Personal Readers: Personalized Learning Object Readers for the Semantic Web [1]

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Abstract. This paper describes our idea for personalized e-Learning in the Semantic Web which is based on configurable, re-usable personalization services. To realize our ideas, we have developed a framework for designing, implementing and maintaining personal learning object readers, which enable the learners to study learning objects in an embedding, personalized context. We describe the architecture of our *Personal Reader framework*, and discuss the implementation of personalization services in the Semantic Web. We have realized two Personal Readers for e-Learning: one for learning Java programming, and another for learning about the Semantic Web.

Keywords. web-based learning platforms & architectures adaptive web-based environments, metadata, personalization, semantic web, authoring

1. Introduction

The amount of available electronic information increases from day to day. The usefulness of information for a person depends on various factors, among them are the timely presentation of information, the preciseness of presented information, the information content, and the prospective context of use. Clearly, we can not provide a measurement for the expected utility of a piece of information for *all* persons which access it, nor can we give such an estimation for a single person: the expected utility varies over time: what might be relevant at some point might be useless in the near future, e.g. the information about train departure times becomes completely irrelevant for planning a trip if the departure time lies in the past. With the idea of a Semantic Web [2] in which machines can understand, process and reason about resources to provide better and more comfortable support for humans in interacting with the World Wide Web, the question of personalizing the interaction with web content is at hand: Estimating the individual requirements of the user for accessing the information, learning about a user's needs from previous interactions, recognizing the actual access context, in order to support the user to retrieve and access the part of information from the World Wide Web which fits best to his or her current, individual needs.

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The development of a Semantic Web has, as we believe, also great impact on the future of e-Learning. In the past few years, achievements in creating standards for learning objects (for example the initiatives from LOM (Learning Objects Metadata [13]) or IMS [12]) have been carried out, and large learning object repositories like Ariadne [1], Edutella [7] and others have been built. This shifts the focus from the more or less closed e-Learning environments forward to open e-Learning environments, in which learning objects from multiple sources (e.g. from different courses, multiple learning object providers, etc.) could be integrated into the learning process. This is particularly interesting for university education and life-long learning where experienced learners can profit from self-directed learning, exploratory learning, and similar learning scenarios.

This paper describes our approach to realize personalized e-Learning in the Semantic Web. The following section discusses the theoretical background of our approach and motivates the development of our Personal Reader framework. The architecture of the Personal Reader framework is described in Section 3; here we also discuss authoring of such Personal Learning Object Readers as well as required annotations of of learning objects with standard metadata for these Readers. Section 4 shows the implementation of some example personalization services for e-Learning. Section 4.4 finally provides information about realized Personal Learning Object Readers for Java programming and Semantic Web.

2. Towards personalized e-Learning in the Semantic Web

Our approach towards personalized e-Learning in the Semantic Web is guided by the question how we can adapt personalization algorithms (especially from field of *adaptive educational hypermedia*) in a way that they can be

1. re-used, and
2. can be plugged together by the learners as they like - thus enabling learners to choose which kind of personalized guidance and in what combination they appreciate personalized e-Learning.

In a theoretical analysis and comparison of existing adaptive educational hypermedia systems that we have done in earlier work [10], we found that it is indeed possible to describe personalization functionality in a manner required for re-use, i.e. describe such personalization functionality in encapsulated, independent modules. Brusilovsky has argued in [5], that current adaptive educational hypermedia systems suffer from the so-called *open corpus problem*. Hereby is meant, that these systems work on a fixed set of documents/resources which are normally known to the system developers at design time. Alterations in the set of documents like modifying a document's content, adding new documents, etc., are nearly impossible because they require substantial alterations on the document descriptions, and normally affect relations in the complete corpus. To analyze the open-corpus-problem in more detail, we started in [10] an analysis of existing adaptive educational hypermedia systems and proposed a logic-based definition of adaptive educational hypermedia with a process-oriented focus. We provided a logic-based characterization of some well-known adaptive educational hypermedia systems: ELM-Art, Interbook, NetCoach, AHA!, and KBS Hyperbook, and where able to described them by means of (meta-)data about the document space, observation data (at runtime required data about user interaction, user feedback, etc.), output data, and the processing data - the adaptation algorithms. As a result, we were able to formulate a catalogue of adaptation algorithms in which the adaptation result could be judged in comparison to the overhead required for providing the input data (comprising data about the document space and observation data and runtime). This catalogue provides a basis-set for re-usable adaptation algorithms.

