Revista de Sistemas de Informação da FSMA
n. 11 (2013) pp. 17-26

SISTEMAS DE INFORMAÇÃO
http://www.fsma.edu.br/si/sistemas.html

TRILHA PRINCIPAL

Oversized or Undersized? Defining the Right-sized Computer Center for Electronic Funds Transfer Processing

Alexandre Andrade, *Master Student in Applied Computing, Unisinos*,
Tiago Jost, *Master Student in Applied Computing, Unisinos*,
Rodrigo da Rosa Righi, *PhD in Computer Science, Unisinos*,
Leonardo Chiwiacowsky, *PhD in Computer Science, Unisinos*,
Cristiano André da Costa, *PhD in Computer Science, Unisinos*

***Resumo*—Electronic Funds Transfer represents an upward trend, which fosters the proximity among consumers and suppliers. Each transaction is sent to a Computer Center, in charge of decoding, processing and returning the results as fast as possible. Particularly, the present article covers the GetNet Company day-by-day, focusing on one of their subsystems. In the article, we model the incoming transaction volume and the corresponding processing to answer the following questions: (i) how is the idleness of the company transaction system settings and what are the rates involed on that? (ii) Given an annual growth of 20% in the transaction volume, which modifications should be made in the current Computer Center to fulfill the need in terms of transactions until 2020? The tests were based on transactions execution logs during one day, which corresponds to the greater volume of 2011. As expected, the results show that the 10 machines composing GetNet system are overestimated for the current situation, which could support the operational load with only 4 machines. In addition, the current configuration could be sustained, regarding the growth predicted before, until the middle of 2017 without loss of transactions.**

***Palavras-chave*—Performance, Simulation, EFT, Electronic Funds Tranfer, Resource Usage.**

I. Introduction

REQUISITION routing and processing systems are fundamental parts of an electronic transactions network [1, 14]. Usually, an electronic transaction is put together with a purchase requisition and goes a roundabout way from the terminal to a processing center. A terminal can be represented by a Point of Sale (POS), Electronic Fund Transfer (EFT), an Automatic Teller Machine (ATM), as well as mobile devices [16]. When discussing the transactions, we can point out those that are connected to credit and debit cards, account balance, prepaid phone cards and public transportation cards, as well as those used to draw funds from and deposit at bank accounts. Each one of those transactions have different CPU and database access needs, requiring different subsystems within the processing center.

Figure 1 shows the traditional way a Transaction Processing Center is organized [6, 14, 21]. Usually, it has a commuter, Attending machines and internal subsystems. The commuter receives the transactions from the input terminals and schedules each one of them to be processed by one of the Attending machines. The output systems in the figure are the target companies for each transaction. Given the goals of processing a growing number of transactions and providing a better experience for the final user, the following goals are highlighted for the requisition processing: (*i*) high performance in the transaction processing with the smallest computation cost achievable and; (*ii*) high availability to avoid transaction loss. These two goals need an efficient transaction scheduling by the commuting element and/or an analysis of the scalability of the current data processing solution. Given that the most common scheduling algorithm used in electronic transaction environment is the Round-Robin [21], the number of Attending machines is the most decisive factor to define the number of transactions that can be processed during peak moments.

Given the task of determining the correct number of Attending machines that will be used to process the requisitions,the following problem definition is pertinent: *given an input rate measured in transactions per second, what is the adequate number of Attending machines that can support it without any transaction loss?* Given the problem characteristics, it is necessary to analyze the highest supported load, for the transaction system must be able to support the highest demand at any given moment [14]. It often happens that the number of Attending machines is empirically overestimated, assuring that all transactions are processed, but also incurring in a higher financial and energetic cost for the processing center.

In this context, this article presents a model for the definition of the infrastructure for an electronic transaction processing system. This model is represent by a fluxogram

Autor correspondente: Rodrigo Righi, *rrrighi@unisinos.br*

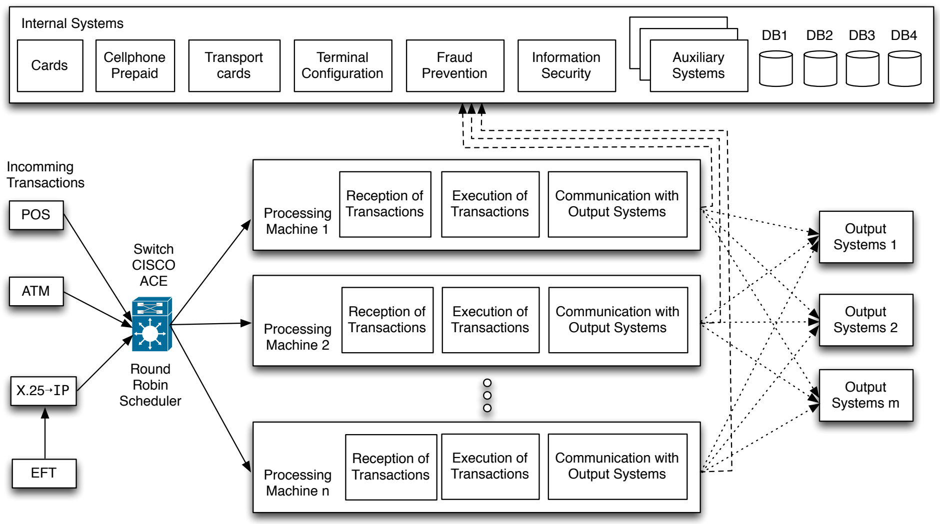

Fig. 1. Usual platform for the processing of electronic transactions, in which a commuter receives transactions from terminals and schedules them to be processed by Attending machines. Each machine can have many internal subsystems and contacts output systems in case the transaction processing needs external systems to be concluded.

of generic procedures. Its output is the most adequate number of Attending machines needed to support a specific input and processing demand. Besides, this output also depends on specific characteristics of the electronic transaction systems, that is the maximum time needed for a transaction to be processed before it is discarded. This treatment defines the main difference between this work and previous related ones [1, 13, 14, 21]. The analysis performed is not limited to the electronic transaction are, given that there are scenarios where processing limitation are also present, such as in a customer queue in a bank agency [20].

