Measurements and Quality of Service Issues in Electronic Commerce Software*†

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Abstract

The performance of network and communication software is a major concern for making the electronic commerce applications in a distributed environment a success. The quality of service in electronic commerce can generically be measured by convenience, privacy/security, response time, throughput, reliability, timeliness, accuracy, and precision. We present the quality of service parameters, software architecture used in e-commerce, experimental data about transaction processing in the internet, characteristics of digital library databases used in e-commerce and communication measurements for such data. We present a summary of e-commerce companies and their status and give an example of electronic trading as an application.

1 Basic Concepts of Quality of Service Control

Quality of service control requires an understanding of the quantitative

parameters at application, system, and network layers. The interplay among these parameters needs to be evaluated by building a transaction oriented system for electronic commerce application on top of a distributed system.

1.1 Quality of Service Layering

There are several efforts which try to formalize the QoS requirements for distributed multimedia systems [10]. There is no global agreement on the precise meaning and formal definition of QoS. We partition the QoS parameters into two subsets, namely application-dependent parameters and application-independent parameters. We classify QoS parameters into three layers: user parameters, application parameters, and system parameters as shown in Table 1. The system parameters can be classified into two categories: network and operating system parameters and device parameters.

Since most electronic commerce applications require multi-media presentation to the customer from the venders, the quality of audio and video is important in addition to images, text and numbers. Application parameters describe requirements for application services and are specified in terms of media quality and media relations. Media quality includes source/destination characteristics such as media data unit rate and transmission characteristics such as response time. Media relations specify relationships among media, such as media conversation, interstream synchronization, and intrastream synchronization. Other application parameters are convenience, price comparison and satisfaction, return policy, guarantee

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QoS Layer	QoS Parameters
Application	Frame Rate Frame Size and Resolution Response Time Throughput Security and Gurantee of Transaction Price and Convenience
System	Buffer Size Process Priority Scheduling Policy Caching Policy Time Quantum
Network	Bandwidth Throughput Bit Error Rate End-to-End Delay Delay Jitter Peak Duration

Table 1: Quality of Service Layers

and atomicity of committed transaction. Some of these parameters at a high level can be included in general parameters defined as accuracy, precision, and timeliness. Timeliness, Accuracy, Precision (TAP) can together form a good criteria for QoS. Timeliness is defined as "when an event is to occur". Maintaining it means meeting a deadline. Accuracy is defined as "the degree to which the output conforms to the semantics and contexts of the applications". Maintaining it means guaranteeing the correctness of the data. Precision is defined as "the quantity of information provided or processed". Maintaining it means maintaining the amount of data being processed or transmitted over the network.

System parameters describe communication and operating system requirements that are needed by application QoS. These parameters are specified in quantitative and qualitative terms. Quantitative criteria are those that can be evaluated in terms of concrete measures, such as bits per second, number of errors, task processing time, and data unit size. Qualitative criteria specify expected services, such as interstream synchronization, ordered delivery of data, error recovery mechanisms, and scheduling/caching mechanisms.

Network parameters are specified in terms of network load and network performance. Network load refers to ongoing traffic requirements such as interarrival time. Network performance describes the requirements that must be guaranteed, such as bandwidth, end-to-end delay, and jitter. The network services depend on a traffic model (arrival of connection requests) and perform according to traffic parameters such as peak data rate or burst length. Hence, calculated traffic parameters are dependent on network parameters and are specified in a traffic contract. Device parameters typically specify timing and throughput demands for media data units.

