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**INTEGRATED OFFICE SYSTEMS
OVER LOCAL AREA NETWORKS :
A PERFORMANCE STUDY**

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INTEGRATED OFFICE SYSTEMS OVER LOCAL AREA NETWORKS : A PERFORMANCE STUDY

by

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ABSTRACT

In this paper an integrated office information system environment, composed of multimedia workstations, printer servers, database servers, electronic mail servers, etc., interconnected by a Local Area Network (LAN), is modeled and studied. The performance of three LANs, namely APPLETALK, STARLAN and ETHERNET, in handling typical office system applications is evaluated. The study is done by discrete-event computer simulation, using the QNAP2 simulation software. Useful conclusions, pertaining to the comparison of the three LANs, are obtained.

Key-words:

Office Systems, Local Area Networks, Performance Evaluation, Document Production, Multimedia Data Base.

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Dans ce rapport, nous proposons une étude de modélisation d'un système de bureautique intégrée composé de stations de travail multimedia, de serveurs de base de données et de messagerie, interconnectés par un réseau local. Les performances de trois réseaux locaux : APPLE TALK, STARLAN et ETHERNET, dans un environnement bureautique, sont évalués. L'étude est faite à l'aide du système de simulation QNAP2. Les résultats fournissent une comparaison entre ces réseaux, qui ont des débits différents, allant de 230 Kb/s à 10 Mb/s, et mettent en évidence l'adéquation de ces réseaux au trafic bureautique.

INTRODUCTION

Many office systems today, whether created from a set of personal computers or traditional workstations, are getting interconnected to constitute what is now called "departmental" or "group" solution. The market has in fact resisted for more than 5 years in accepting the idea of Local Area Networks for the office. ETHERNET(4), which was one of the first LANs to be announced at 10 Mbits/sec in 1981, has been used in a few thousands of sites. Many studies and some simple observations have shown that it is "underused" (1% or .1% usage), especially when it interconnects between 5 to 25 workstations (PCs,WP,etc.) exchanging files and short text messages with printing,file and mail servers. Less expensive networks providing lower bandwidth have appeared introducing a complete set of non standard networks ,with a variety of interfaces and protocols (e.g. Novell,Omninet, and IBM's PC-Net based on Sytek technology at 2 Mbits/sec). The two latest networks announced are Apple's APPLETALK(1) at 230.4 Kbits/sec,and AT&T's STARLAN(3) at 1 Mbit/sec.

On the other hand, from the application side, we are watching a growing number of workstations with graphic features, and some with voice input for annotation in WP or short message exchange (voice mail) (e.g. AT&T UNIX-PC, IBM PC-AT and Apple MAC from the PC side , and from the WS side, the XEROX STAR, SUN WS, SYDIS etc.). These workstations are connected to NIP servers and shared multimedia databases. With such a powerful environment, data exchanges will increase potentially putting more strain on the new generation of LANs, which are decreasing in bandwidth.

In this paper , we have selected a set of present and future applications, such as manipulating multimedia data : multimedia database, formatting and printing and electronic mail. In each application, assumptions have been made on the nature of traffic which would be generated in typical departmental configurations. Then for each application , we have studied how 3 networks can match the need for these configurations. The networks selected are ETHERNET, STARLAN and APPLETALK. We will first present a typical Office Information System(OIS) and give the general characteristics of the various applications. Then we will briefly describe the three selected networks. Subsequently, we present Modeling and Simulation principles and describe QNAP2(5) , the Queueing Network Analysis Program which has been applied for this study. Finally, we present some results showing the performance of each network in every application environment described and obtain some useful conclusions.

All traffic which was studied, was generated in asynchronous mode and does not include any real-time traffic ,such as voice exchange between two human users, or animated images between two videoconferencing rooms. The reason is that the latter type of traffic causes a constant and heavy data load, which will definitely saturate the three networks selected.

OFFICE SYSTEMS AND THEIR TRAFFIC

A typical office system is (or will be) comprised of a set of workstations with graphic capabilities, some with high disk capacity and others diskless. This is an important remark in our study, because in the latter case a station which is sequentially browsing a multimedia document through the network would generate a heavy traffic between the server and the workstation during the complete session, which may take 5 min to 1 hour or more. While in the former case, the browsing is done locally, and may necessitate from time to time a copy of a big document from the server to the WS disk.

