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AN ANALYSIS OF TRANSACTIONS IN E-PAYMENT SYSTEM USING MOBILE AGENTS

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ABSTRACT

Commercial interactions between merchants and customers pose a significant concern as they are associated with a large volume of data and complex information, especially when there is a need for switching requirements. This paper presents an agent-based analysis of e-payment transactions with the switching operations. The model adopts an inter-bank transaction network and consists of a terminal point of sale (POI) and three essential players in e-payment: customer, bank (merchant), and the Switch. This study analyses the various payment interactions using agent technology. The agent coordinates movement while the negotiation protocol serves as an internal control of the payment agreements, while the interactive hosts are the platforms that determine the status of transactions. Each agent host is equipped with a Certification Authority (CA) to secure communication between the merchant and the customer. Different transactions that agents could make are examined with formal descriptions. The implementation is achieved in Jade and compares with the object serialization mechanism. The simulation results show higher quality adaptation of agent systems and evidence of agentisation of e-transaction with Switch.

Keywords: Electronic Payment, Mobile Agents, Payment Security, Inter-bank Transactions, and Distributed Databases.

INTRODUCTION

Information technology has its basis in the simulation of human thinking and behaviour. In this respect, it has become glaring that interaction and distribution should be regarded as staple intelligence requirements. The conditions involved in the interactions between merchants and customers concerning price, the brand of products, services, and most importantly, payment are not trivial. In e-commerce, payment is considered the most critical aspect because of its sensitivity. E-payment allows a transition from paper to e-cash, which offers a more convenient method of settling the transaction. High speed, transaction anywhere at any time, and low cost of the transaction are but few of its advantages (Reaves *et al.*, 2015). Other benefits of e-payment include reducing human error, an increase in accountability, the transformation from large equipment to mobile tools, and fast billing. For these reasons, there is the likelihood of transaction database with faster, smarter transactions enjoyed by the participants (Guan *et al.*, 2004; Zoran et al., 2007; Vincent *et al.*, 2017;

Santos and Inline, 2004; Yuan *et al*., 2020). The participants in e-transaction are mainly merchant, customer, Issuer, Bank, Switch.

Transactions are settled through a switching company that enables different banks to inter-operate and interconnect without incurring the overhead cost of individually interconnecting parties. The financial switching companies differ but are closely related from country to country (Wang and Li, 2020; Staykova and Damsgaard, 2020). For example, in Nigeria, the financial transaction switching companies include InterSwitch Limited, Cards Technology Limited (CTL) in conjunction with MasterCard International, e-Transact and ValuCard in collaboration with VISA International, etc. (APACS, 2002; Benou, 2010; Duric *et al*., 2007; Sheng *et al*., 2004; Aron, 2015; Zhu *et al*., 2019). Interswitch remains the dominant of all. The points of interaction (POI) include point-of-sale (POS) terminals, automated teller machines (ATM), Internet, mobile phone, and the recently evolving Kiosk. E-payment transaction is generally between the merchant and the customer who interact on business services either online or offline. Its challenges among others include validation of transaction, verification of transaction and security (Barskar et al., 2010; Claessen *et al*., 2003; Hanafizadeh, and Khedmatgozar, 2012; Santos and Inline, 2004; Eldegwi et al., 2015; Egger, 2003; Zhao et al., 2018).

Consider a situation when a group of independent cardholders reside in the same location with the merchant, say in an e-marketplace. In a distributed environment, provincial authorities can access, access, manipulate data, and services extend to payment transactions. The following questions could arise in such a situation: (i) what commercial interactions occur between merchants and customers? (ii) What are the possible transactions in e-payment systems? (iii) How does e-transaction gets validated and more? These interactions pose great difficulties associated with a large volume of data and complex information that has to be processed.

Therefore, to address the problems of volume and complex information in payment interactions, the need for modularity, abstraction, distribution, and intelligence, which are expected to be displayed by both merchants and customers, cannot be overemphasized. This implies an essential requirement for intelligent distributed modules, hence the use of agents. In this paper, e -transaction with switching interaction using agent technology is presented. The model consists of the three interactive players in e-payment: the purchaser, merchant (bank), and the Switch. The model adopts inter-bank transaction network principles where parallel transactions are processed.

The rest of this paper is organized as follows: Section 2 provides the related works. Section 3 presents the concept of the mobile agent, its security issues, and different transaction in e-payment. Section 4 describes the implementation procedure and the performance evaluation with discussions. Section 5 concludes the work.

