# Migrating Office Connections for Site Services

## from Token Ring to Fast Ethernet

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# Introduction

The intent of this paper is to share our experience in migrating offices (in NHD Building 664 in RTP, NC) from token-ring to Fast Ethernet connections for access to site services. As part of the ProNet mission to test pre-GA products with customer-like traffic, we designed a network that connects office desktops to site services through a network of IBM Ethernet and ATM products.

This paper describes our implementation of the network and what we learned from the experience in the following sections:

## Network design

We configured a network that connected 46 office desktops to Ethernet edge-devices over an ATM backbone to a site services network. The offices were previously connected to site services through a token-ring network. The primary objectives of the network design were:

- To demonstrate the key network design principles that marketing recommends to customers
- To validate NHD equipment with production traffic
- To enable future expansion of the network for pre-GA product testing.

We included key network design principles to provide the required tight integration between the service provider (IGS site network) and the service deliverer (the ProNet network) for high availability of IP services. We implemented some of these principles when the initial network became operational, and we are investigating the others for future implementation.

We implemented these design principles:

***Duplicate services**:* With this design principle, services must always be available, but disruption of a service is acceptable. The availability is achieved by having duplicate servers in place so that the user may be able to re-access a service. Our design duplicated Network Neighborhood and printer services. We did not duplicate Lotus Notes services because it's owned by, the site services provider, IGS.

***Hardened subnet**:* With this design principle, disruption of a service due to a network failure is not acceptable, but disruption can occur if the server hardware fails — including the adapter. Our design used OSPF to route and Spanning Tree to bridge through multiple network paths.

We are currently investigating and implementing these design principles:

***Virtualized service**:* With this design principle, disruption of a service due to network failures is not acceptable, but a disruption can occur if the application fails or its server fails. It is our intention that our servers have two Ethernet cards installed and attached to multiple networks.

***Hardened service***: With this design principle, disruption of a service is not acceptable due to a network failure, but disruption can occur if the server hardware fails — however, the user can immediately achieve access back to the service. We are currently investigating simulating Network Dispatchers on the 2216 Nways® Multiaccess Connector to provide this capability.

Our network design was comprised of these major sections:

- Desktop-to-LAN closet connection
- ProNet network
- Site LAN connection

The deployment of each section required that we work with the site services provider, IGS.

***The Desktop-to-LAN closet connection*** connected the desktops to an 8275 Ethernet Switch, which connected into the ProNet network. To prevent any disruption to non-ProNet users, IGS required that we locate the switch in our own secure room adjacent to the site building LAN closets. We ran jumper (Cat-5) cables from the site LAN closets into the switch as shown in Figure 1.

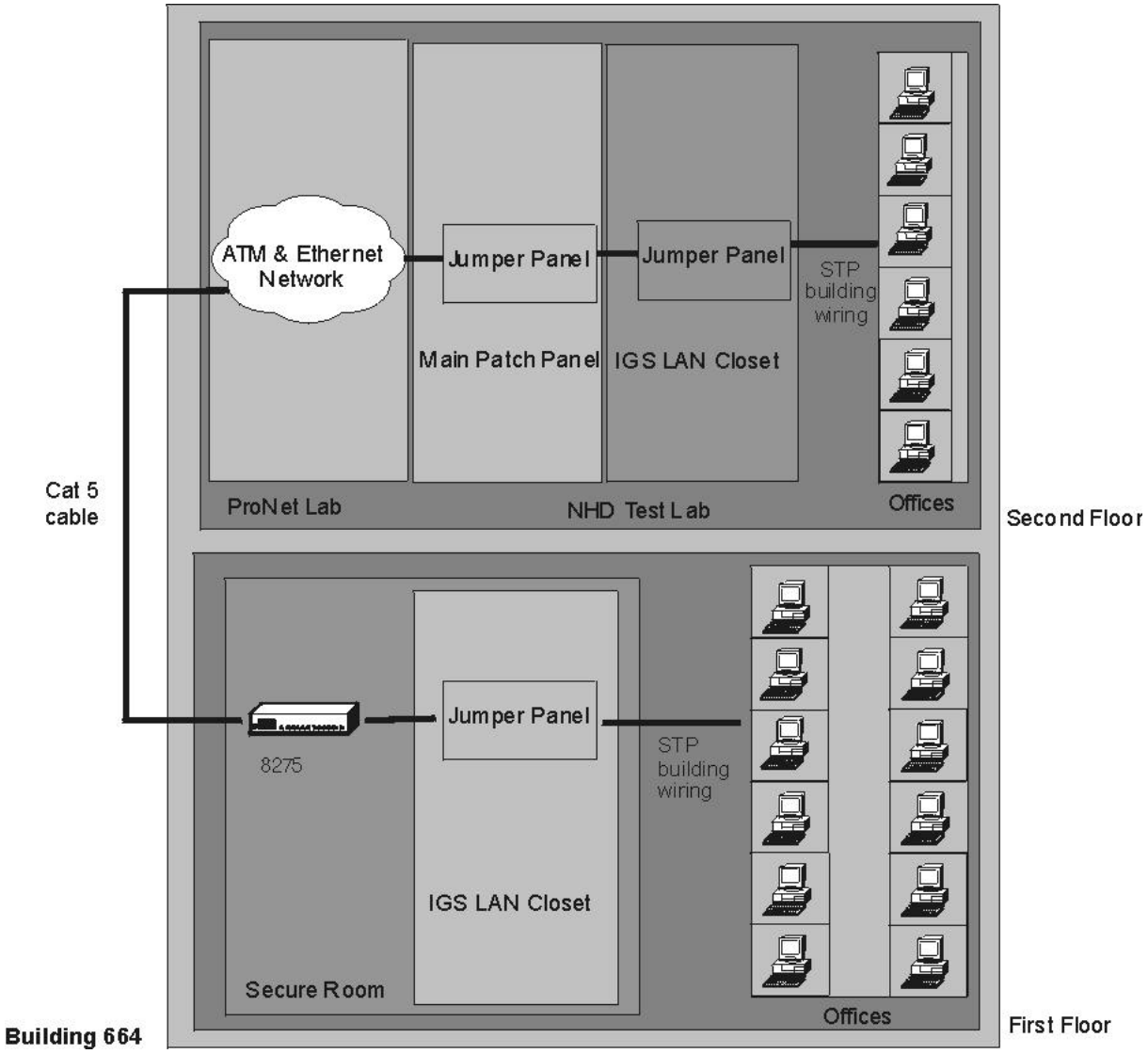



Figure 1. Office Connection Cabling Plan

We used a new cabling solution to support Fast Ethernet traffic over the existing cabling system, which previously supported token-ring traffic. The solution enabled us to attach the workstation and wiring closet switches to the existing IBM Cabling System. New 10/100-Mbps Ethernet Cable/Connectors allowed us to connect the office workstation Network Interface Card (NIC) to the existing Cabling System wall plate. Another cable was used in the LAN closet to attach to the Ethernet switch.

We attached one end of the cable into the IBM Cabling System patch panel that existed within the IGS LAN closets. We connected the other end into a separate RJ-45 panel that was fabricated and placed within the LAN closets. From this point, a Cat-5 cable was used to "patch or jumper" the connection out to the switch located adjacent to the IGS Site LAN closet.

***The ProNet network*** consisted of products that we tested by running traffic between the offices and the IGS site as shown in Figure 2.

