Framework for Evaluating Reusability of CaaS

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May 2013
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Research Motivation (1)

- **Service-oriented Computing**
  - Characterized by SOA and Cloud Service
  - A representative reuse paradigm

- **Component-as-a-Service (CaaS)**
  - To provide a reusable functionality which is subscribed by applications
  - To fulfill a part of the functionality needed by the applications
Research Motivation (2)

- **Issues in Evaluating Reusability of CaaS**
  - Technically Challenging to Assess Reusability of CaaS
    - Since CaaS reveals characteristics of software components and cloud services
  - Existing works on reusability are mainly for software components and Software-as-a-Service.
  - Not to cover essential aspects of reuse assets in the metrics

- **In this paper:**
  - To identify reusability attributes for CaaS by applying a logical and effective procedure
  - To define metrics for key reusability attributes
Related Works
Research Work (1)

- **Choi’s Work**
  - To propose QoS metrics for service providers to evaluate reusability of the SOA services
    - Utilized in developing reusable SOA services
  - To propose QoS metrics for consumers to evaluate the reusability of the SOA services
    - Utilized in checking whether to reuse the service in developing service-based applications

- **Oh’s Work**
  - To propose a framework for evaluating reusability of cloud services
    - Four quality attributes and six metrics
  - Not to mention a specific type of cloud services
Research Work (2)

- **Washizaki’s Work**
  - To propose a metrics suite for measuring reusability of components
    - Three factors and five metrics by adopting McCall’s model

- **Hristov’s Work**
  - To propose a reusability metrics for component-based software development
    - Eight metrics by considering key non-functional requirements (NFRs) of components

- **Rotaru’s Work**
  - To propose metrics for quantitatively and qualitatively measuring adaptability and composability of components

- **Limitations**
  - Not to consider intrinsic characteristics of CaaS
  - To partially deal with reusability aspect of other types of reusable units
Reusability Attributes for CaaS
CaaS Reusability Attributes

- Derived from 2 Aspects

Reusability Aspect of Components

Reusability Aspect of Services

Quality Model for CaaS Reusability
Reusability Aspects of Components

- **Commonality**
  - To provide a common functionality/capability to various members in a domain

- **Modularity**
  - To embed a high modularity to be effectively composed into applications

- **Adaptability**
  - To provide variation points
  - To resolve partial matching problems through connectors

- **Comprehensibility**
  - Essential to be effectively used by consumers

- **Portability**
  - Need be effectively ported from one environment to another

- **Composability**
  - To easily composed with other components and/or integrated into the target application

- **Interface Soundness**
  - Used as a basis for contracts
**Reusability Aspects of Services**

- **Sharing Reusability Aspects of components**
  - Commonality, Modularity, Adaptability, Comprehensibility, Composability, and Interface Soundness

- **QoS Assurance**
  - Services with low QoS assurance will result in runtime faults of service-based applications.

- **Publicity**
  - Need to publish their newly deployed services in order that service consumers can easily look for required services
## Deriving CaaS Reusability Attributes

<table>
<thead>
<tr>
<th>Quality Attributes</th>
<th>Reusability Aspect of Components</th>
<th>Reusability Aspect of Services</th>
<th>Selection for CaaS Reusability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commonality</td>
<td>✓</td>
<td>✓</td>
<td>○</td>
</tr>
<tr>
<td>Modularity</td>
<td>✓</td>
<td>✓</td>
<td>○</td>
</tr>
<tr>
<td>Adaptability</td>
<td>✓</td>
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<tr>
<td>Comprehensibility</td>
<td>✓</td>
<td>✓</td>
<td>○</td>
</tr>
<tr>
<td>Portability</td>
<td>✓</td>
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<td></td>
</tr>
<tr>
<td>Composability</td>
<td>✓</td>
<td>✓</td>
<td>○</td>
</tr>
<tr>
<td>Interface Soundness</td>
<td>✓</td>
<td>✓</td>
<td>○</td>
</tr>
<tr>
<td>QoS Assurance</td>
<td>✓</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Publicity</td>
<td></td>
<td>✓</td>
<td>○</td>
</tr>
</tbody>
</table>
Metrics for Reusability Attributes
Modularity of CaaS (1)

- **Degree of independence of the CaaS in terms of functionality and interaction**

- **Two Metrics**
  - Cohesiveness of Services (CoS)
  - Minimality of Dependency (MoD)
Modularity of CaaS (2)

