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Evaluation of the IBM Token-Ring Network via the Proposed Standard Wiring Plan

JoAnn T. Glassell

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ABSTRACT

When installing a local area network (LAN), one of the decisions that must be made is the type of cabling to use. The choice is among twisted-pair, coaxial, or fiber optic cables. Each type has trade-offs. Twisted-wire cable's advantages over coaxial cable are its light weight, small size, flexibility, relative inexpensiveness, and ease of installation. Disadvantages include its lower bandwidth and installer's inexperience with it. Twisted pair, however, can be used in a modular wiring scheme, which makes for easy and safe portability. This report covers the results of a test of the IBM token-ring network, which communicates via a modular wiring scheme by using unshielded twisted pairs as its medium, to determine at what cable length token-ring network performance would degrade. Test configurations and results are reported, and recommendations specific to IBM token-ring equipment operation are made. Note: A companion report (ORNL/TM-11080) covers the results of tests with Ethernet twisted-pair products.

1. INTRODUCTION

When installing a local area network (LAN), one of the decisions that must be made is the type of cabling to use. The choice is among twisted-pair cable, coaxial cable, or fiber optic cable. Each type of cable has trade-offs, but most LAN analysts predict a shift to twisted-pair cable. According to Bart Gunter of Atlanta Technologies, "There is a trend toward twisted-pair, especially with the introduction of twisted-pair Ethernet-based products."[1]

However, this fact does not mean that all companies are using or intend to use twisted-pair cable. According to Sujoy Banerjee at Microncon, a LAN (VAR, or value added reseller) in Lawrenceville, New Jersey, the ratio of facilities using twisted-pair to other types of cable is 1:1. And still others in the industry believe that fiber optic, not twisted-pair, is the cable of the future.[2-6]

When installing a LAN today, the basic choice is usually between twisted-pair and coaxial cable because of the lack of fiber optic devices. Twisted-pair has five advantages over coaxial cable: it is smaller, lighter, more flexible, easier to install, and less expensive. The thinnest coax is larger than the heaviest shielded twisted-pair. Shielded plenum weighs ~18 lb/1000 ft, whereas common 22-gage RG-62 coax weighs 42 lb/1000 ft. Most twisted pairs have a smaller "bend radius" than coaxial cable, which makes installation easier. Installation of twisted pairs is also made less time-consuming by the use of specialized tools developed by the telephone industry. An obvious advantage occurs when cabling does not have to be installed. Many existing buildings have enough twisted pairs installed, but they are not in use. Unshielded (that is, individually the twisted pairs are not shielded, but the group of four pairs is surrounded by a shield) twisted-pair cable is approximately half the cost of coax. However, shielded twisted-pair is about the same cost as coax.

Twisted-pair does have some disadvantages compared with coaxial cable. Coaxial has a higher bandwidth then twisted-pair, enabling it to carry more information at higher speeds. If communication needs involve the use of many channels of data via one cable, twisted-pair cannot be used. The impedance of coax cable allows it to carry signals for longer distances than twisted-pair. Coax is a proven technology in the area of baseband networks. It has been used from the very start, and coax installers are more familiar and experienced with it.

In spite of its disadvantages, twisted-pair can be used in a modular wiring scheme. This type of scheme makes it easy and safe to move a device around simply by unplugging the device, carrying it to its new location, and plugging it in again. This feature is made possible by wall outlets connected to preinstalled wires that run to a centrally located wiring closet containing patch panels and communication equipment. According to some cable companies, studies have shown that 60% of terminals are moved within the first year after installation.

This fact, and the advantages of twisted pairs over coax, are two primary reasons for evaluating twisted-pair products.

This report covers the results of a test of the IBM token-ring network, which communicates via a modular wiring scheme by using unshielded twisted pairs (the proposed standard wiring plan) as its medium. These tests were performed over a 3-month period. The Computing and Telecommunications Division (C&TD) requested that the Instrumentation and Controls (I&C) Division perform this test so that the C&TD recommended wiring plan could be examined while being used as the main transmission medium for an IBM token-ring network. A separate report has been written on the results of Ethernet twisted-pair products.[7]

Accutech and Teledyne cable were used during the test period. The cable acted as the lobe wiring or the wiring between a personal computer (PC) workstation and a multistation access unit (MSAU) in all test configurations. The results given in this report pertain only to IBM equipment; it should not be assumed that they apply to other vendors' products.

2. OBJECTIVES

Different lengths of unshielded twisted-pair cable from Accutech and Teledyne were tested with the IBM token-ring network. The objective was threefold: to determine at which cable length IBM token-ring equipment performance would begin to degrade; to examine at which length of cable IBM equipment would not transmit; and to examine the effects of cross talk between two token-ring networks, between token-ring and Ethernet networks, and between token-ring and RS232-C networks. The IBM PC LAN program's mail facility and two BASIC programs were used to achieve these objectives. In the following sections, the test setups and their results will be described.

3. METHODOLOGY

3.1 THE MEDIA ACCESS METHOD

The IBM token-ring network is configured in a star-wired ring topology (see Fig. 3.1). When a user on a PC workstation wants to send information over the network, he either executes a network command or changes the default drive to the shared network drive. The token-ring protocol is transparent to the user except for executing the network command or drive selection.

A uniquely formed packet, called a "token," circulates on the ring. Each station receives the token and then retransmits it. If a certain station wants to transmit information, it grabs the token off the ring and adds the message, the sender's address, and the receiver's address to the token. The transformed token is called a "frame."

The receiver's address in the frame tells every other station on the ring whether or not the message contained in the frame is intended for it. If it is, the station passes the information in the frame to its user and indicates in the frame that the message has been received. The frame then continues around the ring until it returns to the station that put the information on the ring. After that station checks the information in the frame to ensure that it has not been corrupted, it generates a new token and places it on the ring.

The IBM token-ring network allows only one token or frame on the network at a time (baseband network). Messages are transmitted and received on the ring at a rate of 4 Mbits/s. When the ring is used with unshielded twisted pairs as its lobe cabling, 72 devices or PC workstations can be used per ring.

3.2 HARDWARE

3.2.1 PC-to-PC Two-Lobe Network

An NCR PC8 acting as a client node and an IBM PC acting as a server node, both equipped with a token-ring adapter board, communicated with each other by way of an eight-port routing device, the MSAU. Figure 3.2 shows the two computers communicating via the IBM standard wiring system. The configuration of Fig. 3.2 was tested to verify proper operation of the IBM token-ring equipment.

Installation of an IBM token-ring adapter card requires that the PC workstations have ROM BASIC installed. A machine without ROM BASIC cannot be used to run diagnostics on a token-ring adapter board. The NCR clones used for the duration of the tests do not have ROM BASICs. That fact will cause problems when IBM token-ring adapter cards are installed in NCR machines or in any other IBM clone because diagnostic routines cannot be executed.

