Digital Video and Hypermedia Based New Services for Working on Patrimonial Archives

Marc Nanard [*], *Jocelyne Nanard* [*], *David Genest* [*], *Michel Chein* [*], *Henri Betaille* [*]

[*] LIRMM, Montpellier, France
E-mail: (nanard, genest, chein, betaille)@lirmm.fr

ABSTRACT
The "Institut National de l'Audiovisuel" (INA) is in charge of keeping records of national TV broadcasts. Its main function is to provide TV producers with authentic sources. It also serves as a patrimonial archive library for researchers such as historians, sociologists, who study historical facts. The Opales Project is a test bed for studying new services empowered by digital video and hypermedia technology. Opales is a private portal, which enables its users to directly work on archive documents in private workspaces, to share elicited knowledge about studied documents, and to collaborate both anonymously and within groups.

The paper focuses on some of the services provided and on their consequences on patrimonial archive access:

- *Community management service* supporting virtual groups of users who declare to share "points of view" about documents. Supporting knowledge exchange (import / export) about documents between virtual groups is the key feature of the system. Video information retrieval services are improved by incrementally sharing user's private indexing of documents. For instance, one may import the "points of view" of some expert's virtual group for a more precise search. A shared ontology can be dynamically expanded according to selected points of view.
- *High precision indexing* empowered by using conceptual graphs. Representing the elicited knowledge in the annotations in a computable format makes inferences possible on annotations elaborated anonymously by independent users.

The new services supported by Opales aim at homing into the portal the results of users work. The direct consequence is a value added to the archives to which elicited knowledge is bound as user points of view.

KEYWORDS: Video, Hypermedia services, Archives, Community management, Knowledge sharing

INTRODUCTION
Patrimonial archives primarily encompass paintings, statues and objects one can see in brick and mortar museums and in their associated web

sites. Currently, many institutions already keep records of the most abstract and volatile aspect of our civilization: "information". Systematic collection of books in libraries is now standard and archiving audiovisual production is already ongoing in many countries. Audiovisual archives, for example the records of everyday TV broadcast, keep track of the history of present time. Just as Mesopotamian engraved clay tablets help researchers better understand old civilizations, audiovisual archives will be of great interest to future generation, provided that technology still exists for reading them! Such archives are rich in detail about our everyday life. Looking at records lasting from the fifties already reminds us of many otherwise forgotten details. Such records already have an important value for TV producers who are fond of genuine archives about historical facts of the recent past, as well as for scientists who study the social, political and economic evolution of the last century. Digital Video and Hypermedia now enable us to provide new services for improving access to audiovisual patrimonial archives.

Indexing techniques for objects and books have been tuned for a while. But information is a material quite different from art crafts. It requires far more precise indexing. Search engines running on the World Wide Web have pointed out the efficiency and the limits of content-based automatic indexing. Tim Berners Lee's Semantic Web project [1], [18] and the various efforts for handling annotations [21], stress the need for more semantics in annotations.

Promoting the reuse and the study of audiovisual archives is intended to provide support for retrieving information with precision. This implies to rely on rich semantic indexing of the video sequence contents at a detailed level.

Whereas data mining techniques are well suited for dealing with large data warehouses of structured data, or even of textual documents, no automated techniques are currently available to study video and audio documents in depth, and with relevance [11]. Understanding how to design raising suspense in a scene, or romantic mood in another still seems to be beyond computer practice and research. Moreover, analyzing and finely indexing video sequences of historical facts, typically requires the help of human experts. Beyond a semantically rich and well organized indexing resulting from a systematic analysis of the document, more informal annotations produced by experts working on these document also constitute a value added to the document for future analysis, like glosses in the margins of medieval manuscripts are to historians now. Providing direct access to annotations from the archive, and computing on the knowledge formally described in them is now in the reach of hypermedia based new services.

This paper focuses on the strategy for annotating and indexing audiovisual archives in the OPALES project, currently under development for the National Institute of Audiovisual Archives (INA) in Paris. The OPALES environment uses web technologies and aims at providing domain experts with support for incrementally adding value to the multimedia archive documents by sharing computable annotations between users. The study relies on research done at LIRMM on knowledge representation and on human computer interaction.

