ISSN 1392-8619 print/ISSN 1822-3613 online
ŪKIO TECHNOLOGINIS IR EKONOMINIS VYSTYMAS
TECHNOLOGICAL AND ECONOMIC DEVELOPMENT OF ECONOMY
http://www.tede.vgtu.lt
2006, Vol XII, No 4, 269–275

MODELLING OF INTERBANK PAYMENTS

Donatas Bakšys, Leonidas Sakalauskas

Kaunas University of Technology Panevėžys Institute, Klaipėdos g. 1, LT-35209 Panevėžys, Lithuania
E-mail: donatas.baksys@ktu.lt
Vilnius Gediminas Technical University, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
E-mail: sakal@ktl.mii.lt

Received 15 June 2006; accepted 20 November 2006

Abstract. Non-cash payments are intensively growing in the payment market. Therefore modern electronic systems of interbank payments are introduced to satisfy this need. The substantial renewal of the payment system was prompted for the implementation of the new banking technologies and aimed at increasing fund turnover as well as complying with the requirements applied in regard of payment systems. Such a system change is a topical theme of discussion on the simulation and analysis of systems of such kind.The article analyses the opportunities for simulating the interbank payment system and presents a model of interbank payments flow. The model is constructed on the analysis of real flow of payments in the payment system.

Keywords: Interbank payments, settlements, payments flow, modelling of interbank payments.

1. Introduction

Active introduction of the means of electronic data transfer in banking and concentration of a great part of settlements at the centres of interbank payments were related with creation of the automated systems of the clearing. The main purpose of such systems is to warrant a fast and rational turn-over of settlements to balance payments and to reduce the movement of money supply. The systems of payments can be divided into systems of discrete clearing and real-time systems. In the systems of the discrete clearing the payments are executed in the regular intervals of time. In real-time systems payments are executed continuously. Non-cash payments are growing in the market of payments. This creates a need to execute real-time payments. To satisfy this need modern information technologies and electronic systems of interbank payments are introduced.

Recently non-cash payments are growing in the market of payments of Lithuania. In 2005, the Clearinghouse of the Bank of Lithuania* processed 17.3 per cent of all non-cash domestic payments in the country. The Clearinghouse processed 18.46 million of payment calls at a cost of 228 billion litas. Compared to 2004, the volume of payment transactions was growing by 18.7 per cent and their value went up by 19.4 per cent. The share of very small value payment transactions was growing gradually and in 2005 made up 88.3 per cent of total payments. The Bank of Lithuania designed and implemented a new real-time payment system LITAS which replaced the discrete clearing payment system TARPBANK that has been operating since 1993. A substantial renewal of the payment system in Lithuania was prompted by implementation of the new banking technologies and aimed at increasing funds turnover and complying with the requirements applied in regard of payment systems in the European Union. After implementation of the new real-time payment system, the value of processed payment calls in this system was gradually growing.

Malfunctions in the systems of interbank payments can destroy the payment between the subjects of the market, influence the needs of management for liquidity and create threat to stability of money. It is especially sharp with the growth of real time payments. Opportunities of modelling of various situations of the market of payments are widely discussed with a view to avoid similar situations in the world practice (i.e., simulation of a system by applying BoF-PSS (Bank of Finland Payment and Settlement Simulator)). We

* In the article the Payment Systems Department of the Bank of Lithuania is called the Clearinghouse of the Bank of Lithuania.

didn't manage to find a similar research, analyzing the situation in the market of payments of Lithuania. Therefore, in this article, we survey the payment system of the Clearinghouse of the Bank of Lithuania and an opportunity of modelling the system by applying BoF-PSS.

Topicality. Usage of new technologies in this field, the growth of very small payments, and the trend of interbank payments flow in the system of settlements, scarcity of the research on modelling Lithuanian interbank payments make this subject of investigation topical both in theory and in practice.

The Object of investigation of this article is the payment and settlement system and simulation of interbank payments flow.

