Wheatstone Corporation

Technical Document

What You Need to Know About Ethernet Audio

Overview

Designing and implementing an IP-Audio Network can be a daunting task. The purpose of this paper is to help make some of these decisions a bit easier and help you decide if an IP-Audio system is right for your facility. Making smart, cost-effective decisions is a must, and with budgets getting smaller it is increasingly difficult to build a fault tolerant network.

Ethernet Technology has been in the Broadcast Facility for many years. Stations have been using file sharing client/server based delivery, of content to air over Ethernet with great success for over a decade. Today, high-availability networks are becoming a staple in the modern broadcast facility. As IP-Audio increasingly becomes the delivery method of choice for broadcast facilities, redundancy and fault tolerance move to the top of the list as requirements. The loss of an audio network can be disastrous and expensive.

Why Ethernet?

Why not? Ethernet provides many benefits in today's studio environment. Allowing delivery of uncompressed Digital Audio, Control data, and Metadata over a single cable cuts down on the costly wire runs to studios that were once mandatory. In the IP- Audio world, the Ethernet network is the equivalent of the punch block wall in a traditional broadcast plant. Using off-the-shelf hardware that is used to link nearly any type of device over Ethernet provides great flexibility, and because the Ethernet switches used are standards-based, most Gigabit Ethernet Switches will work with the WheatNet-IP Audio system.

About the Nomenclature

Throughout this paper you will see terms like "Core" and "Edge". Let's take a minute to get you familiar with some of these terms.

- ***Core Switch*** - A "Core" Switch is the switch at the center of the Star Topology, as discussed later in this paper. This switch would likely be placed in a central area such as the Technical operations center (TOC). This central location could also be in a server room or equipment closet somewhere in your facility.
- ***Edge Switch*** - The "Edge" switch is a switch that would be strategically placed to accommodate connections for one or more devices that may not be located near the "Core" switch. This reduces the number of runs from a studio back to TOC. There are fanless versions of switches that can be placed in a studio without the worry of fan noise.

- ***Switching Fabric*** - A Combination of hardware and software that takes data coming into the network from a device and delivers it to the next point in the network until reaching its destination.
- ***Line Card*** - This is the card that provides port connectivity in the larger chassis based switch solutions. Please refer to www.cisco.com for more information.
- ***Host Device*** - A device connected to the network such as a WheatNet-IP or PC.
- ***Layer 2*** - This is the second layer (Data link Layer) of the Open Systems Interconnect Reference Model (OSI Model). Most switches operate in this layer designed for point-to-point or point-to-multipoint communications.
- ***Layer 3*** - This is the third layer (Network Layer) of the Open Systems Interconnect Reference Model (OSI Model). Routers operate at this level. Layer 3 switches operate in this layer because they are capable of routing. Layer 3 switches are faster than routers because they also have switching technology built in, merging the technology of traditional switches with that of routers.

About the Acronyms

Throughout this document you will see terms with which you may or may not be familiar. Details of these terms are outside the scope of this document. There are many references to these topics on the internet or in publications. Let's take a minute to briefly discuss some of them.

- ***IGMP*** (Internet Group Management Protocol) – IGMP is a communications protocol that manages membership of hosts to IP multicast groups. It is a vital part of the IP multicast specification and the backbone of the WheatNet-IP Audio system.
- ***IP Multicast*** – IP multicast is a method for one-to-many communications over IP, providing delivery of information to a group of destinations while only placing it on each network link once.
- ***IGMP Snooping*** – IGMP Snooping is the process of listening to the multicast traffic on the network sent by host devices. When the switch hears a host's report, that host's port is added to the multicast list for that group. A switch using IGMP Snooping will then only forward multicast traffic to devices requesting it. This process dramatically reduces the amount of processing at the switch.
- ***VLAN*** – A Virtual LAN is similar to a LAN (Local Area Network), with the exception that the VLAN will allow host devices to exist in a broadcast domain even if they are not located on the same physical switch. VLANs are created to provide segmentation, providing broadcast filtering and traffic flow management.
- ***RTC*** – Request for Comment is a document published by Internet Engineering Task Force that details a method, behavior, information, etc. This is the official publication channel for the Internet Engineering Task force. The task force then accepts some of the published RFCs as internet standards.

Where to Start

The underlying network plays a major role in the successful deployment of an IP-Audio system. As such, careful consideration should be given to network topology when planning your installation. Because the size and type of network you design and deploy directly depends on the amount of hardware you are installing, it is wise to build a network that has reasonable overhead and room to grow as formats and audio distribution needs change over time.