CONTEXT OF THE WORK

INA, created in Paris in the seventies, is in charge of keeping records of national TV broadcasts. It can already be considered as a kind of "information museum". Its main function is to provide TV producers with authentic sources. It also serves as a patrimonial archive library for researchers such as historians, sociologists, who study historical facts.

The French ministry of Economy initiated the OPALES project [15] to develop a distributed environment able to support collaborative knowledge work on INA's archives, in order to improve their value. The underlying idea is simple and well known: the value of information depends upon the usability of its attached metadata. The OPALES project is a test-bed for studying new services empowered by digital video and hypermedia technology. OPALES is a private portal, which enables its users to directly work on archive documents in private workspaces, to share elicited knowledge about studied documents, and to collaborate anonymously as well as within groups. One can find detailed studies of some aspects of the OPALES project in [3] and in [15]. This paper focuses on the indexing and search mechanisms in OPALES.

ANNOTATING VERY LARGE SETS OF DOCUMENTS

The huge amount of data already collected raises a specific problem and equally suggests an original solution. On the one hand, no institution can afford a staff specifically dedicated to finely indexing all of their records at detailed level. Currently, only some records corresponding to very narrow topics are enhanced with highly relevant detailed metadata. Such enhanced audiovisual archives are produced either to be used just as a showcase of the institution know-how or when making them available on the marketplace has the potential for significant revenue. Institutions cannot sustain such an effort for larger sets of archives. On the other hand, distributed computing on the web has proved its efficiency in tasks which were supposed far out of the reach of the largest computers, such as breaking encryption codes. The sum of individual work done by end-users accessing data on the Internet represents a huge distributed power, which can be captured to help indexing audiovisual archives. Such is the solution chosen for OPALES.

Beyond its sociological aspect, this approach raises several scientific issues that we summarize as follows:

Issues related to the consistency of the elicited knowledge:

- In order to be usable, the system must capitalize the independent works in such a way that it preserves the consistency of elicited knowledge.
- In order to be shared by end-users, the collaboratively elicited knowledge must be represented in a computable format and rely on a shared ontology.
- In order to assert the seriousness of annotations and indexes, a regulation mechanism must be available in order to maintain authority in annotations and to rely upon communities of experts.

Issues related to human computer interaction:

- In order to be sustainable, the effort for annotating documents on line must be smaller than the comeback from working on annotated documents.
- In order to enable each expert to

focus on her own expertise, no one should be constrained by the system.
- In order to support the interest of newcomers, the shared ontology as well as the annotation and indexing language must be extensible.

Some of these issues seem conflicting at first sight. One originality of OPALES is to provide simple and efficient tradeoffs.

Although the Web has succeeded as an open system without any centralized regulation mechanism, a potential problem arises that an open collaborative approach for indexing may lead to inconsistency. The context of OPALES partly reduces the risk. The application domain and the end users of the system are precisely targeted. OPALES is a private portal, at least at the beginning, with limited access to domain experts for research purposes or to TV producers. Thus, most of them are already quite familiar with searching and indexing techniques and fully aware of limitations of keyword-based approaches. Therefore, a more precise and extensible tool is one of their major needs. They are ready to accept some more effort when annotating, provided the overall outcome is worthwhile. Such experts also need to work alone but they are conscious of the need for precise indexing schemes and of a rigorous ontology to easily retrieve information.

SUPPORT FOR PRIVACY, COLLABORATION AND CONSISTENCY

OPALES provides private and sharable workspaces to support individual work as well as the emergence and the life of virtual digital communities of experts. It enables users to collaborate freely and anonymously to a shared given task in a consistent manner. Each registered user works in a private workspace, which induces a feeling of ownership. She works directly on documents as if they were private, for instance annotates, indexes or edits them at will. Furthermore, any displayed document, even an annotation, is enhanced by the annotations attached to it either by the user itself or by selected communities of experts. One may import enhancements from others, and export one's own. Details can be found in [3] and [15].