The Objective of the article is to investigate and survey the system of interbank payments and settlements, analyze the possibility of simulating the interbank payment system by BoF-PSS (Bank of Finland Payment and Settlement Simulator) and present a stochastic model of interbank payments flow.

The Methods of the article are the systematic analysis of literature, practical analysis of the Payment and Settlement Simulator BoF-PSS, analysis of real flow of payments in the payment system LITAS and modelling of interbank payments flow.

2. Interbank payment system

2.1. Participation in the Payment System

Payment systems may be grouped into retail or large-value payment systems and private or public systems depending on the application. This distinction has been important because of the different risks involved and differences in service speed and efficiency. Most retail payment systems are currently settled on a net basis using very simple algorithms. In these systems, the liquidity impact and settlement risks are generally low and therefore no sophisticated liquidity and risk management tools are warranted. The opposite is true for large-value payment systems, which often contain sophisticated risk and liquidity management features [1]. The settlement institution is the institution across whose books transfers between participants take place to achieve settlement within the settlement system [2]. The central bank is mostly the principal settlement institution in domestic payment systems. The settlement asset in such systems is central bank money. For large value payments, the most common settlement asset is central bank money [3].

The payment system is designed to process applications in real time and at a designated time. In Lithuania the Bank of Lithuania is the owner and operator of the system. Settlements are carried out in the national currency litas.

The payment system processes all kinds of interbank and customer payments regardless of their value. The system also settles payments arising from the Bank of Lithuania's own transactions with participants. Additionally, the payment system provides cash leg of securities transactions in real time following the delivery versus the payment principle. It also establishes conditions for other payment systems to perform settlements through the accounts of their participants with the Bank of Lithuania and provides a possibility to perform not only credit transfers, but also debit transfers.

The payment system is regulated by the Rules of Operation of the Payment System and bilateral bank account agreements between the Bank of Lithuania and system participants.

In addition to the Bank of Lithuania, the system is open to banks that have a banking licence issued by the Bank of Lithuania and foreign bank branches that have a permission of the Bank of Lithuania to operate in the country, Central Securities Depository of Lithuania, brokerage companies, Central Credit Union of Lithuania and clearing houses registered in the Republic of Lithuania. A credit institution of a state located in the European economic area and, on the decision of the Board of the Bank of Lithuania, a financial or clearing institution of such state may also join the system. The detailed list of participants of the payment system is presented in the Official List of Systems [4].

The system is designed for the following goals [4]:

- to process payment instructions of system participants by performing real time gross settlements (RTGS) and designated time settlements (DTS);
- to warrant the processing of payment instructions for securities transactions according to the delivery versus the payment principle jointly with the Securities Settlement System;
- to fulfil the functions of information exchange between system participants.

The operation of the system is based on the principles of stability, efficiency, security, and open access.

The system operator must grant the opportunity for a payment participant to submit payment instructions of other system participants to the system on the basis of a document presented by the payment participant confirming his right to submit payment instructions of other participants.

The system operator presents the following technical documentation to the persons that submitted an application to participate in the system: requirements and recommendations with regard to information systems of system participants and the system software and hardware of connecting stations, descriptions of application structures, descriptions of the information exchange flows, list of instructions for changing payment instructions and their processing conditions, and the list of succession and user manual [4].

A system participant has the following rights [4]:

- to submit payment instructions to the system for performing RTGS and/or DTS;
- to submit instructions to the system to change the settlement conditions of application submitted earlier and not yet entered into the system;
- to change the priority of applications for making credit transfer and to revoke an application;
- to receive real-time information on the settlement of applications submitted to the system by other participants where it is indicated as a beneficiary;
- to monitor the latest information on its payment instructions submitted to the system and its settlement account (accounts);
- to receive the end-of-day reports: information on the settlement results of its applications, the settlement of applications affecting the change of the balance in the settlement account and the final balance of its settlement account;
- to receive information from the system operator on the fee calculated for the settlement of applications in the system. On ascertaining an error in the calculation of the amount of the fee, to request its correction.