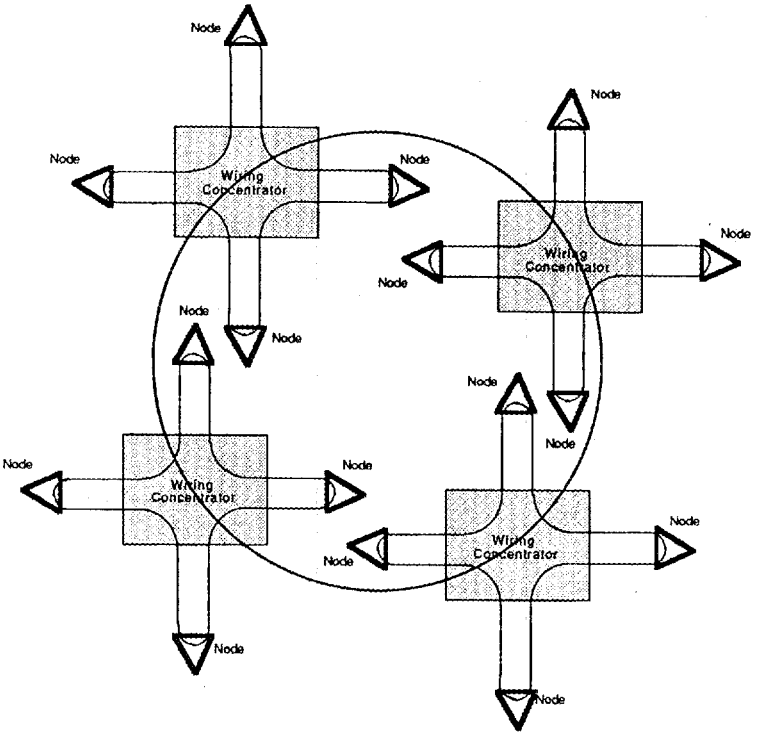

Fig. 3.1. Star-wired ring configuration of the IBM token-ring network.

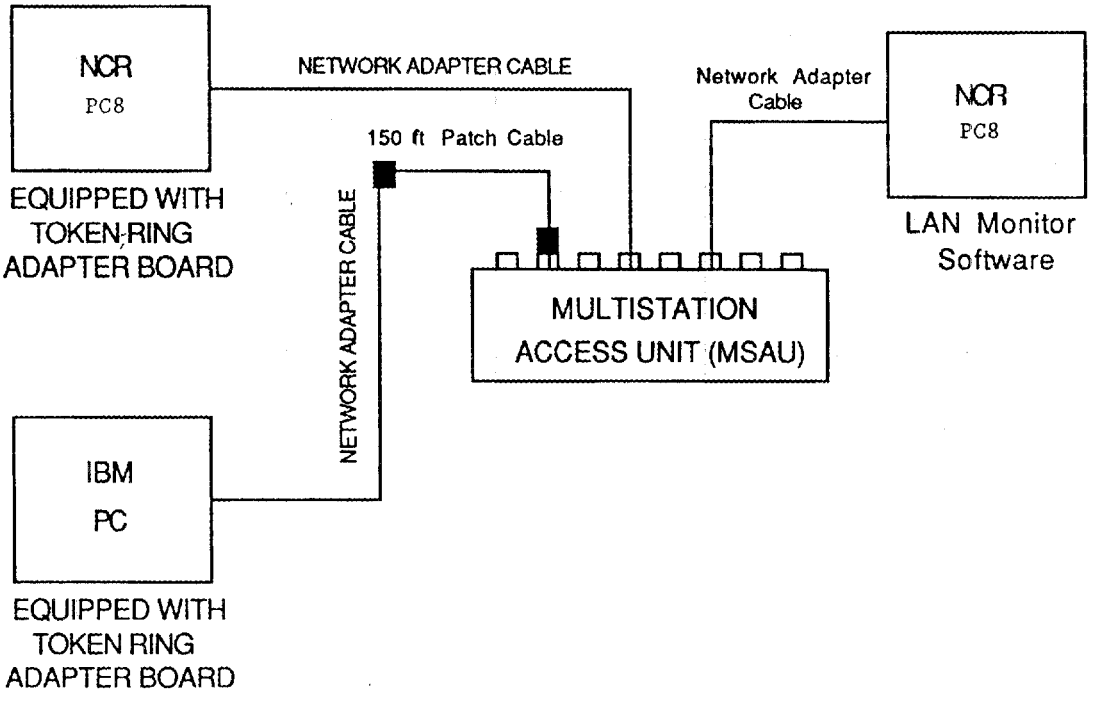

Fig. 3.2. Equipment checkout of NCR PC8 to IBM PC via IBM cabling system.

Figure 3.3 shows the two computers communicating via the proposed wiring standard. In IBM's cabling system, the lobe wiring used between the PC workstation and the local communication closet is known as "type 3 cable," and the IBM adapter unit that connects the output of the token-ring adapter board in the PC workstation to the local wall-mounted data receptacle is known as a "type 3 media filter." The NCR PC8, via this filter and a data receptacle, fed the twisted-pair cable that was under test. The MSAU, located at the punch-down blocks, fed the IBM PC (simulating a server) and another NCR PC8 (system monitor) via still another adapter unit known as a "data grade to type 3 filter." The only difference between these two types of filters is the interfacing cable to the filter, but the filter electronics serves the same purpose. The MSAU was connected to the client node (NCR PC8) via another adapter unit known as a "type 3 media jumper cable."

To make these connections properly, careful examination of the RJ11 connection to the recommended RJ45 receptacle was needed. Figure 3.4 shows the pin-outs for the proper connection to the RJ45 receptacle, punch-down blocks, and MSAU. Because the RJ11 (located on the end of a type 3 media filter) had its key in the center of its connector, it made the connection to the RJ45 wall receptacle through pin-outs 1, 2, 5, and 6. To make this connection on a receptacle already set up for Ethernet, two wires had to be moved to different positions on the punch-down connector. Therefore, when the standard wiring plan is implemented, it is imperative for the installer to ensure that the proper pin-outs are being used and that the drain wire on the type 3 cable is properly grounded at only one end. Pins 1, 2, 5, and 6 are used for a token-ring connection, and pins 3, 4, 5, and 6 are used for an Ethernet connection. Because the type 3 media filter has an RJ11 modular jacket, an adapter to RJ45 should be used to prevent accidental misalignment of the pins. The objective of the test configuration shown in Fig. 3.3 was to examine at which length the IBM token-ring network performance would begin to degrade and to examine at which length of cable IBM equipment would not transmit. These tests were performed using various lengths of Accutech and Teledyne cable.

3.2.2 Four-PC Four-Lobe Network

A four-lobe token-ring network similar to the one described in Sect. 3.2.1 was set up. The primary difference was that two of the "downstream" lobes shared the same twisted-pair cable, with each lobe using two of the four available pairs. The objective of this test was to inspect the effects of cross talk between the unshielded twisted pairs when two token-ring networks are running via one cable (see Fig. 3.5). The second token ring consisted of an NCR 386 acting as the client node and an IBM XT acting as the server node. The hardware connection for both token-ring networks in this test was exactly the same as the one described in Sect. 3.2.1.

