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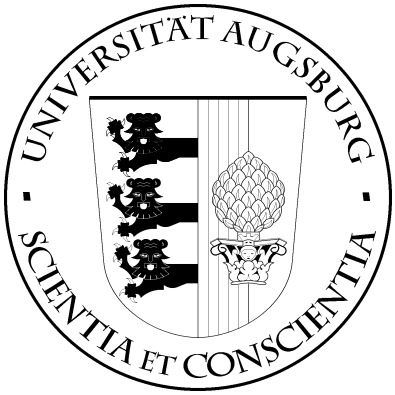
Angaben zur Veröffentlichung / Publication details:

Balke, Wolf-Tilo, Jose Gonzalez-Pinto, Qiuyue Wang, and Werner Kießling. 2003. "P-NEWS: A Personalized Notification Service for MPEG-7 Libraries." Augsburg: Universität Augsburg.

Universität Augsburg



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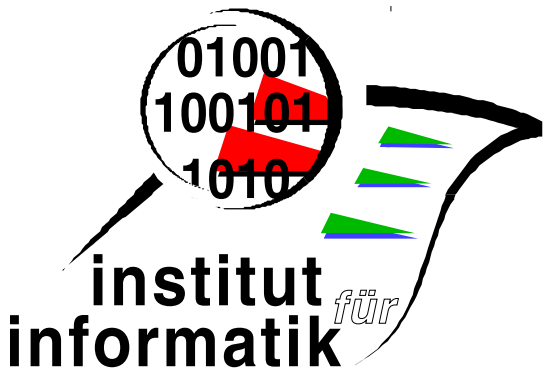
Report 2003-2 April 2003



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P-NEWS: A Personalized Notification Service for MPEG-7 Libraries

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Abstract. Many users of libraries or subscribers of news services have suffered the well-known troublesome problem of getting 'properly' notified about latest publications or events. Definitively this should happen in a personalized manner as much as possible. The acquisition and maintenance of sophisticated user preferences about topics of interest as well as knowledge about a user's personal situation are prerequisites for better solutions than current ad hoc approaches. The P-NEWS project tackles this challenge by applying a highly flexible preference engineering methodology with powerful preference query capabilities. Choosing an MPEG-7 setting we focus on the description of the overall P-NEWS component architecture. A novel 'Personalizer' component will automatically compose queries from preference patterns stored in a preference repository. These queries are efficiently evaluated against the MPEG-7 database using Preference XPATH. The delivery of selected documents will be done in a personalized mode, too. We exemplify our approach with a use case scenario for an IT news notification service. Eventually this work in progress targets to contribute technological advances for next generation digital news services, supporting diverse user groups registered for large multimedia libraries.

1 Introduction

The amount of information available e.g. via the Internet nowadays is overwhelming and the task of extracting all valuable knowledge from it is increasingly time-consuming. Especially in highly specific areas like IT what is considered to be relevant will strongly differ among various user groups like business-oriented consultants, technology-oriented developers or specialized researchers. Today's users find themselves confronted with a well-known dilemma: Spending too much time on going through new but probably irrelevant information will cost valuable research or working time, whereas spending less time may result in missing helpful information. Thus there is a trade-off between the expected gains from new information versus wasted work time. To overcome these problems publishing companies have recently introduced customizable news letters. Users can subscribe to a variety of general terms describing areas of interest, and are e.g. once a month informed which new

books might be of specific interest (e.g. 'Springer-Alert' [1]). However, these services have still a long way towards personalization, because users might not find all categories needed, might find that the publisher has chosen too broad terms as categories, or may have an entirely different understanding of categories altogether.

The area of data dissemination therefore has moved to employing advanced techniques for keyword matching in the texts of documents. Engines like SIFT [24] show already good results for full-text retrieval featuring IR techniques and prove that the task of finding relevant documents for notification can be efficiently performed even for large numbers of concurrent users. With the advent of XML engines for the search in XML documents like XFilter [2] applied the keyword-based retrieval to structured XML documents. However, none of these techniques focused on cooperative retrieval in multimedia attributes that is needed for MPEG-7 documents. There not only full-text data is involved, but numerical and categorical attributes in addition, demanding a personalized multimedia search engine that can cope with a variety of data-types. Compound documents containing text, images, audio or even video files together with adequate annotations or comments are quite common. Due to standardization efforts of the ISO/IEC MPEG-7 has evolved as the most complete framework for metadata annotations of multimedia documents. Thus querying an MPEG-7 database will involve a multi-attribute search over all kinds of data types, not only full-text.

