Journal of Computer Science 2 (9): 690-697, 2006
ISSN 1549-3636

Ontology-based Knowledge Networks for Users' Training: The Enterprise Resource Planning (ERP) Case

Macris Aristomenis
Department of Business Administration, University of Piraeus, Greece

Abstract: This paper presents a prototype model for the design and development of training material, where both the multimedia objects used in training scenarios and the knowledge built into them are captured and fully reusable. Knowledge found in the logic, the structure and the ways of use of domain specific literacy is represented as a knowledge network (a collection of educational scenarios), based on a domain specific ontology. Each educational scenario combines ontology entities with supportive multimedia objects (text, image, video, animation etc.) and helps trainees (1) understand which are the domain specific issues, how they are linked and interrelated and (2) consider the differing views of these issues, as they are represented in the knowledge network, before reaching a decision or judgment. In order to demonstrate the approach, a prototype ERP ontology and two self-contained sample educational scenarios have been developed.

Key words: Ontology-based training, Educational Knowledge Networks, Ontology-based Knowledge Networks, ERP ontology, ERP training

INTRODUCTION

Perception is the process of building a working model that represents and interprets sensory input (mosaic of percepts) into a more abstract part (conceptual graph) [1]. A conceptual graph or concept map [2] is made of concepts (the simplest possible self-contained entities) and the relations between them. Therefore, when a trainee is asked to understand the training material accompanying a training process, the act of consuming this material can be modeled as a two stage process: (i) the analysis process, where the material is broken down into concepts and (ii) the synthesis process where concepts are linked to other concepts (found in the training material on hand and other related material that the trainee has already analyzed before) in order to form more complex structures (conceptual graphs). Therefore, meaning is not discovered but constructed and training material has meaning only in relation to other material, being interconnected to each other as codes and systems in the culture and in the minds of trainees.

Digitized educational aids developed with existing technology are essentially collections of multimedia objects. These multimedia objects are grouped, indexed and combined in order to support various educational scenarios. But all this grouping, indexing and combining simply restructures the educational material without representing the knowledge itself that is hidden into the material and that must be decoded by the trainee himself.

The proposed methodology scopes to represent the knowledge found interspersed into any educational material in the form of knowledge networks (collections of educational scenarios serving specific educational needs) that will simulate the approach of analysis and synthesis of knowledge discussed and that will be therefore easier to be decoded and comprehended by the user.

Each knowledge network consists of various educational scenarios. The building block of these educational scenarios is a domain specific ontology. The ontology captures all domain specific knowledge in the form of concepts (the simplest possible self-contained entities), instances of concepts and the relations between them. Educational scenarios combine the concepts, instances and relations found in the ontology with supportive multimedia (text, image, video, animation etc.), thus combining the knowledge built into the ontology with the collections of multimedia objects (MMOs) currently used for training.

In this context, this paper examines the combination of an ontology (concepts and their relations) that captures domain specific knowledge, with reusable MMOs, in order to form knowledge networks that can help trainees understand: (i) which are the building blocks of a domain of knowledge, (ii) how they relate with each other and (iii) how they can be combined in order to support specific educational needs.

For the needs of this research a simple case from an Enterprise Resource Planning (ERP) training material was considered. An ERP system is a complex business software, as it optimizes business processes using

Corresponding Author : Macris Aristomenis, Department of Business Administration, University of Piraeus, Greece

enterprise resources, depending on the availability of internal or external enterprise objects or conditions. It consists of many integrated subsystems (modules) that are linked together in order to satisfy unique enterprise needs. End-user training is a key success factor in ERP implementations since the subsystems' customization and integration is not achieved through programming (as it used to be in the past) but through end-user parameterization (setting correctly the appropriate set of parameters).

In order to demonstrate the proposed approach, an upper ERP ontology was defined and two educational scenarios were built (and the associated lower ontology concepts and relations were defined to support them), with the tools developed by the CULTOS project [3].

Enterprise Resource Planning (ERP) Systems: An ERP system is a set of highly integrated applications, consisting of applications modules, which can be used to manage all the business functions within an organization. An ERP system is designed in a way that will fit to a variety of different vertical markets (types of business). This is achieved through the extensive use of multiple levels of parameters (optionality levels), which when set properly, can adapt the ERP system to the specific needs of the organization implementing it [4].