2 Architecture of Electronic Commerce Software

The architecture to set up the software for an electronic commerce systems is based on the client-server paradigm[9, 6]. A simple workstation or personal computer with internet connection serves as the client at the customer site. The window based interface with color can be useful. A large pool of webservers, a router with an incoming link to the outside world, a switch that routes the incoming package to a webserver and a large disk for the database are the main components at the vender site. A backend webserver software such as the "Apache" server or a dynamic content server can take care of most transactions and provides fairly enhanced capabilities. The database is usually a large depository of multi-media images including video, text, and files. The user interaction is through a window based system but eventually presented to the system in the form of database transactions. The book [6] discusses network infrastructure, architecture framework for electronic commerce along with issues of security and payments. The research work at Carnegie Mellon University [5] present the security issues, business models, set of protocols, and certified delivery mechanisms. A prototype implementation is also discussed. The research at MIT media laboratory [4, 3] discuss the software agents that are intelligent versions of transactions and mobile processes. Software agents are employed to help with difficult and time consuming tasks in electronic commerce activity. The researchers have experimented with a prototype system called Kasbah. It was found that agents reduce transaction costs associated with end-consumer to end-consumer transactions where financial, timing, and trust issues can impede negotiations and commerce.

Based on the authors personal discussions with people who are involved in building web (or internet) based commerce system, a small scale system can be set up at fairly low cost (app. $3,000) that can handle about 2000 hits a day. It may consist of a NT box with 450 MHz, 20 Gigabyte storage, and 1 Gigabyte of memory. This may be good enough for a small shopkeeper with say 2,000 items. However to go from this small scale to large scale system is not a trivial task. The small system is just not extensible to large scale system that may have to deal with thousands of transaction per minute with million of hits per day. The Oracle Corporation (a database system company) is providing upto 75% of the software for transaction processing in large companies requiring enterprise class software and dynamic content servers.

There is a major effort underway in industry to provide software that can match more closely the needs and buying patterns of the customer. This can help the customer in increasing the response time for a transaction and allow the system to actively help in finding items that may be of interest without endless browsing over millions of pages.

But the core software in an e-commerce company is a distributed system in which the users transactions span over a wide area network. The system software/hardware of the vendor is usually in one location but proxy servers may exist at multiple locations to cache information needed by many users repeatedly. Even though some companies are providing dedicated communication lines (T1-56Kbps, T3-45Mbps lines) for large customers, much of communications takes place over the internet via Internet Service Providers (ISPs). ISPs offer high speed connections to Internet. Global internet ISP may use ISDN [6]. Fiber optic-based integrated switching and transmission systems may allow for 155-1000 Mbps and may allow upto tens of millions of hosts in the future. Basically it is a local area network (LAN) environment in the customer and the vendor sites but they are conducting transactions via wide area network (WAN).

In the following sections, we present the behaviour of the communication environment, transaction processing over the Internet, and the digital library model of the database. These data are relevant for the design, implementation, and performance study of any e-commerce architecture and system.

3 Distributed Transaction Processing in an Internetwork

The communication software is a crucial component of Distributed Transaction Processing (DTP) software. Various components of a DTP system rely on this for high-performance and acceptable QoS. Customer and business communicate with each other via transactions that need to satisfy atomicity, durability, and consistency requirements. The servers at client, at business site, and for database content must communicate via message exchange. The DTP demands high performance and reliable communication among servers.

The performance of the communication software is largely dependent on the underlying communication media. Networks with different technologies and characteristics have been merged by the internetwork connections. Thus, the communication network spanning large number of geographically dispersed hosts will vary in speed, reliability, and processing capability.

There is a need for designing efficient and reliable communication facilities and scalable algorithms for DTP software components. We have experimented with the transaction processing on the Internet using different protocols for various needs. We briefly report the results of the performance evaluation of these protocols in the WAN environment.

3.1 Communication in the Internet and its Impact on Distributed Transaction Processing

To study the performance of DTP in WAN environment, the need for understanding the communication latencies and packet losses in an internetwork is essential. We have conducted the experiments to study the performance of message delivery in the Internet. A complete illustration of the experiments can be found in a technical report [2].

