Towards Pro-active Adaptation with High Confidence
Augmenting Monitoring with Online Testing

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Agenda

• Motivation and Problem Statement
• State of the Art
• Solution Idea & Technical Challenges
• Conclusion & Future Work
Need for Adaptation

- **Highly dynamic SBA contexts**: changes of
  - requirements
  - user types
  - 3rd party services
  - service providers
  - ...

- Need to respond to **deviations during run-time**
  - no guarantees that 3rd party service fulfils its contract (SLA)
  - hard to assess behavior of infrastructure (e.g., the Internet) during design time
  - ...

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Reactive vs. Pro-active Adaptation

- **Reactive adaptation**
  - observe running SBA instances ("monitoring")
  - trigger adaptation in case of failures, deviations, changes, ...
  - drawbacks: execution of faulty services, reduction of performance, inconsistent end-states, ...

- **Pro-active adaptation**
  - adapt SBA instances to prevent them from failing

Our focus:
- Adaptation of SBA instances
- Adaptation by replacing services

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Pro-active Adaptation

• Illustration

SBA instance 1

adapt pro-actively?

SBA instance 2

adapt pro-actively?

SBA instance n
Avoiding Unnecessary Adaptations

- Unnecessary adaptations can be
  - **costly** (e.g., SLA negotiation; expensive alternative services)
  - **faulty** (e.g., binding of a “buggy” service)

Pro-active adaptation should be based on **confidence** that failure will occur in SBA instances.

- **But:** difference from traditional SW systems:
  - lack of control on 3rd party services
  - functionality and QoS can vary between service invocations (even if input is identical)
  - Service implementation can change without notice

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State of the Art (1)

- **Statistical evaluation / data mining of monitoring data** [Liang et al. 2006, Fu et al. 2007, Sahoo et al. 2003]
  - requires large volume of monitoring data
  - adaptation may invalidate past monitoring data and thus prediction

- **Statistical testing** [Poore et al. 1998, Trammell et al. 1995]
  - prediction of overall system’s reliability (and not individual failures)
  - based on usage profile of the system
  - requires large number of test cases (significant effort/costs due to invocation of external services)

  - prediction of overall system’s reliability (and not individual failures)
  - static analysis technique (can complement monitoring & online testing)
State of the Art (2)

**Joint monitoring & testing efforts** [www.secse-project.eu]

– Proposed applications:

1. Use monitoring data to mimic service behaviour
2. Generate test cases to violate the SLAs (search-based technique using monitoring data)
3. Analyse the monitoring data to infer invariants

**Online testing** [Wang et al. 2004, Deussen et al. 2003, Bai et al. 2007]

– “Definition”: SBA is fed with dedicated test input in parallel to its normal use and operation (“production system”)

– Current techniques not used for building confidence
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Solution Idea

response
time

confidence

Threshold (800 ms)

95%

computed confidence

monitored data

online testing data

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Assumptions

1. **Failure** in constituent service
   \[\rightarrow\text{requirements deviation}\] (end-to-end quality violation)
   
   – not necessarily the case in all situations
   
   • *e.g.*, slower response of service B compensated by faster response of service A

2. Test of services has **no side effects**
   
   – *e.g.*, no books are delivered if testing online book service

3. Services **notify about changes** that could invalidate monitoring/testing data
Steps of the Approach

Two possible kinds of triggers:

A) Failure observed by monitoring

B) Change of service

1. Determine Representative Data

2. Determine Current Confidence
   - [not sufficient]
   - [sufficient]

3. Execute Online Tests

4. Predict Failure Occurrence

5. Decide on Pro-active Adaptation

Important for Trigger B!

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Technical Challenges

1. Determine Representative Data
2. Determine Current Confidence
   [not sufficient]
3. Execute Online Tests
   [sufficient]
4. Predict Failure Occurrence
5. Decide on Pro-active Adaptation

How can we exploit
- prediction models,
- non-parametric statistics,
- data mining techniques?
Technical Challenges

1. Determine Representative Data

2. Determine Current Confidence

[not sufficient]

3. Execute Online Tests

[not sufficient]

4. Predict Failure Occurrence

5. Decide on Pro-active Adaptation

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Technical Challenges

1. Determine Representative Data
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3. Execute Online Tests
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What’s the right cost model?
Probability and cost of failure vs. Risk and cost of adaptation

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Relaxing the Assumptions

1. **Failure → requirements deviation**
   - S-Cube approach: **Run-time verification** [Bianculli et al. 2008, Gehlert et al. 2010]
   - Reduces effort for online testing:
     - Initiate steps only if deviation (Strategy A)

2. **Tests have no side effects**
   - *Service invocation = query only*
   - *Dedicated test mode / interface*

3. **Notification about changes**
   - *Novel service registries*
   - *New SLA constituents*

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Conclusion and Future Work

• Avoid unnecessary pro-active adaptations
• Many data points needed for confident prediction
  – Thus: augment monitoring with online testing
• Interesting challenges remain to be addressed

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