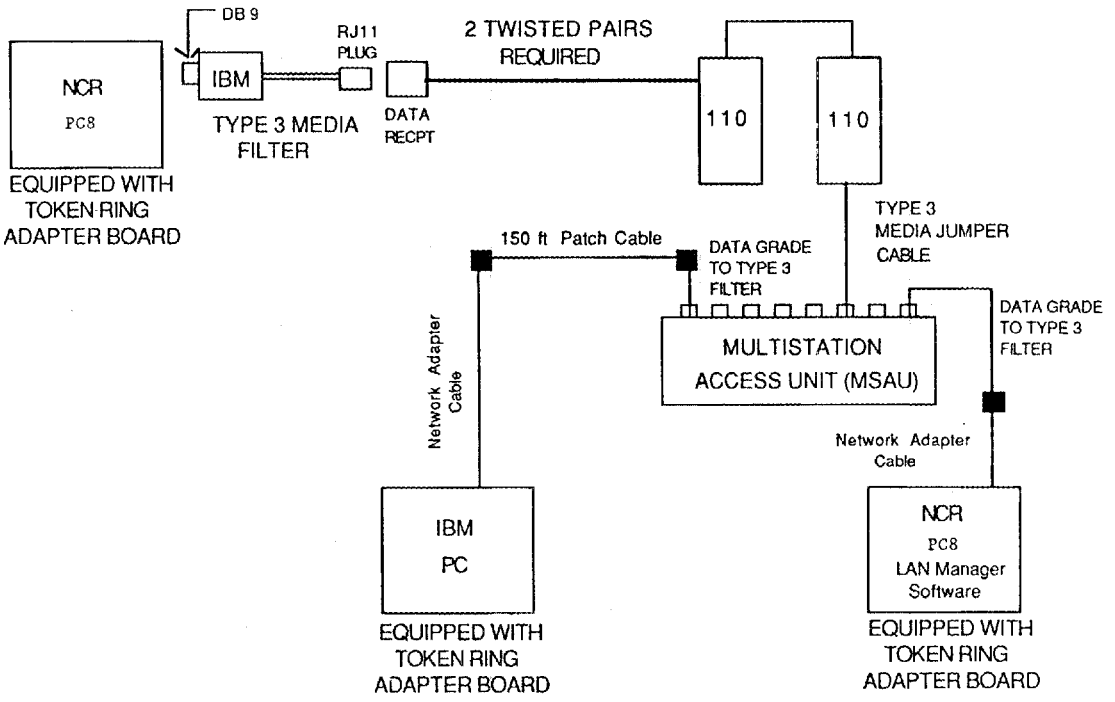

Fig. 3.3. Preliminary test of NCR PC8 via twisted-pair to IBM PC via IBM cabling system.

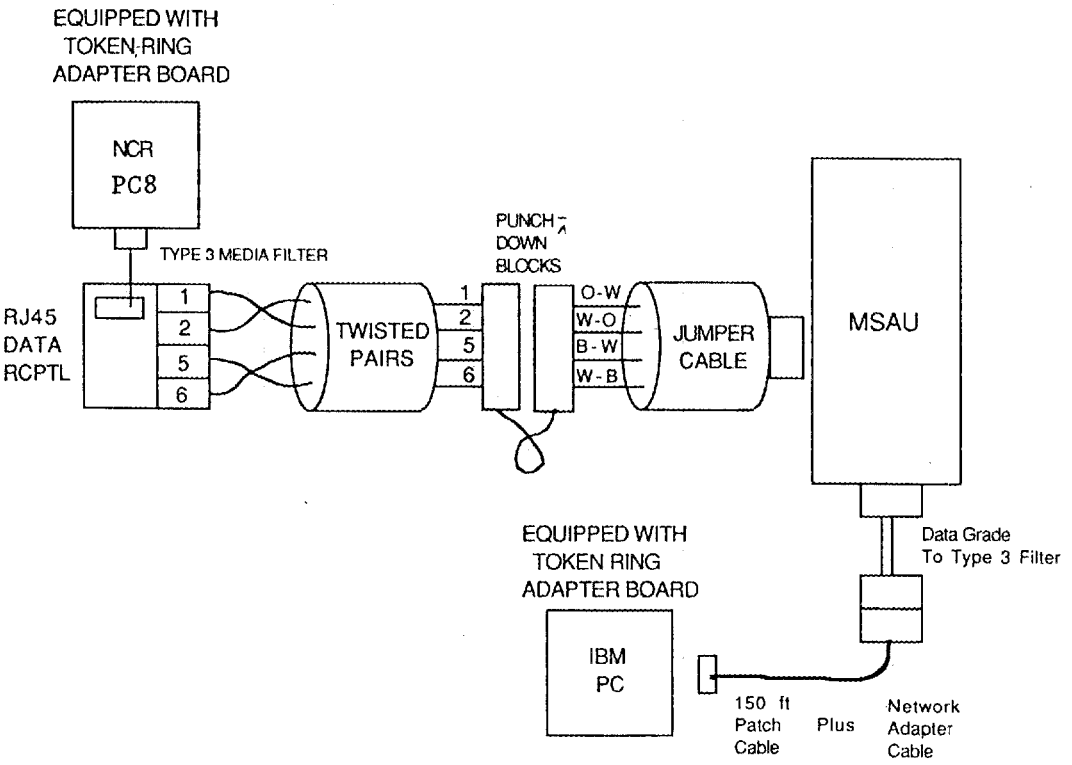

Fig. 3.4. Pin-outs for token-ring network.

