

A Framework for an Intelligent On-line Education System

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Abstract

This paper addresses the issues of personalization in on-line education. It discusses problems of knowledge structuring, user modeling, and adapting educational material to individual learners. The primary focuses of the paper include: (1) employing knowledge domains structure for a more effective personalization, (2) presenting an integrated personalization design that aims at sharing information between different adaptation techniques to achieve a better adaptation results. The proposed architecture of the intellectual on-line education system consists of knowledge model, user model, and adaptation model. Knowledge model is composed of concepts ontology, sequencing relations, and media objects. Design of conceptual part of the knowledge model, visual part of the knowledge model and the sequencing relations is done independently, which provides a greater consistency and presents a better structuring decision. Adaptation model executes navigation and presentation navigation of the educational material. Sharing information between adaptation techniques enables more effective adaptation. Knowledge domains structure is also taken into account in the personalization process. Discussed approach to the personalization will provide an advanced adaptation capabilities for an on-line education system. Intellectualization of the personalization will make a distance learning environment more comfortable for a wide variety of learners and will contribute to a greater dissemination of the educational opportunities.

1 Introduction

Recent advances of network technologies and multimedia capabilities have greatly enhanced education technologies. The amount of online educational resources is growing rapidly. Many web-based courses are being offered and a lot of lectures are being broadcast via the Internet. Distance education (DE) has many advantages, such as its geographical independence and schedule independence (though some deadlines are helpful). However, due to the lack of interaction between the instructor and students, distance education has not been widely accepted. Many online courses contain statically coined pages and rigidly formed course flow. This style of online courses lacks flexibility and fails to satisfy diverse groups of learners. Due to the impossibility to have a course designed to be “all things to all people”¹, it is only feasible to have dynamic assembly of course material to fit the specific personal needs of the learners and adjust to various learning styles.

Personalization techniques can be applied to distance education to provide flexible education material assembly and adaptive course flow. Recently a lot of research has been conducted in the field of adaptive hypermedia education systems^{4,12}. Generally, most of these systems can be modeled as consisting of four main components: user model, interactive component, personalization component, and knowledge model. User model captures learner’s personality

features and learning patterns. Interactive component delivers educational contents to the learner and collects learner's input or feedbacks. Personalization component makes decisions on how to modify the educational contents and course flows for specific users based on concrete user model profile and history of user's interaction with the system. Knowledge model are a collection of the knowledge description fragments (pieces of education material in various granularity) and the structural relations among them that comprise the on-line courses. Knowledge model is the fundamental component in the education system and has a critical impact to the success of its personalization process. Consider a group of knowledge description fragments. Without proper specification of their precedence relations (what information should be introduced first), it is hard to adaptively construct a reasonable course flow. Without proper classification of these knowledge description fragments, it is hard to recognize, for example, which fragments are the main material and which ones are supplementary. However, existing research works on adaptive education systems focus mainly on user modeling techniques and adaptation methods while research in knowledge domain modeling lags behind.

There have been two main approaches in knowledge domain modeling, topics hierarchy approach and ontology-based approach. Topic hierarchy approach has been used extensively in many adaptive education systems. In this approach, knowledge domain is defined recursively as a set of topics that have (or don't have) sub topics^{5,9}. Hierarchy of topics can be easily mapped to course flow, for example, traversing topics from parent node to the subtopics. The design of knowledge domain model is also simple (e.g. use chapter-topic-paragraph hierarchy). However, knowledge domain semantics is missing in topic-oriented approach. Also, topic decomposition is very controversial and granulation of the information is very coarse.

Ontology-based knowledge modeling approach is also commonly used in adaptive education systems. In this approach, knowledge domain is represented as an ontological hierarchy of concepts connected with typed relations⁴. This method describes semantics of the knowledge domain more precisely. Semantic relations between concepts are important for understanding the knowledge domain. But from semantic relations, the precedence relation in the presentation flow (i.e., in what order should they be presented to the learner) cannot be inferred easily, if at all possible.