3.1.1 Communication Performance

Based on our understanding of the Internet, we identified the three factors that are most important in assessing the performance of message delivery: the physical connection, the size of message, and the cross-traffic. The physical connection between two sites includes the distance, the type of links, and the number of hops (gateways). To establish the connection, we studied the performance across different sites on the Internet. We examined the effect of the size of the message transmitted to its transmission time. The delays and losses due to cross-traffic were quantified but a useful relationship with the communication performance could not be established due to uncontrolled and dynamically varying usage of Internet by various foreign agents. Also, there is no easy way to determine the cross-traffic on a particular link. One way to circumvent the problem is to determine the traffic pattern at large, for the Internet. We suspected that it would be a function of the working hours, as the Internet usage determined the traffic pattern. To verify this, we examined how the time of the day and day of the week affects the message delivery performance in the Internet.

To summarize, we have conducted measurements in three dimensions: the *time* dimension by periodically repeating the experiments, the *site* dimension by repeating experiments with different sites, and the *size* dimension by varying the message sizes. We are interested in two performance measures: the round-trip time of a message and the message loss rate. In our DTP model, round trip time is the time for a site to send a request message to another site and receive a reply message back. Message is said to be lost when the transport service of the Internet fails to deliver the message in time.

Our experiments involved over 2000 sites and 500 networks in the United States. We probed the Internet with ICMP and UDP messages periodically and collected the data [2]. Based on these measurements, we can make the following observations.

- We observed that there is a large variation in parameters such as communication delay and message loss. The variations exist in two dimensions: along the time axis and across the networks.

- We observed that the time of day has strong influence on the message delivery. The message loss rate is much higher in the noon working hours, and much lower in the early mornings. The round-trip time for a message, on the other hand, does not have a strong correlation with the time of the day, except for the hourly peeks. This we believe is caused by the hourly jobs scheduled to run on gateways.

- We observed that the message delivery has an unbalanced performance across the wide area networks, although most of the hosts reported within 400ms round-trip. The *"clustering"* effect in the Internet is also observed. The communication between a site and many different sites on another local network has similar performance, which can be represented by any host on that network. Therefore, the latency between two networks can be used to estimate the communication delay between two hosts in these two networks.

- Finally, we observed that for small messages that can fit in an IP data gram without fragmentation, there is an approximate linear correlation between the transit time and the size of a message. However, the message loss is not affected by the size.

3.1.2 Impact on Distributed Transaction Processing

The performance analysis of communication in the Internet, reported in the previous section has a significant impact on distributed transaction processing on the Internet. In a WAN, message loss rate is much higher. The percentage of message loss is usually 5%, sometimes as high as 30% [2]. Early detection of changes in communication performance, such as latency and message loss rate must be considered.

networks.

4 Digital Libraries database for E-Commerce

One of the important needs in electronic commerce system is the need for providing customers unlimited, timely access to large depository of information about products, prices, and promotions. Digital libraries encompass the technology of storing and accessing data, processing, retrieval, compilation and display of data, data mining of large information repositories such as video, audio libraries, management and effective use of multimedia databases, intelligent retrieval, user interfaces and networking. Digital library data includes texts, figures, photographs, sound, video, films, slides etc. that represent a product. transmitting, consistent

4.1 Digital Libraries as a Database in e-commerce Environment

Existing repositories are distributed, and the data needs to be shared by many users. Information processing is distributed, and particularly, the user's queries can be so complicated that the process of information retrieval requires multiple rounds of message exchange between users and the various servers of the e-commerce information system. These factors result in communication behavior being one of the most important parameter for providing QoS.

The current network technology does not provide the bandwidth required to transmit gigabytes of objects representing products for sale. The cost of access in the context of communication and networking is the response time required to access data. A customer might have to wait for several minutes to receive the data due to bandwidth limitations.

In Table 2 we give a few estimates of the size of data objects to give an idea of the size of packets in an application. The figures do not represent an average or generalized size of data items of a particular media, but a sample of possible data item sizes.