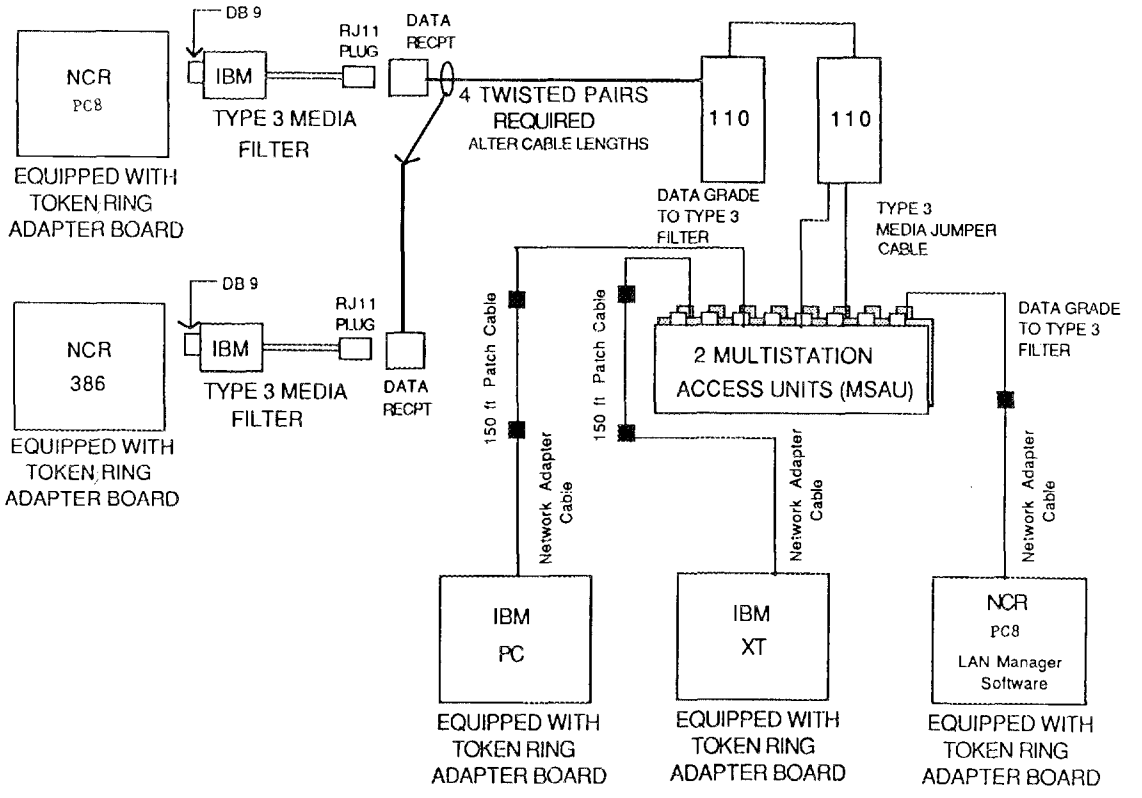

Fig. 3.5. Two token-ring networks via one cable.

3.2.3 Token Ring and Ethernet

This was the first of the two mixed-media access method test configurations performed. An NCR PC8 and an IBM PC equipped with token-ring boards were used with an MSAU to establish a token-ring network (client node and server node). The other NCR PC8 and an IBM XT equipped with 3COM's Ethernet boards via SynOptics Communications' Lattisnet product were used to establish an Ethernet network. One machine of each pair communicated with the punch-down terminal blocks over two of the four twisted-pair conductors in a single cable, thereby allowing a single cable to carry both token-ring and Ethernet information. The objective of this test (shown in Fig. 3.6) was to examine the effects of cross talk between a token-ring network and an Ethernet network via one cable.

3.2.4 Token Ring and RS232

The second mixed-media access method was implemented with an NCR PC8 and an IBM XT making up a token-ring network and a Fireberd 2000 performing the RS232 communication. The NCR PC8 and the Fireberd 2000 communicated with the punch-down terminal blocks over two of the four twisted-pair conductors in a single cable, thereby allowing a single cable to carry both token ring and RS232-C. The objective of this test (shown in Fig. 3.7) was to examine the effects of cross talk between a token-ring network and an RS232-C network running over the same cable.

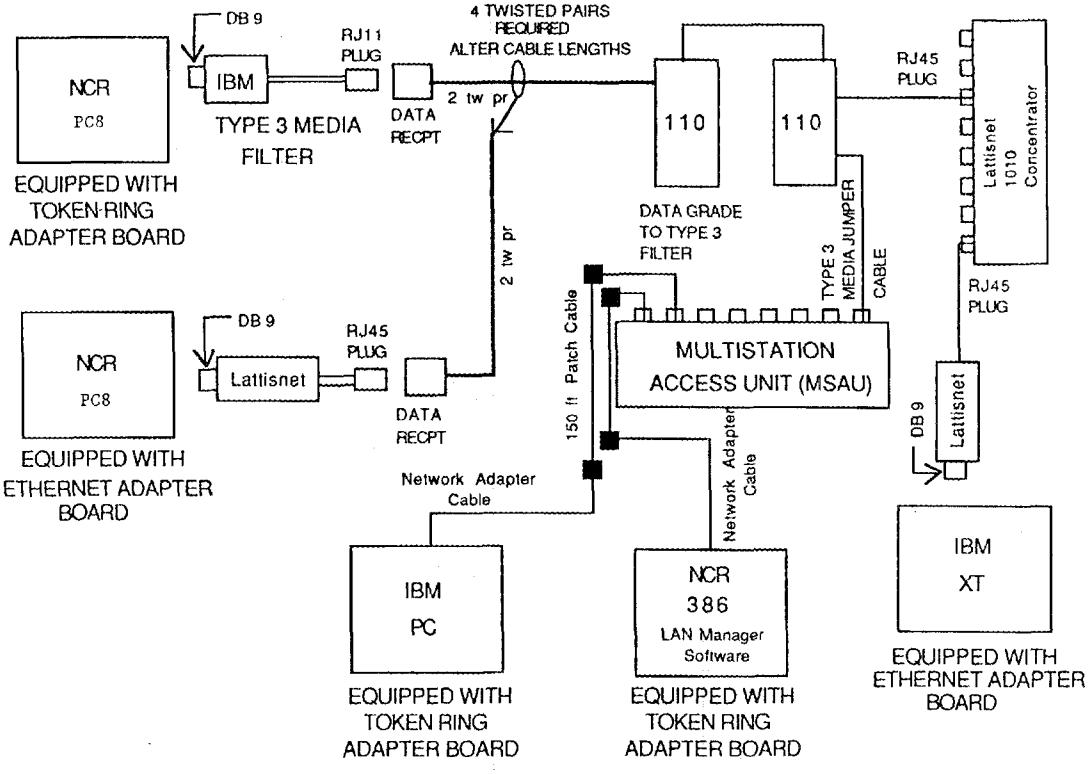

Fig. 3.6. Token-ring and Ethernet networks via one cable.

3.3 SOFTWARE

3.3.1 Mail Messenger

The IBM PC LAN program can send mail. Specifically, the mail facility can store and send a maximum of 1599 bytes of information. This maximum size was used during an I&C evaluation of the IBM token-ring network using the proposed wiring standard. The ability to send mail correctly was used as a quick test to verify the hardware connections.

