

## Chapter 4.2

# Enabling Scalable Semantic Reasoning for Mobile Services

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### ABSTRACT

With the emergence of high-end smart phones/PDAs there is a growing opportunity to enrich mobile/pervasive services with semantic reasoning. This article presents novel strategies for optimising semantic reasoning for realising semantic applications and services on mobile devices. We have developed the mTableaux algorithm which optimises the reasoning process to facilitate service selection. We present comparative experimental results which show that mTableaux improves the performance and scalability of semantic reasoning for mobile devices.

### INTRODUCTION

The semantic web offers new opportunities to represent knowledge based on meaning rather than syntax. Semantically described knowledge can be used to infer new knowledge by reasoners in an automated fashion. Reasoners can be utilised

in a broad range of semantic applications, for instance matching user requirements with specific information in search engines, matching match client needs with functional system components such as services for automated discovery and orchestration or even providing diagnosis of medical conditions. A significant drawback which prevents the large uptake and deployment of semantically described knowledge is the resource intensive nature of reasoning. Currently available semantic reasoners are suitable for deployment on high-end desktop or service based infrastructure. However, with the emergence of high-end smart phones / PDAs the mobile environment is increasingly information rich. For instance, information on devices may include sensor data, traffic conditions, user preferences or habits or capability descriptions of remotely invocable web services hosted on these devices. This information can be highly useful to other users in the environment.

Thus, there is a need to describe this knowledge semantically and to support scalable reasoning for mobile semantic applications, especially in highly dynamic environments where high-end infrastructure is unsuitable or not available. Computing power is limited to that available on resource constrained devices and as shown in Figure 1, there is insufficient memory on these devices to complete reasoning tasks which require significant time and memory to complete.

Since mobile users are often on the move and in a highly dynamic situation, they generally require information quickly. Studies such as (Roto & Oulasvirta, 2005) have established that mobile users typically have a tolerance threshold of about 5 to 15 seconds in terms of response time, before their attention shifts elsewhere, depending on their environment. Therefore, there is a need for mobile reasoners which can meet the twin constraints of time and memory.

For example, consider the following mobile application scenario. A mobile user has just arrived in Sydney airport and wishes to search for food and other products. Sydney airport provides touch

screen kiosk terminals which allow the user to search for stores (and other airport facilities) by category. The location of the store and facility is then displayed on a map as well as the location of the user (which is the fixed location of the kiosk), as illustrated in Figure 2. These kiosks are not very convenient as they are only located at fixed point locations, are limited in their search options and user request complexity and do not take user context into account. Additionally, they do not scale, as kiosks can only be used by one user at a time.

Alternatively, the increasing abundance of mobile devices such as PDAs and mobile phones as well as their increasing computational and communication capabilities provide new opportunities for on-board service discovery. Consider the case where the information kiosk is a directory/repository of services available in the airport which mobile users can connect to from their phone or PDA. The user can then access, search and use this information using their respective phones at their convenience.

There are two modes of service matching:

- centralised service matching which occurs on a server on behalf of the user and
- partially or completely decentralised approaches where matching occurs on the resource constrained device itself.

*Figure 1. Error showing that there was not enough memory to perform reasoning when attempting to run Pellet on a PDA (the reasoning task was the Printer inference check given in section 6.1).*



Under a centralised approach (see Figure 3) the kiosk (or a connected machine) is a high-end server which handles all service discovery requests on the mobile user's behalf. However, there are two major drawbacks with this approach. Firstly, although purchase of a server is relatively cheap, there are significant costs involved for this kind of service provision, including scalability to handle potentially thousands of requests, wireless network provision, maintenance costs, security considerations and quality of service issues. The significant costs would outweigh the limited benefit to a central authority such as the Sydney

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