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Project-Team WAM

Web, Adaptation and Multimedia

Rhône-Alpes

THEME SYM

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2. Overall Objectives

The WAM project (Web, Adaptation and Multimedia) was created in January 2003 to explore the field of adaptative multimedia on the Web, with a special focus on structured documents transformation and adaptation.

2.1. Multimedia Web

Diversity on the Web increases steadily, be it the diversity of information or the diversity of access devices and communication networks. Diversity of information comes from the multimedia Web. Information shared on the Web consists of text for a significant part but also of pictures, drawings, video, animations, music, voice, etc. These media can just stand independently from each other, such as a movie or a song, but they can also interact with each other in genuine multimedia documents that tightly integrate pieces of information in different media.

Devices are also multiple. The workstation or personal computer that was typically used in the early days of the Web is no longer the dominant access device. In Japan, for instance, more cell phones than PCs are now used to access the Web. TV sets are also following this trend. Recent developments in the TV industry clearly show the convergence between television and the Web. Web users can watch at TV programs on their desktops while TV sets can be used to access Web sites. The digital television technology is borrowing more and more techniques from the Web, such as XML, for instance. The automotive industry is also developing embedded devices that provide access to the Web. The Web is ubiquitous and all sorts of devices with very different capabilities are involved in Web access.

Simultaneously, these devices are using new kinds of networks, ranging from personal networks such as Bluetooth to the global Internet. In the broad range of communication technologies, wireless and mobile networks (UMTS, WiFi) are taking an increasing part. Their original features make a big change from the traditional wired Internet and have a strong impact on the way information is exchanged over the Web.

2.2. Document Adaptation

The increasing diversity of information, devices and networks makes the original scheme of the Web inefficient. The usual model of a single Web page designed for a large color screen accessed through a high speed network does not work any more. Some information providers face this problem by developing their contents into different versions, each one suited to a specific class of devices. Another approach is to create the information in a single, universal format and to adapt it automatically to the environment where it is delivered.

The WAM project works along the second approach. It aims at developing models, methods, architectures, protocols, formats, languages that allow content to be adapted "on the fly" to the context in which it is actually used. In this approach, no restriction is put on the type of the information that has to be adapted; multimedia information is considered with the broad diversity of media that are now commonplace on the Web.

Content adaptation is not something that comes into play at the last moment, when information has to be delivered to the client. To enable efficient adaptation, the original information must present some features that make adaptation easier or even possible at all. This means that the production methods should also be involved in the whole process of content adaptation. The WAM project is especially interested in authoring tools for the Web, with the perspective of creating multimedia documents that ease adaptation and improve device independence. Two editors are currently under development. LimSee2 is dedicated to the production of multimedia documents in the SMIL 2.0 format, while Amaya addresses multi-namespace XML documents containing text, mathematics, animated graphics and using CSS style sheets.

2.3. XML Transformations

It is clear that a major means to adapt documents is to transform them according to the actual context where they are used. The project focuses on structured multimedia documents represented as XML structures. Regarding transformations, the objective is first to characterize the theoretical and practical tools needed for efficiently transforming XML structures, and then to develop models, formalisms and algorithms that are necessary for transformation languages.

A strong motivation for this research on transformations is adaptive multimedia, but transformation of XML documents and data has actually a broader range of applications. Transformations are ubiquitous in the processing of structured information on the Web, ranging from formatting to repurposing and life-cycle management. Actually, XML transformations are considered as a key paradigm for document processing.

3. Scientific Foundations

3.1. Transformations

Keywords: *XML structures transformation*, *XPath*, *document models*, *document transformation*, *logic*, *path expressions*, *transformation languages*, *tree automata*.

Participants: Pierre Genevès, Nabil Layaïda, Vincent Quint.

Structure transformation is a specific domain that can be approached following different abstraction levels with respect to programming specifications. The lowest level is based on general purpose languages, such as Python or Java, associated with dedicated libraries and toolkits that implement a standard structure manipulation API, typically the DOM. On the opposite, there are dedicated languages, such as XSLT, which abstract over data and control complexity through a tree-based data model and a powerful execution model. Some properties are expected from specialized languages in order to help solving the most common problems: expressiveness, verifiability, efficiency, modularity, reusability, scalability, simplicity, clarity, etc.

