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Integrating Adaptive Educational Content into Different Courses and Curricula

Charalampos Karagiannidis
Informatics and Telematics Institute (I.T.I.)
Centre for Research and Technology – Hellas (CE.R.T.H.)
1, Kyvernidou Str., Thessaloniki, GR-54639 Greece
Tel.: +30 31 868324, 868785, 868580, internal 105
Fax: +30 31 868324, 868785, 868580, internal 213
karagian@iti.gr
http://www.iti.gr

Demetrios Sampson
Informatics and Telematics Institute (I.T.I.)
Centre for Research and Technology – Hellas (CE.R.T.H.)
1, Kyvernidou Str., Thessaloniki, GR-54639 Greece
Tel.: +30-31-868324, 868785, 868580, internal 105
Fax: +30-31-868324, 868785, 868580, internal 213
sampson@iti.gr
http://www.iti.gr

Fabrizio Cardinali
GIUNTI Interactive Labs S.r.l.
Via al Ponte Calvi 3/15, 16124 Genova, Italy
Tel.:+39 010 2465178
Fax: +39 010 2465179
f.cardinali@giuntilabs.it
http://www.giuntilabs.it

ABSTRACT

This paper addresses the problem of automatically integrating adaptive content into different courses and curricula, thus exploiting the potential of the Internet in education. The paper focuses on the work of the IST KOD "Knowledge on Demand" European project in this context, for developing adaptive content in an interoperable and interchangeable format, so that it can be easily transferred across different Internet-based personalised learning applications and services.

Keywords

Internet-based education, Personalised learning, Adaptive content, *e*Learning standards

1. Introduction and Background

The rapid evolution of Information and Communication Technologies (ICT) and the emergence of the Information Society create numerous new opportunities for the improvement of the quality of education. Especially the Internet and the WWW facilitate mouse-click access to enormous information repositories, and learning material and services, providing an unprecedented potential for education and training. On the other hand, it can be argued that education has not yet realised the full potential of the Information Society: "there is a shortage of solid evidence to back up the belief that telematic learning systems provide real advantages" (European Commission, 2000). Besides the apparent benefits for delivering education to distance learners independently of time and location, several studies question whether there is a "significant difference" with respect to learning effectiveness when ICT is employed in education (Russell, 1999; Gilbert & Han 1999).

Personalised learning (PL) is widely considered as one promising direction towards the full exploitation of the potential of the Information Society in education (Cronbach & Snow, 1997; Corno & Snow, 1986; Sararin, 1998). PL advocates that it is the learning context that should be adapted to the individual learner, as opposed to "traditional" learning settings, where it is the learner's responsibility to adapt to the learning context in order to maximise the "learning outcome". Along the same lines, personalised (adaptive and intelligent) learning environments have attracted considerable attention, since they constitute the "enabling technology" which can

realise the PL concept (Park, 1996). Despite the intensive R&D efforts in this field, however, PL technology – intelligent tutoring systems (Shute & Psotka, 1996), adaptive educational hypermedia (Brusilovsky et al, 1998), intelligent pedagogical agents (Johnson et al, 2000)– is still far from being mainstream (Brusilovsky et al, 2000).

One of the most important reasons for this fact, and the "under-exploitation" of ICT (and especially the Internet) in education, in general, is that the information available in the Internet is generally "unstructured". There are several on-going international efforts for the development of standards for the description of the (educational) information available in the Internet (towards the "semantic web"): one can easily describe, for example, the structure and contents of learning resources through educational meta-data, content packaging information, etc.

On the other hand, it is still not feasible to describe the conditions that determine which part(s) of the educational material are appropriate for different learner characteristics. As a result, and also due to the limitations of currently available searching technologies, educational applications retrieve the same material for all learners (or, for the "average learner"), without taking into account the diverse needs of each individual learner (e.g. previous knowledge, background, skills, preferences). Therefore, the material available at the Internet cannot be fully exploited, and thus the Internet is under-exploited from an educational point of view (i.e. Internet content is not "educationally useful"), both for "formal" curriculum-based, as well as in self-directed, "informal" educational settings, vocational training, and other learning settings.