Within the German Research Foundation's strategic research initiative 'Distributed Processing and Delivery of Digital Documents' the P-NEWS project aims at constructing a novel situation-oriented personalized notification system for MPEG-7 libraries. The key technology of P-NEWS is a flexible preference model in conjunction with a powerful personalized query language for XML. Despite the undeniable importance of preferences for real world applications preference research in databases did not receive a more wide-spread attention until recently. Starting already in 1993 there has been the long-term research vision and endeavor of "*It's a Preference World*" at the University of Augsburg. These experiences have been compiled into a comprehensive framework for preferences in database systems in [11]. Preferences are modeled as *strict partial orders*, and as an essential feature the use of *intuitive preference constructors* is promoted. This preference model is the basis for *Preference SQL,* a commercial product released in 1999 ([13]), and for *Preference XPATH* ([12]), a query language to build personalized query engines in XML environments.

Notifications in P-NEWS are supposed not only to involve matching content-based preferences, but also adapting to particular situations. Let's envision a sample scenario: Cathy is a professor at a University carrying out teaching duties, research projects and she is involved in a spin-off business. At her office she has fast Internet access with a modern PC Desktop. She also owns a mobile phone to keep track of events. Assume that Cathy currently wants to find projects related to her research and there is a suitable document in P-NEWS' MPEG-7 database, e.g. a new research article. The preference matching process first will recognize from the semantic representation of Cathy's preferences that the relevance of the new article justifies to decide for notification. Next, the situation refinement begins: e.g. Cathy's location at her office currently using the desktop computer triggers an immediate notification to be directed to her PC. The technical possibilities of the PC together with the high bandwidth available will furthermore affect the notification style of delivering the entire multimedia document. Now, suppose sometime later there is another interesting new

document in the MPEG-7 database concerning business news for her spin-off. However, Cathy is currently in an auditorium giving a lecture. Again P-NEWS will judge the document as interestingly enough, but this time will delay the notification, since Cathy's profile shows that she does not want to be disturbed during lectures. Since Cathy only carries her cell-phone with limited capabilities, also the notification style will be automatically adapted to delivering only the headline and a short abstract.

For the rest of this paper in section 2 we shortly review our preference model and introduce the P-NEWS personalization approach. Section 3 discusses how to represent user profiles and preferences in MPEG-7 and outlines a use case for P-NEWS in an IT news setting. In section 4 we close with a short summary and outlook.

2 The P-NEWS Personalization Approach

2.1 Preference Modeling and BMO Query Languages

User modeling is a critical task for adaptive systems [10], hence also for P-NEWS. At the very heart of P-NEWS is the intuitive as well as powerful preference model from [11]. Let's give a short introduction to make the paper more self-contained.

People express their wishes intuitively in the form "*I like A better than B*". Mathematically such preferences are *strict partial orders*. Let $A = \{A_1, A_2, \ldots, A_k\}$ denote a set of attributes A_j with domains $dom(A_j)$. Considering the order of components within a Cartesian product as irrelevant let $dom(A) = \times_{Aj \in A} dom(A_j)$, then:

- A ***preference*** *P* is a strict partial order $\mathbf{P = (A, <_P)}$, where $<_P \subseteq dom(A) \times dom(A)$.
- "$x <_P y$" is interpreted as "I like y better than x".

For ease of use a choice of ***base preference constructors*** is assumed to be predefined. This choice is *extensible*, if required by the application domain. Commonly useful constructors include the following:

- For *categorical* attributes: POS, NEG, POS/POS,POS/NEG, EXP
- For *numerical* attributes: AROUND, BETWEEN, LOWEST, HIGHEST, SCORE

POS specifies that a given set of values *should be* preferred. Conversely, NEG states a set of disliked values *should be* avoided if possible. POS/POS and POS/NEG express certain combinations, EXP explicitly enumerates 'better-than' relationships.

