Redundant Physical Network Considerations

This chapter summarizes hardware options for implementing redundant DSL network environments. The following sections are included:

- Customer Premise Equipment (CPE) Considerations
- DSLAM 61xx/62xx Considerations
- Cisco 6400 Universal Access Concentrator (UAC) Considerations
- Chassis Redundancy
- Example Network Redundancy Solutions

Customer Premise Equipment (CPE) Considerations

Cisco Customer Premise Equipment (CPE) associated with DSL deployments are summarized as follows:

- Cisco 67x series products, including the Cisco 675, Cisco 675e, Cisco 677, the Cisco 678 and Cisco 673, are Ethernet to DSL bridge/routers.
- Cisco 627 is an ATM-25 to ADSL modem for single user connections as well as for data service unit (DSU) connectivity to business-class routers,
- Cisco 633 is a serial symmetric DSL (SDSL) data service unit (DSU) for business router connectivity.
- Cisco 827 is an Ethernet to ADSL fixed configuration, Cisco IOS-based router that includes a 10BaseT interface and an ADSL interface. The Cisco 827-4V version includes four analog telephone Foreign Exchange Station (FXS) ports.
- Cisco 1417 is a business class ADSL router that provides firewall and QoS features included with Cisco IOS.

Table 3-1 outlines relevant attributes and briefly describes the application of each of these devices.

Table 3-1 Details of Various Cisco ATU-R Devices

	Modulation	OS	Description
Cisco 627	Discrete Multi-Tone (DMT)-2 and G.Lite	CBOS	ATM-25 to ADSL modem
Cisco 633	2B1Q[1] (encode)	CBOS	SOHO/telecommuter SDSL router (1168 Kbps)
Cisco 673	Cisco 673	CBOS	SOHO/telecommuter SDSL router (1168 Kbps)
Cisco 675	Carrierless Amplitude Phase (CAP)	CBOS	SOHO/telecommuter ADSL router
Cisco 675e	CAP and G.Lite	CBOS	SOHO/telecommuter ADSL router
Cisco 677	DMT-2 and G.Lite	CBOS	SOHO/telecommuter ADSL router
Cisco 678	DMT-2, CAP, and G.Lite	CBOS	SOHO/telecommuter ADSL router
Cisco 827	DMT-2	Cisco IOS	SOHO/telecommuter ADSL router
Cisco 827-4V	DMT-2	Cisco IOS	SOHO/telecommuter ADSL Router (4 analog FXS[2] ports)
Cisco 1417	DMT-2	Cisco IOS	ADSL Router (small/medium businesses and branch offices)

1. 2 Binary 1 Quaternary. An amplitude modulation technique used for ISDN and High bit rate Digital Subscriber Loop (HDSL) service in the United States. This is defined in the 1988 ANSI specification T1.601. 2B1Q has four levels of amplitude (voltage) to encode 2 bits. Each voltage level is called a quaternary. Because of the four voltage levels, each level translates to 2 b/Hz.
2. Foreign Exchange Station interface This interface is an RJ-11 connector that allows connection for basic telephone equipment, keysets, and PBXs. It supplies ring, voltage, and dial tone.

Supported data rates for CPE:

- DMT: 8 Mbps downstream; 0.8 Mbps upstream
- CAP: 7 Mbps downstream; 1.0 Mbps upstream
- G.Lite: 1.5 Mbps downstream; 0.512 Mbps upstream

Reliable twisted-pair lines from the customer premise xDSL router (such as a 6xx) to the central office (CO) are terminated at plain old telephone system (POTS) splitters. No redundancy is available in this path and lines are maintained by the local Telco provider.

For SOHO redundancy can be implemented here by using two DSL lines, using one to backup the other.

