A Model of Quality-in-Use for Service-Based Mobile Ecosystem

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Introduction
Features of Mobile Devices

- **Diverse Networking Supported**
  - Wi-Fi, 3G, etc.
  - Available Everywhere

- **Mobility Supported**
  - Location-Sensitive

- **Supporting Diverse Sensors**
  - Accelerometer, Light Sensor, Orientation Sensor, Temperature Sensor, etc.

- **Limited Computing Power**

- **Limited Resources**
  - Main Memory, Second Memory, Bus Size, etc.

- **Constrained I/O Devices**
  - Small Screen Size
  - No Physical Keyboard
  - No Mouse Support

- **Additional I/O Devices**
  - Speech Recognizer, Touch Screen, etc.
Research Motivation (1)

- **Emergence of Services and Mobile Computing**
  - A solution to remedying the resource constraints while utilizing benefits of service-oriented computing

- **Issues / Challenges in Service-based Mobile Computing**
  - Unstable Quality of Services (QoS)
  - Difficulties in Managing Quality of the Heterogeneous and Black-box Services
  - Limited Network Bandwidth for Mobile Devices
Research Motivation (2)

- **SME as the Solution to the Challenges**
  - Equipped with autonomous service management process

- **To realize SME with the autonomous service management process,**
  - Inevitable to monitor the quality of services so as to detect problematic situations of deteriorating overall quality
  - Correspondingly, need to devise a quality model for SME

- **In this paper,**
  - To present a model for measuring quality-in-use for services in SME
    - By focusing on two quality attributes of quality-in-use as defined in ISO 9126; *Productivity* and *Effectiveness*
  - To define a set of quality metrics for measuring the two quality attributes by considering the need for self-stabilizing SME.
Related Works
Research Work (1)

- **Mei’s Work**
  - To present an approach to quantitatively measuring end-to-end quality of transaction-based services
    - Response Time and Download Time

- **Xiong’s Work**
  - To present a computer service performance model for the cloud infrastructure
  - To estimate performance of service, in terms of response time

- **Deora’s Work**
  - To present a quality of service management framework based on user expectation
  - To consider functionality, conformance, and reputation
• **Limitations**
  
  • To only consider external quality of the services
  
  • Not to consider the characteristics of services and service-based mobile ecosystem
Service-based Mobile Ecosystem (SME)
A Model of Quality-in-Use for Service-based Mobile Ecosystem
A Model of Quality-in-Use for Service-based Mobile Ecosystem
Metrics for Quality-in-Use in SME
Quality Model of SME (1)

- **Purpose of the Quality Model**
  - To check current status of SME so that SME manager can manage a consistent level of SME quality

- **Criteria of Defining Quality Model**
  - Quality should be *quantitatively* measured *at runtime*.
  - Quality metrics should represent current quality *objectively*.
  - The quality model should reflect *different concerns* of different participants.

- **Important Quality Attributes considered in SME**
  - Task Time for Productivity
  - Task Completion for Effectiveness
Quality Model of SME (2)

- **Three Levels of Quality Attributes**

![Diagram showing three levels of quality attributes in the context of a mobile application ecosystem.](image)
Measuring *Task Time (TT)* (1)

- **TT in ISO/IEC 9126-4**
  - A quality attribute evaluating how long a system or functional unit takes to complete a task for the given input

- **TT in SME**
  - To consider both the *Network Time* for sending requests and receiving results, and the actual *Computation Time* of the service instance

\[
TT_{App}(Node_x \cdot App_i, S^k_j) = \text{NetworkTime}(Node_x \cdot App_i, S^k_j) + \text{ComputationTime}(S^k_j)
\]
## Measuring Task Time (TT) (2)