Experts need to define new indexing schemes and to extend the ontology in order to take their expertise into account. As a tradeoff between the suitable freedom and the need for a consistent management of annotations and of extensions to the ontology, OPALES takes advantage of the notion of "point of view". Besides information indexing, points of view induce a user-defined classification scheme based on expertise domain, which applies to any information in OPALES. Points of view are used as a filtering mechanism, which enables to handle locally consistent clusters of annotations.

Basically, a point of view identifies the concerns and the rules of a given community of users, which may even be reduced to a single user. Any piece of information, especially an annotation, always has a "point of view" stamp, which characterizes its concern. While authoring, points of view are used as a stamping mechanism. While reading, points of view are used as a filtering mechanism for searching or selecting enhancements. Information pieces that belong to a given point of view are supposed to share the same concern. For instance, a group of experts in "environmental issues" may annotate political speeches from this point of view. Of course, contradictory interpretations may exist among the annotations stored with this point of view; nevertheless, they all have the same concern. Conversely, annotations done by another expert group whose concern is, say "studying relationships between the color of ties wear by politicians and theit speech contents" should be written with this specific point of view. As exemplified by the previous example, the classification induced by points of view is not simply a part of the classification induced by the indexing. Indexing or annotating applies information contents whereas points of view concern the focus used by annotation authors.

Any user may freely create points of view. Points of view are private or public. To make a point of view public, i.e. to "export" it from one's workspace, one has just to informally describe its subject matter for easy informal understanding and to formally index it in terms of the shared ontology, so that it can be retrieved later, and thereby reused. Similarly to any document, a point of view has an owner who may act as the moderator of the point of view.

When a public point of view is read-only, only its moderator is allowed to stamp information with this point of view. When a public point of view is unprotected, any user who imports the point of view into her own workspace may stamp her own annotations with this point of view.

Rules can be attached to points of view. For instance, editing always takes place within a given point of view. Thereby, the editing tools available in the selected context are those defined for the selected authoring point of view. If none is defined, default ones are used. Many strategies of use can be defined upon this simple mechanism. For instance, let us suppose that a moderator has defined the DTD of an indexing scheme and wants to make it mandatory for a public point of view she manages. She has just to add it into the preferences of the point of view, then she can be sure that any indexing done by other users who import the point of view will be valid with respect to the prescribed DTD. Conversely, no guarantee can be provided about the semantics of the annotation itself. To assert the consistency of contents, couples of points of view can be used. The moderator owns both a public read-only point of view that she is responsible for keeping consistent, and another public unprotected point of view which any user may freely annotate. Thereby, users who need only secured points of view may import the read-only point of view, whilst those who do not care about the background noise but are interested in fresher annotations may import the free one.

As a conclusion, points of view constitute a very flexible mechanism. It helps cluster the elicited knowledge in a relevant manner to support collaboration, by mapping the knowledge clustering to the user groups clusters. This aims minimizing conflicts and inconsistencies. This approach is fully open and can support many strategies of use.

SUPPORT FOR ANNOTATING, INDEXING AND SEARCHING

In OPALES documents can be accessed either by navigating in the document catalog, by using private workspace bookmarks, or by searching. Once accessed, any document can be annotated, i.e. other pieces of information can be attached to it, either as metadata or as a hypertextual structure. We use the generic word of annotations for such information regardless to its use. There is no constraint on annotations in OPALES. An annotation can be simply a private and informal piece of text and drawings authored by the user as well as more formal data such as "Indexing Patterns DTDs", or even computable annotations formally described as "Nested Conceptual Graphs" (see next section). Specialized editors are available and are parameterized according to the authoring point of view.

The interest of such formal annotations is that a computer can reason about them, and their semantics is unambiguous for humans as well as for machines. As a consequence, they can be used for any purpose, especially for precise information retrieval, and for sharing points of view on information description among experts.

The formalism of the NGC model also enables one to evaluate similarity between annotations of multimedia documents, thus allowing fuzzy search. The distance between annotations depends upon the shortest transformation, which makes their conceptual graphs equivalent. Annotations in audiovisual documents are linked to spatio-temporal, possibly overlapping, anchors. As a consequence, retrieving a set of video segments matching a query involves computing distances between the annotations which represent the document base and the query. Beyond the OPALES project, the used technology is well suited to preserve and reuse collaborative annotations on documents.