These problems are studied using the fundamental connection between tree automata and related logics. Most of our theoretical work follows this approach.

For XML structure transformations, some more properties are of particular importance:

- *Type checking*: Considered types are structural constraints over documents expressed in formalisms such as DTD or XML Schema. Few techniques are able to exploit typing information of the input or output documents to provide type-safety of transformations. In this domain, algorithmic advances have led to the creation of new research languages (such as XDuce, based on efficient containment of regular tree types). Many challenges remain. While type-checking full XSLT or XQuery is theoretically impossible (since these are turing-complete languages), one challenge is to push the "decidability envelope" further for type-checking standard XML transformations. Another challenge is to provide effective algorithms usable in practice for realistic scenarios.
- *Efficiency:* Transformation languages may benefit from static analysis whenever performance is concerned. Static analysis techniques usually take advantage of robust formal semantics to help development of optimized compilers and runtimes.
- *Processing with Restricted Access Policies* : Some applications may require particular policies for accessing XML data, that are incompatible with current state of the art. For instance, many transformation languages assume that the whole structure to be transformed is available when the transformation process is run. In streaming applications however, the input data flow may be very large or even infinite and the transformation has to be performed on the fly, with bounded memory resources.

3.2. Adaptation

Keywords: *World Wide Web*, *adaptation*, *adaptive multimedia*, *authoring*, *device independence*, *document formats*, *multimedia*.

Participants: Sébastien Laborie, Nabil Layaïda, Tayeb Lemlouma.

The purpose of multimedia document adaptation on the Web is to customize web content for the variety of devices and networks that are now sharing the Web with traditional desktop PCs. As a result of these changes, the Web infrastructure need to be reconsidered towards a device-independent architecture, where information resources can be efficiently accessed with various types of devices and networks.

To reach this goal, the WAM project is following two complementary approaches, a comprehensive, global approach that requires several changes in the current Web infrastructure, and an approach that uses the current infrastructure and legacy content for adaptation.

There is no general solution to the problem of device independence today. Most efforts are rather dedicated to the development of good practices. To make progress towards a solution, two aspects are considered in the project: device-independent architectures and automatic content adaptation.

Ideally, content would be created or generated in a single universal format that could be delivered "as is" to any conceivable device. In practice this seems impossible, so the real techniques seek to minimize the number of variants needed, each variant being targeted at as wide a range of devices as possible.

The problem of adpative infrastructures is addressed through, profiles, negotiation protocols and transcoding techniques. A profile is a formal representation of the context in which content is used: user abilities and preferences, device capabilities and limitations, network characteristics, etc. These descriptions must cover both static and dynamic parameters since the system conditions may change over the time.

To transform multimedia documents, one can rely on their semantics. The semantics considered here do not deal with the document content, but with the composition that is made explicit in a Web document:

- temporal semantics: in what order and when should each piece of information be presented to the user,
- spatial semantics: what are the relative positions of the document components on the display space,
- navigational semantics: how are pieces of information related in the hypertext network.

With this approach, adaptation can be donein very general semantic terms, independently from the multimedia objects. This makes it also possible to abstract (model) existing content into a unified representation and then to facilitate the adaptation process.

3.3. Multimedia Documents Authoring

Keywords: *authoring environments, constraints, editing, multimedia, structured editing, timeline.*

Participants: Romain Deltour, Stéphane Gully, Nabil Layaïda, Vincent Quint, Cécile Roisin, Irène Vatton.

The WAM project works on interactive authoring environments. Developing such environments is a challenging issue: structured multimedia documents are complex objects and the process of creating and updating them is complex too. Well-established paradigms for static office or technical documents do not work. The traditional WYSIWYG approach does not apply in a context where the final form of the document (What You Get) is multiple and unknown at creation time. In addition, writing the description of a document in some multimedia document language is extremely difficult given the various levels of representation that are involved: content, logical structure, layout, style, synchronization, hypertext structure, navigation, dynamic behaviours, etc. New approaches are needed.

