LOGISTICS FOR LEARNING OBJECTS

Bernd Tschiedel, Aleksander Binemann-Zdanowicz and Bernhard Thalheim
Computer Science Institute, Brandenburg University of Technology at Cottbus

Abstract: The increasing attention paid to the importance of context-awareness of content has contributed to more useable e-learning websites. While existing approaches mostly cover static learner characteristics, to date it has been difficult to cover the dynamics of context. E-learning content must be delivered in the right doses, at the right moment, and in an appropriate form. Our work presents a storyboarding-based approach for specifying content-intensive websites. E-learning sites can be validated with regard to learner context. The practicability of our method is shown upon the e-learning project DaMiT. The SiteLang methodology helps overcome the limitations of existing approaches based on pre-defined, structuring of content. It allows a flexible content generation upon learner context, depending on the dynamics of the learning process.

Keywords: Database, Learner Centred Learning, Learning Systems, Modelling

1. INTRODUCTION

Many scientific papers and working group specifications have identified the fundamental insight that a high level of granularity of learning units leads to better user-adaptive systems. One guideline for implementing this is to deal with many different types of units from the same topic. Learners just want the most appropriate content delivered just in time and to the right place and device. They should not be confronted with unnecessary content. Therefore, some services are needed to fulfil the learner's needs. Information logistics can provide acceptable strategies that satisfy the requirements for the delivery of the correct unit of information. The goals of information logistics are readily adapted to the e-challenges of e-Learning.

1.1 Information logistics

Information logistics aims to provide optimised information—to serve textually correct and needed information at the right time and place—to users (Lienemann, 2001). The information should always be adapted to the user's preferences and communication facilities. Lienemann explains some principles in information logistics, which are relevant to e-Learning.

- *Several information sources*: The user looks for additional or extended information in distributed, correlated content bases. At the moment we restrict this to one database of one domain.
- *Information on the tick*: Information at the right time depends on the value of the information and the user's context. The value depends on the deliverable content in the knowledge bases. High value demands a detailed description of the content. Users of an e-Learning system may interact with the system in different roles with special characteristics. This is the primary context for the user. The system has to choose, on demand, what the preferred content for the user at any given moment.
- *Consideration of user preferences*: Applications of information logistics must be able to satisfy the individual needs of the users. User needs must be specified for optimal operation and implemented in an explicit and an implicit way. Explicit data, like the preferred presentation style or difficulty, must be treated as granularly as possible. Implicit data are the user's history, current and recorded interaction and utilization behaviour.
- *Flexibility of presentation*: Users have (depending on their working place and working context) different communication devices and channels. The system automatically recognizes the user's system, the network connection and application. In any case, the presentation style must be adapted according to the individual working context.

The *working place and context* are features of information logistics. They do not belong to a web-based e-Learning environment, as they depend on Internet access. The issues described above are related to the challenges our department faced during the development of the *SiteLang* approach.

1.2 Challenges in e-Learning

While creating an e-Learning application there are challenges that have already been investigated and adopted. It is also necessary to restrict the aforementioned aspects of information logistics in the following aspects:

- Full flexibility: E-learning services require full flexibility of learning scenarios. The set of scenarios necessary to be supported looks graphically similar to a complete graph. It is possible in such cases to use any menu point and to jump to any other dialogue step (Caumanns, 2000). The usage of a proven scenario theory for the application development is a basic assumption to realize full flexibility.

– Multiple usage of content: Content authors must be able to index, research, reselect, recombine and update existing content. This demands a flexible data structure. For this reason we adopt learning objects based on the Reusable Learning Object Strategy (Cisco Systems Inc., 2001).
– Adaptivity: Learners want to get content depending on their specific information requirements. There are some general user profiles in the area of content format like text or formula-oriented learners that can be used to create pre-made scenarios with associated learning objects. To realize full user adaptation, learning objects should be enhanced at run-time with specific user information from the current user profile.

2. THE SITELANG METHODOLOGY

The *SiteLang* methodology facilitates the verification of the behaviour of an information service before its actual implementation. It supports the stepwise development of a website (Feyer et al., 2000) and allows the parallel specification of database behaviour and user interaction of the system. The major goals we have achieved are the ability to refine the obtained *SiteLang* specifications and the possibility of executing and validating an abstract specification at any level of abstraction. This has been achieved thanks to the operational semantics of Abstract State Machines (Gurevich, 1993) that *SiteLang* is based on.

The *SiteLang* language comprises constructs for specifying *database functionality* (database schema, database operations, transaction management, integrity constraints, database content), as well as *user interaction* (event-driven interaction model, multiple users and devices, scenes, dialogue steps with transaction semantics, dialogues, media objects) (Düsterhöft, 2001) in parallel. It allows the specification of distributed system architectures. The user interaction model of *SiteLang* is event-driven; the event frame differs from the classical ECA model and comprises well-founded transaction semantics.