ANNOTATING DOCUMENTS WITH CG

Computable annotations aim at binding semantics to multimedia documents in order to enable automatic reasoning on the elicited knowledge, especially for retrieval purposes. We have chosen conceptual graphs as a unified knowledge representation formalism to express and handle annotations. Directly working with experts at a knowledge representation level allows one to eliminate ambiguities inherent in natural language processing. Of course, if, in the far future, an automatic system were able to elicit the semantics of multimedia documents, it would be possible to plug it in our system! Furthermore, the formalism used enables computing directly on annotations which are elaborated by different people, since they share a unique but incrementally extensible ontology. Computing on annotations and searching for multimedia information matching precise queries is an important feature of the system.

A few word about conceptual graphs

Different languages have been built, in artificial intelligence, using entities and relations between these entities, known as semantic networks (see e.g. [12]). Sowa [20] introduced such a model called the conceptual graph (CG) model, which offers interesting properties for developing knowledge representation systems and information retrieval systems [9], [14]. But, the common term of CGs hides a great diversity of models. We are using the model developed by Chein and Mugnier, and their research group at LIRMM, since 1992 [4], [5]. Their knowledge and reasoning model allows dealing with facts, production rules, transformation rules, and constraints [13]. Roughly speaking, a simple CG is a labeled bipartite multigraph, in which nodes of one class, the concept nodes, represent typed entities (generic or individual), and nodes of the other class, the relation nodes, represent typed relations between these entities as shown in figure 1. Nested CGs (noted NCG) [6], [7] allows building hierarchical structures by embedding a (N)CG within a concept node. The fundamental operation, called "projection", is a homomorphism between CGs. This operation, which maps a CG onto a more specific one, is logically founded. Indeed, CGs corresponds to a first order logic fragment (positive, conjunctive, existential) and projection between CGs is equivalent to deduction ([4], [7]). By using rules and constraints different kinds of knowledge can be represented and different reasoning can be done [1].

Linking conceptual graphs and multimedia data

International Standards such as MPEG 4 for Content-Based coding of video [MPEG4], and MPEG 7 for metadata description are designed for handling annotations into multimedia documents. Unfortunately, these standards are not yet fully usable. Consequently, a simpler but reusable technique has been chosen. It relies on XML/SMIL/SVG standards. Its major advantage is to strongly separate three aspects:

- the read only archive video or sound tracks documents, owned by INA,
- the annotations described as NCG, stored in the user's workspaces,
- a database of information units descriptors

Separating these 3 layers avoids the need to make any change into video archives format or in the NCG platform data structures.

In OPALES , we use the term "information unit" to denote any selectable part of a document, for instance anchors. Any information unit in OPALES has a descriptor, which enables to access it, and stores its point of view and owner tags. Anchoring an annotation onto a user-defined segment of an archive video automatically creates an information unit descriptor to represent the selected virtual segment, and support the anchoring. For efficiency reasons information units descriptors are stored in a database, but are externalized in XML format.

Linking a NCG to an audiovisual document simply consists in using a NCG node of type "Anchor," whose referent is the unique ID of the information unit descriptor, which represents the anchor. The production and edition of the information unit descriptor is fully transparent to the user. The annotation editor automatically handles it, whenever an annotation is linked to a selection within an archive document. There is no constraint on anchor overlapping. SVG/SMIL description can be associated to a video segment descriptors enable to define regions, optionally animated, to support spatial anchorage into images or video. Direct anchoring from NGC is possible onto any kind of document, since the linking always relies on information units descriptors. Since video archives are, by nature, not editable, this technique is robust, efficient, and simple.

AN EXAMPLE OF ANNOTATION

To illustrate the approach, let us sketch the annotation of a video archive about ACM Hypertext conferences by several experts who share a "Hypertext expert" point of view.

One expert recognizes a sequence as recorded during the ACM ECHT 94 conference, and selects it in order to add the following annotation: "Picture taken at *ACM conference ECHT 94 in*

Edinburgh, in Scotland". As a consequence of the annotate command, the system creates an information unit descriptor for the selected segment and gives it an Id. A Video anchor concept node is also created with this Id. Then the annotation editor enables the user to describe the annotation in the NCG formalism, by defining relationships between the video anchor node and other concept nodes or NCGs, as shown in figure 1, left side. The annotation is stored in the database, with this user as owner.