Careful planning can save you lots of time and money. It is a good idea to sketch or formally draw your system, noting the number of needed switch ports, how many potential multicast streams, wire runs, switch locations, number of PCs, number of I/O BLADEs and Surfaces. This gives you a baseline to use when deciding what switch or switches to buy.

Designing the Network

Many small Ethernet audio network applications may be assembled without much preparation or difficulty while medium to large systems will require careful planning. When designing your IP-Audio network it is useful to consider the following parameters:

- Scope – What are the requirements for today and potential future growth?
- Physical Infrastructure – Star topology, switch placement, CAT-5e/CAT-6 cabling.
- Throughput – Is there enough switching throughput?
- Headroom – Is there room for growth built into the network?
- Applications – Will this be an audio only or shared use network?
- Serviceability – Consider Update and Upgrade paths.
- Monitoring – What network monitoring software tools are required?
- Remote Access – Is there a secure path to remotely monitor or troubleshoot the network?

What Switch Do I Need?

There are literally hundreds of choices of Ethernet switches on the market today. Chances are you have a compatible switch in your facility already. It is recommended that the WheatNet-IP Audio network be isolated from any existing network using separate switches or VLAN's on existing switches. VLAN configuration is outside of the scope of this document. Contact your network administrator for more details on VLAN Setup.

The key choice you face is whether to use managed or unmanaged switches, and the amount of Ethernet audio hardware you deploy ultimately drives this decision. Keep in mind, most gigabit switches will work with the WheatNet-IP Audio system to a degree. Unmanaged switches are relatively inexpensive, so in a small system this may be an acceptable cost vs. performance compromise. As your system grows, so do the chances of exceeding the capability of inexpensive unmanaged switches. Careful consideration of current and future needs should be given when choosing switch hardware.

Unmanaged vs. Managed Switches

An unmanaged Ethernet switch is a low cost *WYSIWYG* (What You See Is What You Get) device and has no configuration software interface. Most unmanaged switches do not support IGMP Snooping and will therefore act as repeaters to IP-Audio multicast packets, effectively flooding all ports on the switch with the multicast traffic.

Managed switches, on the other hand, allow users to configure the switch hardware with a software interface of some kind (e.g. Telnet, Web, Terminal, etc.). Primary configuration features applicable to your Ethernet audio network are the ability to configure VLAN's, IGMP management, built-in diagnostics, and routing.

There are several types of managed switches on the market today. Low end managed switches or "Smart Switches" offer some configuration but may not provide the level of configurability required in a medium to large Ethernet audio network. For example, these switches may forward IGMP host messages and multicast traffic but cannot act as the IGMP router. Do your homework and research your switch choices before you make a purchase decision. Mid priced Layer 2 or Layer 3 managed switches are better suited to the task and will provide more configuration flexibility.

The WheatNet-IP system software utilizes RFC standards initially developed for VoIP applications to synchronize and distribute packetized audio between BLADEs, control surface processing, and PC's. Specifically, the Internet Group Management Protocol (IGMP) is used to manage the distribution of multicast audio packets which are integral to the WheatNet-IP design.

Bandwidth Considerations

Your IP-Audio system can quickly exceed the maximum bandwidth capability of your network. Below are the WheatNet-IP Bandwidth requirements that will help you calculate and allow for sufficient headroom when designing your IP-Audio Network.

- Each I/O (88a, 88d, 88ad) BLADE requires 36.9Mb/s for eight Stereo connections.
- Each I/O (88a, 88d, 88ad) BLADE requires 73.7Mb/s for 16 Mono connections.
- Each Engine (e) requires 147.5Mb/s for 32 stream-unique stereo connections.
- Each E-6 surface requires a 100Mb connection.
- Each Surface requires an Engine (e) connected to the same GbE switch.
- Each PC driver requires 19.6Mb/s for eight Stereo outputs.
- An aggregate of eight BLADEs requires roughly 295Mb/s of bandwidth with each having eight stereo connections.

The Multicast channels used by the WheatNet-IP System are as follows:

- one per audio source
- one for system announce messages
- one for metering data
- one for Logic messages

Topology

Ethernet networks can be designed a number of different ways to create everything from very simple unmanaged networks to complex, fully redundant, self healing networks. The level of redundancy you wish to achieve obviously drives the cost of the hardware. This section of the document will give you some general information about a commonly used network topology that may be deployed in an IP-Audio network.

