ONTOLOGICAL MODEL OF THE CONCEPTUAL SCHEME FORMATION FOR QUEUING SYSTEM

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ABSTRACT
In the article the authors propose an extended ontological model for distance learning, concerning pedagogical and cognitive requirements of the teaching/learning process. The main characteristic of the dedicated ontological model is reusability, which manifests itself in the possibility of adapting the knowledge model to different contexts and for different users by simply enabling knowledge sharing and knowledge management. The conceptual schemes are used for modelling the knowledge about queuing systems for knowledge repository and ontology development purposes. Authors have taken advantage of the computational models theory in order to create a model which combine theoretical and procedural knowledge.

KEY WORDS
conceptual schemes, queuing systems

INTRODUCTION

Motivation

Distance learning environment brings in new problems connected to effective knowledge transferring. It occurs especially in the case of asynchronous learning, when a student is able to absorb knowledge at any, convenient for him, time, without any supervision from a teacher.

Didactic materials in this case have to be prepared more carefully, as the teacher during the teaching process will not have the possibility to correct the student instantly. Distance learning most of all has high requirements, demands and expectations when it comes to the teacher preparing didactic materials.

A course dedicated to the learning environment cannot be prepared through simple publishing of materials used for the traditional course but should be based on materials created especially for this case. Of course it is possible and allowed to base on the existing materials but the aspects discussed below have to be taken into account.

With the absence of the teacher supervising the learning process in real time the problem of mutual understanding with the student occurs. During classes held in traditional way the teacher is able to observe the reactions of students on a real-time basis, which allows him to change the contents being taught and adapt them accordingly to reach his students in the best way. In distance learning environment there is no such flexibility, student uses the fore-prepared materials. Preparing the didactic materials that deal with every problem in a very detailed way, so that in case of any doubts student is able to refer to them and complement his knowledge, seems to be the solution to this problem. This leads to two problems. First of all, preparation of such materials is very difficult, time-consuming and expensive. In reality very few universities will be able to fully realise this idea.
Secondly, this way of leading the student by the hand will cause a decrease in his or hers intellectual activity as whenever a problem occurs he or she will be able to find answers to all the questions bothering him in the huge didactic materials.

On the other hand, one cannot assume that every problem the student comes across during the studies he or she will be able to solve unaided. Of course in the distance learning environment it is still possible to contact the teacher. However the frequency of the students queries and asking for further explanations of the problems occurring during the independent learning process reflect the quality of the prepared materials. The decrease in the need for contacting the teacher naturally involves the decrease in the cost of distance education.

The distance learning systems become important part of the knowledge management systems. In the knowledge based organisation the distance learning systems are used to transfer different kind of knowledge. The theoretical and procedural types of knowledge required different modelling approaches. The problem appears: How to prepare distance learning’s course that combine different types of knowledge?

**Research Goals**

The didactical content of the distance learning systems is an important and vital research problem. The most important reason for this statement is the fact that knowledge possessed by a person is quickly becoming outdated due to rapid growing of the amount of information and knowledge that appears in the world that surrounds us. This calls for methods of fast knowledge acquisition and modelling for the distance learning systems regardless of the time and space constraints. Fast knowledge outdating leads to long-life learning, which usually is realized by the distance learning systems. Because of the technological progress some jobs change their definitions every few years and without continuous vocational development it would be impossible to work in these fields.

From the knowledge management perspective, both at a university and in a corporation, one of the greatest challenges standing in front of the distance learning is ensuring high quality of didactical material. The problem of high quality of didactical material is difficult to solve because: (a) there are several functional requirements of modern learning material like reusability, openness, accessibility, (b) knowledge users have different cognitive characteristics, (c) there exist different types of knowledge (e.g. procedural, formal).

In the article authors propose an ontological knowledge model for the Queuing Systems domain. The model fulfils all three (a-c) requirements and allows creating a complex content for distance learning.