Along another direction, an important concept in knowledge structuring, separating content from the conceptual knowledge model, has been introduced^{4,8}. Designing multimedia presentation objects (education content) independently from knowledge structure of the domain gives more flexibility and consistency in knowledge design. Domain structure is less prone to changes. Once designed it undergoes minor modifications as the course is used. On the other hand, the course presentation can change more often and requires more adaptation to fit personal needs. Keeping them separate gives an opportunity to change presentation without affecting the knowledge structure. It was also suggested to impose structural relations on multimedia objects (fragments of text, pictures, animations etc used to build up knowledge description) to capture the semantics⁴. For example, image and a piece of text describing it are connected with a typed relation "A describes B". However even this sophisticatedly structured multimedia objects catalog has room for improvement. This suggested multimedia objects catalog is still a loosely structured collection that contains only information about objects' modality⁶ and some relations between them. No specification is suggested to address the didactic role that multimedia object plays in describing knowledge or how big is the contribution of the multimedia object to the general understanding of the knowledge concept – the so-called level of detail². Multimedia objects currently are used passively to build hypertext pages of the course and are not actively

involved in personalization. While properties and structure of the multimedia objects can help make adaptation more efficient.

In this paper we will present a framework for adaptive on-line education systems that features advanced knowledge design capabilities and integrated solution to tightly couple knowledge structures with adaptation methods and user model. The goal of our approach is to:

- provide advanced knowledge structuring solution that captures both the semantics and precedence characteristics of the knowledge domains;
- enable advanced structural design of the multimedia presentation for the knowledge; and
- aim at providing additional dimensions of personalization in on-line education.

In the section 2, a general outline of the proposed on-line education systems framework is introduced. Knowledge model is discussed in detail in section 3. Knowledge concepts ontology is covered in subsection 3.1 and knowledge transition relations are considered in subsection 3.2. Multimedia objects repository is discussed in section 4. The integration of knowledge model with user model and personalization techniques is a focus of section 5. After that section 6 presents a case study. Paper will conclude with a summary (section 0).

2 On-Line Education System Framework

There were many models of on-line education system suggested. A simplified generic model for current adaptive on-line education systems is shown in Fig. 1. The system consists of four major components. User model stores learners' profiles that specify system users in the part of their name, some social information, their knowledge background, preferences, learning styles, and the log of their interaction with the system. Knowledge model contains a collection of knowledge description fragments and relations between them. Interactive component builds up the interface of the system. It queries the knowledge model for the courses content and the user model for the user profile. Then it formats the courses content according to the user profiles and presents the assembled pages to the learner. Interactive component also logs all user input and feedbacks and stores them in the user profile. Personalization component processes statistical information about users taken from the user profile and infers hypotheses about users, such as: users' preferences, the knowledge already possessed, and learning styles. Inferred information is then put back to user model.

In our approach, we add two more information flows between the components, that make the structure and semantics of the knowledge accessible for the personalization component and user model (shown as thick arrows in Fig. 1). It is very important for the user model and the personalization component to be aware of the structure and semantics of the knowledge model. The whole education system can be thought of as an advanced mechanism of knowledge delivery. The content of the on-line courses is being modified according to learner's personal features and then sent to him/her. In this sense, the content of the courses is the central figurant of the personalization process.

To enable effective courses personalization (read learning material manipulation) the learning material should be well granulated and structured. And the information about granulation and structure of the courses should be widely available for the educational system components. If the content of the courses is not logically divided into pieces or divided, but information about

relations between these pieces is unavailable, then the courses cannot be transformed to suit various users.

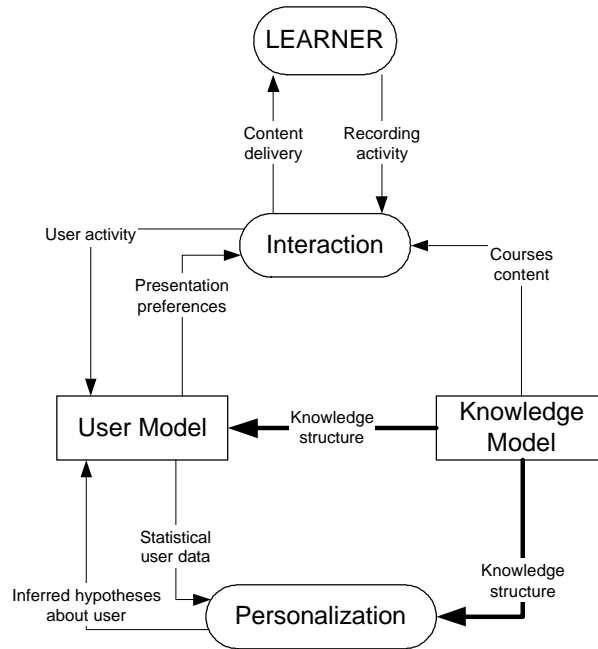


Fig. 1 Overall education system framework

The major focus of our on-line education systems framework is to offer an effective knowledge modeling approach that enables a greater flexibility during on-line course design, and more adaptation dimensions to provide a high quality personalization at run time. We subdivide the knowledge domain model concepts ontology, knowledge transition relations and multimedia objects repository (Fig. 2).