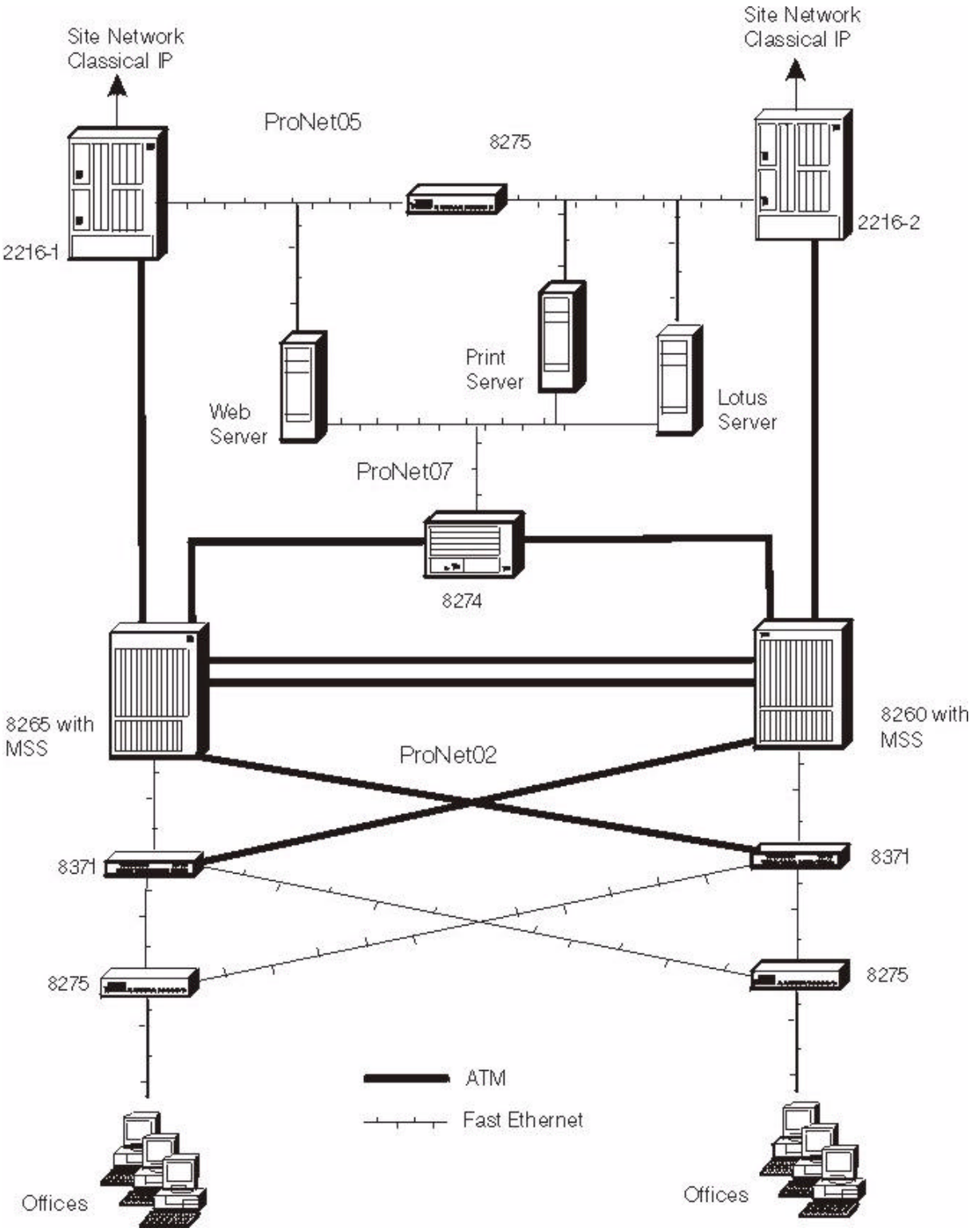



Figure 2. Physical Design

We provided resiliency by having redundant networks. For the ATM backbone, the 8260 Nways Multiprotocol Switching Hub was a backup for the 8265 Nways ATM switch with redundant PNNI connections between them. Nways Multiprotocol Switched Services (MSS) Server on the 8260 was a mirror image of the MSS Server on the 8265 with redundant LECS and LES/BUSs. The MSS Server on the 8260 served only as a backup. The 8274 Nways LAN RouteSwitch provided Fast Ethernet connections to the Lotus Server, Web Server, and ProNet Network printer. For redundancy, it had two ATM uplinks to the ATM backbone, although only one was active at a time (to the active ATM switch). The connection to the 8260 was in a blocking state unless the 8260 switched from a backup to an active state. We took advantage of redundant gateways when we configured IP routing on the 2216s. We also configured redundant 8371 Multilayer Ethernet Switches using virtual router redundancy protocol (VRRP) support.

***The site connection*** established a direct, 155-Mbps, IP Classical connection into the site IGS ATM backbone which was important because we wanted to give all of our users, whether located in the lab or offices, access to IGS Site LAN services (for example, Lotus® Notes™). The previous connection was a direct 16-Mbps attachment to the IGS token-ring network. IGS allowed us to attach our network, recognized as a private network, directly to their ATM backbone if we followed the following guidelines:

- Requirement for a UNI (router) connection to their network.
- No Layer 2 Spanning Tree
- No Layer 3 OSPF

**Product summary**
Table 1 lists the devices and code levels we used.

| Description | Code Level | Part Number |
|---|---|---|
| **Ethernet Adapters** | | |
| 10/100 Etherjet CardBus Adapter | | 08L3147 |
| 10/100 Etherjet PCI Management Adapter | | 34L1201 |
| **Ethernet Switches** | | |
| 8275-416 Fast Ethernet Desktop | V1.0 | 31L3597 |
| 8275-324 Fast Ethernet Desktop | V1.07 | 30L6613 |
| 8371-A16 Multilayer Ethernet Switch | V1.0 | 90G0645 |
| 2-port 155-Mbps MMF (for 8371) | | 90G0523 |
| 8-port 10/100BASE-TX (for 8371) | | 90G0530 |
| 9-ft U.S. Power Cord (for 8371) | | 6952300 |
| 8274 Nways LAN RouteSwitch W53 | V3.2.7 | 86H0012 |
| Management Processor Module (MPM) | | 86H0586 |
| 2-port 155-Mbps MMF | | 02L0866 |
| 12-port 10/100-Mbps Ethernet | | 86H3029 |
| **ATM Backbone** | | |
| 8265 - 17S | V4.1.2 | 3J8690 |
| 8210 MSS Model 1 blade | V2.2 PTF 3 | |
| 8260 Nways Multiprotocol Switching Hub | V3.2.2 | |
| 2-port 155-Mbps MMF | | 51H3882 |
| CPSW | | 42H1350 |
| MSS Server Module | V2.2 PTF 3 | |
| **Router** | | |
| 2216 - 400 Multiaccess Connector | V3.3 | 41H7700 |
| 1-port ATM MMF | | (F/C) 2284 |
| 1-port 10/100-Mbps Ethernet | | (F/C) 2288 |
| 2-port 10-Mbps Ethernet | | (F/C) 2281 |

Table 1. Product List

## Logical design

To meet requirements for the different floors in the building, for an aggregate server, and for future expansion, we created 16 subnets, with an emulated LAN (ELAN) or a physical LAN for each subnet. The 2216 routed IP traffic between IP subnets (logical and physical) and bridged, using Spanning Tree, non-IP traffic, such as NetBIOS. We implemented transparent bridging to handle services that required bridging. We used OSPF routing within the network. The 2216 connection to the IGS site LAN provided Classical IP only. MSS provided LES/BUS services and managed the logical subnetworks—ProNet02 and ProNet07. The 8275s provided Ethernet switching to the desktop. The 8371s provided Ethernet-to-ATM routing from a physical Ethernet subnet to a ATM logical Ethernet subnet.

Because our network ran IP-based traffic and we wanted end users to be able to access the IGS Site Services (for example, Lotus Notes), we had to use a valid range of IP addresses and subnets assigned to us by IGS. We received the address (9.37.2.45) for the router, which was attached to the Site network, from *http://iptools.raleigh.ibm.com*. The addresses 9.67.234.1 to 9.67.235.254 with netmask 255.255.254.0 were also assigned to us. We further subnetted the networks with a netmask of 255.255.255.224 to give us more networks. Figure 2 shows the logical and physical networks and associated devices.

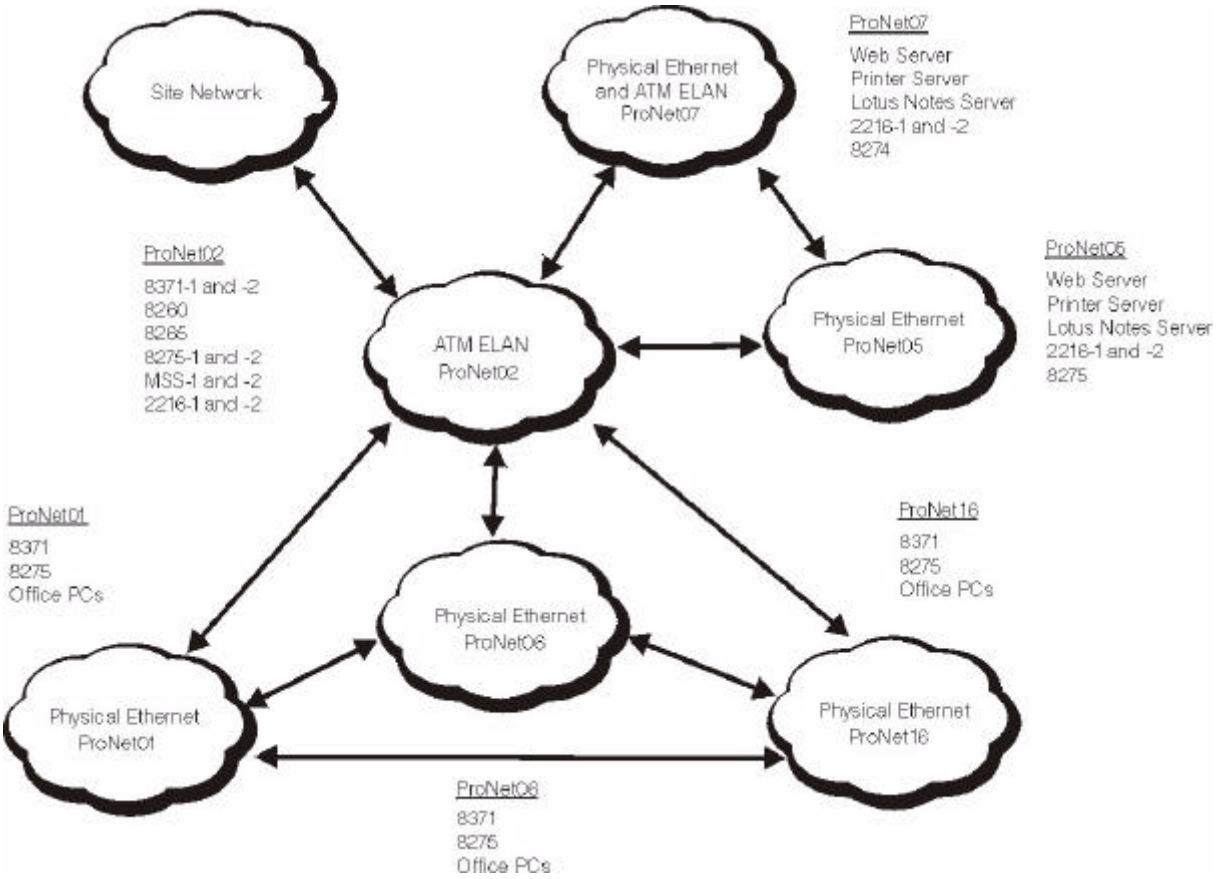



Figure 3. Logical Design

The following are the subnet address ranges utilized in the network:

| | |
|---|---|
| subnet ProNet01 | 9.67.234.0 through 9.67.234.31 |
| subnet ProNet02 | 9.67.234.32 through 9.67.234.63 |
| subnet ProNet03 | 9.67.234.64 through 9.67.234.95 |
| subnet ProNet04 | 9.67.234.96 through 9.67.234.127 |
| subnet ProNet05 | 9.67.234.128 through 9.67.234.159 |
| subnet ProNet06 | 9.67.234.160 through 9.67.234.191 |
| subnet ProNet07 | 9.67.234.192 through 9.67.234.223 |
| subnet ProNet08 | 9.67.234.224 through 9.67.234.255 |
| subnet ProNet09 | 9.67.235.0 through 9.67.235.31 |
| subnet ProNet10 | 9.67.235.32 through 9.67.235.63 |
| subnet ProNet11 | 9.67.235.64 through 9.67.235.95 |
| subnet ProNet12 | 9.67.235.96 through 9.67.235.127 |
| subnet ProNet13 | 9.67.235.128 through 9.67.235.159 |
| subnet ProNet14 | 9.67.235.160 through 9.67.235.191 |
| subnet ProNet15 | 9.67.235.192 through 9.67.235.223 |
| subnet ProNet16 | 9.67.235.224 through 9.67.235.255 |

## Network installation and configuration

After we received the IP addresses and approval for the network design, we configured the network from the ATM backbone out to the edge switches using the assigned IP addresses.

