OFAUMP: An ontology-based framework for user adaptation and intelligent multimedia presentations

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Abstract

This paper presents an ontology-based framework (OFAUMP), focusing on the coupling of the dynamic presentation model and user model that are main components in the environment of the Semantic Web. In OFAUMP, Private ontology (i.e. user profile), transferred between user terminal devices and a special server, is automatically constructed for each user and shared by web sites/applications in order to realize user adaptation. We optimize Geurts [1] approach to automatically and intelligently generate multimedia presentation with the redefined domain, discourse and media knowledge. To combine the two models mentioned above, a new ontology is introduced, where usable resource for each kind of user and user's path are described. This framework achieves the aims of dynamically selecting and presenting the multimedia data according to user profile in the Semantic Web.

1. Introduction

With the technological projections in the field of the networks and the vertiginous increase of the capacities of calculation of computers, a number of media types (image, audio, and video) come to be added to textual data and constitute now the informational content of most of Web-based Information Systems. From a conceptual point of view, such a Multimedia Web-based Information System (MWIS) is generally organized around the following axes: a data model, a functional model, a presentation model and a user model [2]. The data model offers a representation of the informative content that is managed by the system. The functional model generally describes the content management activities. The presentation model defines the way that the informative content appears in web pages and how to navigate through those pages. The user model aims at representing the needs and characteristics of the system's users. This model is required in order to build a system able to adapt itself to the diversity of its possible users. Such diversity among users can be observed at several levels: they can have different interests, knowledge levels, backgrounds, preferences in terms of presentation and can also use access devices having different characteristics. In this context, presentation features have also to be studied from an adaptation point of view to really provide each user with a MWIS whose set of dimensions is adapted to her/him. Data, functional, presentation and user model are not four isolated parts in a MWIS. On the contrary, the design of MWIS is an inherently knowledge-driven process. It requires sufficient knowledge about the data of domains to be able to convey the essential semantic relations for selecting and managing data. It requires knowledge about how to effectively order, group and prioritize this information and about media design for presentation. Finally, it requires knowledge about user's needs or interests. Unfortunately, deploying professional designers to design MWIS is only feasible if the underlying data, semantics and target audience are relatively homogeneous. The variety of data sources and semantic relations, combined with a variety of output devices and different user profiles, quickly leads to a combinatorial explosion that forces content providers into a one-size-fits-all approach that ignores the different knowledge sources sketched above. Clearly, some form of automation is needed, and this automated process will need to take these knowledge sources into account.

The first ideas of using ontologies for learner modeling have been reported by [3]. [4] also argues for the use of ontologies for reusable and "scrutable" student models. More recently the idea of using sharable data structures containing user's features and preferences are proposed in order to enable personalized interactions with different devices to the user's benefit. For this purpose, a user modeling mark-up language for ubiquitous computing built on XML technology has been proposed as a platform for communication by [5].

Geurts approach concentrates on improving the presentation of the retrieval results. This approach uses ontological domain knowledge to select and organize the content relevant to the topic the user is interested in. Explicit discourse and narrative knowledge allows selection of appropriate presentation genres and creation of narrative

structures, which are used for conveying these domain relations. In addition knowledge of graphic design and media characteristics is essential to transform abstract presentation structures in real multimedia presentations. Geurts approach uses domain and discourse knowledge to transform a semantic graph into a structured progression and than users discourse and design knowledge to transform this into a multimedia presentation. This approach has focused on effectively conveying the relevant domain semantics and being generally applicable.

In this work, we mainly focus on the coupling of the presentation model together with a user model in order to personalize the generated presentation according to each user's profile. Our objective is to propose "Ontology-based Framework for Adaptable User and Multimedia Presentations (OFAUMP)", which is an ontology-based framework for making web sites/applications adaptable to user profile and for intelligently generating multimedia presentations. The approache adopted by OFAUMP: 1) Automatic construction of the *Private* ontology (i.e. user profile) for each user and sharing these ontologies by web sites/applications. This method solves the problems of the cost and multiple required similar procedures, which plagues the conventional system. 2) Automatic and intelligent generation of multimedia presentations with optimized Geurts approach that concentrates on improving the presentation of the retrieval results with redefined domain, discourse and design knowledge. 3) *Resource and Path* ontology that combines the two models mentioned above is introduced.

