

ANALYSIS OF AUTOMATED GLOBAL INTERBANK SETTLEMENT ALGORITHMS

Donatas Bakšys¹, Leonidas Sakalauskas²

¹*Kaunas University of Technology Panevėžys Institute,
Klaipėdos st 1, LT-35209 Panevėžys*

²*Institute of Mathematics and Informatics, Akademijos st 4,
LT-08663 Vilnius, Lithuania*

Abstract. The aim of this paper is to analyse the automated trans-continental interbank settlement algorithms. By perfecting the processing of settlements and/or developing algorithms for solving the grid-locks, or by applying the tools of refinancing and using reserves of requirements, one can change the efficiency of settlement systems. In this paper, the settlement algorithms of the Trans-European Automated Real-time Gross settlement Express Transfer system (TARGET2) are tested. The system of modelling, simulation, and optimization of settlements is used for testing of algorithms. The parameters of simulation are estimated according to the real data.

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

1. Introduction

A rapid development of economy, globalization of markets, free capital motion and growth of money mass have influence on the settlements processes. In the period 2002-2006, the volume of non-cash payment transactions in the euro zone was growing by 34.9 per cent and their value increased up by 41.7 per cent (ECB, 2008). The non-cash payments were growing in the market of payments of Lithuania, too. Compared to 2006, in 2007 the volume of payment transactions in the Payment and Settlement System of the Bank of Lithuania was growing by 25.3 per cent and their value increased up by 42.7 per cent (Bank of Lithuania, 2008). The development of new information technologies allow the agents of economy to effectively manage the assets in the bank accounts. Settlements systems with various architectures and processing are used to pursue the demands of efficient performance of payments. A rapid development of the process of eurointegration and the outlook of expansion of the Euro zone has imposes new requirements for national central banks to integrate national payments and settlement systems (NPSS) into the unified Trans-European automated settlement system. To satisfy the general monetary policy such tools of payments are necessary which enable us to perform the transactions between the national central banks (NCB) and other banks safely and opportunely, and induce the solidarity of money markets of the Euro zone. The mentioned aims in the Euro zone are accomplished by joining the NPSS to the Trans-European Automated Real-time Gross settlement Express Transfer system (TARGET).

The target of this paper is queue ordering algorithms in the TARGET2.

The aim of article is analysis of the automated trans-continental interbank settlement algorithms.

The rate of payments flow and the aspiration of NCB to improve the payments and settlement systems to meet the requirements of systems make this subject of investigation topical both in theory and practice.

The objective of the article is to compare the efficiency of settlement algorithms in reordering the queue of transactions.

2. The structure of the interbank settlements system

Transactions of settlements consist of the procedures of account debit and credit. The assets move from one correspondent account to another and access on the final receiver's account (BIS, 1995). Some participants of the system generate transactions, while the others received them. Therefore, two flows of settlements and their influence on the participants of the system are different (Angelini *et al.*, 1996). These flows change the balance of settlements.

The basic purpose of payments and settlement systems is to guarantee an efficient settlement process. The settlement process in a settlement system consists of the following (Leinonen *et al.*, 2003):

- the submission phase;
- the entry phase;
- the booking phase;
- the queueing phase;
- the gridlock identification and resolution phase;
- the queue allocation phase;
- the end of the settlement phase.

In the first phase, the participants of the system send a transaction to the system for processing. In this phase, the internal transaction queue is formed as well as the participants of the queued system are arranged in the transaction priority. The real data of one order of the payment and settlement system $y = (ID, a, b, t, p, e)$ consist of:

- the application number ID ;
- the application sender's name or code a ;
- the application receiver's name or code b ;
- the application submission time and date t ;
- the application volume p ;
- complementary information e .

The complementary information is assigned to the receiver of transaction. Using this information, the account of the participant to the final transaction receiver is credited.

In the entry phase, the settlement instructions received by senders are estimated and the methods of transactions are chosen. In this phase, the possibilities of performing transactions as well as that of splitting and queueing them are analyzed. The transaction sender is informed about the status of transactions and the settlement process.

During the entry phase the booking on a participant's account is executed. In this phase, the account of a transaction sender is debited and the account of a transaction receiver is credited.