On the Web, multimedia documents are based on XML. They are considered through several types of structures: layout, time, navigation, animations. The WAM project develops techniques that allow users to manipulate all these structures in homogeneous environments. The key idea is to present simultaneously several views of the document, each view showing a particular structure, and allowing the user to manipulate it directly. As the various structure of a documents are not independant, these views are “synchronized” to show the consequences of every change in all other views. The XML markup, although it can be accessed at any time, is handled by the tools, and the author does not have to worry about it.

Two editing tools based on this concept are under development, Amaya and LimSee2. In Amaya the emphasis is put on the integration of several XML vocabularies and associated technologies, and on direct interaction with the Web: the user can edit remote documents in exactly the same way as local files. LimSee2 is dedicated to a single XML language, SMIL, and the focus is on the time dimension of multimedia documents and their dynamic contents.

Adaptation and transformations are used to make Web information accessible to people with disabilities and through terminals with limited features (e.g. Braille terminals). In cooperation with W3C we investigate techniques and develop editing tools that help authors create accessible information.

We are also investigating the integration of natural language processing services in authoring environments. This is done in cooperation with the CLIPS laboratory from Grenoble University. The goal is to develop translation systems which interact with the user during translation in order to disambiguate the text. The result of this dialog is a tree of disambiguation information that is considered as a valuable complement to the source document. The idea is to integrate this disambiguation phase in the authoring process with a two-fold objective: creating enriched, self-explanatory documents and helping authors to learn how to create less ambiguous text. We are working on a document model that encompasses the required structures and on the associated authoring and visualization services.

3.4. Multimedia Document Formats and Description

Keywords: *digital library, document description, document query, metadata, multimedia.*

Participants: Marc Caillet, Nabil Layaïda, Cécile Roisin, Joseph Roumier.

The WAM team is working on standard multimedia document formats that accomodate the constraints of different types of terminals. SMIL is the main target of this activity and the focus is given to modular and scalable formats that combine efficiently the different dimensions of a multimedia document: synchronization, layout and hyperlinking.

Whereas document formats such as SMIL represent a multimedia document with all its internal structures, description languages describe a document from outside and provide metadata. In the area of description languages for multimedia documents significant standardization efforts have been spent recently, such as MPEG-7 for instance, but the problem is not solved yet. Many application domains cannot cope with the description languages available today. The WAM team is working on this issue in two complementary directions:

- Uniform access to heterogeneous document bases with multiple entry points (metadata attached to documents, terminology and ontology bases). The goal of J. Roumier's Ph.D. thesis is to model the various components of an architecture that comprises document servers, access points, and interfaces to provide integrated document query and annotation services. The target application is a technical document management system for maintenance.
- Description structures for audio-visual documents, focusing on formal consistency to make descriptions usable in very large bases, such as archives of audio-visual documents. This is the topic of M. Caillet's Ph.D. thesis in cooperation with INA, the French archive of broadcast radio and television. Typical applications of this work are the production of a thematic audio-visual offer from archives or producing the same interactive application on various media (CD-ROM, DVD, Web).

4. Software

4.1. Amaya

Participants: Stéphane Gully, Vincent Quint, Irène Vatton.

Amaya is an open source Web editor, i.e. a tool used to create and update documents directly on the Web. Browsing features are seamlessly integrated with editing features in a uniform environment that allows users to save files locally and on remote servers as well. This follows the original vision of the Web as a space for collaboration and not just a one-way publishing medium.

Work on Amaya is a joint effort with W3C that started to showcase Web technologies in a fully-featured Web client. The main motivation for developing Amaya was originally to provide a framework that can integrate many W3C technologies during their development with the goal of demonstrating these technologies in action while taking advantage of their combination in a single, consistent environment.