Besides the fluxogram, this article describes its implementation through a simulation and modeling system. Different from related works [8, 21], the proposal presented here can also predict the infrastructure of machines as a function of the company's growth (increase of the incoming transactions per second rate). The tests were performed using real data obtained at one of the processing centers of the GetNet company (a company that works in Latin America and is specialized in the electronic transaction business).

This article is divided in 6 sections. The next one describes the general workings of a typical transaction system. Section 3 presents the fluxogram used to estimated the number of Attending machines as a function of the demand.Sections 4 and 5 present the test methodology and the results achieved, respectively. Section 6 discussed some of the related work and section 7 presents our conclusions, where we emphasize the main contributions of this work.

II. Electronic Transaction Systems

ELECTRONIC commerce is an increasing ubiquitous reality in our consumer society [7, 10, 16]. In order to make it viable, it is current practice to use cards to transfer funds and to help tasks that once were performed either mechanically or manually. This process causes the arrival of transactions in processing companies that are affiliated with each type of card. A financial transaction includes a series of message exchanges, which include registration and transaction status control, card bearer data integrity assurance, besides the correct operation and connection with the company that is the target of the transaction [1]. A typical processing center includes modules such as those shown in Figure 1. The efficient interaction between modules and the existence of redundancy schemes is critical for acceptable performance indexes to be achieved. Without an adequate addressing of those issues, it is possible for some subsystems to stop and for a large amount of transactions to be lost.

A financial transaction system presents a load curve that follows the pattern of consuming behaviour of the population, which is characterized by an alternance between high, average and low transaction volume [21]. Typically, periods of time before holiday and close to payment have a higher volume of shopping. The volume of messages in measures in number of transactions per second, or TPS.

In figure 2, we can see the typical behavior of the volume of transactions that occur in a open commerce day. The graph was obtained through purchase message logs from a processing system from a company that provides electronic transaction services. During the first hours of the day, the volume is quite low and remains at that level until approximately 07h00. From that moment on, there are peaks close to 12h00 and 19h00. These peaks refer to lunch and office closing hours. Based on this information, a transactional system must be defined in order to provide service during low demand hours but also to present the same availability and performance during peak hours.

The average size of a credit card purchase message is about 200 bytes. This transaction follows the protocol ISO 8583, which is used in the market as the standard layout

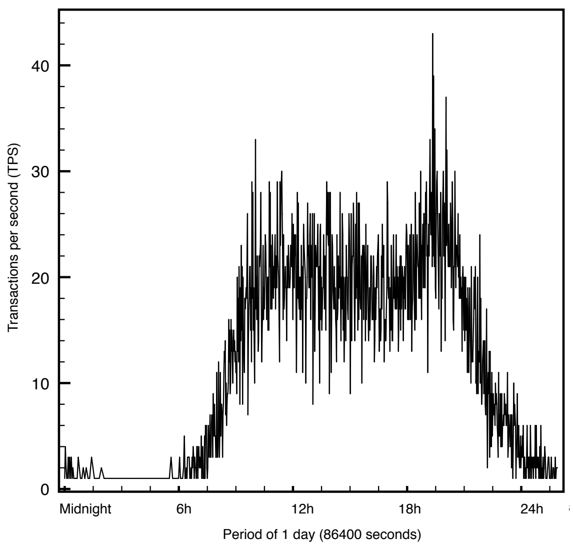

Fig. 2. Transaction flux capture by the Getnet company at the busiest work day during the year of 2011 (December). The graph indicates the higher number of transactions per second in the period between 12h00 and 19h00

of electronic financial transactions [6]. When Ao received by the system, those purchase transactions are treated by several internal subsystems (see transactional architecture organization in figure 1). Those systems perform several validations on the shop data, credit limit and a series of controls that intend to guarantee the integrity of the information before proceeding with the card debit solicitation. Each of those internal subsystems will act on the transaction and will directly influence on the performance of the whole system. If any of those systems does not respond to the transactions within the specified time limit, it will affect the total transaction time. As a result, there will be an effect on the customer that is performing the purchase. In the most undesirable situation, the time can expire and the transaction will need to be repeated (*timeout*).

A problem with an internal subsystem may cause other problems to the transactional system. Due to the high response time of the internal subsystem, the system module that is responsible for receiving transactions may be subject to a message queueing in the input buffers. The purchase messages remained queued waiting to be treated and forwarded.Nevertheless, the buffer size limit may be reached and the system may be interrupted with the consequent loss of input messages [21, 22]. Hence, we may come to a crash in the transactional system that may represent a huge financial impact for the service provider. Besides the immediate financial loss, due to transaction loss, there will also be an image deterioration of the service provider at the card market.

The module that is responsible for receiving the transactions and forwarding it to the other modules in called Attending (Figure 1). This module also performs an uniformization of the protocols due to the different input devices,such as POS, EFT, ARU (Audible Response Unit) and transactions performed from mobile devices (*Mobile Payment*). All the other system modules are directly dependent on the service performed at the input. Hence, this point is characterized by a high demand and high criticality.