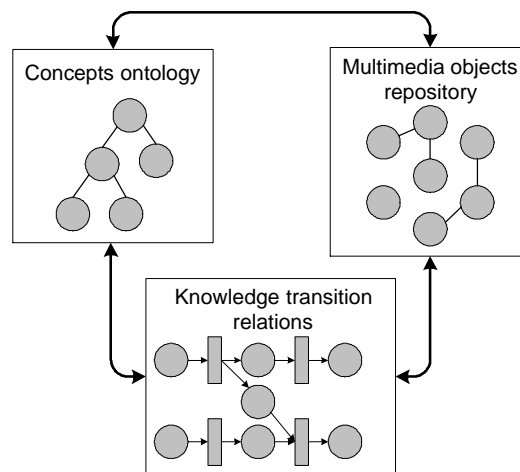


Fig. 2 Knowledge model

Concepts ontology describes semantic relations between concepts of the knowledge domain. Knowledge transition relations are introduced to impose an order on the process of covering concepts. They describe all possible learning paths that a user can choose while taking the course. Multimedia objects repository contains multimedia objects with their specifications to build up

visual presentation of the knowledge. In subsequent sections we will discuss the knowledge model in more detail.

3 Knowledge Model

As discussed earlier, topics hierarchy and concepts ontology approaches have their drawbacks. We develop a novel knowledge structuring model to effectively support adaptive presentation. Concepts ontology describes semantic relations between concepts of the knowledge domain. Transition relations are introduced to impose an order on the process of covering concepts. They describe all possible learning paths that a user can choose while taking the course. Multimedia objects repository contains multimedia objects that build up visual presentation of the knowledge

The division of knowledge transition relations and knowledge concepts ontology components is crucial. Concepts ontology and transition relations describe knowledge from two different points. Concepts ontology describes semantic relations between concepts and transition relations describe in what order the concepts should be learned. The semantics contained in ontology is more inert. Ontology does not change much during the on-line course lifecycle. Once designed it remains mostly the same. A set of transition relations between concepts, on the other hand, can be significantly extended as the course is being designed. If the course design is done stage by stage then first only some basic learning paths can be encoded by transitions. Then as course development progresses, more learning paths can be added and the ones previously designed can be altered. And since ontology and transitions are separate, these changes can be done without affecting predefined knowledge concepts ontology structure.

3.1 Concepts Ontology

Knowledge ontology in our approach is a hierarchy of concepts key to the described domain. Each concept represents an idea or a notion that addresses certain portion of domain's knowledge. Concepts are connected into a hierarchical structure with the help of typed relations. The set of these relations is constructed such that it is possible to structure a fairly complex domain in any field. Many of the relations are known from various approaches recently developed^{4,7}. More detailed description of concepts ontology can be found in¹³.

3.2 Transitions

Knowledge transition relations are a novel feature presented in our approach. The role of transition relation is to enforce the order of presenting the concepts. Every transition relation is a hyper edge that connects two groups of concepts. The first group includes requirements – concepts necessary to execute a transition and the second group includes results and concepts that a learner can proceed to after covering requirements (Fig. 3).

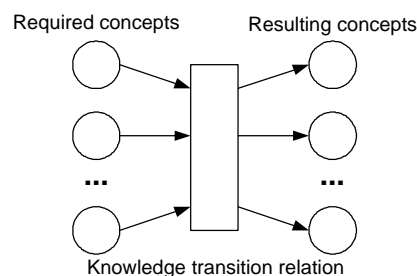


Fig. 3 Knowledge transition relation, required and resulting concepts of a transition

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In some sense transition relations and knowledge concepts correspond to Petri nets¹⁰. Concepts thus play the role of Petri net places and knowledge transition relations are Petri net transitions (the term transitions itself is borrowed from Petri nets terminology). The process of learning the concepts is then represented by a nondeterministic firing of transitions and passing the markers. The state of knowledge of a learner is thus denoted by the markup of the Petri net.

Every knowledge transition relation taken separately is a local constraint for moving from one set of concepts (requirements) to another (results) while acquiring the knowledge of the specific course. In global sense knowledge transition relations establish knowledge learning paths for the given course. Usually for a learning system there is a requirement for such paths to be acyclic. Here we eliminate this constraint simply because learning is generally a non-linear process. Even the most traditional “linear” learning sources – books – are often used in a non-linear manner. Clearly there exist concepts that must be learned one after another, but the order is a question of the learning strategy or approach to teaching. Thus knowledge transition relations in our approach can create cycles for the course in general.

