Proceedings of the 1997 Winter Simulation Conference
ed. S. Andradóttir, K. J. Healy, D. H. Withers, and B. L. Nelson

EVALUATING THE PERFORMANCES OF ELECTRONIC COMMERCE SYSTEMS

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ABSTRACT

Electronic commerce over the Internet is a new concept. In recent years, several companies, including CyberCash, DigiCash, First Virtual, and Open Market started to provide a variety of electronic commerce services. To be successful, these services must meet their customers' needs. The purpose of this paper is to propose a general simulation model that can be utilized to evaluate the performances of various electronic commerce systems in meeting their customers real time access and responsiveness needs.

1 INTRODUCTION

The exponential growth of the Internet and the World Wide Web (WWW) created a new type of commerce: electronic commerce (E-commerce) on the Internet. E-commerce on the Internet is the exchange of goods, services, and information for money using the Internet capabilities. There are many forms of E-commerce: virtual shopping malls, electronic bill payment services, and electronic newspaper stands, to name a few. The volume of E-commerce on the Internet is expected to grow very quickly in the next few years, and according to some estimations it will reach 600 billion dollars by the year 2000 and 1250 billion dollars by the year 2005 [Lynch and Lundquist, 1996].

Currently, the most common E-commerce payment method is by credit cards, but the use of credit cards for this purpose has several deficiencies: credit cards are not suitable for micro payments (payments of less than $5, such as buying a single copy of an electronic newspaper), and without additional security measures, credit cards do not provide an adequate level of security. To address these issues, several companies have begun to provide a variety of electronic commerce payment services: CyberCash provides secured money transactions using alternative payment methods (credit-cards, digital checks, and digital coins); DigiCash provides a service that enables its users to transfer money into electronic cash in the form of encrypted electronic mail messages; First Virtual uses electronic mail to process debit transactions; and Open Market uses credit cards with additional security (PIN, passwords, and encryption).

2 A TYPICAL E-COMMERCE SYSTEM

2.1 E-Commerce System Architecture

The typical architecture of an E-commerce system consists of three major components: a "digital wallet" application which is connected to a WWW browser, and is installed on the customers' PCs; an "electronic store" application which enables the transfer of funds via the Internet; and a central processor application system which tracks and controls the transferred funds and provides access to banking institutions that are not directly linked to the Internet. In addition to that, the customers are connected to the Internet via Internet Service Providers (ISP). The E-commerce system architecture is shown in Figure 1.

2.2 E-Commerce System Operations

The communication between the different components of the E-commerce system is accomplished using a set of pre-defined messages.

For example, to buy a certain product using a credit card, the customer uses a WWW browser to reach the merchant web site. After the customer selects a product or service, he or she initiates the transaction by sending a C1 message to the merchant. Next, the merchant sends a C2 approval request to the Central processor. After the customer details are validated, and the transaction is executed, the Central processor sends a C3 approval message back to the merchant. Finally, the merchant

completes the transaction and sends a C4 acknowledgment back to the customer. The primary E-commerce messages are listed in Table 1.

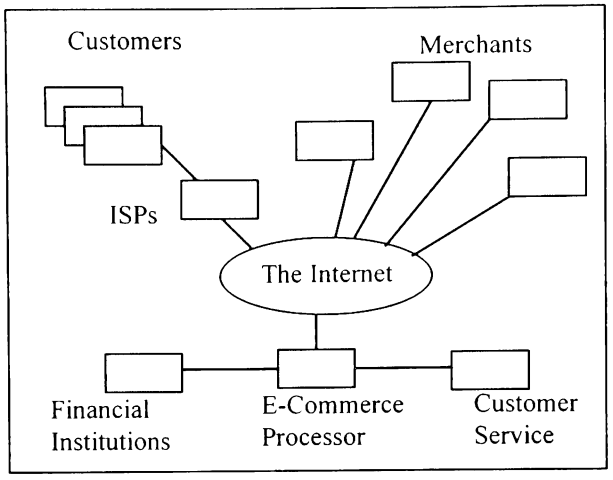

Figure 1: E-Commerce System Architecture

Table 1: E-Commerce Messages

Type	Description	From	To
R1	Register new user	Wallet	Processo
R2	Approve	Processo	Wallet
M1	Move funds	Wallet	Processo
M2	Approve transfer	Processo	Wallet
B1	Initiate cash sale	Wallet	Merchan
B2	Request approval	Merchan	Processo
B3	Approve cash sale	Processo	Merchan
B4	Finalize cash sale	Merchan	Wallet
C1	Initiate credit sale	Wallet	Merchan
C2	Request approval	Merchan	Processo
C3	Approve credit sale	Processo	Merchan
C4	Finalize credit sale	Merchan	Wallet