The commuter receives the requisitions through two different protocols. For EFT equipments, the transaction is received through a X.25 communication link. This connection oriented protocol is standard in EFT networks in Brazil [21]. This link is physically connected to a X.25 card. Once the transactions are read by the application, they are converted to the TCP/IP protocol and sent to one of the processing machines. The other transaction input protocol is TCP/IP which is used by POS and ARU units, as well as those that communicate using GPRS (*General Packet Radio Service*) and Ethernet [18]. Particularly for POS with communication through phone lines *dial-up* there is a hardware that performs the conversion of the X.28/SDLC input protocol to the TCP/IP standard [18]. Hence, the Attending machine does not differentiate among the different types of POS that arrive at the system, given that for him all of them connect using the same way.

III. Fluxogram to Analyze the Infrastructure of an Electronic Transaction System

DUE to the nature of the system under study, we can see that there are demand peaks. Hence, there is a difference of the input flow during service hours, what characterizes a system with oscillations. Besides, there is a fluctuation in the transaction processing time for each Attending machine that cannot be foreseen a prior, because they can depend on internal subsystems and output systems that show dynamic behavior. We know only that there is a maximum time limit for a transaction not to be discarded. Therefore, we cannot use the mathematical models of the Queueing Theory to analyze the system under study [11]. Queueing theory mathematical models can only be applied to systems that reached their equilibrium state or permanent regimen, that is, systems in which we can verify a standard behavior for a long period of time [5].

Figure 3 illustrates the proposed fluxogram to analyze the number of Attending machines in a transaction system. The analysis starts by the definition of the day and period of time in which the system will be analyzed. We recommend choosing the day with the highest transaction volume in order to assure a worst case scenario analysis. Related work perform their analysis with samples collected from the last days of the year, given that such period usually shows the highest business volume [8, 9]. As for the period of time, it is pertinent to watch the system during for 24 in order to determine the peak hours in that interval. Afterwards, the fluxogram follows with the action of capturing relevant data for the processing of transactions, such as arrival and transaction processing events. These data can be obtained using a profiling technique at the transaction input commuter and in each of the Attending machines.

The analysis of transaction arrival includes verifying its frequency, that is the number of transactions that come into the processing company per second (TPS). The TPS rate is a common metric for the treatment of this type of system [21]. Based on that, we capture the highest TPS value read, given that the system must be defined according to its worst case scenario. In order other, working with the average TPS is not a viable scenario. Although the system may respond in a satisfying way most of the time, there may be transaction loss with the adoption of the average rate for the transactional modelling.

Step 5 of the fluxogram, shown in Figure 3, represents the ti processing time capture for each of the transactions during the evaluate time period. At this point, we adopt an interval width to verify the relative frequency of processing time. For instance, with an interval of 0.4 seconds, we verify the number of transactions processed in]0s,0.4s], then in the interval]0.4s,0.8s] and so on. Based on these data, we identify a probabilistic function that fits better the frequency histogram we just built. A traditional software for this task in adherence test is EasyFit[1]. EasyFit allows us to verify average processing time that can be used to measure the number of Attending machines. Besides, it is common in transaction processing system establishing the maximum time limit that a transaction can remain in the system. At this line, tests that consider the worst processing time scenario lead us to a different configuring at the machine infrastructure.

Step 8 in Figure 3 is responsible for modelling the transactional scenario and executing it using a simulator. Up to this step, we have the data concerning the amount of transactions that arrive (in TPS), the average and maximum times for transaction processing and the current number of Attending machines. Transactions are dispatched to the Attending machines using the FIFO (*First In First Out*) algorithm. Simulation results in the perceptual usage of the Attending machines and the perceptual loss of submitted transactions. Steps 11 and 13 decide on the need to reconfigure the transactional model.

If necessary, steps 12 and 14 change the amount of Attending machines and the transaction arrival rate, respectively.This option is specially important to measure the life span of the infrastructure, that is, once there is no transaction loss when we use the average and/or maximum processing time, we can assume an increase on the arrival rate and reevaluate. If the company is planning for an annual growth in the number of electronic transactions received, it is possible to forecast the TPS index expected at each year and verify whether the system will support the demand. Last, the activity 15 defines the number of Attending machines for the previously reconfigured situations.