Moreover, the authors applied the computational models approach which allows to create simulation learning environments.

The reason for continuous repository designing, development and learning is resulting from present situation on educational market [Różewski and Ciszczyk, 2009]. The students are possessing almost unlimited access to different educational resources, courses and curriculum [Kusztina et al., 2009]. In case of Europe, the European Higher Education Area has been developed and provides a coherent educational system. In such a situation the quality of repository has a strong influence on a whole quality of a learning process.

**Paper’s Content**

The article consists of three parts, introduction and conclusion. In the first part the ontological model of the conceptual scheme formation is presented. The proposed approach is optimized to combine the procedural and fundamental knowledge into one model. In the second part the main knowledge models of domain area are given. The modelling subject comprises the queuing systems. At the third part the problem of courseware designing for simulation is discussed. The article unites the notions from different knowledge areas, such as:

1. Ontology knowledge representation.
2. Queuing systems and queuing networks.

**Ontological Approach for Domain Modelling**

**The Approach to Teaching in the Distance Learning**

The knowledge of a certain domain may be presented with a help of a semantic network [Sowa, 1991], one of the techniques designed for visualising knowledge. A semantic network consists of concepts that are joined together by relations like: IS A, PART OF, HAS A and others [Storey, 1993]. With the help of such a network it is possible to show what relations occur between concepts.

For each domain a semantic network can be built. Therefore we have a semantic network presenting the knowledge of simulation, knowledge of industrial en-
The learning process in this context can be presented as a process of building by each student his own semantic network. If we assume that the initial knowledge of a student can be presented in the form of a complex semantic network then learning will be a matter of complementing this network with new concepts. The main problem is simply showing the student where in the network the new concept should be placed and what are the relations between the new concept and the ones already existing in the network [Ausubel, 1960].

This task is a complex one since everyone has their semantic network created and built differently, what is caused by the differences in education level, environment one comes from, personal experience and many other matters. That is why the teacher has to find such a way of presenting the knowledge that will allow a fast adaptation of it through referring to certain concepts the students are already familiar with and thus creating relations between the new concepts and the student’s semantic network. Example semantic network for simulation problem is shown in the figure 1.

The teacher preparing didactic materials for the distance learning can use the formalisation brought by the semantic networks for creating the course. That means he will have to prepare semantic networks of the domains that make the course, e.g. in case of the course of simulating production processes semantic networks of the following domains should be prepared: simulation, production systems, statistics and maybe also some others. Of course those semantic networks do not have to contain the domains mentioned above in a complex way but in such a scope that is required and necessary in the course.

The next step will be determining by the teacher the level of initial and basic knowledge of the student that the course is prepared for. That means that in the semantic networks the areas of knowledge already mastered by the student should be marked and excluded, what can be achieved by testing the student or by analyzing his so-far education path. This way the teacher will discover the areas that will become the object of the course. So far we have been discussing separate semantic networks concerning different domains but as it was proposed before, the human knowledge will be considered as one complex semantic network. For this reason, gaining knowledge will be interpreted as creating new relations between the concepts of the semantic network. Gaining knowledge is discovering the relations between concepts and facts we had so far no idea existed.
The responsibility of the teacher is to define which concepts of the separate semantic networks are joined together in some way. Defining the relations between concepts of different domains is a very important stage because in this moment the final quality of the prepared didactic material is decided. Connecting the concepts of different networks results in creating one network that provides help for explaining aspects and facts concerning the course being prepared.

Joining the knowledge from several domains can be achieved by mapping the concepts [Kusztina et al., 2004]. The point of it is finding equivalents in the semantic networks. For example the semi-finished article in simulation maybe regarded to as “entity”. This makes it the joining point of the semantic networks presenting simulation and production. Similar mappings can be usually done on many concepts in the network. Through mappings we can discover that some parts of the networks are identical, with the same relations. The only difference is the ontology used in each case.