The set of knowledge transition relations corresponding to the concepts ontology together with knowledge ontology itself comprise the knowledge map of the course. Each knowledge transition relation corresponds to a node of the knowledge map, and in a presentational context corresponds to a page or a document. In this context the grouping of the concepts incident to the transition is slightly modified. The resulting concepts set stays intact, while required concepts set is divided into two groups, prerequisite concepts and covered concepts (Fig. 4).

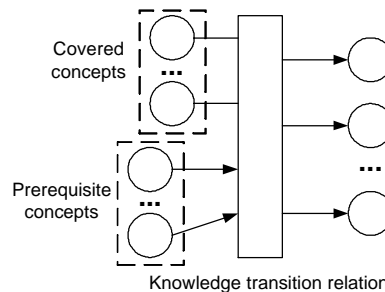


Fig. 4 Transition-page, prerequisite, covered and resulting concepts of a transition

The meaning of the groups of concept incident to the transition-page is the following:

- Covered concepts are displayed (read learned) at the page of the transition.
- Prerequisite concepts must be learned before learner can browse the page of the transition.
- Resulting concepts can be learned after the covered concepts are learned.

The decision on adding a new transition to a course is decomposed to the following sub-decisions:

- what concept(s) should be covered at this point;
- what concept(s) should have been covered before and must be known prior to leaning the covered concept(s);
- what concept(s) will can be learned after learning the covered concept(s).

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4 Multimedia Objects Repository and Knowledge Visualization

Multimedia objects constitute the content of the courses or presentations. These objects are stored in the multimedia objects repository which provides correlation structures to describe the relations among objects and assigns special personalization-oriented attributes for each object. Imposing structure on multimedia objects repository and assigning special attributes to them creates a solid multimedia objects classification solution. It will improve the ability of the system to manipulate the content of the on-line courses effectively. Multimedia objects correlation structure and attributes are discussed in the following subsections.

4.1 Correlation Structure between Multimedia Objects

Multimedia objects are grouped according to their modality into modality classes e.g. text fragments, images, animation, etc. Multimedia object repository is not a loose set of objects. Between objects there exist relations that relate these objects to one another. The relations are of the following types:

- text A describes image/animation B;
- image/animation A illustrates text B;
- object A before object B (if the order of two multimedia objects is important);
- object A depends on object B (when B can be shown only if A was shown);
- object A is a caption to object B (covers the use of captions for images/animations/tables);
- object A is an alternative to object B.

More relations can be added later. These relations between multimedia objects have many benefits. First, multimedia objects repository relations in general increase consistency of the multimedia objects repository and introduce structure. Second, it eases the design of adaptive knowledge presentation. The additional relations reflect important rhetorical-didactic links between multimedia objects. Third, discussed relations make possible automatic generation of textual logical links between multimedia objects that are connected with these relations. For example if a piece of text is connected to an image with “image/animation A illustrates text B” relation, then the text “Refer to the following illustration” can be when the text goes before the image on a page. Insertion of such textual fragments will augment the coherence of the multimedia objects and will make media pages more solid⁴.

The correlation structure facilitates automatic generation of text fragments for smooth textual transitions and there is no need to explicitly store the text fragments in the multimedia object repository. Also if for every type of correlation between the multimedia objects, there is a standard textual transition, it can increase the coherence of the presentation.

4.2 Personalization-Oriented Attributes

The correlation structure contributes significantly in constructing a coherent course presentation. However, it is not sufficient for personalization purpose. Here, we introduce the techniques in tagging the multimedia objects in order to guide the personalization process. The

personalization-oriented attributes include level of details, didactic roles, and alternatives of multimedia objects.

As was said in ², desired levels of details in a presentation vary for different learners. If a learner is a novice, scarce material layout will not contribute to her/his understanding significantly. On the other hand, unnecessary details will only distract attention for an expert learner. To address this issue we introduce a level of detail index for multimedia objects. Every multimedia object is assigned a numeric weight denoting the importance of this object in describing the corresponding concept. If the importance of the multimedia object is very high then the index assigned is 1. As the significance decreases the index increases. The utilization of the index discussed will be discussed in the next section.