STAR Network

One of the most commonly used networks is the STAR Network. In a simple form the Star would consist of a Central or Core switch placed in a Technical Operations Center (TOC), and each I/O BLADE, PC, XY Controller, and surface would connect back to this device. In a larger deployment it could consist of a Central or Core switch with other smaller switches (Edge) placed strategically in studios or other physical locations away from the Core Switch. Below are some sample diagrams of what the network might look like.

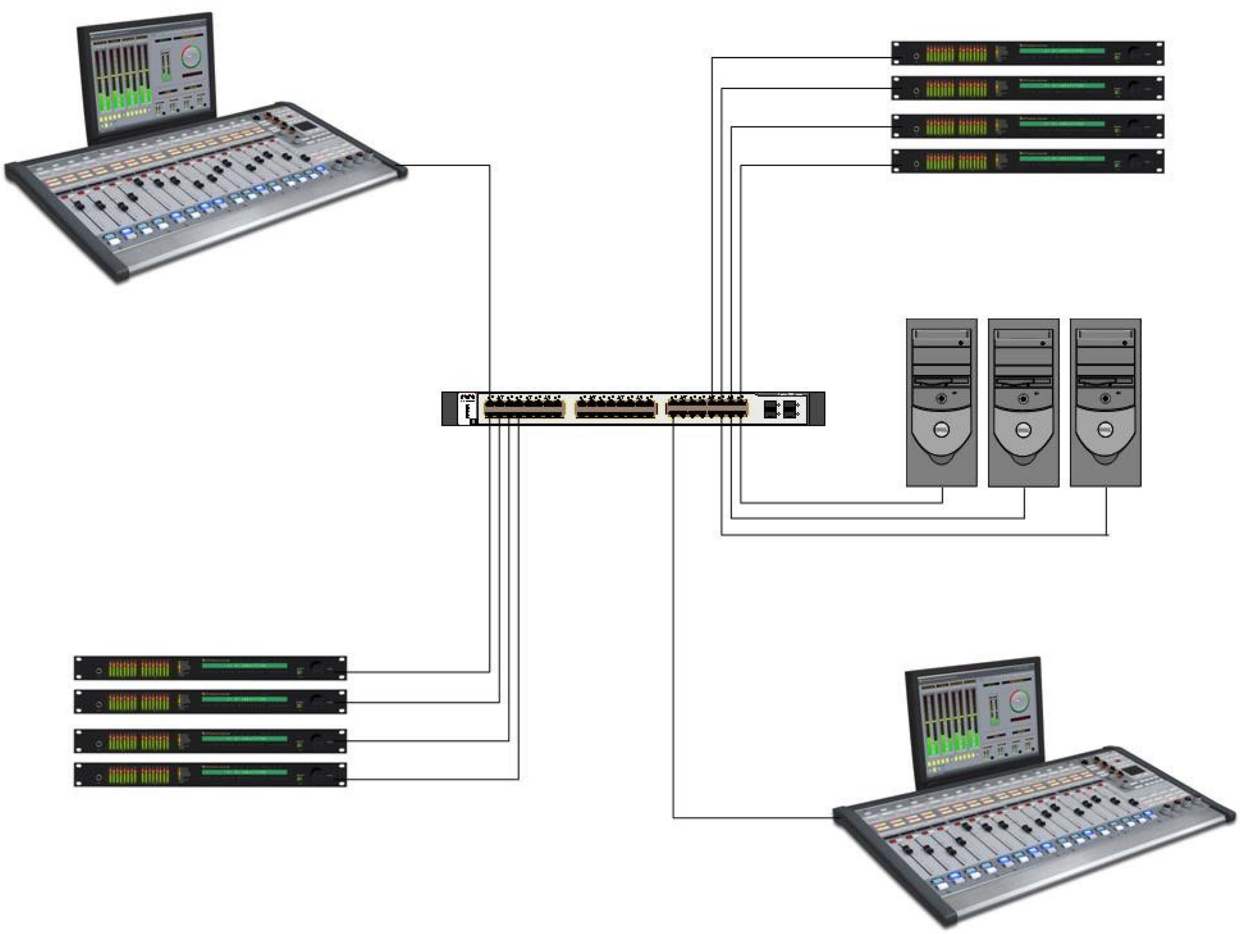