For that reason learning can be understood as going from one domain ontology to another. Finding that path is one of the goals of learning. The ability to move from one domain ontology to another is very important as it is thanks to that mechanism that one can use the mastered theoretical knowledge to solve practical problems.

The next stage in preparing the didactic material is dividing it to create the so-called Learning Objects. Learning Object is a portion of knowledge that the student is able to adapt and master during one learning session. Its content-related capacity can be defined as 4 to 6 concepts from the semantic network.

This is actually where the role of the teacher preparing the course for the needs of the distance learning ends. Now the last thing left to do is to arrange created Learning Objects in a sequence of learning adapted individually for the needs of every student. This problem was discussed in [Zaikin et al., 2006].

**Semantic Knowledge Unit**

The ontology structure of the extended ontological model includes the way of describing concepts structure and the accepted relations between concepts [Różewski et al., 2008; Kusztina et al., 2006; Kusztina et al., 2007]. The relations have been divided into taxonomic and non-taxonomic ones and also a set of axioms making up the platform of domain knowledge of the modelled domain. Thesaurus defines the vocabulary that can be used while defining concepts and relations and also references for concepts and relations. The ontological model (OM) can be presented as follows:

\[
OM = \{S, T, F, R\},
\]

where: \(S\) – ontology structure, T – domain description thesaurus,

\[
S = \{S_c, R, T, A\},
\]


\[
T = \{T_p, T_r, F_p, F_r\},
\]

where:

- \(T_p\) – thesaurus for the set of concepts,
- \(T_r\) – thesaurus for the set of relations,
- \(F_p\) – references for concepts,
- \(F_r\) – references for relations.

When developing knowledge models presented to the student in DL systems, it is necessary to consider the goal of learning, aiming at required competences and student’s basic knowledge. In such a situation it is not enough anymore to use terms, precise representation of knowledge capacity and depth contained in each concept becomes necessary. The level of knowledge capacity corresponds to the subset of objects counted to the class which was nominated by the name of the concept. The level of knowledge depth corresponds to the set of characteristics’ values of each object recognized as a member of a certain class, with consideration of constraints forced by a specified goal of learning and level of required competences.

In literature we come across many definitions of a concept [Zaikin et. al., 2006]. The main characteristics of a concept is usually a mental representation structure created through abstraction and generalization. [Wong and Mylopoulos, 1977] proposed an interpretation of a concept as a nomination of a certain class of objects which have similar features. In our research the following definition of a concept will be used: concept is a nomination of classes of objects, phenomena, abstract category, for each of them the common features are specified in such a way that there is no difficulty with distinguishing every class.

The approach bases on using semantic operations PART_OF, IS_A, KIND_OF (Figure 1). Aggregation (PART_OF), generalization (IS_A) and specialization (KIND_OF) are semantic operations, which can be considered as results of abstraction creation method. Concept can be seen as an abstraction [Różewski et al., 2008], what helps to understand a complex object through decomposing it into less complicated components. Through PART_OF relation it is possible to describe the set of characteristics sufficient to recog-
nize a certain abstract object as a member of the considered class. IS_A states that a specific object with the given values has been counted as a member of the same class. KIND_OF means that specific objects listed by name have been counted into the considered class.

Developing a concept matrix structure (Figure 2) bases on choosing and using existing definitions of concepts. For this, intentional and extensional approaches can be used. Each of the definitions is the basic point for specifying the characteristics of the object being defined, finding sets of defining characteristics and creating classifying schemas.

![Figure 2. Concept's Matrix Description Structure](image)

Source: [Kushtina et al., 2006].

Formally the content, capacity and depth of knowledge can be described in the following way as a matrix concept structure:

\[ G = \prod_{i=0}^{\infty} G_{ij}^{i} \]  

where:

- \( G_{ij} \) is the set of concepts of all objects belonging to class \( G \),
- \( G_{ij} \) is a description of the depth of knowledge corresponding to the term of concept \( G \).