RELATED MODELS

The literature on agent-based e-payment systems is immensely growing; though, most studies considered a one-sided merchant environment, focusing on just the merchant's impact on the cardholders and vice versa. The few studies that examined market environment find some participants like the Merchant, the Issuer, the Acquirer, and the Cardholder but do not analyze payment transactions. At present, no literature deals with the types of transactions.

Shamoun and Sarne analysed the best-valued agent by investigating agent search for the agent with the best value in a multi-agent system using a threshold. Since agent values are independent of one another, classic state-space search methods were not considered suitable solutions since they must probe all agents' importance to determine who the best-valued agent is. The technique was studied to make more effective the number of agents that need to be investigated by iteratively publishing thresholds on acceptable agent values. Experiments on how threshold-based search can augment existing economic as an economic search technique itself were examined. The analysis was extended to the case of search for multiple agents. Their method's important implication was that it improves the performance of legacy economic-search methods that were commonly used in ‘search theory’ (Shamoun and Sarne, 2013).

The research introduced a minimum agent-based model for financial markets to understand the stylized facts' nature and self-organization. The paper focused on four essential parameters, namely, fundamentalist agent which tend to stabilize the market, and chartist agents were introduced to induce destabilization, analyze the price behaviour for the two strategies, and herding behaviour that governs the possibility of changing policy. However, the model does not consider what happens in the market after the agents are dispatched (Alfi, *et al*., 2009; Hayashi, 2006). Agents, MObility, and tRansaction (AMOR) is an agent-based transaction management protocol for the wired peer-to-peer environment with Decentralized Serialization Graph Testing (DSGT). AMOR uses resource agents to wrap local database, log local service invocations, and record regional conflicts (Haller *et al*., 2005). Transaction agents use such information to resolve conflicts collaboratively. However, local autonomy and indirect conflicts were not considered (Ontang *et al*., 2008).

Transactional Agents for Pervasive Computing (TAPCO) was another close work that proposes a transaction management infrastructure for a pervasive environment. The model utilizes mobile agents to resolve conflicts of transactions. This serves as an update to AMOR and builds a globally agreed schedule before execution at the local level. TAPCO preserves Atomicity, Consistency, Isolation, and Durability (ACID) properties, guaranteeing reliable database transactions. It also allows parallel processing of global transactions and accommodates dynamic changes of the ad-hoc environment. It handles indirect conflicts without violating the data sources (Ontang *et al*., 2009). Though TAPCO does not impose any restrictions on the nature of disconnectivity and the transactions, and it does not integrate intelligence to its mobile agents. The mobile agents cannot learn, initiate and process transactions, and negotiate with other agents or data sources.

Another study was the one that describes an agent-based Transaction Management scheme for Mobile Multidatabase (AT3M) systems. The model uses autonomous agents to enable a fully distributed transaction management, supports users’ mobility, allows parallel execution of the global sub-transactions. Autonomous agents presented global transactions and sub-transactions. The protocol offers quality service-based prioritization on the user’s profile (Ontang, Hurson,

& Jiao, 2008). AT3M does not enforce any constraints on the structure of the global transactions or the disconnections' nature. Zhoa et al. (2019) considered trust as a critical factor in online payment transactions. The study examined the factors that contribute to trust-building and payment decisions in China's online transaction. Sone questions trust were analysed from the perspective of knowledge contributor characteristics and the reputation on the paid Q&A platform. It also examined how to price moderates the relationship between trust and payment decisions. The finding showed that price was a substantial factor for trust (Zhoa et al., 2019).

This study examines and analysis what happens in the banking transaction using the mobile agent technique. Agents are used to conducting transactions on behalf of the user to foster faster and much easier traction.

The proposed E-Payment Transaction using Mobile Agents

This study adopts the definition of the mobile agent given in Braun and Rossak (2005) in which MA was considered as self-contained and identifiable computer programs, wrapped with its code, data, and execution state, which can move within a heterogeneous network of computer systems. Computer programs interact with minimum intelligence because they are considered the outcome of many interactions (Muller, 1996). Mobile agents consist of three main components: code, data, and state execution a described in Eq. (1).

$$MA = A_C + A_D + A_E \quad (1)$$

AC, AD, and AE represent the agent code, data, and the execution state. The code contains the agent's logic, and all agents of the same type use the same code. The logic is a formal representation of the agent's information. The codes are separated from the agency code to be transported alone to another agency, and the code must be identifiable and readable by the agency. This implies the code must be written in a language understandable by the recipient agency.