This paper is organized as follows. The section 2 describes the OFAUMP framework which is the heart of this paper. A scenario is given in section 3 in order to illustrate our approach based on an example of e-learning domain. The section 4 concludes this paper.

3. OFAUMP Framework

Figure 1 shows the architecture of OFAUMP. The user browses web sites or uses the web applications using a user interface (browser) on terminal devices such as PCs, PDAs, cellular phones, etc. Web sites/applications built on OFAUMP use the *Private* ontology to enable a user adaptation. While the user is browsing the web site or using the application, a *Private* ontology is automatically constructed based on the interaction between the user and the web site/application. The constructed *Private* ontology is shared by web sites/applications.

For realizing the purpose of sharing *Private* ontology, each user must have only one *Private* ontology instances. In addition, *Private Ontology* server connected to the web must hold all users' *Private* ontologies instances. When user logs on or logs off web sites/applications, the *Private* ontology will be transferred between *Private Ontology* server and user's terminal device.

There is another server named *Public Ontology* server in the OFAUMP framework. *Public Ontology* server includes three kinds of ontologies concerning each user of system. *Domain*, *Discourse* and *Design* ontology, created respectively by experts of domain, discourse and design, are used to intelligently generate multimedia presentations. Each web site/application should build Resource *and Path* ontology by designers of the web site/application in order to combine presentation model and user model.

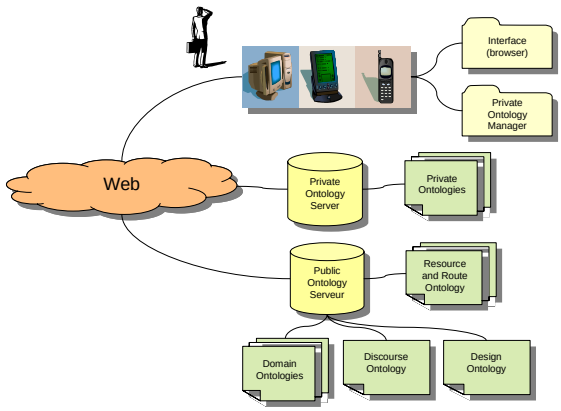

Figure 1: Overview of OFAUMP framework

3.1. User adaptation

Private ontology

A user profile is represented by *Private* ontology. A *Private* ontology is defined as a classified tree written in OWL [6] proposed for Semantic Web [7], which consists of an explicit part provided by user through User Data Editor (UDE) and an implicit part maintained by Intelligent Service (ISV). UDE and ISV are the most important components of Private Ontology Manager (POM) described below. Though the explicit part of *Private* ontology is a very small part and contains a few information, however it remains an important element. User's private information requested by web site/application is entered through the UDE, and added by the UDE into explicit part of *Private* ontology when user first registers in the web site/application. Once logging on again in the same web site/application or even in another different one, the user will get his own *Private* ontology back by matching the user's information of logging on to the content of the explicit part.

The implicit part of *Private* ontology involves three parts: expected Resource, User Path and Presentation. The expected Resource describes the characteristics of user's favorite resource. We record user's preferred trace in User Path so that the user can keep on driving himself on his preferred path from the end point last time. Finally, Presentation defines user's favorite output medium for displaying generated dynamically multimedia presentation.

The implicit part of *Private* ontology is automatically constructed based on interactions between user and web site/application by intelligent service (IS). For example, when a user studies a lesson in an e-learning web site and passes the final exam, it is reasonable to consider that the user has knowledge of that course. On such situation, the resource on the lesson is added to the appropriate category of the implicit part. If necessary, a new category is made or the implicit part is reconstructed.

