NASH: Networked Adaptive Structured Hypermedia

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Summary

Many organizations need to provide access to a large body of multimedia information to a widely distributed community of users. Internet provides the means for sending large amounts of data to individual users all over the world. World Wide Web has made people familiar with hypermedia structures and interfaces for searching and browsing. In order to make the search for information in large collections of data objects a comfortable and efficient process information systems need to offer personalized interfaces and data selection. This personalization takes into account the background, preferences and interests of the user, semantic information about the available data, the capabilities of the user's interface platform (which can be as simple as a WAP-enabled mobile phone or as sophisticated as a high-end multimedia workstation) and the quality of service of the network connection between server and user.

The biggest challenge in creating personalized hypermedia access to semi-structured multimedia information is to *automate the generation* of the hypermedia interfaces and presentations. Through past and ongoing joint research between the Database and Hypermedia research group at the TUE and the Multimedia and Human-Computer Interaction research group at CWI we have identified three research sub-areas that need to be studied in order to form a complete framework for the *automatic generation of personalized hypermedia access to semi-structured heterogeneous and distributed information sources*. Our research groups are currently working on parts of these sub-areas. This NASH proposal identifies the areas where additional research effort is needed in order to complete the overall framework.

1. The Semantic Web. The information that is made available through Web-based interfaces typically comes from several different (and distributed) sources. It needs to be semantically (and often virtually) integrated so as to make it appear as a single source or (multimedia) database. A PhD student (AIO) at TUE (Richard Vdovjak) is already investigating this issue. The emerging new Web infrastructure will incorporate semantic information (or metadata) *into* the Web-based data structures. This makes it possible to disseminate *machine-processable* semantic information, or in other words to *automate* the semantic integration of data. To ensure that the NASH project leverages on the developments of the Semantic Web, new research and alignment of the global framework in the context of the Semantic Web is required. First, since the state-of-the-art focuses on text-based applications, new research is required to explore the use of Semantic Web technology in the context of time-varying and adaptive hypermedia [OCGRH01]. Second, to ensure that the approaches described in all sub-areas of the framework benefit from and contribute to developments on the (Semantic) Web (including contributions in standardization bodies such as W3C), we require a more senior researcher to be actively involved with the project on a daily basis. (Candidates for NASH are Jacco van Ossenbruggen as post-doc and Frank Cornelissen as PhD student.)
2. User Adaptation. The hypermedia interfaces for querying and navigating through Web-based information need to be personalized. This involves adaptation of the interface style itself, adaptation of a user's queries and navigation steps, and adaptation of the results of these queries. Such adaptation is done based on personal characteristics such as knowledge, interests and preferences. Adaptation of the interaction style is currently being investigated by a PhD student (OIO) at TUE (Susanne Loeber, NWO project 612.061.003, which we also call a part of HERA). Adaptation based on manually authored relationships between information items is being investigated by another PhD student (OIO) at TUE (Hongjing Wu, NWO project 612.013.001, hereafter called AHAM) [DHW99]. In NASH we will concentrate on adaptation that is based on

semantic information that is available with the data items, thus taking advantage of the emerging Semantic Web. The NASH project candidate for this topic is Carlos Cumberbatch. He will be working at TUE. Unlike in the AHAM project, adaptation in the NASH context explicitly considers adaptation in the query phase and in the result phase. In general the input to a database system cannot be sufficiently specific to avoid the need for filtering the database output. Also, some adaptation will be done on instance-level information, i.e. the actual data content of a query result, and some adaptation will also be done based on schema-level information, or the metadata that becomes available with the data in the context of the Semantic Web.

