SIMULATION SYSTEM OF NETWORK DATABASE MANAGEMENT SYSTEM WITH LIMITED CIRCULATION OF SEGMENTS

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ABSTRACT

Development and modernization of databases often involve simulation stage. Simulation of distributed databases is of particular interest and it should take into account the peculiarities of the exchange of data between network nodes. Simulation system, which is considered in the article, makes it possible to analyze processes occurring in the network database management system with limited circulation of segments.

ENGLISH SUMMARY

Background. *An important direction in development of computer systems is the development of high-performance database management systems (hereinafter- DBMS). Continuously increasing capabilities of modern computer networks pose to the developers a problem of choice, and in some cases, modernization of DBMS architecture. Modernization, in turn, cannot do without preliminary simulation [1, 2].*

There are many languages and simulation systems, namely GPSS, AnyLogic, DASIM etc., which have their own advantages and disadvantages [1, 6–8]. For example, languages such as GPSS, have considerable potential for the construction and analysis of models, but it is difficult to use them, and the development of model schemes on their basis requires high programming skills and can take a lot of time. Therefore, distributed simulation systems are used only to increase computing power, but not for the interaction of models.

With account for analysis conducted in [3] it can be assumed that all available modeling systems can't afford creating models, interacting via computer network communication channels. That was the reason for the development of original simulation system that implements a network DBMS with limited circulation of segments. Its special case is a centralized DBMS architecture, if one segment is used for the entire database. At the same time it should be noted that the department «Computer systems and networks» of MIIT University led by professor A. B. Barsky also conducts research of network databases with circulating information.

Objective. *Objective of the authors is to study functioning of DBMS with limited circulation of segments.*

Methods. *The authors use mathematical method, simulation and analysis.*

Results. *Currently, there exist some technologies of information exchange in network databases (DB) which are file server, client-server, circulating technology [4, 5]. In circulating DB, databases are divided into parts called segments. Segment may be a group of tables, one table, a group of records or a single record, depending on the configuration of DBMS in each particular case. Further, the term «segment» will be used to refer to the smallest unit of data from the database, which is transmitted over the network.*

Each DBMS serves a stream of requests or enquiries from «its» work station (WS). It allows dividing a general stream of requests to DB (ρ), weakening the influence of critical ratio:

$$\rho = \frac{\lambda}{\mu} < 1, \quad (1)$$

where λ is an intensity of stream of requests to DB, and μ is an intensity of processing stream.

Ratio (1) influences average request processing time ($T_{обсл}$):

$$T_{обсл} = \frac{t_{обсл}}{1-\rho}, \quad (2)$$

where $t_{обсл}$ – «pure» processing time per request.

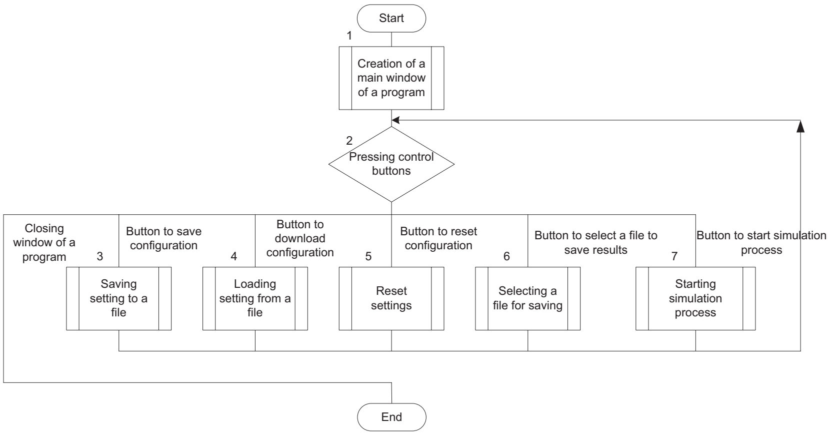
If we assume that with presence of DBMS on each WS processing time will depend on the situation developing on this WS, then:

$$T_{обсл} = \frac{t_{обсл}}{1-\rho_1}, \quad (3)$$

where $\rho_1 = \frac{\lambda}{n\mu}$, n is a number of WS. A centralized DB shows a certain disadvantage of data access process as the location of data within the sole server causes queues and operation interruptions. Within a distributed DB the data is divided by segments which are located at respective WS. But this causes problems of access to DB segment located at a certain i WS from another i+n WS.

