Parameter Dependencies for Component Reliability Specifications

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EU Project Q-ImPrESS

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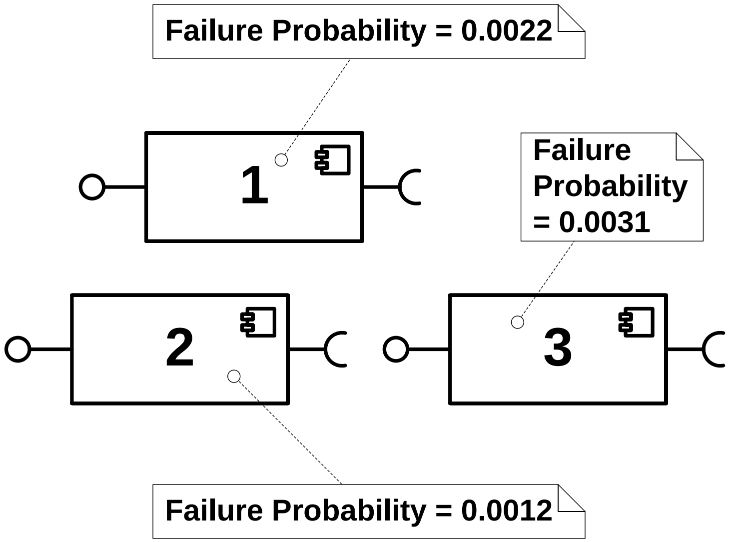
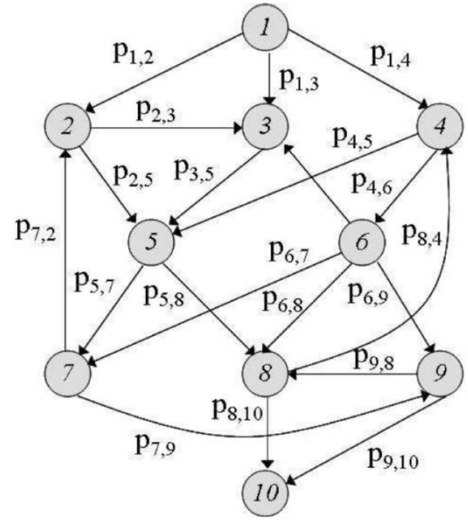
Software Reliability

"The probability of failure-free operation of a program for a specified period of time in a specified environment." [Musa1987]

Architecture-based Reliability Analysis



Component Architecture



Markov Model

$$R = \prod_{i=1}^{10} \left(R_i^{\nu_i} + \frac{1}{2} R_i^{\nu_i} (\log R_i)^2 \sigma_i^2 \right)$$

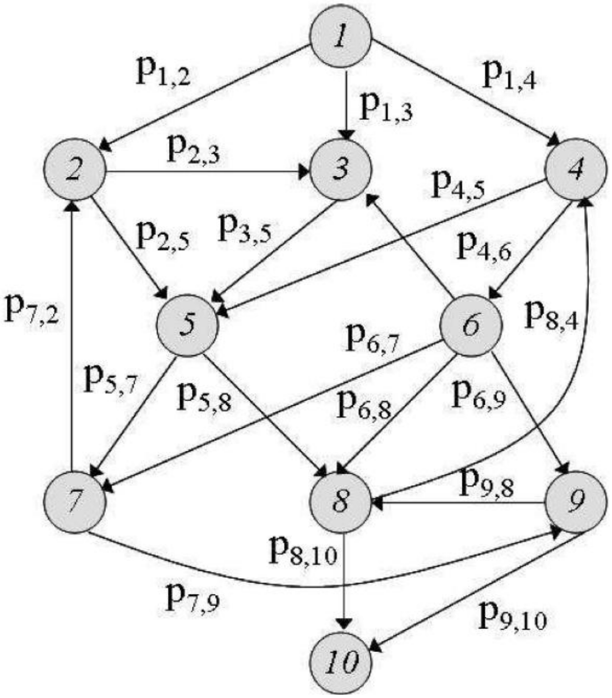
Markov Model Solution

[Trivedi2001]

