Mask and Multiple Format:
Two Notions for a Progressive and Adapted Access to Information

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Abstract

This paper introduces the notions of mask and multiple format for setting up a progressive access to information in an Information System. Masks consist of more or less complete representations of the structure of information while multiple formats correspond to different representations available for a multimedia datum. We describe how these two notions are integrated into AROM, an object-based knowledge representation system which supports a UML-like formalism, by instantiating a model called PAM (Progressive Access Model). More generally, a progressive and adapted access to information can be given to users of any Information System by simply adapting the PAM to the underlying data schema and coupling it with the target data or knowledge base.

1. Introduction

Today, more and more Information Systems are accessible through the Web. These Web-based Information System (WIS) become popular and address different application domains such as e-business, geography, education, etc. However, if as web sites, WIS must offer visually attractive pages, the quality of a WIS not only relies on its graphical appearance, but also and mainly on its usefulness and on the way its users are efficiently given access to pertinent information.

WIS must be able to manage large amounts of information, with distinct sources and formats, and are characterized by complex services they offer to their users, such as, for instance, the reservation of train tickets on the web site of a railway company. Recent systems, developed by commercial companies ([1], [2], …), announce a new generation of web applications able to track down the behavior of the users and to dynamically react, by adapting the presentation of information. More generally, a WIS is said to be adaptable when the user gets the impression that the system has been specially designed for her/him. Then adaptability (and its dynamic version called adaptivity [3]) can be defined as the ability a WIS has to provide its users with some relevant information with regard to their rights, needs, individual characteristics and material configurations (WAP, browser, etc.), in terms of both content and presentation. When information is not appropriate, users are confronted to a cognitive overload due a too massive and difficult to understand quantity of information. This is highly prejudicial to the life of the system. For this reason, information must be organized, managed, and displayed in a personalized way.

In this paper, we propose specific mechanisms for adaptability, which are based on information reorganization using two notions called mask and multiple format. These notions offer a higher flexibility for accessing data in an IS. Each user or group of users can be provided with a personal information space which is organized in different levels through the masks. From a level to another, the user can navigate and then progressively access information. When information has a multimedia type (text, image, sound, video), multiple formats can be taken into account in order to fit the user's preferences at displaying time.

As a consequence, security management and data confidentiality can also be addressed by these notions: appropriated specification of masks and multiple formats allow to present partially, and then to hide, some information to users. Our approach is described by a model called Progressive Access Model (PAM). PAM is a model for describing how masks and multiple formats can be used in a data or knowledge base within an IS.

We have implemented PAM in AROM [4], an Object-Based Knowledge Representation System (OBKRS). AROM relies on a class/association schema similar to the notions adopted in UML [5], and on an Algebraic Modeling Language for expressing equations, constraints and queries. PAM and AROM are themselves integrated in an environment, called KIWIS (Knowledge for Improving Web Information Systems), that we currently develop [6]. KIWIS is dedicated to the design and generation of adaptable WIS in which users are given progressive access to information. For this purpose, both PAM and AROM are integrated into KIWIS.

The paper is organized as follows. The principles of masks and multiple formats are introduced in section 2.
Section 3 shows how these notions can be integrated in an IS, particularly in AROM. Section 4 presents the model PAM, which allows the definition of masks and multiple formats, upon an AROM’s knowledge base. Section 5 gives an overview of related work.

2. Masks and Multiple Formats

2.1. The Notion of Mask

The notion of mask allows to represent more or less completely a piece of information, with regard to its structure. We call Maskable Entity (ME) a set of information which can be structured in different subsets we call Representations of Maskable Entity (RoME). Each RoME is then associated with a level of detail, also called mask (cf. Figure 1).

![Figure 1 - ME structured in different RoME, each one corresponding to a detail level.](image)

Let ME={e1, e2, ..., en} be a Maskable Entity, where ei is an information element. For each RoME associated with ME, we have: RoME ∈ Set of parts of ME.

The specification of the RoME of a given ME must comply to the four following rules:

1) **Prerequisite**: a set of information can be considered as a Maskable Entity only if its number of elements n greater or equal to 2: 
   \[ n = \text{Card} (ME) \geq 2. \]

2) **RoME ordering**: as ordered representations of a ME, RoME are numbered from 1 to m where 1 and m respectively denote the less and the more detailed level of information. A RoME is defined as “more detailed” than another one if it includes it. Therefore, the higher the number of elements of RoME is, the higher the detail level is. We adopt the following convention:
   - RoMEi refers to the detail level i, available on the ME with 1 ≤ i ≤ m, m being the maximum detail level.
   - RoMEi contains at least one element of ME.

