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Information Modelling for Adaptive Composition in Collaborative Work Environment

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***Abstract*—** Extensive information is required within a R&D environment, and a considerable amount of time and efforts are being spent on finding the necessary information. An adaptive information providing system would be beneficial to the environment, and a conceptual model of the resources, people and context is mandatory for developing such applications. In this paper, an information model on various contexts and resources is proposed which provides the possibility of effective applications for use in adaptive information systems within a R&D project and meeting environment.

***Keywords*—** Adaptive Hypermedia, Adaptive System, Context Awareness, Information Model, Information System, Personalisation.

I. Introduction

THE amount of readily available information has been increasing exponentially for the last few decades, and now it has become far more than one can possibly assimilate. To overcome this information overload phenomenon, there have been several researches on providing the right information at the right time by context-awareness and personalisation[1][2][3]. Although it would be ideal to develop means for providing the relevant information for general public with all different kinds of interests and purposes, it is virtually impossible to establish such a generic model for all people and/or contexts. Even if such a universal model were built, it would contain a significant amount of redundant information when it comes to developing an application for a particular purpose. Hence, previous researches usually assume specific purposes within limited domains or some closed environments. Those researches are proven to be useful to some extents, however, very few support collaborative work environments, or more specifically, R&D environments, although extensive information is required within a R&D process.

Therefore, this paper presents the Information Model for Adaptive Composition(IMAC) that enables providing adaptive information at the right time within a R&D meeting process. The model proposed in this paper describes the characteristics of various information on a R&D environment, including resources, people, context, and so on, for the purpose of providing the required resources depending on the circumstances and personal preferences. Moreover, the intended purpose of this model is for the applications not only providing the right information but also in the right form via adaptive composition methods as seen in various adaptive hypermedia and Adaptive Web Information Systems(AWIS)[4][5].

In this paper, first, some related standards are to be introduced. Then, the scope of the IMAC is described followed by a detailed specification. After that, the use of an ontology that gives more semantics for this model is discussed, and finally, it is concluded with some suggestions on the use of the IMAC.

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II. Related Work

Currently, there are no existing modelling or profiling standards suitable for supporting collaborative work environment, or more specifically, R&D meeting environment. However, there are several existing standards for information modelling and user profiling for other purposes, and it is worth investigating them prior to developing a new model.

A. Metadata

1) IEEE 1484.12.1 Standard for Learning Object Metadata: THE IEEE Standard for Learning Object Metadata(LOM)[7] defines a conceptual data schema that describes the structure of data elements for a learning object. The main elements in the current specification are:

- General: General information describing the learning object as a whole.
- Life Cycle: History and current state of the learning object.
- Meta-Metadata: Information about the metadata itself.
- Technical: Technical requirements and characteristics of the learning object.
- Educational: Educational and pedagogic characteristics of the learning object.
- Rights: Intellectual property rights.
- Relation: Relationship with other related learning object.
- Annotation: Comments on the use of the learning object.
- Classification: Relation to a particular classification system.

There are several metadata schemata based on this standard, including IMS LOM[8], SCORM[9], CanCore[10], UK LOM[11], FAILTE[12], the National Learning Network, University for Industry[13], and so on.

2) Dublin Core: The Dublin Core metadata standard[14] is an element set intended to facilitate discovery of electronic resources. Its fifteen data elements can map directly to the elements in the IEEE LOM standard. The main elements are defined as following:

- Title: Formal name of the resource.

- Subject: Topic of the content of the resource(keywords, key phrases, classification codes).
- Description: Account of the content of the resource.
- Type: Nature of the content of the resource.
- Source: The source that the present resource is derived.
- Relation: Related resource.
- Coverage: Spatial, temporal, jurisdictional scope of the content of the resource.
- Creator: Entity making the content of the resource.
- Publisher: Entity making the resource available.
- Contributor: Entity making contributions to the contents of the resource.
- Rights: Rights held in or over the resource.
- Date: Date related to the life cycle of the resource.
- Format: Media type of dimensions of the resource.
- Identifier: Formal reference to the resource.
- Language: Language of the content of the resource.

B. User Model

The main objective of user modelling or user profiling is providing personalised information depending on each user's preference, background knowledge, current task, and so forth. Most existing standards are aiming for managing and representing user profiles in *learning environment*. Some other uses of user profiling are commonly discovered in recommender systems[15][16][17], but they usually use a simple, single-parametered profile thus are not very seriously considered upon designing the IMAC.