Second personalization-oriented attribute is the didactic role. Modality classes specify the format of the data contained in the multimedia object. However these modality classes do not specify what kind of educational information the object conveys. Knowing whether the object contains graphical or textual or tabular data is important. It simplifies visual design and enables extraction of user modality preferences, provided specific techniques are used. Though having didactic characteristics at hand provides even more descriptive and finer specification of the educational material. In our approach we assign multimedia object one of the following didactic roles (this list can be further extended):

- introduction;
- definition;
- description;
- summary;
- example;
- note.

The last attribute we discuss provides every multimedia object with an alternatives. Often one and the same idea can be laid out in more than one way. There exist interchangeable wordings for one and the same definition or description. A text paragraph can sometimes be substituted with a self-explanatory picture. To address this aspect of educational material presentation, alternatives attribute is introduced. Each multimedia object can have substitutes. Thus objects can form groups of alternatives. Each multimedia object of such group is equivalent to any of the rest of the objects in the group. Alternatives fall into one of the following categories:

- complex information layout;
- simplified information layout;
- textual information layout;
- pictorial information layout;
- plain alternative.

For example a definition can have two options – complex (scientific terminology) and simplified (in-ones-own-words terminology) versions. Learner can choose either textual or pictorial description.

4.3 Visualization of Knowledge

Design of the visual presentation in our approach is done by presentation sets. Presentation set is an ordered sequence of multimedia objects grouped together to form a unit of description. Every concept of the knowledge model has a presentation set assigned. This set provides full and explicit description of the concept.

Every multimedia object of the concept’s presentation set is marked up with the level of detail. When the learner is viewing a page where a content of knowledge concept is displayed, one of the viewing parameters is the desired level of details. Presentation level of detail can be easily adjusted by simply changing the desired detail level parameter. Selection of appropriate presentation objects is very simple. Multimedia objects are merely filtered according to their index of significance. Also preferred didactic roles and alternatives can be specified as concept’s viewing parameters.

It is very important for a knowledge transition relation to have its own multimedia objects. Presentation sets of concepts are rather autonomous. Each concept is an independent self-contained idea. Transition relation’s multimedia objects contain information that addresses not a specific concept, but interrelations between concepts. These multimedia objects are vital for good understanding of the educational material. Learning is described by cognitive scientists as the process of connecting new information to the already acquired. Knowledge transition relations’ multimedia objects provide these crucial cognitive connections (Fig. 5).

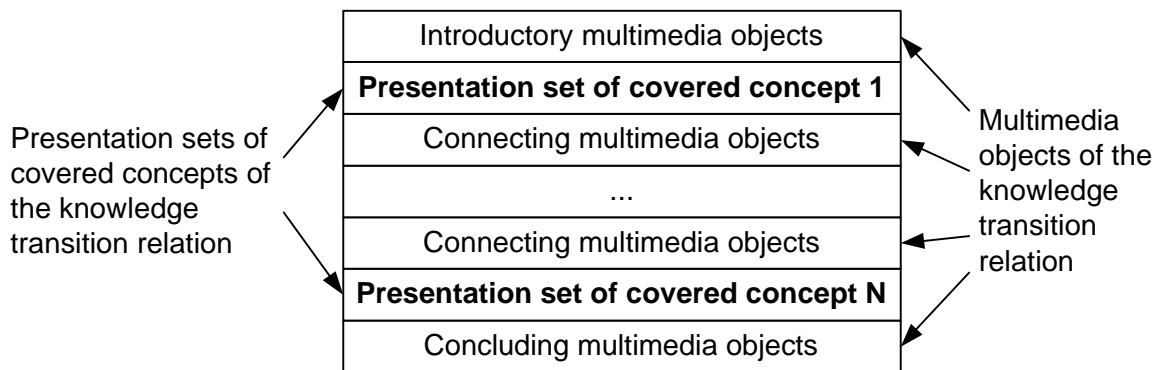


Fig. 5 Presentation set of the knowledge transition relation

It is worth mentioning here that information contained in multimedia objects of transition relations cannot be assigned to concepts’ presentation sets. Since these logical connections are actually beyond the scope of individual concepts, it is knowledge transition relations that should contain them.

5 Integration of the models

A major goal of our on-line education systems framework is personalization capabilities. Both the knowledge model and the multimedia objects repository should not only be consistent in their structure, but also possess features that can be actively used for adaptation of the on-line courses

to the preferences of individual learners. One of the means for achieving this is the integration of knowledge structure model and multimedia objects repository into user model and personalization methods of the system.

Let us first look at the multimedia objects repository. Multimedia objects are assigned various attributes that can be used to extract various user presentation preferences, to be used later for adaptation of presentation¹. User preferences can be extracted from the logs to address:

- preferred level of detail;
- preferred modality of the multimedia object;
- preferred didactic role;
- preferred type of alternative.