[1]http://www.mathwave.com

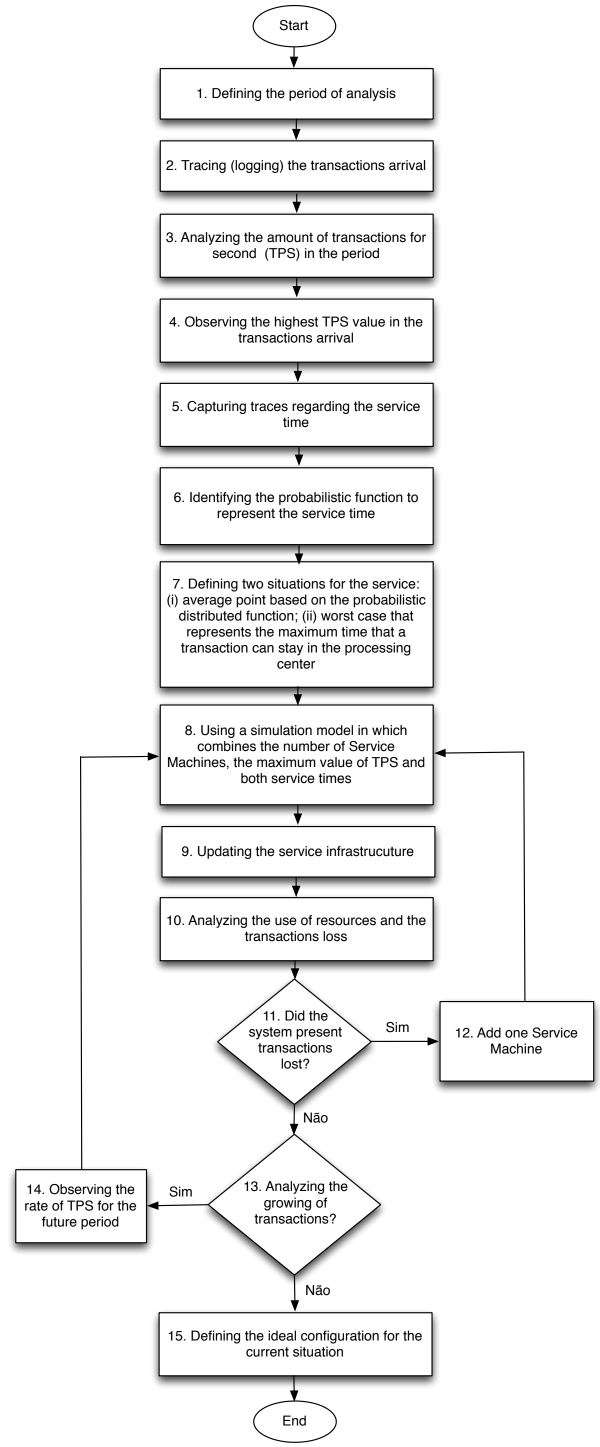

Fig. 3. Fluxogram for the analysis of the Attending machines in an electronic transactions processing center.

IV. Evaluation and Implementation Methodology

BASED on the fluxogram in Figure 3 we implemented a simulation model using real data obtained from a company at the financial transaction business called Getnet. The parameter estimation for the test was performed assuming two different types of transactions that correspond to approximately 90% of the transactions processed by this company. The verified data concern debit and credit operations and prepaid phones recharge. The period under study was from 8h00 up to 22h00, what represents approximately 92% of the processing volume of a work day. The rest of the period was discarded because it has an extremely low volume of transactions and does not represent a bottleneck for the actual system. The day chosen for data gathering was the one with the highest transaction number in 2011, in the month of December. This was the system modelling was performed with the goal of preparing it for the highest demand currently verified. The graph at Figure 2 illustrate the transaction arrival rate that will be used for evaluation.

GetNet works nowadays with 10 homogeneous Attending machines and a transaction receiving commuter of the model CISCO Catalyst 6500. The highest TPS rate adopted was 43, given that this represent the highest value found in the time frame considered (Figure 2). Next we modelled the estimative of the theoretical probability distribution that best describes the service times. In this context, we used the EasyFit software to identify the probability distribution that is a best fit on the attending data. The function found was a Normal with average processing time of 4,798 seconds and standard deviation of 2,119 seconds, as shown in Figure 4. The values found in Chi-squared, Kolmogorov-Smirnov and Anderson-Darling adherence tests [11] , do not reject the hypothesis that this theoretical function N(4,798;2,119) is the most adequate to represent the service times.

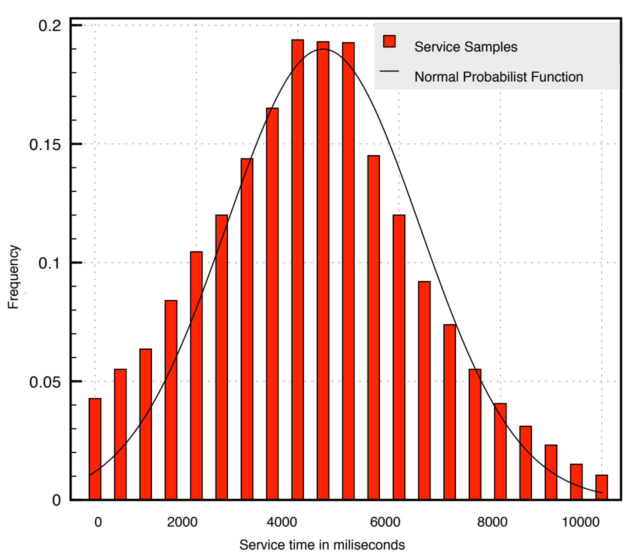

Fig. 4. Normal probability distribution function N(4,798;2,119) for transaction processing

Once we obtained the transaction input and processing models, we analyzed the system performance for different processing capabilities: (*i*) Norlam probability function with average equal to 4,798s; (*ii*) worst case or exception. The latter is characterized by the fixed time of 28 seconds, which is the actual limit defined by GetNet for a transaction to be processed. When overcome, an error machine is returned to the user terminal. The simulation was performed using the software Rockwell Arena Simulator[2] [12].

Figure 5 presents the model used in the simulation. Four models were developed in the Arena: (*i*) transaction receiver, at a 43 TPS input rate (see peak in Figure 2); (*ii*) transaction dispatcher that works according to the Round-Robin algorithm; (*iii*) 10 Attending machines that perform the processing and; (*iv*) transaction excess that cannot be processed. This excess can be related to each of the Attending machines or even with the initial scheduling part. In case all machines are 100% busy, a transaction is dispatched to the General Excess module. Besides, a transaction can be already mapped for execution at a target machine, but its waiting time has exceeded 28s. In this situation, our limit indicates that this transaction will be discarded.

