CELEBRATE's Lessons

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Abstract. The CELEBRATEproject developed and successfully demonstrated a federated learning object brokerage system architecture and made available to schools over 1350 learning objects produced by both public and private sector content developers. Despite its encouraging results in terms of acceptance by the participating teachers and pupils, some of the assumptions the technical infrastructure was originally designed upon proved to be problematic, which hampered broader adoption of the proposed solution.

1 Introduction

CELEBRATE was a strategic, large-scale (_7M Information Society Technologies – IST) demonstration project that ran from June 2002 to November 2004. It developed and successfully demonstrated a federated learning object brokerage system architecture and made available to over 319 schools in six countries approximately 1350 learning objects produced by both public and private sector content developers.

Thanks to this infrastructure, the project permitted us to demonstrate that:

- Teachers are enthusiastic about Learning Objects (LOs);
- Emerging standards (for interoperability) make it easier for schools to exchange and reuse LOs;
- Given simple, user-friendly authoring tools, teachers who are experienced with information and communication technology (ICT) are capable of developing high-quality learning resources;
- Several Ministries of Education are interested in supporting national teams of teacherdevelopers and finding new mechanisms in order to quickly develop a critical mass of "open content" and are particularly interested in exchanging resources via a new educational content web portal.

Despite these encouraging results, some assumptions that the project was originally built upon proved to be problematic (and in retrospect somewhat naive). They hampered broader adoption of the developed infrastructure. This paper reviews these assumptions and attempts to explain what went wrong. A brief overview of the interoperability aspects of the project is provided in Section 2. The technical infrastructure of CELEBRATE is discussed in Section 3.
The approach used to build semantic interoperability is discussed in Section 4. Finally, digital rights management is discussed in Section 5.

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2 An Overview of CELEBRATE

CELEBRATE aimed at providing an easy way for teachers and pupils to get access to learning resources scattered between different e-learning systems: online educational portals, learning (content) management systems, and learning object repositories[1].

The access to resources consisted of four steps:

(1) Search the pool of existing resources;
(2) Assess their usefulness on the basis of search results;
(3) Obtain relevant resources and (re)use them transparently regardless of the technical complexity associated with the resources and the technical platforms involved, and
(4) Do all this in a way that respects the intellectual property associated with the resources involved.

This scenario was made possible by federating the participating e-learning systems around a brokerage system. This approach had the advantage of being more flexible than more centralized architectures and less complex than peer-to-peer solutions, the two architectures on which already existing networks of learning object repositories were based at that time [VAM04]. It provided a good balance between trust and autonomy. It was decentralized enough to allow content providers to manage their collections autonomously and was secure enough to ensure the trust necessary when dealing with content for sensitive groups like pupils.

The CELEBRATE brokerage system was responsible for:

- Carrying and routing messages exchanged by the federation members (technical interoperability);
- Enforcing semantic interoperability; and
- Digitally managing rights.

3 Technical Interoperability: All Or Nothing ?

Although most e-learning systems (or systems) are connected to the Internet, they can be seen as isolated islands of knowledge. Their content is ignored by search engines, which are generally not able to get access to, and to index, the resources hidden in the system repositories. One of the first problems to be solved by CELEBRATE was to break the isolation of the participating systems by putting in place an infrastructure that makes their content accessible (i.e., discoverable and exchangeable).

As already mentioned, the central part of this infrastructure was a brokerage system (or broker), with which registered systems opened sessions in order to exchange messages. In this infrastructure, no direct exchange between systems was allowed, except those explicitly authorized by the broker. Systems authenticated transactions and messages via synchronous calls to webservices. Messages such as the

[1] In addition, one of the project objectives consisted of understanding, from a pedagogical standpoint, how these new types of standards-based learning resources commonly referred to as "learning objects" are used and re-used in classrooms and what is their pedagogical impact.

queries used during a federated search were Java Messaging Service (JMS) asynchronous text messages.

E-learning systems avoided the hassle of implementing such a complicated communication scheme by using a special software library (or brokerage client) that hid the complexity of the system-broker communication behind a simplified application program interface (API). This technique led to a first communication protocol that let systems focus on the content of messages (e.g., query, result set) without having to worry about the lower-level details of message exchanges.

Despite the relative simplicity of the low-level protocol necessary to use its communication infrastructure, CELEBRATE was victim of its ambition to offer a complete solution for the discovery and exchange of learning resources. All together, a dozen messages based on approximately the same number of XML schemas were necessary to carry out activities such as federated searching [ML04], semantic interoperability [MVA03], learning resources exchange [VAM04] and digital rights management (DRM) [CS03, SC04]. For an e-learning system that wanted to join the federation, it was necessary to support all of them, even when only a subset of them was actually useful to the system under consideration. For example, the DRM protocols are not needed for systems that provide only free resources. As a consequence, it was quite a complex task to connect to the federation. The only result of this all-or-nothing integration policy (that wanted to force systems to "do things well") was to discourage people. As a consequence no one joined the federation after the project.

4 Semantic Interoperability: Is It Affordable ?

Even when they are publicly available online, the dynamic and multimedia nature of most learning resources makes them unlocatable using text-based search engines such as Google which, in addition, return results that are difficult to assess by teachers and pupils. This problem is usually solved by creating metadata to "adequately" describe learning resources.