A common theme in ERP literature is the inherent complexity of ERP systems [5] and extensive training is needed in order to help managers and users solve problems within the framework of the system. Computer-based training via Intranets and/or through the Internet has been found to facilitate ERP implementations [6] and therefore ERP vendors are using extensively the Web as their preferred environment in order to provide ERP users' education and training [7].

One important consideration when developing ERP systems (which are process-oriented information systems), is to enable and promote active user participation since users are required to think of their tasks as constituents of business processes and, hence, to instill their knowledge and expertise in the definition and automation of business processes. Indeed, user participation has been strongly advocated by several studies as a way for ensuring that genuine user needs are satisfied and for gaining user acceptance of a new system [8-10]. The basic contention of these studies is that users who participate in the system development process will likely influence design and implementation decisions in accordance with their needs and desires, resulting in a system they perceive useful and usable and an implementation strategy they perceive suitable for the particular situation. Thus, users are expected to develop positive attitudes toward the new system, increasing the likelihood of system success.

The hierarchical structure of an ERP system (consisting of integrated subsystems-modules, broken down to processes, tasks, sub-tasks etc.) and the complexity of relations between them make it an excellent candidate for representing it as an ontology of concepts and instances linked with relations.

MATERIALS AND METHODS

Ontology-based knowledge networks: Most of the existing automated training aids are essentially collections of MMOs. These MMOs are usually grouped hierarchically (e.g. in units and sub-units), indexed and combined, through hyperlinks, in order to support various training needs. However, these training aids only provide for manipulating and restructuring MMOs in order to create training material, serving specific needs, for the knowledge domain under consideration. Hence, this knowledge must be externalized and made explicit by the user in order to become diffused and reusable.

The approach proposed in this paper enables domain experts to externalize the domain knowledge in the form of ontology-based knowledge networks (collections of training scenarios serving specific training needs) and, hence, better communicate it and make it reusable. The basic structure of the proposed approach is a domain specific ontology which captures the relevant knowledge [11, 12]. Thus, training scenarios combine ontology constructs with supportive MMOs helping trainees acquire an in depth understanding of the knowledge domain.

In designing an ontology-based training aid, the main objective is to capture and represent the knowledge which is implicit in the application domain so that it can be made reusable. Thus, domain experts record their knowledge on the particular field under consideration in terms of an ontology which is recorded in the *ontology repository* [13]. Hence, each ontology construct is recorded only once and can be made available to every training scenario using it. In addition, relevant supportive material (either existing or created) in the form of MMOs (e.g. text, image, video and animation) is used in order to develop a collection of reusable MMOs that are related to the knowledge domain under consideration [14]. This collection of MMOs comprises the *content repository*. The ontology and content repositories are then used to create knowledge networks recorded in the *knowledge repository*.

Contrary to traditionally designed training scenarios which are based on mere user navigation to MMOs, training scenarios that are based on the proposed approach are enhanced and empowered in that they allow users to navigate into the domain knowledge which has been represented in the form of a knowledge network. Thus, the user of the training scenarios is guided either through a concept search followed by a navigation to the knowledge network or directly through navigation to the knowledge network. To enhance his/her understanding of each ontology construct included in a knowledge network, the user can access relevant supportive material in the form of MMOs and identify the relation of the particular construct with other relevant constructs.

The ERP business Ontology: The ontology built for the needs of this research is based on the work on the subject of (a) the ontological analysis of Sowa [11], (b) the resource-event-agent (REA) model for enterprise economic phenomena [15], (c) the work of Geerts and McCarthy [16] on a domain ontology for business enterprises, based on the REA model and (d) the Enterprise Ontology[17].

The ERP business ontology built consists of two layers (a) the upper ontology and (b) the lower ontology.

The upper ontology: The upper ontology consists of the top concepts (Figure 1). The concepts are organized in a subsumption hierarchy (specialization) and are linked with relations. The upper ontology consists of the six categorizations proposed by Sowa [11]. These basic concepts are then further specialized (lower level sub-concepts) in an object-oriented fashion. For the next level of the Physical Concepts the categorization of Geerts and McCarthy [16] is used (Economic Agent, Economic Resource, Economic Event and Commitment).

The Abstract Continuant concept is further specialized in two sub-concepts: (a) Economic Structures and (b) Economic Entities.