We shall solve the problem of synchronization and access if we use principles of cycle circulation of DB segments within the network. All the segments can pass consequently from one WS to another, once there is a mechanism that provides for circulation of segments exclusively among the WS that interact with those segments. The work [4] suggested such mechanism which is a method of limited circulation or of addressed segments. The same article described the technology of operation of a DB with limited circulation of segments, WS's behavior during accessing the segments, as well as analyzed the time of request processing and conflict solution during processing of complex enquiries within network DB with circulating data, and algorithm of searching and neutralizing of cross-references.

For each segment, the server creates a table of addresses (TA) of workstations where this segment is to be processed. This table changes dynamically over time. TA of workstations includes



Pic. 1. Block diagram of the user's interaction with the system.

the following fields: a field containing a list of addresses (numbers, names) of WS, to which a segment should be directed; reference frequency of WS's requests to this segment (the number of requests for a certain time interval) and other statistical information [4, 5]. Besides TA a list of priority addresses of a WC is also compiled and then permanently located at a respective WS.

The server executes the main function of transmitting and modifying of a table of addresses. This operation is similar to WS's operation of segment transmitting, the sole difference been the need to generate relevant coefficient for complex requests which is a priority of a complex enquiry [5]. A WS executes simple operations of generating a recording number, of defining a number of a segment for this recording, and of a calling for the method of segment receiving. A WS does nothing until it receives all necessary segments. Then it adds time which was necessary to receive a segment for processing to the variable, common for all WS, as well as it incriminates another common variable for further calculating of mean queuing time (first variable will be divided by the second).

As an auxiliary technique of reducing DB server's load, one can use a variant referring to distribution of DB segments among auxiliary servers [4, 5]. Different algorithms can be used to that purpose, and the choice there-of depends on divers parameters like request frequency, dimensions, mean number of WS between which a segment circulates, distance or route between a WS and the server [5].

DB with limited circulation has certain advantages:

• its maximum flexible applicability due to the mechanism of limited circulation;

• its applicability in global networks;

• minimization of access time due to SPMD technology and limited circulation [4];

• restructuring DB to the new conditions occurs automatically and without additional costs;

• since mechanism of limited circulation – is a mechanism of functioning of a client and a server, it is possible to combine it with any existing DB.

While creating simulation system Java script was considered as most appropriate. The development environment was Eclipse which is free share soft package of Java applications developed by IBM.

The time of access to DB (time of waiting by WS of a requested segment) is the integral criterion of efficiency of DBMS. The criterion is illustrative and important as a WS which has generated an enquiry to get a record should be able to get it as soon as possible and that depends on developer of a DBMS. The main task is to determine the influence of different parameters of the system and its operation conditions on segment waiting time.

The developed system contains two main modules. The first one is that of user – system interface and the second one is a simulation module.

Block diagram of the user's interaction with the system is shown in Pic. 1. In block 1 occurs initialization of graphic interface. The program window contains several fields to specify the input parameters, as well as points of control menu which provide procedures specified in blocks 3-7.

The block diagram of the simulation module is shown in Pic. 2. In blocks 7-1 variables are initialized (their values are received from the first module). One of the variables is the number of WS used for the starting cycle of streams- workstations (7-2 – 7-4), as well as for stopping (7-6 – 7-8). After starting the streams the main module suspends its performance for time equal to one run (block 7-5), so that, at this moment only streams- workstations work. In block 7-9, the average waiting time for records of WS is calculated.

