HYBRID ONTOLOGY-BASED FEEDBACK E-LEARNING SYSTEM FOR MOBILE COMPUTING

Ahmed Sameh, Abdalla Mahmoud and Amr Ibrahim
Department of Computer Science
The American University in Cairo
P.O.Box 2511, Cairo

Keywords: LOM, LMML, Dublin Core, Fragments, Metadata, RDF, Web Repositories, Mobile Computing.

Abstract: An E-Learning system that provides vast quantities of annotated resources (fragments or learning objects) and produces semantically rich feedback is very desirable. It is an accepted psychological principle that some of the essential elements needed for effective learning are custom learning and semantic feedback. In this paper we are making use of a collection (ontology) of meta-data for the design of a custom E-Learning system that also provides learners with effective semantic educational feedback support. The learning domain is "Mobile Computing". We define various concepts in the domain and the relationships among them as the ontology, and built a system to utilize them in customizing the E-Learning process. The ontology is also used to provide informative feedback from the system during learning and/or during assessment. The focus in this research is on the representation of ontology using languages/grammars, grammar analysis techniques, algorithms and AI mechanisms to customize the learning and create effective feedbacks. The proposed mechanisms, based on Ontology; are used to assemble virtual courses and create a rich supply of feedbacks, not only in assessment situations but also in the context of design-oriented education. We are targeting feedbacks similar to ones in programming environments and design editors.

1 VIRTUAL COURSES

The proposed system aims to expose vast quantities of annotated resources (fragments or learning objects) that have been created over time and space by educators and instructional designers to data-mining end users in order for the latter to assemble sequences of "learning objects" (virtual classes). Towards this goal we are proposing an ontology-based feedback model to achieve a number of high-level objectives: Dynamically Generating On-Demand Virtual Courses/Services, Providing Component-based Fragments, and facilitating rich Semantic Feedbacks.

An organization repository is a repository of course components (fragments) at various levels-of-details. As such, these fragments can be reused for several courses and contexts and can be distributed over a number of sites. A virtual course authoring process points to various learning components (fragments). A learning fragment is a self-contained, modular piece of course material. It can be either passive or active (e.g. live or recorded lecture). These fragments are annotated (for example by author) according to ontology metadata schema that provides efficient mechanisms to retrieve fragments with respect to the specific needs of a virtual course. With similar details; administrators cooperate in building various service repositories. This follows the new direction in what is called "Semantic Web" .

An organization local architecture consists of Repositories, a Mediator, Concept Storage Fragments, Storage Systems, and Clients. The Mediator provides transparent access for all client requests to all distributed repositories fragments. The huge amount of metadata we have to deal with indicates the need for efficient storage and query mechanisms. The repositories can be accessed either synchronous or asynchronous. Customers can either access their composed virtual courses/services either on-line or off-line, in distance and/or conventional education.

The development of electronic course material suitable for different learners takes much effort and incurs high costs. Furthermore, professional trainers have huge expenses to keep course content up to date. This problem occurs especially in areas where knowledge and skills change rapidly, such as in the Computer Science domain. Thus, we need new approaches to support *(semi-)automatic virtual*

Sameh A., Mahmoud A. and Ibrahim A. (2006).
HYBRID ONTOLOGY-BASED FEEDBACK E-LEARNING SYSTEM FOR MOBILE COMPUTING.
In *Proceedings of WEBIST 2006 - Second International Conference on Web Information Systems and Technologies - Society, e-Business and e-Government / e-Learning*, pages 347-356
DOI: 10.5220/0001247203470356

course generation in order to keep up with current knowledge and perhaps even to adapt materials to individual user needs. In this proposal *repositories* are used as infrastructure to support the automatic generation of virtual courses from similar course repositories, while also aiming to achieve a high degree of reusability of course content. A popular, promising approach is to dynamically compose virtual courses “on-demand” within the course repositories. The idea is to segment existing course material (e.g., slides, text books, animations, videos) into so-called learning fragments. Such learning fragments represent typically self-contained units that are appropriately annotated with metadata. Tailored training virtual courses are requested and generated "on-demand" by assembling single fragments, such as in (Tendy,1998) (Kolb, 1984). Using this approach that is similar to modularization in software engineering, we intend to achieve a high degree of *reusable content*, and have learning fragments that can be used in new contexts. This reduces costs for the development of real courses. User adaptability is achieved by means of allowing users to specify queries, and dynamically construct courses. As a result, a course may contain fragments from various sources such as textbooks, instructional movies, or slides from several knowledge providers (e.g. teachers) as well as fragments from similar remote repositories. Note that there is a tradeoff between granularity (size) of learning fragments, reusability, and annotation effort. Having small units of learning fragments increases the annotation effort, but implies better reusability since small fragments can be composed more flexible. The same can be said about virtual services for students/administrators.

