

Petri Net Modeling for Parallel Bank ATM Systems

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ABSTRACT

In this paper the real time operation of an automatic teller machine (ATM) is analyzed using a Timed Petri Net (TPN) model. In the modeling, the probability of arrivals, the speed and attentiveness of customers (clients) are taken to account. Different parameters are based on the statistical data. The model is simulated for 24 hours. The diagrams of number of succeeded customers, failed references to ATM, idle times of ATM and wait times of customers are the outputs of TPN model.

KEYWORDS: *TPN model - ATM - Petri*

1. INTRODUCTION

A bank ATM is composed of several objects such as: display unit, card verifier, communication components, keypad, printer, etc. Each of these units needs a special TPN model [1] to predict its action in response to statistical references to it. These models can be simple or complicated. To analyze the entire system each component must be analyzed and then the interrelations between them are modeled to get the final result. However the analysis of systems that have interactions with human is a very difficult task because of his/her unpredictable behaviors in particular, especially in panic, conditions. In such conditions different types of actions in the ATM system may occur, which is very difficult and sometimes impossible to consider all of them in classic models based on statistical analysis. In such conditions, softwares for real time modelings [2, 3] and simulation tools such as TPN [4] will be useful. In this paper the dynamical behaviors of ATM systems are modeled and analyzed using Petri Net.

2. A BRIEF REVIEW OF ATM SYSTEM

The ATM components may be classified into three main classes namely: ATM machine,

ATM controller and Credit Card authorization system, as shown in Fig. 2.

The modeling of the system is carried out by the following steps:

i) Events and states of the three components are identified. The possible events are: Customer arrives, credit card is inserted, pin code is entered, and pin code is validated. Caused by these events, the possible states are identified added to the states list.

ii) Three time Petri Nets are constructed for events and states of ATM machine, ATM controller and Credit Card authorization system. Figure 3 shows the structure of the primitive model adopted in [1] to design the entire Petri Net model of the ATM system shown in Fig. 1.

iii) Additional mechanisms are added to base Petri nets to make their behaviors more realistic.

iv) Each model is tested separately to find different ill conditionings and to resolve them, before the construction of the entire model.

v) The three models are connected, based on the logic of ATM operation to construct the entire model of the system. To do this, the interaction places are designed and two types of transitions are used: timed transitions and immediate transitions.

vi) The model is tested, employed and the results are plotted for different outputs.