For example, consider a user who prefers (detail level 2, pictures, complex definitions and examples). If the page contains examples marked with detail level more than 2, they will be shown to answer the user’s preference. Complex definitions will be chosen from a set of options and pictures will be shown whenever possible.

Knowledge structures provide valuable personalization information too. The history of accessing the pages can be used for navigation adaptation¹¹. Also access patterns can be extracted to form navigation stereotyped classes of users³. In parallel with transition pages, navigation of concepts ontology can be monitored. The two navigations, knowledge transition relations and concepts ontology, can be used together for personalization to achieve better adaptation.

6 Case study

In this section we will illustrate our approach with an example. Further we will demonstrate each of the discussed features of the approaches to knowledge structuring and multimedia objects repository design. The focus of the case study is a fragment of the “data structures” domain. For simplicity domain size is kept small and will be discussed only in part to show the key points stated above. 11 concepts were picked from the chosen domain. Concepts are connected with 12 ontological relations (Fig. 6).

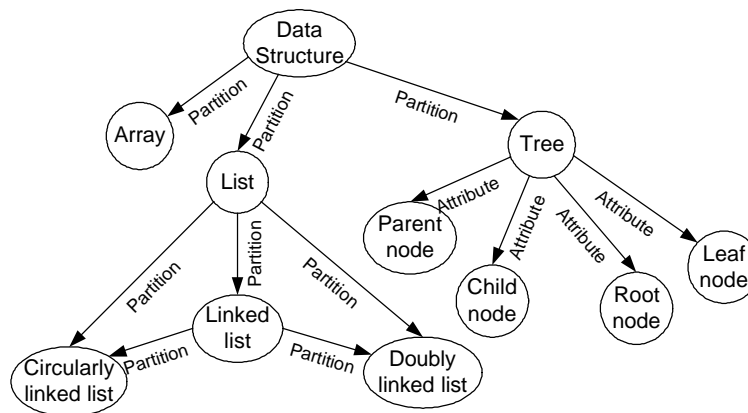


Fig. 6 Knowledge concepts ontology

Ontological relations (Fig. 6) were used of 2 types: “Partition” and “Attribute”. E.g. Concept “Array” partitions concept “Data Structure” and concept “Root node” is an attribute of concept “Tree”. Intuitively, ontological relation “partition” points from a general concept to a specific concept and “attribute” concept characterizes its predecessor.

The knowledge map containing knowledge transition relations and incident concepts of the described domain is shown in Fig. 7. Notation was borrowed from the Petri nets¹⁰. The knowledge map consists of 10 knowledge transition relations. Concepts that are prerequisites for transitions are connected with an arrow pointing to a transition relation. Resulting concepts are connected with an arrow pointing to a concept. Concepts covered at the page of the transition relation are connected to same transition relations with a thick line.

Note that knowledge transition relation “List in Array” does not have any concepts that are covered at its page. The purpose of this transition relation is to provide information summarizing prerequisite concepts or discussing material that involves all of the prerequisite concepts (here “Array” and “List”).