`AROUND` prefers values closest to a stated value, `BETWEEN` prefers values closest to a stated interval. `LOWEST` and `HIGHEST` prefer lower and higher values, resp. `SCORE` maps attribute values to numerical scores, preferring higher scores.

Preferences are be combined inductively by ***complex preference constructors***:

- *Pareto* preference $\mathbf{P := P_1 \otimes P_2 \otimes ... \otimes P_n}$: P combines *equally important* preferences, implementing the Pareto-optimality principle.
- *Prioritized* preferences $\mathbf{P := P_1 \,\&\, P_2 \,\&\, ... \,\&\, P_n}$: P evaluates *more important* preferences earlier; P_1 is most important, P_2 next, etc.
- *Numerical* preferences $\mathbf{P := rank_F(P_1, P_2, ..., P_n)}$: P combines `SCORE` preferences P_i by means of a numerical ranking function F.

The formal definitions of preference constructors can be found in [11]. Preference construction is inductively closed under strict partial order semantics. Since numerical preferences have a *limited* expressiveness ([8, 5]) many strict partial order preferences cannot be described by numerical preference constructors only. Thus the support of the full preference constructor spectrum as described is a practical necessity.

Extending declarative query languages by preferences leads to *soft selection conditions*. To combat the notorious 'empty-result' and 'flooding' effects in [11] the ***Best-Matches-Only*** **(BMO)** query model has been proposed. Assuming a preference $P = (A, <_P)$ and a relation R, BMO query answering conceptually works as follows:

- Try to find *perfect matches* in R wrt. P.
- If none exist, deliver *best-matching alternatives*, but *nothing worse*.

Existing implementations are Preference SQL and Preference XPATH for XML. The latter can be applied in other XML key technologies like XSLT, XPointer or XQuery. Preference XPATH supports the full preference constructor spectrum mentioned above. Note that numerical attributes as well as categorical attributes can occur in MPEG-7 metadata. Concerning keyword search on full-text attributes it is important to realize that standard information retrieval models, like e.g. the vector space model, can be characterized as numerical preferences of type $rank_F$. Thus any such IR-based solution is part of our overall preference model. Moreover, keyword search can be integrated with Pareto or prioritization constructors ([12]). As a consequence, any keyword-based full-text search offered already by standard XPATH or developed by a third party (e.g. [20]) can be used as a Preference XPATH preference.

2.2 General Architecture of P-NEWS

Aiming at a personalized news service that will notify users about relevant digital documents we will first have to focus on the necessary steps. The tasks can be split into several parts as illustrated by figure 1. The central component is the *Personalizer* having two main components: the *Composer* and the *Synthesizer*. Subject to some given notification strategy, the Composer matches user profiles (in the sense of stereotypes) against newly arrived documents in the MPEG-7 library. Commonly used strategies include 'immediate' (i.e. at each new document arrival), 'periodically' (e.g. once a week) or 'after k docs'. User profiles are specified by so-called *preference patterns* [4, 21], being preferences constructed under our preference model. For persistent storage they are kept in a *Preference repository*.

Guided by situational knowledge, the Composer extracts relevant preferences from the repository and assembles them into one overall preference P. This process is possibly augmented by extra knowledge from a *Domain repository*, e.g. containing ontological knowledge. Then this P is turned into a Preference XPATH query. Note that this essential step is quite simple here, because we don't have an impedance mismatch between the preference model used for user profiles and for the search engine! Then returned BMO query result must be analyzed before a notification can be decided. Since the quality of an object in the BMO set may in general range from a perfect match to a worst possible alternative, at this stage a quality assessment procedure has to be performed. In fact, this part is far from being well understood by now. But assuming the quality test succeeds, the Synthesizer component takes over.