3. Adaptation of queries and results, in order to match the capabilities of the (virtually integrated) multimedia database system and of the user-interface platform. The database may not be able to produce exactly the desired data objects and data structures, and results may be defined in terms of a database model that is different from what is desired to generate a hypermedia presentation. This problem is being investigated by a PhD student (OIO) at TUE (Flavius Frasincar), in collaboration with a post-doc at CWI (Frank Nack). This project, NWO 612.061.009, is commonly referred to as the Dynamo project, and is a direct predecessor of the NASH project (but runs partially parallel to it). In Dynamo, adaptation of the presentation is also needed to fit the network characteristics and the capabilities of the user's interface platform. This research on the influence of network and platform is partially funded through the ITEA RTIPA project on "Real-Time Internet Platform Architectures" (in which TUE and CWI participate). The importance of adapting a hypermedia interface to platform and network characteristics becomes apparent when one considers that commonly used networks differ a factor of 10.000 in speed (GSM vs. 100Mbps ethernet), and platforms differ a factor of at least 1.000 in screen size (pixels) and CPU power. Manual design of hypermedia interfaces for all platforms and network connections is not feasible. Of course the adaptation done in the Dynamo project, the adaptation to user characteristics and the use of semantic information all need to be integrated into a common framework. This is why in this NASH project proposal we often refer to the related Dynamo and RTIPA projects. The NASH post-doc is responsible for the integration of NASH, Dynamo and RTIPA research results.

The NASH project is a result of the identification (and partitioning) of research problems by the joint research teams of TUE and CWI who are collaborating in NWO, ITEA and W3C projects related to the generation of hypermedia interfaces for semi-structured multimedia information. Besides the applicants, the two whole research teams will be working together with the NASH researchers to complete the networked adaptive structured hypermedia generation framework, involving all three aspects mentioned above. Also, through the Dynamo and RTIPA projects we collaborate with the Internet research group of dr. Warner ten Kate of Philips Research (Eindhoven).

The overall framework (NASH+Dynamo+RTIPA) is based on and extends the Standard Reference Model for Intelligent Multimedia Presentations (see [BFMRRTW97]) to include design rules for all the intended types of adaptation (adaptation to user, data and metadata, data structure, network and interface platform).

Candidates for the requested research positions are available (See aspects 1 and 2 above and the list below.)

Classification

1.2 (distributed systems, electronic highways) 2.3 (information retrieval: hypertext, hypermedia), 2.6 (tele-applications) 3.1 (architecture, reference models) 4.5 (user interfaces)

NOAG-i theme: DISH (Digital Information SuperHighway)

Composition of the Research Team

Technische Universiteit Eindhoven, Database and Hypermedia research group
head: **Prof. dr. Paul M.E. De Bra**
participating staff members: **dr. ir. Geert-Jan Houben**, dr. Ad Aerts, dr. Licia Calvi, dr. Alexandra Cristea (as of April 2001), **dr. Lynda Hardman** (part-time)
junior researchers: **Carlos Cumberbatch** (NASH PhD student), Flavius Frasincar, Susanne Loeber, Richard.Vdovjak, Hongjing Wu.

Centrum voor Wiskunde en Informatica, Multimedia and Human-Computer Interaction research group
head: **dr. Lynda Hardman**
participating staff members: **drs. Jacco van Ossenbruggen** (NASH postdoc and coordinator, PhD defense is on April 10, 2001), dr. Lloyd Rutledge, dr. Frank Nack, **prof. dr. Paul M.E. De Bra** (part-time)
junior researchers: **Frank Cornelissen** (NASH PhD student), Joost Geurts, Michèle Huijberts.

Research School

SIKS: School for Information and Knowledge-based Systems

Description of the Proposed Research

A. Scientific Problem and Research Approach

In the description of the research problem, goals and research approach we distinguish between the overall framework that the participating research groups are developing and the specific research problems for the proposed NASH project.

The overall research goal is to increase the level of automated adaptation during the process of creating hypermedia presentations and user-interfaces for semi-structured data, in a networked environment. In particular, the generation process should adapt to varying user, data, system and network characteristics and should be based on semantic information. This overall goal explains the choice of our project title:

- **Networked**: We explicitly consider applications that gather information from a variety of sources that are reachable through Internet, create a (partially) unified view on these sources, and offer access to that information through Internet clients in a way that takes into account the potential of the Semantic Web. The global framework also takes into account the possibilities for negotiating guaranteed levels of quality of service (QoS) of the network. (This part is studied in RTIPA.)
- **Adaptive**: The interface (style), type and quality of media objects, information content, navigational structures (e.g. links) and query facilities can all be adapted to each user. This adaptation can be based on user characteristics such as background, knowledge, preferences and interests, but also on characteristics of the environment such as the user-interface platform (ranging from WAP enabled phone to high-end workstations), the (negotiable) QoS of the network, and issues such as time or geographic location. We explicitly assume that even the content of a single media object can be adapted each time it is delivered to a user. (This can for instance be done through text summarization, image resizing or image or video compression.) We assume that the content delivery of the correct data is not disturbed by technologies such as caching, which could interfere with direct data delivery in an attempt to save network bandwidth. A brief overview of adaptive hypermedia research can be found in [DBH99].
- **Structured**: In previous and ongoing research (AHAM and a new project subsidized by Stichting Nlnet) we have investigated adaptive hypermedia that is authored at the instance level. We also developed a first prototype system for instance level adaptation, called AHA [DC98]. In NASH (as well as in HERA and in the Dynamo project) we consider data that is at least semi-structured, and (at least conceptually) available from a database system. This then involves schema-level adaptation or adaptation based on semantic metadata, and adaptation to queries *and* query results.

- **Hypermedia**: The presentation of information to the user, and the interaction of the user with the system are done through hypermedia. This means that information can be presented using different media (text, images, sound, video) simultaneously (or according to a time schedule), and that it offers interaction through hyperlinks as well as search or query forms. In NASH we consider structured hypermedia, meaning hypermedia interfaces for multimedia data that is at least partially structured and for which a hypermedia interface can be designed and in NASH even generated, as opposed to more traditional hypermedia that is manually authored.

For the description of the specific research problems of the NASH project we assume that the results of other parts of our overall architecture are in place. In particular, we assume that there exists a (virtual) "database layer" that can be queried using a language like SQL, Quilt, XML-GL or the XML Query Algebra, and that produces output that conforms to an extended RMM data model [ISB95] and is represented using XML. (See e.g. [H00], and forthcoming results from the Dynamo project). We also assume that an application can negotiate levels of QoS with the network. (Such networks will become available during the time frame of this project and are studied in RTIPA. In the meantime the negotiation can be simulated.) We also rely on the availability of basic user modeling facilities (as results from AHAM project).

A.1 Adaptation to the User

Most research in adaptive hypermedia considers only situations where either the system learns to adapt to fixed (but initially unknown) characteristics of a user, or where the user is going through a learning process. The system then tries to adapt the information and some presentation aspect to the increasing level of knowledge and expertise of the user. (See e.g. [B96, DBH99].) In NASH we explicitly consider the situation where the system must try to adapt to user characteristics that may be changing in an arbitrary way. Some characteristics can be more or less easily known, such as preferences (that are set by the user), environment (closed or open office, home, train, outdoors, etc.), geographic location, time of day, etc. Other characteristics are more difficult to observe, especially when they change a lot. The system should be able to adapt to changing tasks of the user, interests, knowledge (possibly acquired from external sources which the system does not observe), mood swings, etc. We also consider adaptation based on relationships between information items that are not manually defined by an author for this purpose but that are available as (or that can be inferred from) metadata that is retrieved from the database along with the information items.

- Adaptation to arbitrary changes in a user model can be done through adaptation rules (as being investigated in the AHAM project, and briefly described in the first paper on the AHAM reference model for general-purpose adaptive hypermedia [DHW99]), but generates fundamental decidability problems regarding termination, confluence and observable determinism. A study of similar problems in active database systems [BS93, SAV95, PD99, BW00] will form the basis for a study of these problems. (The prototype AHA system [DC98] uses a much simplified user model and rule system to avoid decidability problems. This cannot be extended without introducing the problems mentioned above.)
- Adaptation to the user in the NASH context also poses another type of problem: the system needs to decide which adaptation should be applied to the (query) input to the database layer, and which adaptation should be done to the (query result) output of that layer, in order to achieve the desired result with minimal wasted overhead such as retrieving objects from the database and then discarding them because they are deemed not relevant for the user. This research aspect involves the study of the expressiveness of query languages that are (or can be) supported by the database layer and comparing them with the expressiveness of the query and navigation interfaces through which the user enters information requests. One can also describe this issue as the expressiveness of the *view* mechanism of the database layer. Inside the database layer itself there is also the issue of the expressiveness of the "real" database query language versus the expressiveness of the "Dynamo" filter that translates a more traditional database model to the extended RMM model. In fact the Dynamo filter mechanism is also a view generator, albeit for a more dynamic view generation process. The research into the expressive power of query and transformation