3.3.2 Basic Programs

Two BASIC programs were developed for testing purposes. These programs, shown in Figs. 3.8 and 3.9, transmitted a file of 135,142 bytes. The difference between the two programs is minimal. Figure 3.8 shows a BASIC program that transmits the file six times, therefore sending 810,852 bytes in 1.6 s at 4 Mbits/s. Figure 3.9 shows a program that transmits the file 330 times, therefore sending 44,596,860 bytes in 1.48 min at 4 Mbits/s. The actual length of the test (which includes disk and screen access time) using the program that transmitted the file six times was ~22 s. On the other hand, the program that transmitted the file 330 times took ~20 min. During certain test configurations, an NCR PC8 and an NCR 386 were used. Because the NCR 386 has a faster microprocessor, its BASIC program was modified to run for 20 min by

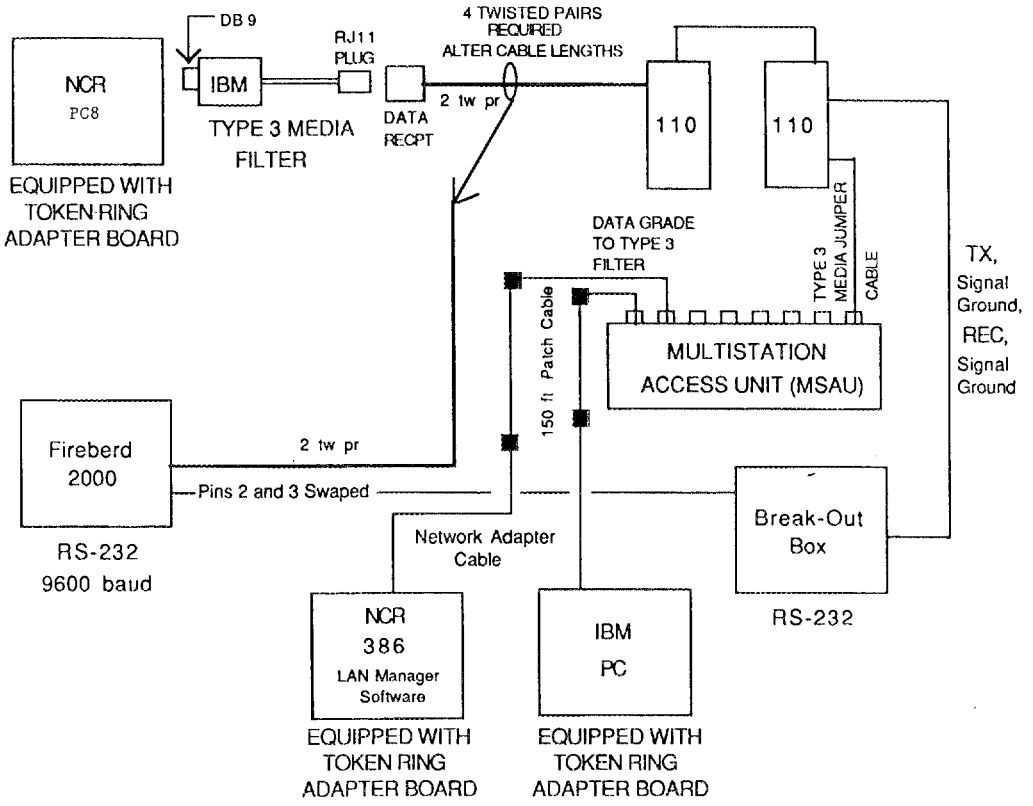

Fig. 3.7. Token-ring and RS232-C networks via one cable.

transmitting the file 550 times. This alteration was needed to increase the possibility that both the NCR PC8 and the NCR 386 would transmit at the same time.

3.3.3 Configuration

Installing the software for the test configuration discussed in Sect. 3.2.1 uncovered some inconveniences about the IBM token-ring software. Each machine on an IBM token-ring network must be running DOS 3.30 or greater for IBM's PC LAN NETWORK program version 1.20 to run at all. To install IBM's token-ring network operating system, it is necessary to run two installation aids, replace DOS if it is not version 3.30 or greater, and run IBM's PC LAN Network software to configure the ring. One such configuration is shown in Fig. 3.10. After installation is complete, each computer's "config.sys and autoexec.bat" files must be edited because the installation aids add commands to those files. This procedure might cause a PC to run out of conventional memory space. For example, IBM's PC LAN network program needs at least 452 Kbytes, and DOS 3.30 needs ~92 Kbytes, which leaves only 96 Kbytes of main memory in a 640-Kbyte main memory machine. A machine with extended memory will not help this problem because most resident programs get loaded into main memory. Therefore, no other resident programs can be put in memory if the PC is using an operating system that will not allow page swapping. Neither MS-DOS nor PC-DOS allow this type of page swapping.

```
rem*****************************************************************
rem
rem   Written by: JoAnn T. Glassell
rem
rem   TEST PROGRAM FOR TOKEN RING VIA UNSHIELDED TWISTED PAIR
rem
rem*****************************************************************
100 cls
200 beep
    locate 12,23
330 print "Raw data file is being transferred"
    locate 14,23
    print "Number of files transferred: "
    locate 16,9
    print "DOS Messages"
    locate 17,1
    print "-------------------------------"
    locate 10,23
300 print "The time is,"time$
220 start.time$=time$
310 for i=1 to 6 step 6
    locate 18,1
    shell "copy d:ictest.dat e:ictest1.dat"
    locate 14,52
    print i
    if inkey$ <> "" then goto 553
    locate 19,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 20,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 21,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 22,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 23,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 18,1:print "                                                "
    locate 19,1:print "                                                "
    locate 20,1:print "                                                "
    locate 21,1:print "                                                "
    locate 22,1:print "                                                "
    locate 23,1:print "                                                ";
```

Fig. 3.8. BASIC program for 22-s test.

```
550 next i
553 end.time$=time$
    locate 14,52
    i=i-1
    print i
    locate 20,13
560 print "Started at,"start.time$," Ended at,"end.time$
600 beep
650 beep
    print
    shell "comp d:ictest.dat e:ictest1.dat"
    print
700 end
```

Fig. 3.8. (continued)

```
rem ************************************************************
rem
rem              WRITTEN BY JOANN T. GLASSELL 8/17/88
rem
rem     TEST PROGRAM FOR TOKEN-RING VIA UNSHIELDED TWISTED PAIR
rem
rem ************************************************************
100 cls
200 beep
    locate 12,23
330 print "Raw data file is being transferred"
    locate 14,23
    print "Number of files transferred: "
    locate 16,9
    print "DOS Messages"
    locate 17,1
    print "------------------------------"
    locate 10,23
300 print "The time is ,"time$
220 start.time$=time$
310 for i=1 to 330 step 6
    locate 18,1
    shell "copy d:ictest.dat e:ictest1.dat"
    locate 14,52
    print i
    if inkey$ <> "" then goto 553
    locate 19,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 20,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 21,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 22,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 23,1
    shell "copy d:ictest.dat e:ictest1.dat"
    if inkey$ <> "" then goto 553
    locate 18,1:print "                                                "
    locate 19,1:print "                                                "
    locate 20,1:print "                                                "
    locate 21,1:print "                                                "
    locate 22,1:print "                                                "
    locate 23,1:print "                                                ";
```

Fig. 3.9. BASIC program for 20-min test.

```
550 next i
553 end.time$=time$
    locate 14,52
    i=i-1
    print i
    locate 20,13
560 print "Started at,"start.time$," Ended at,"end.time$
600 beep
650 beep
    print
    shell "comp d:ictest.dat e:ictest1.dat"
    print
700 end
```

Fig. 3.9. (continued)