Students can customize whatever they want to learn according to their learning style, the amount of time they wants to spend in a certain learning session, the surrounding environment, their mode, how deep they wants to dig into the subject, etc. Based on the available metadata annotations, on-line virtual courses are generated semi-automatically from course repositories by selecting appropriate course fragments and by structuring them into a virtual course, which is a composition of fragments. The selection and composition is based on a query that specifies concepts to be taught and restrictions (e.g., author, source, date of authoring). For these specified concepts, any *pre-knowledge* concepts are retrieved and appropriate fragments are selected. This means that the virtual *course structure* is build *dynamically* on the corresponding pre-knowledge conditions of fragments to be selected. We call this *bottom-up* approach, that stands in contrast to *top-down* course composition, where the course structure (e.g., a table of content) is static and given a priori. Further, didactic, content-specific and course-specific needs can be considered for the selection of fragments. The structuring and selection processes are strongly correlated. In case that no fragments are found that map exactly to the restrictions (e.g., the date of authoring is older than specified in the course request), the algorithm selects fragments that do not map optimally to the specification, but also fit to the course. This proceeding avoids the ad hoc generation of missing fragments for a requested course. As a result, complete virtual courses can be generated. A course end user also has the option to refine an automatically composed virtual course. The complete virtual course is then presented to the end user who has access to a web portal.

In fact, research groups can open their own repositories (e.g. Robotic-repository) where fragments of group member’s contributions can be stored in and annotated. Again, an end-user can compose his virtual tour among these fragments. For example, the AUC annual conference proceedings can be fragmented and stored there.

2 SEMANTIC FEEDBACK

In a classroom learners and teachers can easily interact, i.e. students can freely ask questions and teachers usually know whether their students understand (basic) concepts or problem solving techniques. Feedback is an important component of this interaction. Furthermore, educational material can be continually improved using information from the interaction between the lecture and the learners, which results in a more efficient and effective way of course development.

Feedback can be given to authors during virtual course development and to learners during learning. In the current generation of E-Learning systems, automatically produced feedback is sparse, mostly hard coded, not very valuable and almost only used in question-answer situation.

In this paper we are introducing mechanisms – based on ontologisms- to create a rich supply of feedback, not only in question-answer situations but also in the context of virtual courses composition. Ontologisms are formal descriptions of shared knowledge in a domain. With ontologisms we are able to specify (1) the knowledge to be learned (domain fragments and task knowledge) and (2) how the knowledge should be learned (education). In combining instances of these two types of ontologisms, we hope that we (1) are able to create (semi-) automatically valuable generic feedback to learners during learning and to authors during virtual course development, and (2) are able to provide the authors with mechanisms to (easily) define domain and task specific feedback to learners.

Feedback describes any communication or procedure given to inform a learner of the accuracy of a response, usually to an instructional question. More general, feedback allows the comparison of actual performance with some standard set of performance. In technology-assisted instruction, it is information presented to the learner after any input with the purpose of shaping the perceptions of the learner. Information presented via feedback in instruction might include not only answer correctness, but also other information such as precision, timeliness, learning guidance, motivational messages, background material, sequence advisement, critical comparisons, and learning focus.

Feedback is given in the form of hints and recommendations. Both a domain conceptual/structural ontology as well as a task/design ontology is used. The ontologisms are enriched with axioms, and on the basis of the axioms messages of various kinds can be generated when authors violate certain specified constraints.

In our research we are generating generic, domain and task feedback mechanisms that produce semantically rich feedback to learners and authors during learning and authoring. We distinguish two types of feedback: (1) feedback given to a student during learning, which we call *student feedback, and (2)* feedback given to an author during course authoring, which we call *author feedback. The* generic feedback mechanisms use ontologisms as arguments of the feedback engine. This is important, because the development of feedback mechanisms is time consuming and specialist work, and can be reused for different ontologisms. Besides generic feedback mechanisms we will provide mechanisms by means of which authors can add more domain and/or task specific feedback. In this research, we focus on "Mobile Computing" domain.

We designed an E-Learning environment for Mobile Computing courses, in which: (1) learners are able to design artifacts of certain domains using different types of languages, and (2) authors are able to develop virtual courses. Learners as well as authors receive semantically rich feedback during learning, designing artifacts and developing virtual courses.

For example, a student first has to learn the concept (communication) network. Assume that a network consists of links, nodes, a protocol and a protocol driver. Each of these concepts consists of sub-concepts. The domain ontology 'communication technology' represents these in terms of a vocabulary of concepts and a description of the relations between the concepts (see figures 1-3). On the basis of an education ontology, which describes the learning tasks, the student is asked to list the concepts and relate the concepts to each other (see figure 1). Feedback is given about the completeness and correctness of the list of concept and relations using different balloon dialog patterns.

In a second step the learner is asked to design a part of a local area network (LAN) using the network model developed during the first step (see figures 2-7). Instead of concepts, concrete instantiations must be chosen and related to each other. The learner gets feedback about the correctness of the instantiations and the relations between the concepts using different star/lamb/scroll dialog patterns. Some protocols for example need a specific network topology. There are various sequences of activities to develop a network, each of them with its own particular efficiency. The student gets feedback about the chosen sequence of activities on the basis of the task/design ontology. Further, the student receives different types of feedback, for example corrective/preventive feedback, critics and guiding. All these feedback types are further customized to the learning style of the learner.