3) **Strict inclusion of RoME**: the RoME associated with a detail level allows to access the elements of the RoME associated with the immediately inferior level and contains at least one additional element. Therefore:
   - for each i,j, RoMEi ⊂ RoMEj.
   - We propose two functions for navigating from one level to another: from a given RoME, the **masking** function \( M \) gives the immediately less detailed RoME, while the **unmasking** function \( U \) gives the immediately more detailed RoME, (cf. Figure 2).

\[
M (\text{RoME}_i) \rightarrow \text{RoME}_i \text{ with } 2 \leq j \leq m \text{ and } j = i + 1
\]

\[
U (\text{RoME}_i) \rightarrow \text{RoME}_i \text{ with } 1 \leq i \leq m-1 \text{ and } j = i + 1
\]

![Figure 2. Masking and unmasking mechanisms.](image)

2.2. The Notion of Multiple Format

Because they manage information of multimedia type (text, video, audio, image, etc.), and more multimedia WIS can be classified as multimedia. The point is that these kinds of data are often voluminous and their diffusion (i.e. the way they are presented) is not always wished by users for various reasons such as for instance the lack of time, the absence of interest, or even unsuited material configurations. Most of the time, access to information in multimedia WIS is governed by a ‘all or nothing’ logic. A previous work we achieved [7] on the automatic generation of video abstracts have initiated an approach towards more flexibility in the handling of the video medium. The goal was to give a ‘busy’ user the opportunity to see an abstract rather than the entire video, taking into account her/his constraints.

Here, we introduce the notion of **multiple format** which is dedicated to multimedia information. The idea is to provide a progressive access to a multimedia datum by associating it with four more or less detailed formats given below in an ascending order of detail:

- the **meta-information format** is the minimum representation of a multimedia datum in terms of content. Such a meta information may refer to its title, its author, its date of creation, its texture, etc.;
- the **excerpt format** gives more details about the content of the multimedia datum. It corresponds to a fragment of the datum’s content obtained by an extraction mechanism;
- the **abstract format** gives a global but concise view of the multimedia datum;
- the **integral format** corresponds to the entire multimedia datum.

![Figure 2. Masking and unmasking mechanisms.](image)
The number of multiple formats is here arbitrarily fixed to four but could be extended. Also, different media can be used for each of these formats. For instance, for a multimedia datum of type video, the meta-information format can \textit{a priori} be of any medium type, the excerpt can be an image or a sub-video extracted from the video, the abstract can also be of any medium type. More generally, the idea behind this notion is \textit{not} to propose techniques for building these different formats (see for instance [8]) but rather to offer a descriptive way to handle those different formats in the data model.

3. Implementation in an Object Context

We describe here how masks and multiple formats can be integrated in the object formalism of the object-based knowledge representation system AROM. The goal is to provide AROM's users with a progressive access to information within a knowledge base. AROM relies on a Class/Association schema for describing knowledge but it is our opinion that the implementation of masks and multiple formats can be achieved in any IS whatever the underlying representation formalism is, being object or not, relational or XML-based for instance.

3.1. The AROM System

AROM (Associating Relations with Objects for Modeling) is an OBKRS in which the structure or schema of a Knowledge Base (KB) relies on two sets of distinct representation entities: \textit{classes} and \textit{associations}. Classes describe concepts to be modeled by means of \textit{variables} (attributes). Associations describe the relations which link these concepts by means of \textit{roles} and variables. Both classes and associations can be instantiated; \textit{objects} are instances of classes, \textit{tuples} are instances of associations. Variables and roles are characterized by sets of \textit{descriptors} (for type, inference, and documentation). Roles in associations are typed by classes (\textit{i.e.} the value of a role is an object or a set of objects), while variables are typed by basic types. AROM also has an Algebraic Modeling Language (AML) for describing operational knowledge (\textit{i.e.} equations, constraints or queries) involving classes, associations, objects, tuples, roles and variables, and handled by specialized solvers.

One can notice that modeling in AROM is very closed to the notations adopted in the class diagrams of UML and it is quite easy to describe an application domain to be modeled, through an interactive graphical editor dedicated to the design of knowledge bases (cf. Figure 5). Once the schema of a KB is described, its instantiation (creation of the objects and tuples), will trigger different control mechanisms to ensure the consistency of the KB or to infer unknown variable values. To query a KB, the AML of AROM can be used as a powerful query language a la OQL [9]. Also a Java API allows to use AROM through Java programs. Last, an AROM KB can be consulted on a Web server, through the WebAROM application.