This paper addresses the problem of automatically integrating adaptive content into different courses and curricula, thus exploiting the potential of the Internet in education. In the context of this paper, "adaptive content" refers to learning material that can be adapted to the requirements of different learners. This is to differentiate from the way that the term "adaptive technologies" is used in the USA, where it usually connotes those technologies that are used to assist people with handicaps to use computers, and include screen enlargers, pointing devices and other items.

The paper focuses on the work of the KOD "Knowledge on Demand" European project (see acknowledgements section) in this context. The KOD project is working on developing methodologies, techniques and tools for developing adaptive content in an interoperable and interchangeable format, so that is can be easily transferred across different Internet-based personalised educational applications and services. The aim is that (potentially any) content available in the Internet can be directly, effectively and smoothly integrated into different educational settings.

2. Overview of the KOD Project

The main scope of the KOD project is to make a contribution to the thematic area of "Open Platforms and Tools for Personalised Learning" of the European Commission, by the design, development and validation of a novel dynamic and adaptive Learning Environment, which enables the individual learners to acquire knowledge just-in-time, anytime and anywhere through the World Wide Web, tailored to their personal learning needs.

The key objectives of the KOD project can be summarised as follows:

- *Tools for Personalised Learning*: to design, develop and test the KOD Learning Environment, as a dynamic and adaptable on-line environment which allows the individual learner to acquire knowledge according to his/her personal learning needs
- *Pedagogical/Didactical Methodology*: to provide the pedagogical/didactical methodology framework to support both the learner and the host organisation in achieving their educational and training objectives, through the use of the KOD system, in a cost-effective and efficient way
- *Learning Resources*: to provide original, reusable learning material of European added-value in order to support the pilot implementation and the demonstration of the KOD System
- *Assessment and Validation*: to provide evidence for issues such as efficiency, scalability and cost-effectiveness from the pilot implementation and use of the KOD system in two different learning settings with different discipline subjects
- *Dissemination*: to contribute to the emerging international and European standardisation efforts in the area, to interact with other EC initiatives towards the sharing of best practice examples and methodologies at a European level, and to demonstrate the achievements of the project to the public
- *Exploitation*: to investigate possible opportunities for market exploitation and commercialisation of the KOD Project Results

In this context, KOD aims to address the up-rising and pervasive needs originating in contemporary Information Society for the effective and efficient distribution of electronically published information, and the provision of personalised learning services in order to favour life-long learning and knowledge transfer experiences through the Web. KOD devises a unique novel approach to dissecting and distributing knowledge , to achieve the goals of life-long learning and information processing in a learning community, while preserving the accumulated knowledge along with introducing new, updated and dedicated knowledge. The idea behind the KOD system is the generation of personal learning paths ("knowledge routes"), generated and updated based on users' (learners') characteristics (background, interests, skills, etc), which are constantly monitored and profiled.

According to the KOD project, "knowledge packets" are thought of as the smallest building blocks addressed within a knowledge transfer process, where learning and information skills are acquired by end users by means of self-directed, personalised and adaptive knowledge routes. These knowledge routes are dynamically tailored to the users needs, prerequisites and goals, chaining knowledge packets in a personalised and flexible environment free to navigate and explore. Knowledge packets may be automatically identified based on inferred user profiles, and chained from internal and external sources, being a full training course on any available format and support, a selected number of Web pages within thematic vertical information portals, and/or any specific multimedia assets stored in the internal KOD repository or in any other online source. The main advancement of KOD technology is the dynamic and flexible combination of knowledge packets into a unique, dynamic and evolving learning and information gathering path (knowledge route), personalised to any specific user and based on his/her experience, prior knowledge and advancement rate, etc.

In the KOD project, the user is the central focus, enabled to self direct and explore different information acquisition paths (knowledge routes) by means of software agents supporting his/her modelling, profiling, needs identification, information collection, collation and transfer, i.e. his/her knowledge acquisition process. In order to better learn/inform the user, the KOD system utilises specific user assessment tools, embodied by intelligent software agents, that can continuously monitor the user's progress, and evaluate his existing knowledge, target objectives and needed information while operating the system.