**8260 and 8265 configuration**
To configure the 8265 ATM switch, we performed the following general steps:

- Gave a unique ATM address to each switch.
- Enabled as UNI the ports that connected to Ethernet switches and servers.
- Enabled as PNNI the ports that connected the 8260 and 8265 together.
  The PNNI connection definition on the 8265 follows:

```
8265#2> show pnni node:0

NODE 0 CONFIG PARAMS (IN ACTIVE CONFIG REPOSITORY):
 leadership priority:      0
 level id:                 96
 peer group id             60.399999999999990000999901
 node id:                  60.a0.399999999999990000999990102.400082650200.00
 node's atm addr:          39.99999999999990000999990102.400082650200.00
 nodal representation:     simple
 node's transit capab:     unrestricted
 additional branching:     supported

NODE 0 OPERATIONAL:
 is not peer group leader
 is not a border node
```

- Created LAN Emulation Clients (LECs) assigning them a MAC address, IP address, subnet mask and default gateway. The LEC definition for the ProNet02 ELAN follows:

```
8265#2> show device
8265 ATM Control Point and Switch Module
Name : 8265#2
Location :
ProNet Lab

For assistance contact :
ProNet

Manufacture id: 930
Part Number: 02L3099 EC Level: F12445
Boot EEPROM version: v.4.1.2
Flash EEPROM version: v.4.1.2 (PNNI)
Flash EEPROM backup version: v.3.3.5 (PNNI)
Last Restart : 07:35:53 Tue 13 Jul 1999 (Restart Count: 31)

A-CPSW
------------------------------------------------------------------------
 > Subnet ethernet: Up
   IP address: 10.100.1.3. Subnet mask: FF.FF.FF.00
   MAC Address: 0006291F861A (BIA)
 > Subnet atm:
 IP address: 10.20.1.160. Subnet mask: FF.FF.FF.00

 > Subnet lan emulation ethernet/DIX
   Up
   Config ELAN Name :"pronet02"
   Actual ELAN Name :"pronet02"
   MAC Address: 0006291F061A
   IP address : 9.67.234.35. Subnet mask: FF.FF.FF.E0
   ATM address:39.99.99.99.99.99.99.00.00.99.99.01.02.40.00.82.65.02.00.00
   Config LES addr:none
   Actual LES addr:
39.99.99.99.99.99.99.00.00.99.99.01.02.00.00.82.10.00.00.03
   BUS ATM address:
39.99.99.99.99.99.99.00.00.99.99.01.02.00.00.82.10.00.00.03
   Config LECS add:none
   Actual LECS add: C5.00.79.00.00.00.00.00.00.00.00.00.00.A0.3E.00.00.01.00
   LEC Identifier: 4. Maximum Transmission Unit: 1492

Device configured for PNNI port capability.
Device configured for Lan Emulation Servers.
Dynamic RAM size is 32 MB. Migration: off. Diagnostics: enabled.
Device defined as primary.
Memory profile: Mixed (32_P_M)
Duplicate ATM addresses are allowed.
Accounting is disabled.
```

Configured a read/write community name and provided the IP address of the management station that will receive traps.

**MSS Server configuration**

To configure the MSS Server, we performed the following steps:

- Added an ATM device interface
- Configured a unique mnemonic ESI (000082100001)
- Added and defined ELANs (LES-BUSs), assigning the ESI, and enabled redundancy. The definition for the ProNet02 ELAN follows:

```
ProNet8210-1 LES-BUS config for ELAN 'pronet02'>LIST
LES-BUS Detailed Configuration
Name:  pronet02
   LES-BUS Enabled/Disabled:                    Enabled
   ATM Device number:                           0
   End System Identifier (ESI):                 00.00.82.10.00.00
   Selector Byte:                               0x03
   ELAN Type:       (S2)                        Ethernet
   Max Frame Size:  (S3)                        1516
   Control Timeout: (S4)                        120
   Max Frame Age:   (S5)                        1
   ELAN Identifier: (S7)                        2
   Mcast Send Disconnect Timeout: (S9)          60
   LECID Range Minimum:                         0x0001
   LECID Range Maximum:                         0xFEFF
   Validate Best Effort Peak Cell Rate (PCR):  No
   Control Distribute VCC Traffic Type:         Best Effort VCC
   Control Distribute VCC PCR in Kbps:          155000
   Control Direct VCC Max Reserved Bandwidth:  0
   Multicast Forward VCC Traffic Type:          Best Effort VCC
   Multicast Forward VCC PCR in Kbps:           155000
   Multicast Send VCC MAX Reserved Bandwidth:  0

    -LES-BUS Options-
   BUS Mode:                                    Adapter
   Security (LECS Validation of Joins):         Disabled
   Partition LE_ARP_REQUEST Forwarding Domain: Yes
   LE_ARP RESPONSE Destination:                 One client
Partition Unicast Frame Domain:             Yes
   Redundancy:                                  Enabled
   Peer Redundancy:                             Disabled
   Redundancy Role:                             Primary LES-BUS
   ATM address of Backup LES-BUS:  39999999999990000099990101000082100000003
   ATM address trace filter value: 00000000000000000000000000000000000000000
   ATM address trace filter mask:  FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF

    -BUS Monitor Configuration-
   Monitor Host Usage of BUS:                   Disabled
   # Top Hosts to Record:                      10
   # Seconds in each sample interval:          10
   # Seconds between sample intervals:         1800
   Frame sampling rate:                         1 out of 10

-Broadcast Manager Configuration-
   IP BCM:                                      Disabled
   IPX BCM:                                     Disabled
   NetBIOS BCM:                                 Disabled
   BCM IP Cache Aging Time:                     5
   BCM IPX Cache Aging Time:                    3
   BCM NetBIOS Cache Aging Time:                15
   BCM IPX Maximum Forwarding List:             50
   BCM IPX Server Farm Detection:               Disabled
   BCM IPX Server Farm Threshold:               20
   No BCM IPX Static Entries defined
-Bus Filter Configuration-
   Bus Filter Enabled:                          Disabled
   Bus Filter's Preferred List                  EXCLUDE LIST
   Bus Filter's Default Action                  EXCLUDE

    -Bus Police Configuration-
   Bus Police Enabled:                          Disabled
   Bus Police Filter Duration                   TEMPORARY
   Bus Police Threshold (packets/sec)           50
```

- Added and configured the LAN Emulation Configuration Server (LECS) assigning the ESI, policies, and ELAN information (including ELAN name, LES-BUS, and policies). We configured automatic database synchronization for backup as shown:

```
ProNet8210-1 LECS config>LIST
LECS Detailed Configuration
   Lecs is                                          Enabled
   ATM Device number:                               0
   ESI:                                             00.00.82.10.00.00
   Selector:                                        0x00
   Validate Best Effort PCR:                        No
   Configuration Direct Max Reserved BW (Kbps): 0
   Maximum number of simultaneous VCCs:             128
   Idle VCC Timeout (in seconds):                   60
   Trace ATM address value: 00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.0
0.00.00
   Trace ATM address mask:  FF.FF.FF.FF.FF.FF.FF.FF.FF.FF.FF.FF.FF.FF.FF.F
F.FF.FF
   Automatic Database Synchronization:              Yes
   Allow Config From Remote LECS:                   No

ProNet8210-1 LECS POLICIES config>LIST

Policy Listing...

Enabled  Priority  Type
=======  ========  ==========
    Yes        10  byElanNm
    Yes        20  byLanType
ProNet8210-1 LECS POLICIES config>


ProNet8210-1 LECS ELANs config>LIST

ELAN Listing...

                              Name  Type  Packet Size  Enabled
================================  ====  ===========  =======
                          pronet02  Ethe         1516      Yes
                          pronet07  Ethe         1516      Yes
ProNet8210-1 LECS ELANs config>
```

- Configured LECs on the LECS, assigning ELAN name, mnemonic ESI, and user-specified MAC address. The definition of the ProNet02 ELAN on the LECS follows:

```
ProNet8210-1 Selected ELAN 'pronet02'>LESs LIST


LESs for ELAN 'pronet02'

Enbld  LES ATM address
=====  ============================================================
  Yes  Local LES for: pronet02
       Backup LES with IBM LES redundancy:
       39.99.99.99.99.99.99.00.00.99.99.01.01.00.00.82.10.00.00.03


ProNet8210-1 Selected ELAN 'pronet02'>POLICY LIST NAME

ELAN names for ELAN 'pronet02'
Enabled  Value  =>  LES
=======  ========================================
    Yes  pronet02
            => Local LES for: pronet02
```

- Assigned IP protocol addresses for the LECs

- Enabled adaptive source routing transparent (ASRT) bridging protocol

**8274 configuration**

To configure the 8274, we performed the following steps:

- Defined ATM parameters, for example, the UNI version, LECS, and ELAN name. The definition of the ProNet07 ELAN follows:

```
   Slot 3 Port 1 Service 1 Configuration

1)  Description (30 chars max)        : ProNet07 Backup
2)  LAN Emulated Group                : 1
    21) LAN type { 802.3 (1),
                   802.5 (2) }        : 802.3
    22) Change LANE Cfg { NO (1),
                          YES (2) }   : NO
3)  LECS Address (40-char-hex)        : 47007900000000000000000000A03E00000100

4)  Admin Status { disable(1),
                   enable(2) }        : Enable
6)  Connection Type { PVC(1),
                      SVC(2) }        : SVC
    60) SEL for the ATM address       : 01

Enter (option=value/save/cancel) : 22=2

   Slot 3 Port 1 Service 1 LANE Configuration Parameters

1)  Proxy { NO (1), YES (2) }                 : YES
2)  Max Frame Size { 1516 (1), 4544 (2)
                     9234 (3), 18190 (4)    } : 1516
3)  Use translation options{NO (1), YES (2)   : Yes (use Swch menu to set)
4)  Use Fwd Delay time { NO (1), YES (2) }    : NO
5)  Use LE Cfg Server (LECS){ NO (1), YES (2)}: YES
6)  Use Default LECS address { NO(1), YES (2)}: YES
7)  Control Time-out (in seconds)             : 10
8)  Max Unknown Frame Count                   : 10
9)  Max Unknown Frame Time (in seconds)       : 1
10) VCC Time-out Period (in minutes)          : 20
11) Max Retry Count                           : 2
12) Aging Time (in seconds)                   : 300
13) Expectd LE_ARP Resp Time (in seconds)     : 1
14) Flush Time-out (in seconds)               : 4
15) Path Switching Delay (in seconds)         : 6
16) ELAN name  (32 chars max)                 : pronet07
```

- Defined SNMP parameters for network management. We changed the default Public community to read-write access and assigned an IP address to it.