In the queueing phase, unfulfilled transactions are queued. In this phase, the various settlement algorithms (i.e., splitting, queue reordering) are used.

In the gridlock identification and resolution phase, using simulation of the execution queue of transactions, the best algorithms for solving the task of the transaction queue are applied. In this phase, the gridlocks of transactions are identified, if a transaction cannot be carried out due to the temporary illiquidity of the participant in the settlement system. The temporary illiquidity of the participant in the settlement system can be solved by reconstructing the transaction queue and settlement processing.

In the queue allocation phase, the queued transactions are realized as soon as they become eligible for booking.

In the end phase of settlement the day balances of participants are made up and the final list of unfulfilled transactions created.

3. TARGET 2 settlement algorithms

The Trans-European Automated Real-time Gross settlement Express Transfer system (TARGET) has a decentralized structure connecting national RTGS systems and the ECB Payment Mechanism (EPM) (ECB, 2007). TARGET2 provides the real-time gross settlement for payments in euro, with a settlement in central bank money. TARGET2 is structured as a multiplicity of RTGS systems.

In TARGET2 the flow of transactions is divided in two queues: highly urgent, urgent and normal payments. The selection of orders depends on the priority class to which it was designated by the system participant. Payment orders in the highly urgent and urgent queues shall be settled by using the offsetting checks. The settlement procedure starts from the payment order at the front of the queue in cases where there is an increase in liquidity or there is an intervention at the queue level (change of settlement time or priority, reordering the transaction queue). The transactions in the normal queue are settled continuously including all not settled highly urgent and urgent payments. Different optimisation algorithms are used for the settlement procedure. If an algorithm is successful, the included transaction will be fulfilled, other-

wise, the included transaction will remain in the queue. To process the payment flows in TARGET2 the following three algorithms are used (ECB, 2007):

- “all-or-nothing” algorithm;
- “partial” algorithm;
- “multiple” algorithm.

The “all-or-nothing” algorithm calculates the overall liquidity position of each TARGET2 participant's payment account in view of all the sending and incoming payments, pending in the queue. If the balance of flows is negative, it checks whether it exceeds that participant's available liquidity. In the second step, the algorithm checks the observance of limits and reservations, set by each participant in relation to each relevant payment account. If the result of these calculations and checks is positive for each relevant payment account, all the payments simultaneously on the payment accounts of the participants concerned are settled.

The “partial” algorithm calculates and checks the liquidity positions, limits, and reservations of each relevant payment account in such case as the first algorithm. If the total liquidity position of one or more relevant payment accounts is negative, the queued transaction is removed until the total liquidity position of each relevant payment account become positive. When the positive liquidity position is recovered, simultaneously all the remaining payments on the payment accounts of the participants are settled. The extracting process starts from the participant's payment account with the highest negative total liquidity position and from the transaction at the end of the queue with the lowest priority.

The “multiple” algorithm compare the pairs of participants' payment accounts in order to determine whether the queued transactions can be fulfilled within the available liquidity of the two participants' payment accounts concerned and within the limits set by them. If the bilateral liquidity is insufficient, payment orders are postponed until there is sufficient liquidity. After performing the multilateral settlement positions are checked.

During the settlement day the algorithms are running sequentially. The processing sequence is as follows (ECB, 2007):

- the algorithm “all-or-nothing”,
- if the algorithm “all-or-nothing” fails, the “partial” algorithm starts,
- if the “partial” algorithm fails, then the multiple algorithm starts, or if the “partial” algorithm succeeds, the algorithm “all-or-nothing” is repeated.

4. The results of simulation

In this section, simulation results are presented, which were calculated using the system of modeling, simulation, and optimization of settlements taken from Bakšys and Sakalauskas (Bakšys and Sakalauskas, 2007). The parameters of the Poisson-lognormal model were estimated according to the real data and are as follows: $\mu = 7,813$, $\sigma = 2,189$.