In CELEBRATE, "adequately" meant adapted to the context of primary and secondary schools in Europe. The problem was three-fold:

- Primary and secondary schools have specificities in terms of organization, pedagogy, and curriculum.
- Although commonalities exist, these specificities vary from one European country (or region) to another.
- In Europe, multilingualism is the rule, not the exception.

These issues were addressed by profiling the IEEE 1484.12.1 Learning Object Metadata Standard (IEEE LOM) [IEE02] as follows:

- Mandatory, recommended, and optional elements of the IEEE LOM standard data model were defined. For example, "Age Range", which was considered as the best way to refer to the audience of a resource regardless of the school system under consideration, was made mandatory.

• New elements were added (such as element 6.4 "CELEBRATE Digital Rights" that permitted the expression of rights associated with a learning resource in a machinereadable form).
• New controlled vocabularies were created, including for "Learning Resource Type".

Each new vocabulary was designed to take into account the specificities of primary and secondary education in Europe. In addition, each vocabulary was translated in different European languages including a neutral form that was used as an interlanguage during the search and exchange of resource descriptions.

Following the CELEBRATE approach, the conformance of the metadata used in the federation to this CELEBRATE metadata application profile [NVA03] was enforced by the brokerage system.

This worked reasonably well. Thanks to the CELEBRATE application profile, a teacher belonging to a school system was able to retrieve a resource created and described in another language (and in the context of another school system).

This being said, the a priori description of resources according to the application profile also has drawbacks. It requires specialized indexers. Its cost in time and money is proportional to the number of resources to describe, which makes expensive the indexing of large collections of resources. In addition, it potentially restricts the use of the resource. For example, the CELEBRATE evaluation demonstrated that a resource described by a publisher as a "drill and practice" learning object could actually be used in more innovative ways (e.g., for collaborative learning) by an experienced teacher, thereby rendering the "Learning Resource Type" description as somewhat inaccurate.

Moreover, as time went by, requirements evolved and it became necessary to adapt the application profile. Although the adaptation itself is a tedious process (it is necessary to collect requirements, build consensus, ensure backward compatibility, translate), the main difficulty of the task consists of finding an affordable way to convert existing metadata to the new application profile.

5 Digital Rights Management: What For ?

Content is a key factor to attract users in a federation such as the one developed by CELEBRATE. The project targeted commercial content providers and, at their request, put in place a technical infrastructure necessary to digitallymanage the rights associated with the learning resources exchanged through the federation.

The digital rights management (DRM) mechanism [SC04] was based on a subset of the Open Digital Rights Language (ODRL) [Ian02]. It permitted description of the rights associated with each resource and storing of these descriptions in the learning resource metadata.

The rights document included in the resource metadata corresponded to an offer. Once a resource requester had the offer, the next step was to initiate a negotiation with the provider and to instantiate an agreement that binds both parties; the requester and the provider. An agreement is dynamic by nature. For instance, a permission may

be granted for a specific number of accesses to the resource, which requires a proper accounting of the resource use.

It was the responsibility of the brokerage system to store and enforce the agreement. Each time a resource was requested, the brokerage system checked that a valid agreement existed and that all preconditions and constraints were met before authorizing the use of the resource by returning a handle to it.

One of the lessons learned in CELEBRATE was that commercial content providers were not ready and/or did not yet have a business model for providing content through a federation. They were unable to define the rights they wanted to associate with their resources although the technical infrastructure to support these rights was in place.

CELEBRATE was a demonstration project; within the available budget, there was only the ambition to develop a critical mass of content in a limited number of curriculum subjects to have a credible validation of the approach with schools. At the end of the project, commercial content providers, although interested in a new channel of distribution (they supplied hundreds of learning objects), did not yet have clear business models to deliver content through the infrastructure. On the other hand, potential users, although interested in the CELEBRATE resources, found the number of available learning objects too limited. This led to a chicken and egg situation: not enough users to draw content providers' attention and not enough content to keep users.

6 Discussion

As a demonstration project, CELEBRATE was a success that proved the usefulness of exchanging and reusing learning resources. This being said, it also showed that proposing a theoretically sound interoperability solution is not sufficient to have this solution adopted.

In our opinion, it should be possible to overcome this limitation by:

- Limiting the role of the brokerage system to carrying and routing messages exchanged by the federation members rather than trying to enforce semantic interoperability. Semantic interoperability will become the responsibility of the federation members that will rely on the brokerage clients to support the negotiation of common metadata formats.
- Making the proposed solution more scalable by breaking the functionalities of the brokerage system into independent services (e.g., resource discovery, resource exchange, semantic interoperability, digital rights management) that can be used separately and combined with any (group) of the others. When connecting a new system to the federation, it should be possible to start with a limited number of services in order to make the integration effort proportional to the number of services being integrated.
- Initially focusing on linking repositories that have large collections of open content in order to obviate some of the more problematic DRM issues and to quickly make available the criticalmass of quality content necessary tomake the federation attractive.

- Trying to improve the quality and quantity of metadata and to lower their costs with new approaches to automatic metadata generation.
- Experimenting with new approaches to social tagging involving teachers as a way to improve the accuracy of the descriptions of "Learning Resource Type" and to help decrease the costs of volume metadata creation.

Since October 2005, these new approaches are partly applied in the context of a European project called CALIBRATE that aims to support the collaborative use and exchange of learning resources in schools. A more detailed description of the technical aspects of these approaches can be found in [CM06]. In addition, it is planned to evaluate automatic metadata generation and social tagging techniques during another European project named MELT that will start in October 2006.

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