**8371 configuration**

To configure the 8371, we performed the following steps:

- Defined ATM parameters, for example, the UNI version, LECS, and ELAN name
- Configured IP with VRRP redundancy. The list of IP addresses follows:

```
8371-1 IP config>LIST ADDRESSES
IP addresses for each interface:
   intf     0  9.67.234.1       255.255.255.224  Local wire broadcast, fill 1
   intf     1                                    IP disabled on this interface
   intf     2  9.67.234.65      255.255.255.224  Local wire broadcast, fill 1
   intf     3  9.67.234.97      255.255.255.224  Local wire broadcast, fill 1
   intf     4                                    IP disabled on this interface
   intf     5  9.67.234.161     255.255.255.224  Local wire broadcast, fill 1
   intf     6                                    IP disabled on this interface
   intf     7  9.67.234.225     255.255.255.224  Local wire broadcast, fill 1
   intf     8  9.67.235.1       255.255.255.224  Local wire broadcast, fill 1
   intf     9  9.67.235.33      255.255.255.224  Local wire broadcast, fill 1
   intf    10  9.67.235.65      255.255.255.224  Local wire broadcast, fill 1
   intf    11  9.67.235.97      255.255.255.224  Local wire broadcast, fill 1
   intf    12  9.67.235.129     255.255.255.224  Local wire broadcast, fill 1
   intf    13  9.67.235.161     255.255.255.224  Local wire broadcast, fill 1
   intf    14  9.67.235.193     255.255.255.224  Local wire broadcast, fill 1
   intf    15  9.67.235.225     255.255.255.224  Local wire broadcast, fill 1
   intf    16                                    IP disabled on this interface
   intf    17                                    IP disabled on this interface
       .
       .
       .
   intf    39                                    IP disabled on this interface
   intf    40  9.67.234.60      255.255.255.224  Local wire broadcast, fill 1
   intf    41  9.67.234.59      255.255.255.224  Local wire broadcast, fill 1
   intf    42                                    IP disabled on this interface
   intf    43                                    IP disabled on this interface
   intf    44                                    IP disabled on this interface
```

The VRRP information follows:

```
8371-1 IP config>LIST VRID

VRRP Enabled

                          --VRID Definitions--

IP address      VRID  Priority Interval Auth   Auth-key Flags Address(es)
9.67.234.1         1       255        1 None   N/A      X
9.67.234.65        2       255        1 None   N/A      X
9.67.234.97        3       255        1 None   N/A      X
9.67.234.161       5       255        1 None   N/A      X
9.67.234.225       7       255        1 None   N/A      X
9.67.235.1         8       255        1 None   N/A      X
9.67.235.33        9       255        1 None   N/A      X
9.67.235.65       10       255        1 None   N/A      X
9.67.235.97       11       255        1 None   N/A      X
9.67.235.129      12       255        1 None   N/A      X
9.67.235.161      13       255        1 None   N/A      X
9.67.235.193      14       255        1 None   N/A      X
9.67.235.225      15       255        1 None   N/A      X
8371-1 IP config>
```

- Enabled and configured OSPF
- Defined SNMP parameters for network management

**8275 Model 416 configuration**

To configure the 8275, we used the default configuration with one VLAN. We performed the following steps:

- Defined an IP address, subnet mask, and default gateway for the device
- Defined SNMP parameters for network management by changing the default public community to read-write access and adding a ProNet community with read-write access
- Ensured that Spanning Tree was enabled because sometimes it is not enabled by default

**2216 configuration**

To configure the 2216s, we performed the following steps:

- Added all devices (ATM and Ethernet modules) in slots
- Configured unique mnemonic ESI for ATM devices
- Configured LECs with the LECS, assigning ELAN name, mnemonic ESI, and user-specified MAC address. The LEC definition of the ProNet02 ELAN follows:

```
ProNet2216 Config>NETWORK 3
ATM LAN Emulation Client configuration
ProNet2216 Ethernet Forum Compliant LEC Config>LIST

                ATM LEC Configuration

   Physical ATM interface number    = 1
   LEC interface number             = 3
   LECS auto configuration          = Yes
   Default LECS ATM address         =  00.00.00.00.00.00.00.00.00.00.00.
00.00.00.00.00.00.00.00.00.00
   C1: Primary ATM address
          ESI address               = 00.00.22.16.00.00
          Selector byte             = 0x2
   C2: Emulated LAN type            = Ethernet
   C3: Maximum frame size           = 1516
   C5: Emulated LAN name            = pronet02
   C6: LE Client MAC address        = 00.00.22.16.00.03
   C7: Control timeout              = 30
  C10: Maximum unknown count        = 10
  C11: Maximum unknown time         = 1
  C12: VCC timeout period           = 1200
  C13: Maximum retry count          = 1
  C17: Aging time                   = 300
  C18: Forward delay time           = 15
  C20: LE ARP response time         = 1
  C21: Flush timeout                = 4
  C22: Path switch delay            = 6
  C24: Multicast send VCC type      = Best-Effort
  C25: Multicast send VCC avg rate  = 155000
  C26: Multicast send VCC peak rate = 155000
  C28: Connection completion timer  = 4

   LE ARP queue depth               = 5
   LE ARP cache size                = 5000
```

- Configured IP with redundant gateways as follows:

```
ProNet2216 IP config>LIST ALL
Interface addresses
IP addresses for each interface:
   intf    0  9.37.2.45      255.255.224.0    Local wire broadcast, fill 1
   intf    1                                  IP disabled on this interface
   intf    2  9.67.234.62    255.255.255.224  Local wire broadcast, fill 1
   intf    3  9.67.234.129   255.255.255.224  Local wire broadcast, fill 1
   intf    4  9.67.234.222   255.255.255.224  Local wire broadcast, fill 1

Routing

route to 0.0.0.0        ,0.0.0.0         via 9.37.1.123      cost 1


Protocols
BOOTP forwarding: disabled
IP Time-to-live: 64
Source Routing: enabled
Echo Reply: enabled
TFTP Server: enabled
Directed broadcasts: enabled
ARP subnet routing: disabled

ARP network routing: disabled
Per-packet-multipath: disabled
OSPF: enabled
BGP: disabled
RIP: disabled

Parameters
ARP-SUBNET-ROUTING    : disabled
ARP-NET-ROUTING       : disabled
CLASSLESS             : disabled
DSCACHE-SIZE          : 1024 entries
DIRECTED-BROADCAST    : enabled
ECHO-REPLY            : enabled
FRAGMENT-OFFSET-CHECK : disabled
PER-PACKET-MULTIPATH  : disabled
REASSEMBLY-SIZE       : 12000 bytes
RECORD-ROUTE          : enabled
ROUTING TABLE-SIZE    : 768 entries (52224 bytes)
(Routing) CACHE-SIZE  : 64 entries
SAME-SUBNET           : disabled
SOURCE-ROUTING        : enabled
TIMESTAMP             : enabled
TTL                   : 64

ProNet2216 IP config>LIST REDUNDANT
Redundant Default IP Gateways for each interface:
   inf   2  9.67.234.33      255.255.255.224  00.00.00.00.00.33  primary
   inf   4  9.67.234.193     255.255.255.224  00.00.00.00.00.F0  primary
```

- Enabled OSPF

- Configured the OSPF interfaces as follows:

```
ProNet2216 OSPF Config>LIST ALL

                        --Global configuration--
                OSPF Protocol:          Enabled
                # AS ext. routes:       100
                Estimated # routers:    50
                Maximum LSA size:  :    2048
                External comparison:    Type 2
                RFC 1583 compatibility: Enabled
                AS boundary capability: Enabled
                Import external routes:
                Orig. default route:    No (0,0.0.0.0)
                Default route cost:     (1, Type 2)
                Default forward. addr.: 0.0.0.0
                Multicast forwarding:   Disabled
                Demand Circuits:        Enabled
                Least Cost Area Ranges: Disabled
                Maximum Random LSA Age: 0

                --Area configuration--
Area ID           Stub? Default-cost Import-summaries?
0.0.0.0            No         N/A           N/A

                        --Interface configuration--
IP address       Area           Auth  Cost  Rtrns  Delay  Pri  Hello   Dead
9.67.234.33      0.0.0.0          0      1      5     1   200     10     40
9.67.234.129     0.0.0.0          0      1      5     1   200     10     40
9.67.234.193     0.0.0.0          0      1      5     1   200     10     40
9.67.234.62      0.0.0.0          0      1      5     1   200     10     40
9.67.234.222     0.0.0.0          0      1      5     1   200     10     40
ProNet2216 OSPF Config>
```