4.2 Communication Measurements for Multi-media Data

Figure 1 illustrates the round trip times in a WAN. The round trip times rise sharply as file size increases and as the number of the hops increases. The difference between the largest size and the smallest size is as high as 23811.691ms.

Media	Size (Mbytes)
Text	0.1
Image	0.8
Video (Uncompressed)	48000
Audio (2 minute ad pitch)	1

Table 2: Examples of Product related Data Sizes

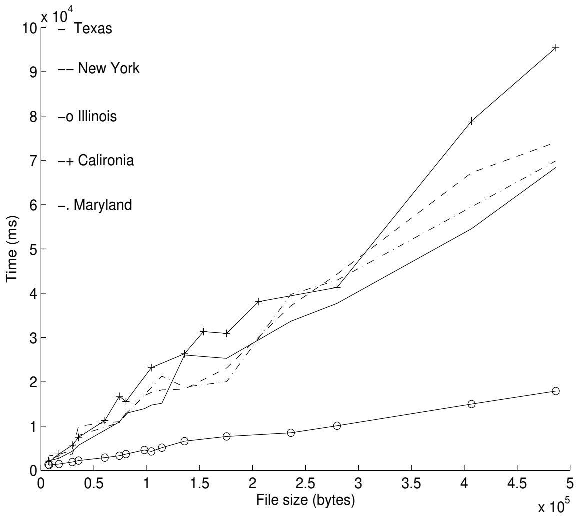

Figure 1: Variation of Transmission Time with File size in a WAN

E-commerce applications can use semantic knowledge of the data to reduce communication time. For example, a display can be represented hierarchically in varying degrees of detail. document document

sender's

Video data can be treated as a stream of images. The techniques described above for the efficient transmission of images apply to video data. Since video data is continuous, there are some issues specific to video data that are discussed in [1]. For further details the reader is referred to [7].

4.3 Quality of Service for Data Presentation

Different users can be provided with different quality of service as we outline below.

- **Presentation Quality:** Data items can be presented at different levels of quality. Visual data items (images and video) can be presented at different resolutions, different color depths, and different sizes.
- **Response Time:** We define response time as the time between the instant the user submits a data retrieval request to the time the data appears on the screen.

5 Electronic Commerce Companies and their Status

Electronic commerce companies can get started very quickly. As far as the software/hardware/communication, it does not take a who lot of resources. The quality of service demanded by customers is not very high particularly when they are not willing to pay for it. For example, day traders of stocks pay hundred of dollars per month charge so they can execute stock trades in less than a couple of seconds and they also go through a school in the use of the system.

Many companies are well known for e-commerce. For example Amazon.com, eBay.com, Ubid.com, Yahoo.com, Priceline.com are well known for their popularity among customers and general public. There are companies that provide for e-commerce in the mode of: business to business , business to customer (Amazon), customer to customer (eBay), and consumer to business (Priceline) Many of these companies have grown big in the last few years and have gone public recently. Their revenues have gone from a few million to several million but the increase in revenue may be several fold. Amazon claims a sale of 200 million dollars in Q4 of 1998. 60% of the customers are repeat customers. The profit margin on book sales is about 21% but the overall loss per share in Q4 is 8 cents compared to 12 cents loss in the previous quarter. Expected sales in 1999 is one billion dollars. Compare that to revenue growth of IBM that is expected to be in single digits. Though most e-commerce companies are in the beginning stages and losing money, eBay has shown a profit of 7 cents in Q4 of 1998 compared to 3 cents in the last quarter. eBay site is the 20th most visited site on the web and the customers stays longer per visit. You can auction any antique or memorabilia such as Mcguire's record breaking home run ball that was auctioned via Sotheby's/phone/eBay for more than three million dollars. While many companies stock has grown ten fold from their original IPO value, according to CNBC and the Wall Street Journal reporter Greg Ip, many of the original e-commerce or just internet companies are trading below the IPO (initial public offering price). They quoted examples of Spyglass, Edify corporation etc. Netscape was recently rescued by AOL.