SiteLang has been successfully used for specifying interactive services of a set-top-box-based television platform that has been developed by an industrial consortium in cooperation with our database group. The positive experience of *SiteLang* has proven its suitability for specifying data-intensive applications. It is also suitable for specifying and validating systems in which the interaction flow is reciprocally influenced by semantic content structures.

3. THE DATA MINING TUTOR PROJECT

The focus of the DaMiT project is the development of a computer-based tutor system to support learning and teaching in the area of Knowledge Discovery and Data Mining. Another important focus is put on the creation of content. The main goal of DaMiT is to provide user-context-aware content. Derived sub-goals are: content generation, creating coherent and consistent content, generating a semantic network using the domain Data Mining, integrating applications for on-line data mining, keeping an architecture open for extensibility and updating, as well as obtaining a knowledge basket adoptable to other projects.

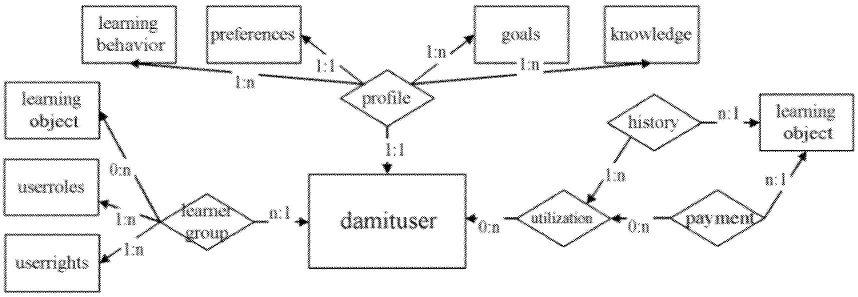

Figure 1. Simplified ER-Schema for DaMiT users

3.1 Modelling the User

For user-context-awareness it is essential to analyse the most typical characteristics, operations and expectations of users who are to work and interact with the planned web service. This concerns the area of rights, educational classification and utilization behaviour. Thus we defined roles (*Content Provider*, *Teacher*, *Administrator*, *Tutor*, *Learner* with the sub-roles *Anonymous*, *Pseudonymous*, *Standard*, *Manager*), metadata and added functionality, e.g. *Payment*, *Rights Management* (of courses, with respect to learner groups), as well as user-role-dependent interface and system functions. The refinement process led us, through the (partially depicted) ER schema, to an appropriate relational database schema.

3.2 Modelling Content

Content and content-related user interaction is modelled in *SiteLang* on various abstraction levels. Content can be seen as a semantic structure with associated metadata. In the stepwise refinement process of *SiteLang* the semantic structure is mapped to an appropriate relational schema. Through this refinement a more thorough validation of system behaviour is possible, as we deal with well-defined database structures and a rich story specification. The specification can again be refined by adding implementation-related details, e.g. distributed architecture, information containers exchange etc. The semantic structure of content is modelled by means of a *content graph*—analogous to the concept of semantic nets.

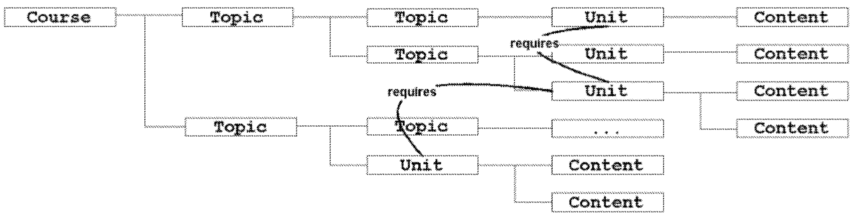

Figure 2. Simplified content graph

Topic-nodes represent the aggregation of units and topics. Units are the smallest pieces of 'customisable' knowledge for the learner and contain several types of atomic content items. Topics and Units are contextual described by a subset of IMS Metadata (Global Learning Construction, 2001).

During the *SiteLang* specification process, the content graph is mapped to a database schema. Classes of objects of the same type in the content graph are mapped to relationship types, links between objects are mapped to relationship types of a higher order. The resulting schema depends on the types of links between nodes on the BUL and of their semantics with respect to learning scenarios, as well as on e-learning content type and paramount manipulation operations performed on the content. As a result we get a complete relational database schema with the corresponding metadata and the user information.

User interaction is specified explicitly. Navigation through content is realized as an execution of a series of scenes; navigation steps through a single unit by means of dialogue steps of a single scene. The scene specification is derived from the content definition. Content graph modifications at run-time result in changes of the derived scene specification.

The obtained conceptual specification can be refined, e.g. by including further implementation details and by adding constructs describing system distribution. Metadata in DaMiT is modelled according to commonly known ideas. It is modelled in *SiteLang* on the BUL directly by means of the HERM model (Düsterhöft & Thalheim, 2001). The metadata schema is then transformed to a corresponding relational schema.