Adding new elements to set \( I = 1, i^* \) while maintaining the content of the concept means broadening the examined class of objects. Adding or removing elements from set \( J = 1, j^* \) means changing the content of the concept. Intersection \( \delta = I \cap J \neq 0 \) is the measure of acceptable tolerance for different forms of the concept, which correspond to the border of the domain being examined. If \( \delta = 1 \cap J = 0 \) we deal with a situation when the same word in different domains of knowledge refers to a different thing or phenomenon. The adequate extended ontological model creation algorithm has been discussed in detail in [Zaikin et al., 2006].

Developing ontological domain model in an educational situation requires analyzing a specific curriculum and a learning goal, which play the role of constraints for capacity and depth of concepts used in didactic materials. In the context of the above presented definition of ontology, using concept’s matrix structure for describing \( S \) leads to a two-level layout of the ontological domain model, where the first level is a network of concepts (similar to semantic network) and the second level defines the depth and capacity of knowledge included in each concept. Rules of creating the two-level arrangement can be used many times in reference to the same originally defined ontological model. This gives the possibility of developing a multi-level ontological model. Using the proposed approach enables adjusting the ontological domain model to specific educational goals. The ontological domain model extended in such a way will allow a significant level of automation of processing the model into a modular structure of didactic materials dedicated to being used in the learning process.

The existing repositories can be used for the purpose of the learning process as a source of outlook shaping, research way development or as a source of didactic materials. There are many repositories created by higher education institutions [Różewski et al., 2008]. This repositories contain didactic materials thoroughly reviewed by experts, which can be adopted for the purposes of different courses. According to the statistics, about 15% of repositories include as a main resource didactic materials in the form of a Learning Object.

The didactic materials repository is designed to present the philosophical, scientific, scientific-technical, scientific – technological state of selected domain [Różewski and Ciszczyk, 2009]. The elements of the repository are dynamically contributed in accordance with the purposes of learning. By using the repository, the elements of domain knowledge are shared, mainly in the form of Learning Objects [Kusztina et al., 2007], which are interpreted as modules of knowl-
edge that arise as a result of the analysis and division of knowledge into "pieces".

The ontology will indicate the main direction in repository filling and its further development. The use of ontological models is intended to leading the oriented repository development as well as its balanced growth in established areas. The ontology based approach lets on marking off procedural knowledge excerpts. On the basis of ontology in the repository there can be loaded: concepts with context, publications containing basic knowledge, case studies and corresponding test tasks.

**Queuing Systems Modelling: Domain Area**

**Concept network**

The objective of the queuing theory is formation of decisions about rational design of the queuing systems (QS), performance optimization and management of incoming process of customer demands to provide high efficiency of QS functioning. To achieve these objectives the tasks of queuing theory are solved, which set the dependence of functioning efficiency of QS organization and parameters [Kleinrock, 1988]. The authors used queuing theory approach as a main theoretical approach for intangible production modelling [Zakin et al., 2005; Zakin et al., 2002]. In the table 1 the taxonomy of queuing systems is presented and in Figure 3 conceptual scheme of queuing systems domain is shown.

**Computational Model for the Queuing Systems**

In the constructing of an e-learning system, the goal is to incorporate the fundamental and procedural knowledge into one cohesion system. The fundamental knowledge can be modelled on the basis of the semantic network approach. The procedural knowledge can be modelled on the basis of the logic rules. In this section authors proposed a number of computational models which can incorporate fundamental and procedural knowledge into one system.

To get some idea about the whole process in this section the theoretical basis is presented as well as final computational models.

Kind of QS according to Kendall notation defines the following parameters of queuing system and its environment, such as:

- $\lambda$ – the rate of arrival of incoming jobs,
- $\mu$ – the rate of servicing of outgoing jobs,
- $m$ – the number of parallel servers,
- $S$ – the input buffer capacity

Using these parameters we can define a number of indices that determine functioning of the QS.