Module of the user's interaction with the system is a convenient graphical framework to set parameters and start the simulation (Pic. 3). Using the interface, the user can:

1) specify a range for each parameter;

2) set time for one run;

3) set the maximum number of runs for each parameter;

4) set a path to the file to save the results;

5) reset all values in all fields to their default values;

6) save the settings to a file;

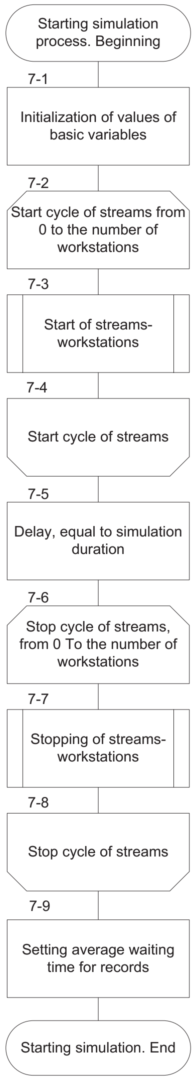
7) download settings from a file;

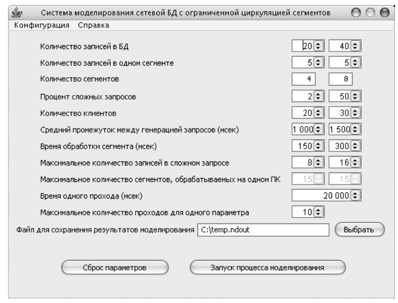
8) start the simulation.

The second module should receive variables of different types as input parameters.

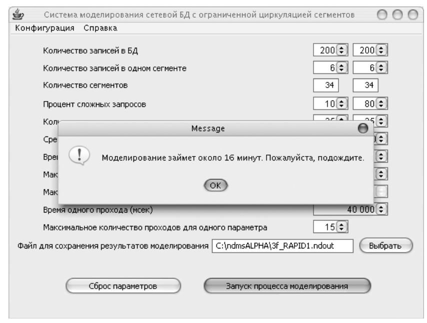
Pic. 4 and 5 show fragments of a simulation system work that implements the model of a network DBMS with limited circulation of segments.

Until the process is complete, system does not make any output. After the program shall have been accomplished, the user will receive a message stating that the result is stored. The ndout-file should be opened in WEB-browser or under text editor.

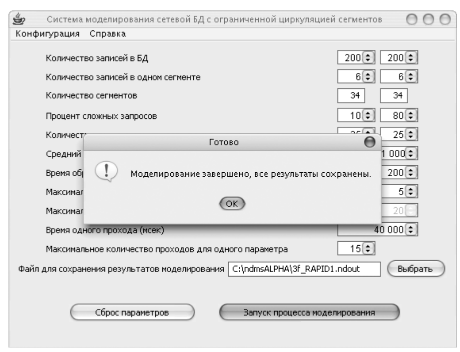




Pic.3. Graphical interface of a system.



Pic.4. Window informing the user about how much time simulation process will take.



Pic.2. Block diagram of the simulation of a network database.

Pic.5. Message to the user on the successful completion of simulation process.

Using the developed simulation system it is possible to track how different parameters affect the waiting time of workstations for segments, as well as to identify the advantages and disadvantages of two DBMS architectures – centralized and with limited circulation of segments.

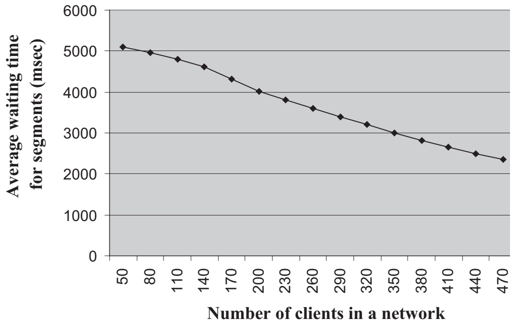
Pic. 6 is a graph assessing the impact of the size of DB on DBMS performance. The number of records in the database varies from 50 to 500. It is a pretty big range, which shows a clear dependence of delays in different sizes of DB. Since the number of clients is constant, the increase in the number of records in one segment reduces the waiting time for segments, because «interests» of WS with respect to different records «intersect» rarely. Thus, a large DB makes it possible to learn advantages of DBMS with limited circulation of segments.