3. Developing Interchangeable Adaptive Educational Content - Making the Internet "Educationally Useful"

As it has been described in the previous section, the KOD Project aims to implement advanced learning and information dissemination techniques, based on user profiling and consequent dynamic content chaining. Therefore, one key operational issue for the success of the KOD project is the development of adaptive interchangeable and interoperable content, open to integration and communication with third party learning repositories and vertical information portals. To this end, KOD aims to build on, and extend existing and emerging international *e*Learning standards, so that the KOD system can easily post adaptive educational content that can be accessed by other educational applications and services; and, similarly, access information posted by third party educational information providers.

The IEEE LTSC Committee proposition for *e*Learning standards (ltsc.ieee.org) is currently gathering an increasing momentum in the Web publishing and *e*Learning arena, as the converging standard integrating pre-existing achievements in both the European Community (e.g. ARIADNE project – ariadne.unil.ch; PROMETEUS initiative – prometeus.org; CEN ISSS – www.cenorm.be/isss) and the USA (e.g. the AICC Committee – www.aicc.org; the IMS Project – www.imsproject.org; the ADL Initiative – www.adlnet.org).

The proposed IEEE standards already encompass (or will, in the next future, mainly by means of the endorsement and ratification of IMS and AICC achievements) all aspects of a standard *e*Learning architecture (e.g. the LTSA, Learning Technologies Standard Architecture), from the description of learning objects meta-data based on shareable XML-based data structures (i.e. LOM, Learning Objects Metadata Schemas), to the assessment of user performances (i.e. QTI, Question and Testing Interoperability Schemas), including standard multimedia components wrapping and delivery (i.e. Content Packaging and content API interfacing to underlying CMI – Computer Managed Instruction systems).

On the other hand, it can be argued that existing standards do not adequately support the definition and interchange of reusable adaptive and flexible learning methods which are beyond the "rigid" approach of directive, curricular-based, linear learning, as enabled by the envisaged hierarchical structure description in the Content Packaging standard (Sampson & Karagiannidis, 2000b). In this context, the KOD project is working on an extension of the content packaging standard, towards the proposition of a specific implementation in order to

support a more flexible description of dynamic and adaptive routing as required by KOD's "knowledge routes" concept.

This proposition is elaborated through the investigation of the needs of both educational organisations and educational content providers. More specifically, the initial phase of the KOD project has involved a user needs analysis phase, where the requirements of the user groups involved in the KOD project have been identified, especially in view of the demonstration scenarios foreseen for the KOD project.

The demonstration phase of the KOD project involves two different scenarios, so as to test its results in different contexts. The first scenario involves an organisation providing tele-medicine education, mainly through ("traditional") international summer and winter courses. The KOD project will enable them to directly insert into their current curriculum (which is mainly based on a tele-medicine CD-ROM that is also available on-line) tele-medicine resources available in the Internet. Moreover, it can facilitate the provision of advanced, personalised educational services (e.g. searching for tele-medicine information), meeting the requirements of their widely diversified user population.

The second demonstration scenario involves a private company which is active in the *e*Learning digital economy. The company will be using the KOD system as a tool (or enabling technology, i.e. vertical learning / knowledge portal) for providing to individual customers personalised access to an open repository of learning material, educational services, and digital content (either their own, or their customers'), especially in the Natural Medicine domain; as well as for providing to other organisations and companies the opportunity to use the KOD system for accessing available information (and directly integrating it into their curriculum), or for automatically posting their content to be easily accessible (and re-usable) across different educational applications and services.

As it is evident from the above description, the user representative organisations involved in the KOD project act both as "content providers" (i.e. providing educational content), and as "content absorbers" (i.e. accessing educational content posted by third party providers). During the user needs analysis phase of the KOD project, specific care has been taken to get insight into the needs of these organisations (and the respective "user groups") for the development of adaptive interchangeable content (Sampson & Karagiannidis, 2000a). These efforts have resulted in the identification of a set of steps for the development of adaptive interoperable and interchangeable content, which are described below.