The *Private* ontology contains resources and its categories. The resource requires a history. This resource has previously been presented to the user who has acquired knowledge about it. Each category has restrictions which are represented by attributes. Because each user acquires different knowledge about a resource, each user has own *Private* ontology. Sharing user ontologies and automatic construction of ontologies solve some problems of conventional adaptive systems, for example, differences in the adaptive precision between systems, or requiring users to answer questionnaire. However, there is another problem concerning the consistency of *Private* ontologies and users' privacy.

The *Private* ontology is constructed by adding resources to ontology. This requires graph manipulations, therefore Document Object Model (DOM) can be adopted, which is an application programming interface (API) for valid HTML and well-formed XML documents. However, if individual web sites are free to construct *Private* ontologies using these manipulations, inconsistency can occur in ontologies. To maintain the consistency of *Private* ontologies, web sites are not permitted to carry out node adding/deleting manipulations directly. They are just permitted to determine when a resource should be added to a *Private* ontology. To select a resource using *Private* ontologies, node referring manipulations such as getNodeName(), getParentNode(), etc. of DOM, are needed. These manipulations might invade user privacy because they specify resources or categories in the *Private* ontology. Therefore, to maintain user privacy, web sites are not permitted to carry out node referring manipulations.

To resolve the problems of consistency and privacy, the direct action such as the construction and the use of the *Private* ontology is performed by POM, is not performed by web sites/applications. Each web site/application can decide when and which action is done, but not how to do it. According to the decision made by the system, the POM decides how to achieve each action and actually performs it.

Private ontology manager (POM).

The Private ontology manager POM located in the terminal devices of user consists of two domain components: UDE and IS which almost achieve all the tasks of POM. The user data editor UDE is a specialized ontology editor for the explicit part of *Private* ontology. The UDE enables the user to enter user data but also to visualize them, revise them and update them afterwards. The definition of the *Private* ontology captures rich metadata about the user profile including characteristics such as user ID, password, email, address, etc.

The intelligent services IS have two main roles in the system: 1) to automatically update and maintain the implicit part of *Private* ontology on the basis of interaction between user and web site/application. The IS supervise user's activities at all time and marks down the appropriate information into the implicit part. 2) To select the appropriate resources to user's needs through using *Private* ontology and *Resource and Path* ontology. The IS queries user's usable resources through the *Resource and Path* ontology and then filtrates these resources through the *Private* ontology in order to gain user's desirable resource.

Private ontology server (POS)

The *Private Ontology* server POS is another main component of the OFAUMP framework. The POS stores *Private* ontologies while users are not accessing a web site. When a user starts to access a web site on OFAUMP, the POS sends the user's ontology to the POM. The POM uses it to select appropriate resource. Then, when the user finishes accessing the web site, the ontology is returned to the POS for storage. Thus, the same *Private* ontology is shared and used to select resources.

To materialize the functions mentioned above, the POS must have some characteristics as follows. First consider the nature of user profile information. Because it constitutes personal data, it needs to be treated rather differently from other parts of an MWIS: it is subject to far tighter requirements for security of the information. For systems to move out of the laboratory, it will have to meet legal requirements such as the European Community

Directive on Data Protection. It is in the spirit of such legislation that users be able to access and control their own data. A server makes sense for the provision of the required security at the same time as ensuring user access and control [9].

Another important problem is that it takes considerable time and effort to build up a detailed user model. When user first comes to an MWIS, they either have to accept a generic interface initially or they have to provide information about themselves. A server should enable the reuse of the user model across web sites/applications. In particular, suppose the user explores one adaptive hypermedia to do some substantial activity such as learning how to program in C language. When he moves to another adaptive hypermedia system that teaches Java, it would be useful for that system to be primed with the user model that has already been built up.

A Generic Transfer Module of POS enables transfer the *Private* ontology between user's terminal device and POS. It might include an interface to identify identity of user when the user takes the *Private* ontology and to check up the validity of the *Private* ontology when user lays it back. The figure 4 shows the user interacting with the Generic Transfer Interface, in turn, interacting with the POS.

The important element of figure 4 is the views of the *Private* ontology available to each web site/application. Another application or web site will typically use a different view. The application writer would define those parts of the user model needed by their application and these would be defined in views established for that application.