FIG. 1 - STAR Network Small Scale

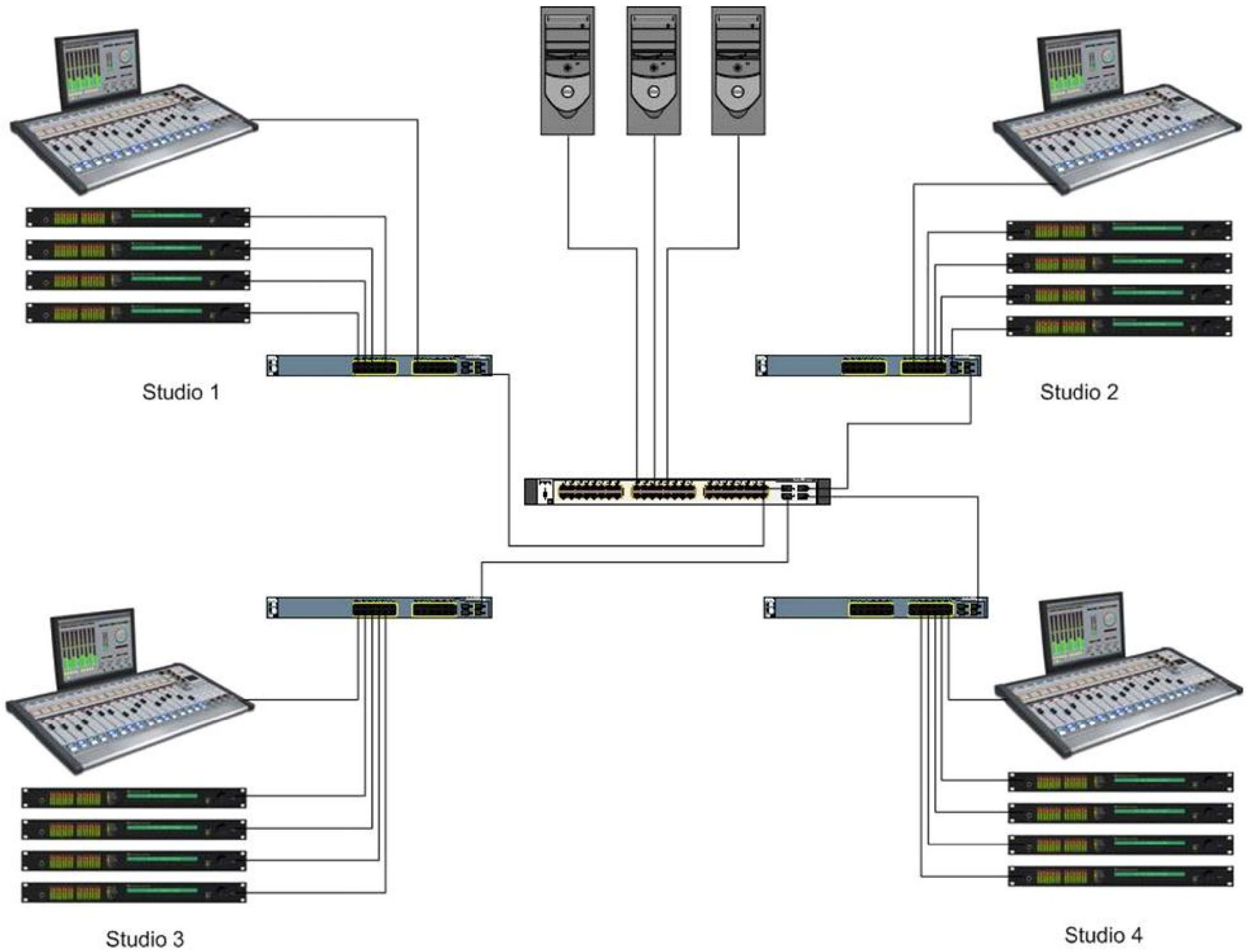


FIG. 2 - STAR Network Large Scale

NOTE: ***This example uses a Cisco Catalyst 3750™ as the Core and Cisco Catalyst 3560™ as the Edge Switches.***

Advantages

The advantage of using this network topology is better performance, scalability, and simplicity. Performance is increased by preventing packetized audio from being passed through unnecessary devices. The network is limited only by the number of ports and the throughput of the chosen switch. The STAR topology is the recommended topology for an IP-Audio Network.