In addition to the WS, there might be a scanner which digitizes the images of the various objects (e.g. pages of documents, pictures, solid objects), which are of interest to the WS users. The scanner might be hooked on the network and include a local intelligence to perform a preprocessing of the image. In this case, the scanner will generate bursts of files to the database server. Those files may vary from 2 Kbytes minimum, corresponding to a full ASCII page that has been recognized with an OCR mechanism located in the scanner, to a maximum of 40 Kbytes of a complete page digitized according to Modified Huffman Code (Group 3-facsimile standard) (the compression in this particular case reaching a factor of 10).

The servers which are useful to add to the network are :Multimedia Data Base (MDB), Electronic Mail, Formatter and Printing Server. In the MDB ,we will find a general purpose processor with dedicated hardware to control the access to the disk. The storage media can be constituted of Optical Disks (12" containing 1 Gigabyte and the new 5"1/4 or Compact Disk with 500 Mbytes capacity), in quantity of one or grouped in a "Juke-Box" of 500 or Disk-Pack of 50. This new medium will motivate the office system designers to create huge data centers that might even be duplicated (to enhance reliability, or to partition the load among different servers). Workstations will send short queries (10 to 100 bytes) and get back short or large files. In some applications, Broadcast or Multicast can be used to send a long file to a group of users (Education Applications, Group Decision Making, etc.).

An Electronic Mail server will manipulate short and long messages. Although present mail systems exchange short messages and sometimes long messages including only text, there are strong reasons to predict that long documents containing graphics, text, and voice comments will be transferred by future mail servers. Thus the mail servers will act as Multimedia Data Base servers with the difference that the messages are stored temporarily (short period of time-1 min, 1 day, 1 week).

