INTELLIGENT SYSTEMS FOR RETAIL BANKING OPTIMIZATION

Optimization and Management of ATM Network System

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Abstract: The article analyzes the problems of optimization and management of ATM (Automated Teller Machine) network system, related to minimization of operating expenses, such as cash replenishment, costs of funds, logistics and back office processes. The suggested solution is based on merging up two different artificial intelligence methodologies – neural networks and multi-agent technologies. The practical implementation of this approach enabled to achieve better effectiveness of the researched ATMs network. During the first stage, the system performs analysis, based on the artificial neural networks (ANN). The second stage is aimed to produce the alternatives for the ATM cash management decisions. The performed simulation and experimental tests of method in the distributed ATM networks reveal good forecasting capacities of ANN.

1 INTRODUCTION

Banks have been employing electronic service delivery technologies aggressively for the past 20 years. This part of banking business is called retail banking. One of the main driving forces of retail banking is cost reduction using self-service technologies. Intelligent systems technologies (neural networks, agent systems and ect.) in retail banking are beginning to show value in fields of cash management, branch optimization, self-service network efficiency, and other core banking business processes.

The main research object of the article concerns contemporary methods of ATM networks optimization, as one of the most urgent topics of managing retail banking self-service infrastructure. The cost of cash in the ATMs network operating environment of Central and Eastern Europe (also in Asia) is the largest category of costs, which make from 20% to 50% of all operating costs.

The ATM cash management and optimization tasks are solved by the efforts of cash management experts and the computerized tools. The software market provides several different solutions for ATM cash management tasks (Wincor Nixdorf PCA; Carreker OptiCash and ect.), but their forecasting capability still can't outperform the experts. The systems architectures are very complex and not adjusted for performance in the distributed environments with huge amounts of data, which are the characteristic features of the ATM networks optimization tasks. Most advanced results for solving these tasks are expected of using hybrid artificial intelligence methods, and in this article we consider the combination of neural networks and multi-agent technologies. The extensive scientific research materials present theoretical frameworks, based on the statistical and economical analysis perspectives (Adam R. Brentnall, et al., 2008; Bezdek J.C., 1992; Heli Snellman and Matti Viren, 2006; McAndrews J. and Rob R., 1996; Sakalauskas V. and Kriksciuniene D., 2008).

The biggest drawback of the present research is lack of description, how to implement different mathematical models into the distributed ATMs network structure. The innovative approach of the elaborated model of intelligent system is based on using two different artificial intelligence methodologies – neural networks and multi-agent technologies. The merging up of these technologies enables to effectively solve ATMs network management problems both from the theoretical perspective and from the practical implementation aspect. The chapters 2 of the article describe the

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problem related to ATMs network management and research achievements in field of ATM networks optimization. The chapter 3 presents the suggested ATM cash optimization system. The overview of the architecture of the ATMs network cash management system is described in the 4th chapter.

2 RELEVANCE OF THE CASH MANAGEMENT PROBLEM

Operating a network of ATMs involves plenty of different functions: purchasing and installing of ATMs, processing transactions, clearing paper jams, repairing broken parts, picking up and processing deposits, and also replenishing cash (D'Ambrosio, et al., 2006). Expenses and operational efficiency is determined by ability of deplorers to manage these functions. Operating expenses can be divided into two main categories: Cash-Related and Non-Cash-Related. Cash-Related expenses, such as cash replenishment, costs of fund, and back office operating account cover almost one third of the total expenses in USA, 59 % in Baltic States, 60 % in Asia. The ATM owners are more aware of the impact that the cost of funds make on their daily operations because of recent tendency of rising interest rates. Creating cash optimization system of ATM networks could help to significantly reduce the ATMs total operating costs.

The most relevant analysis in the field of ATM networks optimization mainly relates to topics of optimal size of ATMs network (McAndrews, J. and Rob, R., 1996; Heli Snellman and Matti Viren, 2006), demand for cash (Adam R. Brentnall, et al., 2008; Amromin, E. and S. Chakravorti, 2007), and cash demand forecasting and optimization for the ATMs network, presented in Simutis et al (Simutis R., et al., 2007; Simutis R., Dilijonas D., et al., 2007; Simutis R., Dilijonas D., et al., 2008), formed the background for the recent study and is more extensively described in the following chapters.