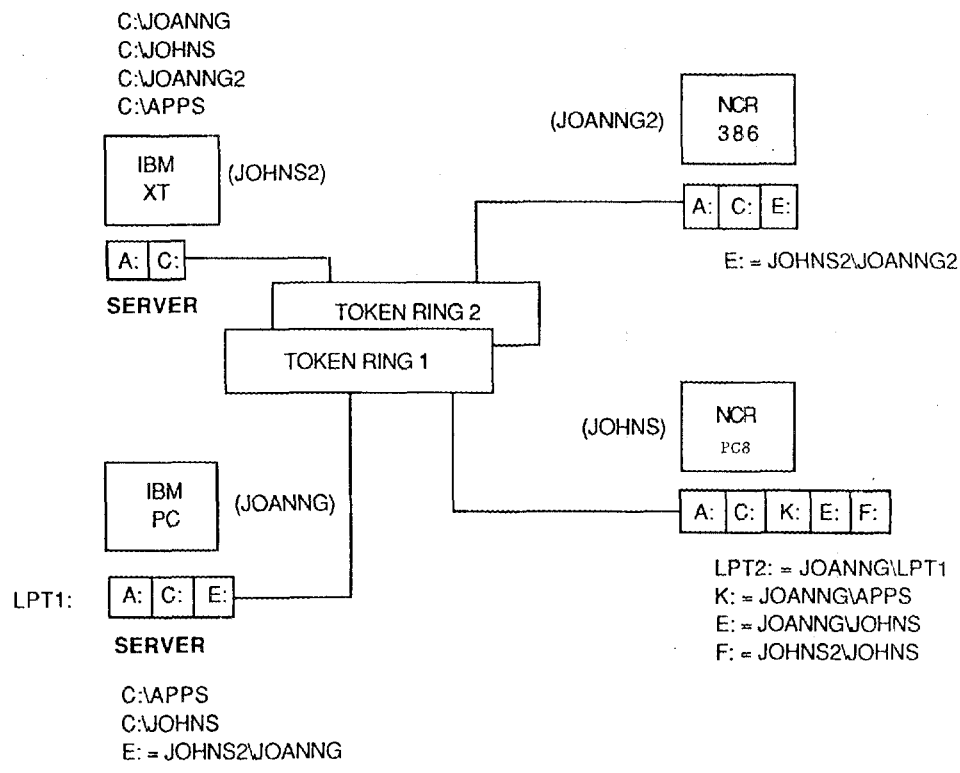

Fig. 3.10. Configurations of two token rings.

Since MS-DOS and PC-DOS are the major operating systems in use, this page-swapping issue becomes a major problem because 96 Kbytes of memory is not sufficient. One solution to this problem is to use OS/2, which performs the page-swapping algorithm (memory manager) and has a communication manager that is transparent to the user.

Other significant problems with the IBM token-ring software are as follows.

1. When the server temporarily disconnects its cable, a regular node cannot find the path back to the server. After the server reconnects, the regular node cannot transmit files to the server. The only way to get the regular node to transmit files correctly is by rebooting and restarting its network operating system.

2. When the client node temporarily disconnects its cable from the MSAU, it cannot transfer files to the server unless its network operating system is rebooted and restarted.

3. IBM's LAN manager software has to be placed on a PC dedicated as the LAN manager. The manager PC cannot be used as a client token-ring node.

4. IBM's LAN manager software was placed on an NCR PC8 clone during this test. When shutting down the LAN manager software (returning to the DOS prompt), it was not possible to get right back into the

LAN manager software and have it work properly. The NCR PC8 (running the LAN manager software) was unable to initialize its ring adapter. Rebooting the machine did not cause the NCR PC8 to reinitialize its ring adapter. It was necessary to turn off the NCR PC8 power before the LAN manager software would operate correctly. However, the LAN manager operated on an NCR 386 machine with no problems.

For all tests performed, the following were used:

1. IBM LAN Manager Program, Version 1.00
   (a) Ring configuration
   (b) Event log
   (c) Full soft error reporter enabled
2. IBM LAN support program, Version 1.02
3. IBM LAN NETWORK program, Version 1.20
4. PC DOS, Version 3.30
5. IBM token-ring adapter cards
6. IBM multistation access unit
7. IBM network adapter cable
8. Type 3 media filter
9. IBM 150-ft patch cable
10. Data grade to type 3 filter
11. Type 3 media jumper cable

The soft error reporter of the IBM LAN manager software will report any retransmissions of packets to the event log via a soft error counter. Therefore, after each test run, an examination of the soft error counter was used on the result sheets as an entry in the column labeled "soft errors." A distinction between retransmissions caused by bad frame check sequences (FCS) or lost frames is not possible with the soft error counter. The LAN manager program will cause an alert to occur when the retransmission rate has exceeded the limit set in the IBM LAN manager software. The ability to receive soft errors was checked by disconnecting one of the machines from the network. When a machine de-asserts itself from the ring, the token will most likely be lost, causing a retransmission to occur. The ability to exceed the soft error limit was also tested. Injecting noise by scraping the copper core of the twisted-pair cable against a wire stripper's jaws while the network was running caused the soft errors generated to exceed the allowable limit. After these counters were proven to be in working order, the tests described in Sects. 3.2.1 to 3.2.4 were performed.

4. EVALUATION AND RESULTS

4.1 RESULTS OF THE TWO-LOBE NETWORK

The method of testing the configuration shown in Fig. 3.2 was to use the IBM mail messenger. This configuration (using IBM standard cabling) verified that all IBM token-ring equipment was working properly.

The test configuration shown in Fig. 3.3 was similar to the one shown in Fig. 3.2 except that the proposed wiring standard replaced one of the network adapter cables. Testing was performed using a BASIC program (see Fig. 3.8) and by sending a mail message of maximum size. The BASIC program read a file of 135,142 bytes from its machine's virtual disk and transmitted the file to its server's virtual disk. The program performed this transaction six times. The results of this test configuration for both the Accutech and Teledyne cables are shown in Table 4.1. The "zero length" test was run as the baseline test to ensure proper pin-out connections through the IBM type 3 media filter, RJ11, RJ45 receptacle, Accutech cable, 110 punch-down blocks, type 3 media jumper cable, data grade to type 3 filter, 150-ft patch cable, and finally through the network adapter cable. During the test shown in Fig. 3.3, a mixture of file transfers and message transfers was performed between an NCR PC8 clone acting as a client node and an IBM PC acting as a server. Table 4.1 shows that up to 450 ft, no retransmissions occurred. IBM recommends that one use type 3 cable no longer than 320 ft. The test at 350 and 450 ft showed good results, but one must remember that the tests were performed in a controlled environment. When the cable is stretched to its fullest length, it will act as an antenna, thus increasing the chance of noise entering the system. Therefore, I&C recommends that the proposed wiring standard adhere to the IBM restriction of 320 ft for type 3 cable runs.