- Configured ATM Classical IP

- Enabled ASRT bridging as follows:

```
ProNet2216 ASRT config>LIST BRIDGE

               Source Routing Transparent Bridge Configuration
               ===============================================

Bridge:                 Enabled                 Bridge Behavior: STB
                  +-----------------------------+
------------------| SOURCE ROUTING INFORMATION |--------------------------------
                  +-----------------------------+
Bridge Number:          N/A                     Segments:          0
Max ARE Hop Cnt:        00                      Max STE Hop cnt:   00
1:N SRB:                Not Active              Internal Segment:  0x000
LF-bit interpret:       Extended
                  +-------------------+
------------------| SR-TB INFORMATION |----------------------------------------
                  +-------------------+
SR-TB Conversion:       Disabled
TB-Virtual Segment:     0x000                   MTU of TB-Domain:  0
                  +-----------------------------------+
------------------| SPANNING TREE PROTOCOL INFORMATION |-----------------------
                  +-----------------------------------+
Bridge Address:         Default               Bridge Priority:     32768/0x8000
SRB Bridge Address:     Default              SRB Bridge Priority: 32768/0x8000
STP Participation:      IEEE802.1d
                  +-------------------------+
------------------| TRANSLATION INFORMATION |----------------------------------
                  +-------------------------+
FA<=>GA Conversion:     Enabled                 UB-Encapsulation:  Disabled
DLS for the bridge:     Disabled
IPX Conversion:         Disabled
Conversion Mode:        Automatic
Ethernet Preference:    IEEE-802.3
                  +------------------+
------------------| PORT INFORMATION |-----------------------------------------
                  +------------------+
Number of ports added: 3
Port:   3      Interface:       2      Behavior:    STB Only   STP:  Enabled
Port:  12      Interface:       3      Behavior:    STB Only   STP:  Enabled
Port:  14      Interface:       4      Behavior:    STB Only   STP:  Enabled
```

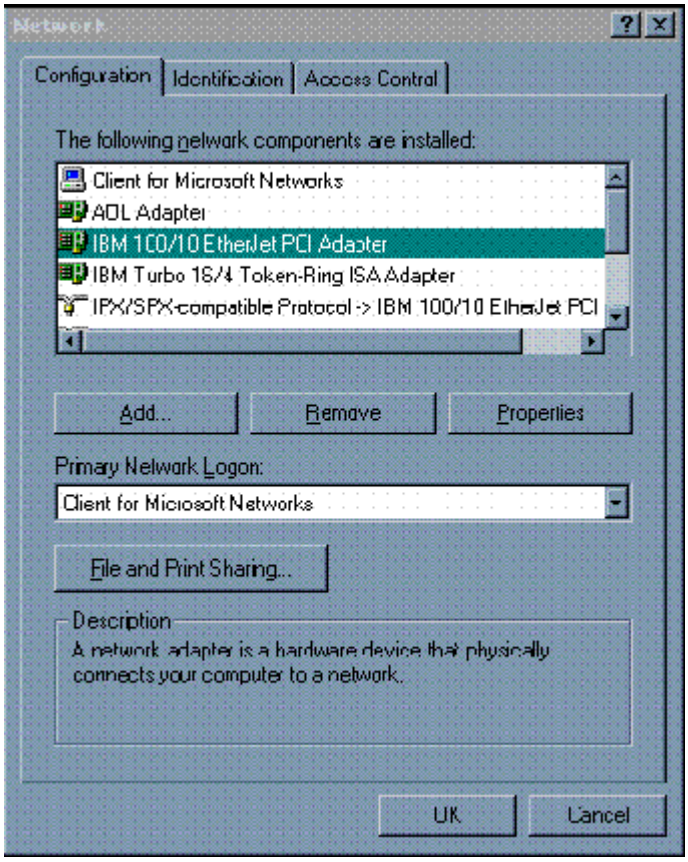
**Ethernet adapter installation**
For office desktops running Windows® 95 or Windows 98, we performed the following steps to install Ethernet adapters:

- Shut off the PC and removed the cover.
- Inserted the Ethernet adapter into the appropriate slot, either ISA or PCI.
- Powered on the PC.
- Windows 95 and Windows 98 are Plug and Play operating systems so they should find the adapter. When it did not find it, we used the driver diskettes for the adapter and the Windows CD-ROM. Sometimes, even when the operating system found the adapter, we still had to install the proper drivers from the driver diskettes.

After the PC recognized the card without any configuration errors, we configured the IP addresses.

***For office desktops running Windows 95 or Windows 98***, we performed the following steps to configure the IP addresses:

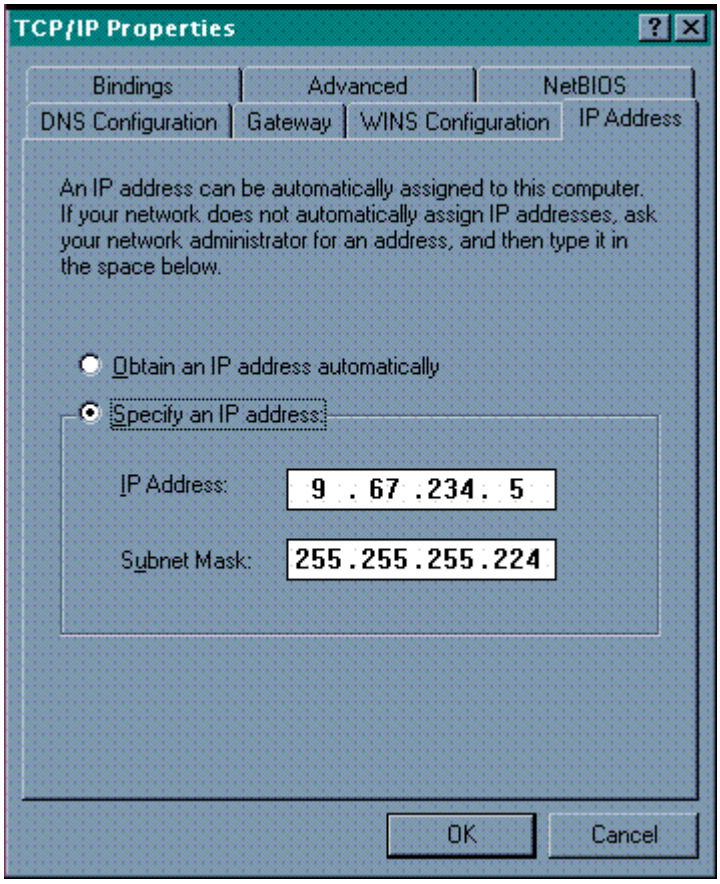
- We checked that the operating system had installed the IP and NetBEUI protocols for the Ethernet cards by double-clicking on the Network icon in the Control Panel. On the Configuration tab of the Network panel, if the protocols were not installed, we highlighted the Network Component type (as shown) and clicked **Add**.



- In the **Select Network Component** panel, we highlighted **Protocol** and clicked **Add**. Then in the **Select Network Protocol** panel, we highlighted the Manufacturer and then the **Network Protocol** (as shown) and clicked **OK**. We performed this procedure for both the TCP/IP and NetBEUI protocols.

- In the **Network** panel, we defined TCP/IP properties by highlighting **TCP/IP** for the Ethernet adapter and clicking **Properties**.

- On the **IP Address** tab, we clicked on **Specify an IP address** and entered the **IP Address** and **Subnet Mask** assigned by the network administrator as shown. On the **Gateway** tab, we entered the **Installed Gateway** address. On the **DNS Configuration** tab, we entered the **Host** name, **Domain**, and **DNS Server** assigned by the Network Administrator. We then clicked **OK** and rebooted when prompted by Windows.




If the adapter failed, we did the following:

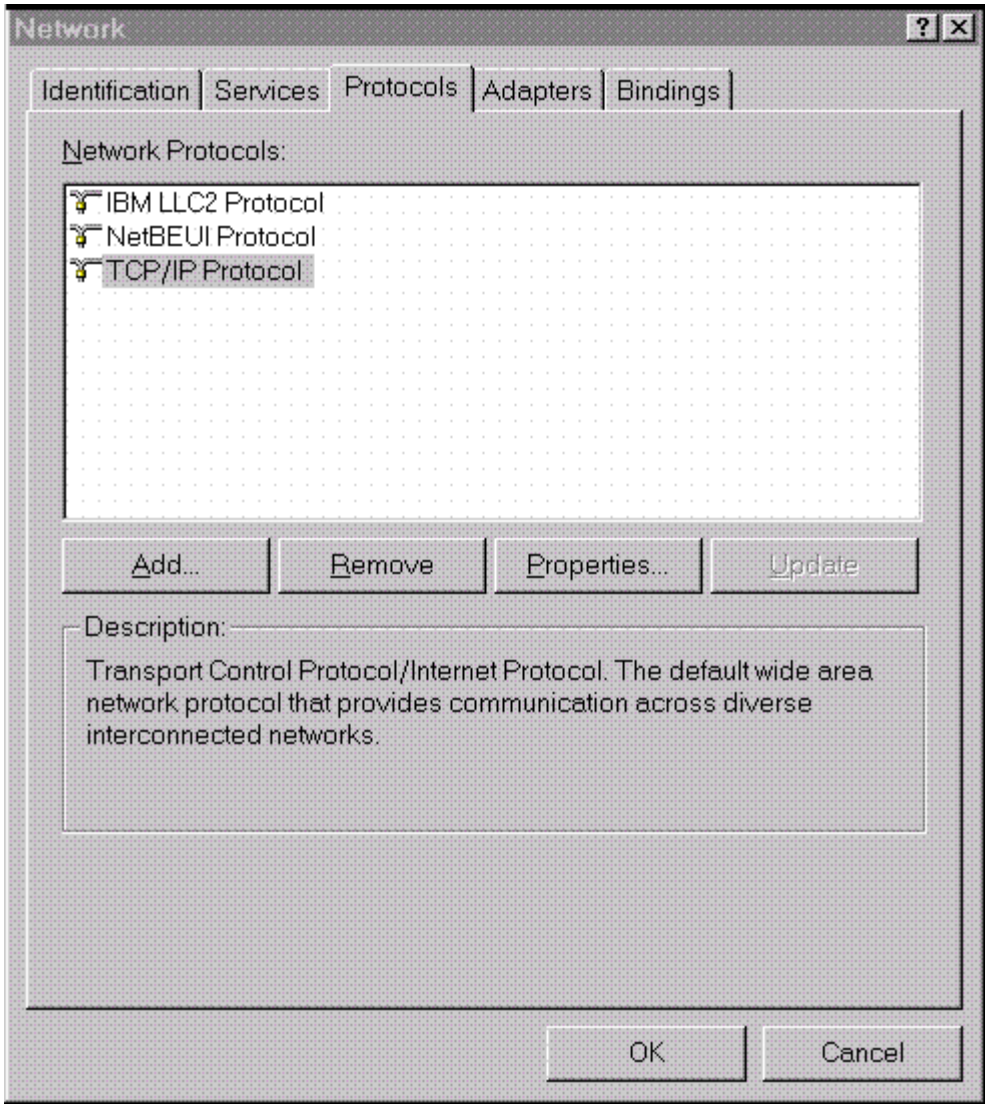
- Checked to see if there was a device conflict by clicking on the System icon in the Control Panel and then clicking on Device Manager. An exclamation mark icon indicated a device conflict.