EL.MAIL MDB SERVER

SCANNER PRINTER

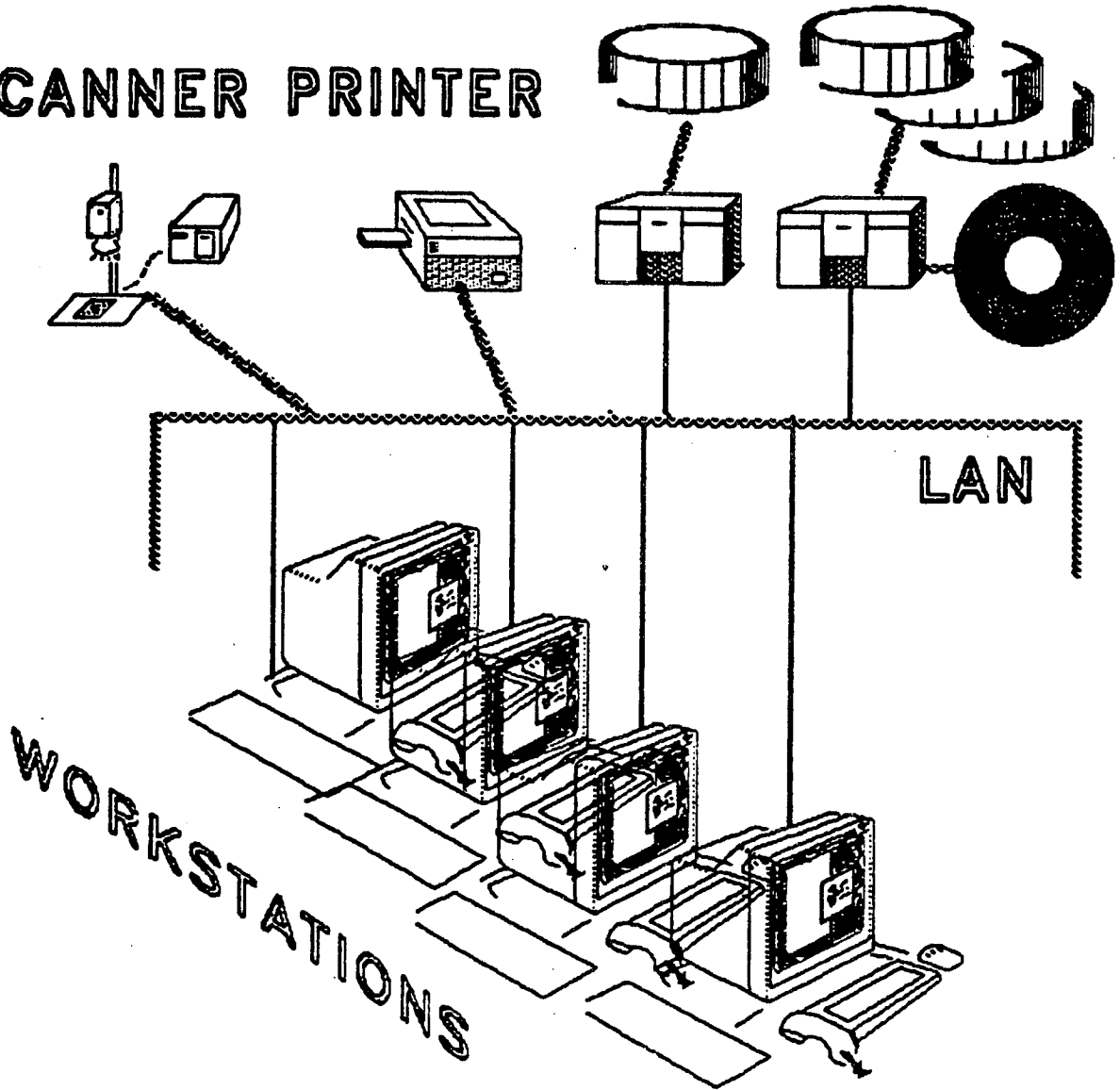


FIG. 1 INTEGRATED OFFICE INFORMATION SYSTEM

Formatting/Printing servers may exist separately or combined. In some particular cases, formatting is done by the workstation Editor and pages, in their final form, are transmitted directly to the printing server which does the rasterization. The assumption made here is that printers in the future will be non impact and thus will be driven by a graphic controller. The rasterization of one page may take 2 sec (alphanumeric) to 2 min (complex page with structured graphics, multifonts text, bitmap or facsimile picture and a form) for a 10 MHz 68000-based controller. The page description that we have adopted as the basis of our study is POSTSCRIPT (7). Printing servers without the spooling function will oblige every workstation to regulate its flow and, hence, create a typical traffic that we will analyse in a further section. When Printing Servers have the spooling function and are equipped with a large capacity disk, another traffic pattern will be generated with long files sent during a short session from the WS to the server. In the case of a formatting function located outside the WS, traffic will be exchanged between the two servers (printer and formatter) in more permanent way than between WS and the server.

THE LOCAL AREA NETWORKS CONSIDERED

Three LANs are considered and compared in this study. They are all using baseband transmission, a logical-bus architecture and Carrier-Sense Multiple-Access (CSMA) protocol.

ETHERNET, using CSMA-CD (collision detection), is a well known standard (4). It transmits at 10 Mbits/sec, using coaxial cable as the physical medium of communication.

STARLAN (3) is a new CSMA-CD, 1 Mbit/sec standard, using a twisted pair of wires. Physically, it is a STAR that converges to a short bus driven in CSMA-CD mode. It was introduced to create a lower cost than ETHERNET LAN standard, by using a lower speed and more economical cabling system. It uses different CSMA-CD parameters, compared to ETHERNET.

APPLETALK (1,2) is a very recent announcement of a LAN by Apple Computer Inc. It uses CSMA-CA (Collision Avoidance) over a twisted pair of wires (300 m maximum length) and its data rate is 230.4 Kbits/sec. It can interconnect up to 32 stations. Its interfaces are very inexpensive, and the Medium Access Control (MAC) protocol is implemented in software. Since it is a new development, a few more words on this MAC protocol are in order. When a station senses the channel idle, it waits for a random time (400 microsec) and then transmits a Request-to-Send (RTS) short (9 bytes) frame. When a Clear-to-Send (CTS) is received by the destination, a data frame (600 bytes of information at most, plus 9 overhead bytes) is transmitted.