A system participant has the following responsibilities [4]:

- to comply with the Bank of Lithuania legal acts regulating settlements, organisation of the internal control of the bank and electronic certification;
- to manage the operational risk of its information systems related to the system;
- to ensure the functioning of organisational, hardware and software facilities of the interface with the system;
- a payment participant must submit a document to the system operator in advance confirming his right to submit applications for transferring the funds of other participants, and the list of system participants that granted this right.

2.2. System Operation

The system is open on each business day established in the Republic of Lithuania. The system starts receiving applications from 7:45 a.m. The submission of ordinary applications ends at 3:00 p.m., while the submission of urgent applications ends at 4:00 p.m. At 4:30 p.m. the end-of-day procedure starts. Information exchange between the system participants and the system is performed by means of electronic messages signed by a digital signature. An application submitted to the system is entered into the payment queue and stays in it until the moment of entry into the system. The moment of entry into the system is the beginning of the settlement of an application. A system participant, the operator or a third party may not revoke the application entered into the system. The application is treated as settled, when the funds are credited into the settlement account of the beneficiary.

An urgent payment instruction is processed in real time if the participant has sufficient funds for settling the application. If the participant is scant of funds, urgent applications are entered into the queue.

Every 20 minutes the system performs the optimisation procedure during which those applications are selected from the queue the netting of which shows that there are sufficient funds for settling these applications.

Unexceptional payment instructions are processed four times per day: at 9:00 a.m., 12:00 a.m., 3:00 p.m. and 4:00 p.m.. Until recent time unexceptional payment instructions have been carried out three times pass. It shows the movement of the whole system to payments of real time.

Information is exchanged between the system participants and the system by means of electronic messages. A digital signature is used to sign:

- application messages and those including instructions to change the settlement conditions;
- messages including the processing results of payment instructions and those including the processing results of instructions to change the settlement conditions of payment instructions;
- messages of the end-of-day reports.

System participants submitting applications to the system assign their priority according to the priority values described in the technical documentation of the system.

A payment instruction submitted to the system is validated by the system, if its structure conforms to the message structure requirements described in the technical documentation of the system. Otherwise, the application is rejected and the system participant who has submitted the application is notified about the reason of rejection.

An application validated by the system is placed into the payment queue, if its settlement conditions are fulfilled. An application stays in the queue until the moment of its entry into the system, i.e., the moment when the system establishes that available funds are sufficient for settling the application and the processing of the application is started immediately by transferring the funds indicated in it from the settlement account of the payer to the settlement account of the beneficiary.

Neither a system participant, nor its operator or a third party may revoke an application entered into the system.

During the processing of applications the settlement account of a system participant is credited with the funds indicated in the application of another system participant or the balance of this account is debited with the amount of funds indicated in the application to be transferred to another system participant. The application is recognised as settled, when the funds are credited into the settlement account of the beneficiary. After settling the application, the system notifies the payer, the beneficiary and the payment participant about it, if the application was submitted by him.

Processing payment instructions in real time and immediately transferring their settlement results to the Securities Settlement System ensure the processing of applications for settling securities transactions based on the delivery versus payment principle.

The processing of applications is completed by the end-of-day procedure during which the following actions are performed in sequence:

- the optimisation procedure is applied to all the applications in the payment queue;
- after the optimisation procedure all the remaining applications where available funds are sufficient for settlement are settled in sequence and the ones where available funds are insufficient are omitted.
- applications that remain not executed due to the lack of available funds are removed from the payment queue and the system participant who submitted the application is notified about it;
- the end-of-day reports are prepared and submitted to the system participants.

In order to manage the operational risk of the system, the system operator sets system security requirements, plans and implements respective security measures, assesses the system security situation and determines the residual risk.

The payment system payment costs are based on the principles of full costs coverage, transparency and equal rights of system participants.