DSLAM 61xx/62xx Considerations

The Cisco 61xx/62xx Series products provide end-to-end service, carrying data between a DSL subscriber's home or office, a telephone central office (CO), and various networks. The Cisco 6100 Series with the NI-1 system sends and receives subscriber data over existing copper telephone lines, concentrating all traffic onto a single high-speed trunk for transport to the Internet or a corporate intranet. A Cisco 6130 it can be subtended to seven (12 using NI-2) systems while in 6260 it can be subtended to 12 systems.

Network Interface 1 (NI-1)

Network Interface 1 (NI-1) consists of three modules:

- DS3 Subtend Host Module (STM)
- Network Interface
- System Controller Module

DS3 Subtend Host Module (STM)

The DS3 STM host module manages subscribers that are sent from a subtended Cisco 6100/6130 chassis and installed in slot 9 of a subtending host chassis.

Network Interface

The NI-1 module provides a high-speed connection for aggregated data traffic from the xTU-C modules

System Controller Module

The system controller module is the central processing and control system for the main access Cisco 6100/6130. The system controller module contains all software required to perform the provisioning, monitoring, control, status, management, alarm reporting, etc.

Physical Slots

Table 3-2 summarizes physical system slot allocation for NI-1.

Table 3-2 DSLAM NI-1 Slot Usage

	Primary	Backup
DS3 Subtend Module	9	29
Network Interface Module	10	11
System Controller Module	12	30

Note The secondary slots are not supported at this time.

Network Interface 2 (NI-2)

Network Interface 2 (NI-2) consists of the Network Interface module.

Network Interface

The NI-2 module provides a high-speed connection for aggregated data traffic from the xTU-C modules

Physical Slots

Table 3-3 summarizes physical system slot allocation for NI-1.

Table 3-3 DSLAM NI-2 Slot Usage

	Primary	Backup
Network Interface Module	10	11

Cisco 6400 Universal Access Concentrator (UAC) Considerations

The Cisco 6400 UAC uses an eight-slot, modular chassis supporting half-height and full-height cards, slot redundancy, and dual, fault-tolerant, load-sharing AC or DC power supplies. This section summarizes the functions of the following Cisco 6400 modules:

- Node Switch Processor (NSP)
- Node Route Processor (NRP)
- Node Line Card (NLC)

The central slots (slot 0A and 0B) in the Cisco 6400 are dedicated to redundant, field-replaceable node switch processor (NSP) modules that support both the 5-Gbps shared memory and the fully nonblocking switch fabric.

The NSP also supports the feature card and high performance Reduced Instruction Set (RISC) processor that provides the central intelligence for the device. The NSP supports a wide variety of desktop, backbone, and wide-area interfaces.

The remaining slots support up to eight hot-swappable carrier modules for node router processors (NRPs) or half-height node line cards (NLCs). NRPs and NLCs can be configured for redundant operation. As a result, you can have up to four redundant pairs of NRPs or any combination of NRPs and NLCs. The NRPs are fully functional router modules capable of terminating PPP sessions uploaded from your OC-12, OC-3, or DS3 node line cards.

Table 3-4 summarized slot assignment for Cisco 6400 NSP, NRP, and NLC modules.

Table 3-4 Cisco 6400 Slot Usage

	Slot 1	Slot 2	Slot 3	Slot 4	Slot 0A	Slot 0B	Slot 5	Slot 6	Slot 7	Slot 8
NSP					*	*				
NRP	*	*	*	*			*	*	*	*
NLC	*	*	*	*			*	*	*	*

Details regarding Cisco 6400 software and hardware implementation are available at the following location:

- http://www.cisco.com/univercd/cc/td/doc/product/dsl_prod/6400/index.htm

Node Switch Processor (NSP)

The Cisco 6400 node switch processor (NSP) provides ATM switching functionality. The NSP uses permanent virtual circuits (PVCs) or permanent virtual paths (PVPs) to direct ATM cells between the NRP and ATM interface. The NSP also controls and monitors the Cisco 6400 system, including component NLCs and NRPs.