- Checked to make sure that the TCP/IP information was entered correctly.

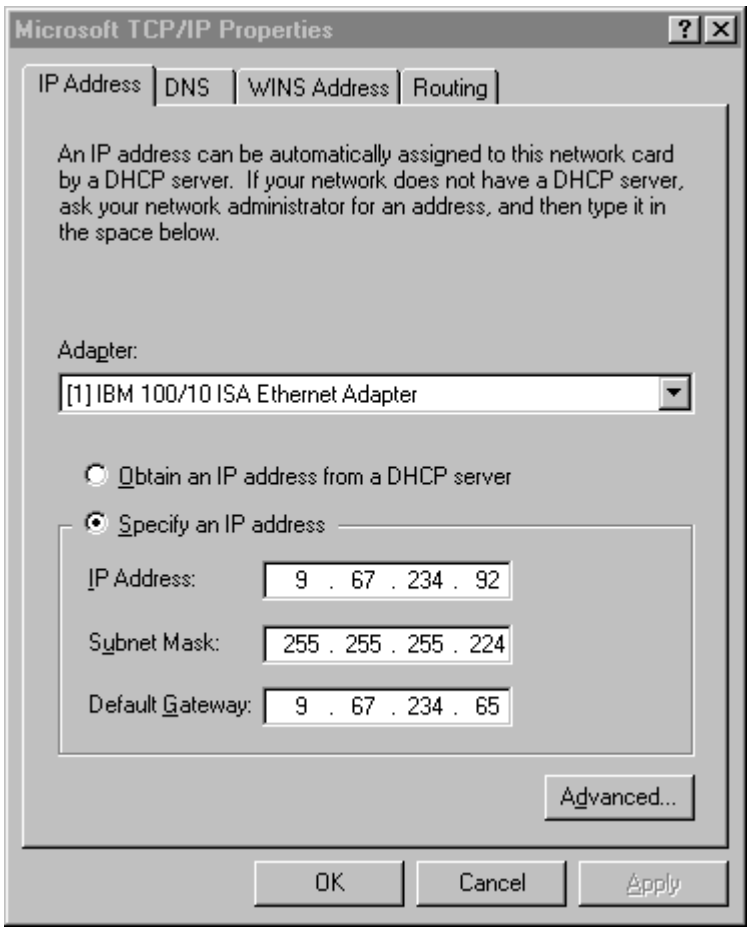
***For office desktops running Windows NT***®, we performed the following steps to install Ethernet adapters:

- We double-clicked on the Network icon in the Control Panel and clicked on the **Adapters** tab and clicked **Add** in the Network panel. If the adapter was not listed, we clicked on **Have Disk** and used the adapter driver diskettes.

- We clicked the **Protocols** tab to check that NetBEUI and TCP/IP protocols were installed. Selected TCP/IP Protocols and clicked the Properties button.



- On the **IP Address** tab, we entered the **IP Address**, **Subnet Mask** and **Default Gateway** as assigned by the network administrator. We clicked the **DNS** tab and entered the **Host Name**, **Domain** and **DNS Server**. We then clicked **OK** and rebooted Windows.




If the adapter failed, we clicked Windows NT Diagnostics under Administrative Tools in the Programs listing. We clicked on the **Resource** tab to check that the adapter was listed. If it was listed, we also checked that the TCP/IP information was entered correctly.

**Printer access**
Branch office users installed the ProNet network printer by performing the following steps:

- Clicked on the Network Neighborhood icon.
- Clicked on the ProNet domain
- Clicked on the pronet07195 computer
- Clicked on the Pronethp printer icon
- When prompted to install the printer, followed the Printer Wizard steps using the Windows 95, Windows 98, or Windows NT CD for the drivers.
- After the printer was installed, clicked on **Properties** in the **Printer** pulldown menu and selected the **Paper** tab. We then clicked on lower tray in the **Paper Source** field.

**Network management**
We used Tivoli TME10 NetView Server for AIX® to manage the devices in the network. We installed Tivoli TME10 NetView Server on a RS/6000® (256-MB RAM and an 8-GB hard drive) running AIX 4.3.2. We had to install the following pre-req AIX files:

- X11fnt.coreX.fnt or X11.compat.fnt.pc
- bos.loc.pc_compat.En_US

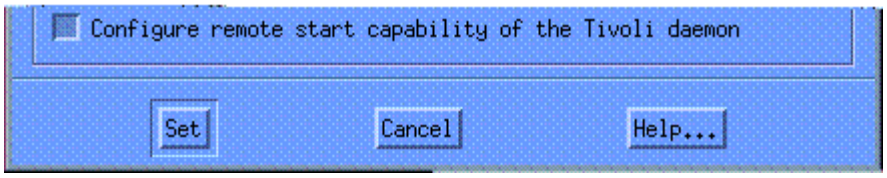
Before we actually installed the NetView Server Version 5.1, we had to perform the following general steps:

1. Installed a software management tool, TME 10 Framework Version 3.6
2. Installed a patch to this tool, TME 10 NetView Framework Patch
3. Made the NetView Server a managed resource

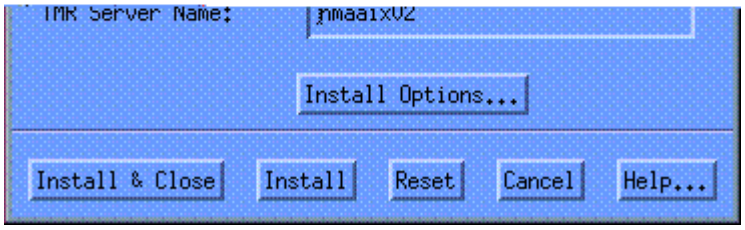
***To install TME 10 Framework Version 3.6***, we performed the following steps:

- Created the necessary directories and filespace:
  - Increased /usr filesystem size to 1 GB and /var filesystem size to 20 MB
  - Created an install directory: /usr/local/Tivoli/install_dir and assigned read-write access to it (`chmod -R 777 /usr/local`)
- Mounted the TME 10 Framework Version 3.6 CD-ROM:
  - Inserted the CD-ROM
  - Created a cdrom directory (`mkdir /cdrom`) and assigned read-write access to it (`chmod 777 /cdrom`)
  - Created a CD-ROM filesystem (We used the smitty interface to add a CD-ROM File System using the `/cdrom` and `cd0` parameters.)
  - Mounted the CD-ROM (`mount /cdrom`)
- Installed TME 10 Framework Version 3.6
  - Changed to the install directory (`cd /usr/local/Tivoli/install_dir`)
  - Accessed to the install file (`/cdrom/WPREIMST.SH`)
  - Started the install program (`wserver -c /cdrom`)

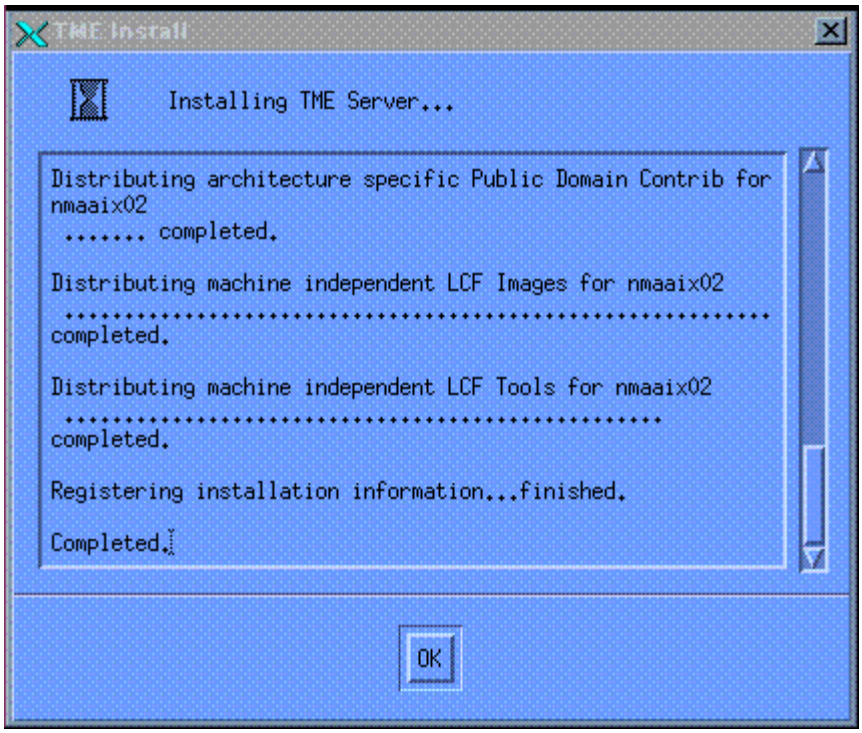
- On the **Install** panel, we selected the **When installing, create Specified Directories if missing** option and clicked the **Set** button. The other two Server Install options were already selected by default.



- On the next panel, we entered the TME 10 **License Key**, chose **Simple** encryption, entered the **Region Name** and entered a **TMR Server Name** that was the host machine name. We clicked **Install**.