Amaya started in 1996 as a HTML editor. Support for the creation and debugging of CSS style sheets was soon added. It was then extended to support XML and an increasing number of XML applications such as the XHTML family, MathML (for mathematical expressions), and SVG (for vector graphics). It now allows all those vocabularies to be edited simultaneously in compound documents. Amaya includes a collaborative annotation application based on the Resource Description Framework (RDF), XLink, and XPointer.

Now that a number of languages are implemented in the editor, developments focus on accessibility and usability. The latest extensions are oriented towards robustness, completeness and ease of use. An important development was undertaken in 2005 for improving the user interface on Mac OS-X, the latest platform supported by Amaya. Support for additional CSS properties was also added.

At the same time, some experimental implementations were made in Amaya to support the standardization process of new technologies proposed at W3C. As an example the latest attribute added to XML, xml:id, was implemented during the Candidate Recommendation phase.

Four public releases were made in 2005, on 6 January, 24 February, 12 July, 9 December.

4.2. LimSee2

Participants: Romain Deltour, Nabil Layaïda.

LimSee2 is an open source authoring tool for multimedia documents using the SMIL 1.0, 2.0, and 2.1 formats. It features a powerful graphical user interface designed to ease the manipulation of time-based scenarios in SMIL multimedia presentations. SMIL (Synchronized Multimedia Integration Language) is an XML language, so LimSee2 is an application that constantly deals with common XML issues: parsing, validation, namespaces, DTD-driven editing, encoding, etc.

The aim of LimSee2 is to keep most of the XML aspects hidden from the user, so that there is no need to manipulate raw data: everything can be done graphically. The main specificity of the SMIL language is that it clearly separates the two main areas of a multimedia presentation:

- Spatial layout specifies where and how multimedia objects should be displayed on a screen.

- Media synchronization specifies how multimedia objects should be synchronized over time.

The development of LimSee2 started in October 2002. The first public release was made in June 2003. Version 1.0 was released in September 2004. The current version is 1.7 and was published on 30 May 2005.

In 2004, a collaboration started with NRCD (National Research Center for Persons with Disabilities, Japan) to make progress in the areas of internationalization, accessibility and ease of use. Joint effort directly resulted in new internationalization features (a Japanese version is now available). Improving usability and adding support for a powerful template mechanism required deeper refactoring. These objectives are the root of a totally new version, LimSee3, which is expected to be released by the end of 2006. Development started in 2005 with use cases and requirements specifications and a new document model was designed. At the same time support was added to LimSee2 for the new features introduced in the latest version of the language, SMIL 2.1, to provide implementation experience before the publication of the W3C standard.

5. New Results

5.1. Transformations

5.1.1. Containment of XPath Expressions

A decision procedure for the containment of XPath expressions has been proposed in 2005. XPath is the standard language for addressing parts of an XML document. The XPath containment problem between two XPath expressions p_1 and p_2 consists in determining if, for any XML tree, the set of nodes obtained by the evaluation of p_1 is included in the resulting set of nodes of p_2. Fundamental questions such as the equivalence of two expressions and the satisfiability of an expression are both by-products of the containment. Other problems directly reduce to containment, such as optimization and key inference. Containment is also important for static analysis of XSLT and XQuery transformations, in which all input data selections are performed using XPath.

In 2005, we have presented a sound and complete decision procedure for containment of XPath queries (inria-391, paper currently under review). The considered XPath fragment covers most of the language features used in practice. Specifically, we have shown how XPath queries can be translated into equivalent formulas in monadic second-order logic. Using this translation, we construct an optimized logical formulation of the containment problem, which is decided using tree automata. When the containment relation does not hold between two XPath expressions, a counter-example XML tree is generated. We have provided a complexity analysis together with practical experiments that illustrate the efficiency of the decision procedure for realistic scenarios.

5.1.2. Stream-Based Processing

The method proposed in 2004 for compiling XPath 1.0 expressions for stream-based evaluation purposes has been supplemented in 2005 [5]. The compilation extends the normalization of XPath expressions into the Core language (as described by the W3C formal semantics draft) for the case of data-flow XML processing. It allows execution of full XPath on any of the emerging streaming subsets.

