საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 8, №1, 2014
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 8, no. 1, 2014

Informatics

Construction of Management Information Systems of Distributed Business Processes Based on Petri Networks and Object-Role Modeling

Giorgi Gogichaishvili[*], Gia Surguladze[**], Nino Topuria[**], Beka Urushadze[**]

[*] *Academy Member, Georgian Technical University, Tbilisi*
[**] *Faculty of Informatics and Control Systems, Georgian Technical University, Tbilisi*

ABSTRACT. The model of the service organs optimum number of client-server architecture based on Markovian processes and algorithmic schemes of its solution are worked out. On the ground of certain facts the Object Role Model (ORM) is created. The concept of the distributed databases creation for various financial structures based on Service-Oriented Architecture is offered. The forms of web-application on Ms Visual Studio.NET platform by NORMA software and Ms SQL Server package are realized. The issues of modeling for business processes of corporate systems, automatization of designing the database structures and the consumers' interfaces are considered. © *2014 Bull. Georg. Natl. Acad. Sci.*

Key words: *management information systems, distributed business processes, Markovian processes, BPMN, Petri Networks, Object Role Model.*

The task of integration of corporate information systems is especially relevant today. It requires reengineering of the existing systems and addressing the user-friendly connection of new systems with the existing ones. At this stage, most important is the time factor of upgrading the system, and the use of CASE technology for reducing time plays important role in this respect. For creation of a unified corporate information system software based on distributed business processes, the proper implementation of software systems life cycle management is needed, which will significantly improve their quality [1].

The design of distributed systems of electronic business and commerce control requires solution of the problems of informational support, software and hardware of separate functional units based on new network information technologies [2,3].

System operation conditions should satisfy the following demands:

- the system should function with the use of internet-intranet networks;
- the system should provide information security and protection;
- the system should have a user-friendly interface;

• the service should be simple.

Computer network system of commercial objects control is oriented to operate in multi-user mode that requires the guarantee of system functioning safety. Network base systems of data have special password systems for users registration (Login ID) and operation [4,5].

Business Process Modeling with BPMN Tool.

The problems of inter-corporate business process management are considered in the paper. The questions of business processes integration, information composition and synchronization related to multi-application environment are discussed. Considering the inter and intra-corporate management aspects, main attention is given to the strategies of software product development in the organizational systems [6]. To provide the integration of the horizontal and vertical management in the inter-corporate applications, the possibilities of service-oriented architecture and its practical realization examples are described. Consider the business process model between the Tax Service of the Ministry of Finance and the Banks, the formation of the incapsulated business functions in the web-services and the inter-corporate application process.

Encashment process in a bank starts at a pre-determined time. Windows service in the database tables views the lists of encashments to be processed and calls the GetActiveOrder; received encashment lists are transmitted to the RequestAmountFromMof, which forms XML messages and calls Revenue Service's web-service. Revenue Service returns XML messages to the bank's web-service, which includes encashment numbers and the corresponding amounts, this information is recorded in the database. Bank employee views encashment list using a program, then the web-service „Get" is called and verified; database procedures are invoked to perform transactions, transfer amounts from the account to the Revenue Service account. If the amount is fully paid, the status will change to "active" and the employee will unlock the card", etc [6].

The Corporate Network and Information Security

Information protection requires solution of two problems: provision of data continuity and guarantee of secrecy (installation of limitations for data receiving). In order to provide database continuity the structural limitations and data value limitations are directly used. Limitations on structural level are based on the description of functional dependences (relations, attributes, etc.) in data bases. The special notions of key attributes, indexes (simple or composite) are introduced. They realize information ordering, retrieval and selection in relational files. The continuity limitations on data value variation is realized with triggers. These are activation functions providing data continuity in logically connected tables (relations). Initiation of standard or private functions in the system is determined by the user, while the triggers do not depend on the program. It is keyed-on every time whenever the information is renewed in the data base. One of their functions is to report the data change statistics in the system.

Study of business processes in a statistical mode on the basis of the theory of queues for investigation of the proposed scheme the mass service model for steady-state regime has been used (M/M/m, M - Markov property, Poisson/Exponential distribution; m - number of servers).

Consider the corporate network model, where there are several users and several servers (service) with services. Suppose, that one of the servers performs a distribution function, i.e., receives a request from a user and sends it to the server (which is available). If all the servers are busy, the request is queued waiting until one of them is available.

As soon as server (Ni, i=1,6) receives request from the distribution server (Nmain), it serves with some specific services and returns the results back to the distribution server, which in its turn sends the response to the user.