Step 1 Definition of Concept Ontology

First of all, we need to define the content to be presented to the learners: the concepts which are to be communicated, and their classification and inter-relation. In other words, we need to define the *ontology* of the content. This description is not directly related to the learning process per se, since it is a factual description of the content. As a result, the description can be performed by a content expert, since it does not require that learning issues are taken into account. For example, if the content to be communicated refers to "computer science", then the sub-concepts can include programming languages, operating systems and databases; programming languages can, in turn, be classified into object-oriented languages, procedural languages.

Step 2 Description of Learning Resources

Subsequently, we need to define the learning objects (the "atomic" units of knowledge) that are actually available for the description (learning) of each concept of the ontology. Learning objects can be available as text files, images, videos, simulations, etc. Each learning object is described through meta-data, and it is "linked" to specific concepts in the ontology. For example, we may define that a specific text file refers to "programming languages", and that it is an introductory description, most appropriate for undergraduate students.

Step 3 Definition of Competencies

Subsequently, we need to define which are the competencies that are related to each concept in the ontology of the learning material. These competencies serve for encapsulating the "pre- and post-conditions" of learning, i.e. defining the expertise required before presenting a specific concept to the learner, and, consequently, the knowledge is gained after understanding each concept.

Step 4 Description of Questions & Tests

For each concept in the ontology, we also need to define the questions and tests which determine whether the learner has understood the concept (and has acquired the respective competencies). That is, we define the "conditions" which specify whether a specific node in the concept hierarchy has been learnt.

Step 5 Definition of Different User Profiles

Then, we need to define the learner characteristics that are related to the specific learning content. That is, we need to define the different user profiles of the learners that are anticipated / foreseen to interact with the learning environment for acquiring the specific learning content. The profiles are defined in terms of the competencies that have been defined (step 3), for the specific concept ontology. These user profiles serve the purpose of classifying learners while they are interacting with the system, and adapting the content based on their characteristics.

Step 6 Definition of Learning Paths

Finally, we need to define how learners should navigate the concepts of the ontology, i.e. how learners are presented with the learning objects, and what are the questions and tests that condition their navigation. We need to define the "rules" that specify the "matching" between the learner profiles and the learning content, that is the "*learning path*" that is appropriate for each different learner profile. This step actually reflects the pedagogical and didactical rationale that underlies the learning process.

A schematic representation of the knowledge that is defined through the above procedure, as well as the inter-relation between the different knowledge sources, is shown in Figure 1.