1) IMS Learner Information Package(LIP): The IMS Learner Information Package[18] proposes a data model that describes characteristics of a learner. This specification supports the exchange of learner information among various systems used in the learning process. The core data structure consists of the following elements:

- Identification: Personal information such as name and contact details.
- Accessibility: Learner's language, disability, preferences and eligibility.
- Goal: Objectives and aspirations.
- Qcl: Received qualifications, certifications and licences.
- Activity: Learning-related activities.
- Competency: Skills, knowledge and abilities.
- Interest: Hobbies and recreational activities.
- Affiliation: Membership of organisations.
- Transcript: Records of academic achievement and performances.
- Securitykey: Security keys for learners interacting with the system.
- Relationship: Relationship between the other data structures.

2) IEEE Public And Private Information for Learners (PAPI Learner) Specification: The PAPI Learner specification[19] defines the semantics and syntax of information associated learners and used by learning technology systems. Instead of describing all possible learner information, it only states the minimum information necessary for the requirements, which enables it to become maximally portable. The main information types are as following:

- Learner Contact Information: Private information for administration.
- Learner Relations Information: Relationship to other users.
- Learner Security Information: Passwords and security Keys.
- Learner Preference Information: Preference information.
- Learner Performance Information: Learner's history, current work, future objectives.
- Learner Portfolio Information: Collection of the learner's works or references.

3) vCard: The vCard is a standard for Personal Data Interchange(PDI)[20], with electronic business cards. It can store personal information such as name and contact details, graphics and multimedia, geographic and time zone, and so on. It also supports multiple languages and is operating system independent.

C. Context Model

There are several researches on context or environment modelling for providing context-aware services. However, no specific model is advanced enough to be regarded as an abstract standard, since the attributes such model should contain vary greatly depending on the intended purpose and service.

A number of researches use physical sensors to construct appropriate context model[21][22], but the use of physical sensors are not considered in this project since the data that can be obtained from such sensors are not very relevant for retrieving and providing the necessary information, which is the purpose of our model.

III. Scope

The main purpose of the IMAC is modelling various information to enable applications to provide the right information at the right time in the right form - in other words, adaptive information with personalisation and context-awareness. Before designing the information model, it is necessary to determine what information is to be modelled, and that can be decided by considering the environment, the users and the target data.

The environment of the IMAC is limited to the research and development(R&D) process. Plenty of information is required during a R&D process and researchers or developers spend a significant amount of time and effort on searching for the necessary information, thus applications that actively provide the necessary information would be of great help for the researchers and developers, and a model on the environment would open a wide opportunity for developing such applications.

In addition, seeing that most R&D project participants work collaboratively, having regular or irregular meetings, support for such meetings is also included in the IMAC design.

Following that, the users to be modelled are easily defined as the participants of R&D projects and meetings. Since the data that the users require vary depending on their background,

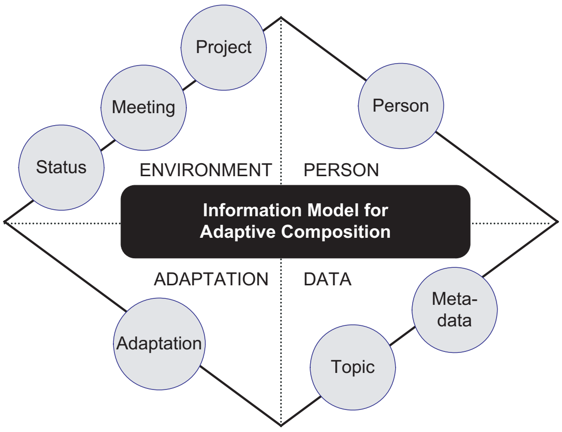

Fig. 1 IMAC Overview

knowledge level, interest, task, and so on, those characteristics are modelled for each individuals.

Finally, not only full documents but also information fragments are regarded as the target data to enable adaptive composition. A fragment here is a reusable unit information object such as a single image, a text sentence or a paragraph, a title, and so on, as well as a collection of such atomic objects, which can be adaptivly composed into an appropriate form. To enable the adaptive composition, a model for various adaptation techniques is also considered separately.