An author develops and optimizes a virtual course from learning fragments. He/she has to choose, develop and/or adapt particular ontologisms and develops related fragmented material like examples, definitions, etc. (see figure 1). Based on analyses of the domain, education and feedback ontologisms, the author gets feedback, for example about: (1) Completeness: A concept can be used but not defined. Ideally, every concept is introduced somewhere in the course, unless stated otherwise already at the start of the course. This error can also occur in the ontology for the course. (2) Timeliness: A concept can be used before its definition. This might not be an error if the author uses a top-down approach rather than a bottom- up approach to teaching, but issuing a warning is probably helpful. Furthermore, if there is a large distance (measured for example in number of pages, characters, or concepts) between the use of a concept and its definition in the top-down approach, this is probably an error. (3) Synonyms: Concepts with different names may have exactly the same definition. (4) Homonyms: A concept may have multiple, different definitions, sometimes valid depending on the context.

The E-Learning environment consists of four main components: a player for the student, an authoring tool, a feedback engine and a set of ontologisms as pluggable components (see figure 1). The player consists of a design and learning environment in which a student can learn concepts, construct artifacts and solve problems. The authoring tool consists of an authoring environment where the author develops and maintains courses and course related materials like ontologisms, examples and feedback patterns. The feedback engine automatically produces feedback to students as well as to authors. The feedback engine produces generic feedback and specific feedback. Generic feedback is dependent of the ontologisms used and is applicable to all design activities and artifacts (e.g. critic, guidance, and corrective/preventive feedbacks). Specific feedback is defined by the author and can be more course, domain, modeling language or task specific. To construct feedback, the feedback engine uses the four argument ontologisms (concept, structure, task, and design feedbacks). Since the ontologisms are arguments, the feedback engine doesn't have to be changed if an ontology is changed for another. The feedback engine can produce the two types of feedback mentioned (student and author feedback). To produce student and author feedback, student and author activities are observed and matched against the ontologisms mentioned.

3 ONTOLOGISMS

In the experimental "Mobile Computing" prototype, fragmented metadata-based repositories that are making use of four standards: Resource Description Framework (RDF), IEEE LOM Metadata, Learning Material Markup Language (LMML), and XML-based Metadata are used to build the prototype. The proposed prototype is providing gateways among these standards.

RDF/RDFS (1-4) is deployed as one of the underlying modeling languages to express information about the learning objects (fragments or components) contained in the repository, as well as information about the relationships between these learning objects (the ontologisms).

Each repository can for example store RDF (Resource Description Framework) metadata from arbitrary RDF schemas. Initial loading for a specific virtual course is done by importing an RDF metadata file (using XML syntax for example) based on this course's RDFS schema. A simple cataloguing (annotation) of its fragments can be deployed using the Dublin Core metadata set (1-4). We can also port these metadata to the LOM standard, using the recently developed LOM-RDF-binding (1-4). With RDF, we can describe for our purposes, how modules, course units, corselets are related to each other or which examples or exercises belong to a course unit, RDF metadata used in this way are called structural or relational metadata.

The IEEE LOM Metadata standard specifies the syntax and semantics of Learning Object Metadata, defined as the attributes required to fully/adequately describe a Learning Object. Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning.

LMML (1-4) proved itself as a pioneer in this field providing component-based development, cooperative creation and re-utilization, as well as personalization and adaptation of E-learning contents. Considering both economic aspects and the aim to maximize the success of learning, LMML is up to the new requirements of supporting the process of creation and maintenance for E-learning contents as well as supporting the learning process itself. Each E-learning application has its own specific requirements structuring its contents.

The ARIADNE (1-4) Knowledge Pool standard is a distributed repository for learning objects. It encourages the share and reuse of such objects. An indexation and query tool uses a set of metadata elements to describe and enable search functionality on learning objects. To ensure simplicity, understandability and adaptability for the ARIADNE community, data elements are grouped into six categories:

- General: groups the general information that describes the learning object such as document title, Document language, etc.
- Semantics: groups elements that describe the semantic classification of the learning object like the science type, main discipline, sub discipline etc.
- Pedagogical: groups elements that describe the pedagogic and educational characteristics of the learning object such as semantic density, interactivity level, etc.
- Technical: groups elements that describe the technical requirements and characteristics of the learning object like OS version, required disk space, etc.
- Indexation: groups elements that describe the general information about the metadata itself of the learning object such as the identifier of the metadata instance, metadata creation date, creator, etc.
- Annotations: groups elements that describe people or organizations notes about learning objects like annotator, language of annotations, and date of annotation.

4 MOBILE COMPUTING PROTOTYPE

We have built a prototype system in the domain of mobile computing to demonstrate the ideas of the proposed model. Hybrid fragments of annotated resources taken from (Amjad, 2004) are used in this prototype. Fragments are encoded in the four representations described above: Dublin cores, IEEE LOM, Learning Material Markup language (LMML), and ARIANE. Figure 1 shows how the underlying ontologisms are used in the prototype to build virtual courses.