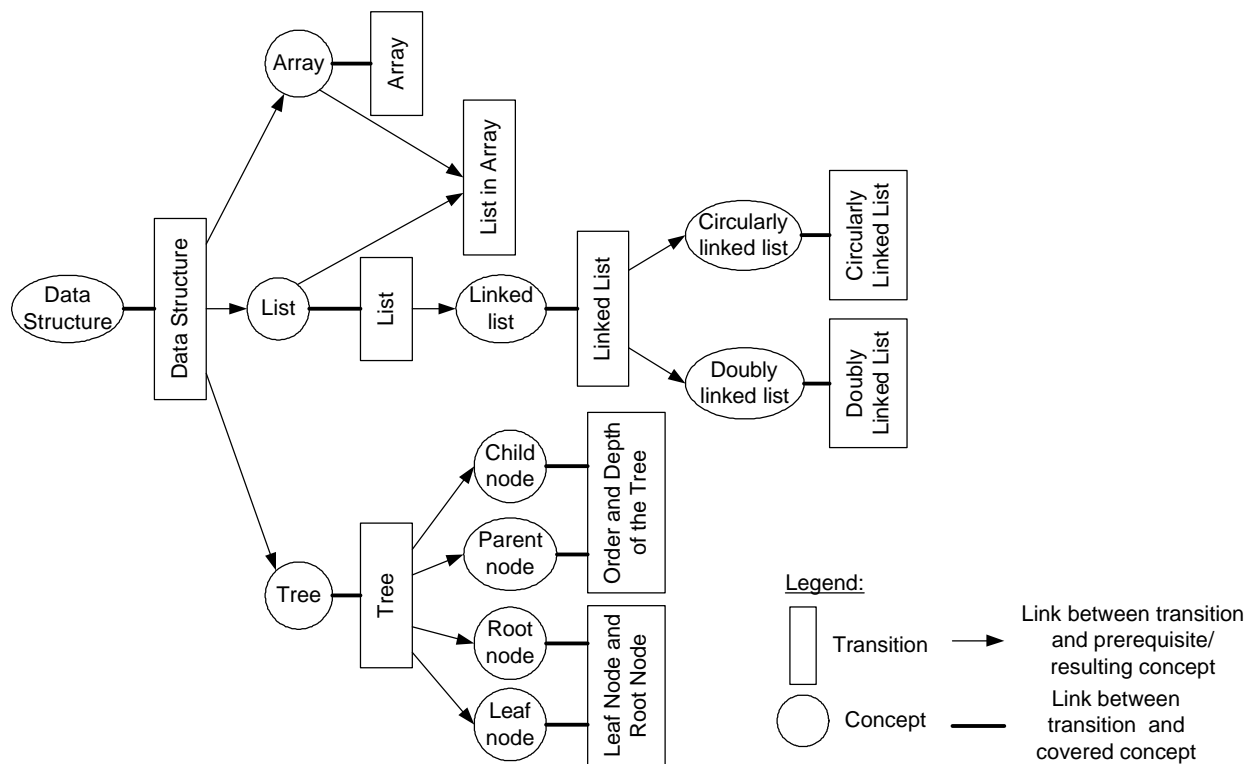


Fig. 7 Knowledge map: transitions and knowledge concepts

Next we will provide a fragment of the multimedia objects repository of the discussed knowledge domain. First we will introduce a presentation set of the concept “Stack”. Table 1 shows specification for multimedia objects that form the presentation set of concept “Stack”.

Table 1 Presentation set of the concept "Stack"

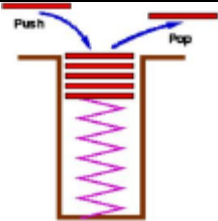
Detail level	Didactic role	Modality	Alt	Contents
1	definition	text	simple	A collection of items in which only the most recently added item may be removed. The latest added item is at the top. Basic operations are push, pop, and top
1	definition	text	simple	A data area or buffer used for storing requests that need to be handled. As new items come in, they push down the old ones. Another way of looking at a stack – is that the program always takes its next item to handle from the top of the stack
1	definition	text	complex	Stack is a data structure with defined operations on it: new(), push(v, S), top(S), and pop(S) where: new() returns a stack $\text{pop}(\text{push}(v, S)) = S$ $\text{top}(\text{push}(v, S)) = v$ where S is a stack and v is a value
2	note	text		Stack is also known as "last-in, first-out" (LIFO) or pushdown list.
2	description	text		Stack is one of the ways of storing data. It is generally implemented with only two principle operations: push - adds an item to a stack; pop - extracts the most recently pushed item from the stack Also the following methods are sometimes added: top - returns the item at the top without removing it isempty - determines whether the stack has anything in it
1	example	text		A common model of a stack is a plate or coin stacker. Plates are "pushed" onto to the top and "popped" off the top.
1	picture	image		
3	note	text		Although a linked list implementation of a stack is possible (adding and deleting from the head of a linked list produces exactly the LIFO semantics of a stack), the most common applications for stacks have a space restraint so that using an array implementation is a natural and efficient one (In most operating systems, allocation and de-allocation of memory is a relatively expensive operation, there is a penalty for the flexibility of linked list implementations.

Fig. 8 shows the structure of multimedia objects from presentation set of concept “Stack”. Multimedia objects are listed top-down in the order of appearance. Alternatives are connected

with “OR” link. Structuring link “illustrates” shows that multimedia object “picture” illustrates multimedia object “example”. Detail level is shown in square brackets

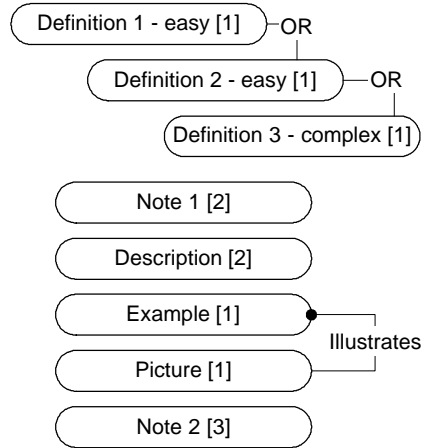


Fig. 8 Structure of the concept "Stack" presentation set

To show how a page of the course can be designed let us now define presentation sets for knowledge transition relation “Root Node and Leaf Node” and concepts “Root Node” and “Leaf Node” covered at the page of transition relation (Table 2, Table 3, Table 4).