3.2. Defining masks in AROM

In order to integrate masks into AROM, one has to list the representation entities which can be seen as maskable entities (ME) and to determine their associated RoME:
- at the higher level, the schema of a knowledge base is a maskable entity (ME) whose RoME are sets of classes and/or associations;
- a class seen as a structured information or a type record [10] built from the types of its variables is a ME whose RoME correspond to super-type records of this class;
- an association seen as a structured information or a type record built from the types of its roles and variables is a ME whose RoME correspond to super-type records of this association;
- an instance seen as a structured information or a value record built from the values of its variables is a ME whose RoME correspond to super-value records of this instance;
- a tuple seen as a structured information or a value record built from the values of its roles and variables is a ME whose RoME correspond to super-value records of this tuple.

Due to lack of space, we only describe here the first two cases. It can be noticed that the notion of mask extends the flexibility of the representations traditionally found in OBKRS by allowing a gradual vision of the structuring of an application domain.

3.2.1. Masks upon a knowledge base schema. In order to define one of the RoME of the schema of an AROM KB, one have to specify which classe(s) and/or association(s) form this RoME, with respect the four given rules. The idea here is to mask the structure of the knowledge base. Each RoME gives access to every class and/or association of the preceding RoME plus to some other class(es) and/or association(s).

Figure 3 gives the example of four mask defined on a knowledge base dedicated to river floods. These levels correspond to the needs expressed by the users of this IS. At level 1, a maximum masking is performed and users can access a minimum information space in which the cognitive overload is reduced: the content only presents what is considered as essential. Then, each next level gives access to more and more information.

Concerning visibility, the hierarchies of classes and/or associations are exploited this way: when a class C of a RoME is a sub-class, variables inherited from its super class are visible when displaying the content of an instance of class C. For instance, in Figure 3, in RoME 1, instances of the class Expert are represented by the variables \textit{name,
firstNamme, address, inherited from the class Author, and by the variables institute and confCode defined in the class Expert. Also, instances which are visible in the class C are those of this class C and those of the sub-classes of C, whether these later belong to the RoME of class C or not. In this case, instances of the sub-classes of C are, from a structural point of view, considered as instances of C (i.e. when displayed, only variables defined in C and in super-classes of C are visible). In Figure 3, instances visible in the class Expert at the RoME1 level, are instances of this class but also instances of the classes Geographer and Historian. These instances are displayed using the variables involved in the description of the class Expert and in its super-class Author (i.e. variables defined in subclasses Geographer and Historian are not visible).

Figure 3 - Masks on the schema of a knowledge base.

Arrows and labels RoME express that this structuring is internal. Each labeled box corresponds to a representation of the Historian class. At level 1, an instance is represented using only 3 variables. At level 2, two more variables are visible. At level 3, all the variables are visible.

Figure 4 – Structuring of a ME class into 3 RoME.

3.2.2. Mask upon a class. When the maskable entity is a class, each of its RoME is defined by a sub-set of variables of this class, which are consequently considered as visible at this level of masking. The successive RoME of a class provide different representations of instances of this class in which the number of displayed variables increases with the level of detail. Such a structuring can be seen as a kind of internal generalization/specialization for the class (cf. Figure 4).

3.3. Multiple formats in AROM

In an AROM knowledge base, multiple formats can be associated with variables whose value is a string containing the name of a multimedia file (text, image, audio or video). Since there is not yet specific media types in AROM, the goal is to provide some information describing the different available formats. Each format is defined by its nature (either meta-information or excerpt or abstract or integral), its type (text, image, audio or video), and a set of information used for the presentation of this format. For example, in the case of a continuous media type (an audio or a video file), it can be useful to know the desired (and not necessarily the effective) duration of this medium.

4. A Progressive Access Model

We present here a model, called PAM (which stands for Progressive Access Model), which describes how the notions of mask and multiple format are linked to the entities of a knowledge base in order to manage a progressive access to information. PAM (cf Figure 5) is written in AROM and some parts of it reflect the specific Class/Association model of AROM. But the PAM also contains general features common to the definition of progressive access in any kind of IS. For setting up a progressive access to knowledge in AROM, two models co-exist and are linked: one for describing the application domain and the PAM for describing on which entities masks apply and which multimedia variables are associated with multiple formats. Classes and associations of the PAM are presented below.

