Towards Self-Adaptive Service-Oriented Architectures

Giovanni Denaro - Mauro Pezzè - Davide Tosi

University of Milano-Bicocca
Milano, Italy

{denaro|pezze|tosi}@disco.unimib.it

Daniela Shilling

University of Paderborn
Paderborn, Germany

das@upb.de
Dynamic SOA Scenario

The Virtual Store Application

- **Product Categories**
  - Books
  - Electronics
  - Musical Instruments
  - Pets

- **Service Characteristics**
  - Shipping Modality
    - TNT express
  - Shipping Times
    - 24 h
  - Payment Modality
    - PayPal
  - Product Availability
    - Required

[from TAV-WEB CfP]

[…] Interfaces play an important role in Web services coordination and interface violations can cause serious problems. […]
Focus: Interaction Protocol Violations

Web services offered by several providers can have:

Same operations (WSDL)...

...but different interaction protocols

Shopping Cart Web Service (WSDL)

- `<operation name="ItemSearch">
  
  <input message="tns:ItemSearchRequest"/>
  <output message="tns:ItemSearchResponse"/>

</operation>

- `<operation name="CartCreate"> ...
- `<operation name="CartAdd"> ...
- `<operation name="CartModify"> ...
- `<operation name="CartPurchase"> ...

Amazon.com protocol

PetStore protocol
Related Work

- Ontologies, semantic web, semantic web services
  \[\text{[OWL-S, WSCI, ...]}\]
  - Difficulty of defining generally agreed domain ontologies
- Protocol automata
  \[\text{[Foster \& al. ICWS’04, Beyer \& al. WWW’05]}\]
  - Allow for checking service compatibility
- Assertions
  \[\text{[Baresi \& al. ICSOC’04 and ’05]}\]
  - Useful for specifying behavior of operations but not the interaction protocol

Enable reasoning about properties of WS, but..
Assume availability of specifications!!
Autonomic/Self-adaptive Approach

Server side

1. Incremental synthesis: model gets refined over time

2. Check compliance and adapt

model the interaction protocol

behavior trace

exported model

retrieve model

WS interface

reqs

resps

Client side

lookup service

use service

SUBMIT REQUEST

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Synthesizing Interaction Protocols from Traces

- Can be formulated as a problem of inferring a language grammar (i.e., the protocol FSM) from a set of sample sentences (i.e., the traces)

**Traces (traced behaviors of WS)**

- IS → CC → CA → CA → CP
- IS → CC → CA → IS → CA → CP
- IS → CC → CA → IS → IS → CA → CP
- IS → CC → CA → CM → CA → CP
- ...

We experimented with a purely algorithmic method: **K-Tail**

Merge states based on **equivalence on future behaviors of length K**

(Other algorithms (K-inclusion, Reiss&Reineri) do not yield significant improvements)

**K-Tail**: [Biermann & Feldman ’72, Cook & Wolf ’96]
Experiments with K-Tail

<table>
<thead>
<tr>
<th>Amazon.com cart web service (K-Tail, k=2)</th>
</tr>
</thead>
<tbody>
<tr>
<td># Traces</td>
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</tr>
<tr>
<td>800</td>
</tr>
<tr>
<td>64</td>
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</table>

K=2 gave the cleanest results

<table>
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<th>PetStore cart web service (K-Tail, k=2)</th>
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<tr>
<td>154</td>
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<tr>
<td>105</td>
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</table>
Goal: check service compliance and adapt based on the retrieved interaction protocols

We are currently investigating a solution in which

- Client-side constraints are given as **partial orders** of operations
- Clients check FSMs against the partial orders and generate **annotated FSMs**, which point out satisfying paths
- Uses the annotated FSM to **(re-)configure adapters**
Conclusions and Research Agenda

• We are investigating a novel self-adaptive approach aimed at improving dependability of dynamic SOAs through:
  - Automatic and incremental discovery of WS interaction protocols
  - Client-side adaptation to “compatible” WS offered through different interaction protocols

• Current achievements
  - Definition and positioning of the approach
  - Experiments showing that synthesis of int. protocols with K-Tail is viable
  - Preliminary ideas on client side adaptation

• Plan
  - Implementation of the approach
  - Investigation of K-Tail using negative samples
  - Further investigation of client-side adaptation mechanisms
  - Empirical evaluation in the field