Design-time Performability Evaluation of Runtime Adaptation Strategies

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Motivation

Evaluate performability-oriented runtime adaptation strategies at design-time (DT) to support SW architects in the decision making process of self-adaptive software systems (SAS)s.
**Contribution**

- **Focus of previous work [1]:** framework development
  - Modeling the operating environment of an Self-adaptive software System (SAS)
  - Analysis approach that evaluates the quality of an adaptation strategy w.r.t. the modelled environment and specific quality objectives

- **Focus of current work:** reuse the concepts of [1] to evaluate adaptation strategies w.r.t. performability-specific quality objectives

- We contribute to the line of work by:
  - C1 **Using SAS to maintain performability attributes of a system:** We generalize formally and informally existing and well-known work from the performability domain to SAS.
  - C2 **Simulation of failure scenarios:** A simulation approach to predict performance attributes which reflect the quality objectives the SAS must maintain in the presence of system failures.
  - C3 **Performability-specific adaptation strategy evaluation:** We integrate performability metrics from literature as performance indicators to assess the quality of an adaptation strategy.
Current state:
Performability evaluation traditionally applied for DT analyses of static systems [2]

Problem:
Structural changes of system configuration over time not covered

Idea:
Extend work on dynamic reconfigurable systems of [3] to SASs by extending MRMs to MDPs

Solution:
- i. Formalize the extension of Markov Reward Models (MRM) to Markov Decision Process (MDP) in the context of SASs
- ii. Identify uncertainty factors in the performability domain and their representation in the SASs environment
- iii. Construct the reward function based on classic performability metrics
- iv. Simulation of failure scenarios
- v. Integrate (i) - (iii) into MBQA framework SimExp [1] and use (iv) for failure simulation
**Proof of concept - Case study and setup**

**Case study:** Znn.com system based loadbalancer [4]

**Setup:** We invested three adaptation strategies
- $\pi_0$ without any adaptation: static system
- $\pi_s$ scaling: re-distributes load by adapting the distribution factor
- $\pi_{sr}$ scaling with node recovery: re-distributes load while considering two factors:
  - (i) detected runtime threshold violations as described by $\pi_s$
  - (ii) detected node failures

**Quality objective:** Performability -> performance under the impact of hardware failures

**Goal:** Strategy $\pi$ to keep system responsive under high load scenarios with a minimum number of resources even in case of failures

**Expected result:** Comparison of adaptation strategies / Evaluating design decisions w.r.t. quality objectives
Evaluation:
- Sampling 50 trajectories length 100:
  Total number of sampled states $T = 5000$
- Reward ratio: $ratio_\pi(t) = \frac{1}{2t} \cdot \sum_{i=0}^{t} r_i$

Results:
- $ratio_{\pi_\emptyset}(T) < ratio_{\pi_S}(T) < ratio_{\pi_{SR}}(T)$
- $\pi_{SR}$ performs best and $\pi_\emptyset$ worst
Conclusion

Summary
- We presented a model-based approach to evaluate performability-oriented runtime adaptation strategies at DT.
- Our contribution combines established performability concepts with an MBQA evaluation framework for runtime adaption strategies to support DT analysis of performability-oriented use cases.
- This enables to:
  - evaluate DT decisions of runtime artifacts
  - gain knowledge from DT analysis applicable at runtime as initial system configuration.

Future work
- Evaluate our approach with a case study to show the accuracy of DT results compared to runtime results.
- Extend the SimExp framework for DT performability optimization of runtime adaptation strategies as presented in [5].
Thank you!

Your questions, comments and suggestions concerning our research activities are most welcome at any time.

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Literature I


