Building Trustworthiness Into the Semantic Grid

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ABSTRACT

The Semantic Grid is characterised by an open system, with a high degree of automation supporting flexible collaboration and computation on a global scale. It promises applications that can be built from dynamically composing disparate sub-systems. Flexible and robust control and co-ordination of this aggregation process will be very important. The mechanism used for this composition must be highly dependable, and therefore trustworthy. A dependable Grid will need to be adaptable. We discuss how to achieve adaptability. We also argue that a co-ordination language that is amenable to automated reasoning should be used for this composition mechanism in order to provide a sufficient level of confidence and trustworthiness in the end-product. We discuss the properties of such a language.

1 INTRODUCTION

The Grid, according to [1], supports the sharing and co-ordinated use of diverse resources in dynamic, distributed "virtual organisations". The Grid aims to integrate, virtualise, and manage resources and services amongst computational nodes that are globally distributed. Although in the last few years, there has been a lot of excitement over the Grid and its "new" service-oriented computing paradigm, the emergence of service-oriented computing is not new. In [2], Greenberger coined the term "information utility", and explored the kinds of services that a generally available information system made possible. In [3], Parkhill explored the legal and social implications of a "computer utility", which he described as "...a remarkable new method for the distribution and utilization of computer power". And in recent years, we have read many optimistic scenarios of the Grid and the kinds of services it will make possible.

Although there are various Grid middleware platforms, such as Globus [4], these platforms are converging on a single standardised next generation architecture, the Open Grid Services Architecture (OGSA). OGSA [5], based on Web services concepts and technologies, represents an evolution of the Grid towards a service-oriented computing architecture, where software systems are services and are autonomous, platform-independent computational elements that can be described, published, discovered, orchestrated and programmed using standard protocols for the purpose of building networks of collaborating applications distributed within and across organisational boundaries.

In the very near future, the Grid infrastructure will meet the world of pervasive computing and the Semantic Web [6]. This union will make possible the introduction of different types of systems, applications, and services, such as [7] [8], that should potentially empower people to create, provide, access, and use a variety of intelligent services, anywhere, anytime, in a secure, cost-effective and trustworthy way.

In our dash towards the pervasive computing world of the semantic grid, it will be apposite not to forget why we are building this infrastructure. This system is being built to be used by people (as well as machines). Users demand that they trust the system they use. This trust is engendered if this system is dependable.

In this paper, we argue that trustworthiness be built into the Semantic Grid. We argue that the way to build trustworthiness into the Grid is by building a dependable Grid. And the way to have a dependable system is by making that system adaptable. We also argue that a co-ordination language with a well-understood computational model for dependability, and is amenable to automated reasoning is sufficient to build trustworthy systems.

1.1 Whom Do You Trust?

In the human realm, you must earn the trust of others, not assume it. You cannot, for example, expect them to simply hand you their money based on your assurances that you are an honourable person (although they may do that through referral). Conversely, you will give someone else your money or your information only after you have established that they will handle it appropriately (responsibly).
Trust can be personal, based on a long-standing relationship, or institutional, based on the rule of law applied to business transactions. While you may not know that supermarket assistant personally, you can safely assume he will not make a copy of your credit card and that, if he does, the law is on your side.

2 Dependability and Trustworthiness

We define **dependability** of a computing system as the ability to deliver service that can be trusted, and the **service** delivered by a system is its behaviour as it is perceived by its user(s); a user is another system (physical or human) that interacts with the former through an interface.

We see that the unprecedented level of complexity and instability of today's IT systems lead to situations where local or component failures can be propagated without control across the systems' infrastructure and degenerate into unwanted and errant behaviours. Introduction of the Grid, with its promises of a highly complex distributed environment with dynamic introduction and removal of components, will exacerbate this problem. The Grid will have to provide an infrastructure that can adapt to changes in the underlying environment and offer dependable quality of service.

3 Building Adaptability into the Semantic Grid

Although the Grid middleware promises to be built on open standardised interfaces, the physical world of PDAs, sensors, RFIDs, and embedded systems it will interact with will be based on **policies** and **rules**. An adaptable system requires a reliable and stable system. To build reliability for such a world of policies and rules will require well-constructed foundation for continuous monitoring.

A policy may express such diverse characteristics as transactionality, security, response time, pricing, etc. For example, a policy of a service may specify that all interactions be invoked under transaction protection, that incoming messages have to be encrypted, that outgoing messages will be signed, that responses may only be accepted within thirty seconds, and that certain operations are subject to a fee to be paid by credit card by the invoker.

A rule expresses the relation of domains in that environment, e.g., a user may express that the sensors in the home should be activated at some particular times, or they may express rules concerning how they want service composition to be done. Such rules may be expressed textually, by speech, or by a combination of both.

Building reliability for such a world of policies and rules will not be easy. The Semantic Web has features within it which can be used as starting points to build such systems. Such rules and policies can be converted into OASIS-type [9] access policies. The resources of the Semantic Grid can be encoded as Resource Description Framework (RDF) [10] and OWL [11] models, and the inference mechanisms provided by inference engines, such as Jena [12], can be used to infer statically, i.e. before interaction, the potential execution mechanisms made possible by these dynamically changing systems. New rules and policies can always be inserted and they will be statically checked. And changes in these resources are reflected back into the system making new inferences possible.

4 Co-ordination language

The Grid promises dynamic composition of services. A high-level scripting language is needed for this service composition to help build dependable systems.

Such language should have the following attributes:

- Be declarative, allowing the programmer to express programs in terms of **what** is to be computed, and not in terms of **how** to arrive at the result. This makes automated reasoning easily performed on its expressions
- Be highly readable for humans
- Be highly expressive
- Give its users good primitives to express models of time and duration
- Have good primitives to express safety and live-ness properties
- Have good primitives to express prioritised conflict
- Have inbuilt mechanisms for prioritised conflict handling
- The concept of semantic web ontology [10] [11] needs to be supported and given first class status
- Have good primitives to express ontological rules

Some previous work exists integrating XML into programming languages [13] [14]. Our work [15] aims to investigate this space providing a high-level scripting language amenable to proofs and which has primitives for web ontology. We believe that this is very important for the visions of the Semantic Grid to become reality.

References

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