Although the information model in this paper is specifically for R&D meeting environment, the IMAC can be imported for other purposes with minor changes. In addition, not all elements defined in the IMAC are compulsory for use in any application, hence the application designers can select the required elements for their particular application, nonetheless it is generally recommended to fully adapt the IMAC.

Note that the means of acquiring the information, specific algorithms or architectures for the application are left for further research by application designers, hence not addressed in this paper.

IV. Information Model for Adaptive Composition

Following the main purpose and scope discussed in the previous section, the Information Model for Adaptive Composition(IMAC) is designed considering four factors: data, person, environment, and adaptation(Fig. 1). Seven domains are defined considering these factors and for each domain, the hierarchy of data elements are determined. For each element, the base schema are speficied including name, explanation, size, order, example, value space, and datatype.

A. Resource

1) Topic: When classifying a data object, the related topic is the key factor. The topics are required to be organised systematically and the topic domain should be able to represent all kinds of resources appropriately. Instead of developing a new topic model, it is decided to adapt the DMOZ Open Directory Project(ODP)[23], which is a large, comprehensive

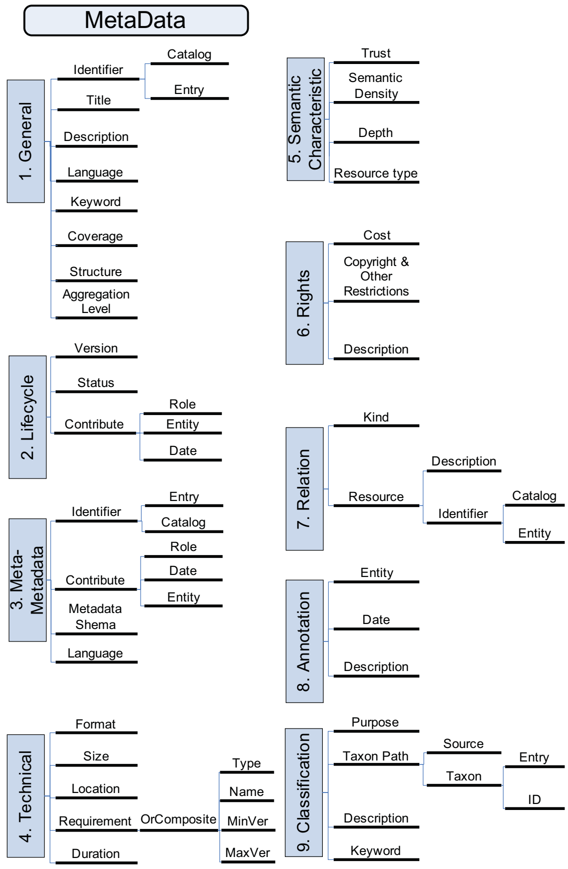

Fig. 2 Metadata Domain

directory of the Web. The DMOZ ODP is a very well defined conceptual model for classifying various Web information, and is also applied for various web directory services including the Google Directory[24]. Therefore, the use of this DMOZ ODP as the *Topic Domain* in our model is a reasonable choice and it also enables to link the application developed on the IMAC with the Web.

2) Metadata: To enable selecting the necessary data object, several additional data about data objects other than the related topic are needed to be defined as metadata. The IEEE LOM and the Dublin Core are excellent standards, but a few modifications are made to construct the *Metadata Domain* suitable for our purpose. The Educational element is changed into the Semantic Characteristics, several sub-elements are excluded, and a few sub-elements are newly added. The elements and structure of the *Metadata Domain* of the IMAC is as shown in Fig. 2.

B. Person

In the *Person Domain*, the personal characteristics such as identification, accessibility, participating projects and goals, level of knowledge, preferences, and so on are described. The use of a *group user model* by combining several individual user models has been suggested[25] rather than modelling each individual user preferences, but we believed that personalising