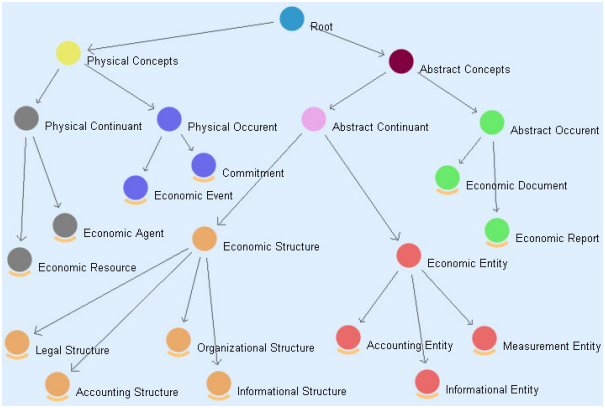

Figure 1. The upper ERP ontology

The concept Economic Structures is further specialized to (i) Organizational Structures [17] for various organizational groupings and hierarchies (e.g. group of companies, company, branch, etc.), since each economic event takes place at the lowest organizational level and then aggregates upwards, (ii) Legal Structures [17] for organizational structures enforced by the legislation. Such structures may extend (be an alternative path for) lower level organizational structures, when the lower level concept/instance (e.g. company) is both a legal and an organizational structure, but there are organizational structures (e.g. branch), which are not legal structures (iii) Accounting Structures. These structures are mainly used for accounting purposes in order to group accounting entities. Such structures are the Plan (chart) of accounts, the cost/profit centers etc. Some accounting structures may extend (be an alternative path for) organizational structures (e.g. cost/profit center) when the lower level concept/instance is both an organizational structure (e.g. a production unit) and a cost center and (iv) Informational Structures. These structures cannot be grouped under any of the above categories and they are either pure informational structures (e.g. software applications, databases, datawarehouses etc.) or virtual organizational structures (e.g. virtual warehouses, such as on board, used to monitor stock movements before their actual arrival to a physical warehouse).

The concept Economic Entities is further specialized to (i) Accounting Entity: This is a grouping of all entities used to either represent physical continuant concepts into the accounting system (e.g. inventory items, personnel accounts, contracting parties etc.) or for pure accounting needs (e.g. GL-General Ledger account), (ii) Informational Entities: An ERP system uses hundreds or even thousands of reference files, which are necessary for the parameterization process (setting system parameters in order to adapt the ERP system to the specific needs of the organization implementing it) and (iii) Measurement Entities used to group various measures of quantity (units of measure), value (units of money) and time (units of time), since each Economic Event or Commitment takes place on a specific point of time and Economic Events aggregate to periods of time [17].

The Abstract Occurent concept is further specialized to the concepts: (i) Economic Document: defines the various types of Economic Events (Invoice, Cash receipt etc.) and Commitments (Customer/Supplier Order etc.) and (ii) Economic Report: identifies the various types of economic reports (Plan of Accounts, Trial Balance, Account Statement etc.).

The lower ontology: The lower ontology (Figure 2) deals mostly with local concepts and relations used by the various multimedia scenarios.

Each ERP system has its own philosophy and therefore the menu hierarchy should be defined using different concepts/instances per ERP application. On top of that, since the functionality of a detail concept (e.g. how to produce the GL Plan report) depends on the specific ERP system used, it is necessary to differentiate Multimedia Instances of concepts, according to the ERP system used. This concept can be used (i) either in the ontology or (ii) to differentiate the scenarios (e.g. through an attribute). For the needs of the scenario built, the first option was chosen and one instance-extending concept (a concept that can be used as an alternative path for other concept instances) was defined, the concept ERP system, to represent the ERP system used. The concept was defined under the ontology path Abstract Continuant - Economic Structure - Informational Structure - S/W application.