Redundancy need not be explicitly specified between NSPs using the slot identification, because only NSPs can be installed in slot 0. If two NSPs are installed in the Cisco 6400, they automatically act as a redundant pair. Use the **main-cpu submode** command to specify synchronization between the NSPs.

It is possible to force a switch-over of NSP from the active NSP to the secondary NSP. This may be needed if the current running NSP requires removal.

The synchronization between dual NSP's is enabled automatically by default. Use the **main-cpu submode** command to customize that behavior.

Node Route Processor (NRP)

The NRP receives traffic from NLC interface ports via the NSP ATM switch. The NRP reassembles the ATM cells into packets, processes (routes, bridges, etc.) the packets, segments the packets, and sends them back to the NSP for transmission out of another NLC interface. The Cisco 6400 can contain multiple NRP modules, configured to operate independently or as redundant pairs (1+1).

NRP redundancy is achieved by *redundant slot configuration in the NSP*. The following configuration example illustrates creating a redundant NRP:

```
NSP# config term
NSP(config)# redundancy
NSP(config-r)# associate slot 7 8
```

To ensure that the configuration is consistent between redundant NSPs or NRPs, you can configure automatic synchronization between the two devices. Possible options include: synchronizing just the startup configuration, synchronizing the boot variables, synchronizing the configuration register, or synchronizing all three configurations.

A secondary NSP/NRP is suspended during initialization and monitors primary for failure. Primary and secondary NSPs communicate via shared backplane signals for synchronization. On failure, the secondary resumes its suspended boot sequence and takes over as master.

Node Line Card (NLC)

Node line cards (NLCs) provide ATM interfaces for the Cisco 6400 system. There are three types of NLC available for the Cisco 6400, each offering a different interface type (OC-12, OC-3). NLC interfaces are controlled by the NSP.

NLC redundancy can be configured between two half-height line cards in adjacent subslots. When subslot redundancy is configured, all ports on the two subslot cards are redundant. The following configuration example illustrates creating a redundant NLC:

```
NSP# config term
NSP(config)# redundancy
NSP(config-r)# associate subslot 3/0 4/0
```

The Cisco 6400 supports 1+1, linear, unidirectional, non-reverting SONET APS (automatic protection switching) operation on its redundant NLC ports. In this 1+1 architecture, there is one working interface (circuit) and one protect interface, and the same payload from the transmitting end is sent to both the receiving ends. The receiving end decides which interface to use. The line overhead (LOH) bytes (K1 and K2) in the SONET frame indicate both status and action.

The protect interface provides communication between the process controlling the working interface and the process controlling the protect interface. With this protocol, interfaces can be switched to the protection channel because of a signal failure, loss of signal, loss of frame, automatically initiated switchover, or manual intervention. In unidirectional mode, the transmit and receive channels are switched independently.

Note Currently, DS3 line card redundancy is not supported on the chassis. 1+1 linear, non-reverting, unidirectional APS is specific to optical interfaces (OC-3/OC-12 in the Cisco 6400). Cisco’s APS is based upon the GR-253-Core Specification.

Power Supply

Cisco 6400 supports dual, fault-tolerant, load-sharing AC or DC power supplies.

Software

The latest Cisco IOS software release supporting the redundancy features for the Cisco 6400 can be found at CCO at the following link:

- http://www.cisco.com/cgi-bin/Software/Iosplanner/Planner-tool/iosplanner.cgi?majorRel=12.1

Note This web location requires CCO registered user login access.

Table 3-5 summarizes Cisco 6400 software support of redundancy.

Table 3-5 Cisco 6400 Available Images

Router Module	Minimum Software Support Requirement
Cisco 6400 - NRP	12.1.1-DC1
Cisco 6400 - NSP	12.1.1-DB1

Component Limitations and Constraints

Important points that must be considered before implementing redundancy in 6400:

- When configuring redundancy between two NRPs or two NSPs, the two cards must have identical hardware configurations. DRAM size, Flash memory size has to be the same.
- Redundancy can be configured only between adjacent (odd and even) slot or subslot pairs.
- In the Cisco 6400 environment, the lower slot or subslot number is for the working device and the higher slot or subslot is for the protection device.

