Personalisation Services for Self e-Learning Networks*

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Abstract. This paper describes the personalisation services designed for *self e-learning networks* in the SeLeNe project. These include personalised search results, view definition over learning object metadata, metadata generation for composite learning objects and personalised event and change notification services.

1 Introduction

Life-long learning and the knowledge economy have brought about the need to support diverse communities of learners throughout their lifetimes. These learners are geographically distributed and have heterogeneous educational backgrounds and learning needs.

The SeLeNe (*self e-learning networks*) project is investigating the feasibility of using semantic web technology to support learning communities and match learners' needs with the educational resources potentially available on the Web. SeLeNe relies on semantic metadata describing educational material, and is developing services for the discovery, sharing, and collaborative creation of *learning objects* (LOs). A SeLeNe will facilitate access to LOs by managing their metadata descriptions. In order to enable effective search for LOs in a SeLeNe, LO descriptions conform to e-learning standards such as IEEE/LOM (Learning Object Metadata), and also employ topic-specific taxonomies of scientific domains such as ACM/CCS (Computing Classification System) or taxonomies of detailed learning objectives. LO schemas and descriptions are represented in the Resource Description Framework/Schema Language (RDF/S), which offers advanced modelling primitives for the SeLeNe information space.

The diversity and heterogeneity of the communities we envisage using SeLeNes means that no single architectural design will be suitable to support all of

* A longer version of this document that includes detailed examples is available from the SeLeNe project website: http://www.dcs.bbk.ac.uk/selene.

them. We have thus defined a service-based architecture that can be deployed in a centralised, mediation-based or peer-to-peer fashion, so the deployment option best addressing the needs of any particular learning community can be chosen (see [1]). Figure 1 illustrates the service architecture of a SeLeNe. The facilities that are the focus of this paper are provided by the User Registration, LO Registration, Trails and Adaptation, Event and Change Notification, and View services.

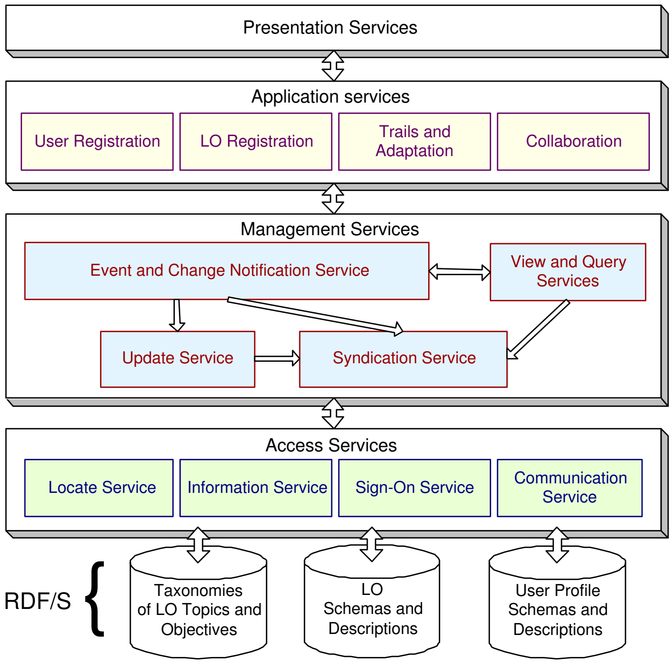

Fig. 1. SeLeNe service architecture

The users of a SeLeNe will include *instructors*, *learners* and *providers* of LOs. When registering, users will supply information about themselves and their educational objectives in using this SeLeNe, which forms the basis of their *personal profile*. LO authors maintain control of the content they create and will be free to use any tools they wish to create their LOs before registering them. We call such LOs, created externally to SeLeNe, *atomic LOs*. Users will also be able to register new *composite LOs* that have been created as assemblies of LOs already registered with the SeLeNe. The taxonomical descriptions for these LOs can be automatically derived by the SeLeNe from the taxonomical descriptions of its constituent LOs and this process is discussed in Sect. 2. The SeLeNe will provide facilities for defining personalised *views* over the LO information space, discussed in Sect. 3, and also personalised searching facilities, discussed in Sect. 4. Provision of automatic change detection and notification facilities allowing personalised notification services depending on users' profiles is discussed in Sect. 5.

2 Registration of LOs

Registration of a LO with a SeLeNe consists of providing a metadata description including the URI of the LO. An important feature of SeLeNe's LO Registration service will be the ability to automatically infer the *taxonomical* part of the description for a composite LO o, from the taxonomical descriptions of its component LOs $o_1, \ldots, o_n$. This description, which 'summarises' the taxonomical descriptions of the parts of o, is called the *implied taxonomical description* (ITD) of o. This is used to augment the *publisher taxonomical description* (PTD) – the set of terms supplied by the LO's provider (which can be empty) – to derive the final taxonomical description used to register the composite LO.

The ITD of a composite LO o expresses what its parts have in common – only terms reflecting the content of all parts are included in the ITD. A LO may thus generate different ITDs depending on what its 'companion' parts are within a composite LO.