languages will be performed in collaboration with the Adrem research group of the University of Antwerp, headed by prof. dr. J. Paredaens. An additional research grant has been applied for (by prof. Paredaens) with the Belgian Science Foundation (FWO, the equivalent of the Dutch NWO).

- In most adaptive hypermedia applications the adaptation is done at the data or instance level only. In a learning environment for instance the application consists of *concepts*, and adaptation is done based on the user's *knowledge* about concepts and on *prerequisite relationships* defined by the author, all at the instance level. In the Semantic Web however, data and metadata will be integrated. A user model no longer considers a fixed set of concepts that is predefined by an author, but extends as more conceptual metadata is retrieved from the database. A typical example (inspired by collaboration with Philips Research in the Dynamo and RTIPA projects) is that of an electronic program guide (EPG). The possible aspects of TV programs that can be taken into account for personalizing the EPG are not a predefined set of program types and attributes, but are gathered from metadata that accompany retrieved program data. (A related research project is PTV, developed at the University College Dublin, see http://ptv.ucd.ie/). In NASH we will investigate an adaptation framework that considers user models built incrementally from metadata, through user actions (querying and navigation) and that considers adapting queries and navigation steps on the one hand and query results on the other hand.

A.2 Time-varying Adaptive Hypermedia on the Semantic Web

Automatic generation of adaptive hypermedia requires knowledge about the application domain, users preferences and platform/network capabilities. In addition, knowledge is needed to encode the way in which relevant information is best presented to the user. While all these different types of information are already used within the current (Dynamo) framework, this information is either encoded using ad-hoc encoding techniques or, more often, remains implicit and hidden in the (procedural) generation software. Semantic Web technology provides a solid and declarative foundation for modeling, encoding, dissemination and processing of the different types of knowledge in a common, interoperable way while respecting the privacy of all parties involved.

- With Recommendations such as XML and RDF, the World Wide Web Consortium (W3C) has already taken a first step in the direction of machine-processable information (including metadata). Together, XML and RDF form the basis of a plethora of new initiatives that are pertinent to the NASH project. Examples of such initiatives include, but are not limited to, RDF Schema (data typing and vocabulary specification), DAML-OIL (ontology specification and reasoning support), P3P (privacy issues) and CC/PP (framework for the specification of user/platform capabilities and preferences "Composite Capability/Preference Profiles"). In addition to these knowledge-oriented techniques, generic document-oriented specifications such as XHTML, SMIL, WML, VoiceXML (presentation formats), XPath, XPointer, XLink (selecting, anchoring, hyperlinking), XSLT (document transformation), CSS and XSL (style issues) are of direct relevance for encoding the final-form presentation, as are (semi-structured) data-oriented initiatives such as XML Schema and XML Query. In addition to the W3C framework, other international standards are also highly relevant to the research, in particular the multimedia description work in MPEG7 and MPEG21. The proposed senior researcher at CWI will keep track of these developments, ensure that the NASH project benefits from work already done in this area and that new research conducted within the NASH project can be integrated within the Semantic Web infrastructure. (A researcher at the post-doc level is required to have sufficient access to and influence on the standards bodies that define and develop the Semantic Web infrastructure.)
- While the above approach focuses on the *use* of Semantic Web technology as a basis for encoding the knowledge that drives the generation process, much new research is still needed to investigate the relationship between the Semantic Web and multimedia content. State-of-the-art technology mainly addresses text-based (i.e. XML) applications and ignores typical multimedia issues such as timing and synchronization, compressed binary encoding, streamed delivery, etc. New (PhD level) research is needed to investigate the annotation of binary, non-XML media formats, annotation of time-varying objects (e.g. a player in a soccer match), support for multimedia

specific vocabularies and ontologies, and streamed delivery of (bulk) annotations at a controlled bit-rate, etc.