Chassis Redundancy

A redundant chassis solution is useful in the NAP or NSP where multiple Cisco 6400s are used to aggregate traffic. This approach is useful in the absence of software and hardware supported mechanism that would otherwise provide box level redundancy. The Cisco 6400 uses an eight-slot, modular chassis featuring the option of half-height and full-height card and slot redundancy (NSP, NRP, and NLC redundancy), along with dual, fault-tolerant, load-sharing AC or DC power supplies. The approach described in this section can be used to provide box-level high availability.

The redundant Cisco 6400 should be ready to act as backup for any of the active 6400, in terms of both software and hardware configuration. The backup aggregation switch will have no ATM or DS3 links coming to the DSLAMs. As a result, the switch will be functionally ready except there will be no incoming user calls.

In the case of a chassis failure the backup 6400 can be used to handle the calls of the failed chassis until it recovers. Human intervention is required to move the ATM or DS3 link from the failed chassis to the backup 6400. The Fast Ethernet or ATM uplinks to the ISP/Internet must also be moved.

This method can be used to provide physical backup for the 6400s.

Considerations

Choosing to deploy a redundant chassis implementation requires planning and resource commitment. Before committing to a redundant chassis solution, be sure to assess factors that might influence the success and supportability of your solutions. Examples of assessment criterion include the following considerations:

- **Real estate for the extra Cisco 6400—**Does your wiring closet have sufficient ventilation for additional Cisco 6400 systems? Can you physically fit additional chassis into your system racks? Do you have sufficient power to support additional Cisco 6400 requirements?

- **Cost of the extra Cisco 6400**—Is the trade-off between downtime and backup hardware worth the capital outlay? Are there mission critical applications running over this connection? Will users accept the downtime associated with failures when no backup exists?
- **Human Intervention Requirement**—Is there a sufficiently knowledgeable staff on hand to handle changes mandated by a redundant chassis swap? Will additional contractors be required to handle remote location swaps?

Advantages

Two important advantages can be attributed to a redundant chassis solutions:

- **Reduced Maintenance Downtime—**The redundant 6400 can be used to reduce downtime to few minutes in case of 6400 software upgrades. Usually the scheduled downtime needed to upgrade a complex system like 6400 can go from half an hour to few hours. Using the backup system approach reduces the downtime to few minutes.
- **Extended Time for Troubleshooting—**In the event of a system problem (crash, memory leak, et.c) the backup Cisco 6400 can be used to handle user calls while support staff (TAC/NSA, Consultant/developer) works to reinstate the failed system and to recover information needed to isolate and diagnose the problem.