Furthermore, the concept of an agent is an instance of a class in object-oriented languages. Data correspond to the value of the agent's instance variables, sometimes called the object state. The execution state is composed of the instruction pointer's current value and the stack of the underlying processor whose elements are neither directly controlled by the processor nor the operating system. This differentiates it from objects state.

E-Transactions with Mobile Agent

The study considers inter-bank transactions. The model consists of a terminal POI and three essential players in e-payment, customer, bank (merchant), and the Switch. Agents are designed to represent these players to make transactions with the control of all events at every stage of various payment interactions by the Switch. The model assumes that the same agent- bank agent (BA) could play Issuer and Acquirer's role as it may apply. At the back-end of the POI is the Switch network connected to the banks' front–end. Transactions from the POI hit the Switch from where it is sent to the issuing bank's front–end. At every front-end is a mini Switch that drives the POI to its destination.

If a customer *agent* uses a card within bank *A* network on POI (*A*), the Personal Identification Number (PIN) is used to retrieve information. This determines the direction of the transaction. Otherwise, the Switch uses the Batch Identification Number (BIN) in determining the transaction destination. If it is within its network, it will automatically send the transaction to the banking host, which authorizes or denies transaction as the case may be. Some of the payment acronyms are further described in Table 1.

Table 1: Description of Payment Terms

Acronyms &Terms	Descriptions
POI (Point of Interaction)	A point at which cards or cards information could be used; examples are POS, ATM, and Kiosk.
POS (Point of Sale)	A terminal that can record and track customer orders, process credit and debit cards, connect to other systems in a network and manage inventory.
Merchant Merchant	Acts on behalf of the banking organization. It offers two kinds of services: selling and from whom payment will be made.
ATM (Automated Teller Machine)	An electronic banking outlet, which allows customers to complete basic transactions without the aid of a branch representative or teller.
Kiosk	A machine that works like ATM but does other functions like Internet facilities
Purchaser	Card-carrying customers.
Issuer Issuer	Mostly banks, that issue the cards
Acquirer Acquirer	The bank that transaction is to be forwarded to.
Switch Switch	A small intelligent hardware device that joins multiple computers together within one local area network (LAN)
Switching Company Switching Company	A company that enables different banks to inter-operate and interconnect without having to incur the overhead cost of individual interconnection.
Batch Identification Number (BIN)	A unique number assigned to a *batch* of checks or other demands for payment.
Personal Identification Number (PIN)	A number allocated to an individual and used to validate electronic transactions.

In the design, *100* customer agents were dispatched by a user with different lists of transactions. The MAs visit each POI server in turn to perform the required transaction. If the desired request is present, the transaction is processed; otherwise, it moves to other servers. When the transaction is completed, the MA returns to the user with the response details of the transactions performed. Details of transaction history are store in a database. While the merchant socket listens to the transaction coming in from the POI, the Switch in Figure 1 decodes all transactions to determine the transaction destination. A transaction manager is saddled with the responsibility of controlling and managing events at every stage with code upgrade notice to all the hosts. Each host is equipped with a Certification Authority (CA) to provide secure communication among the hosts. Figure 1 shows the agent's operations for inter-bank transactions.