Table 4.1 also shows that using Accutech cable at 550 ft, the NCR PC8 could not open the relay inside the MSAU. Thus, the NCR PC8 could not insert itself into the ring, but at this length it still could transmit messages. Therefore, the limiting factor is the voltage drop of the "phantom" voltage that rides on the twisted-pair cable to open up the mechanical relay in the MSAU.

Table 4.1 shows another interesting fact. Teledyne cable at 550 ft and up can open the mechanical relay in the MSAU. One possible explanation for this fact is that Teledyne cable's characteristic impedance might match the characteristic impedance of the IBM token-ring adapter board. Nevertheless, I&C recommends restricting the lobe length of type 3 cable to 320 ft.

4.2 TWO-TOKEN RING NETWORKS VIA ONE CABLE

Table 4.2 shows the results from a baseline test performed on the additional two machines that would be used in Fig. 3.5. The two additional machines were the NCR 386 clone acting as the client and an

Table 4.1 Test results for NCR PC8 via twisted-pair to IBM PC via IBM cabling system

Cable type	Length	Test number	Test	Number of soft errors
Accutech	0 ft	1	File transfer[a]	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer[b]	0
		7	Message transfer	0
Accutech	300 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer	0
		7	Message transfer	0
Accutech	350 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File Transfer	0
		6	Message transfer	0
		7	Message transfer	0
Accutech	450 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer	0
		7	Message transfer	0
Accutech	550 ft	1	File transfer	N/A
			Received a NET807 ERROR: Netbios error, adapter could not relay into ring.	
Accutech	650 ft		Same results as at 550 ft.	

Table 4.1. (continued)

Cable type	Length	Test number	Test	Number of soft errors
Teledyne	300 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer	0
		7	Message transfer	0
Teledyne	350 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer	0
		7	Message transfer	0
Teledyne	450 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer	0
		7	Message transfer	0
Teledyne	550 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer	0
		7	Message transfer	0
Teledyne	650 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer	0
		7	Message transfer	0

[a]There were five file transfers in each test, each consisting of six copy commands. The transfer copied a file from virtual disk to a server's virtual disk. Message transfer: see Table 4.2.

[b]Send largest message possible through IBM's electronic mailer (comes with the IBM PC LAN program).

Table 4.2. Baseline test of PC XT to NCR 386

Cable type	Length	Test number	Test	Number of soft errors
Accutech	0 ft	1	File transfer[a]	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer[b]	0
		7	Message transfer	0
Accutech	550 ft	1	File transfer Received NET807 ERROR: adapter could not relay into ring.	N/A
Teledyne	550 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
		5	File transfer	0
		6	Message transfer	0
		7	Message transfer	0

[a]There were five file transfers, each consisting of six copy commands. The transfer copied a file from virtual disk to a server's virtual disk.

[b]Send largest message possible through IBM's electronic mailer (comes with the IBM PC LAN program).

IBM XT acting as the server. The test results from this configuration concurred with previous results.

Table 4.3 shows the results of the two token-ring networks via one cable test (shown in Fig. 3.5) with Accutech and Teledyne, respectively, using the BASIC program shown in Figure 3.8. The test was run four times, sending 810,852 bytes of data for each run. Two test runs were monitored by the LAN manager software on ring 1, and the last two runs were monitored on ring 2. Both rings were monitored to ensure that cross talk was not occurring. According to the test results shown in Table 4.3, no soft errors occurred during the test of two token-ring networks via one cable. Therefore, installing two token-ring networks in the same type 3 cable will work.

4.3 TOKEN-RING AND ETHERNET NETWORKS VIA ONE CABLE

Table 4.4 shows the results of the token-ring and Ethernet networks via one cable (Fig. 3.6) using Accutech and Teledyne cable. The test was performed by using the BASIC program shown in Fig. 3.9 for the token-ring network and by using the DECNET-DOS loop back command for the Ethernet network. The IBM LAN manager program kept track of any retransmission errors that might have occurred via its soft error reporter. The loop back command transmits packets of a given size for a given number of times, and it keeps track of the number of retransmissions. The loop back command batch file is shown in Fig. 4.1. This batch file caused the loop back command to run ~20 min. Since the BASIC program takes 20 min to execute, forcing the loop back command to do the same would increase the chance that both networks would be transmitting information down the "cable under test" at the same time. As the results show, the token-ring network did not experience errors, but the Ethernet network experienced some errors. This would be expected because Ethernet, running at 10 Mbits/s, is already experiencing a rounding of its signal's edges, and any cross talk could definitely cause errors to occur. Therefore, the results of the test indicate that a token-ring network and an Ethernet network via one cable would cause some retransmissions on the Ethernet network. Using Teledyne cable would cause the Ethernet to experience more retransmissions than if one used the Accutech cable. Additional retransmissions degrade network performance. Therefore, I&C recommends not using token-ring and Ethernet via one cable if the Ethernet network is heavily loaded (>50 active nodes).

4.4 TOKEN-RING NETWORK AND RS232-C VIA ONE CABLE

Table 4.5 shows the results of the token-ring network and RS232 via one cable test using Accutech and Teledyne respectively. The IBM LAN manager software was used on the token-ring network to indicate any retransmissions via the soft error reporter. The BASIC program shown in Fig. 3.9 was used to generate traffic on the token-ring network. The Fireberd 2000 generates 9600 bits/s in a randomized pattern, and it also

Table 4.3. Test of two token-ring networks via one cable

Cable type	Length	Test number	Test	Number of soft errors
Accutech	0 ft	1	File transfer[a]	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
Accutech	300 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
Accutech	350 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
Accutech	450 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
Accutech	550 ft	1	File transfer Received NET807 ERROR: adapter could not relay into ring. NCR PC8 could not relay into ring, but NCR 386 could.	N/A
Teledyne	300 ft	1	File transfer[a]	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
Teledyne	350 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0
Teledyne	450 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0

Table 4.3. (continued)

Cable type	Length	Test number	Test	Number of soft errors
Teledyne	550 ft	1	File transfer	0
		2	File transfer	0
		3	File transfer	0
		4	File transfer	0

[a]Copy file from virtual disk to server's virtual disk 330 times. Both transmitters on each token-ring network were running the same program and started at the same time. Figure 3.9 shows the listing of the BASIC program used.

Table 4.4. Test of token-ring and Ethernet networks via one cable

Cable type	Length	Test number	Number of soft errors: BASIC program token ring	Number of soft errors: Loop back Ethernet
Accutech	0 ft	Control[a]	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0
Accutech	300 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	2
		4	0	0
Accutech	350 ft	Control	N/A	1
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0
Accutech	450 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0
Teledyne	300 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	1
		3	0	2
		4	0	1
Teledyne	350 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	1
		4	0	0

Table 4.4. (continued)

Cable type	Length	Test number	Number of soft errors: BASIC program token ring	Number of soft errors: Loop back Ethernet
Teledyne	450 ft	Control	N/A	3
		Control	0	N/A
		1	0	0
		2	0	1
		3	0	0
		4	0	1

[a]One device is connected and the other is disconnected at the adapter board.

```
rem ***************************************************************
rem
rem   LOOP BACK COMMAND BATCH FILE
rem
rem   written by: JoAnn T Glassell
rem
rem ***************************************************************
ntu loop circuit node 53.011 with mixed length 512 count 4480
beep
beep
```

Fig. 4.1. Loop back command batch file.

keeps track of any bit errors. The test configuration is shown in Fig. 4.2. As the results show, neither the token-ring network nor the RS232 network displayed any errors when using the Accutech or Teledyne cable.