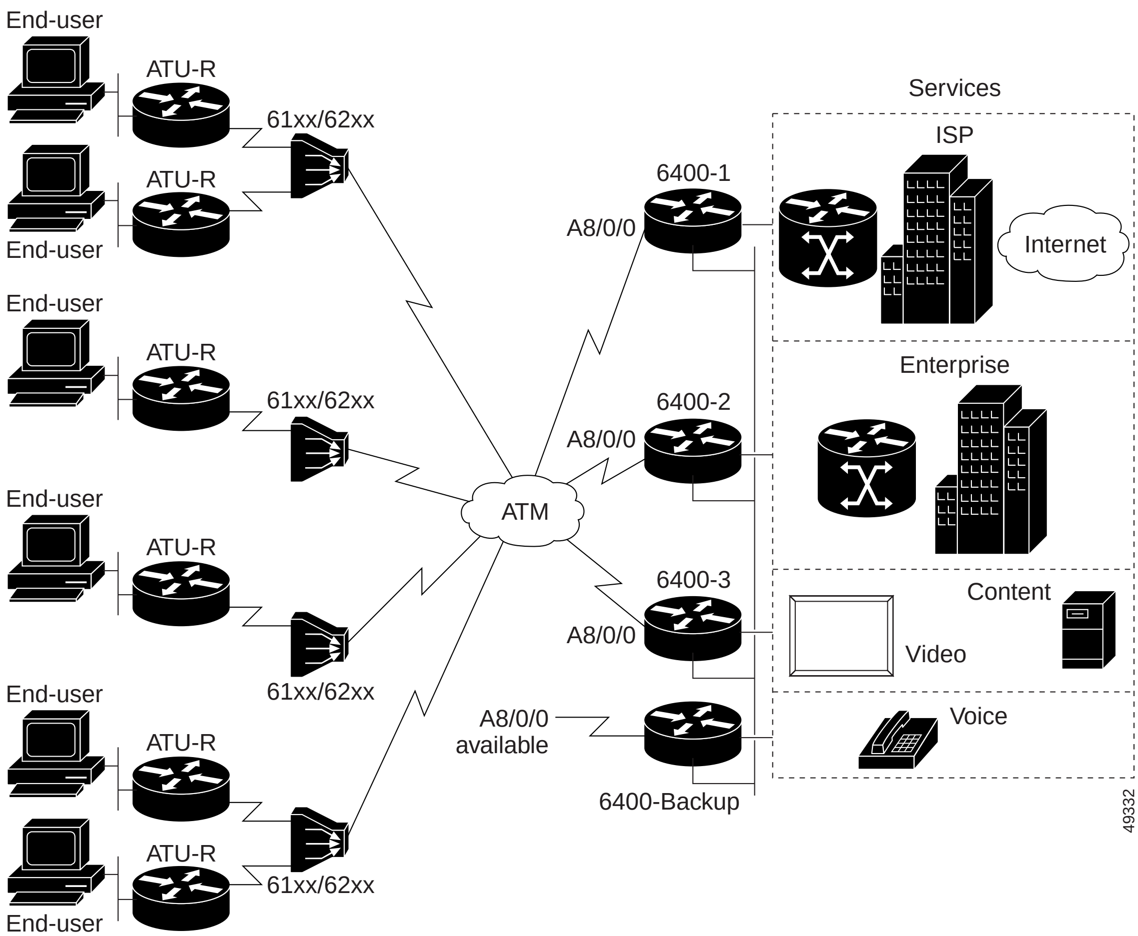
Note In the absence of a backup system the failed 6400 would have been immediately rebooted to establish network connectivity.

Example Network Redundancy Solutions

Figure 3-1 illustrates an example redundant chassis network topology. Optional design solutions are summarized in the sections that follow this illustration:

- Design I: Redundant Chassis Solution
- Design II: Software Configuration Redundancy Solution

