Achieving Dependability in Service-Oriented Systems

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Abstract. Service-orientation is a useful means of developing highly flexible and adaptive software systems, and it is a paradigm that has been increasingly adopted into Grids and Clouds. However, service-oriented architectures and designs also bring with them new challenges in the fields of dependability and security that need to be addressed carefully in order to provide sufficient support to enable service-oriented systems to offer non-trivial Quality of Service guarantees. In this paper we examine such challenges and introduce several advanced techniques developed at the University of Leeds to achieve dependability and security in service-oriented systems and applications. These techniques include schemes for achieving fault tolerance, privacy protection, and dynamic authentication, as well as a method for assessing dependability based on fault-injection. We describe and discuss each technique alongside the results of experimental evaluations of it.

Keywords: Dependable software, evaluation, fault tolerance, security, service-orientation.

1 Introduction

Service-orientation aims to facilitate the creation of flexible, dynamic, inter-organisational software systems. A service can be regarded as “a mechanism to enable access to a set of one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description.” [6] A service-oriented architecture (SOA) offers “an application architecture within which all functions are defined as independent services with well-defined invokable interfaces, which can be called in defined sequences to form business processes.” [4] Loose coupling is the main benefit resulting from operating in SOA. It is obtained by abstracting the description of a service from the implementation(s) of that service; thereby allowing different implementations to offer interchangeable services. This can then enable dynamic or late binding, where service implementations can be selected just before service consumption by composing applications at runtime from suitable services based on their service descriptions. SOA also provides the ability to share services (e.g. third-party services) outside of traditional organisational boundaries, and promotes the reuse of services in new applications and contexts not initially planned for, leading to lower development cost, operational expenditure and maintenance effort.

SOA has been increasingly adopted into Grid and Cloud systems in order to help solve the fundamental problem of coordinated resource sharing and problem solving.
in a dynamic, distributed, and multi-organisational environment. However, the advantages of SOA raise immediate problems not faced by traditional distributed systems research, in areas such as dependability, security, and dependability assessment. These are of especial interest when developing highly dependable systems (systems that require levels of dependability and security that far exceed normal enterprise needs, and invariably experience high consequences in the event of a system failure.) The new challenges concern not only the dynamic nature of service-oriented systems and the use of third-party services, but also the network environments that the services are deployed upon, which are ever more spatially disparate, heterogeneous, and spread across many administrative domains.

The remainder of this paper is organized as follows. Section 2 examines some new dependability challenges arising from service-orientation. Section 3 introduces a software fault tolerance scheme that resolves the common service problem while Section 4 describes a technique for protecting privacy against faults and attacks from external and non-trusted services. A protocol for multi-party service interactions is presented in Section 5 that authenticates dynamically the participating services of a business process. Section 6 discusses a fault taxonomy for dynamic service binding and introduces a framework for assessing dependability in service-oriented systems before Section 7 concludes the paper.

2 Dependability and Security Issues Due to Service-Orientation

Many of the new challenges due to the advent of service-orientation can be related to the concepts of dependability and security. Dependability is used here as a generic term, defined as the quality of the delivered service such that reliance can justifiably be placed on this service. It is important to state that this definition of dependability is not simply a synonym for reliability; rather, reliability is just one attribute of the overall concept.

Traditionally, dependability is a global concept, and subsumes the attributes of reliability, availability, safety, integrity, maintainability, and confidentiality. However, these attributes are becoming increasingly differentiated; for example, the work reported in [2] distinguishes between dependability and security attributes - as shown in Figure 1 - in order to highlight the main balance of interest given to these attributes.

![Fig. 1. Dependability and security attributes in [2]](image-url)