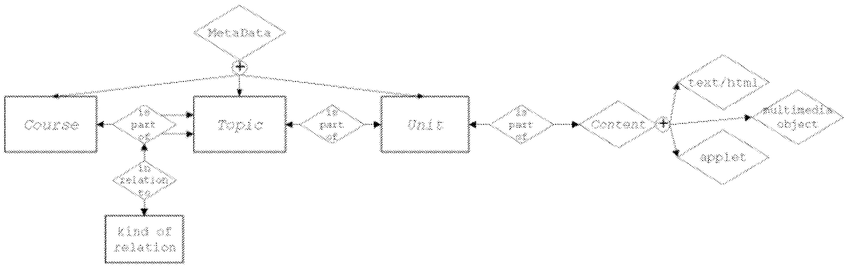

Figure 3. Simplified ER-schema for DaMiT content

3.3 Content Generation

e-Learning content in DaMiT is generated according to the user's needs and is closely related to content-adaptivity. This is done in two ways.

– *Content-to-Context Matching:* the existing content structure is matched with the user's preferences and history. The generated content is assembled from the matching topics and units, chosen from the content graph and is presented to the user as a *lesson*. It is being realized in our prototype by means of parameterised views and mappings of user-context-dependent generation rules. The currently implemented generation method is conform to the top-down approaches, further development of the system will comprise an implementation of the bottom-up approach (Caumanns, 2000).
– *Semantic Content Evolving:* the content structure is enriched by new subgraphs built on the basis of common learning objects. The new lessons can be more valuable to the learner, as they have new semantic relationships previously not present in the content graph; they are also reusable for later usage. Representing content generation rules in *SiteLang* is subject to further research.

3.4 Content Versioning with SiteLang

In the learning process, it is essential to provide every user with the correct content version. To do this, the following needs to be considered:

– *Content Stability:* After the user has begun a course, any changes on the course content must not be released to the user as long as he has not completed it. This intuitive condition cannot be realized in a trivial manner, i.e. just by freezing the course version, as it would cause an overhead when dealing with massive amounts of users.

- *History Continuance:* Older content versions may need to be kept for later usage. It must be possible to recall any older version at any time.
- *Similarity Versioning:* Depending on the user's knowledge and usage history, it may be necessary to use different parallel versions of the same content, which are assigned to the same unit. For instance, there may be different difficulty versions of the same content, e.g. 'basic', 'intermediate', 'advanced'. Such parallel versions may also be subject to 'classical' versioning in terms of updating content, e.g., for improvement.

3.4.1 Content Modification Versioning

Course (content) modifications occur by integrating a new subgraph into the existing content graph, by deleting a subgraph or by updating a node. To preserve content stability when a course modification is made it must not affect unfinished interactions related to the course. New interactions may be started after the modification: the new version should be applied to them.

- Course Versioning: Each course is versioned separately.
- Extending courses: Adding a subgraph (into the content graph) increases the course version. All vertices and edges of the subgraph also get the increased version. The new edge leading from the existing graph into the added subgraph also receives the new version number.
- Removing course parts: Removing a subgraph from a course increases the course version and adds another edge of type *deleted* from the subgraph's father to the subgraph.
- Updating courses: Updating a node in a course (topic, unit or content node) increments the course version and creates a new node of the same type which is connected with the same nodes and by new edges of the same type as the original node; the new edges' version is incremented.

3.4.2 Maintaining Parallel Unit Versions

Versioning is also an important aspect of user adaptivity on e-Learning content, as it is necessary to provide users with content of appropriate difficulty level. Therefore, multiple units with similar content of varying difficulty are grouped in a topic that is specially marked with the property *unit group*. In this way, a group of units on the BUL can be identified as 'similar units'. The transformation into the Conceptual Layer is analogous to the one of the entire content graph.

4. SUMMARY

We have presented a methodology for specifying information logistics for e-learning applications. It is based on the operational semantics of Abstract State Machines and has proven suitable for specifying content adaptivity in the DaMiT project. Further research will be focused on deeper aspects of context-aware content generation. The DaMiT system is to be enhanced by means of implementing bottom-up content generation (Caumanns, 2000). Details of the actual top-down approach are accessible to the public at the URL *http: //neumann.dfki.uni-sb.de/damit.*

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BIOGRAPHY

Bernhard Thalheim held professorships at Dresden, Kuwait, Rostock, Cottbus and is now at Kiel. He works on relational data model theory and pragmatics of Entity-Relationship modelling, object oriented databases and their design. Aleksander Binemann-Zdanowicz's work explores the semantics of conveying learner-specific content in e-learning applications. Recent work includes method development for specifying and validation of content-intensive websites. Bernd Tschiedel, is responsible for the database development.

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