Our second goal, designing and realizing personalized e-Learning in the Semantic Web which allows the learners to customize the degree, method and coverage of personalization, is subject-matter of the present paper. Our first step towards achieving this goal was to develop a generic architecture and framework, which makes use of Semantic Web technologies in order to realize Personal Learning Object Readers. These Personal Learning Object Readers are on the one hand *Readers*, which mean that they display learning objects, and on the other hand *Personal Readers*, thus they provide personalized contextual information on the currently considered learning object, like recommendations about additional readings, exercises, more detailed information, alternative views, the learning objectives, the application where this learning content is relevant, etc. We have developed a framework for creating and maintaining such Personal Learning Object Readers. The driving principle of this framework is to expose all the different personalization functionalities as *services* which are orchestrated by some mediator service. The resulting personalized view on the learning object and it's context is finally determined by another group of services which take care on visualization and device-adaptation aspects. The next step to achieve our second goal is to create an interface component which enables the learners to *select and customize* personalization services. This is object of investigation of our ongoing work. Other approaches to personalized e-learning in the Semantic Web can be taken, e.g. focusing on reuse of content or courses (e.g. [11]), or focusing on metadata-based personalization (e.g [6,3]). Also portal-strategies have been applied for personalized e-Learning (see [4]). Our approach differs from the above mentioned approaches as we encapsulate personalization functionality into specific services, which can be plugged together by the learner.

3. The Personal Reader Framework: Service-based Personalization Functionality for the Semantic Web

The Personal Reader framework [9] provides an environment for designing, maintaining and running personalization services in the Semantic Web. The goal of the framework is to establish personalization functionality as services in a semantic web. In the run-time component of the framework, Personal Reader instances are generated by plugging one or several of these *personalization services* together. Each developed Reader consists of a browser for learning resources *the reader part*, and a side-bar or remote, which displays the results of the personalization services, e.g. individual recommendations for learning resources, contextual information, pointers to further learning resources, quizzes, examples, etc. *the personal part* (see Figure 2). This section describes the architecture of the Personal Reader framework, and discusses authoring of Personal Readers within our framework.

3.1. Architecture

The architecture of the Personal Reader framework (PRF) makes use of recent Semantic Web technologies for realizing a service-based environment for implementing and accessing personalization services. The core component of the PRF is the so-called *connector service* whose task is to pass requests and processing results between the user interface component and available personalization services, and to supply user profile information, and available metadata descriptions on learning objects, courses, etc. In this way, the connector service is the mediator between all services in the PRF.

Two different kinds of services - apart from the connector service - are used in the PRF: personalization services and visualization services. Each *personalization service* offers some adaptive functionality, e.g. recommends learning objects, points to more detailed information, quizzes, exercises, etc. personalization services are available to the PRF via a service registry using the WSDL (Web Service Description Language, [15]). Thus, service detection and invocation takes place via the connector service which ask the web service registry for available personalization services, and selects appropriate services based on the service descriptions available via the registry.

The task of the *visualization services* is to provide the user interface for the Personal Readers: interprete the results of the personalization services to the user, and create the actual interface with reader-part and personalization-part.

The basic implementation guideline in the Personal Reader framework is the following: Whenever a service has to communicate with other services, we use RDF (Resource Description Framework, [14]) for describing requests, processing results, and answers. This has the immediate advantage, that all components of the Personal Reader framework (visualization services or personalization services) can be independently developed, changed or substituted, as long as the interface protocol given in the RDF descriptions is respected. To make these RDF descriptions “understandable” for all services, they all externalize their meaning by referring to (one or several) ontologies. We have developed an ontology for describing adaptive functionality, the l3s-ontology[1]. Whenever a personalization service is implemented, the provided adaptation of this service is described with respect to this adaptation ontology, such that each visualization service can interprete the meaning of the adaptation, and can decide which presentation of the results should be used in accordance to the device that the user currently has, or the available bandwidth. This has the consequence, that local context adaptation (e.g. adaptation based on the capabilities of the user’s device, bandwidth, environment, etc.) is not done by the personalization services, but by the visualization services. Figure 1 depicts the data flow in the PRF.