- Semantic information, platform information and user preferences need to be used together to steer the negotiation for network QoS and to select appropriate compression and encoding of simultaneously retrieved (multimedia) data objects so as to achieve an optimal presentation (for the given platform) at a reasonable cost. A "reasoning engine" is needed to bring together all aspects in Dynamo, RTIPA and NASH research, so as to generate presentations that use the style and type of media objects the user wants, that contain only those information items that are relevant for the user (based on the user model), and at a QoS and according to a timing schedule that fits the network characteristics. In the Semantic Web context, all the information needed to make these decisions is available with the data items in the form of metadata. This aspect of the NASH project is a true *integration* step that goes beyond NASH itself by including research issues and results from Dynamo, RTIPA and the other projects (some funded by NWO) we mentioned earlier.

B. Research Context

The NASH project is part of ongoing collaboration between the Database and Hypermedia research group at the Eindhoven University of Technology and the Multimedia and Human-Computer Interaction research group at the Centrum voor Wiskunde en Informatica. This collaborative research effort has several origins:

- At CWI the Multimedia and Human-Computer Interaction research group has been investigating synchronized hypermedia applications and frameworks for a number of years. This has resulted in the Amsterdam Hypermedia Reference Model [HBR94] (a descendant of the Dexter model [HS90, HS94] on which the AHAM model [DHW99] from TUE is also based), the PhD thesis of dr. Lynda Hardman (NASH co-applicant) and of drs. Jacco van Ossenbruggen (candidate NASH post-doc, thesis defense planned for April 10, 2001). It has also resulted in a large contribution to the W3C standardization effort for synchronized multimedia (the SMIL standard) and the startup of the company Oratrix.
- At TUE the Database and Hypermedia research group has been investigating the generation of hypermedia user-interfaces for multimedia database information for a number of years. This has resulted in the HERA project [HL00] (NWO project 612.061.003 and internal research efforts as well). HERA has its roots in the RMM model [ISB95]. This model has been extended to make it more suitable for automatic generation. To this end dr. ir. G.J. Houben of TUE has been working with dr. Michael Bieber of the NJIT institute and Rutgers University.
- A second research topic in the TUE Database and Hypermedia research group is adaptive hypermedia [D97, DC97, DC98]. While initially started in a learning environment, it has now resulted in the definition of a general framework for adaptive hypermedia: the AHAM reference model [DHW99] and the AHA prototype general-purpose adaptive hypermedia system [DC98]. This prototype is being developed further through a research grant from the NLnet Foundation. TUE is very active in the adaptive hypermedia research field. The research group hosts the world-wide Adaptive Hypertext and Hypermedia Homepage (http://wwwis.win.tue.nl/ah/) and co-organizes the Third International Workshop on Adaptive Hypertext and Hypermedia in 2001, at the ACM Hypertext Conference.

In 1998 the two research groups have come together and started a collaborative effort to study and develop a common framework for the automatic generation of hypermedia interfaces for multimedia databases. The first identified research topics are being investigated through internally or externally funded research separate activities (like AHAM and HERA) and through the common NWO Dynamo project. This collaboration also involves the Internet research group at Philips Research (in the Dynamo and RTIPA projects, in which dr. Warner ten Kate and drs. Mark van Doorn participate), and the company Oratrix (through the ITEA RTIPA project). Starting January 1, 2001 the collaboration has been further intensified through an exchange of the NASH applicants. Prof. dr. Paul De Bra has a part-time position (0.2fte) at CWI and dr. Lynda Hardman has a part-time position (0.2fte) at TUE. As part of this

collaboration dr. Hardman has already started actively co-supervising Susanne Loeber, OIO in the HERA project.