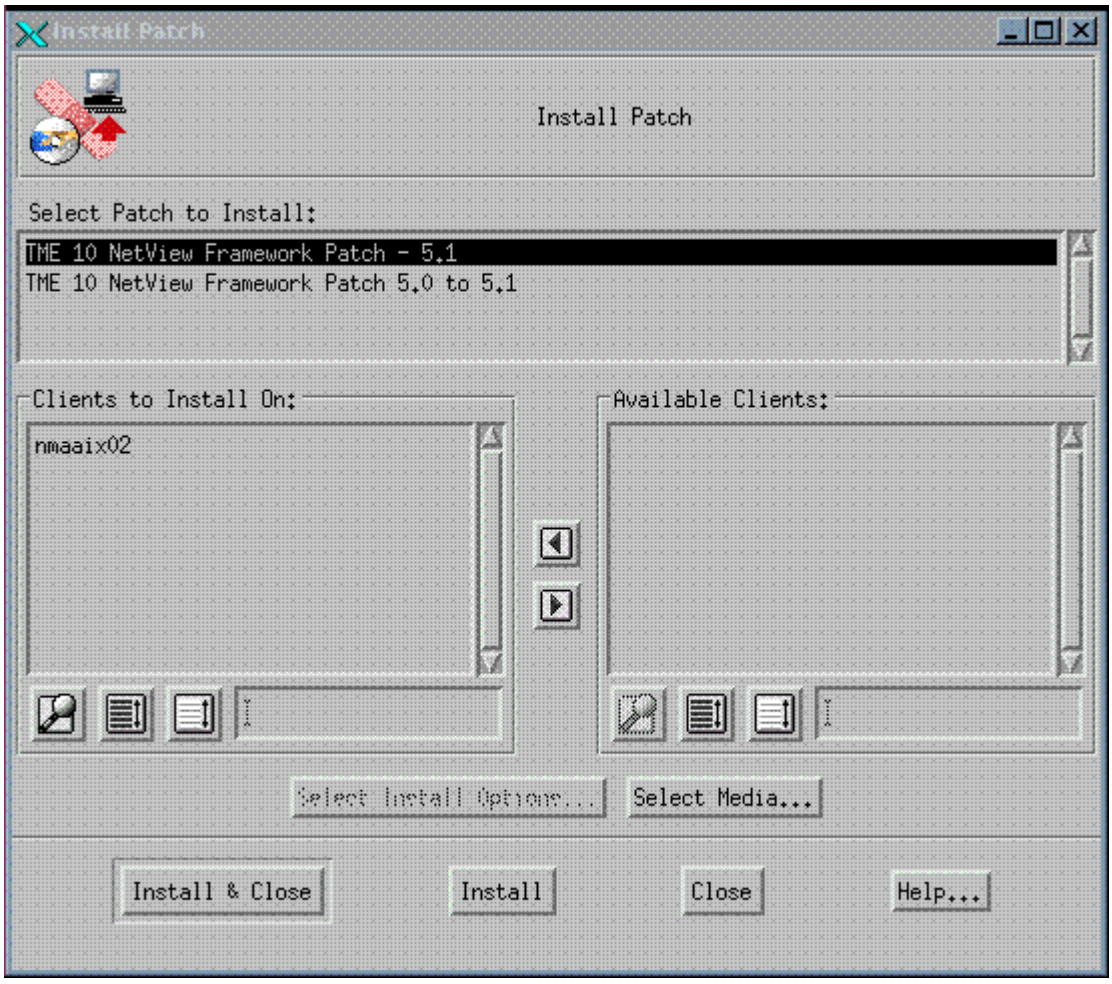



- On the **TME Install** panel, we verified that there were no prerequisites missing and clicked **Continue Install**. We waited for the `Completed.` message and clicked **OK**. TME started automatically and we unmounted the TME 10 Framework Version 3.6 CD-ROM.



***To install TME 10 NetView Framework Patch***, we performed the following steps:

- Mounted the TME 10 NetView for UNIX Version 5.1 CD-ROM:
  - Inserted the CD-ROM in the drive and mounted it (`mount /cdrom`)
- Installed the TME 10 NetView Framework Patch:
  - On the TME desktop, we selected **Install** and **Install Patch** from the **Desktop** pull-down menu.
  - On the **Install Patch** panel, we chose **TME 10 NetView Framework Patch - 5.1** and clicked **Install & Close** to install the framework patch. We verified the information and clicked **Continue Install** and then **Close**.

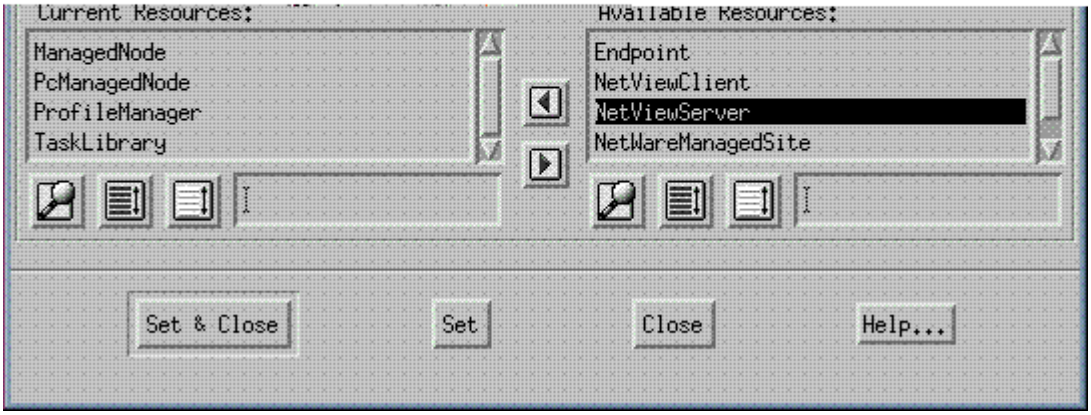


***To make the NetView Server a managed resource***, we performed the following steps:

- We entered **tivoli** at the command line to bring up the TME Desktop for Administrator and double-clicked on Policy Region icon.

- In the **Policy Region** panel, in the **Properties** pulldown menu, we selected **Managed Resource** then **Set Managed Resources**.

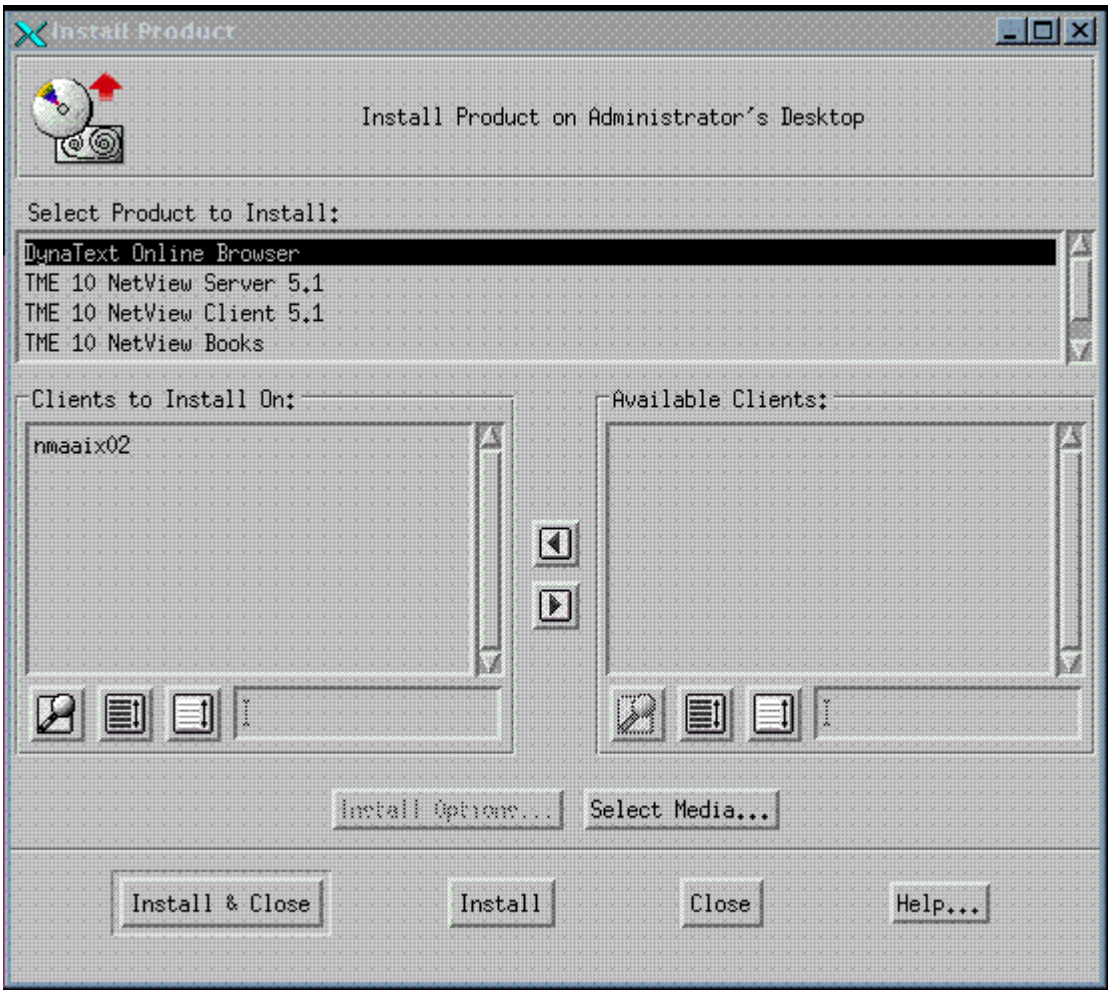
- In the **Set Managed Resources** panel, we selected **NetView Server** from the **Available Resources** list and moved it to the **Current Resources**, by clicking on the left arrow, and then clicked **Set & Close**.