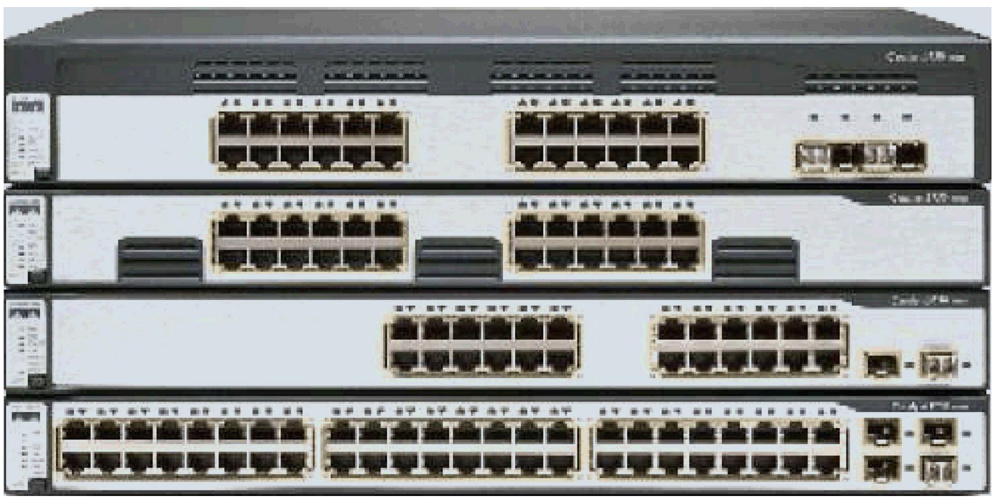
Disadvantages

The biggest disadvantage of a STAR network small scale (FIG. 1) is the dependency of the devices on the Core or Central switch. A failure of a single link is not critical but the failure of the central switch could render the network inoperable. If a large scale STAR (FIG. 2) has been implemented, the risks are lower in that each "Edge" switch can work with devices to act as their own network in the event of a link failure.

Cisco's Stackwise Technology™

One method of overcoming the dependency of the host devices on the Core switch is to use Cisco Stackwise Technology™(1). This is an innovative method of collectively utilizing the capabilities of stackable switches by joining them to create a single Switching unit with a 32 Gbps switching fabric. Switches can be added or removed without impacting the performance of the stack.

The switches form a single logical device using stack interconnect cables that allow topology and routing information to be updated continuously. Up to nine switches can be joined together in this manner. The stack has one master and up to eight subordinate (member) switches, with each having the ability to become the master at anytime.



Stack of Cisco Catalyst 3750 Series Switches with Stackwise Technology

FIG. 3 - Cisco Stackwise Technology Resilient Cabling

Each stack has a single IP address and is managed as a single unit. Each stack has only one configuration that is distributed to the other members of the stack by the master. If a new switch is added, the master copies the running Cisco IOS software image and the configuration to that switch.

This technology is available on the Cisco Catalyst 3750™ family of switches. This family of switches is the recommend choice when designing your IP-Audio network.

Chassis Based Solution

Cisco also offers high availability chassis-based switch solutions. These switches can be configured with redundant power supplies and redundant Supervisory Engines. While these switches are more expensive they offer the best resiliency. The 4500 and 6500 Series switches are designed for a high level of resiliency and scalability.

The deficiency in this solution is clearly the Line card that provides the connectivity to the BLADEs and PC devices on the IP-Audio Network. If a line fails all resources connected to the card become unavailable to the network for use.

For more information about the Cisco Catalyst Family of switches please refer to www.cisco.com and navigate to the products page.

Summary

Before making any purchasing decisions it is beneficial to document as much as you can about your needs to help make intelligent, cost-effective choices. Sketching out network diagrams, getting the correct I/O count, switch requirements, and any other information will help you save time and money when it is time for the install.

Best practice is, take your time and think it through. If you are not up on IT solutions, find someone who is and discuss your options. The system installation will be easier in the long run. Below are a few network diagrams of what typical Small, Medium, and Large installations might look like. The system will vary from facility to facility, based on the needs of that install.

