BUSINESS INTELLIGENCE SYSTEMS

ANALYSIS OF THE THROUGHPUT OF THE PROCESS OF DISTANCE LEARNING

Sergey Maruev, Evgeniya Gorbunova

Abstract: *We consider queuing systems as models of distance learning system we analyze how characteristics of business process in the system affect on throughput and on learning outcomes. The processes of executing tasks and tasks validation process are the key processes in the distance learning. A model of the process performed by a student is a queuing system with refusals. A model of the process performed by the teacher is a multi-channel queuing system with limited queue. We present a structure of one of the courses of the University, where the authors work to form individual trajectory of learning. for students with different levels of knowledge. Such an approach allow to increase the throughput of distance learning system.*

Keywords: *distance learning, process modeling, queuing system analysis*

ACM Classification Keywords: *K.3.1 Computer Uses in Education, Distance Learning*

Introduction

The term throughput is used at different levels of detail to describe the various characteristics of educational systems. In the analysis at the macro level, throughput refers to the number of people who have got education by age and grade level [35 R, 2007; Hugjen_en, http]. According to some surveys [Bowen, 2011; DL, http], the development of information technology and distance learning leads to increased throughput of educational systems. At the micro level of throughput depends on the resources of education institution, used in the learning process. The throughput analysis helps to identify key resources and to determine a number of students in the system [Maruev, 2012]. A lot of research is devoted to evaluation of throughput of hardware and software in distance learning systems. But the characteristics of the business process in the system also affect on a throughput and learning outcomes. This aspect of distance learning is analyzed in this paper. In this case, we assume that there are sufficient resources and technical capacity to process performance.

Process modeling and description

As an example, we consider processes in the system of distance learning of the Russian Presidential Academy of National Economy and Public Administration. The Academy is located in Moscow and has 67 branches in different regions of Russia. Considered a distance learning program is an additional training for students to prepare them for their education in graduate programs in Moscow. The training in our case adds to fulltime learning. The following processes are performed in the system: the teacher puts on a platform of educational materials, the student work with them and do a task, the teacher checks the result of the task and make comments. At any time a student applies for and receives the recommendation via its internal e-mail. On-line

discussions carried out periodically on schedule. The process of executing tasks and tasks validation process are the key processes in the system (Fig.1). They provide the main channel of feedback between a student and a teacher. These processes determine the time of the working cycle of the system as a whole.

A complete course is divided to pieces - didactic units. Every didactic unit is related with the activities and learning outcomes. The special task is used to estimate of these learning outcomes. Task flows circulate in the system: 1- flow from distance learning platform (DLP) to student, 2 – flow from student to DLP to estimate an executed task, 3- flow with assessment result from DLP to student.

A student executes many tasks for many courses. We accept that the student does not choose a task and he start working on a task, obtained at the time when he is not busy. This allows us to accept the flow 1 as a Poisson flow without consequences. If a student makes a mistake, he makes a task again after a teacher recommendation. A mistake is a random event, remaking tasks add to the flow 1.