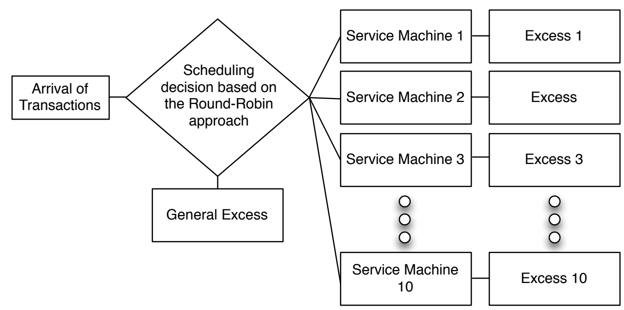

Fig. 5. Modelling of the transaction system with 10 Attending machines in the Arena simulator

Starting from an infrastructure with 10 Attending machines, we developed two different trials, as following:

- Trial 1 - Simulate the occupation of the Attending machines and the loss of transactions for the incoming rate of 43 TPS over both processing regimens: average according to Normal probability distribution function and exception;
- Trial 2 - Given an annual 20% growth of the incoming transaction rate to the Getnet company, what should be the planning of the computation resources so that the company does not lose any transactions until 2016?

In each trial we processed 50,000 transactions and the processing time of this amount varied according to service times and input TPS. For each simulated scenario we performed 10 consecutive runs and the results presented correspond to the average of the values obtained.

Trial 1 represents the current situation at the company. The value of 43 TPS for input rate and 28s for maximum processing time represent the worst case in the transaction system. This situation is not frequent but is being considered here because it covers all the remaining input and processing possibilities for the current situation at the transaction processing center.

Trial 2 analyzes possible future modifications that might be necessary at the system infrastructure. These changes may be necessary to keep at a satisfactory level the

[2]http://www.arenasimulation.com/

company's performance in the next years. In this scenario, we kept the processing index and varied the TPS input rate for the system.

V. Result Analysis

FIGURES 6 and 7 show the average occupation results on the transactional system and the loss of transactions in a 43 TPS input rate, respectively. Firs, let us analyze the Trial 1 taking into consideration the 10 Attending machines of the GetNet company. A 100% resource occupation rate in Figure 6 implies in transaction loss. In this sense, a configuration with a processing time of 4.8s can become viable with only 3 servers. The occupation rate with this configuration decreases as the available resources increase. Quantitatively, using 10 Attending machines implies in a 20% occupation rate in the total machine infrastructure. In spite of the fact that the 4.8s processing time represents an average service time, it does not represent the worst case scenario. For that, the configuration with 28s processing time shows an occupation of 100% for the current 10 Attending machines at GetNet. As illustrated in Figure 6, increasing one server causes the loss of transactions to cease. More precisely, 11 machines will cause a resource occupation rate of 93%.

Figure 7 presents the percent of transaction loss when 50,000 transactions arrive at a 43 TPS incoming rate. The values of 38,90% and 0,004% represent the losses for the processing configuration of 4.8s. More precisely, the second percent rate was obtained with 2 machines and indicates that only 2 transactions in the whole set were lost. The worst case Attending configuration (or exception) shows that the losses decrease as new resources are added(to the Attending infrastructure). A total of 44,851 and 39,384 transactions were lost when using 1 and 2 Attending machines, respectively. The loss rates of 5.59% and 0.07% were observed when using 9 and 10 machines, respectively. The value of 0.07% represents a loss of 35 transaction and adding an eleventh machine causes the losses to cease completely.

Table I presents the results of Trial 2, where we assumes that the transaction processing time to be 4.8s. For each year this table show the number of resources that will characterize a situation with transaction loss. Besides, analyzing this table allows us to realize that the increase on the transaction input rate causes an increase on the losses. Hence, we need to increase the number of resources to solve this problem. For instance, while the 3 Attending machines was enough for no losses to occur in 2012, in the year 2016, 4 machines will be needed to operate with no losses. Taking into consideration that the case study already has 10 Attending machines,we can come to the conclusion that the in the next 4 years GetNet will keep a satisfactory service level even with half the existing infrastructure.

Figure 8 shows the analysis of Trial 2 for the processing time of 28s. The current configuration will cause transaction loss from 2012 to 2016. Besides, analyzing the figure allows us to observe that there is an increase in this period, that is, as the volume of transaction increases, so does the amount of transactions lost. Hence, the closest we are to 2016, the largest the need for extra results in order to operate entirely without losses. The current infrastructure causes a transaction loss of 47.41% for the project incoming rate at 2016. For that same year, it is necessary to double the number of Attending machines in order to avoid discarding transactions. More precisely, we will need more 1, 2, 5, 7 and 10 additional machines to deal with the projected incoming rates for the years 2012, 2013, 2014, 2015 and 2016, respectively.

TABELA I
Forecast incoming transaction per second rate and amount of Attending machines that present transaction loss

Year	TPS	Attending Machines	Perceptual transaction loss
2012	43	1	38.90%
		2	0.004%
2013	51	1	47.82%
		2	0.16%
2014	61	1	52.67%
		2	12.90%
2015	73	1	63.73%
		2	27.86%
		3	0.05%
2016	88	1	70.40%
		2	40.86%
		3	12.33%

VI. Related work

ELECTRONIC payment has been increasingly adopted instead of paper money and personal checks [23, 25]. Besides the convenience for the consumers, using electronic cards is beneficial for the commerce and also makes it easier the access to Internet applications and services. Virnes et al. [23] say that this transition is present both at baks and e-commerce systems as well as in electronic governance, entertainment, health systems and mobile devices. One of the most studied topics in electronic transaction systems in information security [18, 19, 24]. Vishik et al. [24] say that both the secure data transmission and the confidence relationship must be reanalyzed as embedded systems and smartphones are as increasingly important platform for applications. Sastre, Bacon e Herrero [18] specially discuss optimized security algorithms to support different transmission media such as ADSL and GPRS.