Sample Diagrams

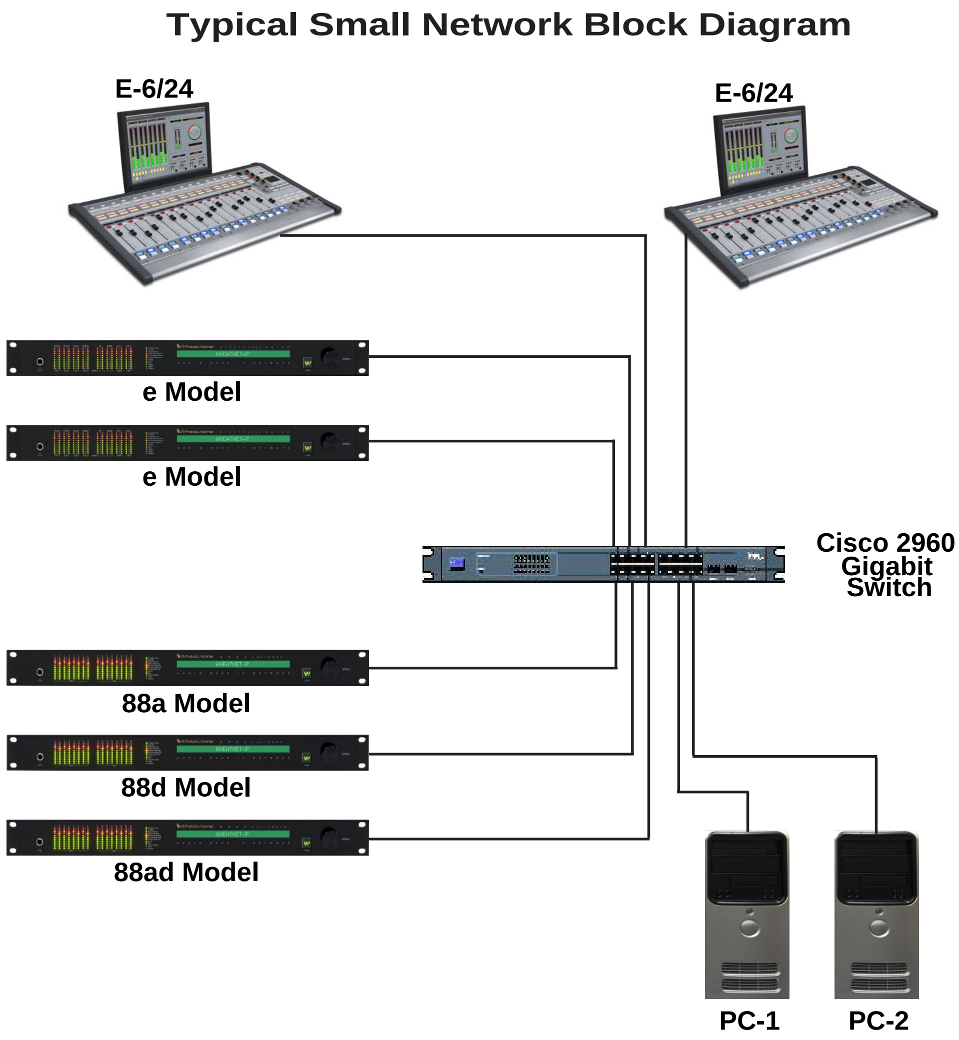


FIG. 4

In this small scale operation a Cisco Catalyst 2960 is a good choice as it can provide adequate throughput (32 Gig Switching Fabric) while being cost effective. In one to two studio facility this could be placed as a core switch initially, but later be placed as an edge switch if the network expands in the future.

The Catalyst 2960 comes in 8/24/48 port models and supports 255 IGMP Groups. Keep in mind that the WheatNet-IP Audio system uses Gigabit technology exclusively, so you will need to specify models with 10/100/1000 ports. The 24/48 port models can also be equipped with the RPS 2300 redundant power supply option, providing an alternate power source in the event of a failure of the internal supply.

