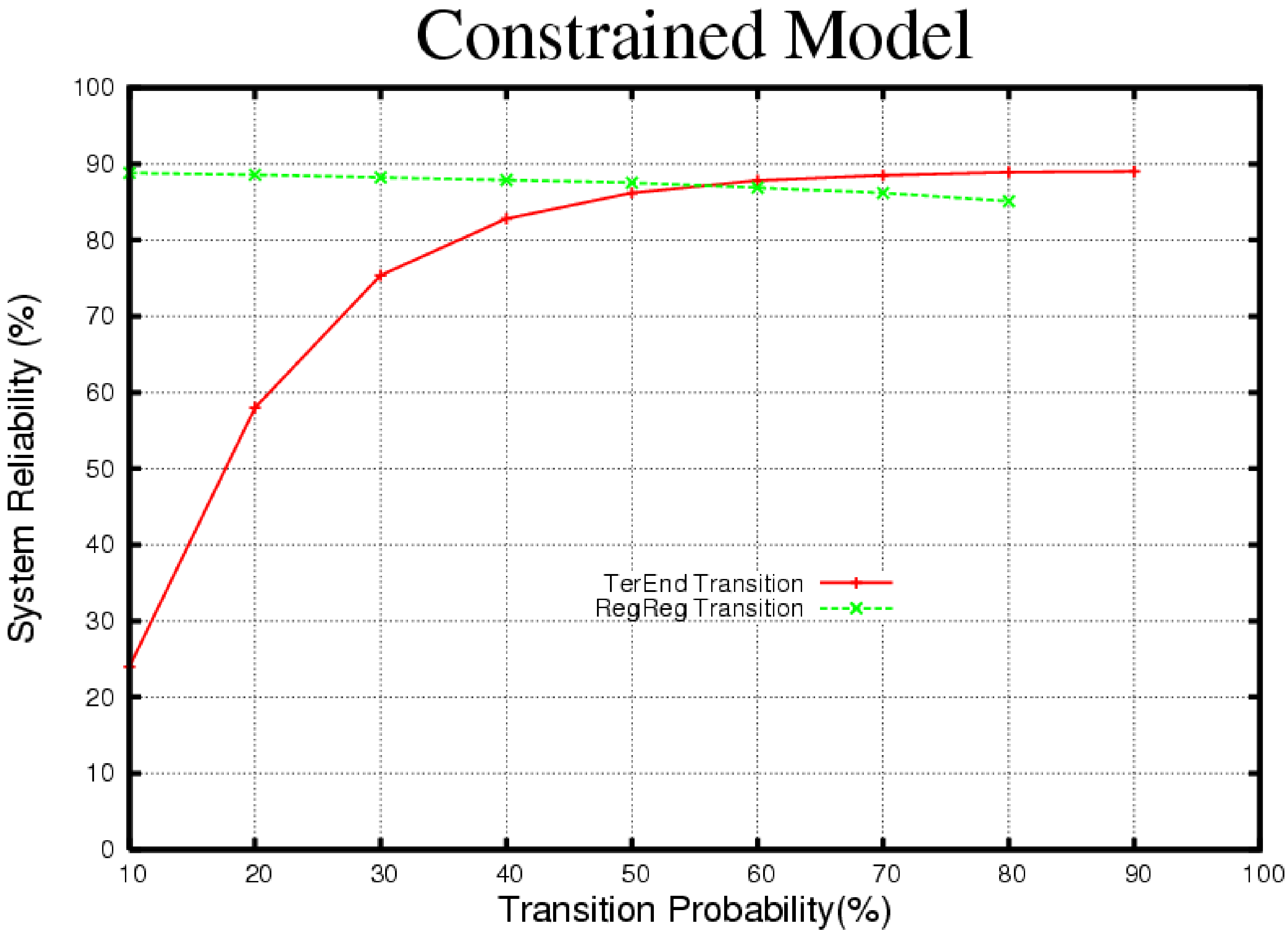
Implied Scenario Impact I

- Prevent previously identified *negative* implied scenario from happening
- Analyse the impact on the previous sensitivity analysis results:
  - For the components reliability
  - For the transition probability

Implied Scenario Impact II



Implied Scenario Impact III



Implied Scenario Impact IV

- System reliability increases in both analyses, e.g.:
  - *Database* results shifted on average 69%
  - *TerEnd* results shifted on average 36%