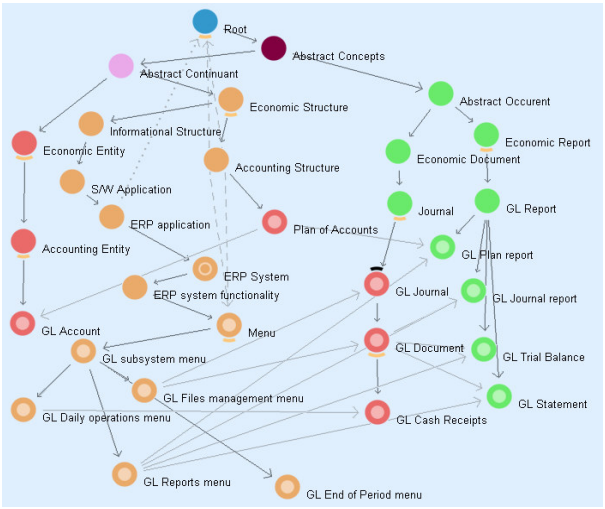

Fig. 2 : The lower ontology for the transactions and reports scenarios

The sub-concept ERP system functionality was defined under the concept ERP System, in order to group various concepts such as ERP system philosophy, Menu, Subsystems, Data entry philosophy, reports etc. For the needs of the scenario the instantiable concept Menu was defined, with one sub-concept, the GL subsystem menu, with sub-concepts the four submenus of the ERP application under consideration: (i) GL Files management menu, (ii) GL Daily operations menu, (iii) GL End of Period menu and (iv) GL Reports menu.

For the needs of the scenarios four new hierarchies are added: (i) Abstract Occurent -Economic Document - Journal - GL Journal - GL Document - GL Cash Receipts, that defines all necessary accounting entities related with GL transactions (a transaction's accounting behavior is determined by a document type, e.g. cash receipt, that appears on a GL journal, e.g. Cash journal), (ii) Abstract Continuant - Economic Entity - Accounting Entity - GL Account, (iii) Abstract Continuant - Economic Structure - Accounting Structure - Plan of Accounts and (iv) Abstract Concepts – Abstract Occurrent – Economic Report – GL Report. The last path introduces the four basic reports examined in the scenarios which are (i) the GL Plan report (showing the plan/chart of accounts), (ii) the GL Journal report (showing all GL transactions for a specific journal, for a period of time), (iii) the GL Statement (showing all the transactions for a specific GL account for a period of time) and (iv) the GL Trial Balance (showing the Debit, Credit and Balance of the GL accounts selected up to a point of time).

On top of the two basic relations which are: the super / sub-concept relation and the instance-of relation (inverse relation 'has instances'), additional relations were introduced for the needs of the scenarios. Those relations are defined between higher-level concepts and are available (through inheritance) to all lower-level sub-concepts:

- The 'choice' relation (inverse relation 'is choice of') between instances of the concept Menu and the concept Root, to show relations between instances of menus and programs.
- The relation 'is composed of' (inverse relation 'compose to') between the sub-concepts of the concepts Economic Structure and Economic entity, since each Economic Structure is composed of various Economic Entities. On the diagram the relation appears as an arrow connecting the concepts Plan of Accounts and GL Account.
- The relation 'updates' (inverse relation 'is updated by') between the sub-concepts of the concepts Economic Document and Economic Report, to show that the various transactions, based on document types defined in an ERP system, update various Economic Reports. The relation is used between the concepts GL Document and GL Journal report, GL Trial Balance and GL Statement.
- The relation 'next step' (inverse relation 'previous step') between the sub-concepts of Abstract Concept. Although this relation does not appear on the ontology diagram, it will be used in order to relate concepts in the scenario and show a sequence of actions.
- The relation 'aggregates to' (inverse relation 'receives entries from') between the sub-concepts of Economic Report, used to show the "flow" of amounts between the various economic reports in the scenarios.
- The relation 'ERP scenario' (inverse relation 'is ERP scenario of') between sub-concepts of Abstract Concepts and instances of Abstract Concepts and is used to link concepts with their instances associated with MMOs showing the functionality of a concept when using a specific ERP system.
- The relation 'defines structure' (inverse relation 'shows structure of') between Plan of Accounts and GL Plan report to show that the GL Plan report shows the structure of the plan (chart) of accounts.

The concept GL Reports menu extends (provides an alternative path to) the four reports (sub-concepts of the GL Report concept) with the relation 'selection' (inverse relation 'is a selection of'). This relation is defined between the Menu concept (sub-concepts of) and the Root concept (sub-concepts of), so that it can be used (through inheritance) to show the relation (selection) between each specific program (concept) and the menu (concept) where it appears.

The Knowledge Network: In order to avoid repetitions of terms that will make the text difficult to read, all concepts and sub-concepts will appear in italics and all relations will be enclosed in single quotes.

In the scenarios appear terms not defined in the ontology. Those terms are (a) local relations referencing

ontology-defined relations (Table 1) and (b) instances of concepts.

