Chapter 5

Exploiting Parallelization to Increase the Performance of Payment Systems Simulations

Tatu Antero Laine
Bank of Finland, Finland

Kasperi Korpinen
Bank of Finland, Finland

ABSTRACT

The large amount of data and the need to perform large numbers of simulations of payment systems are a challenge and a starting point for this paper. Parallel and distributed simulation systems are widely used in many applications such as in military applications and entertainment. Parallel computing has been applied in other econometric areas such as VAR models but not in payment system simulations. In this empirical paper, a reduction in total execution times of payment system simulations is studied by exploiting computational parallelization in a one multicore PC environment. The preliminary results of parallel simulations are reported and the possible benefits of analyzing financial market infrastructures using this technique are discussed. This information can be very useful for choosing a parallelization strategy and designing the next generation platforms for parallel processing of payment and securities settlement system simulations. This is the first time parallel computing techniques have been applied to payment system simulations.

INTRODUCTION

Payment and settlement systems are a crucial part of financial market infrastructures (FMIs) (Kokkola, 2010; Manning, Nier & Schanz, 2009). Since 2000 the resilience of FMIs, including payment systems, has attracted increasing attention (BIS, 2001; BIS, 2011). A payment system is a network that links market players together and supports other FMIs such as securities settlement systems and central counterparties (BIS, 2008). It is important to study the effects of defaulting participants and how these effects spread in the network. The authorities also want to know how the resilience of payment systems can be

DOI: 10.4018/978-1-4666-8745-5.ch005

further improved. This is a challenging task, as payment system networks are often large and complex. Payment system simulations have proven their usefulness in testing and studying the robustness of payment systems (Diehl, 2013; Heijmans & Heuver, 2013; Laine, Korpinen & Hellqvist, 2013). Payment systems research covers stress testing in respect of participants in the payment system (Bedford, Millard, & Yang, 2005; ECB, 2013), liquidity saving mechanisms (LVMs) (Galbiati & Soramäki, 2013; Norman, 2010; McLafferty & Denbee, 2013), and development of new features in the payment system (Koponen & Soramäki, 1998; Imakubo & McAndrews, 2007).

There seems to be an increased interest in operative economical monitoring (BIS, 2012). Payment system simulations can assist in this work. As the number of scenarios to be run increases and the delivery time requirements shrink, something needs to be done to meet the growing challenges. Especially for stress testing, the set band of required scenarios and assessment frequencies tend to increase. This means that our simulation techniques need to be improved. In some of the largest large value payment systems (LVPS) a hundred thousand transactions are processed each day, and the participants amount to thousands. The overseers and operators of such a system are interested in liquidity issues, stress tests on participants, and the testing of new features of the payment system. Obviously, a critical payment system has high requirements for timely analysis and the large amount of data-specific challenges for simulations. The processing time of serial simulations increases rapidly with the number of simulation days and the number of stress test scenarios. The number of stress test scenarios can be in the thousands if they are performed for all participants individually, and the total simulation time can be several weeks.

Parallel and distributed simulation systems are widely used to speed up computation times in many communities such as in high-performance computing communities, defense communities and interactive gaming and internet communities (Fujimoto, 2000). In this study we explore the applicability of parallelization approaches to payment system simulations. The aim is to show that payment and securities settlement systems' total simulation times can be improved by parallelizing the execution of simulations. This is the first time the parallel computing technique has been applied to payment system simulations.

SIMULATING PAYMENT SYSTEMS

Factors Affecting Payment and Securities Settlement Simulation Performance

Except for communication protocols between participants and operators, the parts that consume the most processing time in simulations are likely to be the same as in live systems. This is because the phenomenon being simulated is physically analogous to the software used for the simulations. As the financial sector becomes digitalized, more and more of its occurrences in real life occur in computer software algorithmic form. In this context, simulating a payment system is analogous to running a live system. Specially, the core parts of the settlement processes in live systems are physically highly similar to their simulator models, depending on the replication accuracy and chosen method.

A general observation made based on the payment system simulation is that computational execution times increase as liquidity shrinks and netting algorithms are used more. This is not exactly the same phenomenon known as the liquidity delay tradeoff, discussed in the literature (Koponen & Soramäki, 1998; Leinonen & Soramäki, 1999; Arjani, 2007). In the context of the liquidity delay tradeoff, payment delay is observed because settlements in real time and gross bases are not possible due to liquidity constraints. It should be noted that increasing execution times for netting algorithms are also likely to cause

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