Pic. 7 shows a graph of assessing the impact of the number of records in one segment on DBMS performance. The parameter ranges from 8 to 200, and the more records there are in the segment, more frequently the segments will be demanded by WS.

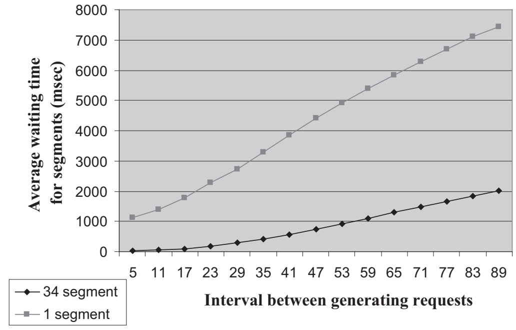
Increasing the number of records in a segment causes that workstations often refer to same segments, so the graph increases. A slight decline at the end of the graph is induced by the fact that when the number of records in the segment is above 100, it is necessary to deal with two segments, and all runs after this mark are, in fact, identical. Dispersion of 70 ms is very small, and it can be considered as an error.

Assessing the impact of the frequency of complex queries on DBMS performance is shown in Pic. 8. Their percentage ranges from 5 to 80, and an increase in frequency indicates how such requests increase the waiting time for segments.

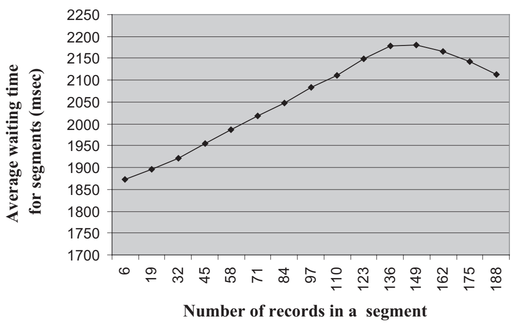
It is obvious that the frequency of occurrence



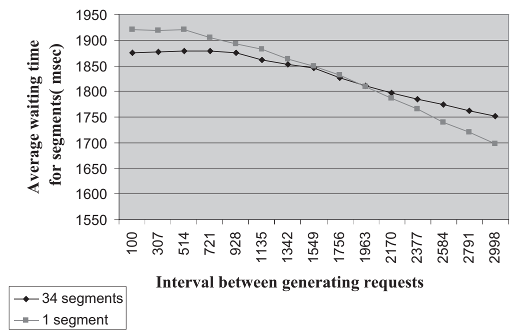
Pic.6. Graph of dependence of DBMS performance from the number of records in DB



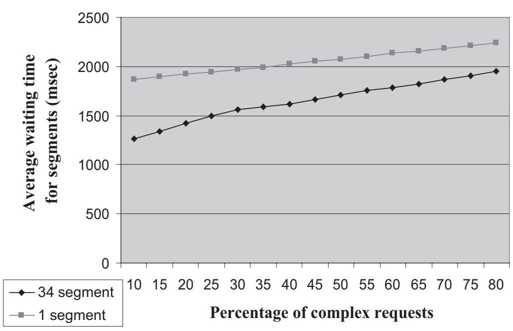
Pic.9. Graph of dependence of DBMS performance from the number of clients.



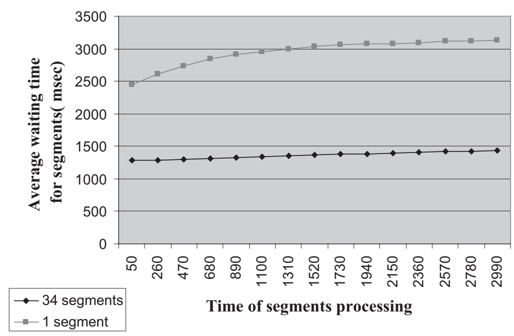
Pic.7. Graph of dependence of DBMS performance from the number of records in a segment.



Pic.10. Graph of dependence of DBMS performance from time interval between requests.



Pic.8. Dependence of DBMS performance from frequency of complex requests.