R = 0.9223

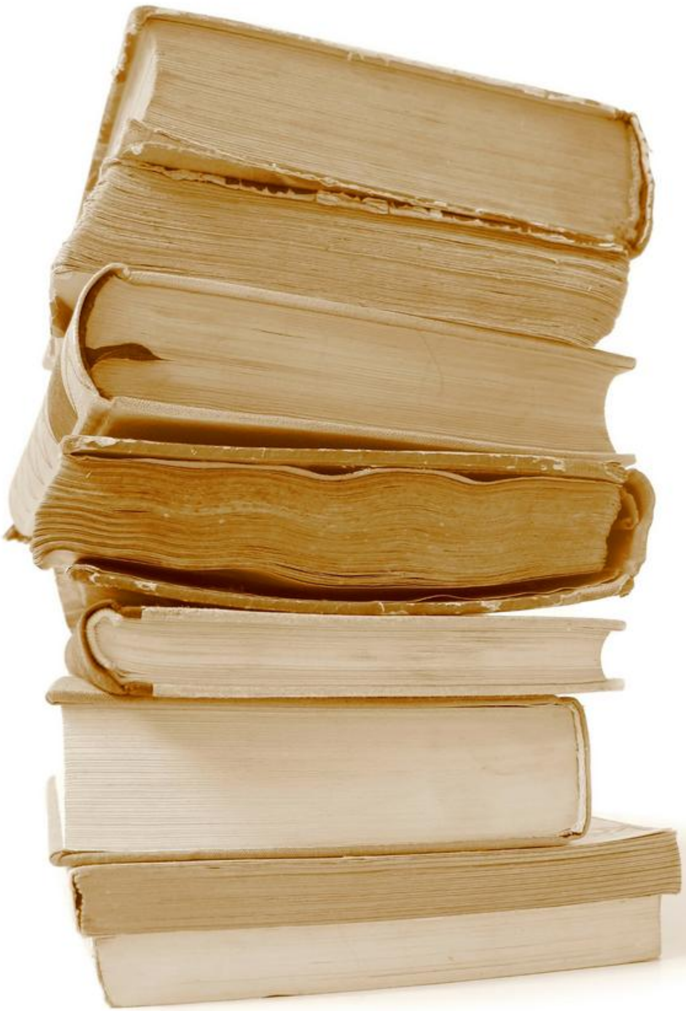
Expected Reliability

Problem



How to determine the transition probabilities?

Literature: Existing Approaches



R. Cheung 1980 (IEEE TSE)

- Transition probabilities via measurements

Hamlet 2001 (ICSE)

- Transition probabilities via measurements

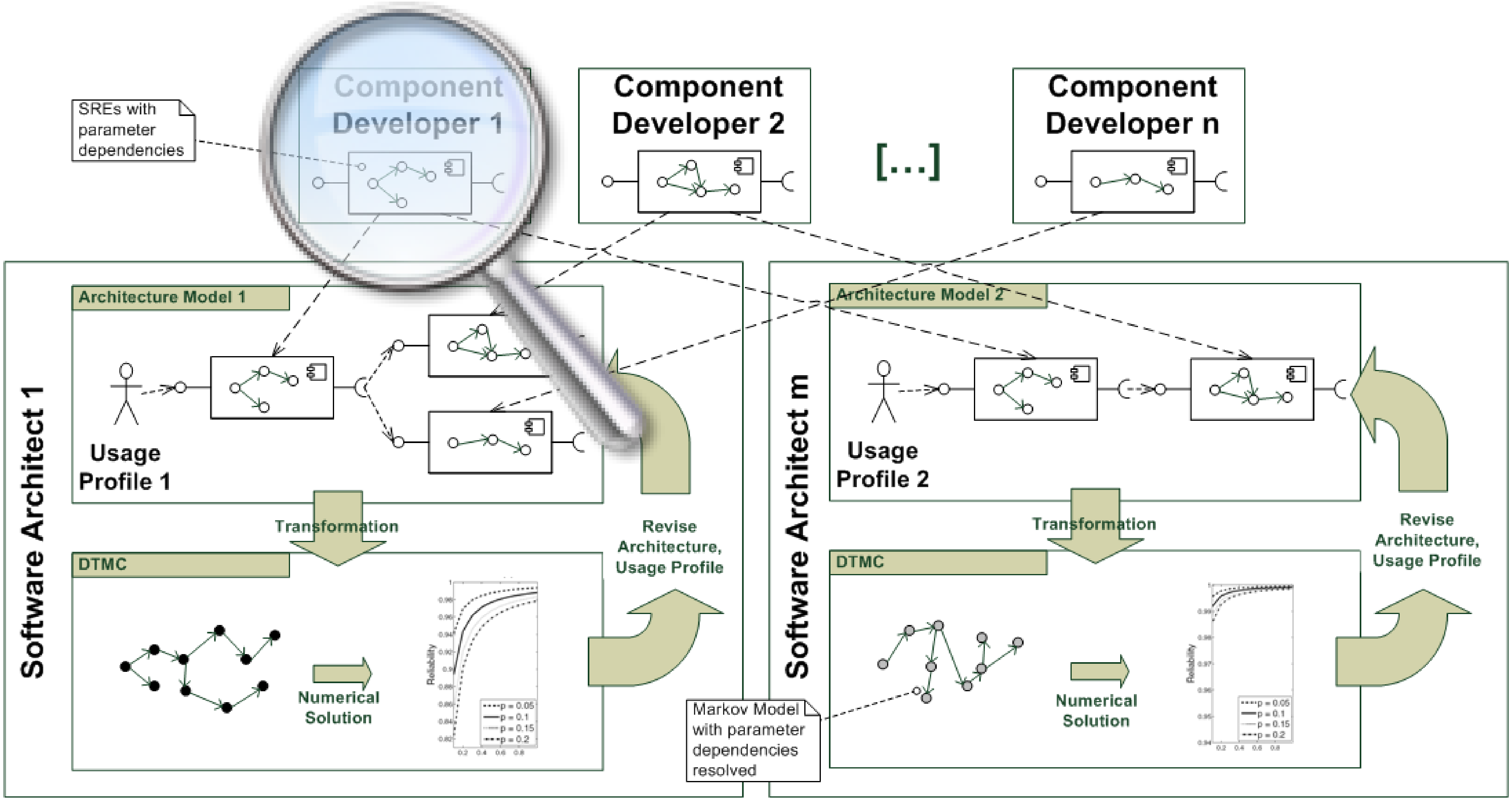
Reussner 2003 (JSS Vol. 66 No.3)

