Towards a Semantic Infrastructure for User Generated Mobile Services

Marcin Davies

Telecommunications Research Center Vienna (ftw.), Austria
davies@ftw.at

Abstract. This paper presents a research approach towards a semantic infrastructure for user generated mobile services. Building on the concept of semantic *microservices*, the aim of this work is to sufficiently lower the barrier for end-users in order to enable easy ad-hoc creation, customisation, and discovery of mobile services.

Key words: semantic web services, end-user development, user-centric service creation, microservices, mobile services, web 2.0

1 Introduction and Problem Description

The current trend of active user participation and service creation on the Internet (Web 2.0, mashups, widgets, etc.) will certainly continue within mobile environments. The enabler technology is mostly available as mobile terminals have an enormous capacity in terms of processing power, interaction, and interfacing. Furthermore, high-speed data coverage as well as flat-fee data plans are increasing to enable an 'always-on' experience in the mobile world.

There is massive potential when mobile devices not only present data but provide valuable information and services to other users. Instant mobile services like traffic jam information, recommended places, or friend locations can be of benefit to a large audience and will pave the way to a new mobile internet empowering end-users to easily find and provide relevant, context-aware information.

Although early approaches towards end-user service creation on the web exist (e.g. Yahoo! Pipes [1]), they cannot be directly transferred to mobile environments (user interface issues, different architecture, etc.). Furthermore, they are too complex for a widespread use (i.e. requiring programming skills) and to facilitate spontaneous service creation on the go.

Driven by the main research question *whether and how much semantic technologies can lower the barrier for end-users in order to enable easy ad-hoc creation, customisation, and discovery of mobile services*, this thesis introduces the concept of *microservices*[1] — small, sharply focused, and semantically annotated services that can be flexibly created, adapted, and discovered by end-users. Leveraging this concept, this work will elaborate a semantic infrastructure as a step towards a broad adoption of mobile microservices.

[1] The term also refers to the fact that these services are running on small devices

2 Related Work and Areas of Contribution

This thesis project will be based on and contribute to the state of the art in three main areas, namely (1) Service Description and Modelling, (2) Knowledge Warehousing and Service Discovery, and (3) End-User Service Creation Paradigms.

2.1 Service Description and Modeling

Semantic Web Services (SWS) commonly operate on service descriptions encoded in OWL [2] or RDF [3] and service models such as OWL-S [4] or WSMO [5]. In addition, there exist more lightweight approaches such as SAWSDL [6] and SA-REST [7] that put a semantic layer on traditional, non-semantic service description methods such as WSDL [8]. However, none of these techniques are tailored to the needs of mobile services, which are fundamentally different in terms of e.g. life span, context dependency, or service availability. Moreover, existing toolkits for describing SWS (e.g. [9]) are directed towards professionals and are not feasible for end-users while on the go. Therefore, the thesis will explore user-friendly ways of mobile service description and annotation.

Microservice descriptions are interpreted by an execution environment (similar to a virtual machine) on a mobile device and can be shared and customised by other users to create new services. Since existing approaches such as WS-BPEL [10] and model-driven architectures and languages like Executable UML [11] are too much focused on big software systems, this work will present a lightweight microservice model building on the REST [12] architecture that allows for easy integration with existing Web standards and protocols.

2.2 Knowledge Warehousing and Service Discovery

A central part of this thesis will consider management and discovery of the previously discussed semantic microservice descriptions. Existing and widespread software like Jena [13] or Sesame [14] allows for arbitrary ontology management, but needs to be enriched by an additional layer supporting community-driven ontologies [15] and ontology matching [16] for microservices and their provided content, revision of knowledge (due to a possibly limited life span of microservices) and content- and context-aware recommendation mechanisms (to deliver meaningful results in mobile scenarios).

2.3 End-User Service Creation Paradigms and Methods

Current examples for end-user created software on the Web such as Microsoft Popfly [17] allow users to create new web applications by visual editing of functional blocks. However, these examples can only be regarded as a first step, both in terms of ease of use (still requiring significant knowledge) and functionality (mostly restricted to aggregation of information not provision of it). With respect to the mobile domain, current service creation approaches (e.g. [18, 19]) are

very limited (again in terms of functionality) or not tailored to mobile devices and usage scenarios (with regard to user interfaces, capabilities, and context information).