Figure 3-1 DSL Network with Redundant Chassis Implementation



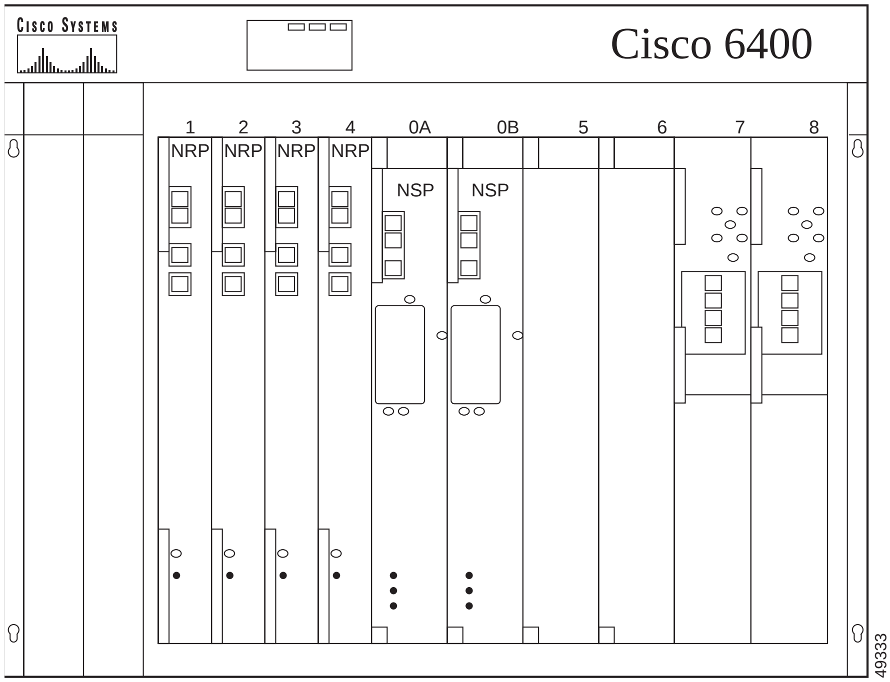
Design I: Redundant Chassis Solution

Given the network topology as illustrated in Figure 3-1, this discussion of a redundant chassis approach focuses on how the chassis redundancy can be used to backup a Cisco 6400. The Cisco 6400 currently handles up to 14,000 simultaneous user calls. The approach can be applied to achieve higher availability for the DSLAM (61xx/62xx).

NRP/NSP/NLC Redundancy Notes

Before the redundant chassis is considered make sure the NRP and NSP within the box are redundant and configured for fail-over. Figure 3-2 illustrates a sample hardware configuration for a Cisco 6400 utilizing NRP/NSP/NLC redundancy features.

Figure 3-2 Example of 6400 with fully redundant NSP, NRP and NLC



To further define the approach adopted for Design I supporting the network illustrated in Figure 3-1, consider the following slot pairings (active/backup) for the Cisco 6400 listed as 6400-1:

- NRP slot 1 and NRP slot 2 are associated; NRP slot 2 is the backup
- NRP slot 3 and NRP slot 4 are associated; NRP slot 4 is the backup
- NSP slot 0B is the backup for NSP slot 0A.

The associated NRPs and NSPs have the same hardware and software configurations including the same size flash and DRAM. Configurations between the two adjacent components will *auto-sync* unless explicitly specified by the **no auto-sync** command. Subslot redundancy association is between subslot 7/0 and subslot 8/0.

One can accomplish the associations suggested here with the following configurations on the NSP:

```
!
redundancy
  main-cpu
    auto-sync standard
!
redundancy
  associate slot 1 2
redundancy
  associate slot 3 4
redundancy
  associate subslot 7/0 8/0
!
```

The other Cisco 6400s in Figure 3-1 (6400-2 and 6400-3) are similarly configured such that NSP, NRP, and NLC are supported with redundant backups.

Design I Backup Chassis Setup Considerations

In the example illustrated in Figure 3-1, The redundant chassis can provide a backup solution for all the three Cisco 6400s (6400-1, 6400-2, and 6400-3). As a result, the backup Cisco 6400 system must have the physical configurations associated with each of the operational Cisco 6400s. Table 3-6 how the configuration mapping should be done.