- Assumes transition probabilities as given

L. Cheung 2008 (ICSE)

- Assumes no control flow propagation

Our Solution



Our Solution: Model

$$P := ia_1 \cdot (E_1 +_\pi E_2)$$

Internal Action

Branch Probability

Sequence

Branch

External Call

Our Solution: Model

Failure Probability

$$P := ia_1 \cdot (E_1 +_\pi E_2)$$

Branch Probability

$$fp(ia_1) = 0.001$$

$$\pi := y < 0$$

$$ei(E_1) = (x, 2 - x) \qquad ei(E_2) = (y, 27 * x + 3)$$

External Call Inputs

Input Parameter

Parameter Dependency

Input Parameter

Parameter Dependency

Our Solution: Model

$$P := ia_1 \cdot (E_1 +_\pi E_2)$$

$$fp(ia_1) = 0.001 \qquad \pi := y < 0$$

$$ei(E_1) = (x, 2 - x) \qquad ei(E_2) = (y, 27 * x + 3)$$

$$P_2 := (ia_1)^v$$

$$fp(ia_1) = 0.0001$$

$$v = x + 2$$

Loop

Number of Iterations

$$P_3 := ia_1$$

$$fp(ia_1) = 0.0002$$

$$UsageProfile = \{(x, 1), (P(y = -2) = 0.3), (P(y = 4) = 0.7)\}$$

Our Solution: Model

$$P := ia_1 \cdot (E_1 +_\pi E_2)$$

$$fp(ia_1) = 0.001 \qquad \pi := 0.3$$

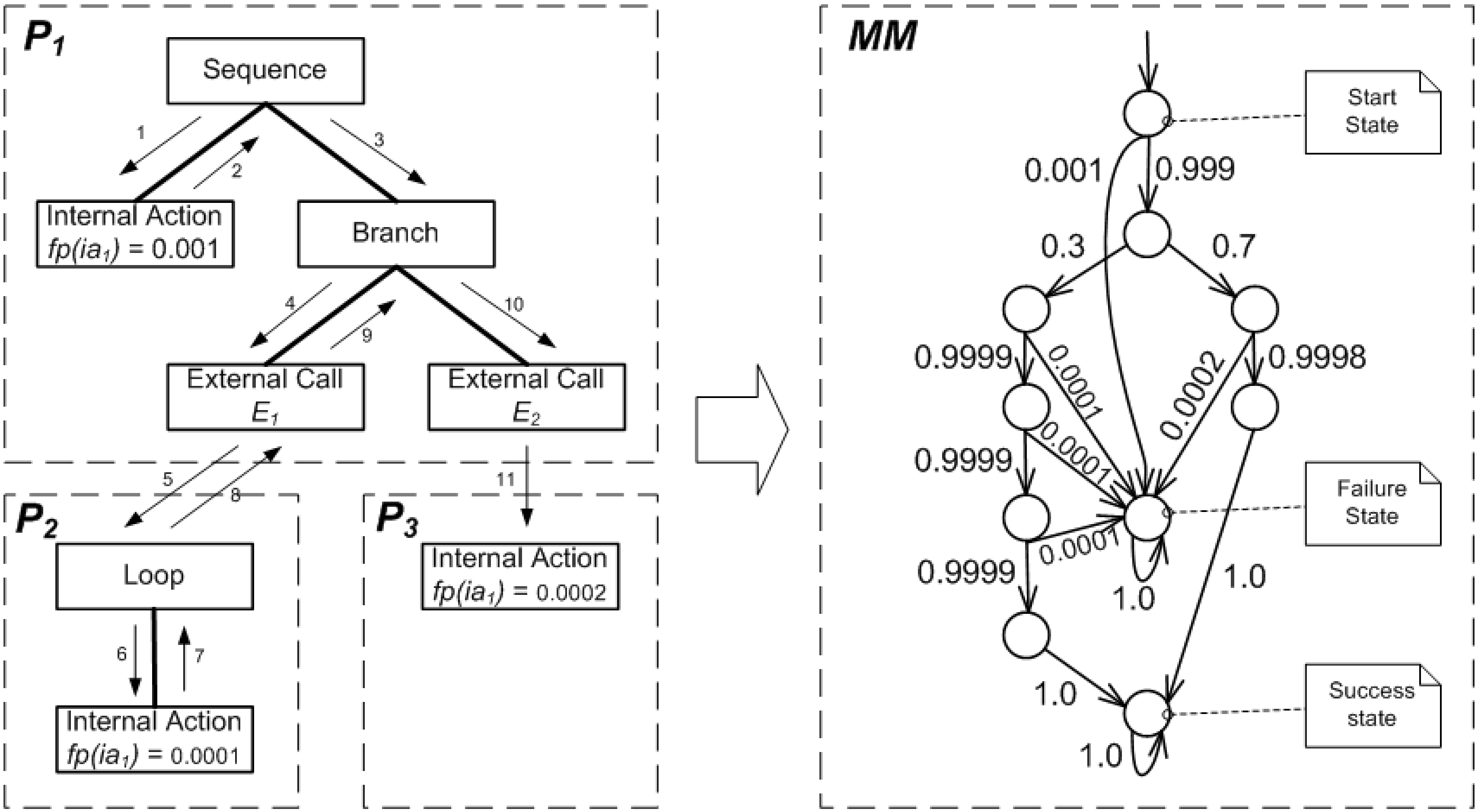
$$ei(E_1) = (x, \; 1 \;) \qquad ei(E_2) = (y, 27 * x + 3)$$