Figures 2-11 show snapshots of the implemented prototype. Figure 2 shows part of the Domain Concept Ontology of "Mobile Computing" in acronyms terminology with semantic feedback (By clicking on an Akron you get the Balloon feedback with colored links to further explanation). Figure 3 shows part of Domain Design Ontology of the "Mobile Computing" in hybrid wired/wireless networking with semantic feedback (The Lamb feedback is always on during hybrid networking design). Figure 4 shows part of Domain Task Ontology of the "Mobile Computing" in Sensor Networking with semantic feedback (By clicking on any element you will get the scroll feedback). Figure 5 shows part of the Domain Design Ontology of the "Mobile Computing" in Bluetooth networking with semantic feedback (the scroll feedback is always on during a Bluetooth network design). Figure 6 shows part of the Domain Design Ontology of the "Mobile Computing" in Wireless PANs Networking with Semantic feedback as well as critics and guidance feedback (a Ribbon banner is always on during a design of a wireless PAN network). Figure 7 shows part of the Domain Structural Ontology of the "Mobile Computing" in wireless networks classification with Semantic feedback (a Balloon provides rich feedback once you click on any class in the classification). Figure 8 shows part of the Domain Design Ontology of the "Mobile Computing" in Wireless LAN Configuration with Semantic as well as generic critic and guidance feedback (a star banner is always on during the design of a wireless LAN). Figure 9 shows part of the Domain Design Ontology of the "Mobile Computing" in Positional and Voice Commerce Design with Semantic as well as corrective/preventive feedback (a Balloon banner popes up upon demand during the design of the network). Figure 10 shows part of the Domain Design Ontology of the "Mobile Computing" in wired/wireless network Design with Semantic as well as corrective/preventive feedback (a Balloon banner is always on during the design of the wired/wireless network). Figure 11 shows part of Domain Task Ontology of the "Mobile Computing" in wireless/Internet heterogeneous networking Design with Semantic task/conceptual feedback (Balloon banners with colored links for further explanations are displayed).

5 CONCLUSION

In this paper, we have presented a flexible course/service generation environment to take advantage of re-conceptualization and re-utilization of learning/service materials. Virtual courses/services are dynamically generated on-demand from fragments' metadata entries stored in the Repositories along with semantically powerful feedbacks. The proposed model achieve the following benefits:

-Costlessness: Simple interface. No preparative steps needed
-Comprehensiveness: Allowing all players to find each other and the existing repositories easily (totality is promoted by costlessness)
-Wideness: Inter-Repositories brokerage for wider collaborative scope
-Heterogeneity: Gathering contributors with different naming schemes (taxonomies) in one collaboration model
-Promotion: Encouraging the unification of the namespace (deepening the common part)
-Flexibility: Repositories can join even partially
-Abstraction: Repositories encapsulate their details
-Semantically Rich Feedback: Four types of visual feedbacks are available

REFERENCES

(1)http://www.mccombs.utexas.edu/kman/kmprin.html#hybrid
(2)http://www.w3.org/2001/sw
(3)http://www.indstate.edu/styles/tstyle.html
(4)http://citeseer.nj.nec.com/context/1958738/0
Tendy S., Geiser W., 1998, The Search for Style: It All Depends on Where You Look, National Forum of Teacher Education Universal Journal, 9(1).
Kolb D.,1984, Experiential Learning: Experience as the source of learning and development, New Jersey, Prentice Hall.
Amjad U., Mobile Computing and Wireless Communications, NGE, 2004

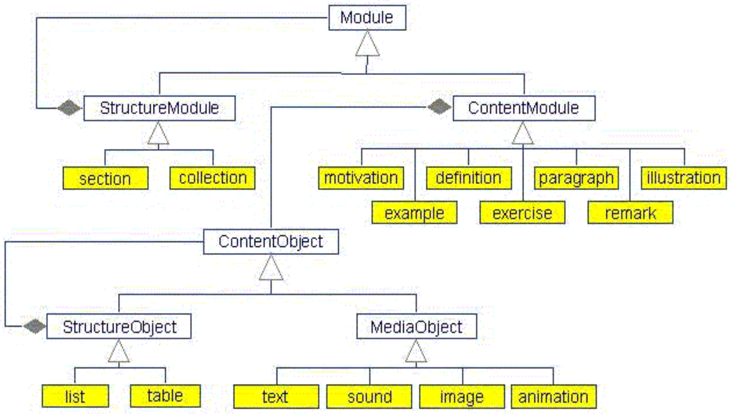

Figure 1: Example of Resource Annotation Structure.

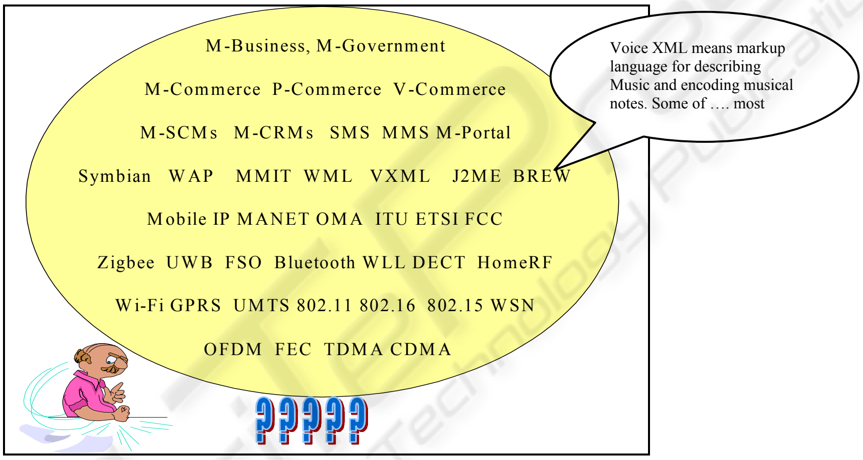

Figure 2: Part of the Domain Concept Ontology of “Mobile Computing” in acorns terminology with semantic feedback (By clicking on an Akron you get the Balloon feedback with colored links to further explanation).