Sousa et al. [21] present a stochastic model to evaluate the performance and perform resource planning for an electronic fund transfer (EFT) system. These authors study the performance of their model taking into account dependability characteristics, such as availability, reliability, scalability and security. According to them, an analysis of an EFT system that does not take into account those criteria may lead to imprecise results. Sousa et al. also report that the criteria above must guide the efficient use of resources so that the service level agreement (SLA) with their customers is respected. Araújo et al. [1] state that the performance analysis must be concerned with the

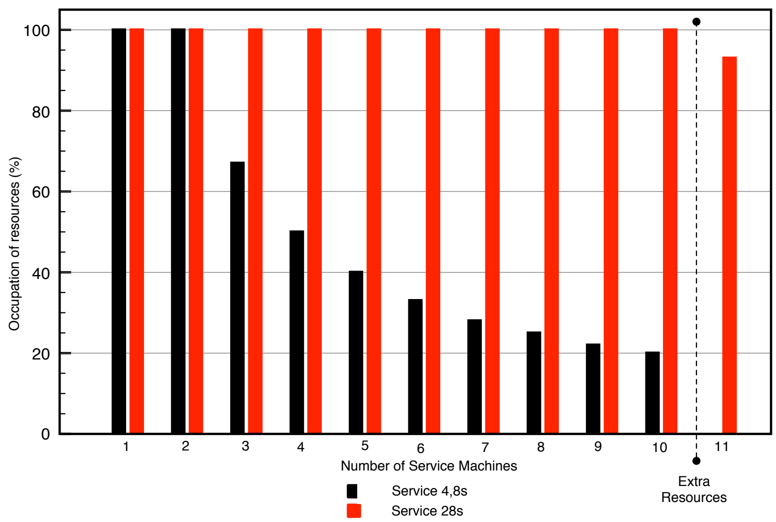

Fig. 6. Resource occupation level in both Attending situations with an input rate of 43 TPS

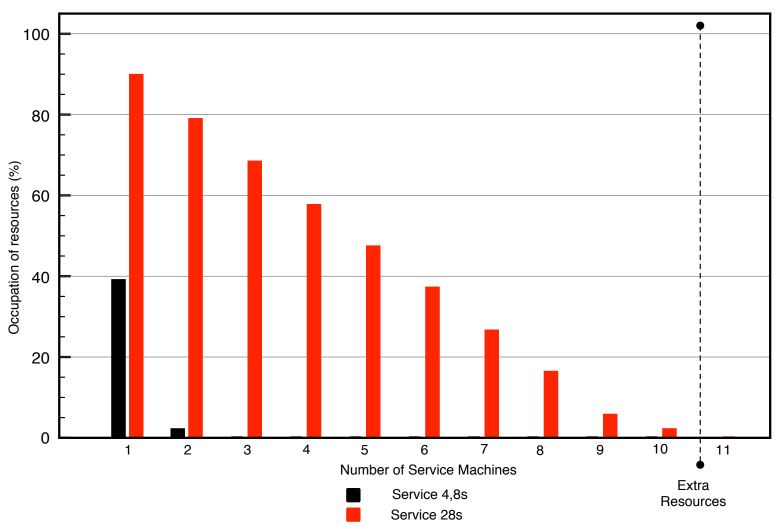

Fig. 7. Loss of transaction considering an input rate of 43 TPS in both Attending regimens

worst case scenario for incoming transactions in order to be credible and conform to the reality of the data processing company. As such, they have adopted Petri Nets and use disk access and storage information, besides transactional volume.

Formal performance analysis is applied in several segments of parallel and distributed computing. Desnoyers et al. [7] developped a system called Modellus, that can model automatically the usage of datacenters in the Internet. Modellus uses Queueing theory do derive application resource usage forecasting models. Its differential consists on the combination of data from several different applications in order to infer the state of a datacenter. In this same line of research, Queueing theory is also applied to wireless sensor network [3].Another work that contemplates the evaluation of strategies for scheduling in computational grids using real workload logs [17]. Formal analysis allows us to evaluate the efficiency of the algorithms and the average wait time for the conclusion of each job.

Luan et al. [15] work with computational grids and jobs migration. They proposed a mathematical framework to model and analyze migration time. As in the case of our work, this paper also makes an estimative of the future performance. They observed the possible gains with migration in the execution of long standing jobs.

The theme of mobile payment is discussed in [14]. The authors developped a platform based on the layer SaaS (Software as Service) of cloud computing in order to implement business. This paper comments on the importance of the correct dimension of transaction processing systems in order to avoid losses and to make clients more faithful.

Performance forecast analysis on an EFT environment requires the definition of the average incoming transaction rate. For that goal, samples are collected with periodicity t in order to guide the calculation of this rate. The paper written by Tchrakian, Basu and Mahony [22] presents a