$$P_2 := (ia_1)^v$$
$$fp(ia_1) = 0.0001$$
$$v = 3$$

$$P_3 := ia_1$$
$$fp(ia_1) = 0.0002$$

$$UsageProfile = \{\boxed{(x, 1)}, (P(y = -2) = \boxed{0.3}), (P(y = 4) = 0.7)\}$$

Our Solution: Transformation



Our Solution: Markov Model Solution

Q R

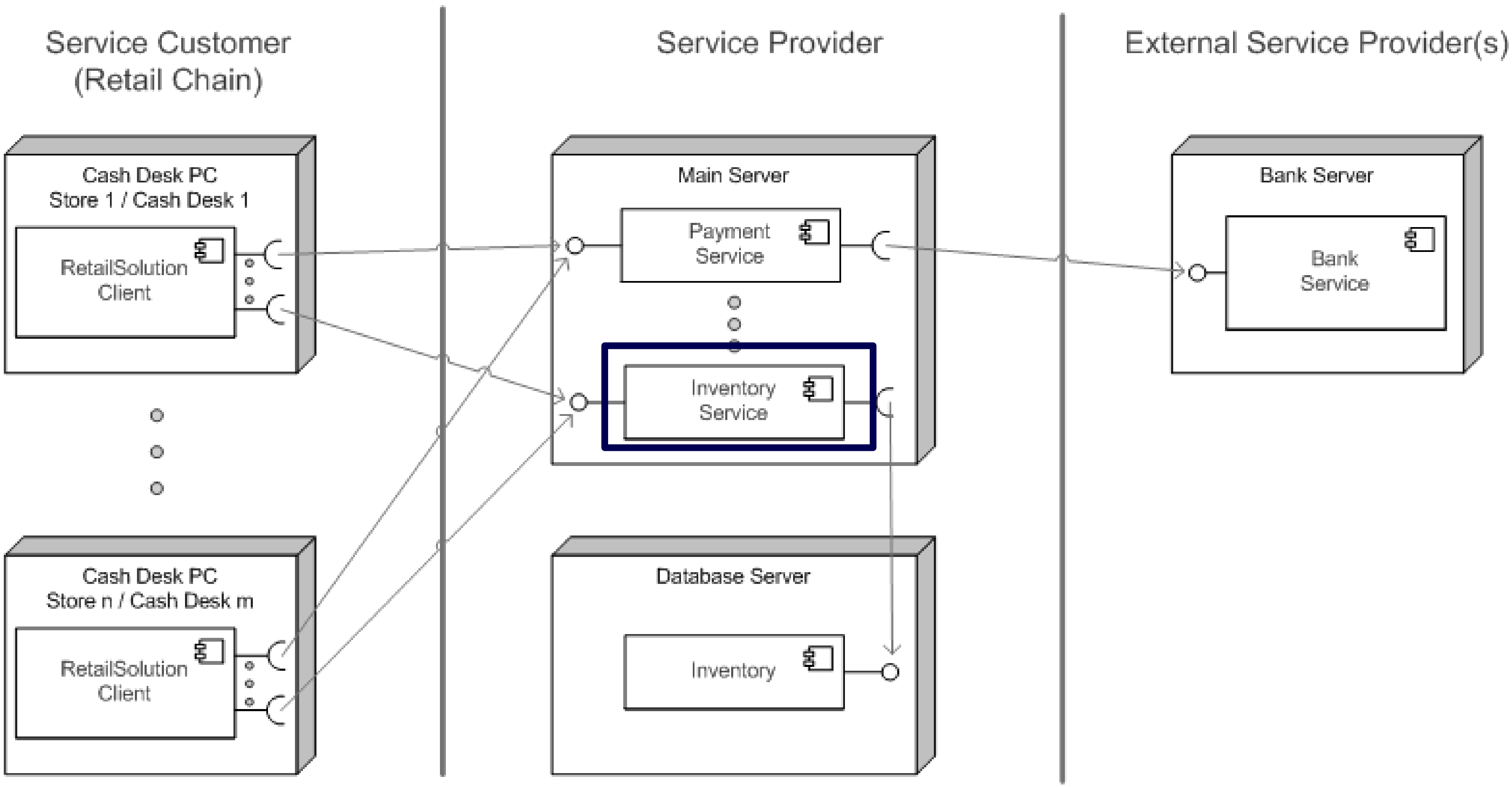
$$P = \left(\begin{array}{cccccccc|cc}
0 & 0.999 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.001 \\
0 & 0 & 0.3 & 0.7 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0.9999 & 0 & 0 & 0 & 0 & 0.0001 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.9998 & 0 & 0.0002 \\
0 & 0 & 0 & 0 & 0 & 0.9999 & 0 & 0 & 0 & 0.0001 \\
0 & 0 & 0 & 0 & 0 & 0 & 0.9999 & 0 & 0 & 0.0001 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0 & 0 \\
\hline
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0
\end{array}\right)$$