2.3 Digital Cash

E-commerce cash transactions are executed using digital cash. Digital cash is the most promising alternative to credit card payments on the Internet, especially for micro-payment transactions. Digital cash is a pointer to money that an E-commerce customer transfers from either a bank account or a credit card into an escrow account. When the customer pays with digital cash, the paid amount is transferred from the customer's escrow account to the merchant.

2.4 The E-commerce Messages Structure

Each message consists of multiple fields (typically between 10 and 50). These fields vary in size between 1 byte and 256 bytes. Each message has a unique transaction number field and a time tag field in addition to the fields that hold the relevant information about the customer, the transaction, and the merchant. There are three types of fields: mandatory (such as credit card number), optional (such as second address), and conditional. The conditional fields enable the use of the same message type for various purposes, for example, using the same M1 message to transfer money from either a bank account or a credit card into a customer's "digital wallet."

2.5 Processing Time

The system central processor validates and processes all the transactions, and records them in a database. Similarly, all the transactions that are sent to a specific merchant are being validated and recorded by the merchant's application. The actual processing time depends on the central processor hardware and software implementation. Additionally, in order to provide an acceptable level of security, the messages are encrypted. In the context of this discussion, the only impact of encryption is additional processing time.

3. ASSUMPTIONS

The following assumptions are made about E-commerce systems and their operations:

1. On average, the E-commerce customers generate 10 transactions per second.
2. All of the E-commerce customers can be represented using a single computer group.
3. The E-commerce merchants can be represented using three user groups, based on their business: product merchants, information merchants, and service providers.
4. The response messages from information merchants to their customers contain the requested information as encrypted attachments. Consequently, these messages are significantly larger than the other messages in the E-commerce system (up to several megabytes).
5. The messages generated by the E-commerce system customer service department may be excluded from the preliminary simulation since their volume is relatively small.
6. The messages inter-arrival time has a negative exponential distribution with mean λ.
7. In order to provide an acceptable level of security, the messages are encrypted. In the context of this

discussion, the only impact of the encryption and decryption processes is an additional processing time.

4 SIMULATING E-COMMERCE

4.1 The E-commerce system model

The proposed E-commerce system model consists of two models: a model of the E-commerce network and a model of the E-commerce user profile. The E-commerce network model is shown in Figure 2. It consists of a single computer group that represents the customers, three separated computers groups that represent the three different types of merchants (product, service, and information), and the E-commerce processor. These components are connected through the Internet. An additional computer group that represents financial institutions is directly connected to the E-commerce processor via a private network.

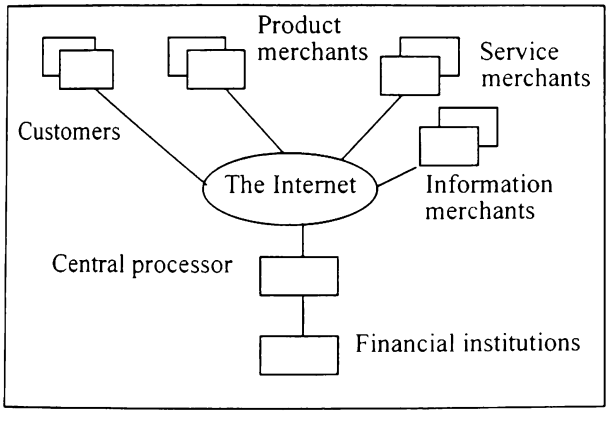

Figure 2: E-Commerce System Model

The detailed design of the simulation requires detailed specification of the various messages, their sizes in bytes, their inter-arrival times, and a definition of the time it takes to process each type of message. The E-commerce users profile model consists of multiple scenarios. These scenarios describe the customers' generated message distributions, their processing times, different message destinations, different digital cash and credit card transaction distributions, and a variety of Internet delays. Table 2 illustrates the contents of these scenarios.