Another expert recognizes in another sequence Douglas Engelbart talking with Tim Berners-Lee. She describes the sequence contents as " *computer scientist Douglas Engelbart who holds a glass, talking to computer scientist Tim Berners Lee* ", as described in figure 1, center.

Douglas Engelbart and Tim Berners Lee are added as scientists into the ontology extension associated to the "Hypertext expert" point of view.

Later another expert, looking for images, takes advantage of the previous annotation to retrieve this sequence and makes spatial selections to identify each person, as shown on figure 1, right side and annotates the name of each one.

Later again , another expert found in a trip report a textual description of this scene, "*during a coffee break at the ACM ECHT 94 conference, Tim Berners-Lee, the head of the WWW project, talks with Douglas Engelbart, the author of NLS, the first hypertext system, and tastes a glass of Scotch whisky*". She annotates that document like illustrated in figure 1, bottom.

Another one, present at the conference, annotates the glass of whisky as being a "*Glen Grant*".

The collaboratively elaborated knowledge is bound to the multimedia data and described in a uniform manner on which computation is possible, enabling very precise retrieval of multimedia data.

Another expert group, not related to the first one, but just concerned with whisky, working on quite different data extends the ontology in the "whisky experts point of view" and annotates a "Glen Grant" bottle as a "*Glen Grant is pure malt Scottish whisky*".

HIGH PRECISION QUERIES

Principle

Representing annotation as conceptual graphs provides with a precise querying mechanism. In a logic-based model [22] of IR, information is represented by a sentence d and an information need (a query) is represented by a sentence q, the truth of d -> q in terms of the logic means that the information represented by d is sufficient to infer the information represented by q (the information satisfies (is relevant to) the query). Given an annotated document base B and a query Q, the system has to extract from B the part which is relevant given Q. Answers to a given query are retrieved by means of graph operations. The existence of a projection between a graph q and a graph d means that d is sufficient to infer the information represented by q.

An important feature of the approach eliminates the drawbacks of pure pattern matching which may cause silence. This feature is addressed in the logical uncertainty principle: given an information d and a query q, the measure of relevance, denoted r(d->q) depends upon the minimal transformation applied to d to obtain some d' such that d'->q. Here, transformations are applied to d with respect to a set of knowledge represented by the ontology (or a thesaurus) allowing considering as (partially) relevant parts of the base that partially answer the query or represent close information. The relevance measure enables to use a relevance threshold to filter answer and limit the exploration depth, it also enables to sort results.