$$B = NR = (I - Q)^{-1} R$$

$$b_{0,0} = 0.99877$$

[Trivedi2001]

Case Study: Retail Management System



Case Study: Inventory Service - Book Sale

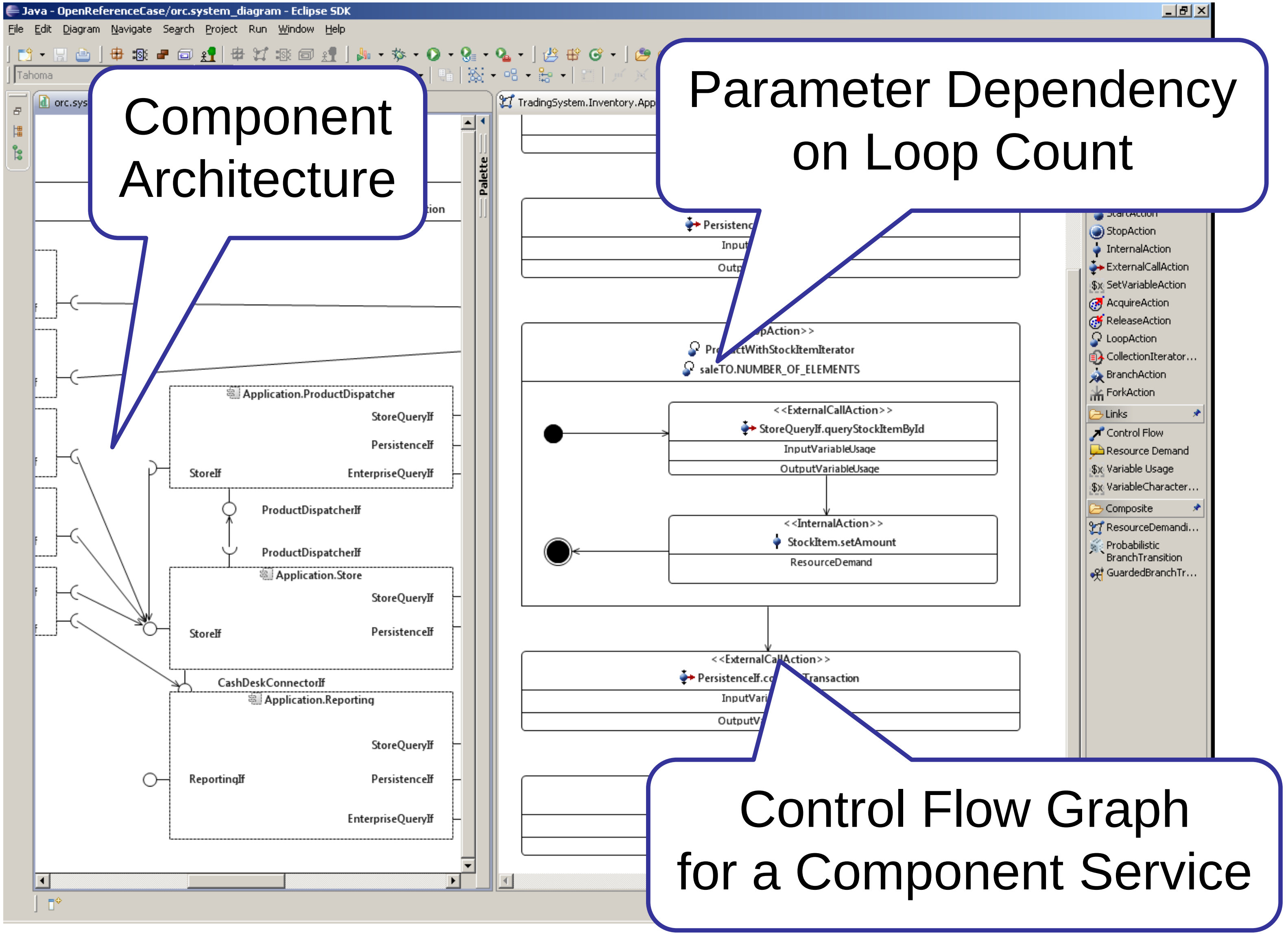
$$P_{bookSale} := E_2(ia_1 +_{\gamma} (E_3 +_{\pi} E_4))^{\upsilon} E_5$$