- **Cohesiveness of Services (CoS)**
  - Computed by considering the mapping relationship between cohesive functionality and functionality provided by CaaS service

- **Metrics**
  - If \( \text{NumRelevantFNs} \leq \text{NumRelevantSVCs} \), then
  \[
  \text{CoS} = \frac{\text{NumRelevantFNs}}{\text{NumRelevantSVCs}}
  \]
  - Else
  \[
  \text{CoS} = \frac{\text{NumRelevantSVCs}}{\text{NumRelevantFNs}}
  \]
Modularity of CaaS (3)

- **Minimality of Dependency (MoD)**
  - Computed by considering how much of the target functionality is provided by the service without relying on other services
  - Metric

\[
MoD = 1 - \frac{\text{Number of Functions Relying on External Services}}{\text{Total Number of Functions Offered by Service}}
\]
Adaptability of CaaS (1)

- **Effectiveness of adapting candidate services for target applications**

- **Three Metrics**
  - Coverage of Variability (CoV)
  - Completeness of Variant Set (CoA)
  - Effectiveness of Service Adaptation (ESA)
Effectiveness of Service Adaptation (ESA)

To measure the effort required to apply adaptations for variation points

- **Automatic** Adaptation done by adapting the service without service consumers’ intervention
- **Semi-Automatic** Adaptation done by passing variants as parameters to services by service consumers at runtime
- **Manual** Adaptation done by service consumers

**Metric**

\[
ESA = \frac{Num_{Auto} \times W_{Auto} + Num_{Semi} \times W_{Semi} + Num_{Manual} \times W_{Manual}}{Number \ of \ Variation \ Points \ Supported}
\]

The weighting factors are typically formed with \(0 < W_{Manual} << W_{Semi} < W_{Auto} = 1\).
Composability of CaaS (1)

- **To measures two aspects of integrating CaaS services**
  - Inter-CaaS Integration
  - CaaS-to-Application Integration

- **Two Metrics**
  - Inter-CaaS Composability (ICC)
  - CaaS-to-Application Composability (CAC)
Composability of CaaS (2)

- **Inter-CaaS Composability (ICC)**
  - To evaluate the aspect of CaaS interacting with other CaaSs
  - Metric
    \[ ICC = \frac{\text{Number of CaaS Services without Complication}}{\text{Number of CaaS Services Interacting with Target CaaS}} \]

- **CaaS-to-Application Composability (CAC)**
  - To evaluate the aspect of CaaS interacting with application specific objects
  - Metric
    \[ CAC = \frac{\text{Number of Objects without Complication}}{\text{Number of Objects Interacting with Target CaaS}} \]
Experiments
Measurement Result

**G.Map Service**
- To be decomposed into 7 CaaS services
  - Map Image CaaS, Directions CaaS, Distance Matrix CaaS, Elevation CaaS, Geocoding CaaS, Time Zone CaaS, and Places CaaS

**Reusability Measures of G.Map Service**
- To consider 3 services:

<table>
<thead>
<tr>
<th>Quality Attributes</th>
<th>Directions CaaS</th>
<th>Distance Matrix CaaS</th>
<th>Geocoding CaaS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commonality</td>
<td>0.34</td>
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<td>0.76</td>
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<tr>
<td>Modularity</td>
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<td>1.0</td>
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<tr>
<td>Adaptability</td>
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<tr>
<td>Comprehensibility</td>
<td>0.903</td>
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<tr>
<td>Composability</td>
<td>0.889</td>
<td>0.889</td>
<td>0.909</td>
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<tr>
<td>Interface Soundness</td>
<td>0.833</td>
<td>0.917</td>
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</tr>
<tr>
<td>QoS Assurance</td>
<td>0.95</td>
<td>0.932</td>
<td>0.959</td>
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<tr>
<td>Publicity</td>
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<td>0.917</td>
</tr>
<tr>
<td>Integrated REUSABILITY</td>
<td>0.839</td>
<td>0.831</td>
<td>0.907</td>
</tr>
</tbody>
</table>
**Observation from Case Study**

- **Proposed metric suite addresses a broad spectrum of CaaS reusability.**
  
  - For example, the commonality of Directions CaaS and Distance Matrix CaaS are 0.34 and 0.28 respectively. If the proposed reusability suite only considered one aspect, commonality, these services would turn out to be less reusable.

- **Proposed metric suite turned out to be practically applicable.**
  
  - Values for terms used in metrics can mostly be measured objectively by using CaaS specification.
Thank You!