3. Settlement balance

The value of δ_i is called as the net balance of bank *i*. The net balance of bank *i* is the total sum of money that other banks send to bank *i* minus the total sum of money that bank *i* sends to other banks [5].

$$\delta_i = \sum_{j=1}^{n}\left(\sum_{k=1}^{n} p_{ij}^k X_{ij}^k - \sum_{k=1}^{n} p_{ji}^k X_{ji}^k\right). \qquad (1)$$

Denote by *n* the number of banks that are participants of the clearing system. Further we use the term "payment" instead of "payment order" for the simplicity. For $i, j = 1,...,n$, let l_{ij} be the number of payments from bank *i* to bank *j*. Clearly, $i \neq j$ in all the cases where we are considering a pair of banks *i* and *j*, so further we do not mention it. Denote by p_{ij}^k the sum of the *k*th payment from bank *i* to bank *j*, $k \in \{1,...,l_{ij}\}$, and by d_i the sum of the covering money deposited by bank *i*. Introduce a variable $X_{ij}^k \in \{0,1\}$, $i, j = 1,...,n$, $k = 1,...,l_{ij}$. Here $X_{ij}^k = 1$ denotes that the *k*th payment from bank *i* to bank *j* is included in the set of settled payments. Respectively, $X_{ij}^k = 0$ means that the payment is not included in the set.

Available funds d_i are the funds available in the settlement accounts of a system participant held with the Bank of Lithuania required for settling a request, when applying the funds usage restrictions set to the system participant, if any. The Central bank or clearing houses install the available funds d_i, to guarantee the fulfilment of payments and stability of banks.

4. Abilities of the Payment and Settlement simulator BoF-PSS

The BoF-PSS is the Payment and Settlement System simulator of the Bank of Finland. The BoF-PSS structure contains three main subsystems [6]:

- Input generation subsystem;
- Simulation execution subsystem;
- Output analysing subsystem.

The input generation subsystem includes means to import and validate transaction data, participant data, as well as data on daily account balances and credit limits. The main importer's task is to check that the input data were formally valid and then transfer them into system database structures.

The simulation execution subsystem includes means for configuring and running simulations. It also contains the actual simulation and settlement logic. It keeps a log of all events and bookings and makes reports and statistics on simulation runs.

The output analysing subsystem has the functionality for reporting basic statistics on the common result parameters. The output database contains raw data for the booking order of transactions and balances of settlement accounts. The input database contains the transaction flow, while the output database contains the settlement flow, i.e. settlement order and timing of submitted transactions.

The BoF-PSS2 software supports a great variety of general system structures. It can model most payment and settlement structures and processes found in real systems.

The simulator supports real-time gross settlement (RTGS), continuous net settlement (CNS) and deferred net settlement (DNS) systems. The processing options for these systems are defined by selecting appropriate algorithms. For example, QUE algorithms define how transactions are released from queues, while PNS algorithms define when and how a partial net settlement of queued transactions will be invoked.

The simulator also has multi-system capabilities, whereby a large number of interacting systems can be included in the same simulation. When transactions occur between systems, they are booked in separate intersystem accounts. There are two types of intersystem transactions: straightforward participant-to-participant transactions or system invoked injection or settlement transactions between the main and ancillary system. In the straightforward case, the sending system's transaction data include a reference to a receiving participant in another system. In ancillary systems it is possible to define the end-of-day settlement system and accounts for each participant. Intraday injections may also be defined. These transfer relate liquidity between the main and ancillary system during the day according to participant needs.

Typical interacting system scenarios include [6]:

- several independent RTGS systems constituting a network of systems;
- a domestic payment system environment consisting of the RTGS system and ancillary systems;
- RTGS system settlement between the RTGS and securities settlement system.

The simulator also supports multi-currency and multi-asset processing, which allows simulation of international payment systems and securities settlement systems. Assets are treated as book-entry currencies. Payment-versus-payment (PVP) and delivery-versus-payment (DVP) processing are supported. DVP/PVP transaction pairs should be connected via a DVP/PVP-link code. In addition to single intra-system DVP/PVP processing in RTGS or deferred net settlement mode, the simulator also supports RTGS DVP/PVP settlement between real-time systems.