Intelligent multimedia presentations

Presentation model that is a view of the static characteristics of an interface is concerned with appearance of information chunks to a user. It is a new abstraction on top of the data model. Traditionally, the presentation model allows describing a presentation according to the three dimensions. The spatial dimension addresses the description of the spatial organization of the presentation components. The temporal dimension defines the presentation scenario. The navigational dimension describes the navigational links which can be activated by the user during the presentation. These three dimensions are generally described in every work which aims at formalizing multimedia presentation. However, little project can personalize data and presentation for each user; at the same time convey the relevant domain semantics.

The evolution of the Semantic Web technology provides a brand-new method for adaptable data and presentation. The Geurts approach is an effective ontology-driven presentation model. It concentrates on improving the presentation of the retrieval results with explicit domain, discourse and media knowledge for conveying the underlying semantics information. However, 1) the Geurts approach didn't consider user's data adaptation. Generally large numbers of retrieval results can't satisfy the request of each user, even though there is explicit semantics between them. 2) though the Geurts approach introduces on *Discourse* ontology for offering the genre of the presentation, this just adapts the presentation on the basis of theme, don't adapts on the basis of user, that is, the different user who queries the same theme will receive the same presentation on the screen. Therefore, a method is necessary for optimizing the Geurts approach.

To solve the two problems described above, we will redefine the *Domain* ontology, *Discourse* ontology and *Design* ontology that are the main components in the Geurts approach. Furthermore, we introduce ontology, named *Resource and Path* ontology, which will cooperate with the Geurts approach and the user model in order to reach our aims.

Redefinition of the Domain, Discourse and Design ontology

Domain ontologies are valuable in the presentation generation process, because effective presentations are those that succeed in conveying the relevant domain semantics to the user. The Geurts approach uses ontological domain knowledge to select and organize the content relevant to the topic the user is interested in. At the present time, building *Domain* ontology is laborious and time consuming. Moreover there is not a one-size-fit-all *Domain* ontology for all the domains. In order to return sufficient knowledge to the user who queries the theme concerned two or many domain such as medicine information system and geography information system, we have to employ multiple *Domain* ontologies.

Fortunately, Web Ontology Language (OWL) provides a owl:imports statement for combining these different *Domain* ontologies. owl:imports statement references another OWL ontology containing definitions, whose meaning is considered to be part of the meaning of the importing ontology. Each reference consists of a URI specifying from where the ontology is to be imported. Syntactically, owl:imports is a property with the class owl:Ontology as its domain and range. The owl:imports statements are transitive, that is, if ontology A imports B, and B imports C, then A imports both B and C. This statement gives us a possibility able to obtain all the relevant data on a theme.

The domain knowledge is used by the presentation generation process through the *Discourse* ontology, which provides three main parts: the Genre class and its subclasses, defining the different genres a presentation can have, e.g. the genre CV and Biography while presenting a artist; the Narrative Unit class and its subclasses, defining the building blocks for each genre, e.g. artist's private life and his career; and the Actant class defining the characters of the presentation. A particular genre and its narrative units, as user path, form the structure of the presentation, that is, the user have to follow the track defined by the creator of *Discourse* ontology. In order to offer the user the maximal liberty, we must define the user path as many as possible without any constraints.
Design ontology, consisting of knowledge of graphic design and media characteristics, is essential to transform abstract presentation structures in real multimedia presentations. Design knowledge determines how the semantics and presentation structure are expressed in the multimedia presentation. As described above, the full-scale *Design* ontology is defined in order to meet all needs of the user. Through the redefinition of these three ontologies, you can find out a rule that we provide the maximal possibility to each user on the retrieval results, user path and media. In the next, we will present how to adapt the multimedia presentation at the first time according to the user by the *Resource and Path* ontology.

The first adaptation by the Resource and Path ontology

The *Resource and Path* ontology is designed and implemented by the creator of web site/application, that is, each web site/application has Resource *and Path* ontology consisting of two parts: Usable Resource and User Path.
In the Usable Resource, we describe all characteristics of the resource that can be applied by the users of this web site/application. This resource is a subclass of the resource of domains, that is, the *Resource and Path* ontology only gathers the resource that concerns their own user and filtrates the irrelevant, redundant and illegal resource. In this way, the resource transferred to the end user is more legible and customized.