Table 3-6 Redundancy Design I Configuration Management Chart

Calls (VPI/VCI)[1]	Active Module	Backup Module (6400-Backup)
1/10 – 1/1010	6400-1 NRP-SLOT-1	NRP-SLOT-1
2/10 – 2/1010	6400-1 NRP-SLOT-3	NRP-SLOT-2
1/10 – 1/1010 2/10 – 2/1010	6400-1 NSP-SLOT-0A 1/10 – 1/1010 outgoing interface ATM1/0/0 2/10 – 2/1010 outgoing interface ATM3/0/0	NSP-SLOT-0A 1/10 – 1/1010 outgoing interface ATM1/0/0 2/10 – 2/1010 outgoing interface ATM2/0/0
3/10 – 3/1010	6400-2 NRP-SLOT-1	NRP-SLOT-3
4/10 – 4/1010	6400-2 NRP-SLOT-3	NRP-SLOT-4
3/10 – 3/1010 4/10 – 4/1010	6400-2 NSP-SLOT-0A 3/10 – 3/1010 outgoing interface ATM1/0/0 4/10 – 4/1010 outgoing interface ATM3/0/0	NSP-SLOT-0A 3/10 – 3/1010 outgoing interface ATM3/0/0 4/10 – 4/1010 outgoing interface ATM4/0/0
5/10 – 5/1010	6400-3 NRP-SLOT-1	NRP-SLOT-5
6/10 – 6/1010	6400-3 NRP-SLOT-3	NRP-SLOT-6
5/10 – 5/1010 6/10 – 6/1010	6400-3 NSP-SLOT-0A 5/10 – 5/1010 outgoing interface ATM1/0/0 6/10 – 6/1010 outgoing interface ATM3/0/0	NSP-SLOT-0A 5/10 – 5/1010 outgoing interface ATM5/0/0 6/10 – 6/1010 outgoing interface ATM6/0/0

1. The virtual path identifiers/virtual channel identifiers (VPIs/VCIs) used are unique across all three 6400s (6400-1, 6400-2, 6400-3).

As illustrated in Figure 3-1, the incoming interface (the link from the DSLAM) is A8/0/0 in each of the Cisco 6400s. Each of the Cisco 6400s, including the backup system, has a link to the local management LAN. The local management LAN includes the AAA server, SSG Server and the DHCP Server (if DHCP services on the NRP are not used).

Because each system has a link to the ISPs/Internet, the backup system will have the current routing/forwarding tables.

Design I Backup Cisco IOS Configurations

In this design, no changes are required in the NRP configurations. For example, the Cisco IOS configuration from 6400-1 NRP-SLOT-3 is copied to 6400-Backup NRP-SLOT-2.

However, the NSP in the Cisco 6400-Backup system must be configured so that it combines the configurations of the NSPs of each active Cisco 6400.

The following NSP configurations on the active Cisco 6400s and the backup Cisco 6400 illustrate how this redundant chassis design is implemented:

1. Relevant Cisco IOS configuration fragment for 6400-1 NSP-0A:

```
interface ATM8/0/0
 no ip address
 atm pvp 1 interface ATM1/0/0 1
 atm pvp 2 interface ATM3/0/0 2
!
```

2. Relevant Cisco IOS configuration fragment for 6400-2 NSP-0A:

```
interface ATM8/0/0
 no ip address
 atm pvp 3 interface ATM1/0/0 3
 atm pvp 4 interface ATM3/0/0 4
!
```

3. Relevant Cisco IOS configuration fragment for 6400-3 NSP-0A:

```
interface ATM8/0/0
 no ip address
 atm pvp 5 interface ATM1/0/0 5
 atm pvp 6 interface ATM3/0/0 6
!
```

4. Relevant Cisco IOS configuration fragment for 6400-Backup NSP-0A:

```
interface ATM8/0/0
 no ip address
 atm pvp 1 interface ATM1/0/0 1
 atm pvp 2 interface ATM2/0/0 2
!
interface ATM8/0/1
 no ip address
 atm pvp 3 interface ATM3/0/0 3
 atm pvp 4 interface ATM4/0/0 4
!
interface ATM8/1/0
 no ip address
 atm pvp 5 interface ATM5/0/0 5
 atm pvp 6 interface ATM6/0/0 6
!
```

Failure Example Notes

Having the setup complete as discussed in “Design I Backup Chassis Setup Considerations”, assume a failure occurs. The following notes summarize actions and considerations associated with recovering from a failure of one of the active Cisco 6400 UACs in the example network presented in Figure 3-1:

- If, for example, 6400-1 fails (not a module failure, as that is redundant, but a chassis failure), then the link from ATM 8/0/0 of 6400-1 needs to be moved to ATM 8/0/0 of 6400-Backup and the user traffic will be reinstated.