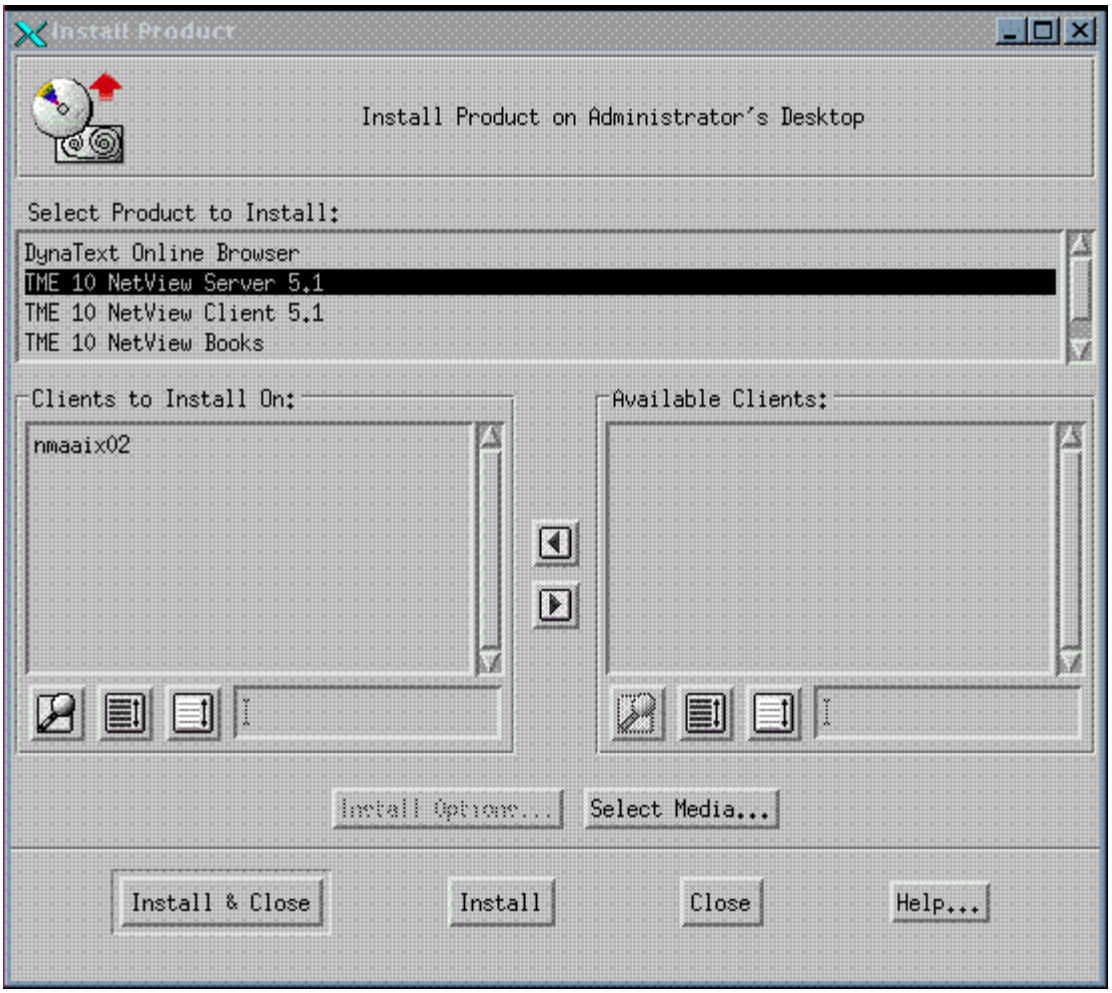
***To install NetView Server Version 5.1***, we performed the following steps:

- We mounted the CD-ROM (`mount /cdrom`) and started the desktop by entering **tivoli**. We highlighted the region icon. In the TME Desktop panel, from the Desktop pulldown menu, we selected **Install** and **Install Product**.

- In the **Install Product** panel, from the **Select Product to Install** menu, we selected the **DynaText Online Browser** (to be able to read help files) and clicked **Install**. We then verified the install information and continued the install.



- Again, from the **Desktop** pulldown menu in the **TME Desktop** panel, we selected **Install** and **Install Product**. In the **Install Product** panel, from the **Select Product to Install** menu, we selected **TME 10 NetView Server 5.1** and clicked **Install**. We then verified the install information and continued the install.




- We then started TME 10 NetView by entering **netview** in a terminal window.

## Redundancy testing

Our network environment was designed to be fault tolerant with no single points of failure. This section describes the redundancies that we tested for the 8371 Ethernet switches, MSS Servers, the 8260 and 8265 ATM switches, and 2216 routers.

For the testing, we measured the time it took for a workstation on the ProNet01 subnet to ping a device on the IGS network. We measured it when we disconnected the primary device (backup takeover time). and when we reconnected the primary device (backup release to primary time). The results are shown in Table 2.

| Devices Tested | Backup Takeover Time | Backup Release to Primary Time |
|---|---|---|
| 8371 Primary<br>8371 Backup | 31 seconds<br>0 seconds | 0 seconds<br>0 seconds |
| MSS Server Primary<br>MSS Server Backup | 45 seconds<br>0 seconds | 45 seconds<br>0 seconds |
| 8265 Primary<br>8260 Backup | See Note (estimated 45 seconds)<br>See Note (estimated 0 seconds) | See Note (estimated 45 seconds)<br>See Note (estimated 0 seconds) |
| 2216 Primary<br>2216 Backup | 20 seconds<br>0 seconds | 0 seconds<br>0 seconds |
| Note: When we disconnected the 8265 or 8260, the 8371 did not function properly so we could only estimate the expected redundancy results. This problem is currently being fixed (Problem Report # 80127). | | |

Table 2. Redundancy Testing Results

Note that when the network changes, Spanning Tree needs to resolve (up to 45 seconds) and OSPF might need to reconverge (up to 30 seconds). The test results include any time required for Spanning Tree and OSPF resolution.

## Issues and observations from the migration

This section describes the main issues that we encountered and resolved during our experience of migrating office connections for site services from token-ring to Ethernet.

**Ethernet adapter installation problems**

We installed Ethernet adapters in a variety of IBM PCs from the Aptiva® to the Thinkpad® 660e. Installation times ranged from ten minutes to almost a whole business day depending on the different hardware configurations and operating systems that we worked with. Some PCs come with more options or features than others, for example an Aptiva has more options than a PC 750 or a ValuePoint. Because we installed the adapters on different PCs, all the installations were unique.

Problems occurred primarily with the hardware configurations. Sometimes interrupts that were assigned to a card were used by another device. To resolve this issue, we either assigned other interrupts that were not in use or if a device was not in use, we disabled it to free up an interrupt.

Problems also occurred with some operating systems. The various operating systems included Windows 95, Windows 98, Windows NT, and NTWS. Windows 95 and Windows 98 are Plug and Play operating systems, so when we added the device, Windows frequently detected it. If Windows found and configured the adapter, installation was easy. However, sometimes depending on the adapter, Windows did not see it and the adapter required more work to configure. This situation occurred less frequently with Windows 98, because it includes more drivers. Drivers that were not on Windows 95 were often on Windows 98. Windows NT and NTWS are not Plug and Play operating systems. When installing the adapters with these operating systems, we almost always needed driver diskettes.

When we encountered a problem with an installation, we found that it helped to get additional information on both the PC and the adapter. Primarily, we referenced the Support pages on the IBM PC product page (*www.pc.ibm.com*) and the IBM Networking page (*www.networking.ibm.com*). There was often a fix for the types of problems that we encountered. Depending on the PC, we were able to download an upgrade or a fix. On the networking site, we found fixes and updated drivers for the adapters. We also checked the frequently-asked-questions (FAQ) sections to look for answers that pertained to problems we were encountering.

**IP address and name management issues**

We were not able to use the Dynamic Host Configuration Protocol (DHCP) function as we initially anticipated in our design. Originally, we wanted to use the DHCP function on the 2216 to have workstations acquire their IP addresses dynamically. However, our 2216 code didn't have dynamic domain name server (DDNS) capability, which our users required because they use applications that refer to the unique machine names for their workstations. Because we didn't implement DHCP, we had to maintain our own database of assigned IP addresses and machine names.

Another issue was that duplicate alias (IP Names) were not allowed on ProNet and IGS networks. In our configuration, all traffic was routed so services that did not route had to be handled by bridging using Network Neighborhood. If a PC was misconfigured with its computer name as one name and its ID another, then it could not be accessed correctly by Network Neighborhood. This was because the DNS knew it by one name or address and Network Neighborhood knew it by a different one. To retain an old IP Alias, the user had to use IPTOOLS (via Web) to delete the old IP Name. We added the alias to the user's new ProNet ID. When users wanted to use their old IP alias (machine name), they had to wait 24 hours for the turnaround time that it took to deregister it in the IGS IP address database and reassign it a ProNet IP address.

**Protocol constraint on the site network**

The site network supported Classical IP and did not support encapsulation of NetBIOS over IP. This protocol constraint led to issues with network printer access and network neighborhood displays.

Site network printers could not be accessed through the ProNet network, because of the Classical IP connection to the site network and the fact that we encapsulated NetBIOS over TCP/IP. The encapsulation was not configured or supported on the site network so users could not access site printers. We contacted IGS to ask that they configure the site network printers in building 664 to support encapsulated NetBIOS over TCP/IP traffic. Their solution will be to enable the printers for an application called Printing System Manager (PSM) through which you can then send and view print queues. In the meantime, we installed additional network printers on the ProNet network. The exception to this situation is if the user is running Wincenter which uses TCP/IP to connect to a server to simulate Windows 95. In this case, the user can get to the site printers but not to the ProNet printers because clients cannot add printers.

The protocol constraint also affected Network Neighborhood on Windows. When an office was connected through the ProNet network, ProNet network machine icons were the only machines that displayed in Network Neighborhood. Machine icons for any client or server machines residing outside of the ProNet network (that is, on the IGS site network) did not display. Network Neighborhood does not route. Because of bridging in the ProNet network, office desktops connected through the ProNet network can see all the machines in ProNet including those in other subnets in the ProNet network. We could not bridge to the site over the Classical IP link so Network Neighborhood could not see those machines. Machines that did not display in Network Neighborhood could still be accessed by finding the computer by name or IP address.

**Supplier delays**

## Summary

Overall, we were able to take advantage of the functionality of our networking products to create an efficient and resilient network. We exercised the flexibility MSS provides in managing logical emulated LANs and the 2216's routing power. We took full advantage of backup capabilities when configuring our devices for redundancy and implemented a production network with minimal unscheduled downtime. We found the migration to Ethernet fairly seamless with the help of migration solutions, such as the new IBM cabling system, and the Plug and Play capability of our Ethernet switches.

Although change is rarely easy, we didn't receive any negative feedback from users about their ability to receive site services during the migration to Ethernet other than the network printer issue caused by a site services network protocol constraint (described in the previous section). We did find that when we provided faster network speed through Ethernet and ATM technology, user desktop hardware became the limitation on speed in accessing site services. Product limitations and user requirements did force us to manage our own IP addresses and names instead of taking advantage of DHCP. And, as described in the previous section, we found that dealing with the different desktop configurations when installing Ethernet adapters caused issues that we had not anticipated. However, overall the migration was relatively easy despite the user and site network requirements and constraints that we encountered.

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