3.2. Authoring

Authoring is a very critical issue for successfully realizing adaptive educational hypermedia systems. As our aim in the Personal Reader framework is to support re-usability of personalization functionality, this is an especially important issue here. Recently, standards for annotating learning objects have been developed (cf. LOM [13] or IMS [12]). As a guideline for our work, we established the following rule:

[1]http://www.personal-reader.de/rdf/l3s.rdf

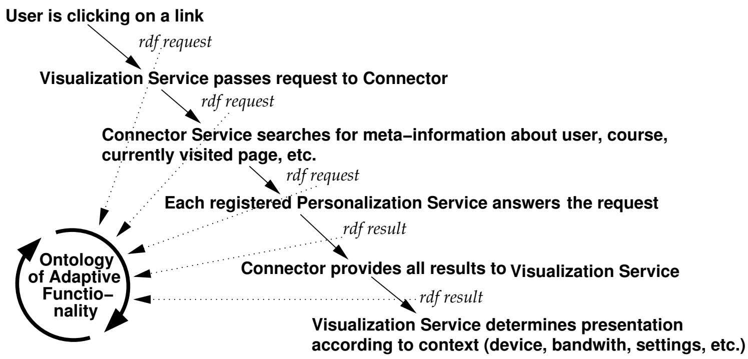

Figure 1. The communication flow in the Personal Reader framework: All communication is done via RDF-descriptions for requests and answers. The RDF descriptions are understood by the components via the *ontology of adaptive functionality*

Learning Objects, course description, domain ontologies, and user profiles *must* be annotated according to existing standards (for details please refer to [8]). The flexibility must come from the personalization services which must be able to reason about these standard-annotated learning objects, course descriptions, etc.

This has an immediate consequence: We can implement personalization services which fulfill the same goal (e.g. providing a personal recommendations for some learning object), but which consider different aspects in the metadata. E.g. a personalization service can calculate recommendations based on the structure of the learning materials in some course and the user's navigation history, while another checks for keywords which describe the learning objectives of that learning objects and calculates recommendations based on relations in the corresponding domain ontology. Examples of such personalization services are given in Section 4.

The administration component of the Personal Reader framework provides an author interface for easily creating new instances of course-Readers: Course materials which are annotated according to LOM (or some subset of it), and which might in addition refer to some domain ontology, can immediately be used to create a new Personal Reader instance which offers all the personalization functionality which is - at runtime - available in the personalization services.

4. Realizing Personalization Services for e-Learning

This sections describes in more detail the realization of some selected personalization services: A service for recommending learning resources, and a service for enriching learning objects with the context in which they appear in some course.

4.1. Calculating Recommendations.

Individual recommendations for learning resources are calculated according to the current learning progress of the user, e. g. with respect to the current set of course materials. As described in Section 3.2, it is the task of the personalization services to realize strategies and algorithms which make use of standardized metadata annotations of learning objects, course descriptions, etc.

The first solution for realizing a *recommendation service* determines that a learning resource `LO` is `recommended` if the learner has studied at least one more general learning resource (`UpperLevelLO`), where "more general" is determined according to the course descriptions: :

```
FORALL LO, U learning_state(LO, U, recommended) <-
  EXISTS UpperLevelLO (upperlevel(LO, UpperLevelLO) AND
                       p_obs(UpperLevelLO, U, Learned) ).
```

Further personalization services can derive stronger recommendations than the previous one (e. g., if the user has studied *all* general learning resources), or less strong recommendations (e.g., if one or two of these haven't been studied so far), etc.

A different realization of a recommendation service can calculate its results with respect to the keywords describing the objectives of the learning object in some domain ontology. In particular, this is an appropriate strategy if a user is regarding course materials from different courses at the same time.

```
FORALL LO, U learning_state(LO, U, recommended) <-
  EXISTS C, C_DETAIL (concepts_of_LO(LO, C_DETAIL)
     AND detail_concepts(C, C_DETAIL) AND p_obs(C, U, Learned) ).
```

Comparing the above strategies for recommendation service we see that some of the recommendation services might provide better results as others - depending on the situation in which they are used. For example, a recommendation service, which reasons about the course structure will be more accurate than others, because it has more fine–grained information about the course and therefore on the learning process of a learner who is taking part in this course. But if the learner switches between several courses, recommendations based solely on the content of learning objects might provide better results. Overall, this yields to a configuration problem, in which we have to rate the different services which provide the same personalization functionality according to which data they used for processing, and in which situation they should been employed. We are currently exploring how we can solve this configuration problem with defeasible logics.