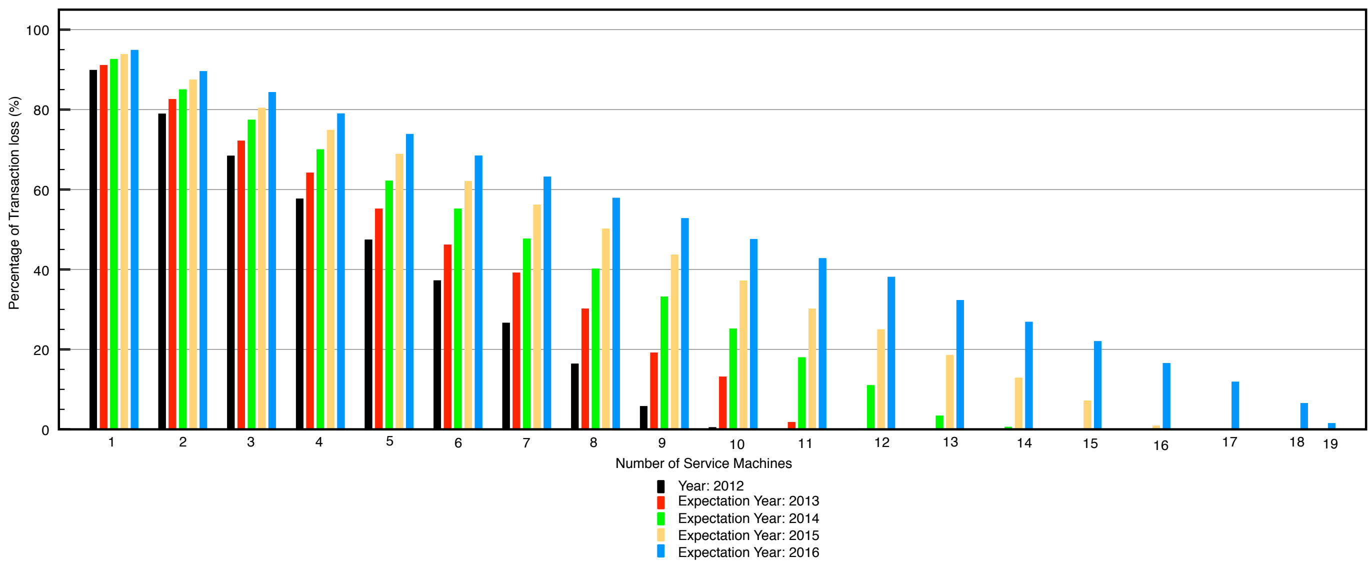

Fig. 8. Transaction loss considering a processing regimes of 28s projected up to 2016. For the year of 2012, we used an incoming rate of 43 TPS and we work with a projected increase of 20% per year in the incoming transaction rate

forecast on the vehicle traffic rate based on time series. For that, they use a data gathering interval of 15 minutes. The same step cannot be applied to an EFT system because we cannot overlook a specific incoming transaction peak. Hence, we take this into consideration and uses an interval of 1 second to gather information, both in the arrival and in the electronic transaction processing.

An analysis of related works allows us to classify [1], [7] and [21] as those with the highest relation to our proposal. When compared to [1] and [21], the simulation model described in our paper differs because it works with the maximum time a transaction can remain in the processing center, which is closer to the reality of those companies. Besides, our article also deserves praise for treating lost transactions and forecast the computational resources needed for several years. Authors in [7] use Queueing Theory but as stated in section 3, this technique cannot be used in the real situation of electronic transactions. The authors in that paper estimate an average time and use a single value for all their evaluations.

VII. Final Remarks

NOWADAYS several researches define the current moment in computer science as the era of Big Data [2, 4]. The state of the art in our field shows that more companies are making decisions based on formal observations and in the combination of large volumes of data input instead of relying on empirical analysis. Hence, the main contributions of this article consist on a fluxogram of activities for the formal analysis of an electronic transaction system, as well as a simulation model to ensure the applicability of this fluxogram. Differently from the standard simulation systems analysis that observe the arrival and processing of events, the fluxogram also takes into account the time limit for a transaction to be completely processed. Therefore, given those three parameters, we find a number of Attending machines that can process all transactions with no losses. Impractical terms, this can cause two consequences (i) more satisfied users and higher usage of electronic cards and financial operations; (ii) reduction of utility costs and smaller equipment purchases by the processing companies, given that those resources need no be oversized.

The implementation part of the proposed fluxogram was made viable with the software Arena and was based on real dada obtained from the records of the GetNet company. Tests have shown that the average processing situation is supported by the current resource configuration of that company, which includes 10 Attending machines, 4 of which would be enough to process the incoming transactions in this processing scenario. Besides the tests that used a normal distribution time with average 4.8s, the processing was also evaluated with the processing time 28s, which represents the worst case scenario. This analysis was pertinent, given that it includes all other processing scenarios. This time limit is pre-established by the GetNet company as a limit for the transaction not to be discarded. Adding 1, 2, 5, 7 and 10 Attending machines each year is necessary to offer a zero loss scenario from 2012 to 2016. Although test used specific GetNet data, it is important to point out that the proposed model can also be used in other environments that also perform electronic transactions processing.

As future work, we plan to develop a scheduler for the commuter module that acts according to the computing data, queue size and communication time need to reach Attending machines. Besides, we plan to develop a notification system with which the Attending machines would inform the commuter on alert situations.

References

[1] C. Araujo, E. Sousa, P. Maciel, F. Chicout, and E. Andrade, "Performance modeling for evaluation and

planning of electronic funds transfer systems with bursty arrival traffic," in *Intensive Applications and Services, 2009. INTENSIVE '09. First International Conference on*, 2009, pp. 65 –70.

[2] K. Bakshi, "Considerations for big data: architecture and approach," in *Aerospace Conference, 2012 IEEE*, 2012, pp. 1 –7.

[3] L. Berardinelli, V. Cortellessa, and S. Pace, "Modeling and analyzing performance of software for wireless sensor networks," in *Proceedings of the 2nd Workshop on Software Engineering for Sensor Network Applications*, ser. SESENA '11, New York, NY, USA: ACM, 2011, pp. 13–18.

[4] S. Chaudhuri, "How different is big data?," in *Data Engineering (ICDE), 2012 IEEE 28th International Conference on*, 2012, p. 5. doi: 10.1109/ICDE.2012.153.

[5] R. B. Cooper, "Queueing theory," in *Encyclopedia of Computer Science*, Chichester, UK: John Wiley and Sons Ltd., 2002, pp. 1496–1498, isbn: 0-470-86412-5. [Online]. Available: http://dl.acm.org/citation.cfm?id=1074100.1074749.