Pic.11. Graph of dependence of DBMS performance from time of segments processing.

of complex queries affects the waiting time for segments in both architectures.

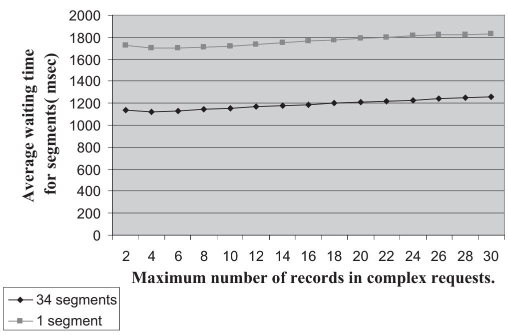
Greater benefit from architecture with limited circulation of segments is available in the case when the number of complex requests in the system is extremely small.

Pic. 9 provides an assessment of the impact of the number of clients on DBMS performance. This parameter varies from 5 to 100.

Graph rise shows that the larger is the number of clients, the more is waiting time for segments. This is due to conflicts, since the number of segments is the same, and the number of clients is more, their «interests» very often «intersect», so workstations wait for release of relevant segments longer. Advantage of a database with limited circulation appears to a greater extent in the case where the number of clients of the system is comparatively large.

Pic. 10 illustrates the impact of DB request frequency on DBMS performance. Let the average time between requests vary from 100 to 3000 ms. The less often arise requests, the less should be the waiting time. For example, 100 msec interval means that after every request «flow-WS» station is «inactive» for a random period of time from 50 to 150 ms.

Increase in station downtime at constant processing time of segments reduces waiting time. This is due to the fact that workstations do not work synchronously. In other words, during downtime of some WS, the rest WS can exchange segments. Increase in downtime reduces frequency of requests to the server, so the graph demonstrates it clearly. Since graphs and numerical values of parameters for each architecture are very similar, in this situation it is difficult to make accurate conclusions about what kind of architecture should



Pic. 12. Dependence of DBMS performance from the number of records in complex requests.

be preferred in case of different frequencies of requests addressed to DB.

Pic. 11 shows a graph of dependence of DBMS performance from processing time of segments. This parameter implies the sum of all time delays during work with the segment, and the major index is a time of segment transmission via the network. Processing time of segments varies between 100 and 3000 ms. The longer segment will be at the i-th WS, the longer should be waiting time to obtain a segment.

The graph confirms the assumption that the longer is segment's processing, the more is waiting time of WS for these segments.

Assessing the impact of the number of records in complex queries on DBMS performance is shown in Pic. 12. The maximum number of records in a complex request varies from 2 to 25 and the more segments will be expected by a WS, the longer should be the waiting time for these segments.

Conclusions. *According to simulation results, the following conclusions can be made:*

- *better performance will be achieved if the ratio of the number of segments to the number of users is greater than 1;*
- *increasing the number of complex queries and the number of segments causes growth of waiting time for the segments, this parameter is also negatively affected by high user activity and frequency of requests to DB;*
- *when using a centralized architecture (one segment) all WS refer to the same segment, so in almost all cases, the total waiting time is more than using architecture with limited circulation of segments (multiple segments);*
- *limited circulation is a promising direction in the development of database architecture;*
- *when the number of segments with the same number of records in the segment grows, waiting time for the segment decreases at constant number of clients;*
- *when size of a segment grows, waiting time increases;*
- *when number of users grows, waiting time for the segment increases.*

If request of a WS does not contain request for data modifications, a segment can be transmitted immediately to the next workstation, without waiting for the completion of processing. Since most requests to DB require a search for information, rather than its change, it allows multiple workstations to simultaneously process a single segment, thus accelerating circulation and reducing waiting time for the segment.

Developed simulation system that implements the model of a network DBMS with limited circulation of segments enables to simulate the behavior of various DBMS architectures and to assess the necessary parameters of engineered DBMS. Simulation system can provide answer to the question whether DBMS engineered under certain conditions and using certain paramters will be really efficient.

Keywords: *information, database management system, system performance, circulation of segments, simulation.*

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