Other researches related to financial optimization using neural networks discus bankruptcy prediction problem (P. Ravi Kumar, V. Ravi, 2007), credit risk analysis (Lean Yu, et al., 2009), but does not address the problems of system implementation in distributed services networks.

We have compared flexible ANN model with SVM (support vector machines) (Simutis R., et al., 2008). Forecasting results for real ATMs were using flexible ANN model MAPE (mean average proportional error) varied between 15-28% and for SVR models between 17-40%. The obtained forecasting results are in some confrontation with the today's opinion about the possibilities of SVR techniques. SVM/SVR (support vector regression) is assumed to be "next generation" technique and some of "panacea" for classification and forecasting tasks.

The analysis of the literature sources has shown that there are no studies in this area (practical implementation of cash demand prediction in ATM networks using hybrid artificial intelligence methods). The extensive scientific research materials present only theoretical frameworks, based on the statistical and economical analysis perspectives.

3 FORECASTING METHOD BASED ON FLEXIBLE NEURAL NETWORK

The system is created by using artificial neural networks for prognosis and optimization. The rational agent technologies are used for data collection in the distributed ATMs networks. Combining both technologies creates the advantage of managing cash optimization dynamically in complex systems, by considering different needs of the participants.

For every ATM machine a separate three-layer feed-forward neural network was designed. The neural network was trained using Levenberg-Marquardt optimization method and RMS (root mean square) error between predicted and real value. Regularization term was also included in the training criterion (Haykin S., 1999). The input variables for ANN were the coded values of weekday, day of the month, month of the year, holiday effect value and average daily cash demand for ATM in last week. The output variable of ANN was cash demand for the ATM for the next basic time interval. For the simplification purpose the ANN structure was chosen the same for all ATMs in the network (the same inputs and the same 15 hyperbolic tangent neurons of hidden units in ANN).

Therefore we proposed a special flexible neural network design procedure for cash demand prediction for every local ATM. The realization of the proposed procedure and this execution steps are presented in Simutis R., et al. (Simutis R., et al., 2007; Simutis R., Dilijonas D., et al., 2008)

Fig. 1 shows the efficiency of the cash upload optimization procedure. Simulation parameters: Number of ATMs=1225; Annual interest rate=6%; Cost of cash uploading in ATM=1 million LT (currency course in Euros 3.45 LT=1 EUR), Average daily cash demand=200000 LT/ATM; Constant maintenance costs=30 LT/ATM;

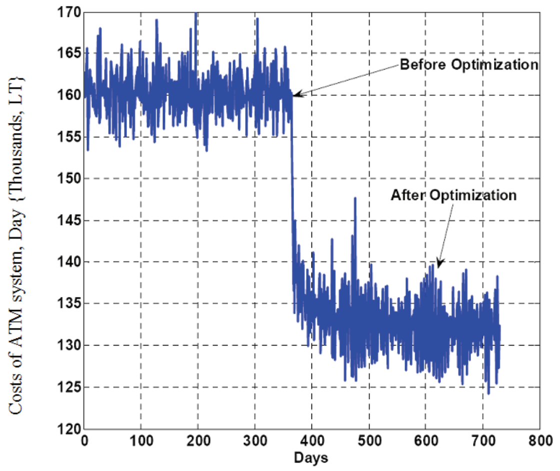

Figure 1: Simulation results for cash optimization system, daily maintenance costs for ATM network before and after optimization.

Optimization procedure allowed decreasing daily costs for ATM network maintenance approximately 18%. The simulation results, presented in Fig.1 reveal that the optimization results depend strongly on the costs of money (annual interest rate) and cash uploading. Maintenance costs decreased only by 2 %, then the simulation was run under annual interest rate 3.5% and the increased cost of cash uploading to 300 LT/ATM. Better results were achieved for simulations, where higher interest rates and lower costs of cash uploading were applied.

4 THE AGENT SYSTEM ARCHITECTURE FOR RETAIL BANKING OPTIMIZATION

This section gives a global design specification, includes agent model specification of the system and provides description for each component of the design package. Figure 2 presents architecture of retail banking optimization systems. The system is based on JADE Framework (Bellifemine, F., et al., 2005) where agents are responsible for use cases realization in Math Processor Business. Agent simulation is performed by using MatLab Runtime. The external interface to the system is provided by ASOMIS Math Web Service. Main components of the system are assigned different tasks.