The part of User Path defines the possible paths of each role (i.e. teacher, student or administrator), that is, each role has the possibility to navigate across what he wants to go and he is admitted to go. This method gives the user the biggest space in the web site/application according to identity of the user. Certainly the User Path is a subclass of the *Discourse* domain.

Because the web sites/applications generally permit all kinds of media, we have not added the design knowledge into the *Resource and Path* ontology.
The *Resource and Path* ontology clearly defines the resource and the path that can be applied by the user of web site/application. This resource and path have sufficient quantity and semantics in order to be chosen by user.

The second adaptation by the Private ontology

After the first adaptation through the *Resource and Path* ontology, the use has had all the resource and path able to be selected. However, each user might have his own preference on the use of resource and the choice of path. This process is guided by the *Private* ontology which contains the user' information and the user's preference collected automatically by POM in the case of interaction between user and web site/application.

The User Path, the Desirable Resource and Presentation of the *Private* ontology defining user's preferred knowledge correspond respectively to *Domain*, *Discourse* and *Design* ontology. Moreover, the knowledge of these three parts is respectively subclass of the *Resource and Path* ontology and the three ontologies of the Geurts approach (Figure 2).

To represent user's preferred information in the *Private* ontology, we propose a simple weight system. This weight system enables the creator of the *Resource and Path* ontology to give each resources or categories a weight. When the user's POM has decided which resources or categories are preferred by user, the weight of these resources or categories will be added in the *Private* ontology. For example all information about course Pervasive Information System has a hasWeight property that must have same values.

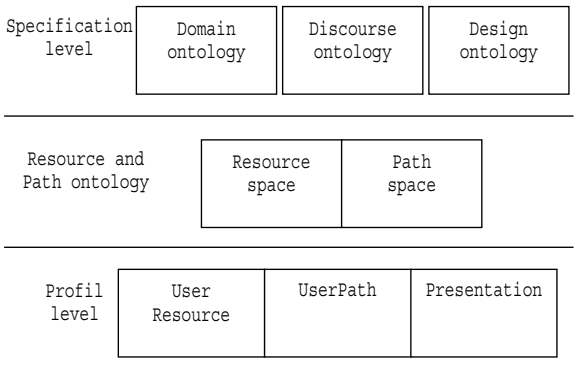

Figure 2: The ontologies levels

4. Example scenario

Theoretically, the OFAUMP framework has completely achieved the aim mentioned at the beginning. We present a working example about a student user who follows some courses in an e-learning web site in order to practically attest to the capability of our framework.

4.1. The first user entry into an e-learning web site

First of all, we will present the e-learning web site where our user can attend some distance courses. This e-learning web site contains two axes of information: user identities and disciplines. The user identities include teacher, student, administrator, etc. Our user is a student who wants to follow some courses (such as Pervasive Information System (PIS), Visual Information System (VIS), etc.) using a Web browser in an e-learning web site. When the user first comes to this web site, he either has to accept a generic interface initially or he has to provide information about himself such as name, password, address, etc. All information is collected by UDE that is a main component of the Private Ontology Manager, and stored by interface DOM into the explicit part of the *Private* ontology which is automatically created by Private Ontology Manager for this user just now. After the registration, the user begins to choose courses. Pervasive Information System is the first course chosen by the user, which belongs to speciality Information System in the discipline Computer Science. In order to know the knowledge level of the user on the course, an evaluation test will be given before the beginning of the course. Finally, from which session will the user start is decided according to the result of the test.