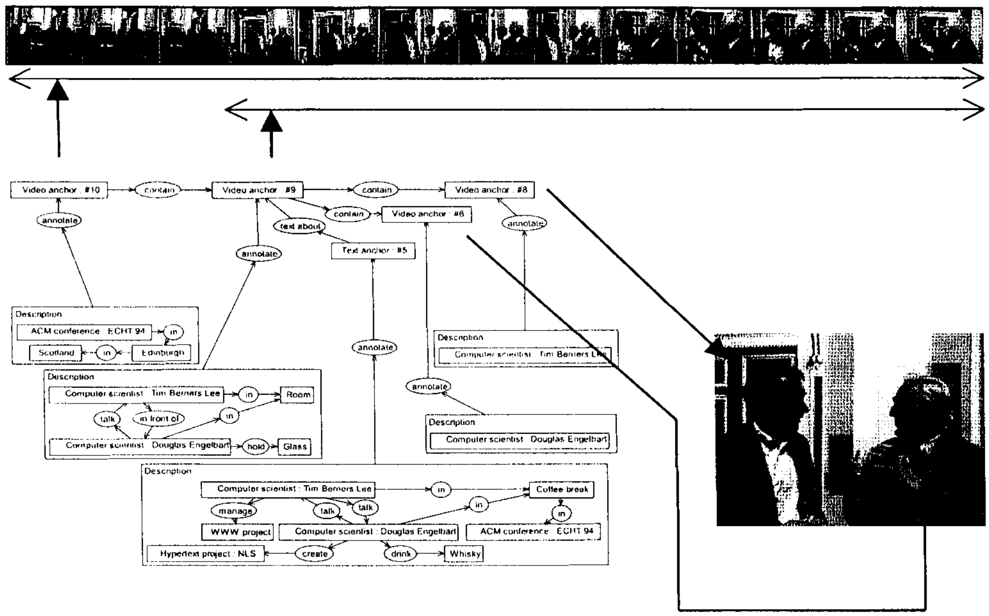

Figure 1: Annotating a video sequence with NCG

Importing knowledge into one's activity space

Suppose the "hypertext expert group" allows sharing the annotations, and that another expert imports them into her activity space. As a consequence, the knowledge which had been elicited and stored as separated pieces is observed for her as a single NCG since all embedded NCG have been built on the shared extension to the ontology and thus share the same support. Notice that, if needed at annotation time, new concepts such as "*computer scientist*" might have been added to the ontology as specialization of "*person*", and "*conference*" as specialization of "*event*". Furthermore the system has already inferred, from the Allen relationships implicitly present in the information units descriptors, some implicit relationship such as: the image about Tim and Doug is included in the sequence about the conference.

Examples of simple queries

Suppose we search for "*a video representing Douglas Engelbart talking with someone*". The graph projection is direct since a computer scientist is simply a specialization of a person.

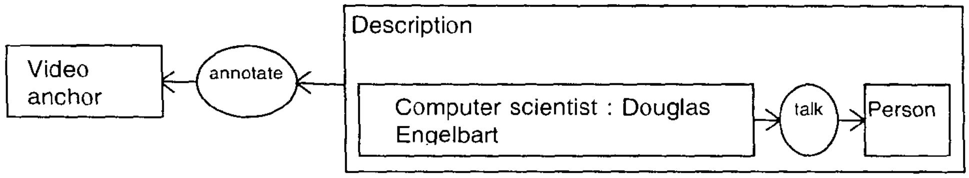

Figure 2: A query as a NGC

Let us suppose we are now searching for "*an image of someone related to the NLS project, within a sequence about a conference located in Scotland*". The graph projection is direct too. Remember that a concept node is unique in the base although it may appear in NCG authored by distinct users. For instance, actually there is only one Engelbart node. So, the sub graph *the image of Engelbart who created NLS, image contained in a sequence about ECHT94 conference in Scotland*, is a projection of the query graph. Thus Engelbart's image anchored in the video directly matches the query.

Similarly, searching for "a computer scientist drinking pure malt whisky" would require to import the "whisky experts point of view" in order to make the " pure malt " notion available in the ontology, when building the query.

Searching for closest partial answers

The drawbacks of exact pattern matching in information retrieval are well known. Partial match is helpful too, provided one can estimate how far the answer is from an exact one. This can easily be done on NCG by determining the shortest transformation needed to make two graphs homomorph. A heuristics provides an estimation function of the "cost" of such transformations. The system evaluates only the simplest transformations. Mainly, it checks for generalization of queried terms in the ontology and accepts partial matching. For instance, searching for "*two people concerned with NLS talking, each one holding a glass*" would fail at exact match. But a transform which consists in dropping in the query one edge about glass, and using the generalization "*hypertext*" instead of "*NLS*" would partial match at a cost which is the sum of those of the two transformations. Thus, if since the exact match fails, the video sequence would be proposed as a partial match of the query.

The overhead of inexact search is not heavy, since anyhow during the search for exact match, the system determines how far from the aim the search failed. Thus the transforms are computed only for the closest candidates.

We have presented simple queries on a sketchy example. Obviously, searching for someone with a glass of pure malt in one hand is not the concern of most of experts, but the example points out the precision of the mechanism since it would not have retrieved a glass on a table! Such queries are harder to answer correctly with keyword based approaches. These tools are extremely powerful. They are available in OPALES but do not prescribe any strategy of use. The openness of the system architecture enables each group of users to extend the ontology in their own domain, and to prescribe the suitable annotations patterns n conformity with their expertise.