- Users and User Groups Description: UserCategory is an abstract class whose sub-classes Group and Individual maintain information concerning a group of users or an individual user. The membership of an individual user to one or more groups is modeled by the association HasGroup. The Boolean variable principal associates a user with a group by default. We impose that for every tuple \((gk, i, pk)\) of HasGroup, there exists one and only one group \(gk\) so that \(pk\) is true.
- Mask Description: The class ME describes a maskable entity as defined in section 2. The specialization of this class expresses that such a ME is either the schema of a knowledge base (class KB), a class (class Class), or an association (class Association). This two latter classes are themselves sub-classes of the abstract class Construct. Please note that this abstraction level simplifies the definition of a Maskable Entity Representation. The link

\(^1\) An extensible type system [11] implemented in the version 2 of AROM will allow the definition of such types.
between a knowledge base and a class (or an association) is modeled by the association BelongsTo. The classes Class and Association are respectively linked to the classes Variable and Field (super-class of Role and Variable). The association Structures links a maskable entity (instance of the class KB or of the class Construct) to a group or an individual (instance of the class UserCategory) and consequently of classes Group or Individual) and to the class RoME (which is specialized in the three kinds of RoME). Instances of the class RoME defined for an instance of the class ME and for an instance of the class UserCategory, all have a distinct and sequential level number (variable levelNum). The variable default_RoME in the association Structures allows to specify the default representation. A constraint similar to the one defined for the variable principal of the association HasGroup ensures the unicity of this representation. The three kinds of RoME (concerning a schema, an association or a class) are respectively created by instantiating tuples of the associations HasConstruct, HasField, and HasVariable. For example, an instance of the class RoMEClass, linked to some instances of the class Variable, means that these variables are visible in the class at the level of detail corresponding to the RoME.

- **Multiple Formats Description:** The association HasFormat describes the link between multiple formats (class Format) and a multimedia variable (class Variable). The multiplicity 0..* expresses that an instance of the class Variable has possibly no instance of the class Format associated with it. The association SpecifiesDefaultFormat defines a format by default, given an instance of the class Variable and an instance of the class UserCategory.

5. Related Work

Views [12] which were first defined in Data Bases (but since broadly applied to OODBMS [13], to XML [14] or to CORBA [15]) are also used to provide the user with a convenient representation of information, according to her/his needs. Then, RoME can be considered as ordered series of views. But, to our knowledge, there is no work dealing with the structuring of several views as the one presented in this paper and favoring a progressive access to information.

Splits objects [16] and RoME share the underlying common idea to split a concept in order to favor the access
to different points of view of this concept. However, one main difference is that split objects, stemming from the theory of prototypes, are defined on objects only, while masks propose a structural definition at a higher level of abstraction which concerns classes but also the whole schema of a knowledge base.

The notion of context [17] can also be considered as a basis for structuring an information space into RoME, at a schema level. Masks can be seen as a specification of contexts having a variable size: the information space is structured in order to be either enlarged or reduced. Our approach is close to the proposal of [18] where the notion of context is enriched with a reference in order to partially mask information. However, this approach does not put the emphasis on adaptability to user needs as ours does.

6. Conclusions

The notions of mask and multiple format presented in this paper aims at favoring a progressive access to information. Using masks, users of an IS gradually navigate through different levels of detail of structured data, while multiple formats adapt the presentation of a multimedia datum to the user's requirements. Masks and multiple formats can be described by a Progressive Access Model (PAM) and then integrated in a information system. We have presented the integration of these notions in AROM, an object-based knowledge representation system. Written in AROM and linked with the model describing the application model, the PAM offer to AROM's users a progressive access to knowledge at different levels of representation. Another interesting use could be made of the PAM for security and confidentiality aspects. PAM and AROM are integrated into KIWIS, a platform for designing and deploying adaptable Web-based Information Systems (WIS). For each WIS generated with KIWIS, both the application domain and the users preferences concerning progressive access are modeled using AROM. The definition of access rights for each user or group of users is achieved by the WIS designer, or by the end-user, if she/he is authorized, by a simple instantiation of the PAM.

This progressive access has been first experimented in the SPHERE project [19] concerning an Information System dedicated to geographic and historical data on river floods. Masks and multiple formats have shown to be of a rather intuitive use for different categories of users (experts, city hall employees, ...) who consult data about the same theme (floods) but at different level of detail.

Our research and developments are now directed towards the design of an interface dedicated to the definition of masks and multiple formats on different data schemas, and on the automatic generation of personalized masks based on the tracking of previous actions performed by the user in the WIS.

7. References