The focal output factors in simulations are typically the counterparty risk and overall risk, liquidity consumption, settlement volumes, gridlock situations and queuing time. In what-if simulations, the input parameters are modified to distinguish effects on output factors. The following input parameters are often used or modified in simulations:

- input transaction flow;
- available liquidity;
- credit limit/debit cap restrictions;
- queuing and netting processes;
- participant behavior;
- new settlement procedures;
- structural changes;
- changes in participant structure;
- new intersystem processes.

Liquidity is introduced into simulations either by defining daily opening balances and/or intraday credit limits. Liquidity can also be introduced via repotransactions and there are more alternatives available: introducing only the money legs between the participants and the central bank account, introducing the money legs in the RTGS system and the asset legs in a separate securities settlement system in DVP mode or having a special collateral account (monetary value only) in the RTGS or securities settlement system.

Participant level risk management features can also be directly introduced in simulations by using bilateral limits (bilateral debit caps). These can be defined at bilateral and also at multilateral level separately from other liquidity arrangements.

Simulations may use available data from current systems or fictional, but representative, data.

The available algorithms are divided into the following main groups:

- Submission algorithms (SUB) fetch the next transaction to be submitted for processing.
- Entry algorithms (ENT) perform the initial processing of each transaction.
- Settlement algorithms (SET) process queued transactions.
- End-of-day algorithms (END) process the final steps during a day or settlement cycle.

The submission algorithm is only available at the simulation level. For each simulation, a submission algorithm must be selected. Its task is to determine which transaction is next to be processed from all the pending transactions in all systems. All the other algorithms are specified at the system level. It can be thought of as the process in which the bank decides, which is the next transaction to be submitted for processing to any of the systems in the simulation. This is the algorithm to modify if new behavioural patterns for banks are introduced.

The other main algorithms are assigned at the system level. For example, RTGS and net-settlement system can use different entry-algorithms in the same simulation. For each system, the entry (ENT) and end-of-day (END) algorithms must be specified. The settlement algorithm is optional.

The following sub-algorithms can be used with ENT entry algorithms:

- Splitting algorithms (SPL) split a large transaction into sub-transactions according to specific rules.
- Injection algorithms (INJ) transfer liquidity between the ancillary and main systems.

The following sub-algorithms can be used with SET settlement algorithms:

- Queue release algorithms (QUE) check and fetch transactions from the waiting queue in the given order once an account or participant has received more liquidity.
- Splitting algorithms (SPL) split transactions into smaller sub-transactions.
- Injection algorithms (INJ) transfer liquidity between the ancillary and main systems.
- Bilateral off-setting (BOS) checks and fetches transactions from the waiting queues that can be bilaterally off-set.
- Partial netting algorithms (PNS) seek to settle part of the queued transactions.

- Multilateral netting algorithms (MNS) attempt to settle all the queued transactions in one netting event.

For each payment and settlement system, there can only be one specific sub-algorithm defined of each category in the current ENT and SET algorithms. This means that the main algorithms will use the same splitting and injection algorithms, if these are defined. The order in which the sub-algorithms are set in the simulator control data specifications is important because sub-algorithms are called from the main algorithms in the order they were set.

The specific algorithms are attached to the specified payment and settlement systems on the System control data specification/modification screen. The required parameter values are given at the same time as a parameter string. The basic controls are made for the parameters, but it is essential that users be cautious when introducing the parameters. Any user-defined modules must be introduced to the system by stating the initial specifications on the User module definition screen. Thereafter, it is possible to invoke them on the System control data specification/modification screen in the same way as the originally provided modules and algorithms.

BoF-PSS simulates with the given data but itself does not generate a stochastic flow of applications. Therefore, in the next chapter we present the stochastic model of interbank payments flow based on the data of the Bank of Lithuania.

