On a Service-Oriented Approach for an Engineering Knowledge Desktop

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ABSTRACT

Increasingly, manufacturing companies are shifting their focus from selling products to providing services. As a result, when designing new products, engineers must increasingly consider the life cycle costs in addition to any design requirements. To identify possible areas of concern, designers are required to consult existing maintenance information from identical products. However, in a large engineering company, the amount of information available is significant and in wide range of formats. This paper presents a prototype knowledge desktop suitable for the design engineer. The *Engineering Knowledge Desktop* analyses and suggests relevant information from ontologically marked-up heterogeneous web resources. It is designed using a Service-Oriented Architecture, with an ontology to mediate between Web Services. It has been delivered to the user community for evaluation.

Categories and Subject Descriptors

C.2.4 [**Computer-Communication Networks**]: Distributed Systems—*distributed applications*; H.3.5 [**Information Storage and Retrieval**]: Online Information Services

General Terms

Design

Keywords

Service-Oriented Architecture, Web Services, Semantic Web

1. INTRODUCTION

A fundamental shift is occurring in the aerospace industry away from selling products to providing services. Companies such as Rolls-Royce aims to make half its engine fleet subject to highly profitable long-term service agreements by 2010 [2]. Essential to success in this market shift is to design new products for the aftermarket. In other words, new products must be designed to provide lower and more predictable maintenance costs. To minimize maintenance costs during the design phase of new products, engineers must obtain knowledge gained from maintenance histories of similar products. This will help engineers identify parts most likely to be problematic throughout the engine's entire life cycle. However, in organisations which perform a substantial amount of engineering design, a very large number of documents are created. It is impossible for any single member of a design team to access more than a fraction of available documentation. As is widely recognised, information systems usually develop over time into a set of heterogeneous resources. As a result, it becomes difficult for engineers to follow a trail through these resources [7]. The challenge for organisations is therefore to develop an information system that is both comprehensive and will satisfy the increasing demands from industry for up-to-date and easily accessible information.

In response to the challenges discussed, we are implementing an integrated knowledge desktop to support engineers to design for the aftermarket. The knowledge desktop searches and analyses relevant maintenance records and design guidelines, and provides design engineers easy access to such information. This paper presents an early prototype of such a knowledge desktop.

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2. MOTIVATION

As is well recognised, the use of past experiences and previously acquired knowledge, either from the designer's own experiences or from resources within their organisation is an important part of the design process. It has been estimated that 90% of industrial design activity is based on variant design [1], while during a redesign activity up to 70% of the information is taken from previous solutions [3]. A cursory consideration of these figures identified two immediate challenges — how to capture knowledge, and how to retrieve it. The purpose of this paper is to present a design environment that can be used within a manufacturing organisation for the retrieval of knowledge. The problem can be illustrated as follows:

> In developing a new variant of an existing family of gas turbines, designers have to consider the redesign of many components. The performance of the original component will provide a guide to future designs, by identifying possible manufacturing or maintenance problems. The engineers can use the knowledge acquired from previous maintenance records to identify parts that are most likely to increase maintenance cost. The *Engineering Knowledge Desktop* will allow searches for parts that are main drivers for engine removals, and present maintenance knowledge in a meaningful fashion.

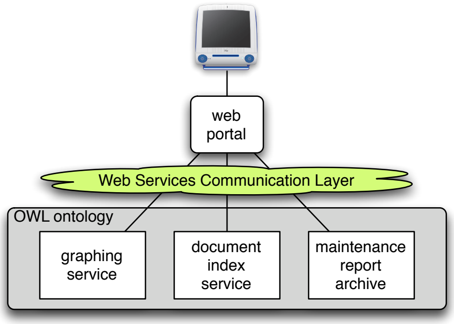

Figure 1: System architecture.

3. ARCHITECTURE

The *Engineering Knowledge Desktop* uses a Service-Oriented Architecture (SOA) for its implementation. SOA is a software architectural concept that defines the use of services to support the requirements of software users. In a SOA environment, functional components expose service behaviors accessible to other applications via loosely coupled standards-based interfaces. These components, called Web Services, interoperate based on a formal definition independent of the underlying platform and programming language. Due to the nature of loose coupling in SOA, applications can be developed and deployed incrementally. In addition, new features can be easily added after the system is deployed. This modularity and extensibility make SOA especially suitable as a platform for an integrated knowledge desktop within large engineering organisations.

Figure 1 explains our proposed SOA based knowledge desktop framework. Web Services are provided by different departments within a company, and can be distributed across multiple sites. A web portal integrates the various Web Services and presents users with a unified view to the available information. An OWL ontology [5] is developed to describe aerospace engineering parts and processes. Maintenance and design knowledge, such as reports for work undertaken, are stored as RDF triples [4] using this ontology. The ontology is also used to mediate actions of the Web Services.

4. IMPLEMENTATION

For our initial version of the *Engineering Knowledge Desktop*, we constructed a simple portal with a Java web application. We also developed three Web Services for use within this portal – a maintenance event report archive, a document index and a graphing service. Currently the maintenance event report archive contains RDF triples harvested from information contained in maintenance reports. This resourse will be augmented over time as other company aide datasets are incorporated. The report archive answers RDQL queries [6] on the triples stored in the archive. The document index service is a full text search engine on web pages available on the companies public internet site. The graphing service creates histograms for any given set of data.

With the *Engineering Knowledge Desktop*, designers can use the graphing service to generate plots of various reliability statistics for a particular engine model from information held within maintenance records. The graphs generated are clickable image maps that link to relevant event reports. Using the engine model selected by the user, the desktop displays a list of suggested documents. The document list is generated by querying the document index service with keywords associated with the engine in the ontology.

5. DISCUSSION

It is now increasingly common for engineers to have to consider aftermarket cost when designing a product. To minimise life cycle cost, engineers must identify possible areas of concern from maintenance records and design guidelines. Our proposed *Engineering Knowledge Desktop* will provide access to tools that will help engineers search and analyse relevant information from disparate internet resources. The knowledge desktop uses a Service-Oriented Architecture, allowing the integration of a wide range of Web Services, including data analysis and information retrieval. In this paper, we presented our initial prototype for such a knowledge desktop. The prototype integrates resources from three Web Services, and uses an ontology to mediate between the services. This version of the *Engineering Knowledge Desktop* has been released to the project consortium for evaluation, and the initial feedback has proved to be very positive. It is however very clear that as we take the development forward, we will need to address several key issues, in particular workflow and provenance.

6. ACKNOWLEDGEMENTS

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