Our goal is to identify the critical point of network functioning with the help of the existing param-

Tab.1 **Wait-positions in the range**

N	Wait	Step	Time_end	Time_wait
1	0	512	1856	1773
2	25	213	1759	1734
3	50	134	1771	1690
4	60	139	1833	1773
5	65	118	1714	1588
6	70	120	1977	1864
7	75	111	1956	1839
8	100	83	1887	1786
9	125	79	2036	1907
10	150	80	2729	2579
11	175	73	2514	2339
12	200	77	2893	2693
13	225	71	2686	2461
14	250	67	2794	2594
15	300	89	5289	4989

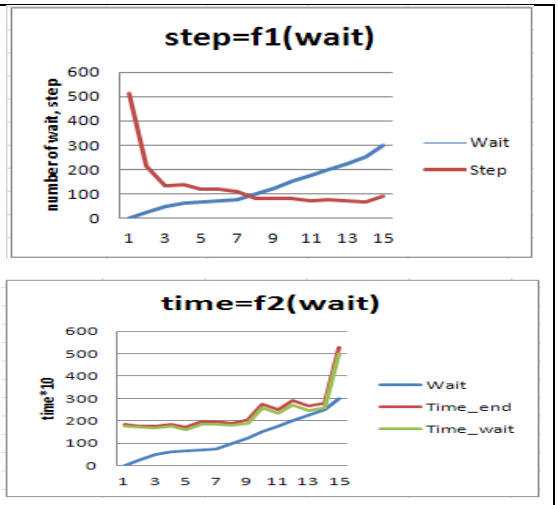

Fig. 1. Results of simulation processes-2

eters to choose the characteristics which ensure its normal functioning creating software product, which performs all of the above-mentioned. According to the theory of mass service the above-mentioned system is of M/M/m type [6].

The Erlang function plays an important role in the research of M/M/m type systems. This function defines the probability of all the servers being busy, and at the same time, it defines the probability of waiting for the request arrival.We are going to use the following equation for the Erlang function:

$$E_c(m,u)=\left(u^m/m!\right)/\left(u^m/m!+(1-\rho)\sum_{k=0}^{m-1}\left(u^m/m!\right)\right),$$

where u and ρ are network characteristics, in particular, arrival rate $u=\lambda * Ts$ and load of server $\rho=u/m$.

The average time of request waiting is very important for a user and is derived from the following expression:

$$T_w=\frac{E_c(m,u)T_s}{m(1-\rho)}.$$

It is necessary to determine the average time of a request being within the system:

$$T_q=T_w+T_s.$$

The probability that the time request spends within the system is less than t depends on whether $u=m$-1 or not. If this condition is met, the following expression is obtained:

$$P=1-\left(1+\frac{t}{T_s}E_c(m,u)\right)e^{\frac{-t}{T_s}},$$

otherwise:

$$p=1+\frac{B+E_c(m,u)}{B}e^{\frac{-t}{T_s}}+\frac{Ec(m,u)}{B}e^{-(m-u)\frac{t}{T_s}},$$

where $B=m$-1-u.

At each point of time there will be a certain quantity of requests within the network. The less the requests, the better the network functions. The probability that there are k quantity of requests in the network is p_k, where

$$p_k=\frac{u}{k!}P_0,$$

when $k <= m$ and

$$p_k=\frac{u^k}{m!m^{k-m}}P_0.$$

P_0 is the probability that there are no requests in the network.

We have discussed probabilities so far. The quantity of requests present within the system is Lq, where