Since there is no collision detection, as in ETHERNET and STARLAN, the transmitting node learns of a collision from the RTS/CTS exchange of control messages, then it tries again, adjusting the random time interval. This adjustment follows a linear algorithm that changes the back-off distribution dynamically in response to recent network traffic history.

MODELING AND SIMULATION

Several Office Information System configurations and protocols, using the three LANs mentioned above, were modeled using QNAP2.

QNAP2 (Queueing Network Analysis Program), copyrighted by CII Honeywell-BULL and INRIA, is a package for Queueing Systems performance modeling and evaluation (5). It incorporates many of the known analytical solvers of queueing networks, as also a discrete-event simulator. It uses an Algorithmic language, based on PASCAL and SIMULA, and a Control language. It is a very powerful and easy to use tool and it has been coded in FORTRAN77 for portability.

The CSMA-CD and CSMA-CA Medium Access Control protocols, as also all other higher order protocols we modeled, were written in QNAP2 language. This was a much easier task than simulating the queueing problems considered by a FORTRAN program, for example.

The QNAP2 simulation programs we developed used the Spectral Method of the package for the 95% confidence intervals estimation and the average performance measures evaluation. The simulations were run on a VAX-11/780 under Berkeley 4.2 UNIX.

In all cases, we considered 32 stations or servers connected to the LAN, because of the 32 nodes limit of APPLTALK on one hand, and the fact that future departmental systems will be installed reasonably with this number of ports as an average.

OFFICE SYSTEM CONFIGURATIONS: PERFORMANCE EVALUATION

We considered the following OIS applications, with details to be given further below:

- Document production : Printing text, graphics, images
 - . Without Formatter
 - .Printer without spooler
 - .Printer with spooler
 - . With Formatter
- Document browsing from a Multimedia Data Base;
- Electronic Mail .

A. Document Production

In this application we consider 31 stations transmitting pages of text, graphics, images or combinations of them to a printer server. It is assumed that POSTSCRIPT coding is used for text and graphics. With it we need only transmit up to 4 Kbytes per page, instead of a bit map of 1-8 Mbits. In our numerical studies we consider pages of a combination of text and graphics to be 3 Kbytes long, after POSTSCRIPT coding. Image bit-maps are 96 Kbytes per page, corresponding to the resolution (1024 x 768) of workstations such as the BUROVISEUR (6).

A.1 No Formatter Case

We consider here that pages are sent to the printer in their final format. No delays for formatting are introduced. Two cases are considered:

A.1.1 Printer with no Spooling

In all the three LAN cases (APPLETALK, STARLAN, ETHERNET) we considered and modeled the following higher level protocols for WS transmitting pages to a printer server with no spooling function, no disk and able to store only one page :

(i) Pages are segmented into frames, transmitted frame by frame, then reassembled at the printer server and printed;

(ii) The first RTS (in APPLETALK) or data frame (in STARLAN and ETHERNET), that succeeds in reaching the printer without a collision, reserves the printer for the entire page. The printer server then broadcasts to all stations a control message that enables only one station and disables all others. The successful station, having thus established a Session protocol with the server, transfers all frames of a page to the printer. After printing that page the server broadcasts another control message that enables all stations to compete again for the channel, etc.

The WS generate pages in a Poisson way, with a mean rate of 1 page per 7 min. No new page can be generated at a WS, while the previous one has not been successfully transmitted over the LAN.

APPLETALK data frames have an information field of 600 bytes, while the ones of STARLAN and ETHERNET are of 1500 bytes size. The frame overheads are 9 and 18 bytes respectively.

Table 1 gives the percentage network utilisation, when the 31 WS transmit pages of a combination of text and graphics to the printer server(3 Kbytes/page). The printer speed is considered as a variable, ranging from 2 to 10 sec per page. The QNAP2 results correspond to 100 min of actual LAN operation.

<i>Printing Time</i> [sec/pg]	APPLETALK	STARLAN	ETHERNET
2	0.8613	0.1844	0.01645
4	0.8426	0.1984	0.01627
8	0.8830	0.1868	0.01759
10	0.8274	0.1772	0.01773

TABLE 1 % LAN UTILISATION (text & graphics)

We observe that in all three cases the LAN utilisation is less than 1%.

In Table 2 we see the network introduced delays (including queueing and transmission time) ,as a function of printer speeds. The 95% confidence limits are also indicated in each case.