**Variables determining functioning of QS**

**Variables determining functioning of QS in time**

- $N(t)$ – the number of customers in the system at time $t$,
- $N_q(t)$ – the number of customers in the waiting queue at time $t$,
- $N_s(t)$ – the number of customer in the service facility at time $t$,
- $P_k(t)$ – the probability of having $k$ customers in the system at time $t$

<table>
<thead>
<tr>
<th>Queuing Systems</th>
<th>M/M/1</th>
<th>M/M/m</th>
<th>M/M/m/m</th>
<th>M/M/1/S</th>
<th>M/D/1/C</th>
<th>G/G//prt</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival pattern</td>
<td>Markov (Poisson) = M(P)</td>
<td>M(P)</td>
<td>M(P)</td>
<td>M(P)</td>
<td>M(P)</td>
<td>General</td>
<td>...</td>
</tr>
<tr>
<td>Kind of Servicing</td>
<td>Markov (Exponential) = M(E)</td>
<td>M(E)</td>
<td>M(E)</td>
<td>M(E)</td>
<td>Deterministic</td>
<td>General</td>
<td>...</td>
</tr>
<tr>
<td>Number of servers</td>
<td>1</td>
<td>m</td>
<td>m</td>
<td>1</td>
<td>1</td>
<td>$\infty$</td>
<td>...</td>
</tr>
<tr>
<td>Discipline of servicing</td>
<td>FCFS</td>
<td>FCFS</td>
<td>FCFS</td>
<td>FCFS</td>
<td>FCFS</td>
<td>Priority</td>
<td>...</td>
</tr>
<tr>
<td>Population</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>C</td>
<td>$\infty$</td>
<td>...</td>
</tr>
<tr>
<td>Waiting queue capacity</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>m</td>
<td>S</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>...</td>
</tr>
</tbody>
</table>

*Source: Authors elaboration.*
Averaged variables of QS functioning
- $\bar{N}$ – the average number of customers in the system,
- $\bar{N}_q$ – the average number of customers in the waiting queue,
- $\bar{N}_s$ – the average number of customers in the service facility,
- $\bar{P}_k$ – the stationary probability of having k customers in the system

Variables determining service of customer
- $W(k)$ – the time spent in the waiting queue by $k$-th customer,
- $X(k)$ – the service time of $k$-th customer,
- $T(k)$ – the time spent in the system by $k$-th customer

Averaged service variables of QS
- $W$ – the average time spent by customer in the waiting queue,
- $\bar{X}$ – the average service time of a customer,
- $\bar{T}$ – the average time spent by customer in the system

The last variable $\bar{T}$ is often called flow-time of QS. Between these variables are established following ratio:
$$N(t) = N_q(t) + N_s(t) \quad T_k(t) = W_k(t) + X_k(t)$$

Moreover the conditions of ergodicity are valid for averaged variables:
$$\bar{N} = \bar{N}_q + \bar{N}_s, \quad \bar{T} = \bar{W} + \bar{X}$$
$$\bar{N} = \lim_{t \to \infty} N(t) = \lim_{t \to \infty} E[N(t)]$$
$$\tilde{N}_s = \lim_{t \to \infty} N_s(t) = \lim_{t \to \infty} E[N_s(t)]$$

Figure 3. Ontological model of Queuing System

Source: [Zaikin et al., 2006].
Indices of QS utilization

Beside of the mentioned above variables there are indices, which characterize utilization of QS. They are $a$ – traffic intensity and $\rho$ – resource utilization. Traffic intensity $a$ is a relation of a rate of arrival and a rate of servicing for one server $a = \frac{\lambda X}{\mu}$.

$$N_q = \lim_{t \to \infty} N_q(t) = \lim_{t \to \infty} E[N_q(t)]$$

In fact traffic intensity is dimensionless in quantity but it is usually expressed in erlangs (named after A.K. Erlang). To understand better the physical meaning of this unit, take a look at the traffic presented to a single resource. One erlang of traffic is equivalent to a single user who uses that resource 100% of the time, or alternatively, 10 users who each occupy the resource 10% of the time. A traffic intensity greater than one indicates that customers arrive faster than they are served and is a good indication of the minimum number of servers required to achieve a stable system. For an example, a traffic intensity of 2.5 erlangs indicates that at least three servers are required.