The Synthesizer uses the information returned by the database in order to tailor the information to be delivered to the user's service preferences. The technology for these components is based on generic XML documents that are transformed automatically according to the service profile using XSLT technology. Basic techniques are e.g. a style sheet library [22] or progressive content delivery [23] to guarantee a maximum degree of flexibility and simple extensibility.

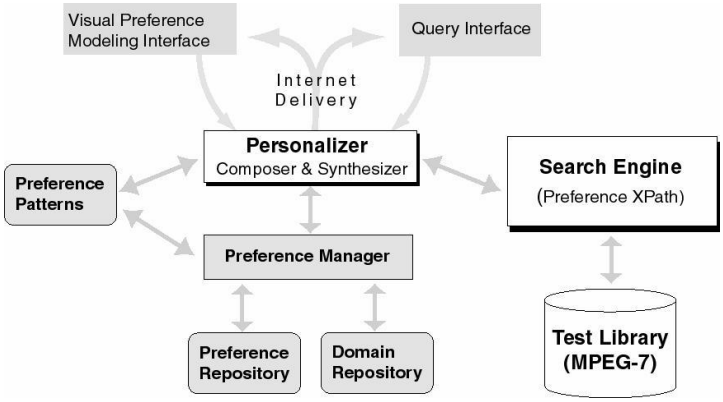

Figure 1. General architecture of P-NEWS

2.3 Preference Patterns

Preference patterns in P-NEWS specify what is considered relevant and how to be informed in case a notification is triggered. When designing a service the providers generally have an idea what kinds of interaction to expect. In the case of P-NEWS related user groups will prevail being interested in specific IT-aspects like business models, application development or research. Providers thus can anticipate different possible usages. Typical interactions for different user groups are referred to as preference patterns. As shown in [21, 4] for proactive service provisioning assigning users to certain patterns will result in improved efficiency, because the choice of useful preferences for each instance of relevance assessment can be limited down to a sensible applicable subset of the entire profile. Some useful default values can be assumed for all important preferences that have not been explicitly provided by a user.

Different interest groups often show different, but within the group mostly similar interests and interaction patterns. Interacting with P-NEWS related to the IT world will make us deal with the following groups of users: developers, researchers, lecturers, students, IT-consultants, network/system administrators. Since some of these groups will show overlaps, e.g. most lecturers will also carry out research, we have to keep different profiles for some users. A certain lecturer may e.g. have explicit preferences towards authors of textbooks and different preferences on authors of research papers, but although these preferences are both on the attributes of 'authors', they can coexist within his or her profile with respect to different preference patterns.

However, the knowledge maintained in preference patterns will play a further important role in P-NEWS, since it can be used to assess the quality of retrieval results within the BMO model. The area of Semantic Web has already shown how to improve the quality of service when enriching the user's profile along suitable ontologies [7]. But having a declarative BMO query language with intuitive preference constructors we can do even more. To distinguish between relevant and non-relevant objects Preference XPATH can offer capabilities that will stop the relaxation at a certain degree of generalization or will only relax within a certain range of objects. (This compares to applying the 'BUT ONLY' clause in Preference SQL.) For instance we can relax constraints for our lecturer only to books that are still textbooks. Thus we have the means to take quality assessment beyond mere numerical thresholds to a relaxation based on all objects that are available within our MPEG-7 collection. In contrast to conventional systems, we can thus retrieve the best matching objects and only deliver those that show a certain still acceptable quality. Such quality assessment functionality will be part of a forthcoming release of Preference XPATH.

3 A Use Case for P-NEWS

3.1 The MPEG-7 Standard and our Video Archive

MPEG-7 [17], the Multimedia Content Description Interface, is an ISO/IEC standard developed by Moving Picture Expert Group (MPEG). It provides a comprehensive set of description tools for describing multimedia information. These tools include a set of Descriptors (Ds), which describe atomic features of multimedia data, and Description Schemes (DSs), which specify the structure and relationships between their components (Ds or DSs). Both Ds and DSs are defined in the Description Definition Language, which is based on XML schema and extends it by new data types. For multimedia documents the *VideoType* DS e.g. contains different components for describing various information about the video data, e.g. *MediaInformation* (storage format, visual coding), *CreationInformation* (title, creator, classification), *UsageInformation* (access rights, distributor), structural aspects (subsegments) and conceptual aspects (text annotation, semantics).