4.2 Quality Of Service (QOS)

In order to evaluate and interpret the simulation results we need to select a set of Quality Of Service [QOS] parameters. According to a recent survey that was conducted by ORC for MCI, the primary QOS parameters for Internet users are: Real time access, Responsiveness, and Reliability. The following QOS parameters represent these requirements:

- The E-commerce system blockage probability
- Time to complete new customer registration
- Time to complete a money transfer
- Time to complete a digital cash transaction
- Time to complete a credit transaction

Table 2: Typical Scenarios

Parameter	Scenario 1	Scenario 2
B1 interarrival time	0.2	0.2
C1 interarrival time	0.2	0.2
% of product trans.	*25*	*33*
% of service trans.	*25*	*33*
% of information trans.	*50*	*34*
% of digital cash trans.	60	60
% of credit cards trans.	40	40

5 APPLYING THE SIMULATION MODEL

5.1 When To Apply Simulation

Simulation should be applied through the E-commerce system life cycle, beginning with a crude simulation model in the design phase, and enhancing this model as we collect more data about the actual processing times and the delays in the system.

5.2 Selecting a Simulation Tool

The process of selecting a simulation tool was discussed at length by the author in a paper that was presented at the 1996 WSC [Yarden, 1996]. In order to shorten the distance between research and application, and to focus on the E-commerce system rather than on the development of the simulation environment, it is recommended to use a Commercial On The Shelf (COTS) communication simulation package, such as CACI's COMNET III ®.

COMNET III is a discrete-event communication networks simulation environment that contains pre-defined hardware, protocol objects, and built-in graphics and reporting. COMNET III has two built-in functions that are particularly relevant for this application. One is the response message capability that makes it very easy to simulate cascades of events. The second function is the ability to capture actual communication loads using standard communication probes (such as HP OPENVIEW) and feed them back into the simulation. For more information about communication network

simulation tools in general and COMNET III in particular, the reader is referred to two papers that were presented in the 1995 WSC [Law and McComas 1995, Jones 1995].

6 CONCLUSIONS

This paper describes a proposed simulation model of an E-commerce system. One of the primary parameters that define the QOS of an E-commerce service is its typical response time. Discrete event simulation can be used to evaluate and project typical response times and delays in E-commerce systems.

The proposed simulation model consists of a model of the E-commerce system network and a model of the E-commerce system user profile. In this model, customers generate request messages that are sent to the system central processor and to the electronic merchants via the Internet. The system central processor and the electronic merchants process the customer requests and send appropriate response messages. In addition to that, the system processor sends messages to financial institutions.

The detailed design of the simulation requires a specification of all the various messages and of the corresponding processing times. Such a model can be easily implemented using a COTS network simulation tool such as COMNET III .

A crude simulation model should be developed in the early phases of an E-commerce system design and implementation. As the E-commerce system expands, a higher fidelity simulation model can be developed using actual measurements.

REFERENCES

Jones, J. 1995. COMNET III: Object-oriented network performance prediction. *Proceedings of the 1995 Winter Simulation Conference*, ed. C. Alexopoulos, K. Kang, W. R. Lilegdon, D. Goldsman, 545 - 547. Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.

Law, A. M.., and McComas, M. G. 1995. Simulation of communication networks. *Proceedings of the 1995 Winter Simulation Conference*, ed. C. Alexopoulos, K. Kang, W. R. Lilegdon, D. Goldsman, 46 - 50. Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.

Lynch, D., and Lundquist, L. *Digital money*, John Wiley & Sons 1996

Yarden, S. 1996. Injecting simulation and modeling upstram in the system engineering process. *Proceedings of the 1996 Winter Simulation Conference*, ed. J. M. Charnes, D. M. Morrice, D. T. Brunner, J. J. Swain, 1421 - 1425. Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.

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