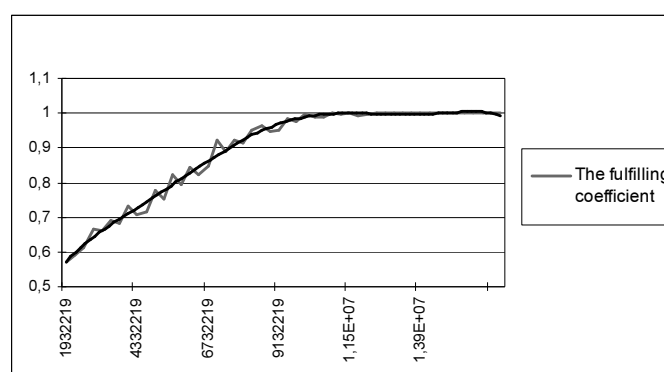


Fig. 1. Dependence of the settlement costs and the fulfilling coefficient on the value of correspondent account by using “all-or-nothing” algorithm

The algorithms have been realised with real parameters of the settlement system participants. For simplicity, the settlement process of three participants has been simulated. During the simulation the in-

fluence of the correspondent account value on the coefficient of settlements as well as on dynamics the value of correspondent account has been explored. In Figures 1 - 3, dependence of the settlement costs and the fulfilling coefficient on the value of correspondent account by using different TARGET2 algorithms is presented. In this figure influence of correspondent account value have on the transaction fulfilling is observed. The figures illustrate, that the growth of the correspondent account value influence the fulfilling of transactions. By using all three algorithms the increase of liquidity is conditioned by increase of correspondent account. The test results show that the “multiple” algorithm is most effective in comparison to other tested algorithms.

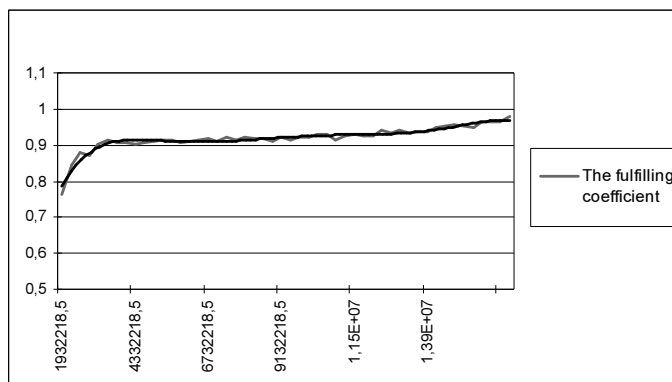


Fig. 2. Dependence of the settlement costs and the fulfilling coefficient on the value of correspondent account by using “partial” algorithm

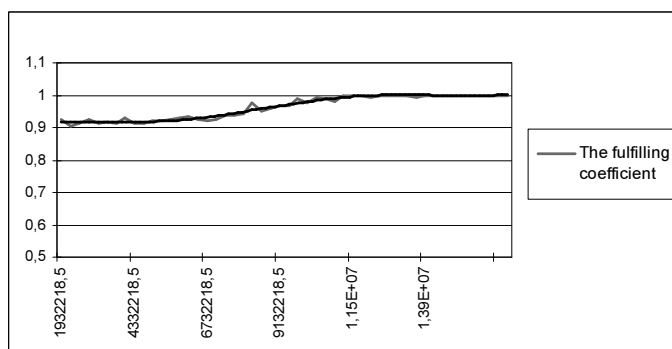


Fig. 3. Dependence of the settlement costs and the fulfilling coefficient on the value of correspondent account by using “multiple” algorithm

5. Conclusion

The results of simulation depend in essence on the balance of the payment intensity matrix. If at least averages of income and outcome payments flow for one participant are different, $\sum_{j=1}^J \mu_{ij} \neq \sum_{j=1}^J \mu_{ji}$, then matrix is unbalanced. In the system with unbalanced matrix the participants have different liquidity position. Thus, in one cluster of participants the position on the correspondent account become positive, in a second cluster the participants require necessarily of liquidity at the end of the settlement day. Therefore for the participants with scarcity of liquidity additional requirements should be applied. The value of requirement will be settled in view of liquidity position at the end of the settlement period. The long-term negative liquidity position shows that the participant has outside incoming assets or is in the pre-bankrupt situation. The result of simulation shows that there exists the optimal value of the correspondent account, which ensures the execution of all transactions.

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