[6] N. Delic and A. Vukasinovic, "Mobile payment solution - symbiosis between banks, application service providers and mobile networkoperators," in *Information Technology: New Generations, 2006. ITNG 2006. Third International Conference on*, 2006, pp. 346 –350.

[7] P. Desnoyers, T. Wood, P. Shenoy, R. Singh, S. Patil, and H. Vin, "Modellus: automated modeling of complex internet data center applications," *ACM Trans. Web*, vol. 6, no. 2, 8:1–8:29, 2012.

[8] C. Edwards, "Getting a purchase on christmas - it ecommerce," *Engineering Technology*, vol. 4, no. 21, pp. 54 –56, 2010.

[9] G. Girardi and M. Camargo, "Forecast production volume: a case study," in *Computers Industrial Engineering, 2009. CIE 2009. International Conference on*, 2009, pp. 1747 –1750.

[10] K. Hirotsugu, K. Mamoru, M. Tetsuya, and S. Kazuhiro, "An electronic money system as substitute for banknotes," in *Applications and the Internet (SAINT), 2010 10th IEEE/IPSJ International Symposium on*, 2010, pp. 316 –319.

[11] R. Jain, *The art of computer systems performance analysis - techniques for experimental design, measurement, simulation, and modeling*, ser. Wiley professional computing. Wiley, 1991, pp. I–XXVII, 1685–, isbn: 978-0-471-50336-1.

[12] W. Kelton, R. Sadowski, and D. Sturrock, *Simulation with Arena*, 4. ed., internat. ed., ser. McGraw-Hill series in industrial engineering and management science. Boston [u.a.]: McGraw-Hill Higher Education, 2007, XXIII, 630, isbn: 978-0-07-110685-6. [Online]. Available: http://gso.gbv.de/DB=2.1/CMD?ACT=SRCHA&SRT=YOP&IKT=1016&TRM=ppn+548108498&sourceid=fbw_bibsonomy.

[13] H. Kinoshita, T. Morizumi, and K. Suzuki, "Financial securitization with digital rights management system," *Applications and the Internet, IEEE/IPSJ International Symposium on*, vol. 0, pp. 197–200, 2009. doi: http://doi.ieeecomputersociety.org/10.1109/SAINT.2009.75.

[14] L. Liu, M. Song, X. Luo, H. Bai, S. Wang, and J. Song, "An implementation of the online-payment platform based on saas," in *Web Society (SWS), 2010 IEEE 2nd Symposium on*, 2010, pp. 658 –662.

[15] F. Luan, M. Nygård, and T. Mestl, "A mathematical framework for modeling and analyzing migration time," in *Proceedings of the 10th annual joint conference on Digital libraries*, ser. JCDL '10, New York, NY, USA: ACM, 2010, pp. 323–332.

[16] H. Matbouli and Q. Gao, "An overview on web security threats and impact to e-commerce success," in *Information Technology and e-Services (ICITeS), 2012 International Conference on*, 2012, pp. 1 –6.

[17] S. N. Mehmood Shah, A. K. B. Mahmood, and A. Oxley, "Analysis and evaluation of grid scheduling algorithms using real workload traces," in *Proceedings of the International Conference on Management of Emergent Digital EcoSystems*, ser. MEDES '10, New York, NY, USA: ACM, 2010, pp. 234–239.

[18] R. Sastre, S. Bascon, and F. Herrero, "New electronic funds transfer services over ip," in *Electrotechnical Conference, 2006. MELECON 2006. IEEE Mediterranean*, 2006, pp. 733 –736.

[19] P. Seltsikas, G. Marsh, M. Frazier-McElveen, and T. J. Smedinghoff, "Secure government in cyberspace?," in *Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times*, ser. dg.o '11, College Park, Maryland: ACM, 2011, pp. 359–361.

[20] L. Sesera, "Applying fundamental banking patterns: stories and pattern sequences," in *Proceedings of the 15th European Conference on Pattern Languages of Programs*, ser. EuroPLoP '10, Irsee, Germany: ACM, 2010, 1:1–1:30, isbn: 978-1-4503-0259-3. doi: 10.1145/2328909.2328911. [Online]. Available: http://doi.acm.org/10.1145/2328909.2328911.

[21] E. Sousa, P. Maciel, C. Araujo, and F. Chicout, "Performability evaluation of eft systems for sla assurance," in *Parallel Distributed Processing, 2009. IPDPS 2009. IEEE International Symposium on*, 2009, pp. 1 –8.

[22] T. Tchrakian, B. Basu, and M. O'Mahony, "Real-time traffic flow forecasting using spectral analysis," *Intelligent Transportation Systems, IEEE Transactions on*, vol. 13, no. 2, pp. 519 –526, 2012.

[23] J. Vines, M. Blythe, P. Dunphy, and A. Monk, "Eighty something: banking for the older old," in *Proceedings of the 25th BCS Conference on Human-Computer Interaction*, ser. BCS-HCI '11, Swinton, UK, UK: British Computer Society, 2011, pp. 64–73.

[24] C. Vishik, A. Rajan, C. Ramming, D. Grawrock, and J. Walker, "Defining trust evidence: research directions," in *Proceedings of the Seventh Annual Workshop on Cyber Security and Information Intelligence Research*, ser. CSIIRW '11, New York, NY, USA: ACM, 2011, 66:1–66:1.

[25] L. Xiaojing, W. Weiqing, and Z. Liwei, "The mechanism analysis of the impact of ecommerce to the changing of economic growth mode," in *Robotics and Applications (ISRA), 2012 IEEE Symposium on*, 2012, pp. 698 –700.