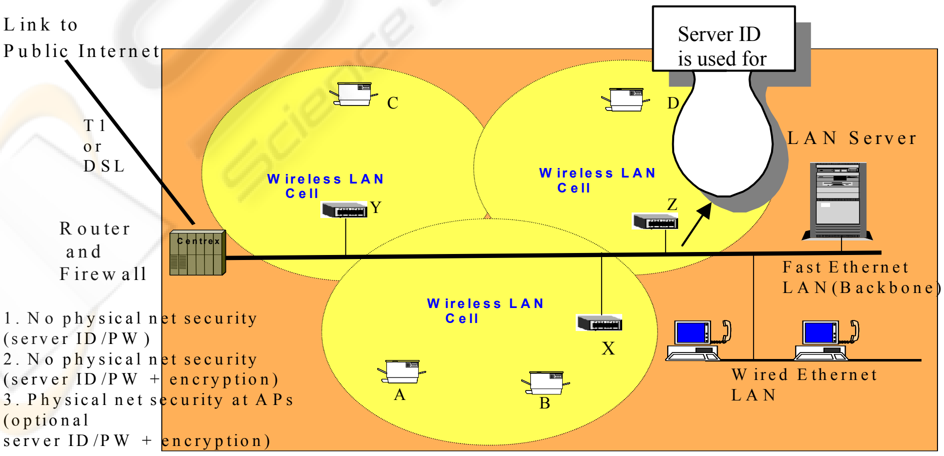

Figure 3: Part of Domain Design Ontology of the “Mobile Computing” in hybrid wired/wireless networking with semantic feedback (The Lamb feedback is always on during hybrid networking design).

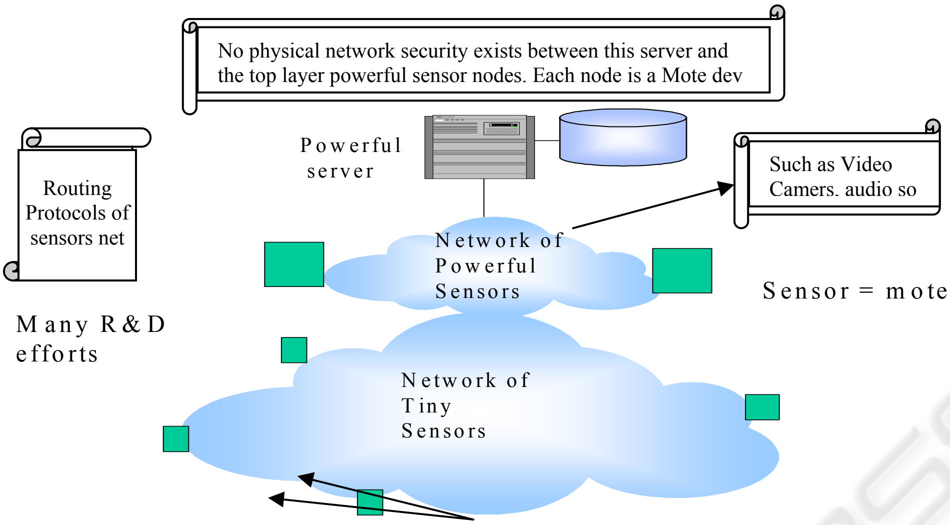

Figure 4: Part of Domain Task Ontology of the "Mobile Computing" in Sensor Networking with semantic feedback (By clicking on any element you will get the scroll feedback).