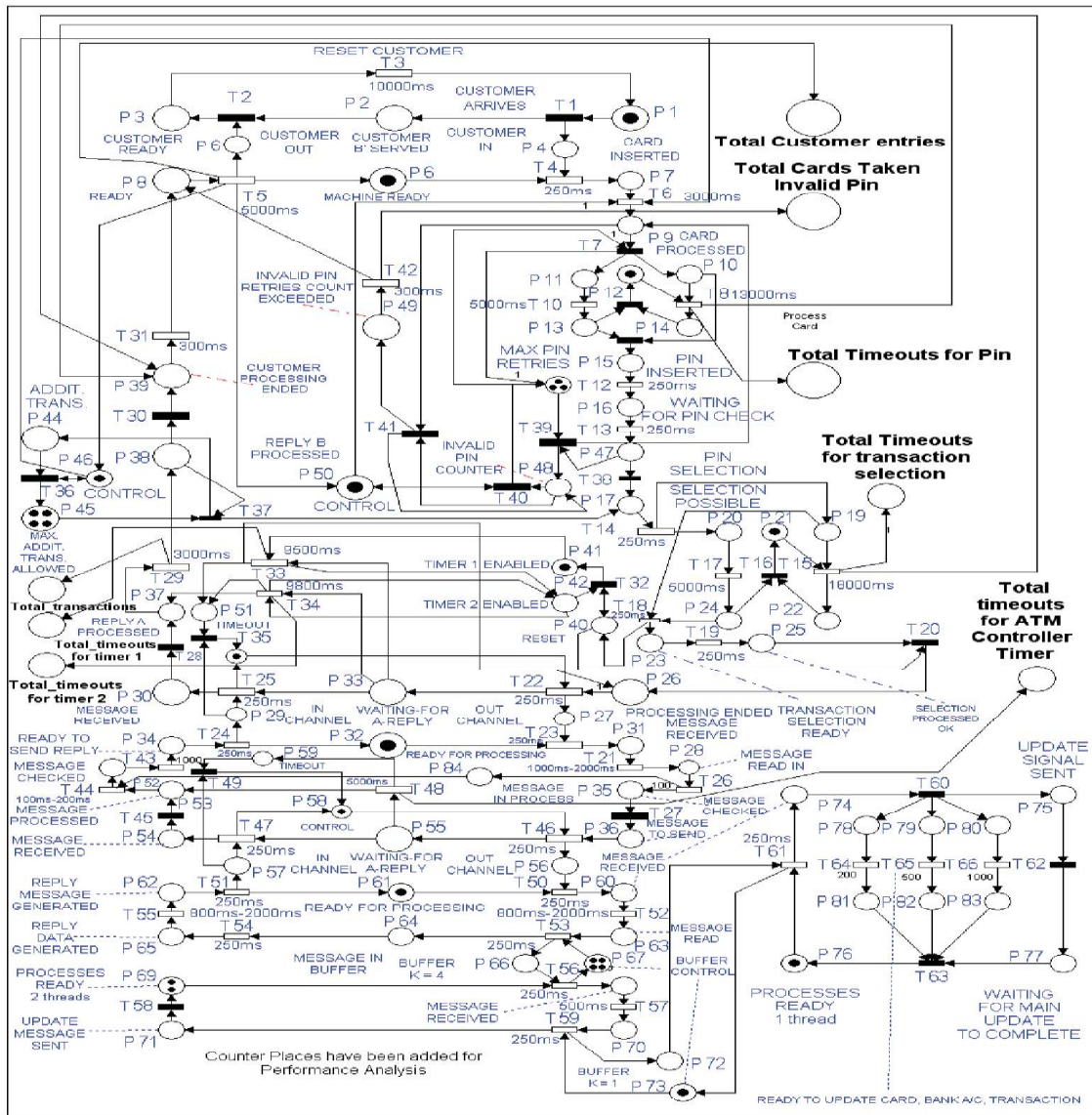


Fig. 1. The entire model of ATM system (Ref. [1])

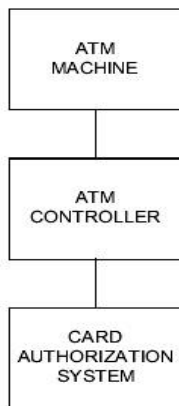


Fig.2. Three components of ATM system

2.1. ENTRANCE TO ATM

In the basic model of ATM, it is considered that clients arrive by a probability density function with fixed parameters. Whereas in the real world, especially in different periods of time (morning, noon, afternoon, night and midnight) the mean times of arrivals of clients are different. To overcome this inconvenience an entrance model representing the stochastic behavior of arrivals of clients is added to the base model. Figure 3 shows the structure of the entrance TPN. Table 1 represents the maximum and minimum interval times of arrivals, and the codes of transitions of entrance model for different periods.

Table 1. Arrival times and transitions codes

$t_{max}[s]$	$t_{min}[s]$	Transient	Time[hour]
540	180	T85	0-6
300	60	T86	6-8
30	6	T87	8-12
48	12	T88	12-14
36	18	T89	14-18
90	18	T90	18-20
120	60	T91	20-24

Considering table 1 and Fig. 4, when the time is for example between 14 and 18, the transition T89 is activated with a random time delay in the range 18- 36 seconds, representing the arrival of a client. Transitions 79 to 84 and 92 have fixed delay times representing the periods of time that the corresponding part of the model is activated. For example in the time period 14 – 18 , transition T82 puts a token in place P117 and transition T89 can be activated . Places P122 to P128 are used to count the number of clients arrived in different periods of time and place P120 is the buffer for counting the total number of clients and is used as the input buffer for the main ATM system.