It appears that the eBay model that allows customer to deal with customer while eBay makes money is a good business model. It has many problems that need technical solutions. Though Ebay has instituted a rating system for customers (some of them have been banned), customers can still be a victim of fraud. As an example, (according to John Hendren of the associated press, 1/28/99, a toy collector found out too late after paying $1,815 for a rare Beanie Baby that she bought on Ebay web site auction and getting a $5 stuffed duck instead. Auction houses say that they cannot be forced to protect consumers against bogus buys, any more than newspaper can be held responsible for the claims of classified advertizers. The eBay CEO Meg Whitman says "I think from a legal point of view, we have no liability". "We actually have a significantly responsibility to make Ebay as safe a site as possible to trade on. We also need to communicate that users have a responsibility as well". According to Whittman, fraud is exceptionally rae among its a million users. Less that 1/100th of 1 percent of its 700,000 daily auctions have problems. Market researcher Jupitor Communications estimates that the number of Internet auction sites will jump sixfold from 1.2 million to 6.5 million by year 2000 when they will spend about $7.1 billion. For eBay, the largest auctioneer, sales grew 724 percent in 1998 to $47.4 million. In an acknowledgement that fraud is a problem, eBay said that it would guarantee items from $25 to $200. One solution is to use an escrow service.

According to the recent revelations, Intel has coded in its lates chip an ID for the workstation. This will allow other to identify the customer. It can be for good use to deal with fraud but could also be used for junk mail that can bombarded to an unsuspecting customer.

6 Electronic Trading Application

In applications of electronic commerce there are many types of transactions. Examples of applications are financial institutions which can provide on-line access to status of accounts, orders, shipping date, pricing etc. Supporting payment by a client over the net brings the issues of security during the financial transaction.

Security can be enforced by authentication or encryption. Authentication has a communication overhead. It involves a lengthy exchange of information between the client and server such as keys before the secure channel is set up. Encryption has a computational overhead. If encryption is used only for small data messages used in a financial transaction, then the overhead is acceptable. But if huge multimedia data items are encrypted, along with the compression and decompression routines the encryption and decryption routines add a huge overhead to the data retrieval process [8].

Electronic trading is the most exciting but financially appealing applications. In electronic trading, there are several overheads. They are computation of algorithms, particularly encryption; I/O time for database access from various files; and the communication time for servers are involved in executing an order. For example, if the user wants to buy a particular stock, the real time quote has to be provided by the quote.com service. The user has to go the server at her machine to a server at the broker's site and finally to a server that has the actual information. In some cases, there could be as much as twenty message exchanges involved due to the additional need for authentication, reconfirmation, and seeking input from the user.

The process of executing a trade electronically is very similar to the process of trading in person or via phone. In person the additional overhead is in physically going to the broker' office. In trading over phone the overhead is in getting a busy signal or being put on hold. It is however rare that using these two methods, the user can be dissatisfied since a human broker is involved. So the quality of service is acceptable even if the communication overhead is high. In electronic trading the quality of service could be bad even for an experienced computer user. In an article in the magazine Individual Investor in Apr, 98 issue, a user mentioned difficulty installing an Internet Browser, getting access to his account and placing the trade. Basically he did not know the problems with all the servers and the communication was poor. It took him several hours to learn that his order was not executed but was good news since next time, he bought it at a lower price. In our experience to trade on phone, we found the steps as follows. The person dials the phone number of the broker (phone may be busy), the person picking up the phone has to page the broker assigned to the account, the caller is identified (not much problem of security on phone). The customer specifies the stock of interest, asks questions like bid and ask price (detailed questions as volume, high/low of the day may not be always possible without being put on hold again). The customer places the order for the trade and the broker calls back with confirmation of execution. The steps take about 3 to 4 minutes and the return call from broker may take up to 15 minutes or more.