DISCUSSION

Most of the results for automatic text indexing cannot be directly transposed to multimedia indexing since automatic analysis of multimedia documents is relevant only on very specific situations. For instance, voice recognition work efficiently on very small vocabulary in multi-speaker situations, thereby recognizing the names of famous persons or of well known locations in a news audio track is currently feasible. Similarly, locating score events in the sound track of a soccer match video record can rely on a simple signal analysis, which recognizes the associated applause. Like in libraries, when precision is needed, a large part of indexing still is to be done manually. One originality of the work consists in letting the end users do this time consuming task, and in interesting them in sharing their effort as a value added to information : groups of experts can export and import annotations from others. In that sense, the purposes and approaches of the OPALES project are very different from that of the Informedia project [16] which uses combined speech, language and image understanding technology to automatically transcribe, segment and index the linear video for feeding intelligent retrieval systems.

The second originality of the work is to rely on a unified knowledge representation, which enables dynamic sharing of knowledge between activity spaces, avoids ambiguities in descriptions and enables reasoning on elicited knowledge. A conceptual graph platform has been developed at LIRMM in the nineties and deeply improved in 1998 [10]. It is used in several applications, especially for precise indexing in libraries. Heuristics are used to boost the speed of algorithms on conceptual graphs in order to cope with large amounts of data. Computation actually deals with large sets of small graphs rather than with large graphs. Many relationships are pre-evaluated at graph construction time rather than at query time. We are currently improving the algorithms and heuristics to address larger and larger sets of data.

CONCLUSION

Information museums will not be simply repositories. New services should enable users to directly work on archives in private workspaces and to share elicited knowledge between users. Identifying any information unit in OPALES with a "point of view" tag creates a clustering of information, which can be maintained in a more secured manner. Selecting the sharing points of view adjust the visibility of annotations to the reader's needs. Homing the results of users work into the portal is a value added to the archives, since it improves their usability.

Sharing annotations supposes one can take advantage of work done by others [8]. One of these works is indexing. High precision indexing is empowered by conceptual graphs. Representing the elicted knowledge in the annotations in a computable format makes inferences possible on annotations elaborated anonymously by independent users.

The features available in OPALES do not prescribe any constraint on their use. It is up to each end user community to decide how to use the features and to set the operating rules. Nevertheless, OPALES implicitly suggests three categories of annotations: free annotations, formal annotations represented as NGC, and constrained annotations driven by indexing patterns. These categories cover a large scope of end users expectations when working on archives.

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ABOUT THE AUTHORS

Marc Nanard is Professor, CNAM (Conservatoire des Arts et Métiers), Paris & LIRMM, Montpellier. His research activity mainly concerns Document Engineering, Human Computer Interaction, and more precisely Hypertext and Hypermedia since 1988. He is Chair of the HCI research group at LIRMM. He was Vice-Chair of ACM SIGLINK (93-97), and Chair of ACM SIGWEB (97-99).
E-mail: *mnanard@lirmm.fr*

Jocelyne Nanard is Professor at Institut Universitaire de Technologie,

Department Telecommunications and Networking, Université de Montpellier. She manages with Michel Chein the OPALES project at LIRMM Her research interests include Multimedia, Open hypermedia and Man-Machine interaction. She is a member of ACM SIGCHI and SIGWEB.
E-mail: *jnanard@lirmm.fr*

Michel Chein is Professor in Computer Science at the University Montpellier 2. He manages the "Knowledge Graphs" research group (*http://www.lirmm.fr/~cogito*) at LIRMM.
E-mail: *chein@lirmm.fr*

David Genest received a BS and a MS in computer science, and recently a Ph.D from the University of Montpellier. During his doctoral thesis, he developed an extension of the conceptual graph model for information retrieval. His research interests are in knowledge representation and reasoning, document retrieval and information retrieval.
E-mail: *genest@lirmm.fr*

Henri Betaille is Associate Professor at Institut Universitaire de Technologie de Montpellier, Computer Science department. His research interests are in Human Computer Interaction and Hypermedia at LIRMM. He has been Proceeding Chair of IHM99. He is a fellow of the Opales Project.
E-mail: *betailled@lirmm.fr*