The ITD of a composite LO o composed of parts $o_1, \ldots o_n$ with descriptions $D_1, \ldots, D_n$ is computed by a simple algorithm that takes the cartesian product of $D_1, \ldots, D_n$, computes the least upper bound of each n-tuple and then 'reduces' the resulting set of terms by removing all but the minimal terms according to the subsumption relation $\preceq$ between the terms of the taxonomy. The overall taxonomical description of a LO o is computed by another simple algorithm: if o is atomic then its taxonomical description is just its PTD. Otherwise its taxonomical description is recursively computed from its PTD and the taxonomical descriptions of its constituent parts. Readers are referred to [2] for more details of both algorithms.

3 Declarative Queries and Views

Finding LOs in a SeLeNe will rely on RQL [3], a declarative query language offering browsing and querying facilities over the RDF/S descriptions that form the SeLeNe information space.

As well as the advanced querying facilities provided by an expressive RDF/S query language such as RQL, personalisation of LO descriptions and schemas is also needed. For instance, a learner might want LOs presented according to his/her educational level and current course of study. To enhance the SeLeNe user's experience we need the ability to personalise the way the information space can be viewed, by providing simpler virtual schemas that reflect an instructor's or learner's perception of the domain of interest. This will be done by using the RVL language [4], which provides this ability by offering techniques for the reconciliation and integration of heterogeneous metadata describing LOs, and for the definition of personalised views over a SeLeNe information space.

One of the most significant features of RVL is its ability to create virtual schemas by simply populating the two core RDF/S metaclasses *Class* and *Property.* A SeLeNe user can then easily formulate queries *on the view* itself. RVL can also be used to implement advanced user aids such as *personalised navigation* and *knowledge maps.*

4 Trails and Query Adaptation

Personalisation of query results will rely on the *personal profile*. This is an RDF description of the user including some elements from existing profile schemas (PAPI-Learner and IMS-LIP), some of our own elements (we have defined RDF schemas for expressing competencies, learning goals and learning styles), and a history of user activity that will allow the profile to adapt over time.

Although the underlying query mechanism in SeLeNe is RQL, users will mostly search for LOs using simple keyword-based queries. Search results will be personalised by *filtering* and *ranking* the LOs returned according to the information contained in the user's personal profile. This is done by the Trails and Adaptation service, which constructs personalised RQL queries for execution and generates personalised rankings of query results by matching the personal profile against relevant parts of the LO descriptions.

SeLeNe will give the user the option of having their query results presented as a list of *trails* of LOs, suggesting sequences of LO interaction. These trails will be automatically derived from information contained in the LO descriptions about the semantic relationships between LOs. We have defined an RDF representation of trails as a sub-class of the RDF *Sequence* (a sequence of LOs) with two associated properties, *name* and *annotation*.

5 Event and Change Notification

We provide SeLeNe's reactive functionality by means of event-condition-action (ECA) rules over SeLeNe's RDF/S metadata. This includes features such as:

- automatic propagation of changes in the description of one resource to the descriptions of other, related resources (e.g., propagating changes in the taxonomical description of a LO to those of any composite LOs depending on it; propagating changes in a learner's history of accesses of LOs to the learner's personal profile; automatic generation and update of 'emergent' trails);
- automatic notification to users of the registration of new LOs of interest to them;
- automatic notification to users of changes in the description of resources of interest to them.

SeLeNe's RDF ECA rules will be automatically generated by the higher-level Presentation and Application services, and may be resource-specific or generic (i.e., they might or might not reference specific RDF resources).

Peers that support the Event and Change Notification service will run an *ECA Engine* consisting of three main components: an *Event Detector*, *Condition Evaluator* and *Action Scheduler*. The Query service is invoked firstly by the Event Detector to determine which rules have been triggered by the most recent update to the local description base, and again by the Condition Evaluator to determine which of the triggered rules should fire. The Action Scheduler generates a list of updates from the action parts of these rules, which are then passed to the Update service for execution. We refer the reader to [5] for a description of the syntax and semantics of our RDF ECA rules, and some examples.

6 Concluding Remarks

This paper has described several novel techniques for providing the personalisation services of *self e-learning networks*. The novel aspects of SeLeNe compared with other related systems[4] include:

- collaborative creation and semi-automatic description of composite LOs;
- declarative views over combined RDFS/RDF descriptions (i.e. over both the LO descriptions and their schemas);
- personalised event and change notification services;
- automatic generation of trails of LOs from their descriptions.

We are currently implementing and integrating the components of SeLeNe. A number of open issues remain. Firstly, there is as yet no standard query or update language for RDF, although we believe that the RQL, RVL and RDF ECA languages we have described here provide sound and expressive foundations for the development of such standards. Secondly, whatever standards eventually emerge for such RDF languages, if ECA rules are to be supported on RDF repositories then the event sub-language for RDF ECA rules needs to be designed so that it matches up with the actions sub-language; another important open area is combining ECA rules with transactions and consistency maintenance in RDF repositories. Thirdly, our algorithms for personalised ranking of query results need to be empirically evaluated. Finally, the design of user interfaces enabling easy and intuitive access to SeLeNe's advanced personalisation services will be crucial – users will need to be shielded from the complexities of RDF and the RQL, RVL and ECA languages, and also from the complex taxonomies of topics, competencies and goals in use by the system.

References

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[4] Such as UNIVERSAL (`www.ist-universal.org`), Edutella (`edutella.jxta.org`), Elena (`www.elena-project.org`), SWAP (`swap.semanticweb.org`).