$$Lq=u+\frac{pE_c(m,u)}{1-\rho}$$

If there are m or less than m quantity of requests,

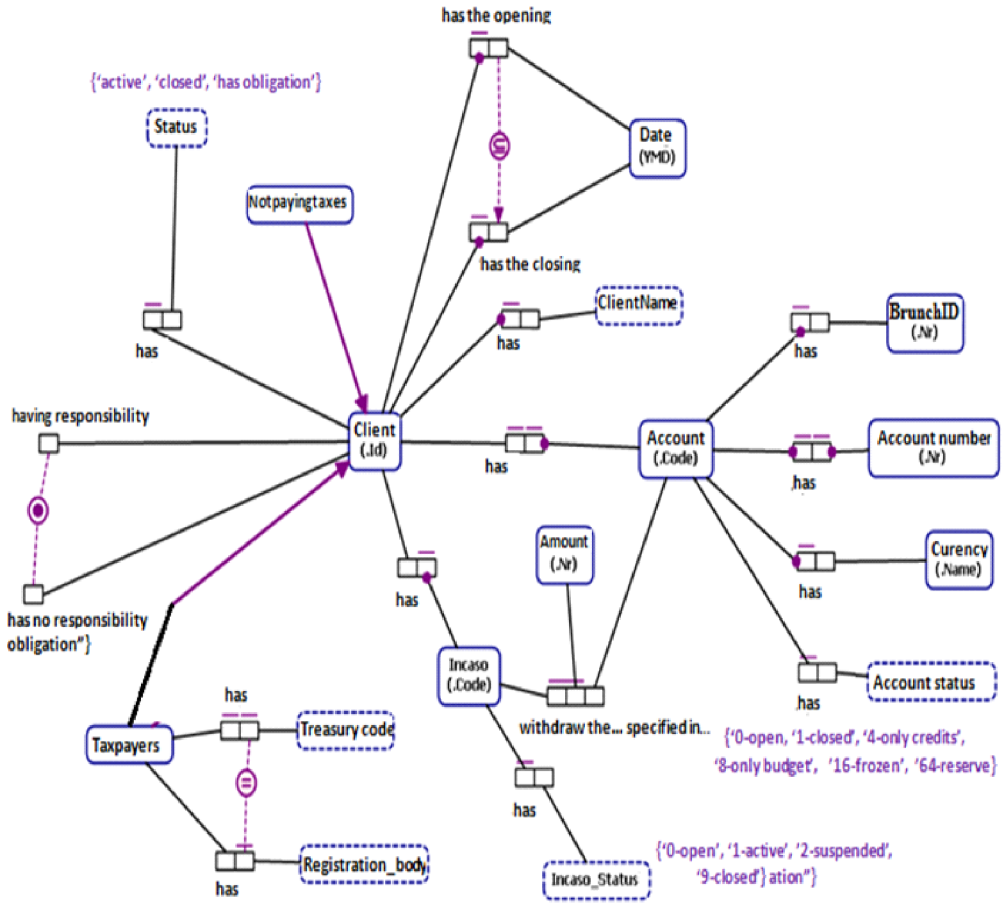

Fig. 2. ORM Diagram

then the quantity of requests being in queue equals 0, and if we know that the request x is in the queue, then there will be $x+m$ requests in the whole system, Thus, we have the following characteristics:

Probability of requests being in queue:

$$p = \sum_{k=0}^{m} p_k \ .$$

Probability of x request being in queue:

$$p = p_{x+m} \ , \text{where} \ \ x > m.$$

Average number of requests being in queue:

$$L_w = \frac{pE_c\left(m,u\right)}{1-\rho} \ .$$

The software developed by us uses the above quantities and equations to analyze network parametres and to find optimal values for them.

The object-oriented visual program modules have been developed. For computer network a class (new type) has been developed, the closed parameters of which are: request arrival frequency, service time, number of servers, etc., while class methods absolutely present the steady-state regime of network operation and provides estimation of optimum values of its parameters.

The study of business processes in dynamic mode with Petri nets.

The problems of modeling and the requests processing in banking corporations are studied based on service applications and systems analysis. The concept of building an integrated automated UML-based standards and service-oriented architecture is introduced. It is proposed to use colored Petri nets (CPN) [7,8] to construct a simulation model of inter-corporate service processes and study the temporal characteristics of its functioning.

Based on the analysis of Petri nets when the parameters change the delay time (Wait - position) in the range [0 - 300], obtained results are shown in Table 1 and Fig. 1.

Designing database with Object-Role Model Object-Role Modeling (ORM) problem for intercorporate automated systems and its implementation is considered in the article. The concept of the distributed database creation for various financial structures on the basis of service-oriented architecture is offered (Fig. 2).

The web-application forms on Ms Visual Studio. NET platform by the NORMA software [9,10] and Ms SQL Server package are realized as a result [5]. ORM is a method for designing and querying database models at the conceptual level, where the application is described in terms readily understood by users rather than being recast in terms of implementation data structures. It views the application world as a set of objects that plays roles. Sometimes it is called fact-based modeling because ORM verbalizes the relevant data as elementary facts [see 11]. It may represent unity elementary facts:

f1 - Client has Name;
f2 - Client has Account;
f3 - Client has Type;
f4 – Account has Account №;
f5 – Account has Currency;
f6- Client has Incasso;
f7-Incaso has Incasso Status;
f8- Account has Account *t* Status;
f9- Account has Branch;
f10- Client has Status.

Conclusion

During the systems designing, the joint work of the business analysts and systems (software) will be required to precisely determine the major requirements for realization systems. From this point of view, application of ORM and BPMN models, being currently considered as the agreed standard for all stakeholders of the business sphere significantly facilitates the elaboration of the problem detection phase thus giving the possibility to create the primary carcass of the automation system [12]. However, the ORM instrument describes the system on the data structure level only and does not provide the determination of the process structures and scenario-relevant system behavior. To describe the workflow and business process lifestyle the BPMN model is applied. Business Process Modeling Notation secures the opportunity of synchronization of the business model and informational model thus being considered as *De Facto* standard for description of the web-service based on business processes. The priority is given to the visual side of modeling the graphic elements and compatibility of the diagrams.