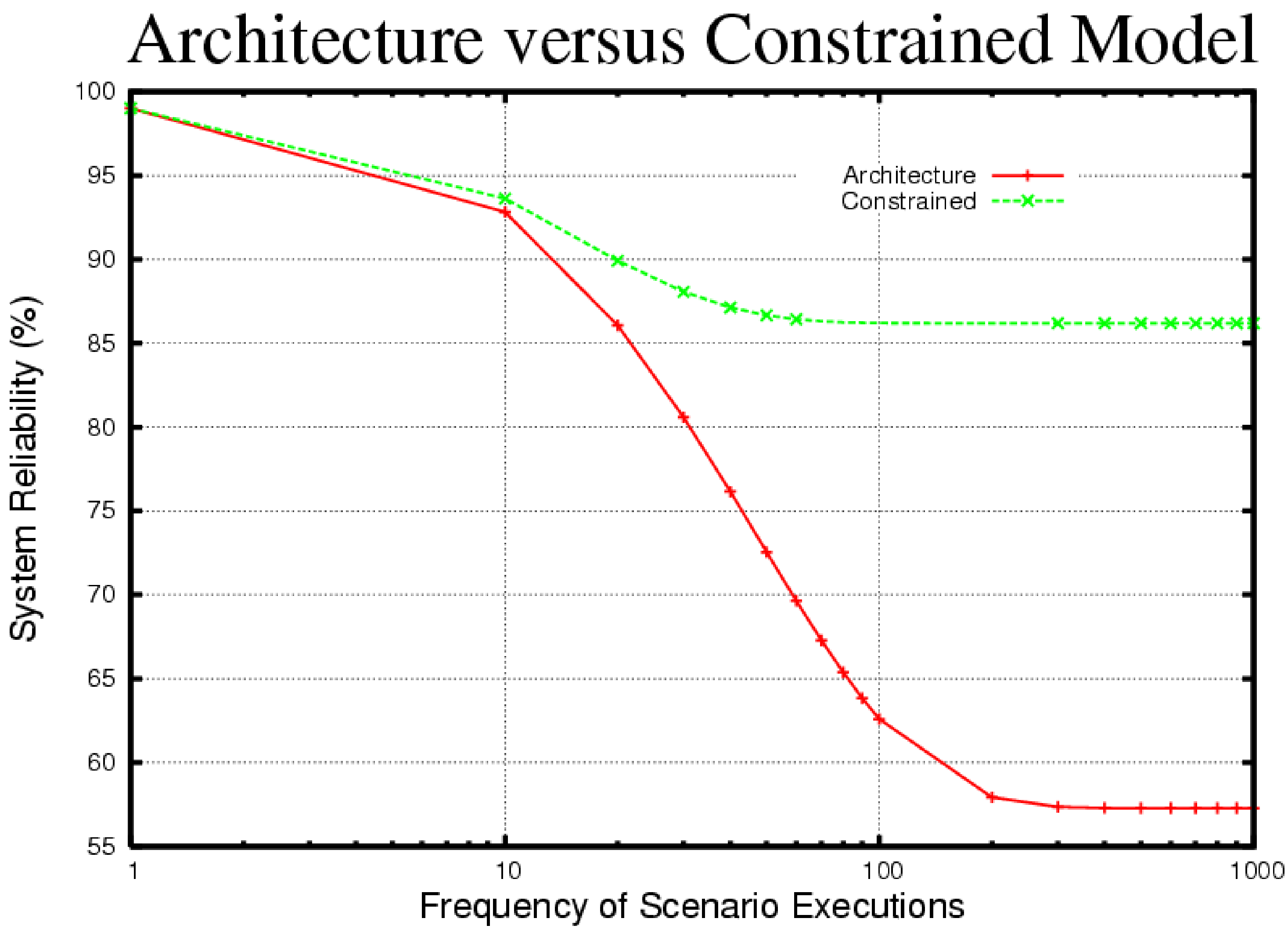
System Reliability as a Function of Scenario Execution I

- Analyse the overall behaviour of the system reliability for the *architecture* model and the *constrained* model
- Based on Cheung definition for failure:

$$E = P^n(N_1; F)$$

  - E = probability of reaching Fault state
  - P = stochastic matrix with all the states in the LTS
  - $P^n(i,j)$ = probability that starting from state i, the chain reaches state j at or before the *nth* step
- System reliability (R) = $1 - E$

System Reliability as a Function of Scenario Execution II



System Reliability as a Function of Scenario Execution III

- The greater the scenario executions, the greater the difference between *architecture* and *constrained* models
- Reliability in the *constrained* model stabilizes after around 70 interactions compared to 300 of the *architecture* model

Related Work

- Analytical
  - Mathematical Function to derive sensitivity analysis
  - Cheung; and Siegrist
- Experimental
  - Results obtained through measurement
  - Yacoub et.al.

Future Work

- Further understand and investigate effects of implied scenarios
- Ongoing work:
  - Integration with Model-Driven Architecture (MDA)
  - Experimenting with PRISM probabilistic model for reliability computation
  - *Validate with large case study!*

Conclusion

- Reliability prediction technique based on scenarios consider:
  - Component structure exhibited in the scenarios
  - Concurrent nature of component-based systems
- Sensitivity analysis:
  - Component reliabilities and transition probabilities
  - Influence of Implied Scenarios

Questions?

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