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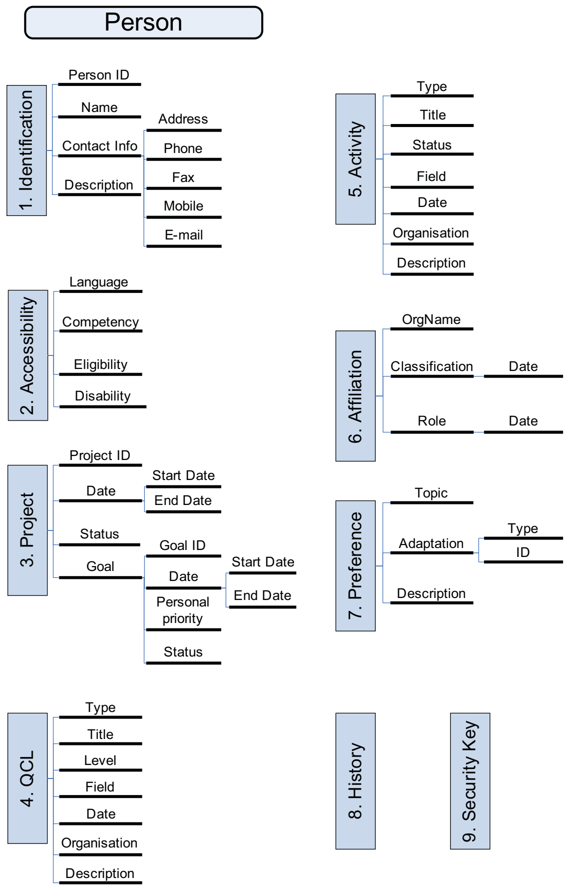

Fig. 3 Person Domain

information for each individual would still be beneficial even in collaborative work environment, since the data each individual requires can still be different even in the same community of practice. Also, depending on the application, the users may be able to share their given information to other collaborators.

The IMS LIP standard describes a very detailed model for an individual, hence this model is adapted with a few changes and simplifications, mainly to make this model fit to the users in R&D meeting environment rather than educational purpose. The model is depicted in Fig. 3.

C. Environment

For the context within the R&D meeting environment, first, it is necessary to describe the projects in general, hence the *Project Domain* is designed. Then, the *Meeting Domain* is constructed with the overall information on a particular meeting to support various meetings within a project, and finally the *Status Domain* is defined as a description of "what is going on" currently.

1) Project: The *Project Domain* defines the general information about a project. The elements in this model are General, Goal, Relation, Resources, and so on. The hierarchy of its data elements is described in Table I.

TABLE I
PROJECT DOMAIN

No.	Name	Explanation
1	General	The general information on the project.
1.1	ProjectID	A unique label identifying the project.
1.2	Title	Name given to the project.
1.3	Date	The start and end dates of the project.
1.3.1	StartDate	The starting date of the project.
1.3.2	EndDate	The ending date of the project.
1.4	Topic	The related topics of the project.
1.5	Keyword	The keywords related to the project.
1.6	Coverage	The extent of the project's application.
1.7	Status	The status or progress of the project.
1.8	Description	A textual description of the project.
2	Goal	The objectives of the project.
2.1	GoalID	A unique label identifying the goal.
2.2	Title	Name given to the goal.
2.3	Date	The start and end dates of the goal.
2.3.1	StartDate	The starting date of the goal.
2.3.2	EndDate	The ending date of the goal.
2.4	Topic	The related topics of the goal.
2.5	Keyword	The keywords related to the goal.
2.6	Priority	The priority of the goal.
2.7	Status	The status or progress of the goal.
2.8	Description	A textual description of the goal.
2.9	Goal	Recursive reference to enable the creation of sub-goals.
3	Organisation	The organisation involved in the project.
3.1	OrgName	The name of the organisation.
3.2	ContributionType	The type of contribution to the project.
4	Person	The person involved in the project.
4.1	PersonID	The unique label identifying the person.
4.2	ContributionType	The type of contribution to the project.
5	Resource	The resource used within the project.
5.1	ResourceID	The unique label identifying the resource.
5.2	Type	The type of the resource.
6	Outcome	The outcome of the project.
6.1	DataObject	The outcome which is a data object.
6.1.1	Catalog	The cataloging scheme for this entry.
6.1.2	Entry	The value of the identifier.
6.2	Resource	The outcome which is a resource.
6.2.1	ResourceID	The unique label identifying the resource.
6.2.2	Type	The type of the resource.
7	Relation	The relationship with other projects.
7.1	ProjectID	A unique label identifying the target project.
7.2	Kind	Nature of the relationship with other projects.