$$\upsilon := x, \quad \gamma := (y = 0), \quad \pi := (z = 0)$$

$$P_2 := ia_2, \quad P_3 := ia_3, \quad P_4 := ia_4, \quad P_5 := ia_5$$

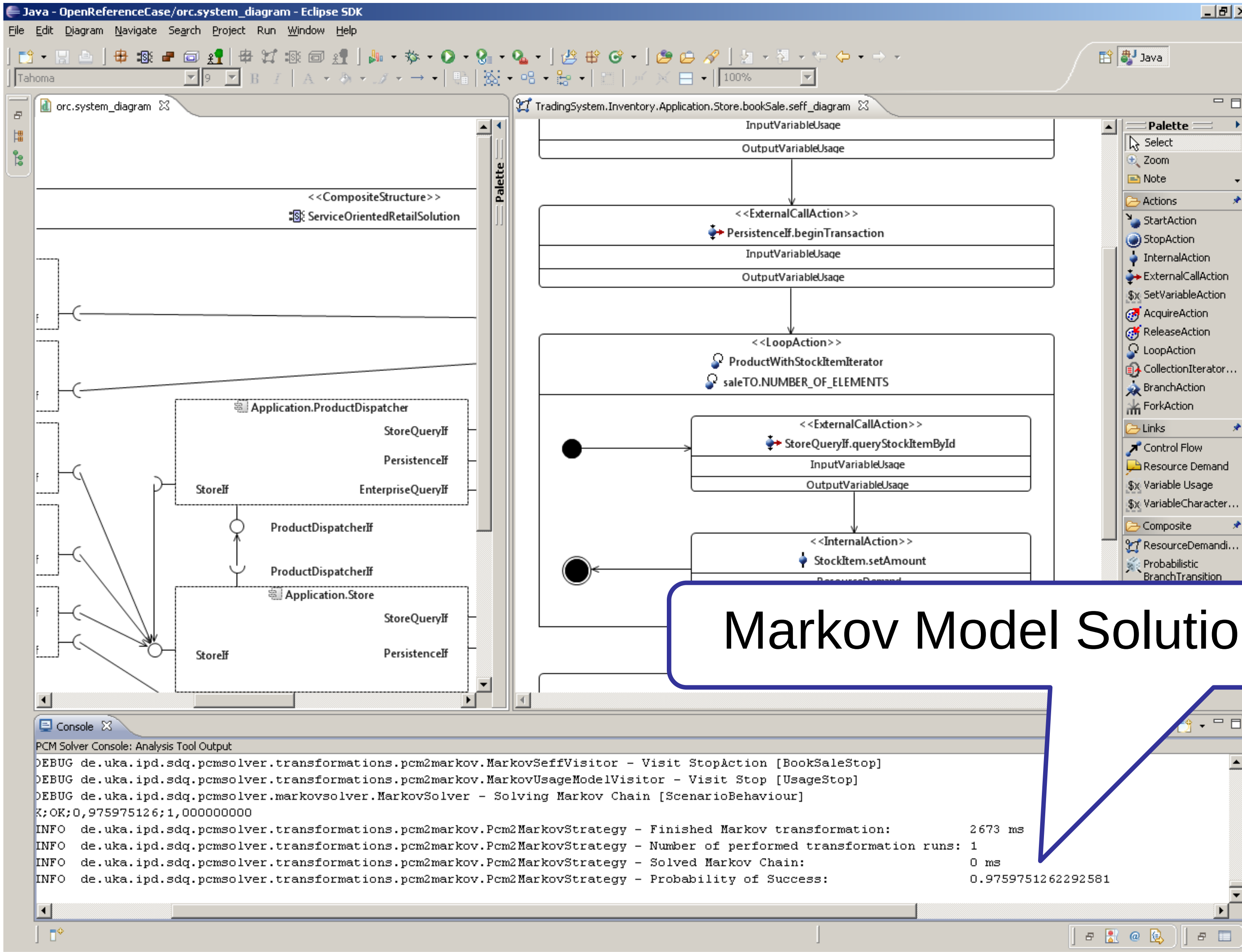
Case Study: Modelling

Palladio Tool



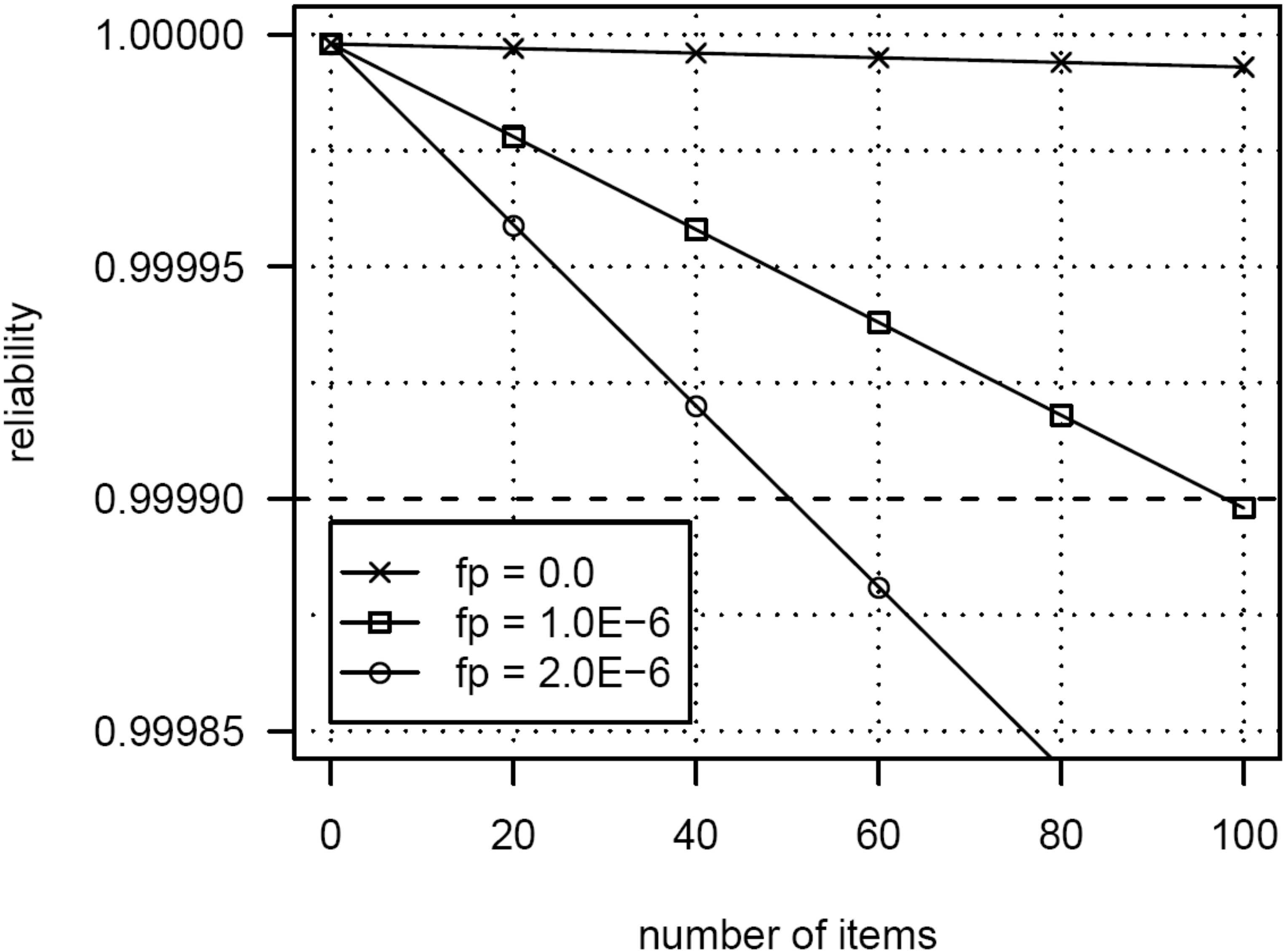
Case Study: Analysis

Palladio Tool

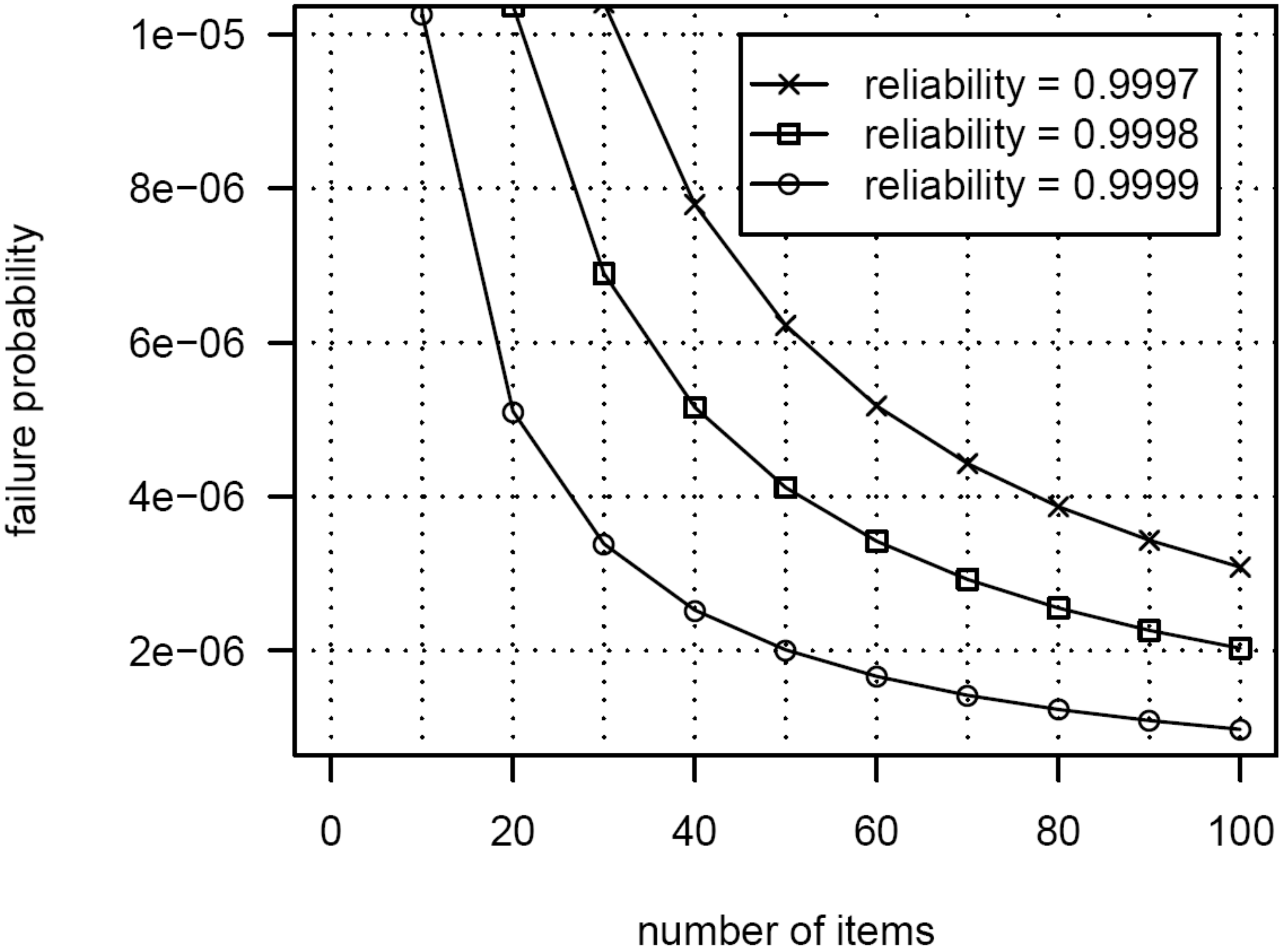