Table 4.5. Token-ring and RS232-C networks via one cable

Cable type	Length	Test number	Number of soft errors: BASIC program token ring	Number of soft errors: 9600 baud RS232-C
Accutech	0 ft	Control[a]	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0
Accutech	300 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0
Accutech	350 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0
Accutech	450 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0
Teledyne	300 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0
Teledyne	350 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0

Table 4.5. (continued)

Cable type	Length	Test number	Number of soft errors: BASIC program token ring	Number of soft errors: 9600 baud RS232-C
Teledyne	450 ft	Control	N/A	0
		Control	0	N/A
		1	0	0
		2	0	0
		3	0	0
		4	0	0

[a]One device is connected and the other is disconnected at the adapter board.

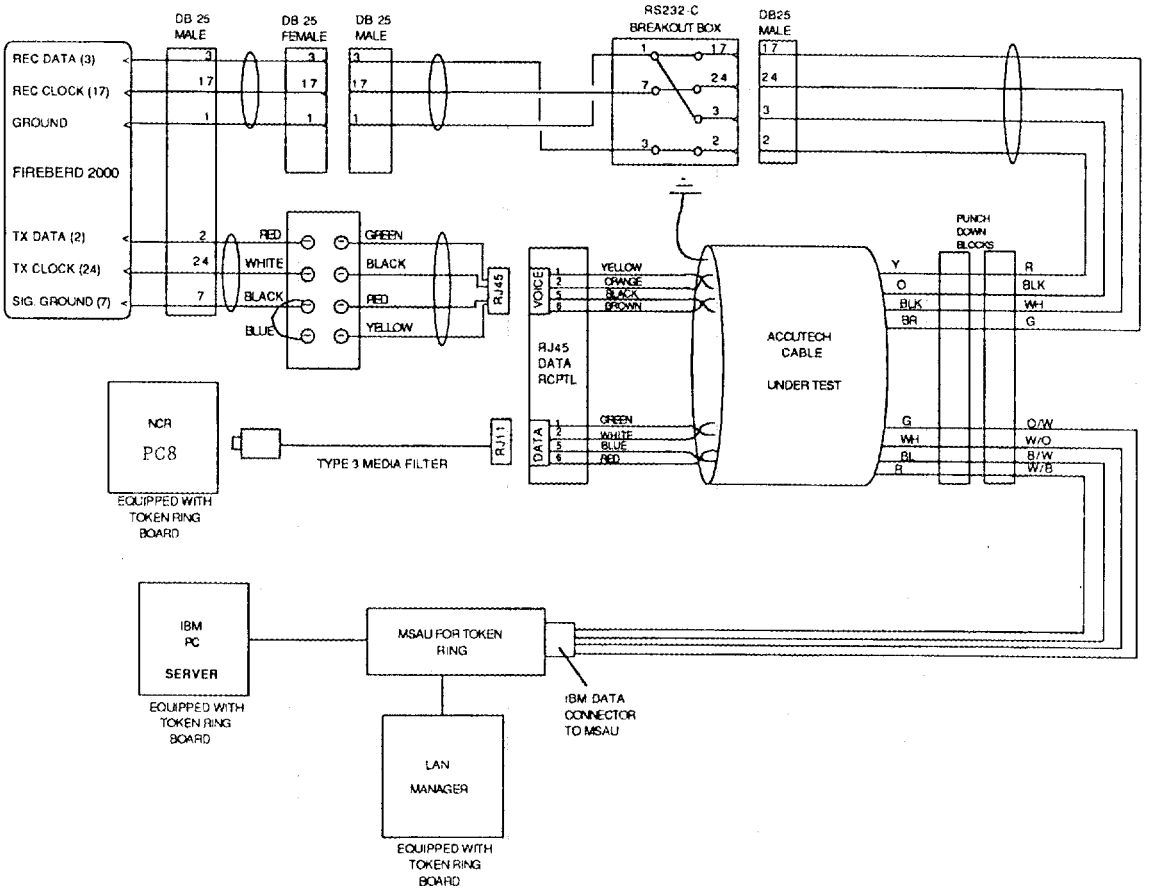

Fig. 4.2. Token-ring and RS232-C hardware connections.

5. CONCLUSIONS AND RECOMMENDATIONS

In summary, Accutech and Teledyne cable were used as transmission media as specified by the proposed standard wiring plan, and token-ring, Ethernet, and RS232 media access methods were used to exchange information via the wiring plan. The objectives of these tests were to determine whether any of the media access methods, in certain combinations, would degrade in performance while running over Accutech and Teledyne's unshielded twisted-pair cable, and to determine at what cable length token-ring network performance would degrade.

Tables 4.1 to 4.5 show the results of the test configurations of Figs. 3.3 to 3.7. As the results indicate, Accutech and Teledyne, while running the token-ring access method or while running two token-ring networks via one cable, can run up to distance of 320 ft without retransmissions. Teledyne tends to experience more retransmissions than Accutech when token-ring and Ethernet media access methods transmit via one cable. Accutech and Teledyne can run token-ring and RS232 media access methods via one cable without retransmissions or bit errors.

The following recommendations apply only to IBM token-ring equipment. Do not assume that these recommendations apply to other vendors' products. The recommendations for twisted-pair Ethernet products will be given in a separate report (to be published) titled, *An Evaluation of Ethernet via the Proposed Standard Wiring Plan.*[2] I&C recommends the following for the IBM token-ring network:

1. Lobe length should *not* exceed the 320 ft recommended by IBM.

2. Additional twisted pairs should be included during installation to allow for future expansion or redundancy.

3. Diagnostic tests cannot be executed on NCR machines installed on the network, or any other IBM clone, because they do not contain ROM BASIC.

4. Employ an operating system on the PC that uses a page-swapping algorithm as part of its memory manager. (One such operating system is OS/2 extended addition.) If this type of operating system is not used, the PCs will not have sufficient memory to perform other tasks while running on the network.

5. Use an adapter from RJ11 to RJ45 pin-outs when connecting the PC workstation to the wall receptacle to ensure proper connection to the token-ring network.

6. Two token-ring networks can operate over one cable.

7. Token-ring and Ethernet networks should *not* operate on one cable if the Ethernet network is heavily loaded (>50 active nodes).

8. Token ring and RS232-C can operate over one cable.

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