5.2. Adaptation

5.2.1. Content Adaptation

A semantic approach has been used to develop an effective method for modelling the content of multimedia documents using qualitative abstractions. These abstactions are used to calculate an adapted content (a model) by combination with the constraints of the environment. When a model cannot be found, the adaptation produces a document whose models are “close” to those of the original documents. The proposed method enforces properties so that the adaptation is applied only when necessary and is minimal. The minimal property states that the adapted document contains the least number of changes compared to the original content. To

this end, the adaptation uses an abstraction function which translates SMIL documents into an Allen-based relational representation. This representation is then combined with the constraints of the environment and an adapted model is then calculated. From this representation a SMIL document is finally produced. The entire method has been implemented and performance measures were reported in [6].

5.2.2. Adaptation Architecture

A complete adaptation architecture was developed [7]. It is made of distributed components for content negociation and adaptation. A metadata model (UPS, Universal Profiling Schema) based on RDF and CC/PP is used to describe the context. Profiles (device profiles, user profiles) are stored in distributed repositories and a new negotiation protocol uses these profiles to make the decision about the final form of the content to be delivered. Adaptation is applied both on media objects and document structures.

Adaptation methods transform the content from its original state into another state in order to meet the constraints of the target environment. In [1], a complete context-aware static and dynamic adaptation infrastructure has been presented. The adaptation considers the context of the client and also the environment changes at every client request but with an incremental context build-up. A device-independent model was also defined in order to obtain a completely automatic adaptation system. This system uses a context description model together with a client repository and offers device context management and querying functions.

5.3. Multimedia Authoring

Techniques for editing structured multimedia documents constitute the backbone of the editors Amaya and LimSee2. Recent work carried out by the team in this area was published in 2005.

A particular emphasis was put on main features needed to turn Web clients into more active and creative tools, by taking advantage of the latest advances of document technology. The original idea of an integrated, user-friendly tool that gives access simultaneously to the many facets of the Web is worth being explored further [8]. A Web user agent such Amaya that supports several languages from the XML family and integrates seamlessly such complementary functionalities as browsing, editing, publishing, and annotating, enables a more creative type of work on the Web, allowing users not only to consume existing information but also to produce new information and to interact with other users.

Another way to offer new editing functionalities and to take advantage of multiple, integrated XML languages was explored in cooperation with the GETA research team (IMAG laboratory). We studied the consequences of integrating DBMT (Dialog-Based Machine Translation) services within a structured document editor (Amaya). The main process, described in [4], is the following: During an editing phase, a source document is automatically associated with the structures required for a disambiguation service (for instance sentence structuration). During the interactive disambiguation and translation phases, these structures are enriched with data related to this process (question trees, answers from the author, translations). Finally, an annotation system provides the author with a user friendly access to the question trees through the source document. The enriched *edited document* and the *companion document* are also synchronized to allow the source document to be updated further.

5.4. Document Formats and Description

An important result in the area of multimedia models and formats is the publication of the latest version of SMIL, SMIL 2.1 [9]. The WAM team participates since day one in the W3C working group (SYMM WG) that created and continues to develop this language. SMIL 2.1 extends the functionalities of SMIL 2.0 in order to better meet the needs of mobile terminals. In particular, SMIL 2.1 provides an enhanced scalability framework, where a family of scalable SMIL profiles, such as the Basic profile [11], can be defined using subsets of the SMIL 2.1 language profile [10]. In addition, a SMIL document can now be made smoothly scalable within a family of profiles. This allows to obtain the desired functionality on a wider range of resource-constrained devices while allowing richer capabilities on a more capable device. SMIL 2.1 has also been extended to better support advanced transition effects and layout features.

The first result of the cooperation with INA was to provide a deep analysis of description needs for accessing and re-using large audio-visual archives. The conclusions presented in [3] was that even if MPEG-7 can describe multimedia content at different levels of granularity, it cannot be efficiently used for developing new applications such as generating new documents (automatic summaries), publishing collections of programs, or offering contextual navigation.