While the user chooses the course and passes the evaluation test, Intelligent Service, the other main component of the Private Ontology Manager, has gathered some information for the implicit part, such as the identity of the user: student, the chosen course: Pervasive Information System and the session which the user will take first: session 2. This information will be mapped to the *Resource and Path* ontology, that is, the Intelligent Service queries the *Resource and Path* ontology by this information. The result returned by the query is a chain of categories that is expressed, in our case, like: Student – Computer Science – Information System – Pervasive Information System – Session 2. Based on this chain, the Intelligent Service constructs the implicit part by node adding manipulation under private:UserPath. After building private:UserPath of *Private* ontology, the Intelligent Service will select suitable resource about the session 2 in order to display it to the student. Firstly, the Intelligent Service queries Resource and Path:UsableResource for all usable resource to the session 2 of course Pervasive Information System. This usable resource being a portion of the resource of the domains can just be applied by the users of this web site. In the next step, the Intelligent Service queries private:DesirableResource for the rules that depict the characteristics of user's desirable resource in order to filtrate large numbers of undesirable resource. Although private:DesirableResource is empty at present, the Intelligent Service will gather the student's activity information and add it in private:DesirableResource for next utilization. Finally, the selected resource combined with the associated semantic relations from the *domain* ontologies is provided for the Geurts approach in the form of RDF graph.

During the student browses pages generated automatically by the Geurts approach for learning the session 2, the related information concerning the Geurts approach is collected and added in private:Presentation by the Intelligent Service, such as the student's preferred kinds of presentations and preferred output medium. The student has to take an exam for evaluating the effect of learning after learning the session 2. Once the student successfully pass the exam, it is reasonable to consider that the user has knowledge of the resource that concerns session 2. On such situation, the resource of session 2 is added to private:UserPath by the Intelligent Service in order to record the track of the user. When the student ends the learning and logs off the e-learning web site, the *Private* ontology will be sent to *Private Ontology* server by the Private Ontology Manager. The Generic Transfer Interface of the *Private Ontology* server examines the validity of the *Private* ontology and put it into the *Private Ontology* server.

4.2. The user reentry into the e-learning web site

After a period of time, our user logs on to the e-learning web site again with user ID and password that are transferred by the Private Ontology Manager to the *Private Ontology* server for identifying the identity of the user. If the result is true, the *Private Ontology* server will send the user's *Private* ontology to the Private Ontology Manager. In this way, our user has had all the information gathered and created the last time, including the point of starting the course, the characteristics of his desirable resource and the preferred genre and output medium of the presentation. The e-learning web site will automatically search the related resource and display it to the user on the basis of this information. In fact, even a single user cannot be considered as a constant unit, because he undergoes changes too, sometime

even in the same session, e.g. mood changes. Our user can change his browse custom or presentation style in the course of learning. All these changes will be noted in the relevant class of the *Private* ontology at any moment.

4.3. The entry of the user into another e-learning web site

Our user stands a good chance of coming into another e-learning web site in order to keep on his study. Traditionally, the user has to register all over again. He entries his private information, chooses an interested course, takes an evaluation test, decides preferred genre of presentation and output medium, etc. Under the OFAUMP framework, all the manipulation described above will be left out. What the user needs to do is just to log himself on with the same user ID and password that he used in the first e-learning web site, and then, the system will perform the tasks presented in the section 3.

5. Conclusion

In this paper, we have proposed an ontology-based framework, called OFAUMP, which aims at offering solutions to the problems frequently encountered while adapting user and generating intelligently multimedia presentations. This framework especially applies to Multimedia Web-based Information Systems in the environment of the Semantic Web. These systems have to deliver and organize a multimedia content in a presentation according to user's needs or interests.

To carry out user adaptation, we use an approach that is automatic construction of the *Private* ontology for each user and sharing the *Private* ontology by web sites/applications. The *Private* ontology as a user profile represents the user's knowledge. The ameliorated Geurts approach gives us a possibility to intelligently generate multimedia presentation through the redefined explicit domain, discourse and media knowledge and to convey domain and discourse relations in multimedia presentations. To combine the user model and the presentation model for personalizing the generated presentation according to each user's profile, *Resource and Path* ontology is introduced. It contains user's navigation and usable resources knowledge that enable to optimize and improve user adaptation and intelligent multimedia presentation. Since the OFAUMP framework is a large project, we have not actually materialized it yet.

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