4.2. Course Viewer

For viewing learning objects which belong to some lecture, it is essential to show the learner the context of the learning objects: what is the general learning goal, what is this learning object about, and what are details that are related to this specific learning object. For example, a personalization service can follow the strategy to determining such details by following the course structure (if such a hierarchical structure like sections, subsections, etc. is given). Or it can use the key-concepts of the learning object and determine details with respect to the domain ontology.

The following rule applies the latter approach: Details for the currently regarded learning resource are determined by `detail_learningobject(LO, LO_DETAIL)` where `LO` and `LO_Detail` are learning resources, and where `LO_DETAIL` covers more specialized learning concepts which are determined with help of the domain ontology.

```
FORALL LO, LO_DETAIL detail_learningobject(LO, LO_DETAIL) <-
   EXISTS C, C_DETAIL(detail_concepts(C, C_DETAIL)
     AND concepts_of_LO(LO, C) AND concepts_of_LO(LO_DETAIL, C_DETAIL))
     AND learning_resource(LO_DETAIL) AND NOT unify(LO,LO_DETAIL).
```

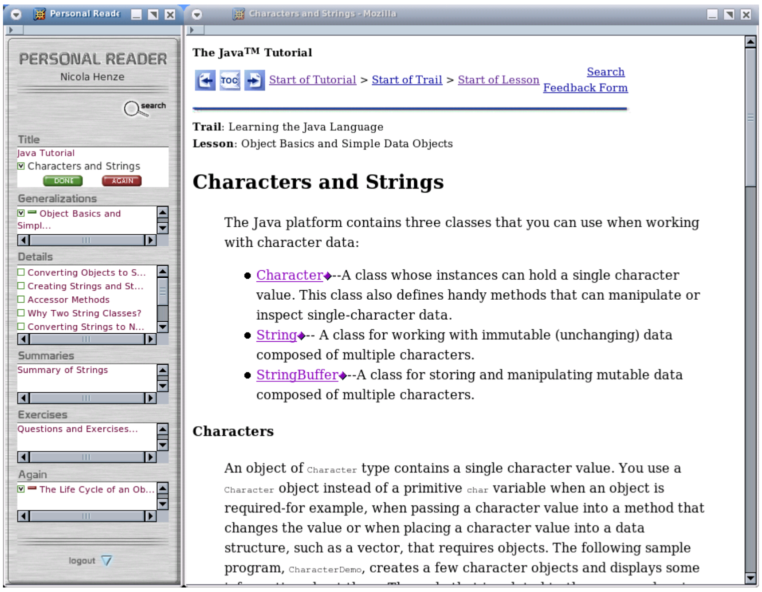

Figure 2. Screenshot of a Personal Reader for a e-Learning course on "Java Programming". The so far implemented Personal Readers are freely available at `www.personal-reader.de`.

4.3. *Basic User Modeling*

At the current state, the Personal Reader requires only few information about the user's characteristics. Thus, for our example we employed a very simple user model: This user model traces the users path in the learning environment and registers whenever the user has visited some learning resource. This simple user model is queried by all personalization services; updating the user model is task of the visualization services which provide the user interface and monitor user interactions.

4.4. *Examples of Personal Learning Object Readers*

Up to now, we have developed two Personal Learning Object Readers with our environment: A Personal Reader for learning the Java programming language (see the screenshot in figure 2), and a Personal Reader for learning about the Semantic Web. The Personal Reader for Java uses materials from the online version of the Sun Java Tutorial[2], while the one for learning about the Semantic Web uses materials of a course given at University of Hannover in summer 2004[3].

5. Conclusion and Future Work

This paper describes our approach for realizing personalized e-Learning in the Semantic Web. Our approach is driven by the goal of realizing a Plug & Play architecture for per-

[2]http://java.sun.com/docs/books/tutorial/
[3]http://www.kbs.uni-hannover.de/ henze/semweb04/skript/inhalt.xml

sonalized e-Learning which allows a learner to select, customize and combine personalization functionality. To achieve this goal, we have developed a framework for creating and maintaining personalization services, the *Personal Reader framework*. This framework provides an environment for accessing, invoking and combining personalization services, and contains a flexible, service-based infrastructure for visualizing adaptation outcomes, and for creating the user interface. Up to know, we have realized two Personal Readers (for the domains of Java programming and Semantic Web). Currently, we are implementing further personalization services, and are extending the user modeling component of the Personal Reader framework. Future work will include an improved way for combining personalization service, and for detecting and solving potential conflicts between the recommendations of these services.

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