Table 2 Presentation set of concept “Root Node”

Detail level	Didactic role	Modality	Alt	Contents
1	definition	text		A node that has no predecessor nodes

Table 3 Presentation set of concept “Leaf Node”

Detail level	Didactic role	Modality	Alt	Contents
1	definition	text	alt	A node that has no child nodes
1	definition	text	alt	A node at the lowest level of the tree (those that have no sub-trees)

Table 4 Presentation set of transition “Root Node and Leaf Node”

Detail level	Didactic role	Modality	Alt	Contents
1	intro	text		There is a notion of "toward top of the tree" (i.e. the root node)
Space for presentation set of concept “Root Node”				
1	connection			There is also a opposite direction “down the tree”, toward the leaves
Space for presentation set of concept “Leaf Node”				
2	note			Nodes that are neither leaves nor root are often called intermediate
2	note			Trees are often called inverted trees because they are normally drawn with the root at the top.
1	picture			

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Fig. 9 shows the structure of web page composed of multimedia objects from presentation set of knowledge transition relation page “Root Node and Leaf Node”. Presentation sets of concepts “Root Node” and “Leaf Node” are shown in grey. Multimedia objects augmenting the presentation of those concepts are shown in white.

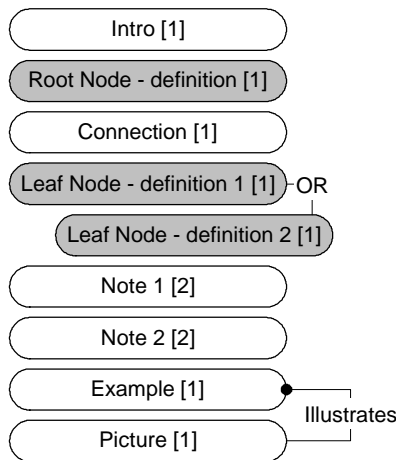


Fig. 9 Presentation set of the transition "Root Node and Leaf Node"

7 Summary

The framework of on-line education system presented in this paper provides extensive means of knowledge conceptual and visual modeling. The architecture of the knowledge model consists of three integral parts: (a) concepts ontology, (b) knowledge transition relations, and (c) multimedia objects repository. The design of these parts is done separately. This increases consistency and efficiency. It also provides a greater structuring flexibility for the knowledge model.

Concepts ontology is a very effective way to describe knowledge domains'. Knowledge transitions relations, introduced in this paper are a new effective tool for knowledge sequencing and modeling concepts' learning order. Knowledge transition relations capture both localized context and global context of learning new knowledge. Concepts ontology together with knowledge transition relations united as the knowledge map is a powerful tool of representing complex knowledge domains. Granulation of concepts in ontology can be chosen by the current task and later can be altered. Transition relations at the course development time can be created stage-by-stage. First to address most common learning paths, later the set of transition relations can be extended to involve more options in browsing course material. Both ontology design and transitions design can be done simultaneously.

Multimedia objects repository presented is a sophisticated yet effective approach to the design of knowledge visualization. Level of detail provides effectiveness of managing the complexity of the material layout. Alternatives of multimedia objects give the course designer to create versatile descriptions and help the learner to study the subject from many points of view. Didactic roles substantially specify the information contained in the multimedia object. Didactic roles and alternatives of the multimedia objects are the state-of-the-art features of the presented approach to visual knowledge design. Didactic roles of multimedia objects along with modality classes increase the effectiveness of the knowledge visualization and meaningfulness of knowledge description. With the help of four (level of detail, modality classes, didactic roles, and alternatives) knowledge specification dimensions it is possible to create highly structured personalization oriented educational material.

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Approach to building up the presentation to the knowledge from the multimedia objects enables fast and efficient instrument of visual knowledge design. Specially designating multimedia objects for logical connections between concepts increase the understanding of the learners.

Presented case-study illustrates the key features of the framework and demonstrates its advantages. Personalization of the on-line courses based on the proposed knowledge architecture is more effective. Suggested structure of the knowledge model and multimedia objects repository makes instruction material an advanced tool of providing personalization capabilities.

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