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TABLE II
MEETING DOMAIN

No.	Name	Explanation
1	General	The general information on the meeting.
1.1	MeetingID	A unique label identifying the meeting.
1.2	Title	Name given to the meeting.
1.3	Date/Time	The date/time of the meeting.
1.3.1	Date	The date of the meeting.
1.3.2	Time	The time of the meeting.
1.3.2.1	StartTime	The starting time of the meeting.
1.3.2.2	EndTime	The end time of the meeting.
1.4	Location	The location of the meeting.
1.5	Description	A textual description of the meeting.
2	Agenda	The agenda lists in this meeting.
2.1	AgendaID	A unique label identifying the agenda.
2.2	Title	The agenda title.
2.3	Keyword	The keywords related to the agenda.
2.4	Type	The type of the agenda. e.g. presentation, discussion, etc.
2.5	Result	The result of the agenda.
2.6	DataObj	The data object used.
2.6.1	ObjectID	A unique label identifying the data object.
2.6.2	UsageType	The way the object is used.
3	Attendee	The set of attendees of the meeting.
3.1	PersonID	A unique label identifying the person.
3.2	ParticipationType	The type of participation.

2) Meeting: The *Meeting Domain* provides an entire key information about a meeting. The information represented in this model can also be regarded as the brief minutes. This model describes the agenda, keywords, results and the resources used, as well as the fundamental information such as date and time, meeting location, and attendees. The data elements' structure is shown in Table II.

3) Status: The information on a particular status at a specific point in time can vary greatly depending on the application purposes and developers, hence the detailed data elements of the *Status Domain* are not specified within the IMAC. In general, these elements can be generated by selecting the required information elements from the other domains above, and a few new elements can be added.

D. Adaptation

The *Adaptation Domain* is particularly for adaptive composition. For each adaptation technique, the method such as structure, layout, navigation, or rule is defined in Adaptation Type, and a unique identifier is assigned. This domain can be freely used by application designers, depending on the adaptive functionalities the application would provide.

V. TRANSFORMATION INTO AN ONTOLOGY

The information extracted from the IMAC was transformed to the conceptual model using an ontology. An ontology is defined as a collection of concepts, relations and hierarchy between them, and constraints[26][27]. In this work, the ontology is employed to create the conceptual model from the information model including various semantics for a R&D environment(Fig. 4). In order to categorise the resource fragments and documents according to the topic, *Topic Class* is defined as conceptual hierarchy, by adapting the *Topic Domain*. The fragments and documents are assigned as instances of the most relevant concept matching the topic of their contents in the hierarchy. Other information, such as person, meeting, project and so on, is defined using the top-down method as the superclasses extracting the general concepts, and the subclasses extracting more specific concepts, respectively. The relations between classes are described as object properties. Through the class hierarchy, class constraints, and property constraints, the ontology can provide data with explicit semantics. It also provides a number of data models such as cardinality constraints, inverse property, transitive properties, symmetric properties and disjoint classes. Inference applying semantics defined through reasoner is realised. The knowledge that are not explicitly defined in the ontology can be inferred from it.

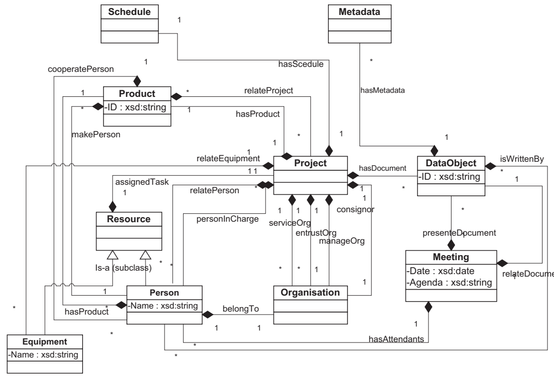

Fig. 4 Ontology Model

VI. CONCLUSION

The design scope and purpose of the IMAC is for the applications supporting R&D environment by providing the necessary information in adaptive form. Apart from the components adapted from existing standards with a few modifications, the notable points of the IMAC are managing the resources in content fragment units as well as documents, and specifying the *Project*, *Meeting*, *Status* domains for context modelling.

Moreover, although only the transformation of the IMAC into the ontology is described in Section V, other kinds of transformation or implementation of the IMAC are also possible, including relational database or XML, which is left for further researches.

Finally, the utilisation of standardised models makes the IMAC easy to understand for experienced developers, and applicable to a wide area of intelligent applications supporting R&D projects and meetings.

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