The reason why local terms were used is in order to avoid over-loading the ontology with too many relations. But this is a decision the designer has to make, i.e. either define all possible relations in the ontology and use them in the scenarios, or define generic relations in the ontology and use local scenario-specific terms.

Finally instances of concepts appear in the various scenarios, which are defined locally and they are linked to MMOs.

Table 1: Scenario-defined relations referencing ontology-defined relations

Scenario	Local term of relation	References the ontology-defined relation
1	'Describes structure'	'Has instances' (inverse)
1	'Defines GL Journals'	'Has instances' (inverse)
1	'GL Document Types'	'Has instances' (inverse)
1	'Enter-Edit GL Journal'	'Has instances' (inverse)
1	'Enter GL Cash Receipt'	'Has instances' (inverse)
1	'Edit GL Cash Receipt'	'Has instances' (inverse)
1	'Enter-Edit GL Document'	'Has instances' (inverse)
2	'Defines Journals appearing in'	'Updates'
2	'Shows how to print a GL Plan Report'	'Has instances' (inverse)
2	'Shows how to print a GL Journal Report'	'Has instances' (inverse)
2	'Shows how to produce a GL Statement'	'Has instances' (inverse)
2	'Shows how to produce a GL Trial Balance'	'Has instances' (inverse)
2	'Shows one GL account entries'	'Receives entries from' (inverse)
2	'Shows periodic totals from'	'Receives entries from' (inverse)

The General Ledger (GL) Transactions scenario: The GL Transactions scenario (Figure 3) aims to show to trainees all the steps necessary before being able to enter into the ERP system a GL transaction, e.g. a cash receipt. The four main steps are (i) enter the plan (chart) of accounts, (ii) define the GL journals, (iii) define the GL document types and (iv) enter the cash receipt using the GL subsystem. This path appears on the right and is constructed using the four concepts *Plan of Accounts - GL Journal - GL Document - GL Cash Receipts*, connected in a sequence using the 'next step' relation.

This scenario uses two types of entities (instances associated with MMOs):

(a) entities (instances) explaining the meaning of their leading concepts: (i) Plan of Accts structure (leading concept *Plan of Accounts*) describing the structure of the Plan/Chart of accounts, (ii) What is GL Journal? (leading concept *GL Journal*) and (iii) Use of GL Documents (leading concept *GL Document*) describing the various GL Document types and

(b) entities (instances) showing the operation of their leading concepts when using the ERP system (the concept *ERP system* is an extending concept for all those entities): (i) Plan of Accts, (ii) GL Journal, (iii) GL Document, (iv) New cash receipt and (v) Modify-Delete cash receipt.

The GL Reports scenario: The 2nd scenario constructed shows the relations between *Economic Documents* and *Economic Reports* in the GL subsystem. The structure of the scenario shows the relation between each node of the main path on the left (using the four concepts *Plan of Accounts - GL Journal - GL Document - GL Cash Receipts*) with various GL reports (Figure 4).

On top of the ontology defined concepts and relations, the GL Reports scenario uses entities (instances associated with MMOs) already defined in the previous scenario and therefore the use of these entities in the scenario is just a drag and drop exercise. Additionally the scenario introduces four new reports - entities (instances associated with MMOs) showing how to produce each of them when using the specific ERP application. These entities are (i) GL Plan Report, (ii) GL Journal report, (iii) GL Statement and (iv) GL Trial Balance.

The relations used between *Economic Report* concepts is the 'aggregates to' relation (inverse relation 'receives amounts from') and the local terms used are: (i) Shows one GL account entries (linking the concepts *GL Statement* and *GL Journal report*) and (ii) Shows periodic totals from (inverse relation linking the concepts *GL Statement* and *GL Trial Balance*).

Finally the entities (instances associated to MMOs) used were linked to their leading concepts using the relation 'has instance' (inverse relation 'is instance of') and the local terms used are: (i) Shows how to print a GL Plan report, (ii) Shows how to print a GL Journal report, (iii) Shows how to produce a GL Statement and (iv) Shows how to produce a GL Trial Balance.

All the entities (instances of sub-concepts of GL Report) are choices (relation 'choice', inverse 'is choice of') of the entity GL reports menu.