Markov Model Solution

Case Study: Reliability Prediction Results



Case Study: Reliability Prediction Results

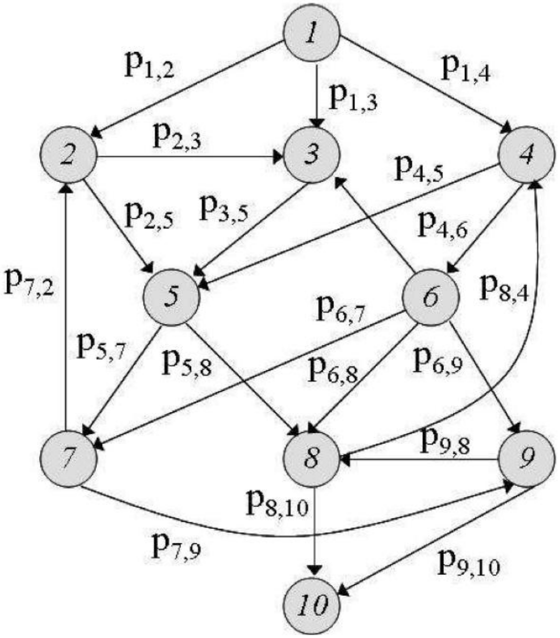


Assumptions & Limitations

- Markov Property
- Failure Probabilities
  - Determiniation?
  - Stochastically Independent
  - Constant
- Expressiveness
  - No Hardware Failures
  - No Concurrency
  - No Repair
- Getting Parameter Dependencies

Conclusion

- Parameter Dependencies for Component Reliability Specifications
  - Modelling by component developer and software architect
  - Easy alternation of system-level usage profile
  - Reusable reliability specifications



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