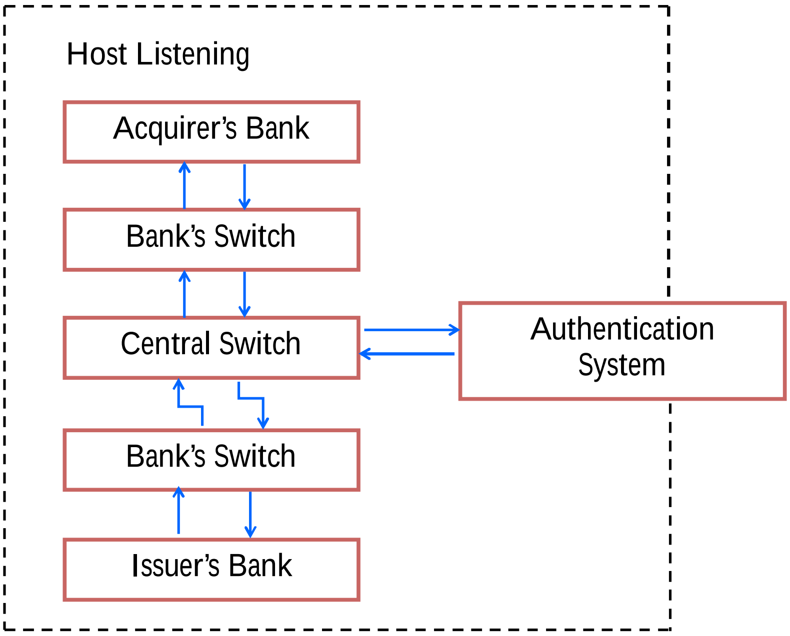

Figure 1: An Interbank E-payment Transaction

Transaction Cases

Possible transactions in e-payment are recognised as follows: *Purchase, Balance Inquiry, Mini-statement, Return, Reversal, PIN Change, Transfer,* etc. It is assumed that an agent carrying bank card *A* could move to bank host *B* for its transaction. Four significant cases are identified as related to the scenario. This work also adopts the functionalities of MA described in (Braun and Rossak, 2005) and analyses the following cases of transaction:

Case 1: Single customer agent making a single transaction (T_s) with the number of requests *R*. This is a situation where a customer agent moves to a server to conduct a single transaction. If purchase, the request may be the purchase of say three items, for example, clothes, shoes, and drinks. In this case, a single transaction is made with three requests. The transaction relation is given as

$$A_s \rightarrow T_s.$$

Case 2: Single-agent with multiple transactions. A single agent is sent to make multiple transactions, say, purchase, withdrawal, transfer, etc. The transaction relation is denoted as $A_s \rightarrow T_m$

Case 3: Multiple agents with single transactions. Different customers are sent to make a single transaction. The relation here is $C_m \rightarrow T_s$. If the transaction is made at the second host, then the agent would only migrate three times. This means it does not carry any reply message from the first host.

Case 4: Multiple agents with multiple transactions. The relation in the case is $A_m \rightarrow T_m$. Agents migrate from its home host to another host h_i, which also produces costs for code, data, and transmission request. Assuming there are transaction denials that may arise from either invalidity of the card number or by other means, the percentage denial of a transaction would be a fraction of total transactions terminated from the total number of transactions executed during the simulation time. A transaction will be denied if, during validation of the request, fraudulent activity is suspected.

Security Problems of MA

The security problems of mobile agent applications could be expressed with the concern of protecting the platform, host, agent, and route. This is explained as *MA* against the host where it is being executed, host against a host, *MA* against *MA,* and *MA* in transit. Security problems are not peculiar to *MA*; challenges are also encountered in other areas, and they are tackled vehemently. Up till now, researchers are still battling with network security. MA's security is encapsulated in Authentication, Secrecy, Confidentiality, and Integrity (Jung *et al*., 2012; Marmot and Perez, 2009).

There have been different approaches proposed to combat these problems. The SET protocol, supported by major corporations such as VISA Inc. and MasterCard, are evolutions of the existing credit-card based payment system which provides enhanced security for information transfer as well as authentication of transactions (Claessen *et al*., 2003; Buccafurri et al., 2011; Vincent *et al*., 2010a; Jailani *et al*., 2008). It uses Secure Socket Layer (SSL), Secure Transaction Technology (STT), and Secure Hypertext Transfer Protocol (S-HTTP) and, to an extent, makes use of some parts of critical public infrastructure (PKI) for its security. Though, there are still some reservations regarding the degree of its security. One of the essential obstacles to SET implementation is that it is very complex and confusing for its users (Singelee and Preneel, 2004; Vincent *et al*., 2010b).

To secure the communication between agents on different hosts, Java Agent Development Framework extra (JADEX) has enabled the Secure Socket Layer (SSL) protocol to provide confidentiality and integrity for all intra-platform connections (Vincent and Lawal., 2018; Vincent, 2012; Vitabile *et al*., 2009). Secure Electronic Transaction/ Transport Layer Security (SET/TLS) protocol was also introduced to e-commerce applications because it satisfies security, scalability, and compatibility (Dwivedi *et al*., 2013; Niranjanamurthy and Dharmendra, 2013; Srivastav, 2015). SSL solves the problem of transmitting secure information between the customer and the merchant.