5. Simulation of the applications flows of the participants of the Payment and Settlement system

We simulate payments flow of the interbank payment and settlement system. The system consists of 11 participants, (*A*, *B*, *C*, ..., *K*) who execute payments between themselves. The participants send applications to the payment and settlement system. An application is described in the system by the name of a sender, name of the addressee, time of delivery of the application, and the volume of the applications. The frequency of delivery, the volume and flow of payments are random. During simulation the following real data from the payment and settlement systems were used: the number of participants of the payment and settlement system, time of delivery of the applications, volume of the applications, and flow of applications. The data were presented by the Bank of Lithuania. The bank has presented the data of two different labour days of the system: a typical day and a critical day. The data of a typical day have made up 74 637 applications of 11 participants of the Payment and Settlement System. The data of a critical day have amounted to 186131 applications. Applying the BoF-PSS simulator, with the data given by the Bank of Lithuania, the Payment and Settlement systems were simulated and the initial parameters for simulation of flow of payments obtained. The mentioned simulations have shown that the flow of applications of the participants of the Payment and Settlement system is distributed lognormally. The matrix was also constructed which reflects bilateral flows of applications of the participants of the system:

$$\begin{array}{ccccc} & A & B & \dots & K \\ A & 0 & p_{AB} & \dots & p_{AK} \\ B & p_{BA} & 0 & \dots & p_{BK} \\ \dots & \dots & \dots & 0 & \dots \\ K & p_{KA} & p_{KB} & \dots & 0 \end{array} \qquad (2)$$

as well as the rates of applications $\lambda = (\lambda_A, \lambda_B, \lambda_C, ..., \lambda_K)$, averages $\mu = (\mu_A, \mu_B, \mu_C, ..., \mu_K)$ and standard deviation s $\sigma = (\sigma_A, \sigma_B, \sigma_C, ..., \sigma_K)$. Accordingly to the obtained data we generate time t_i of flow of applications of each participant by the principle of a normal log, applying such a formula $t_i = t_{i-1} + \tau_i$, where $\tau_i = \frac{-\ln(\zeta)}{\lambda}$, ζ is uniformly random and λ is rate of applications. Then the sum of applications of the agent X_i is found by the formula:

$$X_i = \exp(\mu + \sigma \cdot \eta), \qquad (3)$$

where μ is the average of the amount of applications, σ is the standard deviation from a normal log of the sum of applications.

6. Conclusions

The growth of non-cash payments, the need to execute real-time payments gives rise to requirements to electronic systems of interbank clearing. The banks attempting to escape ineffective consumption of circulating assets should simulate possible cost of the transactions with a view to maximize the future profit. In this situation it is especially important to select the optimal thresholds of the clearing accounts. The exaggerated limits of the clearing accounts are increased by the costs of transaction. Insufficient limits of the clearing accounts can not satisfy the credit obligations and destabilize interbank payments. Simulators, such as Bof-PSS, can help in the analysis of systems, such as interbank Payment and Settlement Systems. By means of a simulator it is possible to change the parameters and observe changes in the system repeating simulation. Using the presented model of generation of applications flow we can facilitate the analysis of payment systems, applying imitating simulation.

References

1. Koponen, R.; and Soramaki, K. Intraday liquidity needs in a modern interbank payment system. Bank of Finland, Studies E:14, 1998.
2. Core principles for systemically important payment systems. Bank of International Settlements Committee on Payment and Settlement Systems. Basel, 2001.
3. Jeffrey Lacker, M. Clearing, settlement, and monetary policy. Research Department Federal Reserve Bank of Richmond. Richmond, 1997.
4. Payment and securities settlement systems oversight policy. Board of the Bank of Lithuania, Vilnius, 2003.
5. Shafransky, M. Y.; Doudkin, A. A. Optimization algorithms for the clearing of interbank payments. United Institute of Informatics Problems of National Academy of Sciences of Belarus. Minsk, 2001.
6. Leinonen, H. and Soramaki, K. Simulating interbank payment and securities settlement mechanisms with the BoF-PSS2 simulator. Bank of Finland, 2003.