The electronic trading over the Internet is the emerging technology and over 20 percent of the trades are done via the Internet. Ameritrade claims to have three million accounts for electronic trading. It costs about $250 to set up an account. This is different than computer trading by institutional investors where computer sell/buy programs are triggered based on some criterion. The electronic trading involves distributed processing and communication among several servers. The network latency plays a major role in the response times. First one must open the browser such as Netscape or the Internet explorer. This takes about 15 seconds on a PC. Next the user accesses the broker's home page that takes another 2 seconds. It takes another 30 seconds to go the trading page where one can be secure and login. After logging, the customer may want to get real time quote from a New York Stock Exchange server (such as quote.com service). It has taken 5 to 10 seconds depending on the time of day. After the transaction is entered, the system presents the order back again to the user for confirmation and that takes about 10 seconds. The user finishes the transaction with a confirmation entry. The user can also check the status of the order in 5 seconds. Other requests for holdings in account, price charts, research reports are simple database queries and take 5-10 seconds.

The whole process of ordering a transaction for stock or option trading takes several round trips among the servers on the person computer, the broker's computer and the NYSE/NASDAQ computers. The communication time over the WAN, LAN, and the security mechanisms affect the response time for the customer. Some time is for the display of pages on the screen. If the communication time can be reduced, the transaction can take place in about two minutes and that may be acceptable quality of service. The stock price can fluctuate in this time so for a day trader, or institutional investor, this is too much time. The electronic broker can not succeed unless the communication behavior can be improved via higher bandwidth. Many individual users have only one line coming in home for voice. The multi-media presentation requires better connections and modems. The user may want to watch a financial channel (CNNFN or CNBC) and at the same time talk on the phone and do electronic trading. The new box recently announced by Sprint Corporation that has one line going in the house but many phone services available inside will be a step forward in meeting such a requirement. The present configuration of having one line for electricity, another for TV, another for Internet going in the house is not very appealing and must be changed. The communications will make or break the success of not only trading but other electronic commerce applications. But buyer beware.

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References

[1] Bharat Bhargava. Network behavior and quality of service in emerging applications. In *Proc of the conference on Computing and Communication, Korea-American Association of Sciencist (KSEA)*, April 1998.

[2] Bharat Bhargava and Yongguang Zhang. A study of distributed transaction processing in wide area networks. In *Proceedings of the COMAD 95 , Bombay, India*, 1995.

[3] A. Chavez, D. Dreilinger, R. Guttman, and P. Maes. A real-life experiment in creating an agent marketplace. In *Proceedings of the Second International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology (PAMM-97)*, April 1997.

[4] A. Chavez and P. Maes. Kasbah: An agent marketplace for buying and selling goods. In *Proceedings of the First International Conference on the Practical Application of Intelligent Agents and Multi-Agent Tecknology (PAMM-96)*, April 1996.

[5] B. Cox, J. Tyger, and M Sirbu. Netbill security and transaction protocol. In *Proceedings of the First USENIX Workshop on Electronic Commerce*, pages 77–88, July 1995.

[6] Ravi Kalakota and Andrew Whinston. *Frontiers of Electronic Commerce.* Addisson Wesley, 1996.

[7] Shunge Li. *Quality of Service Control for Distributed Multimedia Systems.* PhD thesis, Department of Computer Science, Purdue University, December 1997.

[8] Changgui Shi and Bharat Bhargava. A light-weight MPEG video encryption algorithm. In *Proceedings of the International Conference on Multimedia Information Systems (MULTIMEDIA 97), New Delhi, India.* IETE, January 1998.

[9] Amjad Umar. *Client/Server Internet Environments.* Prentice Hall, 1997.

[10] Andreas Vogel, Brigitte Kerherve, Gregor von Bochmann, and Jan Gecsei. Distributed multimedia and QOS: A survey. *IEEE Multimedia*, 2(2), 1995.