The P-NEWS test library consists of around 200 videos available from the Computer Chronicles archive [6]. Computer Chronicles was a popular television program on personal computer technology, broadcast from 1982 through 2002. It covers a variety of high-tech subjects, such as operating systems, security, e-commerce and etc. Each video episode lasts around 30 minutes, and its size in MPEG-1 is around 250 Megabytes. We used MovieTool [16] from Ricoh Company for manually annotating the videos, which is able to describe all meta-data defined in MPEG-7.

In practice only a subset of description tools is relevant to a particular application. To reduce unnecessary computational complexity, MPEG-7 is usually profiled to support a certain class of applications. We hence work along this line and customize MPEG-schema based on *Simple Profile* [19], which addresses our application needs, i.e. filtering and retrieval of entire pieces or temporal segments of audiovisual material based only on textual metadata. The customized MPEG-7 schema supports the

description tools about the structural information of the multimedia data, i.e. *Segments* and their *Temporal* and *MultimediaSource* decompositions. This enables the fine-grained retrieval of multimedia content. Associated with each segment, there is a set of tools for describing different information about the segment. Low-level features (signal-based information like color, shape and texture) are not considered since the retrieval is only based on textual information. All the graph structure, relation or relationship types are not supported as they need post-processing to locate requested information. This reduces the complexity of the retrieval process, and thus is adopted in our first-step experiments with P-NEWS.

3.2 Mapping User Preference Descriptions to Preference Queries

When a new user registers to the system, P-NEWS will automatically generate a default user profile according to the user group that she or he belongs to, which is determined by her or his personal data. The user profile is specified using the MPEG-7 standard *UserPreferences* DS [18]. A diagram of *UserPreferences* DS is shown in Fig. 2. It enables users to specify their preferred multimedia content in terms of attributes related to the creation, classification, and source of the content, and also their preferred ways of browsing the multimedia content. In addition, the *UserPreferences* DS enables users to specify preferences that apply only in a particular contexts or situations, in terms of time and place.

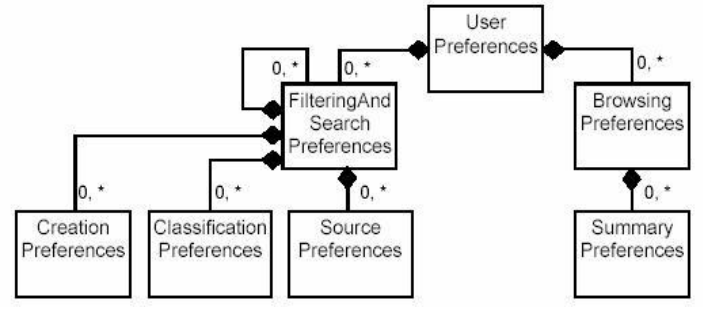

Fig. 2. UserPreferences description scheme

An example user preference description is shown in Fig. 3. Since the MPEG-7 standard does not assign a specific semantics to user preferences its interpretation is not pre-defined, but can be fixed by the application. It turns out that for P-NEWS there is a very natural interpretation as follows:

- All preference components in the UserPreferences description are treated as base preference constructors under our preference model.
- Sibling relationships between preference components are considered equally important, hence are translated into Pareto preferences.
- Parent-child relationships specify hierarchical relations between preferences, i.e. child preferences can apply only on the condition that the parent preference is satisfied. This naturally corresponds to a “more important” semantics, hence prioritization preferences.

```
<UserPreferences>
   <FilteringAndSearchPreferences>
      <CreationPreferences>
         <Keyword> DataBase </Keyword>
      </CreationPreferences>
      <FilteringAndSearchPreferences>
         <SourcePreferences>
            <MediaFormat>
               <FileSize> 300000000 </Filesize>
               <VisualCoding>
                  <Format href="urn:mpeg:mpeg7:cs:VisualCodingFormatCS:2001:1>
                     <Name> MPEG-1 Video </Name>
                  </Format>
               </VisualCoding>
            </MediaFormat>
         </SourcePreferences>
      </FilteringPreferences>
   </FilteringAndSearchPreferences>
   <Filtering AndSearchPreferences>
      <CreationPreferences>
         <Keyword> Wireless </Keyword>
      </CreationPreferences>
   </FilteringAndSearchPreferences>
</UserPreferences>
```