Bandwidth Required for the Small Network

3 Audio BLADEs @ 36.9 Mb/s = 110.7 Mb/s

2 Engines @ 147.5 Mb/s = 295 Mb/s

2 PC Drivers @ 19.6 Mb/s = 39.2 Mb/s

TOTAL Bandwidth required is roughly 445 Mb/s

Typical Medium Network Block Diagram

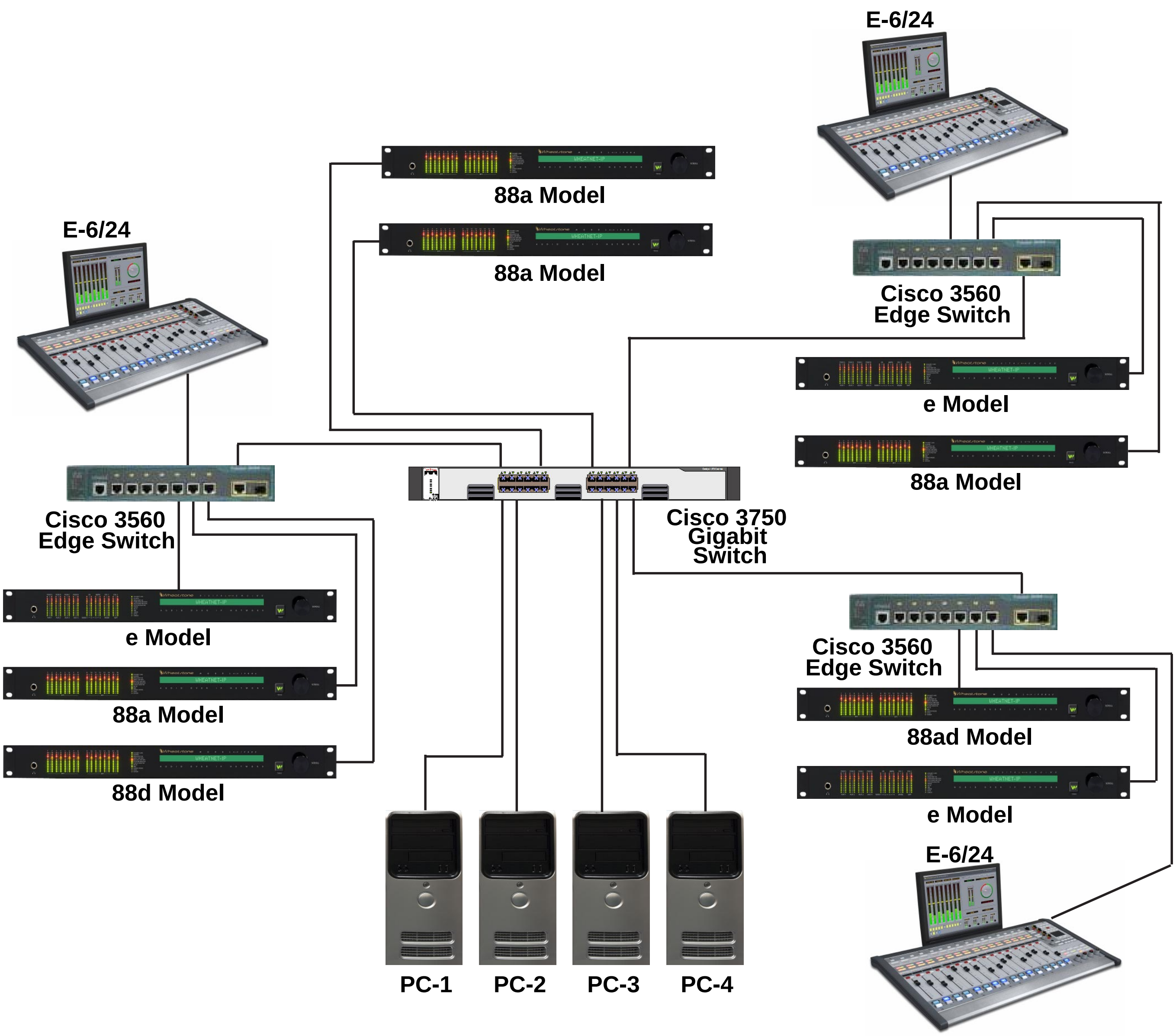


FIG. 5

Bandwidth Required for the Typical Medium Network

6 Audio BLADEs @ 36.9 Mb/s = 221.4 Mb/s

3 Engines @ 147.5 Mb/s = 442.5 Mb/s

4 PC Drivers @ 19.6 Mb/s = 78.4 Mb/s

TOTAL Bandwidth required is roughly 742 Mb/s

Typical Large Network Block Diagram

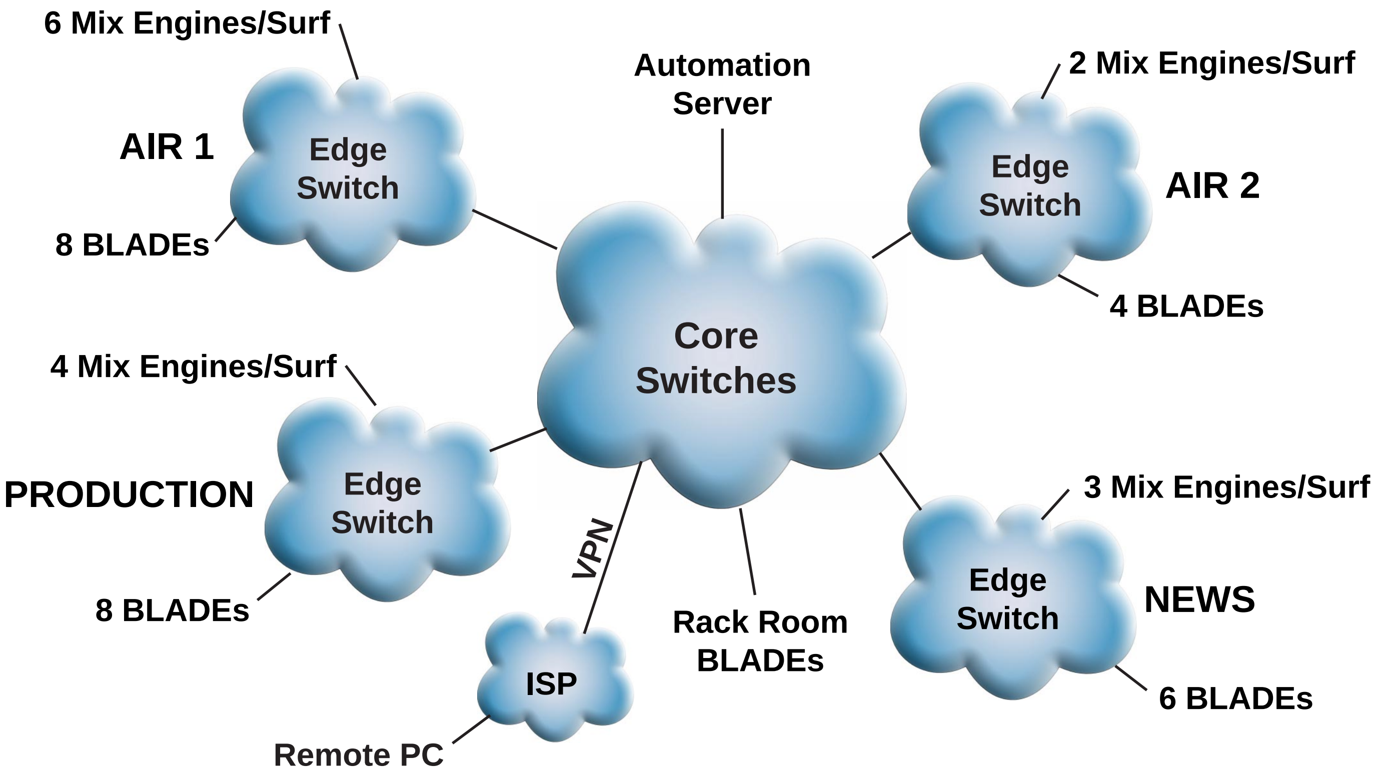


FIG. 6

Bandwidth Required for the Typical Large Network

Bandwidth requirements for large networks will depend on the amount of hardware you deploy. The same concept used to calculate Bandwidth in the Small and Medium networks can be applied for larger networks.

In mid-sized to large scale studio facilities, it is a good idea to move to the "Core-Edge" Model. A mid-sized facility may have 10-plus studios. In this type of setup, placing a Cisco Catalyst 3750 at the Core and Cisco Catalyst 3560 on the Edges will provide exceptional performance. Because both the 3750 and the 3560's are Layer 3 switches, processing requirements for the core switch are minimized because IGMP requests can be handled at the Edge switch.

Depending on the level of redundancy you require, the 3750 can use the Stackwise Technology, previously referred to in this paper, by using up to nine 3750 switches to create a single switching unit.

Both the 3750 and the 3560 support the RPS 2300 redundant power supply option, providing an alternate power source in the event of a failure of the internal supply.

When planning a large scale enterprise network, the Cisco Catalyst 4500/6500 series switches may be a more suitable option. Providing built in hot swap redundant power supplies, Supervisory Engines, and cooling fans, theses switches provide sub-second failover for seamless audio in the event of a failure.

References

1. Cisco Stackwise Technology - prod_white_paper09186a00801b096a.pdf
   San Jose – Cisco System Inc.