With the above assumptions, it is believed that platform, host, and route problems could be easily tackled. This work has it focus more on the host authentication and, more importantly, the integrity of the agent. Moreover, since e-payment applications involve electronic cash, agents are targeted objects for attackers. Therefore, to secure this, elliptic curve cryptography is used for the platform, host, and agents' protection. The details on the elliptic curve cryptography (ECC) employed in this work and its security strength in e-payment applications have been presented (Vincent *et al*., 2010a).

IMPLEMENTATION AND RESULTS

The implementation of this work is in two dimensions: object serialization and Jade implementation. The agent language is FIPA-SL0, with banking operations as the ontology. Communication was in many actions of what transpired among the agents. Constant communications exist between the customer agent and the bank. Immediately a transaction is invoked by a customer agent. All the other players start listening. In the first phase of any transaction process, the elliptic curve verifier authenticates a customer agent's integrity and encrypts its information. The certification authority ensures that the purchaser has the right to make any transaction in the network. The result of the transaction process is used to upgrade the information which is sent back to the verifier to ensure that the agent is still in its original. Algorithm 1 shows the first operation.

Algorithm 1: Banking Transaction with Agent
Input: Card Information
Output: Encrypted Transaction Result

```
(request
:sender    (customer@transaction.net)
:receiver  (bank@transaction.net)
:language           (FIPA-SL0)
:ontology (banking operations)
:content  (action
                    (transaction request)
                    (agent registration  :name - :pin . . . :bin …)
                    (data
                        (ecc security check)))
:ecc security       (: type encrypt m
                    :root of  p_m = (x,y)
                     :P multiplied by k = point Q)
```

The second phase was done by serialising objects and sending them to another Java Virtual Machine (JVM) via sockets. This was achieved with bouncy Castle Java API version 1.23 with the class comparison.java. When the serialized object arrives at the destination JVM, it is deserialized and reactivated by invoking a specified method. This method is specified as a parameter. A database is designed to hold all the data about the banking system, like details of customers, transactions completed, accounts updates, etc., which is distributed by replication. The database is made with MySQL Server. Once a tuple of the database is opened, no one can access it until this entity has released it. Thus, at any time, a tuple is under control of only one MA. This feature facilitates parallel transactions whereby multiple agents can access the same database in parallel, and concurrency control is achieved.

The different hosts are also equipped with a certification authority to certify incoming agents as either valid or malicious. This authority checks the authentication of the agent before an agent could be allowed to make transactions. An abstraction of processes that contain Elliptic Curve Cryptosystem (ECC) with curves recommended by NIST and Federal Information Processing

Standard (FIPS) based transaction is provided to avoid compromising the integrity of data transferred.

Performance Evaluation

In this section, some evaluation of the model was analysed by considering multiple agents with multiple transactions and the implications on the bandwidth, the transaction delay as against transaction request, and throughput of the serialized objects with Jadex agent.

Multiple Agents with Multiple Transactions

An investigation was done on the effect of sending multiple agents to make multiple transactions for cases 3 and 4. The performances were examined by determining the variations in the number of hosts visited against response time. The result shown in Figure 2 reveals that time increases at a higher rate as the transaction increases. This shows that when multiple agents are used, response time increases.