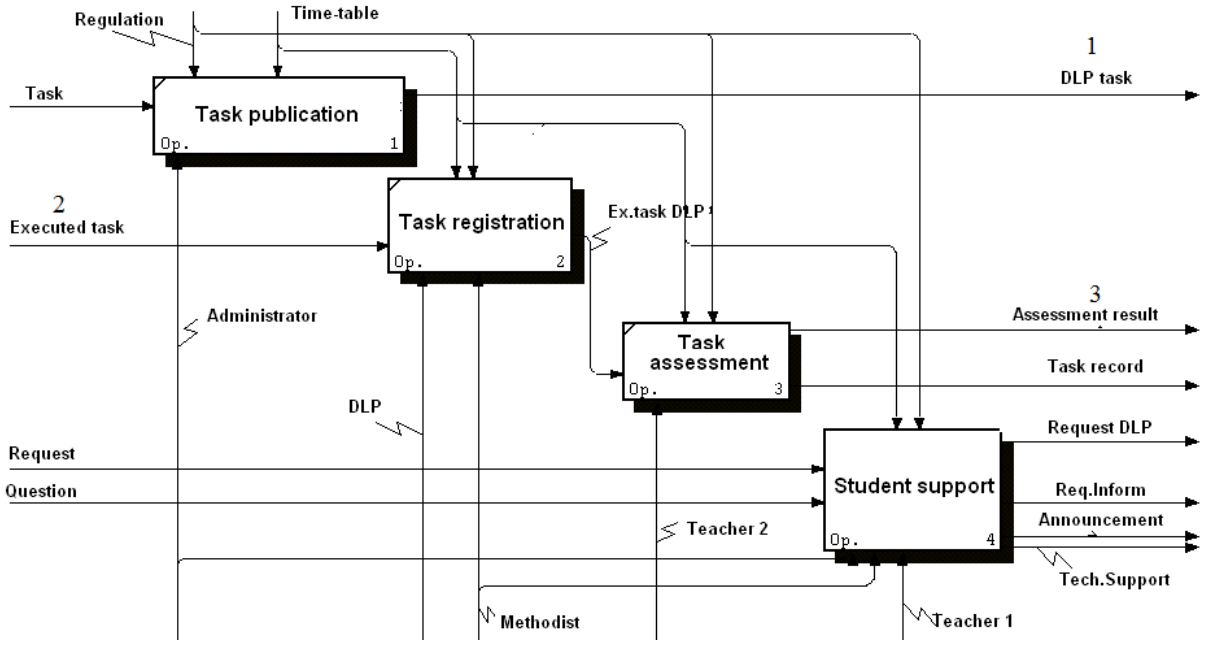

Fig. 1. A functional model of the process "Tasks validation and student support"

Executed tasks came to the system independently, each task from one student. The probability of receiving a new task does not connected with previous receiving task. A number of tasks in any disjoint time period do not depend on a number of tasks in another disjoint time period. So the flow 2 is a Poisson flow.

Approach

3.1. Problem definition

The quality of education depends on the quality of all processes in the system of distance learning (DLS). The quality of the process "Tasks validation and student support" depends on the consistency of the intensity of flows between the student and the system. The student receives a flow of tasks from the system, executes them and sends them for assessment to DLS. He gets the assessment and comments from DLS. Student also sends to the system requests for additional information, and receives it from DLS.

The intensity of the flows in the system depends on the number of tasks, the speed of their implementation and verification. Inconsistency of the intensities of flows leads to non-fulfillment of tasks and to default of students'

knowledge. The problem is to determine the appropriate flow parameters for each recipient, and to harmonize the parameters of flows between the actors.

The throughput of the system evaluated both in terms of student actions, and actions of the teacher. A model of the process performed by a student is a queuing system with refusals. A refusal means that a student is busy (is working with a previous task) and can not start to perform a new task. The probability of it depends on the number and complexity of the tasks and the time available for a student.

A model of the process performed by the teacher is a multi-channel queuing system with limited queue. A time of stay the executed task in the system shall not exceed the time allotted to the study of the didactic unit.

The processes are balanced if they do not interrupt each other.

3.2. Individual trajectory of learning

Different initial level of knowledge gives students a possibility to pass same topics and tasks, it means to design individual trajectory of learning. Individual trajectory of learning could be only in case of an assessment of passing topics. A graph of logical structure of knowledge of the training program is used for it. Didactic units are nodes of the graph and edges show a direct following between didactic units [Maruev, 2003].

The graph of logical structure of knowledge is used for training program design and learning outcomes validation [Maruev, 2006a; Maruev 2006b]. An algorithm of the graph construction includes the following steps. After Step 1 we have a complete list of didactic units. In step 2, the experts determined the immediate predecessors of each didactic unit. In step 3, a sensitivity of the model to individual estimates is evaluated. On step 4 we construct the levels of didactic units, eliminate cycles and check the connectivity of the graph. Fig.2 illustrates the graph of logical structure for “Microeconomics”. It includes 8 levels of didactic units. Same units have more than one incoming arrow, call them “gathering points”. A way of individual trajectory of learning design is to test students' knowledge in gathering points and avoid paths leading to points with a reasonable knowledge. For example a successful test of knowledge at a point 223 will reduce the number of didactic units from 41 to 27.

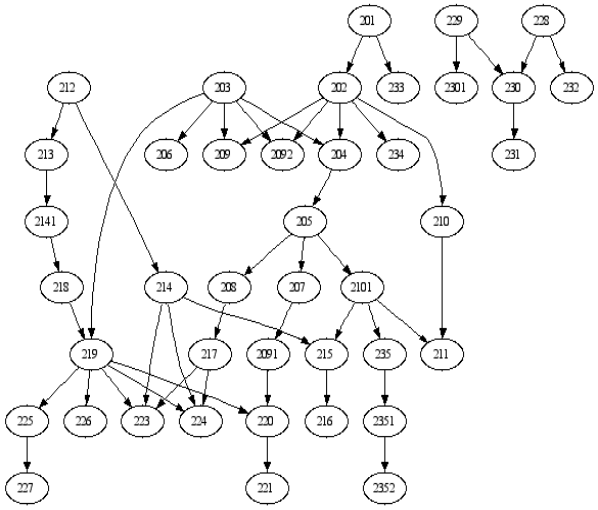

Fig.2. The graph of logical structure of knowledge for “Microeconomics”