To express real utilization of servers another parameter $\rho$ is used for multi-server QS. Resource utilization $\rho$ is relation of rate of arrival and rate of servicing for all servers.

$$\rho = \left( \frac{\lambda}{m \mu} \right) \cdot \frac{1}{1 - \frac{\lambda}{m \mu}} = \frac{\lambda}{m \mu} \cdot \frac{1}{1 - \frac{\lambda}{m \mu}}$$

It characterizes fraction of time when QS is occupied by servicing of jobs. It is easy to note that for single-server QS $a = \rho$ and for multi-server QS $a = mp$

Indices of functioning efficiency of QS

These indices depends on physical content (specification) of QS, for example:
- the average income, providing by QS per time unit,
- the average cost of servicing of jobs per time unit,
- the work-in-progress, which is average cost of jobs being at QS in time, etc.
In the figure 5 and 6 the computational model for M/M/1/S and M/M/M systems are presented. In the computational model the subject domain is described by the node’s formal description (variable) and relation between nodes. Moreover, based on the approach from [Tyugu Enn, 1989] it is possible to calculate some knowledge from the models. For example:

\[
\text{COMPUTE \ Utilization of servers FROM QS capacity, Rate of servicing, Rate of arriving KNOWING M/M/1/S.}
\]

Source: Authors elaboration.

\[P_0 = \frac{1 - \rho}{1 - \rho^{\text{ext}}},\]

\[P_k = \rho^k P_0,\]

\[P_m = \frac{(1 - \rho) \rho^m}{1 - \rho^{\text{ext}}},\]

\[N_S = \rho(1 - P_S)\]

\[N = \frac{\rho}{1 - \rho} \left( \frac{1}{1 - \rho} (S + 1) P_k \right)\]

\[\lambda' = \lambda(1 - P_S)\]

\[W = \frac{N_q}{\lambda'}\]

\[T = \frac{N}{\lambda'}\]
Simulation courses are given as lectures for many specialisations like: computer science, industrial engineering, management, mechanics and others. The characteristic feature of those courses is the fact, that they require the student to master theoretical and practical knowledge and that means that he should be able to successfully transfer the theoretical knowledge given during lectures onto a specific problem to solve it [Zaikin, 2002].

It is rather simple to teach students certain abilities, like operating in Arena environment, by explaining the meaning of most important options of the program. Very often we come across such approach when the task given to the students is solving in each class a previously prepared simple problem that most of the time concerns only one issue. In this case occurs the danger of having the student bring his activity in the class down to blindly following the teacher’s instructions instead of understanding the deeper sense hidden in the problem.

However, the goal of higher education should be teaching the student not only to do but rather to think, creating in him/her the ability of adapting the mastered theoretical knowledge to unaided solving the given problems.

Returning to simulation, the goal of the course cannot be teaching to handle some software but showing that simulation is one of the possible ways of solving complicated problems that the present student will approach in his/her later professional work.

**Teaching simulation**

**FIGURE 6. COMPUTATIONAL MODEL OF M/M/M QUEUING SYSTEM**

Source: Authors elaboration.
The simulation course is also supposed to improve the analytical and system thinking of the student.

The point of the teaching process is to complement the knowledge of the students with new concepts and ideas. In this case that would be concepts concerning simulation, like: resource, size, attribute, events list etc., during class the student has to understand their sense and adopt them. These actions of purely intellectual nature are an attempt to fit the new concept into the systems already existing in the student’s consciousness.