ინფორმატიკა

განაწილებული ბიზნეს-პროცესების მართვის საინფორმაციო სისტემების აგება პეტრის ქსელების და ობიექტ-როლური მოდელირების საფუძველზე

გ. გოგიჩაიშვილი[*], გ. სურგულაძე[**], ნ. თოფურია[**], ბ. ურუშაძე[**]

[*] *აკადემიის წევრი, საქართველოს ტექნიკური უნივერსიტეტი, ინფორმატიკისა და მართვის სისტემების ფაკულტეტი, თბილისი*
[**] *საქართველოს ტექნიკური უნივერსიტეტი, ინფორმატიკისა და მართვის სისტემების ფაკულტეტი, თბილისი*

განიხილება მართვის საინფორმაციო სისტემების დაპროექტებისა და პროგრამირების საკითხები, მათი პროცეს-ორიენტირებული და ობიექტ-ორიენტირებული მოდელირების, ანალიზის და რეალიზაციისათვის. მასობრივი მომსახურების მოდელების საფუძველზე ჩატარებულია კომერციული მართვის სისტემის ქსელის აგების მაჩვენებლების ანალიზი. მარკოვული პროცესების გამოყენებით განისაზღვრება კლიენტ-სერვერული არქიტექტურის სტრუქტურა და შემოთავაზებულია ალგორითმული სქემების რეალიზაცია მათ გადასაწყვეტად. განიხილება ობიექტ-როლური მოდელირების პრობლემა ინტერკორპორაციული ავტომატიზებული სისტემისთვის და შემუშავებულია მისი განხორციელების გზა. წარმოდგენილია სხვადასხვა ფინანსური სტრუქტურების განაწილებული მონაცემთა ბაზების შექმნის კონცეფცია სერვის-ორიენტირებული არქიტექტურის საფუძველზე. შედეგად შემოთავაზებულია Web-აპლიკაციის ფორმები Ms Visual Studio.NET პლატფორმაზე NORMA პროგრამული პაკეტის და MsSQLServer მონაცემთა ბაზების მართვის სისტემის საფუძველზე. განსაკუთრებით გამახვილებულია ყურადღება კორპორაციული სისტემების ბიზნეს პროცესების ავტომატიზებული დაპროექტების, მონაცემთა ბაზის სტრუქტურების და მომხმარებელთა ინტერფეისების შემუშავების ერთიანი მეთოდოლოგიის ჩამოყალიბებაზე CASE ტექნოლოგიებით.

REFERENCES:

1. *G.O. Langford* (2012), Engineering Systems Integration: Theory, Metriccs, and Methods. CRC Press. 406 p.
2. *K. Watson, Ch. Nagel, J.H. Pedersen, et al.* (2008), Visual C# 2008. ISBN 978-0-470-191354. Wiley Publishing, Inc., Indianapolis, Indiana, 1211 p.
3. *S. Robinson, O. Cornes, J. Glinn, et al.* (2001), Professional C#, v.1,2. Wrox Press, Birmingham, 1002 p.
4. G. *Surguladze, E. Turkia, N. Topuria* (2012), Proc.of the 5th Intern. Conf. "Problems of Cybernetics and Informatics" (PCI' 2012), Baku,Azerbaijan: 16-19.
5. *G. Surguladze, O. Shonia, L. Kvavadze* (2004), Distributed database management systems. (Ms Access, SQL_Server, InterBase, JDBC, Oracle). ISBN 99940-35-18-5, GTU, Tbilisi, 230 p. (in Georgian).
6. *G. Surguladze, I. Bulia* (2012), Integration and Building of Web-Applications for Entererpises. ISBN 978-9941-20-165-3. GTU, Tbilisi, 334 p. (in Georgian).
7. *G. Surguladze, E. Turkia, D. Gulua* (2008), Proc. of Intern.Conf. "Education, science and economics at universities. Integration to international education area", Poland, 9-14 Sept. , 2008: 557-562.
8. *K. Jensen, M.L. Kristensen, L. Wells* (2007), Coloured Petri Nets and CPN Tools for Modelling and Validation of Concurrent Systems. Univ. of Aarhus. Denmark. p 40.
9. *G. Surguladze, I. Bulia, B. Urushadze* (2012), Transactions. Georgian Technical University. Automated Control Systems. 2(13): 7-22 (in Georgian).
10. *T. Halpin* (2005), ORM 2 Graphical Notation, Neumont University. Technical Report ORM2-01, September 2005, 17 p.
11. *G. Surguladze, E. Turkia, N. Topuria* (2010), Transactions. Georgian Technical University. Automated Control Systems. 2(9): 50-54 (in Georgian).
12. *G. Surguladze, E. Turkia, N. Topuria, et al.* (2009), Proc. of the 3rd International Conference on Computational Intelligence (CI'09). June 26-28, Tbilisi: 294-298.

Received January, 2014