Distributed reasoning for context-aware services

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Abstract—**Traditional services nowadays offer a strict interface to predefined functionality. Given the current atmosphere of data-integration and interface adaptation according to the user's profile and context, there is a clear need for a well-structured and organized approach. Ontologies, as a semantic and first-order-logic founded mechanism, are being used in our research to facilitate such a meaningful integration. However, it is still necessary to develop distributed mechanisms for such integration. The research presented in this paper focuses on the one hand on the development of efficient partitioning and distribution algorithms and on the other hand on the implementation of a scalable service platform for distributed semantic agents.**

Keywords— **Distributed Reasoning, Ontology, Context-Awareness**

I. Introduction

Recent years have seen an increase in the research on intelligent services. Adding intelligence to services creates the added value that the functionality and business logic exposed to a client, is adapted and enhanced according to the context and environment in which the client and service collaborate. By using ontologies as modelling language, and more specifically the Ontology Web Language, one creates the possibility to formally reason over these models. This aspect is supported by the foundation of ontologies in first-order description logic. However, as this process can become rather resource-intensive in large data-oriented systems, there is a clear need to study these mechanisms in a distributed environment and to develop an enabling service platform for distributed ontology-based reasoning. An important research topic concerns the efficient partitioning, allocation and scheduling algorithms in such a platform. It is clear that these algorithms must have the necessary context-information describing all the entities in the platform. The on-going research presented in this paper addresses these issues.

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II. Main research objectives

One of the main objectives of this research is the development of a service platform and supporting context-modelling, to facilitate the autonomous application of distributed reasoning on a collection of ontological models. Apart from this platform, algorithms and heuristics to support the service-platform will be implemented and evaluated. These algorithms support both the reasoning itself as well as the monitoring of the platform at-runtime. A number of aspects play an important role. Each of these will be discussed in this section and their current status will be presented.

- *Development of a hierarchical context-model*: This part of the research looks into the characteristics and requirements of the distributed reasoning mechanisms in order to develop a comprehensive and complete context-model. This model is the collection of all context-information of the different actors in the network, whether they be services, network nodes or client devices. This model is currently in an advanced form, and the results have been published in [1].
- *An ontology generator to support the simulation environment*: In order to be able to thoroughly evaluate the algorithms and heuristics developed for the autonomous distributed rea-

soning service platform, there is a need to be able to generate a number of ontologies with varying complexity and sizes. For this, we have developed OTAGen: A tuneable ontology generator. A full overview of OTAGen can be found in [2].

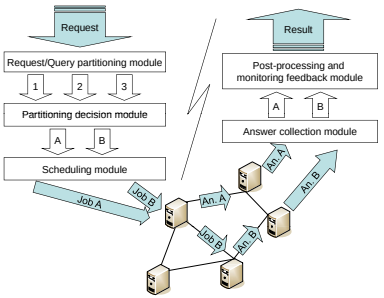

Figure 1. Reasoning engine workflow

• *Distribution and scheduling algorithms for reasoning tasks*: The first results of this task are available, but further research into optimising the algorithms and developing the heuristics is still to be done. The focus in this task is on the development of partitioning mechanisms for queries or reasoning tasks, taking into account the context information stored in the hierarchical model. In this way, not only the semantic information is taken into account, but also the network topology and the status of the nodes in this network. Once the reasoning task is partitioned, the next step is to schedule these smaller reasoning subtasks onto nodes in the network. Existing research in Grid-computing is taken into account, and the algorithms and heuristics developed for the Grid environment will be enhanced according to the needs of the Semantic Collaboration platform. The workflow of the distributed reasoning engine for this service platform is illustrated in Figure 1.

• *Evaluating use-cases*: The developed algorithms and heuristics will be demonstrated and evaluated in two use-cases. A first use-case is the natural progression from the results of my Master's thesis. In this research a service platform for next-generation train-backbones has been developed. This platform has now been extended with a number of generic ontology-processing services, as can be found in [3]. Additionally, an example implementation of a number of services to perform ontology-based and reasoner supported diagnostics of an emulated on-board Passenger Information System (PIS) has been completed [4].

• *Re-engineering of the algorithms to support mobility of nodes in the network*: A last important aspect of this research will focus on the support of mobility inside the network. After all, the location of client devices constantly changes. It is important to take this feature properly into account, as the location plays an important role both in the context parameters as well as in the network topology and availability of nearby services and processing nodes. The influence of this extra feature on the algorithms will be studied and the algorithms and heuristics will be enhanced accordingly.

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