For that reason, we propose a new language called FDL (FERIA Description Language) for the definition of audio-visual document description classes that are organized according to both inheritance relationships and structure compositions. Thanks to reusability and extensibility obtained that way, this framework should avoid to redefine how to access content for each new type of audio-visual production. We have experimented this approach in the PACE experimental application [2] developed in the FERIA RIAM project. This application provides automatic Web publishing of collections of TV programs with contextual navigation services.

6. Contracts and Grants with Industry

6.1. RIAM Satin Project

Participants: Nabil Layaïda, Vincent Quint, Cécile Roisin.

Satin (Synchronized applications for interactive digital television) is a joint project with the httv company, funded by the French ministry of industry through the RIAM network. Satin was terminated in August 2005.

Most interactive television services broadcasted today are completely independent from the audio-visual streams, as if the two worlds of television and interactive applications were only sharing the same broadcast channel. The main goal of Satin is to introduce some synchronization between the two kinds of contents. To achieve this goal, a comprehensive environment was designed and implemented for creating, producing, broadcasting and presenting interactive digital television applications that are synchronized with audio-visual contents. This project is based on both the Web standards and formats created by W3C (XML, SMIL, XSLT, etc.) and the digital television standards from the MPEG group. It is a contribution to the next generation of the PrimeTV product from httv.

The main contributions of WAM concern formats (based on XML and SMIL), the editing environment, and the simulation component, which allows authors to immediately get feedback on user experience.

7. Other Grants and Activities

7.1. National Actions

Ministry Grant: Satin is a RIAM project carried out with the httv company.

WAM participates in CNRS network RTP 33, Documents and content.

Collaboration with INA on description languages for multimedia documents.

7.2. International Actions

The WAM project cooperates with NRCD (National Rehabilitation Center for Persons with Disabilities, Japan) on accessibility and internationalization features in the LimSee2 editor.

The Amaya Web editor is developed jointly with W3C. The software is distributed by W3C.

Continued collaboration with IBM T.J. Watson research center lead to a joint publication on compilation of XPath expressions for evaluation upon streaming XML data [5].

8. Dissemination

8.1. Leadership within Scientific Community

Vincent Quint was nominated co-chair of the W3C Technical Architecture Group (TAG) in January 2005. He is also a member of the W3C Advisory Committee. Nabil Layaïda is a member of the W3C Synchronized

Multimedia working group and is the editor of several chapters of the SMIL 2.1 standard. Tayeb Lemlouma is a member of the W3C Device Independence working group.

Vincent Quint is a member of the steering committee of CNRS RTP 33: Documents and content; Cécile Roisin is a member of AS95: Time in digital documents.

Emmanuel Pietriga was the recipient of a PhD award from INPG in May 2005.

8.2. Conferences, Meetings and Tutorial Organization

Cécile Roisin is a member of the steering committee of the ACM Symposium on Document Engineering.

8.3. Teaching

Nabil Layaïda and Cécile Roisin give lectures on Structured Multimedia Documents in the joint Master of UJF and INPG, University of Grenoble.

Nabil Layaïda and Vincent Quint teach on XML Technologies at the third year of ENSIMAG, Grenoble.

Cécile Roisin teaches on XML Technologies at the third year of INSA, Department of Telecommunication, Lyon.

Vincent Quint gave a course at the CNRS-VAST research school on Multimedia, 7-18 November, Do Son, Vietnam.

8.4. Conference and Workshop Committees, Invited Conferences

Cécile Roisin is a member of the editorial board of the journal Document numérique.

Members of the WAM project were on the following program committees: International Workshop on Managing Context Information in Mobile and Pervasive Environments (MCMP'2005), ACM Symposium on Document Engineering DocEng2005, 20th Annual ACM Symposium on Applied Computing SAC 2005, Web Information Systems and Technologies (WEBIST 2005), Euro American Conference on Telematics and Information Systems (EATIS 2006), 21st Annual ACM Symposium on Applied Computing SAC 2006.

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