The research area of End-User Development [20] considers different approaches for end-users to create software (e.g. Programming by Example). However, these directions will need to be explored in the context of software services, open communities, and mobile usage patterns. In addition, current end-user development methods are still at an early stage and can benefit from semantic technologies (e.g. by using annotations or rules to describe the behavior of functional blocks).

3 Methods and Approach

The overall methodology for the thesis is shown in Fig. 1 and explained in detail below.

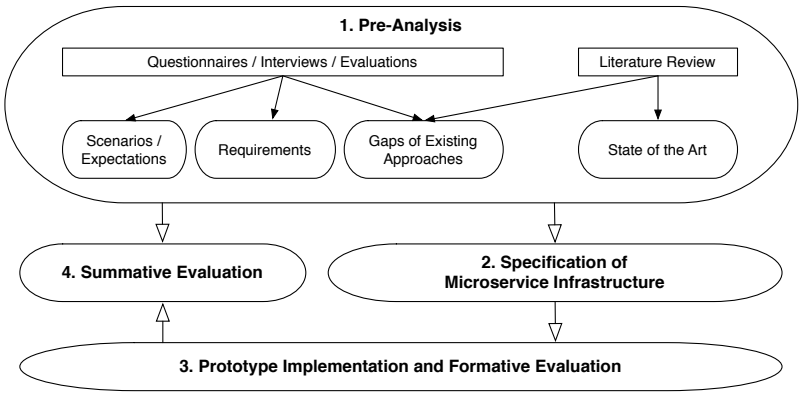

Fig. 1. Overall Methodology

1. *Pre-Analysis*
   In this first phase of the thesis, initial requirements, possible usage scenarios, and user expectations for microservices will be collected by interviews and web questionnaires. In addition, existing frameworks and tools (e.g. LabView [21], Yahoo! Pipes [1], Microsoft Popfly [17]) and small mockups for alternative approaches (e.g. question-based service creation) will be evaluated with regard to specific criteria, e.g. time needed, perceived complexity, and quality of experience (QoX). This pre-analysis should also help to explore gaps in existing solutions that semantic microservices might be able to fill.
2. *Specification of Microservice Infrastructure*
   Based on these results and, of course, review of existing work and the state of the art, a suitable semantic microservice infrastructure will be specified and described. This also includes semantic descriptions of the basic components needed to build microservices.

3. *Prototype Implementation and Formative Evaluation*
   The next step of the thesis will be a prototype implementation of the semantic microservice infrastructure. This framework will consist of server-side software to search and discover microservices (knowledge warehouse) as well as a mobile client that allows for creation, customisation, and execution of microservices. By following an iterative design approach, the semantic components derived in early stages of the development will be evaluated in small-scale user studies[2] in order to gather early user feedback and to refine the prototype implementation.
4. *Summative Evaluation*
   Finally, the validity of the developed infrastructure will be assessed in a final user study with regard to easier service creation, customisation, and discovery and by considering the criteria derived in the pre-analysis phase. In addition, the study will also show the applicability to different usage scenarios, e.g. tourism, gaming, recreation, or social networking.

4 Preliminary Results

Besides a first definition of scenarios, requirements, and a general system architecture for microservices (cf. [23]), the most relevant achievements so far are towards a specification for the microservice description language. As outlined in Sect. 2.1, microservice descriptions will be used during the whole microservice lifecycle (e.g. creation, modification, execution) and are therefore an essential part of a microservice infrastructure. Currently, the specification foresees the following language parts (more information can be found in [24]):

- *Microservice Profile:* provides a descriptive and functional definition of the microservice by an extensible set of metadata elements
- *Microservice Logic:* controls the data flow, capability and content handling, and all other operational aspects of a microservice
- *Microservice Rendering:* defines the service user interface and provides an abstract and device-independent layer for service presentation
- *Microservice Content:* describes the content that is manipulated or offered by a microservice

5 Conclusions and Future Work

This paper introduced the idea of microservices and described related work and areas of contribution. After outlining the planned approach, this work also presented some preliminary results. According to the methodology shown in Sect. 3, the next major steps are to complete the pre-analysis phase (already started) in order to receive a sound basis for the infrastructure specification (where work has been started too — cf. Sect. 4). Finally, this infrastructure will be prototypically implemented and evaluated in user studies.

[2] If needed, 'Wizard-of-Oz' techniques [22] will be applied that simulate behavior that is actually not yet or fully implemented

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