**Practical realisation of the introduced idea**

The discussed idea of preparing didactic materials and making them available for students has been used for creating a course of production processes simulation. The course was designed for 4th year students of five-year-long uniform master studies of management and industrial engineering. Within the confines of the course 30 hours of lectures, 15 hours of tutorials and 30 hours of laboratory sessions are being held. The course lasts for one semester (15 weeks). Around 80 students are registered. Topics of simulation course are limited to problems related to the power supply manufacturing process:

- Modelling of production line
- Operations times and resources
- Analysis of first results
- Transport between working posts
- Line balancing
- Designing of experiments
- Output analysis

The process of creating didactic materials for distance learning was commenced with the most difficult part and that means preparing materials for the laboratory sessions. The difficulty in this case results from the fact that during laboratory classes students have to get to know the way of using the theoretical knowledge acquired during lectures for solving real-life problems. At the same time during those classes they have to master, at least to the basic extent, one of the simulation packets, in this case Arena.

Referring to the approach presented above the goal of laboratory classes is showing the students how ontologies from different domains overlap each other (Figure 7). During lab sessions students have to discover which concepts can be mapped onto other concepts.

Distance learning environment Moodle (www.moodle.org) was chosen. This is a CMS (content management system) class software and it is distributed under Open Source licence. It is one of the most popular environments that has already more than 50 thousand users. In Moodle it is possible to place didactic materials being in accordance with the SCORM standard. The Moodle itself requires to work only a web-server, PHP and access to a database (MySQL lub PostgreSQL).

In order to create good quality materials it has been decided to prepare them gradually. In the first step it was determined that the new didactic content will be placed in a CMS class program, thus the Moodle, being freeware, was chosen. At this stage traditional classes with students are being held at the basis of the materials made available for students through

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**Figure 7. Mapping of notations related to the input stream of the queuing systems**

*Source: [Kushtina et al., 2004].*
Moodle. Therefore teacher is present in every class, gives instructions to the students, makes a short introduction and then students are to independently, using the fore-prepared materials, solve the tasks they are faced with. It is the responsibility of the teacher at this stage to intently observe students, see the moments when they are lost and answer the questions that arise during work.

Results of the observation will be used for improving the content of the course. Changing the content may include adding new topics, dropping some of them, changing the way that stress is placed. The goal of the stage of reediting the course is improving the easiness of learning it by the students and eliminating those parts that make problems arise.

The subsequent step will be testing the new version of the course again in traditional classes. If the teacher doesn't notice students having significant problems it will be possible to assume that the course prepared in this way is suitable for distance learning.

Currently the first testing stage of the didactic materials is about to end. During the present semester many valuable remarks have been gathered. It was possible to observe, like it was foreseen, that students have sometimes problems with a different part of the material than expected. The held classes showed that students using the CMS class environment very often show a much bigger independence and initiative than in the traditional approach to learning. Enthusiasm and will to try out the possibilities of the new approach were noticeable.

Conclusions

The main idea of the article is to unify the notions from different knowledge areas, such as: queuing systems, queuing networks and ontology knowledge representation. The reason of that is to create efficient mechanism for mathematical-rooted knowledge presentation for distance learning proposes. Authors presented several computational models including: Concepts network for the Queuing Systems domain, Classification of QS, Computational Model of M/M/1/S queuing system, Computational Model of M/M/M queuing system.

The proposed in the paper computational models can be applied in different aspects, for example:
1. Simulation: on the experimental environment development stage the one should identify the simulation model class. Proposed computational models represent a computational ontology for simulation problem. The simulation model class can be recognized based on the computational models.
2. Distance learning process: the distance learning process maintaining in the asynchronous mode is based on the knowledge object utilization [Zaikin et al., 2006]. Any knowledge object (learning object) includes following parts: theoretical knowledge, procedural knowledge, and assessment. The computational models in figure 5 and 6 are the main components of procedural knowledge for knowledge related to queuing systems.

In the field of conceptual scheme formation for the queuing systems, the next research goal is to expand the set of computational models for queuing network and other queuing systems.

References