<i>Printing Time</i> [sec/pg]	APPLETALK	STARLAN	ETHERNET
2	0.3685 +/-0.0838	0.2398 +/-0.087	0.2133 +/-0.08532
4	1.101 +/-0.3389	1.088 +/-0.994	0.8377 +/-0.2584
8	9.923 +/-3.408	7.308 +/-4.080	7.830 +/-4.575
10	13.970 +/-4.510	10.300 +/-3.709	9.479 +/-2.042

*TABLE 2 AVERAGE DELAY PER PAGE(sec)
(text & graphics)*

We observe here that LAN speed does not play a significant role, since the printer speed controls the page transmission.

Table 3 is similar to Table 1, but for the case of all 31 WS transmitting uncompressed image bit-maps (96 Kbytes/page) to the printer server, at an average rate of 1 page per 7 min per WS.

<i>Printing Time</i> [sec/pg]	APPLETALK	STARLAN	ETHERNET
2	26.80	6.170	0.5423
4	27.18	5.777	0.5146
8	27.57	5.909	0.5188
10	25.64	5.649	0.5351

TABLE 3 % LAN UTILISATION (image bit-maps)

We notice here that APPLETalk is showing a considerable utilisation, while ETHERNET is still used less than 1%!

Table 4 is analogous to Table 2 and gives the average network delay per page, for a network operation of 5 hours. 1400 pages were transmitted in each case.

Observe that in this case of large data entities transmitted, APPLETalk is still not saturated, but it gives delays an order of magnitude larger than STARLAN or ETHERNET.

<i>Printing Time</i> [sec/pg]	APPLETALK	STARLAN	ETHERNET
2	6.038 +/-0.341	1.183 +/-0.0593	0.3006 +/-0.0322
4	8.888 +/-0.852	2.027 +/-0.314	0.9125 +/-0.1701
8	70.95 +/-35.17	9.132 +/-1.875	6.2600 +/-1.784
10	201.60 +/-51.15	21.38 +/-10.82	21.490 +/-7.034

TABLE 4 AVERAGE DELAY PER PAGE (sec)
(image bit-maps)

A.1.2 Printer with Spooling

We assume now that the printer server has a spooling function and a large disk. No need for establishing a session protocol between the WS and the server exists now; Stations transmit their frames to the server without any control from the latter. Pages are assembled at the printer server and printed on a FIFO basis. Since the printing delay per page does not affect the LAN operation, we only consider the case of a printer with speed 10 sec per page.

Table 5 gives the percentage network utilisation, the average network delay, the average printer delay (queueing plus printing), the total delay (network plus printer) and the average disk occupancy for the case of 31 WS transmitting text and graphics (3 Kbytes per page).

	APPLETALK	STARLAN	ETHERNET
% Network Utilisation	0.8534	0.1832	0.01634
Average LAN Delay(sec/pg)	0.1195	0.0244	0.00240
Average printer Delay(sec/pg)	26.890	22.730	22.7300
Total Average Delay(sec/pg)	27.010	22.754	22.7324
Average disk occupancy(Kbyt)	6	5.2	5.2

**TABLE 5 TRANSMISSION TO PRINTER WITH SPOOLING
(text & graphics)**

Comparing the above numbers with the ones in Tables 1 and 2 (the case without spooler), we remark:

- the network utilisation is almost the same;
- the network delay is much smaller, but the total delay (including LAN delay and printer delay) is roughly the same in the case of STARLAN and ETHERNET and only slightly higher in APPLETALK;
- the average disk occupancy at the printer is small.

Table 6 gives similar results for the case of transmitting uncompressed image bit-maps (96 Kbytes/page) to the printer server at an average rate of 1 page per 7 min per station. We consider that the rasterization time, introduced by the printer (possibly having different resolution than the WS) on the received pages, is included in the printing delay of 10 sec/page.