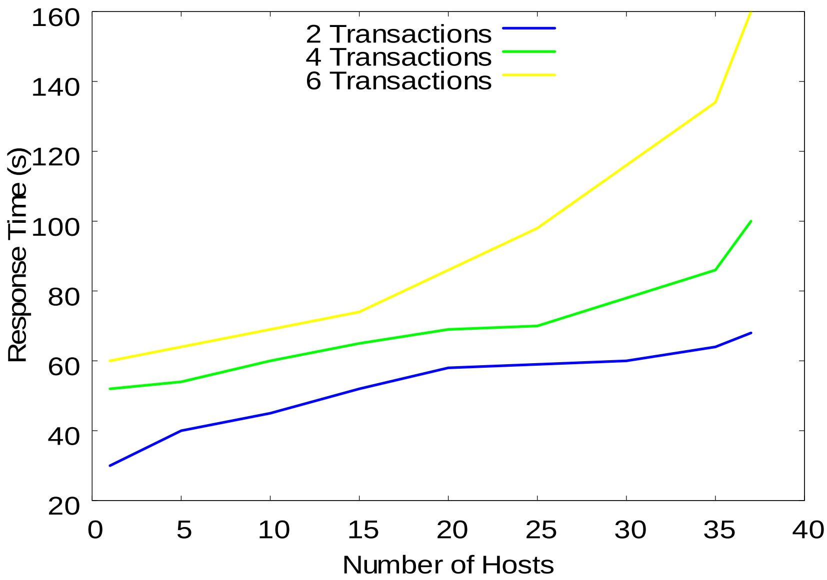

Figure 2: Number of Hosts versus Response Time

Transaction Delay Examined Over Transaction Request

The transaction delay as against the number of transaction requests was examined, as shown in Figure 3. This measures the adaptive strength of the two approaches varying the rate of transaction delay. The reduction in delay reflects the advantages of the advantage of AATEPMA over the AT3M. Consequently, fault tolerance and robustness of the POI network are revealed in high capacity by reducing the dependency of the operations on the Switch.

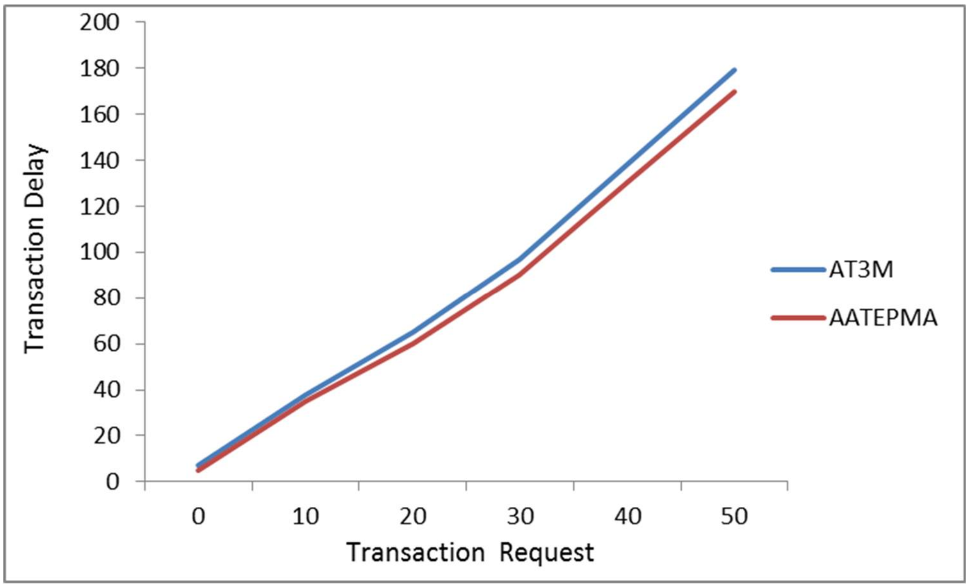

Figure 3: Transaction Delay against Transaction Requests

Throughput

Efforts were also extended to measuring the rate of transaction performance. The comparisons were made according to the number of transactions requested against transaction throughput. Throughput is plotted against the number of transactions, and the result is shown in Figure 4. The number of communication messages depicts the required bandwidth, which is plotted against the number of transactions. Figure 5 shows the result obtained. From the Figure, AATEPMA gives higher throughput than AT3M. Figure 6 shows the performance of the proposed method over others in the literature.