Directory Facilitator (DF) agent acts as specified by FIPA. The Agent Management System (AMS) is the agent who exerts supervisory control over access to and use of the Agent Platform. Broker agent (BA) is the agent responsible for service agents, such as life-cycle management (create-kill, resume-suspend) and dispatching the service request to a proper service agent. Train Agent (TA) is the realization of Train and Adapt Neural Network use cases. Forecast Agent (FA) is the realization of Replenishment Forecast use case and provides cash amount forecast service, based on the trained neural network. Each device is represented by its own FA. Optimize Agent (OA) is the realization of Replenishment Optimization use case, which provides service for replenishment optimization, based on the forecast results. Session Agent (SA) is responsible for holding current neural network parameters per device. Data Provider Agent (DPA) is the agent responsible for collecting historical data from the external source, such as database or file system, and providing it to service agents. MatLab proxy is a wrapper for MatLab Runtime and responsible for wrapping atomic MatLab runtime operations in use cases realizations of ASOMIS Math Processor service level operation (Dilijonas D., Zavrid D., 2008). The realized platform is created by using Java 2 Platform, Enterprise Edition (J2EE). This technological solution meets the essential requirements for the system including application of numerous tools, clear programming model, and work on different a platform, which is very important for the distributed systems (Dilijonas D., Bastina L., 2007).

5 CONCLUSIONS

The research works in ATM networks optimization sphere address main topics of optimal ATMs network size, demand for cash and forecasting cash withdrawal amounts in ATMs. The software solutions, applied for cash management processes, lack of sufficiently robust forecasting and optimization tools, they are mostly based on simple forecasting models, and are not capable to work effectively in distributed environments. As the ATM networks have features of the distributed systems, the hybrid artificial intelligence methods should be applied for optimization of such systems. The practical model, proposed in this article, is based on the combination of neural networks and multi-agent technologies. The combined application of these technologies gives the advantage of managing cash

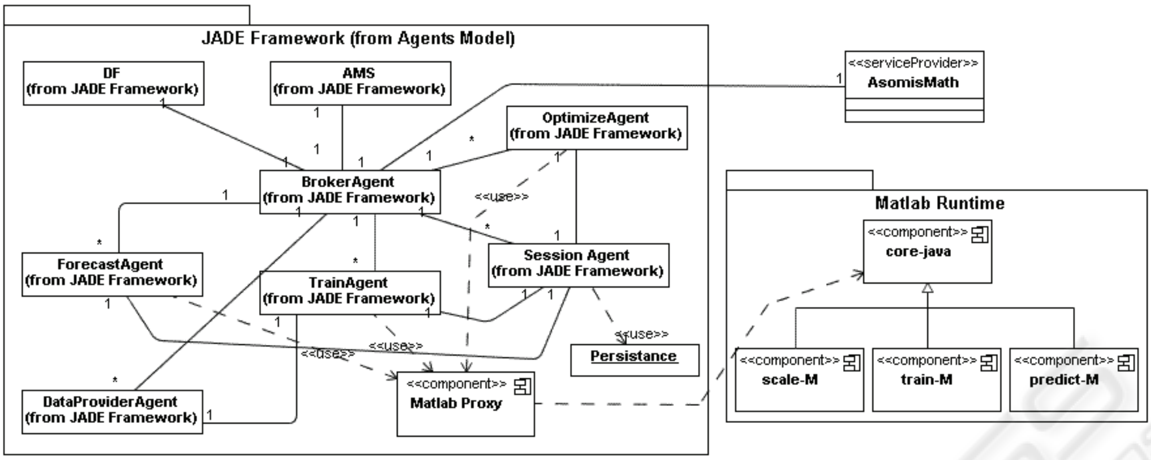

Figure 2: Agent model overview (Global design specification).

optimization dynamically in the complex systems. Application of the proposed model resulted in cash reduction by average 20 – 30%. The current stage of design is accomplished by development of system, based on agent technologies (JADE Framework). The future researches are directed to the integration of reasoning agent capabilities (Dilijonas D., Zavrid D., 2008) into the designed ATM cash management and service support system.

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