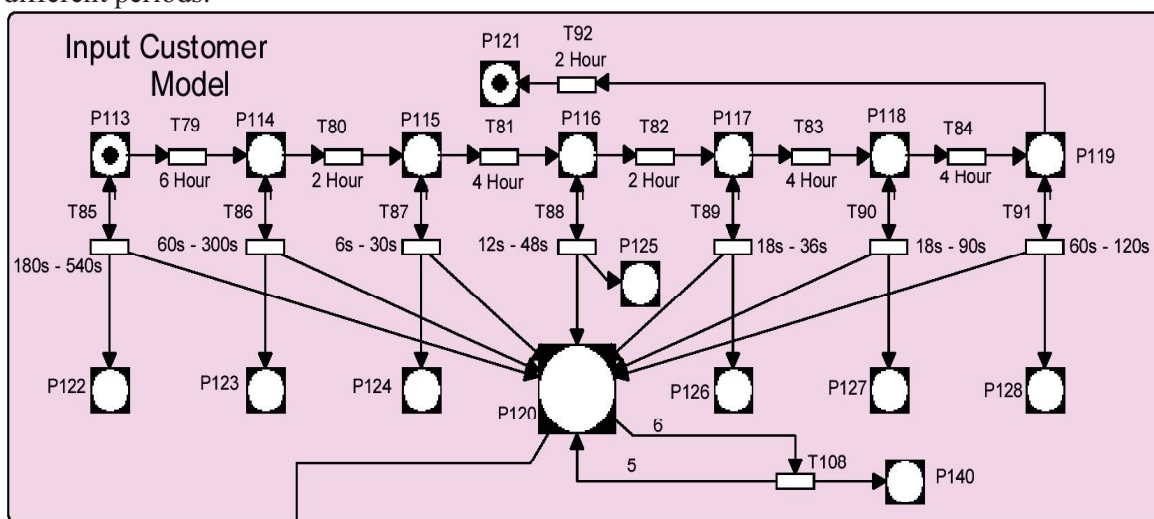


Fig.3. Entrance TPN model

2.2. INTERACTION SYSTEM

The keypad has an important role in the interaction between client and ATM. In the model of Ref. [1] a delay time of about 5 to 18 seconds is considered for interaction between client and ATM via keypad. In real time applications this delay depends on different conditions and environmental effects such as the sex of the client, his/her age, period of time (noon or midnight ...), coldness. In this paper only the period of time is considered as a main cause for the randomness of the interaction time. Table 2 shows the ranges of interaction times (including keypad delays) for different periods of times. In the introduced model the transition T12 of model 1 is replaced by the Petri net model of Fig. 4. By this way the real time randomness is applied to the main model without any major changes in its

structure. Note that this model can be developed to consider different situations such as distraction, stress, etc.

Table 2. Interaction delays and transitions codes

$t_{max}[s]$	$t_{min}[s]$	Transient	Time[hour]
90	60	T104	0-6
60	40	T103	6-8
30	10	T102	8-14
40	15	T101	14-18
50	20	T100	18-22
80	50	T99	22-24