C. Related research (elsewhere)

Related research projects are plentiful. Rather than summing up the many related research initiatives we point to information sources for these initiatives. The Adaptive Hypertext and Hypermedia Homepage (http://wwwis.win.tue.nl/ah/) lists many projects that deal with adaptive information systems in many application areas. RDF, DAML OIL and CC/PP are just a few of the initiatives to incorporate metadata into Web-based information, either for resource descriptions, reasoning or user/platform capabilities. Many of these initiatives are endorsed by W3C and described on the W3C website (http://www.w3.org/). Other related research projects are already mentioned in sections A and B of this proposal.

D. Relevance (for society)

The *true* potential of Internet, and its most prominent application: the Web, lies in the ubiquitous access to information sources. While there certainly is room for manually authored documents that are delivered directly to Web users, the vast majority of valuable information and almost all services that are available through the Web are make use of Web-gateways to (corporate) information systems. In many cases the gateways offer access to several sources at once (through a unified view mechanism). The Web then acts as a *storefront* (or for multiple information sources a *portal*) that is available world-wide, and that can be accessed by human users as well as by (software) agents that act on behalf of a human or corporate user. More and more organizations come to realize that the only way to have a high-quality electronic storefront (that is never outdated) is to have a direct link between the Web-presentation and the corporate information systems.

While the current Web infrastructure has proved its worth in terms of the number of users and applications developed, almost all the information within it is captured using *document mark-up* languages and proprietary databases. The goal of the Semantic Web is to allow not only the data on the Web to be accessible in an automated fashion, but to allow the content itself to be machine-processable. Semantic integration of data in the above-mentioned Web-gateways to information systems can thus be automated. The benefits the Semantic Web for text are already large, since users will be able to find relevant and related information rather than finding information that is syntactically similar to the information they want. For multimedia the potential benefits of the Semantic Web are even greater, since current multimedia data formats are not amenable to the same syntax-based processing tools already in use for text. CWI's position as an active W3C member and role as national W3C office will ensure that the project's research results will find their way into the relevant W3C working groups in addition to being disseminated through scientific papers.

Internet is a very heterogeneous network. Network speed between clients and servers can vary from as low as 9,6 Kbps on a GSM phone to 100 Mbps or more on high-end workstations. The difference is a factor of 10.000. Screen size (in pixels) can vary a factor of 1.000 or more, and CPU power varies about the same. A multitude of presentations and interfaces are needed to serve all Internet users. WAP, Web-TV and normal Web presentations cannot be identical due to these differences in user-interface platform and network characteristics. The manual design and implementation of several widely different presentations and interfaces for a single portal site is prohibitively expensive. (It is also rapidly becoming too expensive to have this design and implementation performed by IT workers in countries with low salaries.) Many Websites therefore offer only a single, one size fits all, presentation and include a message like "best viewed with Internet Explorer 4.0 or higher, at 800x600 resolution, with 56K modem or better". Such an approach is clearly not acceptable in the long run. Together, the Dynamo, RTIPA and NASH projects are developing methods and techniques for automating the generation of hypermedia interfaces that are adapted and can adapt on the fly to differences in network QoS, screen size, CPU power and preferences of the user regarding interface style and presentation as well as interests, background and knowledge. The ultimate goal is to generate hypermedia interfaces that are just as good as manually designed interfaces for a specific user, platform and network. We do realize that within the

NASH project we will not reach that ultimate goal. But we do aim at (automatically) generating highly usable interfaces for a large variety of user aspects, platforms and networks, in a framework that is suitable for many application areas that require users to have hypermedia access to (semi-)structured multimedia data.

Work Programme

In NASH a post-doc researcher will concentrate on the integration of the research in the context of the Semantic Web, involving activities in standards bodies such as the W3C. We need (and already have) an experienced candidate for this part and are therefore applying for a post-doc and not an OIO (PhD student). The post-doc will also coordinate the work of the two OIOs, and the integration of the NASH work with the HERA, Dynamo and RTIPA projects. The adaptation and the multimedia aspects of the Semantic Web will be studied by the OIOs. Since this is a four-year research project involving 3 main researchers it is not possible to accurately predict exactly when which activities will take place. Also, depending on the outcome of activities in Year 1, the actual activities in subsequent years may be different. Therefore, the given time schedule should be considered as highly speculative. The importance of the schedule is that it shows the division of tasks between the three NASH researchers.