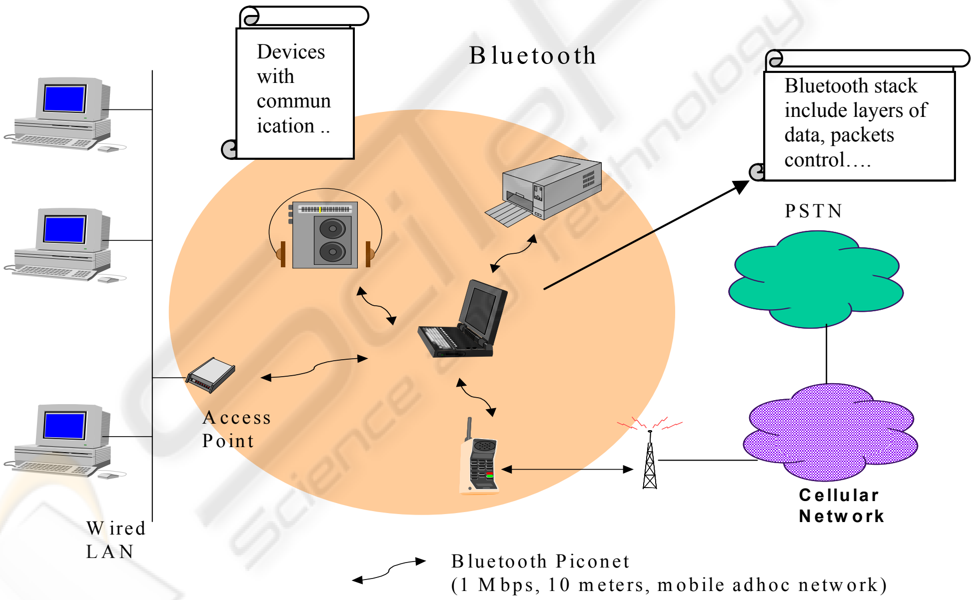

Figure 5: Part of the Domain Design Ontology of the "Mobile Computing" in Bluetooth networking with semantic feedback (the scroll feedback is always on during a Bluetooth network design).

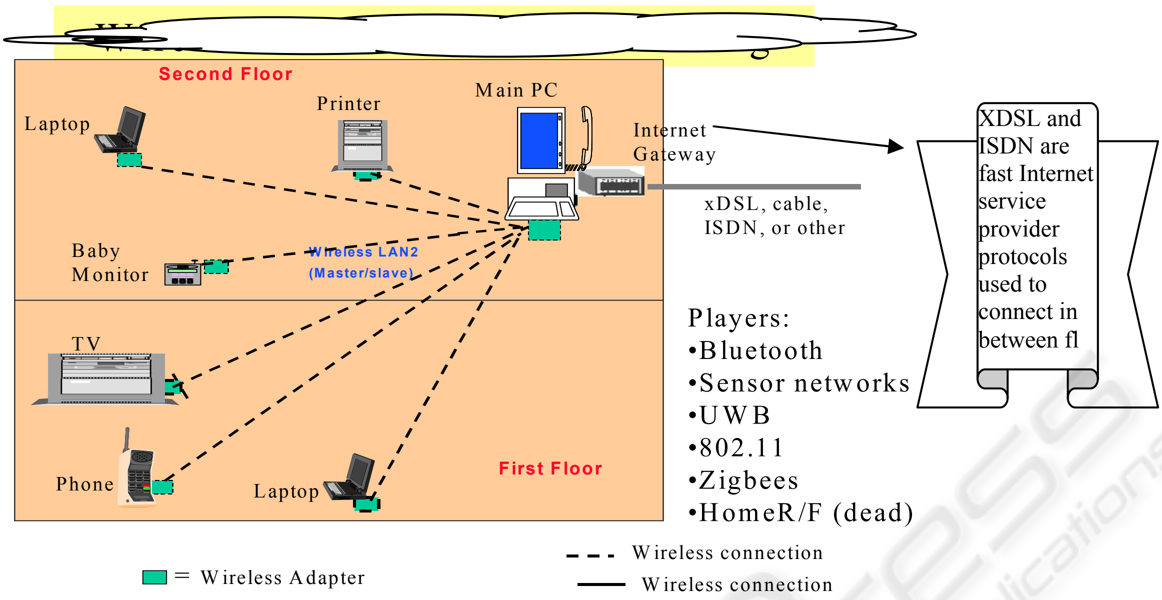

Figure 6: Part of the Domain Design Ontology of the "Mobile Computing" in Wireless PANs Networking with Semantic feedback as well as critics and guidance feedback (a Ribbon banner is always on during a design of a wireless PAN network).