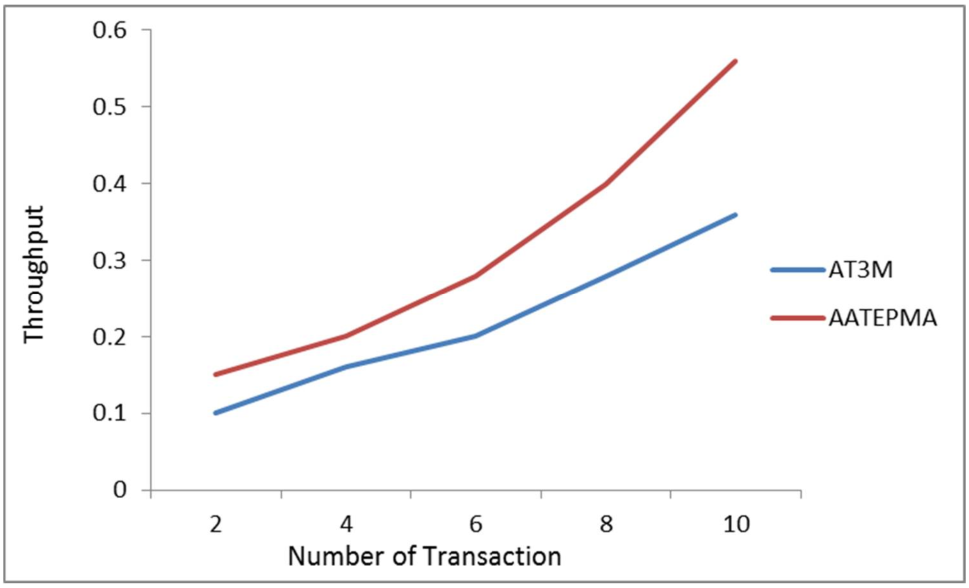

Figure 4: Throughput against Number of Transactions

Multiple Agents versus Response Time

An investigation was also done on the effect of sending multiple agents to conduct various transactions. Observing the performance by varying the number of agents with response time, the result in Figure 4 shows a certain period of stable response time experienced by both the RPC and the MA approach. The periodic stability in response time indicates that there should be a limit to the number of agents sends for optimal and reliable results. From Figure 5, stable and secured transaction could be achieved when the number of agents is within the range *A* and *B.* Furthermore, in the MA approach, response time does not necessarily increase after this limit while in RPC, it multiplies.