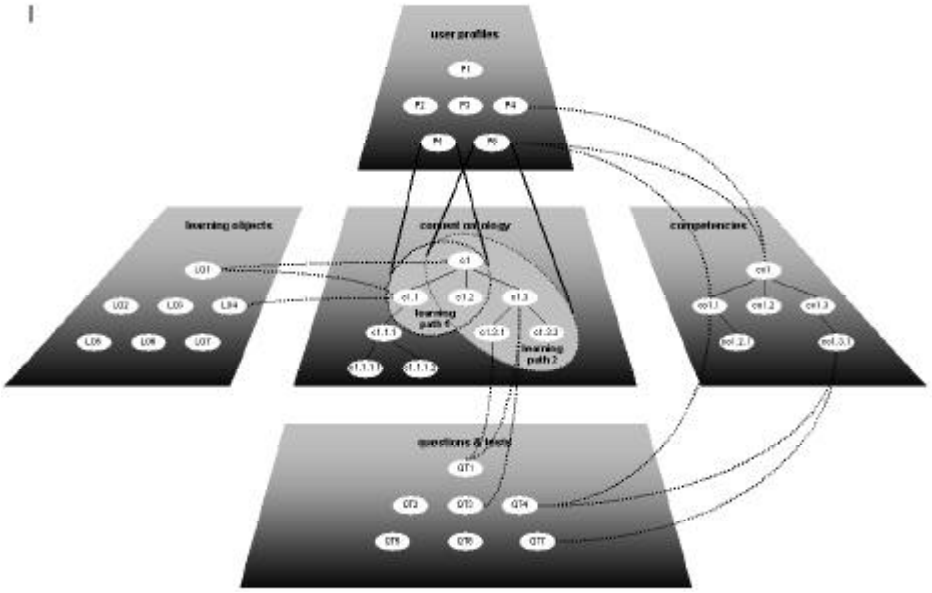

Figure 1. Schematic Representation of Adaptive KOD Content

4. Discussion and Conclusions

The different types of information that are defined through the procedure described in the previous sections are necessary for the provision of adaptive content. In order for this information to be transferred across different applications, it needs to be maintained following the existing and emerging *e*Learning standards. For example, the description of the learning objects (step 2) needs to be based on the Learning Objects Metadata (LOM) standard of the IEEE LTSC P1484.12 Working Group; the competencies (step 3) need to be represented following the specification of the IEEE LTSC P1484.20 Competency Definitions Working Group; etc.

On the other hand, *all* the above types of information need to be represented *together* following a single specification. To this end, the KOD project is currently working on the proposition of an extension of the Content Packaging Specification of the IMS Project. This standard provides means for describing the learning resources that are included in a learning package. The standard also includes the "organization" field, where the structure of the learning material can also be described.

Currently, the organisation field in the XML schema (the one enabling the IMS content packaging manifest) is open to any notational description of navigation, however, it mainly considers rigid hierarchical tree-based content structures description; no standard declarative notation, toolkit and viewer is thought of for conditional branching navigation or for path redirection. According to IMS, which has developed this standard: *"It is possible to imagine organizations that will take into account such approaches as hierarchical "branching", indexes, custom learning paths utilizing "conditional branching", and complex objective hierarchies. While many content organization approaches may be developed, a default approach is included as part of this specification. This default approach to content organization is referred to as a "Table of Contents" scheme and is encompassed in a <tableofcontents> element"*. (IMS Project, 2000)

Under this perspective, the KOD project is working on extending publishable file formats (not hooked to exclusive internal, proprietary, database supported working), porting ITS approaches (intelligent, i.e. adaptive and dynamic, tutoring systems) to the Content Packaging exchangeable flat file format approach; the aim is to enable users and publishers to share not only content and content routes but also navigation algorithms (i.e. conditional branching based on user performances). That is, the content packaging format is extended to hook user profiles and domain description as it currently hooks content meta-data and to define some sort of XML-based notation for conditional navigation structuring of content.

Such a format, which could be called *"**knowledge packaging**"*, can be changed dynamically within the KOD system (e.g. rewriting the new organisation field content dynamically), while "frozen" versions implementing conditional branching can be published together with links to content, user profiles and domain description for reuse externally to the KOD environment. This specific implementation can support a more flexible description of dynamic and adaptive routing as required by KOD's knowledge routes concept, addressing the modular delivery of content (meta-data & semantics) together with the description of related navigational algorithms (from conditional routing to dynamic paths).

