Semantically Annotated Hypermedia Services

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ABSTRACT
Hypermedia systems' researchers investigate the various approaches in the way documents and resources are linked, navigated and stored in a distributed environment. Unfortunately, those systems fail to provide effortlessly usable discrete services, since it is difficult both to discover and to invoke any of them. This paper proposes the usage of emerging technologies that try to augment the Web resources with semantics in order to provide Hypermedia services that can be easily discovered, and integrated by potential third party developers. In this context, we analyze the benefits for the Hypermedia community upon the adoption of Semantic Web technologies for the description of Hypermedia services, and we implement an initial corresponding ontology.

Categories and Subject Descriptors
H.5.4 [**Hypertext/Hypermedia**]: Architectures, Theory, User Issues. H.3.5 [**Online Information Services**]: Web-based services.

General Terms
Design, Standardization.

Keywords
Hypermedia Systems, Hypermedia Services Description Language (HSDL). Semantic Web technologies.

1. INTRODUCTION
Hypermedia systems is a field in computer science that has been actively researched for more than a decade. This research has resulted in innovative, but not easily usable services. These systems have never had the opportunity to meet global adoption and usage [1]. One significant reason for this phenomenon is that any hypermedia-unaware third-party developer faces several difficulties when the time comes to integrate hypermedia services into his own existing system [2].

The Semantic Web is a vision of a web where the resources, like documents and services are semantically annotated, facilitating their discovery and invocation. A great deal of effort is being put into the standardization of technologies and techniques that will enable the insertion of the Semantic Web into the everyday life of the simple web user. That is, the definition of the Resource Description Framework (RDF) [3] and the Web Ontology Language (OWL) [4] enables the creation of rich semantic content into the Web. Moreover, the definition of the Web Ontology Language for Web Services (OWL-S) [5] enables the creation, composition, discovery, invocation and monitoring of a new kind semantically rich Web services, called Semantic Web Services [6].

This short paper tries to identify reasons for the low acceptance and public-awareness of research developments in the area of Hypermedia systems and underlines the need for self-descriptive Hypermedia services. It proposes the usage of the emerging Semantic Web technologies in order to provide Hypermedia services with features, like easy discovery, automatic invocation, and semi-automatic integration. Finally, it presents an ontology (under-construction), that can be used as an initial point of reference for the description of the services provided by Hypermedia systems, and subsequently offers a new way to characterize and categorize the various Hypermedia systems and services. This simple ontology is based on a previous effort to map the capabilities of Hypermedia services and make use of registries for their discovery [7]. To our knowledge, although ontologies have been used in the representation of the data as well as the relationships in Hypermedia systems, there is as yet no reported effort that uses Semantic Web technologies for the description of the services provided by a Hypermedia system.

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2. SEMANTICS INTO HYPERMEDIA

2.1 Self-Descriptive Hypermedia Services
The implementation of a sophisticated web application often requires the integration of foreign services into the specified application. The web developer desires to be able to integrate off-the-self services into his system. Hypermedia systems are able to provide services such as information organization, authoring, versioning, annotation, sophisticated backtracking, and information restructuring, to name few. The deployment of such Hypermedia functionality into web applications would be valuable. In order to accomplish this target any Hypermedia system should be able to describe on its own the services that it provides and it should also be able to give additional instructions on how to invoke them. Furthermore, this must be done in a standardized formal way, and not with a use of a customized vocabulary, so that an appropriate registry mechanism or a matchmaker [8] accommodates the whole process. Thus, this requirement raises the need for a common format in the description of the various hypermedia services.

The Hypermedia community identified the whole problem and proposed solutions that as a first step tried to facilitate the discovery of Hypermedia services for any potential client. Solutions like the Server Information Management (SIM), which collects server name and location information from servers and distributes it to clients [9], as well as the notion of Hypermedia Resource Descriptors (HRD) that can describe both documents

and servers [10], have been proposed. Furthermore, the Open Hypermedia Protocol (OHP), which was initially designed to address interoperability problems between different hypermedia servers, can be used by a client to discover all the services of a specified hypermedia server [11]. Service discovery via OHP is a powerful tool, but its main disadvantage is that it provides no help for the client to discover the hypermedia server. Finally, an extension of WSDL adapted to Hypermedia systems has been proposed in order to take advantage of the industrial adopted Web services mechanism and offer Hypermedia services as Web services to the web developers [2]. In this paper we go a step further, and we propose the adoption of emerging Semantic Web technologies for Hypermedia systems within this scope. This approach not only facilitates the discovery of Hypermedia services, but it enables the automatic discovery as well as invocation, and possibly composition of them.

2.2 An Ontology for Hypermedia Services

This presented technique does not require rigorous changes in the way Hypermedia systems operate, or the extension of an already established mechanism (like WSDL, and UDDI). On the contrary, it requires only the formation of a domain-specific ontology for Hypermedia services, and then well-known techniques for the creation and use of Semantic Web services can be applied.

As a test bed for this approach we created an ontology based on Hypermedia Service Description Language. HSDL was initially designed and proposed in order to enable Hypermedia systems to describe the capabilities of their provided services. This language provides all the necessary information for a Hypermedia service in order to communicate and interoperate with external applications. Briefly, HSDL (which is described in detail in [7]) includes information about the location, the API, the naming methodology, and the behaviors of the Hypermedia service. HSDL is extendable and open in order to be able to augment new language characteristics and specifications for supporting specific servers or servers of new Hypermedia domains. The developed ontology is actually a mapping of the various fields of HSDL into the appropriate places of OWL-S with the use of OWL. In particular, the `ServiceGrounding` component contains information about the API of the Hypermedia service, the `ServiceProfile` describes the characteristics of the service (like the provider name, and the inputs-outputs-preconditions-effects of the service), and the `ServiceModel` has information about how this particular Hypermedia service works. This description of Hypermedia services is in a both human- and computer-understandable format, and a wide set of tools is available for its manipulation.