<table>
<thead>
<tr>
<th></th>
<th>Meaning</th>
<th>Metrics</th>
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<tr>
<td>TT at Service Instance Level</td>
<td>To represent how fast the service instance returns its results to mobile applications during the time period</td>
<td>[ TT_{ServiceInstance} \left(S_j \right) = \frac{\sum_{i=1}^{n} TT_{App} (APP_i, S_j)}{n} ]</td>
</tr>
<tr>
<td>TT at Service Type Level</td>
<td>To represent how fast all the service instances for a service type return their results for the given period of time</td>
<td>[ TT_{ServiceType} (T_j) = \frac{\sum_{k=1}^{n} TT_{ServiceInstance} (S_j)}{n} ]</td>
</tr>
<tr>
<td>TT at SME Level</td>
<td>To represent how fast all service types in current SME provide their services for the given period of time</td>
<td>[ TT_{SME} = \frac{\sum_{j=1}^{n} TT_{ServiceType} (T_j)}{n} ]</td>
</tr>
</tbody>
</table>
Measuring *Task Completion (TC) (1)*

- **TC in ISO/IEC 9126-4**
  - A proportion of tasks to be completed over a period of time

- **TC in SME**
  - To represent a ratio of returning its results successfully for a given period of time
## Measuring Task Completion (TC) (2)

<table>
<thead>
<tr>
<th>Meaning</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC at Service Instance Level</td>
<td>$TC_{ServiceInstance} \left( S^k_j \right) = \frac{\text{number of task completed}}{\text{total number of task received}}$</td>
</tr>
<tr>
<td>TC at Service Type Level</td>
<td>$TC_{ServiceType} \left( T_j \right) = \frac{\sum_{k=1}^{n} TC_{ServiceInstance} \left( S^k_j \right)}{n}$</td>
</tr>
<tr>
<td>TC at SME Level</td>
<td>$TC_{SME} = \frac{\sum_{j=1}^{n} TC_{ServiceType} \left( T_j \right)}{n}$</td>
</tr>
</tbody>
</table>
Managing SME with Quality Metrics
Usages of Quality Metrics

- To give information of current state to figure out problematic situations
  - To evaluate quality stability

- To assess whether quality stabilizing actions solve potential problems effectively
How to Evaluate Stability (1)

- **Three States**
  - Normal, Poor, Exceeding

- **By using two threshold values, determine the acceptance of quality.**
  - \( \text{Threshold}_{\text{high}}(x) \) for the high-bound threshold value of \( x \).
  - \( \text{Threshold}_{\text{low}}(x) \) for the low-bound threshold value of \( x \).
How to Evaluate Stability (2)

- Three States of Each Metric

![Diagram showing three states of each metric with attributes and actions for different states.

- Exceeding:
  - Waste of resources
  - Consider ROI.
  - Reduce resource consumption.

- Normal:

- Poor:
  - QoS is poor.
  - Needs remedy actions, s.a. migration and replication

- Exceeding:
  - Waste of resources
  - Consider ROI.
  - Reduce resource consumption.

Threshold_{low}(x)  \rightarrow  Exceeding

Threshold_{high}(x)  \rightarrow  Poor

\text{TT}_{SME} \text{ or } \text{TT}_{ServiceType(S_i)}
How to Evaluate Stability (3)

- QoE and QoS Level Determination with \( TT \) and \( TC \)

![Diagram showing QoE and QoS level determination with TT and TC](image)

- Quality satisfied, but resource consumption in doubt
- Can be considered as an ideal area after additional examination
- Ideal
- Faulty State

- Low (i.e. faster response)
- High (i.e. high throughput)
- Threshold\(_{low}\)
- Threshold\(_{high}\)
- Low (i.e. low throughput)
- High

- \( TT \)
- \( TC \)
Experiment
A Model of Quality-in-Use for Service-based Mobile Ecosystem
Quality of Applications and Services

A Model of Quality-in-Use for Service-based Mobile Ecosystem

Quality of Applications and Services

Threshold_{Low}

Threshold_{High}

Faulty Case #1

Faulty Case #2

Quality of Service

Threshold_{Low}

Threshold_{High}

Time (sec)

Time (sec)

Faulty Case #1

Faulty Case #2
Conclusion
Summary of the Work

- **To present quality metrics to assess current states of SME**
  - To extend 2 quality attributes in ISO/IEC 9126-4
    - TT for Productivity
    - TC for Effectiveness

- **To present a method to evaluate the current stability with the metrics**
  - To trigger the further activities of Self-Stabilizing Management Process
Thank You!