Post-doc, Year 1: The post-doc will first ensure that the CWI OIO is given guidance in which specifications are relevant to the research. On the basis of activities in the various standards bodies, topics will be selected for the OIO to concentrate on. The post-doc will concentrate on the overall design of a software architecture for incorporating the results of the two OIO's, and also for the other aspects of the framework (points 1-3 in the introduction). An important research contribution of this work will be to make explicit how the different types of knowledge influence the overall hypermedia generation process and how to model and encode the interdependencies in a declarative manner.
TUE OIO, Year 1: The TUE OIO will start by studying the literature on adaptive hypermedia and active databases, in order to define user modeling and adaptation primitives that fit into the Dynamo/NASH framework. This partly builds on previous work in AHAM project. However, significant differences with that previous project are (a) the availability of *retrieved* metadata that can be used for adaptation in addition to the more traditional *authored* metadata used for building a user model and performing adaptation, and (b) the distinction between adaptation of the *query* or *request* on the one hand and of the *query result* on the other hand. Initially, in this phase we assume that adaptation in the content selection is done at the data or instance level, and adaptation to presentation preferences such as media selection is done at the schema level. This first year will be mostly concerned with data- or instance-level adaptation.
CWI OIO, Year 1: The CWI OIO will study the relevant W3C and ISO standards applicable to the project (e.g. RDFS, DAML-OIL, MPEG7, MPEG21), in order to gain an understanding of the research issues for embedding multimedia in the Semantic Web. Emphasis will be put on the streaming of semantic annotations, on the encapsulation of hypermedia characteristics in a domain-independent ontology, and on the problem of semantically annotating arbitrary multimedia data formats. (The semantic annotations are just one example of the kind of metadata that are needed by the TUE OIO to base the adaptation on.)

Post-doc, Year 2: The post-doc will continue with keeping up-to-date with developments on the Semantic Web. He will (guide and) coordinate the collaboration between the TUE and CWI OIO. In addition, a prototype will be developed to test the overall framework, along with initial versions of the various modules implementing the knowledge sources (user profiles, device characteristics, media information, etc.). Emphasis will be put on the integration of the bottom-up query filtering approach and the top-down presentation adaptation techniques.
TUE OIO, Year 2: The TUE OIO will investigate the integration of user adaptation into the Dynamo/NASH framework. This means studying how adaptation can be distributed over the different steps in the framework between the initial user request and the presentation of the result. In particular there are at least the following steps: adaptation (extension) of the query to better indicate which objects (and in which media types) the user is looking for, adaptation of the immediate query result to eliminate

unwanted objects and/or media items, and adaptation of the hypermedia-structured result to guide the selection between space (layout), navigation (links) and time (synchronized multimedia presentation).
CWI OIO, Year 2: The CWI OIO will carry out research into semantically annotating multimedia using the methodology, tools and languages investigated in the first year. Emphasis will be put on the influence of multimedia aspects at all levels of the information chain, e.g. in media data formats, at the feature level, at the XML document level, at the transport level, at the schema language level and at the ontology level.

Post-doc, Year 3: The initial result of the various research lines will be integrated into a common demonstrator. The post-doc will continue to guide the overall design and development of the framework. The actual construction of the demonstrator will be a joint effort of the HERA, Dynamo and NASH teams, including help from Philips Research (Mark van Doorn) and programming and research staff from TUE. The post-doc will be responsible for the coordination of this development effort. The post-doc will also ensure timely dissemination of the results through the relevant standardization bodies and scientific publications.
TUE OIO, Year 3: The TUE OIO will investigate the integration of different adaptation techniques into a common framework. Adaptation can be based on authored and retrieved data and metadata, on information that is present at the instance level (with each object) and on semantic information that can be retrieved from the (database) schema level (with each object class). The aim is to define a more generally usable framework in which the type of desired adaptation is fully decoupled from the choice between data or metadata, and instance or schema. In this phase attention will also be paid to decidability problems that were previously identified for data/instance level adaptation (in the AHAM project).
CWI OIO, Year 3: The CWI OIO will collaborate with the TUE OIO in expressing the user-centered knowledge within the Semantic Web framework, and at the same time use example scenarios from the TUE OIO for testing out the techniques developed. The OIO will investigate how the different types of semantic information can be represented in the alternative approaches to the Semantic Web. Possibly the CC/PP initiative can be used or extended for representing user-related information. The OIO will also work on the presentation layer of the common demonstrator platform.