BANKINIŲ ATSISKAITYMŲ MODELIAVIMAS

D. Bakšys ir L. Sakalauskas

Santrauka

Bankinių mokėjimų kiekio didėjimas, augantis poreikis atlikti mokėjimus realaus laiko režimu kelia papildomų reikalavimų bankinių atsiskaitymų sistemoms. Straipsnio tyrimo objektas – bankinių atsiskaitymų sistema ir perduodamų sistemai paraiškų srauto modeliavimas, tikslas – atskleisti bankinių atsiskaitymų imitatoriaus *BoF-PSS* taikymo galimybes, nagrinėjant bankinių atsiskaitymų sistemas, bei pateikti stochastinį bankinių atsiskaitymų paraiškų imitavimo modelį. Bankai, siekdami kuo efektyviau naudoti savo aktyvus ir ateityje minimizuoti su atsiskaitymais susijusias sąnaudas bei maksimizuoti pelną, yra priversti modeliuoti atsiskaitymus. Tokioje situacijoje ypač svarbu parinkti tinkamus korespondentinių sąskaitų likučius ir numatyti jų kaitą atsiskaitymų metu. Per didelis korespondentinių sąskaitų likutis gali lemti neefektyvų aktyvų naudojimą ir sumažinti galimas pajamas. Nepakankamas korespondentinių sąskaitų likutis gali nepatenkinti įsipareigojimų įvykdymo ir destabilizuoti bankinių atsiskaitymų sistemos darbą. Straipsnyje analizuojamas *BoF-PSS* bankinių atsiskaitymų imitatorius gali padėti spręsti šias problemas. Imitatorius suteikia galimybę keisti nagrinėjamos atsiskaitymų sistemos parametrus ir stebėti sistemos elgseną, dėl to sudaromos galimybės parinkti optimalius parametrus. Straipsnyje siūlomas atsiskaitymų srauto imitavimo modelis palengvintų stochastinį atsiskaitymų sistemos modeliavimą ir sudarytų sąlygas nenaudoti realių atsiskaitymų duomenų.

Reikšminiai žodžiai: bankiniai mokėjimai, atsiskaitymai, mokėjimų srautas, bankinių mokėjimų modeliavimas.

Donatas BAKŠYS. PhD student. Department of Operational Research. Institute of Mathematics and Informatics.

First degree in Management and Business Administration, Kaunas University of Technology (1999). Master of Science (2002). Tester of the Bank of Finland Payment and Settlement Simulator BoF-PSS2 in the 4rd simulator workshop for payment and settlement system experts (Helsinki, Finland, 2006). Research visits to Bank of Finland (Finland, 2006). Member of community of the users and developers of the Bank of Finland Payment and Settlement Simulator (BoF-PSS). Author of about 10 scientific articles.

Research interests: interbank payments, modelling of interbank payments, electronic money, liquidity needs, risk issues of interbank payments, settlement algorithms.

Leonidas SAKALAUSKAS. Doctor Habil, Professor. Department of Operational Research. Institute of Mathematics and Informatics.

Doctor (1974), Kaunas University of Technology. Doctor Habil (2000), Institute of Mathematics and Informatics. Professor (2005). Research visits to International Centre of Theoretical Physics (ICTP) (Italy, 1996, 1998).

L. Sakalauskas is a member of the New-York Academy of Sciences (1997), vice-president of the Lithuanian Operation Research society (2001), Elected Member of the International Statistical Institute (2002), member of International Association of Official Statistic (2001), member of European Working Groups on Continuous Optimization, Financial Modelling and Multicriterial Decisions. Author of more than 100 scientific articles.

Research interests: continuous optimization, stochastic approximation, data mining, Monte-Carlo method, optimal design.