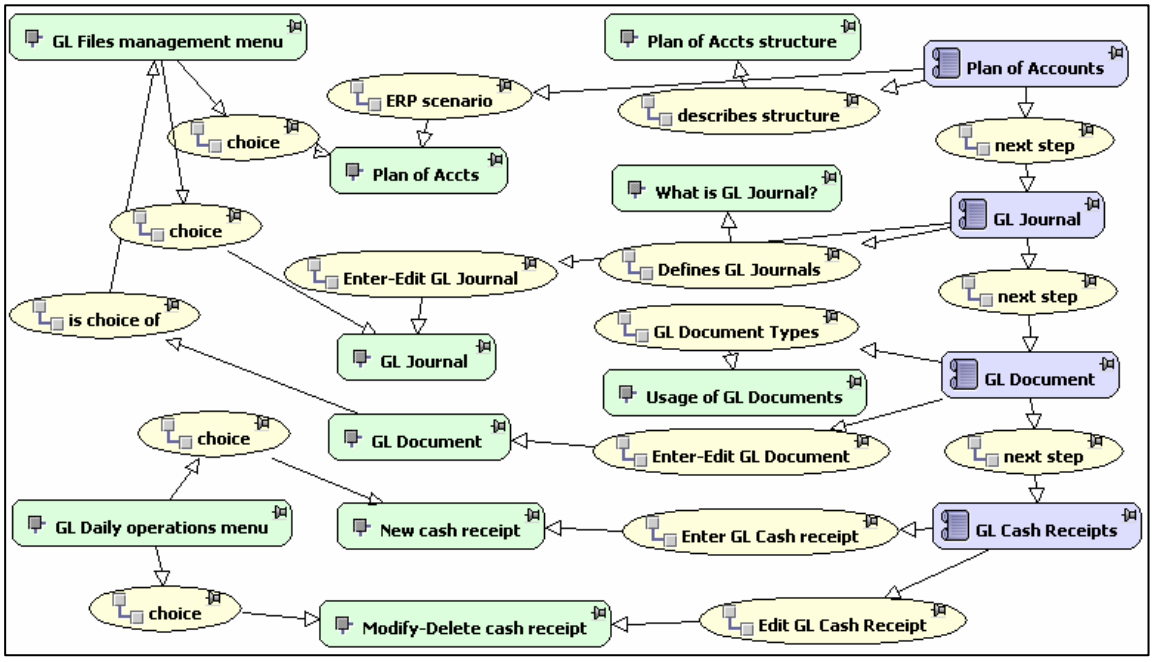

Fig. 3 : The GL Transactions scenario

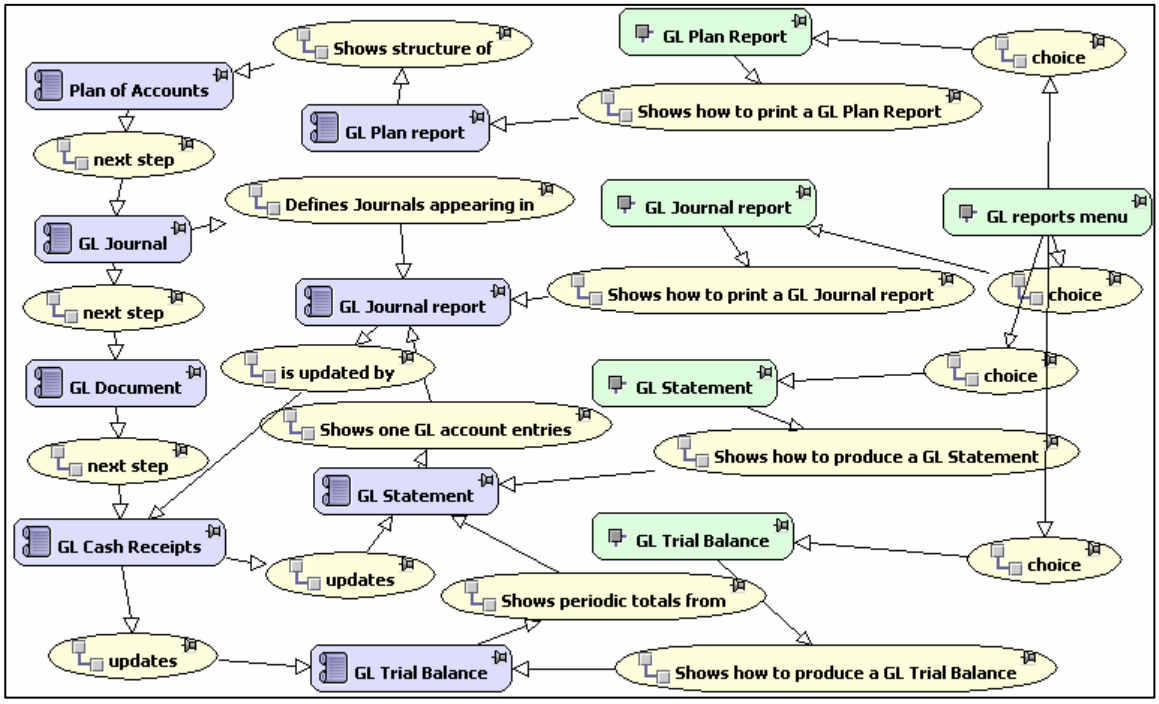

Fig. 4 : The GL Reports scenario

RESULTS AND DISCUSSION

This paper presents an ontology-based prototype approach for the construction of user training scenarios on ERP process modelling concepts, whereby both the multimedia objects used and the knowledge built into the training scenarios are fully reusable. The approach consists of the following steps: (i) define and implement a general ontology, (ii) design the training scenario that best fits training objectives and define the multimedia objects required, (iii) refine the general ontology by adding all ontology constructs required by the various

training scenarios, (iv) develop or select the multimedia objects which are deemed necessary to support the various ontology constructs to be used in the training scenarios, and (v) construct each training scenario (knowledge network) by combining ontology constructs with multimedia objects. The objective of the approach presented in this paper is to enable users get familiar with and, hence, participate actively in ERP process modeling activities. In this context, two sample training scenarios were built, using the CULTOS tools, that are based on a self-contained reusable knowledge repository which combines the ontology constructs (stored in the ontology repository) with supportive multimedia objects (stored in the content repository). Hence, this training scenario can also be used by third party hypermedia production tools in order to present both the knowledge and the content of the training material for various purposes.

The approach proposed is mainly concerned with capturing and representing the knowledge found in the logic, the structure and the ways of use of ERP processes as an ontology-based knowledge network (training scenarios serving specific training needs). The ontology contains all the relative concepts and instances of concepts and the relations between them. The knowledge network relates the basic entities defined in the ontology with the various multimedia (text, image, video, animation etc.), which are supportive for better understanding the ontology constructs. Thus, the user of the resulting training material is enabled to search for an ontology construct (for example a data entry screen for cash receipts) and understand its meaning and usage with the help of the supportive multimedia. Furthermore, the user can navigate to associated ontology constructs (for example, GL documents that define the behaviour of a GL transaction, GL statements that are updated each time a GL transaction is posted etc.) in order to acquire an in depth knowledge about the ERP process tasks, the data and control flows between those tasks and the needs for designing new or redesigning old ERP processes.