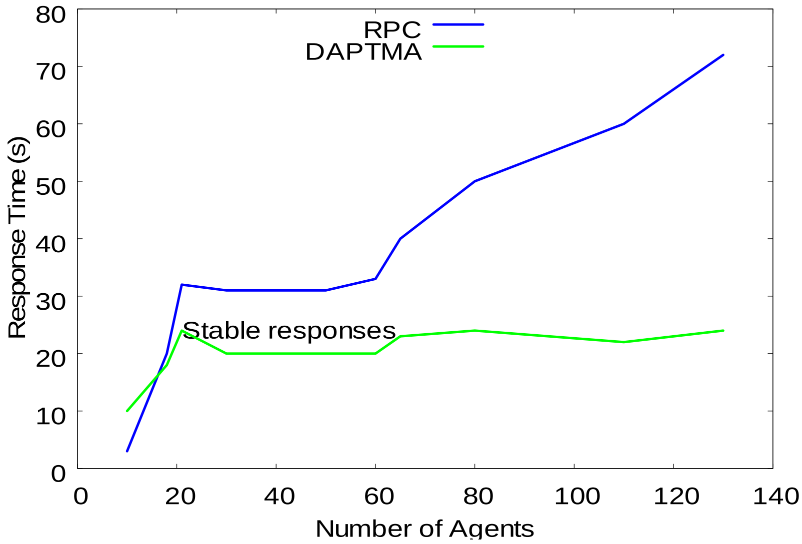

Figure 5: Number of Agents versus Response Time

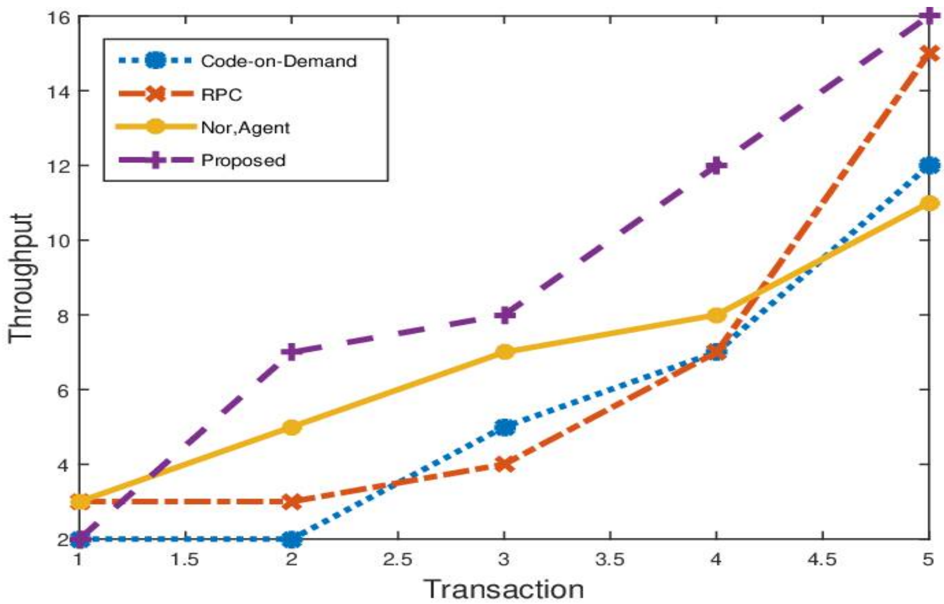

Figure 6: Throughput of Different Models

DISCUSSIONS

Figures *3* and *6* show a property similar to the distribution of $Y = Ke^{ax}$,where $a \geq 0$. Suppose *a = 0*, *Y = K*. If *a* is negative, *Y* is a rapidly decaying function. If *a* is positive, *Y is* a fast-growing function which grows to infinity. This shows the exponential property, which is always difficult to solve. It is agreed that this seems difficult to handle. As a result, the predictability of its behaviour might seem limited, and the system becomes error-prone. Thus, the waiting time also determines the genuineness of the agent. The implication of this is that, if the current state of the agent at time *t* is recorded, the transition to a new *state* at time *t+1* is independent of all previous *states*. This proves that specifying the agent's *state* at any time *t* would ensure integrity.

When there is a reoccurring multiplication of a particular base of a system, then that system is said to be exponential in behavior. Its behavior is explained, say, there is one agent represented with integer *k*. When two agents are sent, then it becomes k^2, which could be generally defined by k^n. A multi-agent system comprises of multiple agents interacting intelligently within an environment called agency. It is always used to solve problems that are mostly impossible for an individual agent. Though, it is subtly agreed that agent problems are better solved when they are to interact independently. Still, when a group of agents is involved for a common goal, such as the one described in this work, then the behaviour may exhibit that of exponential property.

Brafman and Domshlak admitted this complicated nature of problems involved in planning for a team of *k* cooperating agents and identified two parameters to avoid the complexity. The parameters are the precise tasks the multi-agent system is to solve. The second is task-dependent on the number of interactions by the most interaction agent of the group (Brafman and Domshlak, 2013). This, to some, extends the exponential problem within the stipulated parameters.

Representing agent's activities with multiple agents cannot be avoided because of its quite numerous advantages. Its advantages are expressed in its robustness, scalability, adaptability to any environment, concurrency over such situation, fault-tolerant in action, and apparent flexibility displayed by its behavior. In multi-agent systems, the failure of an individual agent is immaterial to the whole system's functionality. When one agent fails, the other gets on. If multi-agent systems have some drawbacks associated with the control and reliability, a single agent representation cannot produce a reliable service.

In another perspective, one solution to the problem of waiting time is that agent is made not to visit the host it had seen before. Agents are also grouped in performing tasks that worked in parallel.

Although parallel transactions are said to be complicated, they are fascinating in this case for several reasons. While agents seem better able to focus their attention on one activity at a time than to transact in parallel, a parallel transaction helps locate and compare agents' state. Handling attacks are more comfortable when the sequence of the agent's events is known. Note that the bandwidth usage in cases *2* and *3* will increase but not necessarily high in proportion to the hosts visited before making transactions as one could have expected. This is because agents would not need to return to its home host before visiting another host.

CONCLUSION

This paper has presented a transaction control model using intelligent mobile agents in the electronic payment system and analysed the performance of its acceptance, delay, and response time. The model consists of interactive methods such as banks, POI, Switch, and the customer. The model scenario gives a detailed description of what happens at any electronic transaction terminal. It was observed that when a single agent makes multiple transactions, it could incite vulnerability to security, and therefore such transactions should be minimized.

Mobile agent-based technology is a promising scheme that brings transactional benefits to both the merchants and cardholders. One of the advantages is reducing transactional costs; the network imposes no-surcharge rule, which prohibits merchants from charging fees to cardholders, unlike client-server, where merchants are assumed to set the same price for cash users and cardholders. The simulation results show the superiority evidence of higher possibility by mobile agent's scheme over the traditional computing of e-transactions. Hence, the mobile agent approach is a promising technique for transaction control in the electronic payment system.

Future work to this is to determine a save network track an agent's routes. How would this happen? Discovering a save network track is realistic in an agent's technology since mobile agents could work in offline situations. Another possible solution to exponentiation's problem reflected in endless waiting times may be to determine the shortest route an agent could follow. This would also further enhance security to a greater extent because the fewer the host encountered, the reduction in security threats.

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