Post-doc, Year 4: While funding from NWO will not be available for the fourth year of the post-doc, internal funding will be used to further integrate the research results of NASH and neighboring projects (such as Dynamo) to complete the overall hypermedia interface generation framework and to further disseminate results in the W3C community.
TUE OIO, and CWI OIO Year 4: This final year is devoted to integration (and further publication) of results and writing the PhD thesis.

Expected Use of Instrumentation

The NASH project deals with the generation of hypermedia interfaces for multimedia database applications. State of the art multimedia workstations are standard equipment for computer science researchers. According to NWO's subsidy rules the institutes (CWI and TUE) are required to provide such standard equipment, which is estimated at 10 kfl per researcher. NWO pays overhead to the institutes to cover these costs.

Travel Budget

In the area of hypermedia and multimedia, even more so than in computer science in general, the dissemination of research results is first and foremost done through presentations (papers and demos) at conferences. International conferences from organizations like IEEE and ACM are highly valued in this research community (and have strict selection criteria and selection processes). The NASH researchers will need to visit at least 2 such international conferences each year. Initially this will be to meet other researchers and obtain recent research results. In later years this will be to publish and demonstrate results from the NASH project. In addition, the researchers will also need to attend international workshops and standards meetings on specific topics such as adaptive hypermedia, metadata formats,

network protocols, etc. A yearly additional travel budget of dfl. 10.000 per staff member will be required at least. The standard travel budget allocated by NWO will be needed entirely for bi-weekly NASH project meetings and for attending activities of the SIKS research school). If NWO expects TUE and CWI to finance the additional travel funds from the subsidy for "overhead" we kindly request NWO to mention this in the subsidy decision, so as to ensure that the NASH researchers will be (financially) able to publish their results at highly valued conferences.

Experts in this field

The NASH research project can only be evaluated properly by leading experts in the fields of adaptive hypermedia, hypermedia design, and multimedia information systems. Three distinguished members of the hypermedia/multimedia research community with experience in adaptation, design and multimedia aspects of the area of hypermedia are:

- Prof. dr. Wendy Hall, Multimedia Research Group, Department of Electronics and Computer Science, University of Southampton, Southampton, SO17 1BJ, United Kingdom.
  email: wh@ecs.soton.ac.uk, tel: +44 1703 592388, fax: +44 1703 592865.
- Prof. dr. Wolfgang Klas, Universität Wien, Institut für Informatik und Wirtschaftsinformatik, Liebiggasse 4, A-1010 Wien, Austria, tel: +43 1 4277 38430, fax: +43 1 4277 38449,
  email: Wolfgang.Klas@univie.ac.at
- Prof. dr. Alfred Kobsa, Department of Information and Computer Science, University of California, Irvine, CA 92697-3425, USA.
  email: kobsa@uci.edu, tel: +1 949 8243007, fax: +1 949 8244056.

Requested Subsidy

Personnel	**amounts in kfl**
1 post-doc, to be appointed at CWI for 3 years: standard (NWO) amount	300,00
	228,00
1 OIO, to be appointed at CWI: standard (NWO) amount	228,00
1 OIO, to be appointed at TUE: standard (NWO) amount	
Travel	14,70
standard (NWO) travel budget CWI:	7,35
standard (NWO) travel budget TUE:	70,00
additional requested travel budget CWI: (7 x 10 kf)	40,00
additional requested travel budget TUE: (4 x 10 kf)	
Computer equipment	
workstations will be provided by TUE and CWI	
Total	888,05

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