The proposed model does not disregard existing methodologies for structuring training material, but enhances and empowers them by allowing the semantic representation of knowledge so that to enable users navigate into a knowledge network based on the characteristics of the application domain under consideration. Thus, the model can combine the existing multimedia material with ontology constructs, using knowledge-based multimedia authoring tools, in order to build user training scenarios and satisfy specific training needs. Hence, in addition to the existing multimedia objects, the knowledge built into both the ontology and the training scenarios is fully reusable.

With regard to the creator of the training material, the main advantages of the proposed model are the following: a) Reusability of the knowledge recorded into the ontology and the knowledge instilled into older scenarios to meet new training needs. b) Unique definition of ontology constructs since they are recorded once and can be used where and when required with the same name and the same features (synonyms, attributes, relations to other concepts, supportive multimedia related to it etc.). c) Inheritance in ontology creation whereby lower-level concepts inherit all the characteristics of higher-level concepts (attributes, relations etc.). and d) Semantic web that allows combining and using geographically dispersed training ontologies by both from creators and specially designed software components (i.e. web services) [18].

With regard to the trainee, the main advantages of the proposed model are the following: a) Semantic search – This allows to search ontology constructs semantically instead of textually (i.e. the search is based on language-agnostic semantic matching instead of keyword matching) putting emphasis on matching the content and the real meaning of each relevant concept searched. b) Knowledge navigation - This allows the use of browsing and navigation capabilities in order to identify the ontology constructs as they are recorded into the ontology repository and used in the training scenarios. c) Knowledge dissemination – This is an important function of any kind of training activity that can only be achieved if the trainee is provided with the ability to extract the knowledge implicit in the problem domain, as opposed to the mere presentation of facts and disconnected information which, in most cases, is not adequate.