	APPLETALK	STARLAN	ETHERNET
% Network Utilisation	25.95	5.767	0.5496
Average LAN Delay(sec/pg)	3.774	0.813	0.079
Average printer Delay(sec/pg)	22.870	21.540	29.750
Total Average Delay(sec/pg)	26.644	22.353	29.829
Average disk occupancy(Kbyt)	163	155	230

TABLE 6 TRANSMISSION TO PRINTER WITH SPOOLING
(image bit-maps)

Comparing with the results of the case without spooling (Tables 3 and 4), we remark the following:

- the LAN utilisation is almost the same;
- the total delay per page is now much smaller in APPLETALK, smaller in STARLAN, and about the same in ETHERNET;
- ETHERNET sends pages to the printer too fast and this results in larger queueing delays there;
- the average disk occupancy is now fairly high;
- only APPLETALK shows a major delay improvement, at the expense of the cost of a large disk at the printer server with spooling function.

A2 Documents Sent to a Formatter before Printing

If we now consider the case of the workstations transmitting pages to a Formatter before final printing, this may add to the delay of each page something of the order of 1 min. This will only affect the LAN performance in the case of a printer server without spooling function. In that case, and without a need of further modeling and simulation, our previously obtained results (Tables 1,2,3,4) will only be modified in the following way:

- the LAN utilisation will not significantly change;
- the average LAN delay per page and the total average delay per page will increase according to the delay introduced by the Formatter.

If the printer server has a spooling function, the LAN delay and utilisation (Tables 5 and 6) will not be affected, but the total delay per page will increase according to the delay introduced by the Formatter.

B. Sequential Browsing From a Multimedia Data Base

Sending documents to a Multimedia Data Base with an optical disk, for example, introduces a modeling and performance evaluation problem very similar to the one we studied above (i.e. document production). As we saw in the case of a printer server with spooling, the service time (printing time) did not affect the LAN performance. Thus, if we consider again 31 WS sending pages to an MDB server for storage, at an average rate of 1 page per 7 min per WS, the LAN utilisation and the average LAN delay per page may be again given by Tables 5 and 6 (text&graphics or images, respectively).

A heavy traffic situation may arise during rapid retrieval of pages from the database. This is the case where one or more WS wish to sequentially browse a file stored in the MDB. If all WS wish to do this browsing from the same MDB, the simulation study of the problem is rather trivial, since the MDB server controls the channel most of the time (one-to-many transmission). We will therefore concentrate on the case of one WS doing browsing, while the other WS do document production.

Pages may be stored in the MDB in one of the following modes:

- (i) Text revisable form (2-3 Kbytes per page) (short time for displaying in the WS);
- (ii) Text revisable form, plus structured graphics (few sec delay for rasterization in the WS);
- (iii) Text revisable form, plus structured graphics, plus image bitmaps at WS resolution (few sec delay, for rasterization in the WS);
- (iv) Text revisable form, plus structured graphics, plus image bit-maps at higher resolution than in the WS (10-15 sec to 1 min rasterization delay in the WS).

Because of the large delays in the latter case, browsing is not practical and we will thus consider that structured graphics and images are stored in the MDB in bit-map mode with the same resolution as the WS.

We are going to study the following OIS senario : of the 32 nodes connected to the LAN, 29 are WS transmitting pages (text& graphics or image bit-maps) to a printer server with spooling (printing speed 1 page/10 sec), at an average rate of 1 page per 7 min per WS , while a diskless WS browses pages (in text revisable mode or bit-map mode) from a MDB. We assume that the MDB server presents to the LAN 1 page every either 20 or 4 sec.

Table 7 presents the results of the QNAP2 simulation for the case of the 29 WS transmitting pages of text & graphics(3 Kbytes/page) to the printer server and one station browsing pages stored in the MDB in text revisable mode(3 Kbytes/page) and emmitted at a rate of 1 every 20 sec.

	APPLETALK	STARLAN	ETHERNET
<i>% Network Utilisation</i>	1.035	0.3032	0.03032
<i>Average LAN Delay on Printed Pages (sec)</i>	0.11960 +/- 0.00013	0.02436 +/- 0.00013	0.002453 +/- 0.000013
<i>Average LAN Delay on Browsed Pages (sec)</i>	0.11950 +/- 0.00013	0.02431 +/- 0.000002	0.002448 +/- 0.00000013

TABLE 7 DATABASE BROWSING (1 page/20 sec)
(pages in text revisable mode)

We remark that the network load presented by the MDB is very low. The delays are the same as in Table 5. Pages arrive at the browsing station almost synchronously.