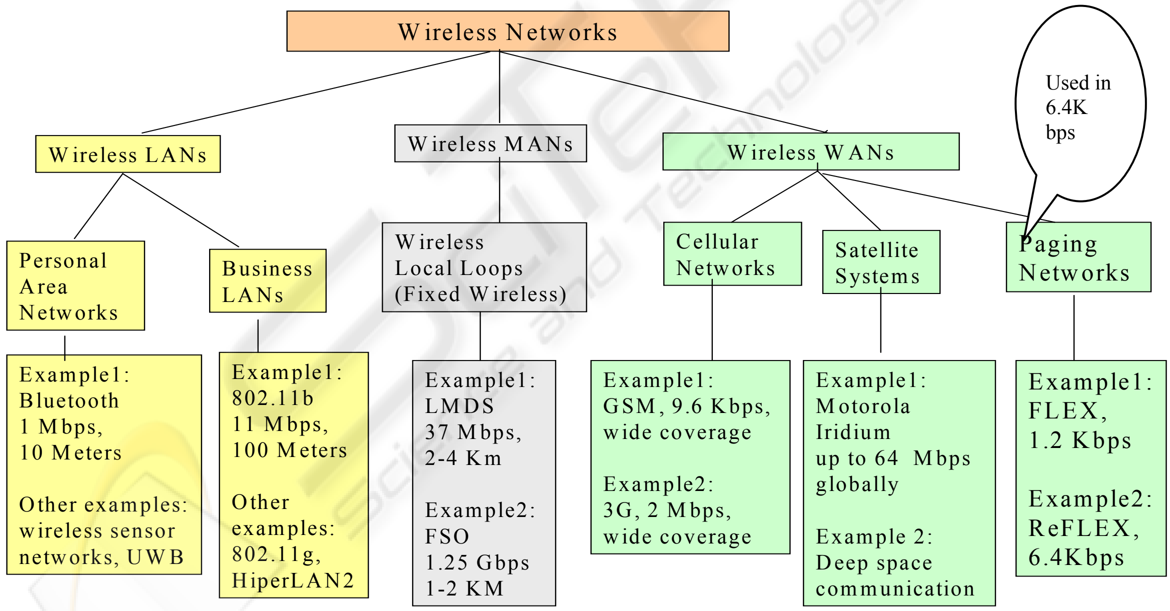

Figure 7: Part of the Domain Structural Ontology of the "Mobile Computing" in wireless networks classification with Semantic feedback (a Balloon provides rich feedback once you click on any class in the classification).

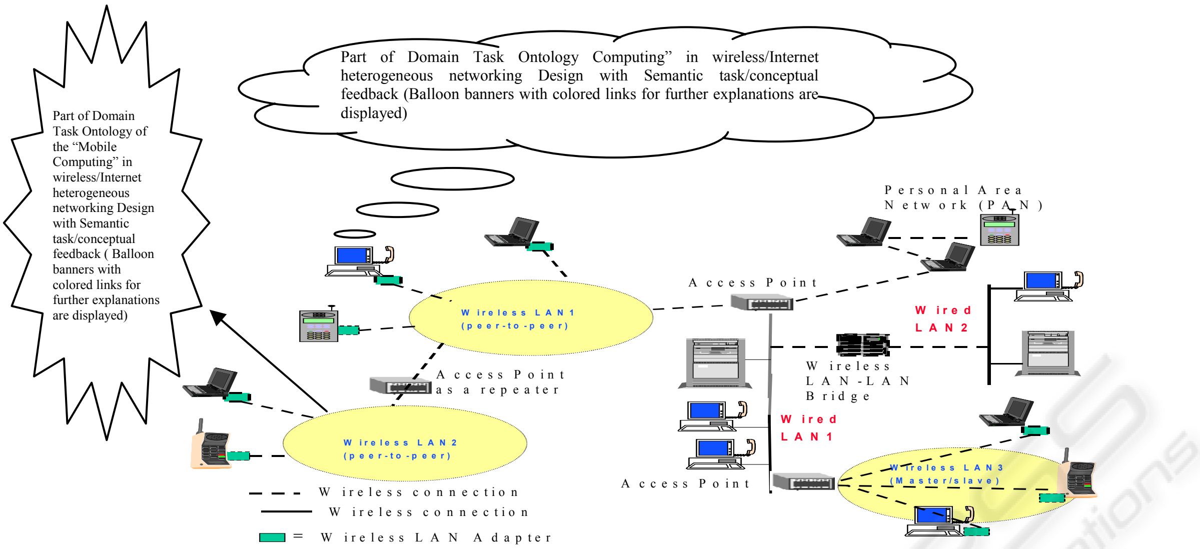

Figure 8: Part of the Domain Design Ontology of the "Mobile Computing" in Wireless LAN Configuration with Semantic as well as generic critique and guidance feedback (a star banner is always on during the design of a wireless LAN).

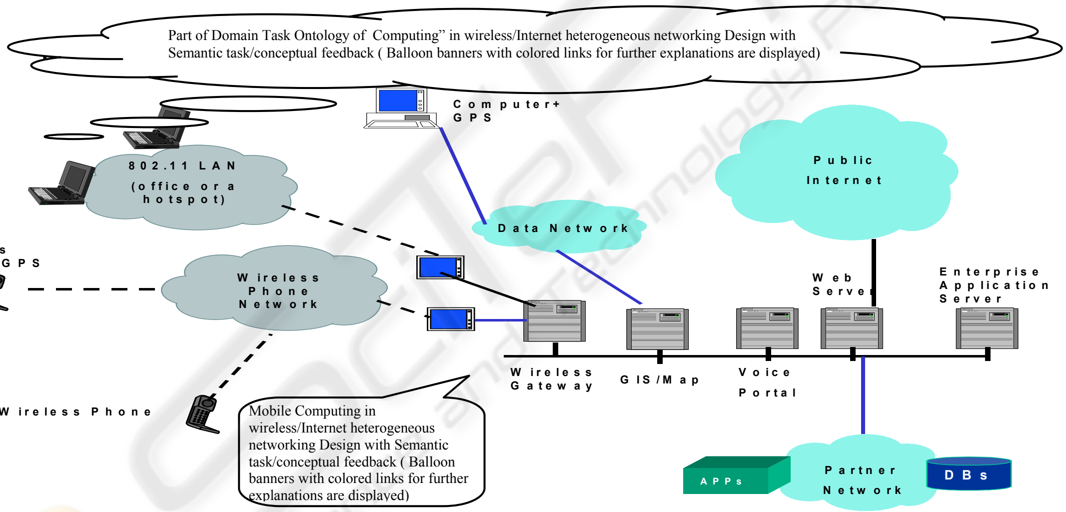

Figure 9: Part of the Domain Design Ontology of the "Mobile Computing" in Positional and Voice Commerce Design with Semantic as well as corrective/preventive feedback (a Balloon banner popes up upon demand during the design of the network).