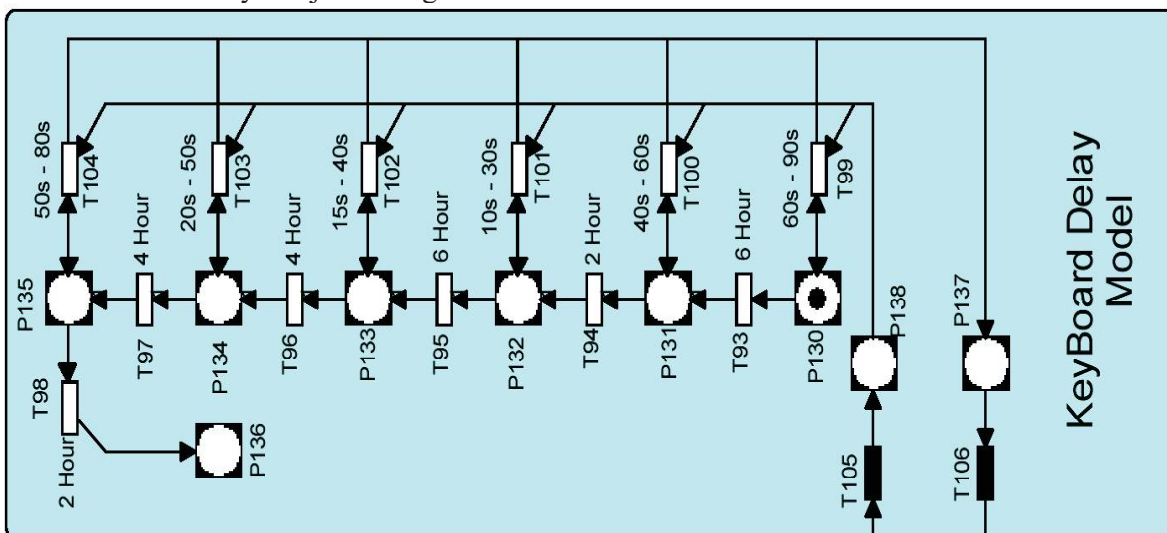


Fig. 4. TPN model of the interaction delays

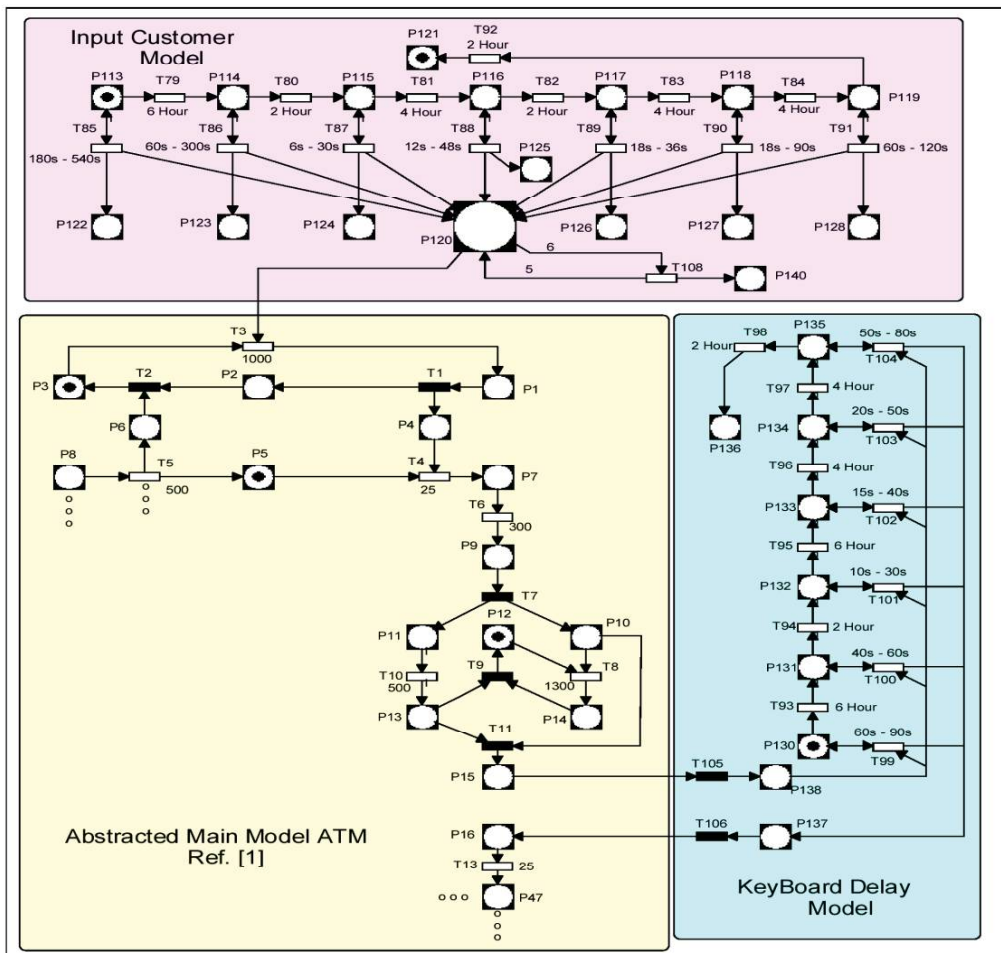


Fig. 5. Entire TPN model of ATM

3. SIMULATION RESULTS

Figure.5 shows the entire TPN model of ATM. The model is extended to two similar ATMs positioned nearby. This model has been run for a period of 24 hours with the precision of 0.1 seconds.