Table 8 presents similar results for the case of a much faster browsing.

	APPLETALK	STARLAN	ETHERNET
<i>% Network Utilisation</i>	3.55	0.7828	0.07832
<i>Average LAN Delay on Printed Pages (sec)</i>	0.1198 +/- 0.00025	0.02440 +/- 0.00032	0.00245 +/- 0.000013
<i>Average LAN Delay on Browsed Pages (sec)</i>	0.1195 +/- 0.000343	0.02435 +/- 0.000055	0.00244 +/- 0.0000002

TABLE 8 DATABASE BROWSING (1 page/ 4 sec)
(pages in text revisable mode)

We remark again that all LANs handle this application with very low utilisation. Pages arrive at the browsing station almost synchronously.

We finally consider the case of 29 WS transmitting image bit-maps (96 Kbytes /pg) to the printer server, while one WS browses pages from the MDB, stored in bit-map mode and at WS resolution (96 Kbytes/pg) . The browsing speed is 1 page per 4 sec.

Table 9 displays the results of the QNAP2 simulation in this high load situation. As in Tables 7 and 8 , the 95% confidence limits for the average LAN delays are also given.

	APPLETALK	STARLAN	ETHERNET
<i>% Network Utilisation</i>	—	25.63	2.538
<i>Average LAN Delay on Printed Pages (sec)</i>	—	0.9669 +/- 0.0373	0.08081 +/- 0.00143
<i>Average LAN Delay on Browsed Pages (sec)</i>	—	0.8178 +/- 0.008473	0.07865 +/- 0.00037

TABLE 9 DATABASE BROWSING (1 page/ 4 sec)
(pages in bit-map mode)

We remark here the following :

- APPLETALK saturates and cannot handle this heavy traffic. Should the browsing be done locally at the WS, however, meaning that the MDB is distributed and the WS has a disk, this difficulty could be overcome;
- STARLAN has almost a 26% utilisation and adds almost 1 sec delays on the browsed pages. Browsing synchronism is not seriously affected.
- ETHERNET utilisation is still very low and delays on browsed pages are negligible. This shows again that ETHERNET has a very high capacity for non real time applications in a "departmental" OIS environment.

C. Electronic Mail

In this OIS application, WS transmit to and, even more frequently, receive their mail from an electronic mail server. A network load peak occurs typically early in the day, during mailbox browsing.

From the modeling point of view, this application is not different from the cases we have modeled and studied above. Thus, there is no need to model it separately. The traffic here is, in general, not as heavy as in the applications of document production and document browsing, thus the LAN utilisation and delays are going to be smaller than those reported above.

CONCLUSIONS

In this paper, we presented results on the performance modeling and evaluation of three Local Area Networks (namely APPLETALK, STARLAN and ETHERNET) in handling some typical Office Information System applications. The study was carried with the aid of the QNAP2 simulation package. We found that an inexpensive and low data rate LAN, such as the 230.4 kbits/sec APPLETALK, can easily handle typical OIS applications in a "departmental" environment of not more than 32 Workstations. STARLAN, running at 1 Mbits/sec and also using an inexpensive medium, could be another good OIS LAN option, if the cost of the CSMA-CD interfaces goes down. For larger office systems, and applications generating very heavy traffic, ETHERNET, which is still fairly costly, will give good performance.

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REFERENCES

1. J.Markoff and P.Robinson " The Macintosh Office ", BYTE ,Febr.1985, pp. 121-134.
2. " High Throughput, Low Cost Distinguish Apple PC Network, Electronic Design, Febr.1985, pp. 38-39.
3. " IEEE Draft Standard P802.3 : 1 Mbit/sec STARLAN ", Rev. A, Draft, July 1984.
4. J.F.Shoch et al " Evolution of the ETHERNET Local Computer Network", IEEE Computer, Aug. 1982, pp. 10-25.
5. D.Potier " New Users Introduction to QNAP2 ", INRIA Technical Report No. 40, October 1984.
6. N.Naffah " Office Information Systems ", North Holland ,1981.
7. "POSTSCRIPT Language Manual ", Adobe Systems Inc.,Aug. 1984.

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