The upper-layer ontology can be used by every developer of Hypermedia system in order to specify the provided services. The procedure is simple: This upper-layer ontology acts as a "blueprint" or class definition for the description of the Hypermedia service. The developer creates an instance of this class and sets the appropriate values into the fields of this instance. This can be done by using the various ontology authoring tools, like Protégé [12]. Tools like Protégé are even capable to generate corresponding OWL-S files from existing WSDL descriptions. Later this instance can be uploaded into an appropriate registry. A simple version has already been authored and it is accessible in [13]. This resource also contains an instance that fully describes the Babylon system [2]. Correspondingly we modified the Babylon Web service so as to conform to its description. It is in our imminent plans to investigate the various Component-Based Open Hypermedia Systems [9], as well as the various systems developed under the discipline of Structural Computing [14], like Themis [15], in order to implement corresponding instances, and identify possible required enhancements for the ontology.

2.3 Transition Issues and Benefits

The presented approach is worthy only when there is available a number of discrete Hypermedia services. However in practice, a small number of Hypermedia systems exist and an even smaller number of them were designed from the beginning with a service-oriented approach. That means that in order to exploit the presented features as a first step the Hypermedia systems (with the use of wrappers or other techniques) should make available discrete services. The transition from complex Hypermedia systems to discrete Hypermedia services is a difficult task and requires a lot of effort. Solutions like those presented in [16, 2] try to address this issue. Once we end up with a number of discrete Hypermedia services, then it is a relative easy task to apply the proposed technology.

A significant advantage of this approach is that once an upper-layer ontology is defined for the domain of Hypermedia services, then the corresponding descriptions of all the developed Hypermedia services can easily be created. Additionally, since this ontology is written in OWL-S there have already been implemented developer tools for the creation of the corresponding Semantic Web services, as well as, registries that able to successfully cross-match the demands of users with the actual available Hypermedia services.

A great deal of research effort has been put into Semantic Web services. Several authoring tools, stable supporting frameworks, and implementation methodologies are available. By adopting Semantic Web technologies as the core technology in Hypermedia systems, the Hypermedia community effortlessly inherits tools for the creation of a new generation of Hypermedia systems and solutions for implementation problems. The developer of Hypermedia services is able to focus exclusively on the service logic of the system he develops, and he does not have to worry about minor implementation issues that would otherwise disrupt him and consume time and effort. The service-oriented systems produced would include the features of Semantic Web services and in particular would facilitate the automatic discovery, invocation, composition, interoperation and monitoring of the operation [5] of those Hypermedia services.

Since the majority of the available Hypermedia systems were created in order to address specific issues it is unclear what services each system can provide and how. With the adoption of an ontology for the description of them the researchers have a categorization technique that can help them have a clear view of all the available services and systems in the area.

3. RELATED WORK

The service-oriented approach is yet an emerging trend in Hypermedia systems. Service-oriented systems, like the Multiple Open Services project [16], and the widely adopted (by the Hypermedia community) concept of Structural Computing [14], indicate this. In the literature we can find efforts towards integrating implemented Hypermedia systems or specific services into web applications [17, 18]. However, those efforts are mostly ad-hoc integrations of a specific Hypermedia system or service.

To our knowledge, in the literature, there is no known effort that provides a technique for characterizing and categorizing the various services of Hypermedia systems. On the other hand, the idea of augmenting the concepts of Semantic Web into Hypermedia systems is not new. The critical difference is that almost all the other approaches are based on the ability of the Semantic Web technologies to describe resources and express the relationships between them. Briefly, [19] proposes the usage of ontologies for the data representation in hypermedia systems. In [20] a more formal representation is given with the use of RDF for the data representation. A general agenda for the usage of semantics in Hypermedia systems is presented in [21]. Finally, in [22] a use case is presented where an Open Hypermedia System is implemented using Semantic Web technologies.

4. CONCLUSIONS

It is a necessity for the Hypermedia community to lower the barriers for third-party developers to use services created under the principles of this domain. It is our opinion that the community should adopt new approaches aiming in the creation of systems that take into consideration the service-oriented feature of Hypermedia systems, facilitate openness and guarantee the delivery of cost-effective and robust Hypermedia services. The web developer demands procedures that will provide him with easy-to-find, easy-to-understand, easy-to-integrate, and easy-to-use 3rd party services for his applications [7]. By approaching the implementation of Hypermedia systems with a service-oriented perspective and with the use of Semantic Web tools, the Hypermedia systems developer will be able to provide services with all that demanded features. We implemented an upper-layer ontology that can be used for the description of Hypermedia services, as a first step towards the exploitation of the Semantic Web technologies by Hypermedia systems. This semantic annotation of Hypermedia services can be beneficial. However, before the developers of Hypermedia systems transform their systems in order to take advantage of it, a widely acceptable annotation mechanism for the capabilities of Hypermedia services must be defined. HSDL is a good starting point. It is a challenge for the community to transform it adequately in order to cover all the capabilities of Hypermedia services, and exploit the advantages.

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