The following results are obtained by analyzing the outputs of HPSim simulator [6]. Figure 6 shows the number of clients that have successfully used the ATM (are served) in the case of one or two ATMs respectively. In this figure “Max input” represents the number of clients that can use a single ATM when there are always clients in the waiting line (as considered in [1]).

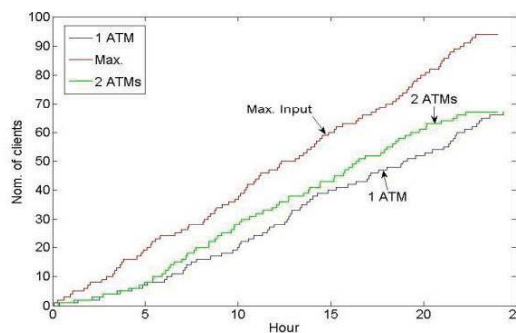


Fig. 6. The number of succeeded (served) clients in different periods of time

Figure.7 shows the amassing of clients (waiting lines) in different periods for one and two ATMs respectively.

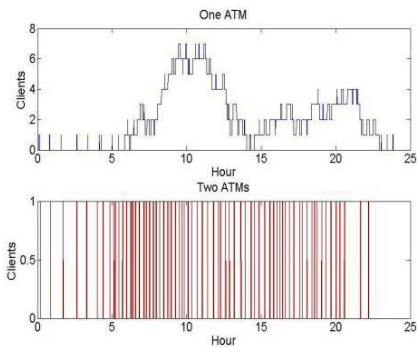


Fig. 7. Waiting lines for one and two ATMs in different periods of times

Figure 8 represents the maximum waiting times of clients in different periods for one and Figure 9 represents for two ATMs respectively.

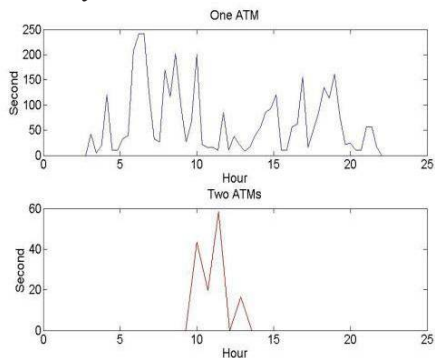


Fig. 8. Maximum waiting times of clients in different periods of times for one and two ATMs

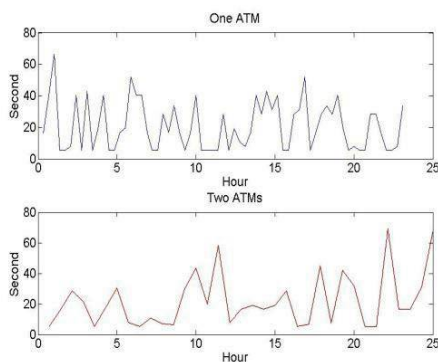


Fig. 9. Service times of clients in different periods of times for one and two ATMs

4. CONCLUSION

In this paper, a new Timed Petri Net model is introduced for modeling and simulation of

ATM in real world applications where the arrival times of clients and their service times are stochastic processes, the arrival times and service time parameters depend on different situations. The analysis of simulation results shows that during the starting time of the working day (normally about 1.5 hours after the start time of the working day) the number of clients increases rapidly while at the end of the working day, it decreases. Also between 14 and 16 the number of clients in wait line is not so high. By using two ATMs, the waiting times of clients considerably decreases, especially in a large period of time there is about no waiting time (fig. 9) However it seems that the service times are appropriately the same for one or two ATMs, meaning that most times of clients are spent because of delays in different steps of ATM operations. Therefore, in order to reduce the times spend by clients it is necessary to improve the different operation times of ATMs.

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- [6] HPSIM Petri Net simulation tool, Copyright (C) 1999 -2001 Henryk Anschuetz was used to build the Petri Net in Figure 6.