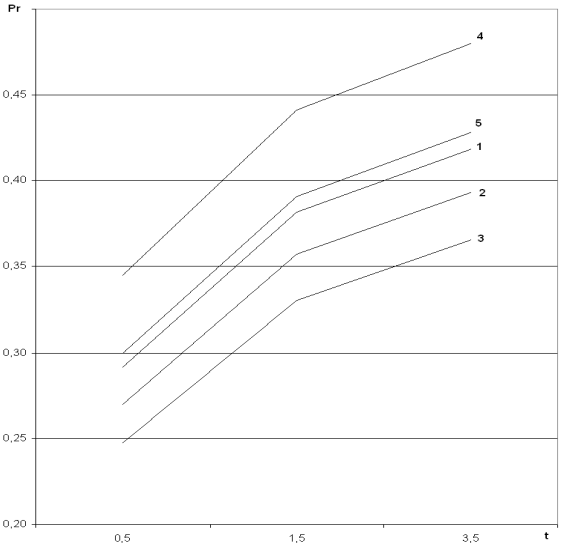

Fig.3. Probability of refusal in DLS

Modeling

The aim of modeling is to show how the structure of the learning materials influences on the throughput of the process. We accepted the standard parameters of learning at Russian university: student work with tasks 27 hours a week, working period proceeds 36 weeks and include 10 courses in different subjects. A course consists of ***N*** topics and has a task for each topic. A teacher can divide a complete course into different number of topics. Obviously to decrease time of the every task processing ***t*** it is necessary to execute more tasks ***N*** . Also a probability of mistake and repeated implementation of small task is less than large. A refusal in the system take place if a student receive new task before he finish previous task. Fig.3 illustrates a dependence between a probability of refusal ***Pr*** and ***t***. Average number of repeated tasks are 1 for line 1, 0.8 for line 2 and 0.6 for line 3. The additional distance courses increase labour intensiveness of students and probability of refusal (line 4). To decrease work of students looking after examinations in former years we eliminate same topics and tasks (line 5).

To assess the capacity of the process performed by the teacher, we take the intensity of the flow of requests received in the first step of modeling. A criterion for the balanced of processes is a time of stay the executed task in the system (waiting in the queue and task assessment) less than 10 hours. The simulation showed that this ratio will be observed if one teacher works with 5 students. Table 1 below examines characteristics of the queue system in the case of 64 tasks per student, assessment time 1 hour and teacher time 10 hours a week.

Table 1. Characteristics of the system performed by the teachers

Number of students	Number of teachers	λ	μ	ρ	P_0	Number of tasks in the queue	Number of tasks in the system	Time in the queue	Time in the system
3	1	0,533	1	0,533	0,467	0,676	1,143	1,268	2,143
4	1	0,711	1	0,711	0,289	2,173	2,462	3,055	3,462
5	1	0,889	1	0,889	0,111	7,889	8,000	8,875	9,000
3	2	0,533	1	0,533	0,538	0,038	0,571	0,071	1,071
4	2	0,711	1	0,711	0,446	0,097	0,808	0,136	1,136
5	2	0,889	1	0,889	0,373	0,212	1,101	0,238	1,238
6	2	1,067	1	1,067	0,312	0,434	1,501	0,407	1,407
7	2	1,244	1	1,244	0,260	0,879	2,123	0,706	1,706
8	2	1,422	1	1,422	0,214	1,848	3,270	1,299	2,299
9	2	1,600	1	1,600	0,170	4,354	5,954	2,721	3,721
10	2	1,778	1	1,778	0,120	13,613	15,391	7,657	8,657
11	2	1,956	1	1,956	0,037	140,911	142,867	72,057	73,057

We do not take into account the psychological factors of distance learning. Students need time for reflect new knowledge, to find creative solutions, the transition to a new job. These activities increase the time of processing tasks.

Conclusion

The paper proposes the solution of problem of consistency of processes in the system of distance learning. The throughput of the system evaluated both in terms of student actions, and actions of the teacher. A model of the process performed by a student is a queuing system with refusals. A model of the process performed by the teacher is a multi-channel queuing system with limited queue. The processes are balanced if they do not interrupt

each other. Matching capacities of the processes is obtained as a result of simulation for different parameters of flows and using education technology. An individual trajectory of learning for students with different levels of knowledge is formed to increase the throughput of the system. Simulation of the system was performed for the distance learning system of the Russian Presidential Academy of National Economy and Public Administration.

We suppose that modeling of distance learning systems in terms of Queuing Theory could be useful for planning educational process under limited resources of an educational institution.

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