Fig. 3. An example UserPreferences description

Under this interpretation the user profile in Fig. 3 can be mapped onto a Preference XPATH query to be matched against the MPEG-7 database as follows:

```
/Mpeg7/Description/MultimediaContent//*

#[(CreationInform-
tion/Creation/Title|CreationInformation/Creation/Abstract
//*|TextAnnotation//* CONTAINS 'DataBase'

PRIOR TO MediaInformation/MediaProfile/MediaFormat
#[VisualCoding/Format/Name IN ('MPEG-1 Video') AND
Filesize AROUND 300000000]#)

AND CreationInforma-
tion/Creation/Title|CreationInformation/Creation/Abstract
//*|TextAnnotation//* CONTAINS 'Wireless']# /MediaTime
```

The Preference XPATH syntax reads as follows: A preference condition is delimited by **'#['** and **']#'**. Comparing to section 2.1, 'AND' denotes Pareto construction (⊗), 'PRIOR TO' means prioritization (&), 'CONTAINS' is a full-text preference constructor, 'IN' denotes a POS base constructor, 'AROUND' is clear.

This multi-attribute query returns all BMO objects as the media time of the video segments. Note that it covers numerical, categorical and textual data types. Since each preference component may carry a preference value attribute indicating the relative

importance of this preference, NEG preferences and POS/POS can be expressed as well. In such a way a preference description in MPEG-7 standard can be translated without impeding mismatch into one Preference XPATH query. However, the expressiveness of the UserPreferences description scheme of MPEG-7 is restricted: There is no natural way to express BETWEEN, LOWEST, HIGHEST preferences. Moreover, there is no obvious way to differentiate between hard conditions and soft conditions. This justifies the approach taken by P-NEWS to maintain its own preference repository, persistently storing more expressive preference patterns.

4 Summary and Outlook

The problem of dividing today's growing mass of newly published literature into documents that are relevant for a specific user or even a group given a certain task from the irrelevant is becoming more and more demanding. Too much time spent on browsing through possibly irrelevant documents costs valuable work time, but missing important developments in any field will often lead to missed synergies. In this paper we described the P-NEWS approach towards a new generation of personalized notification systems for MPEG-7 compound multimedia documents.

The preference model of [11] with its full spectrum of intuitive preference constructors is at the heart of the preference-driven approach behind P-NEWS. Such preference constructors are used to specify user profiles, which in turn drive the personalization process. The composer part of our novel 'Personalizer' component is in charge of dynamic query building using Preference XPATH. Very importantly, this task can proceed smoothly as there is no impedance mismatch between the user model and the query engine model behind Preference XPATH, returning best matching objects (BMO). Once a notification has been decided, which may be a situation-dependent procedure, the synthesizer part of the 'Personalizer' takes over in a preference-driven mode, again, employing familiar XSLT possibly in combination with Preference XPATH again. Since MPEG-7 metadata have plentiful of attributes with a variety of different data types, a powerful multi-attribute search engine like Preference XPATH is mandatory, exceeding keyword search in full-text attributes. In the course of this paper we have exemplified various aspects of such a complex notification process by a use case drawn from the IT news setting.

Currently P-NEWS is work in progress with many exciting research challenges. To name one, the problem of quality assessment for BMO query results warrants more research. Results on quality assessment like [15] are possibly relevant for P-NEWS. Investigations for intuitive, non-numeric preference constructors are under way in the COSIMA project [9] for E-Procurement applications, being part of the Bavarian Research Cooperation FORSIP (www.forsip.de). Other techniques fostering P-NEWS, may be ontologies [7] and cognitive query building [2]. In the more global picture, P-NEWS is one of several concurrent projects within our continuing "*It's a Preference World*" research program, including a novel Preference Query Optimizer.

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