With regard to ERP process modelling, trying to change users' perception of their work (from function-oriented to process-oriented) an in-depth analysis of each process and its tasks is required. Considering an ERP process from another viewpoint besides your own leads to deeper understanding of the processes under consideration and this understanding is essential when trying to develop critically thinking users. And the ability to think critically is a necessary criterion in order to say that knowledge has been disseminated. Obviously, this ability is much more important when studying complex ERP processes that consist of many interrelated tasks that combine various resources available.

The impact of the proposed methodology in users' participation and system acceptance may be significant. ERP applications' users have a chance to clearly understand each task making up an ERP process, decide which are the key supportive documents per task (in the form of MMOs), the relations between tasks and participate in the combination of tasks in the most appropriate way in order to perform various cross-departmental process. That way users' participation and involvement can be significantly enhanced and system acceptance guaranteed. And when flows of processes change, these changes can be easily presented by simply

manipulating concepts, instances, relations and MMOs already defined in the ontology or in knowledge networks. Due to the encouraging results of the approach described, it is intended to evaluate it extensively using more elaborate implementation tools and more complex ERP processes in real-world situations.

REFERENCES

1. Sowa J., 1984. Conceptual Graphs. In: Conceptual Structures, information processing in mind and machine pp. 69-126. Addison-Wesley Publishing Company Inc.
2. Novak J.D. and D.B. Gowin, 1984. Learning How to Learn. New York and Cambridge, UK: Cambridge University Press, pp: 15-25.
3. http://www.cultos.org
4. Soffer, P., B. Golany and D. Dori, 2003. ERP modelling: a comprehensive approach. Information Systems, 28: 673-690.
5. Bingi, P., M. Sharma, and J. Godla, 1999. Critical issues affecting and ERP implementation. Information Systems Management, 16 3: 7-14.
6. Mahapatra, R.K. and V.S. Lai, 1998. Intranet-based training facilitates on ERP system implementation: a case study, in: E.D. Hoadley, I. Benbasat (Eds.). Proceedings of the Fourth Americas Conference on Information Systems, Baltimore, MD: 1070-1072.
7. Macris, A., 2004. Enterprise Resource Planning (ERP): A Virtual lab implementation for managers' and users' training. "SPOUDAI" Journal, 54(4): 13-38.
8. Dvir, D., 2005. Transferring projects to their final users: The effect of planning and preparations for commissioning on project success. International Journal of Project Management, May 23(4): 257-265.
9. Cavaye, A.L.M., 1995. User participation in system development revisited. Information & Management, 28(5): 311-323.
10. Anderson, E.E., 1985. Managerial considerations in participative design of MIS/DSS. Information & Management, November 9(4): 201-207.
11. Sowa J., 2000. Knowledge Representation - Logical, Philosophical and Computational Foundations, Brooks/Cole, USA.
12. Gruber, T.R., 1993. A translation approach to portable ontology specifications, Knowledge Acquisition, 5: 199-220.
13. Seely-Brown, J. and P. Duguid, 1991. Organizational Learning and Communities of Practice. Organizational Science, Vol 2(1).
14. Steinmetz, R. and C. Seeberg, 2003. Meta-information for Multimedia eLearning. Lecture Notes in Computer Science, Springer-Verlag, Heidelberg, 2598/2003: 293-303.
15. McCarthy, W.E., 1982. The REA accounting model: a generalized framework for accounting systems in a shared data environment. Accounting Review 57: 554-578.
16. Geerts, G.L. and W.E. McCarthy, 2002. An ontological analysis of the economic primitives of the extended-REA enterprise information architecture. International Journal of Accounting Information Systems, Volume 3, Issue 1: 1-16.
17. Uschold, M., M. King, S. Moralee, and Y. Zorgios, 1998. The Enterprise Ontology. The Knowledge Engineering Review, developed in the Enterprise project (IED4/1/8032), supported by the UK's Department of Trade and Industry under the Intelligent Systems Integration Program, Vol. 13:1: 31-89.
18. Berners-Lee, T., J. Hendler and O. Lassila, 2001. The Semantic Web. Scientific American, May 2001: 28-37.