- This approach is not only applicable for a chassis failure, it can be used to decrease scheduled maintenance downtime. The backup chassis is available to take the place of any of the active Cisco 6400s incase one of them needs to be taken out of service.
- The configuration on the NSP (on 6400-Backup) can be modified so that ATM 8/0/1 is used and it can act as active backup for multiple chassis.

Design II: Software Configuration Redundancy Solution

Keeping the same logical topology as illustrated in Figure 3-1, a second possible design approach is to have the software configurations of the active chassis stored in the backup Cisco 6400.

This is useful when all the active chassis are fully loaded without NRP redundancy.

The running configurations from the active Cisco 6400s must be copied to the backup system and saved in flash as defined in Table 3-7.

In this way the backup system can be used to replace any of the active 6400 by just switching to that system's configurations.

Table 3-7 Redundancy Design II Configuration Management Chart

Backup Module (6400-Backup)
NRP-SLOT-1 6400-1-NRP-SLOT-1.CFG 6400-2-NRP-SLOT-1.CFG 6400-3-NRP-SLOT-1.CFG
NRP-SLOT-2 6400-1-NRP-SLOT-2.CFG 6400-2-NRP-SLOT-2.CFG 6400-3-NRP-SLOT-2.CFG
NRP-SLOT-3 6400-1-NRP-SLOT-3.CFG 6400-2-NRP-SLOT-3.CFG 6400-3-NRP-SLOT-3.CFG
NRP-SLOT-4 6400-1-NRP-SLOT-4.CFG 6400-2-NRP-SLOT-4.CFG 6400-3-NRP-SLOT-4.CFG
NRP-SLOT-5 6400-1-NRP-SLOT-5.CFG 6400-2-NRP-SLOT-5.CFG 6400-3-NRP-SLOT-5.CFG

Table 3-7 Redundancy Design II Configuration Management Chart

Backup Module (6400-Backup)
NRP-SLOT-6 6400-1-NRP-SLOT-6.CFG 6400-2-NRP-SLOT-6.CFG 6400-3-NRP-SLOT-6.CFG
NRP-SLOT-7 6400-1-NRP-SLOT-7.CFG 6400-2-NRP-SLOT-7.CFG 6400-3-NRP-SLOT-7.CFG
NSP-SLOT-0A 6400-1-NSP-SLOT-0A.CFG 6400-2-NSP-SLOT-0A.CFG 6400-3-NSP-SLOT-0A.CFG

Design I and Design II Comparison

While these two design approaches both provide redundancy solutions for the hypothetical network arrangement illustrated in Figure 3-1, each makes certain assumptions about the active UACs. These assumptions influence the way the redundancy solutions are implemented.

Design I assumes that half the NRP, NSP, and NLC slots (as illustrated in Figure 3-2) of each active Cisco 6400 systems are used as backup slots. As a result, each active Cisco 6400 includes four NRPs, two NSPs, and two NLCs.

In contrast, Design II assumes that all the NRP slots in each of the active Cisco 6400s is operational with two redundant NSPs and NLCs. The only NRP backup modules in Design II reside in the backup Cisco 6400 system (6400-Backup).

In both designs, the redundant chassis (6400-Backup) includes six NRPs, one NSP, and one NLC.

In Design I, each active module is backed up by two specific modules:

- One module on the same active Cisco 6400
- One module on the backup Cisco 6400

In Design II, the backup environment differs, as follows:

- No backup NRP modules on the active Cisco 6400s
- One backup module supports three active modules (one from each active Cisco 6400)

From an operational perspective, the chief result is that Design I provides a higher level of inherent redundancy, while Design II provides for more total concurrent access connections.

Note Assuming two additional incoming ATM lines are added to the backup Cisco 6400 in Figure 3-1, Design I can be made to accommodate up to three concurrent Cisco 6400 UAC failures. Design II can only accommodate one complete UAC failure at a time.