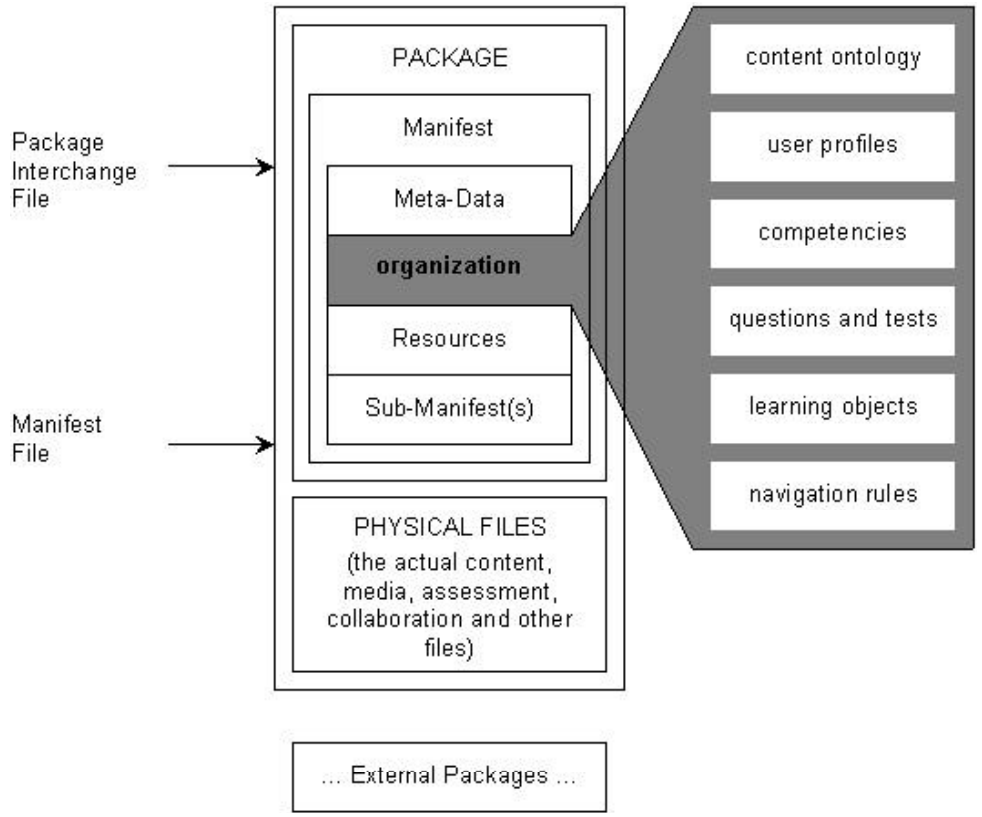

Figure 2. The IMS Content Packaging Standard (from IMS, 2000) Grey area indicates the extensions proposed by the KOD project, for supporting the interchange of Adaptive Educational Content

In this context, the vision for KOD is to use native XML repositories for describing users, contents and paths, based on the IMS (next IEEE) notation, and to conceive some notational and functional extensions of the content packaging standard in order to enable it to deliver (and publish) not only content and rigid navigation structures, but also adaptive navigation mechanisms, hooked to user profiles, domain models and content models to be summarised in packaged XML files as in the style and approach introduced by IMS content packaging.

The adaptive navigation notation can be rule-based, and also easy to use: user friendly data entry agents can be conceived to ease system tutoring if a human expert is entitled for defining adaptive navigation rules. A "suite" of KOD agents could perform user driven (portal manager) or automatic generation of knowledge packaging XML files to be dynamically created within KOD for adaptive content or published in "frozen" versions for re-use and interchange with third party users and providers.

In summary, this paper has addressed the issue of developing adaptive content in an interoperable and interchangeable format, so that it can be easily transferred across different Internet-based personalised educational applications and services. The paper has focused on the work of the KOD project in this direction, towards the identification of the knowledge that is necessary for defining adaptive content, the procedure for defining this knowledge, and the possibilities for representing this knowledge utilising the existing and emerging *e*Learning standards.

The aim of this work is to facilitate the development of adaptive content which can be easily transferred across different educational applications and services, and can thus be easily integrated into different courses and curricula. This, in turn, can facilitate "quality" (i.e. advanced, targeted, personalised) access to educational resources, and therefore render the Internet "educationally valuable", since the information can be easily, directly and smoothly be imported in different educational settings; and can contribute towards the exploitation of Information and Communication technologies for the improvement of the quality of the education provided to the citizens of the Information Society.

Our current and on-going work in this context includes the definition of a generic PL model and a generic PL architecture which can support the definition and interchange of adaptive educational content, as this has been described in this paper. The PL model and PL architecture can be parameterised and re-used for the development of different Internet-based PL environments, thus promoting the dissemination and commercial exploitation of PL environments. The overall aim is to contribute towards the realisation of the PL concept, and the full exploitation of ICT for the improvement of the quality of education provided to the citizens of the Information Society.

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