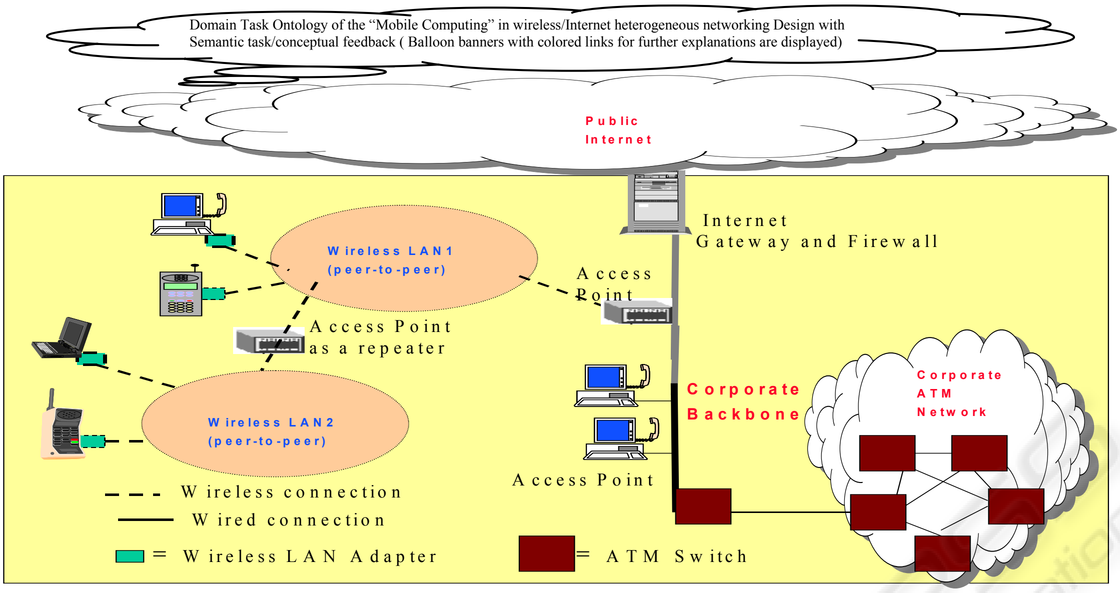

Figure 10: Part of the Domain Design Ontology of the "Mobile Computing" in wired/wireless network Design with Semantic as well as corrective/preventive feedback (a Balloon banner is always on during the design of the wired/wireless network).

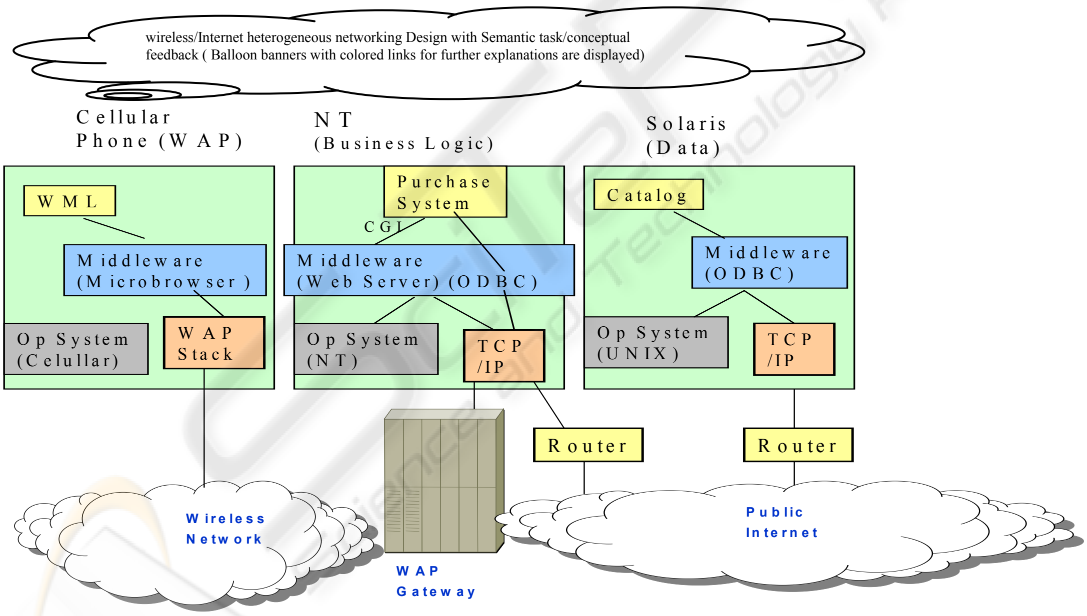

Figure 11: Part of Domain Task Ontology of the "Mobile Computing" in wireless/Internet heterogeneous networking Design with Semantic task/conceptual feedback (Balloon banners with colored links for further explanations are displayed).