

ILLINOIS STATE
UNIVERSITY



The ISUnet Gigabit Core Project

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Scott Genung
Manager of Networking Systems
Telecommunications and Network Support Services

The ISUnet Gigabit Core Project

1 - Introduction

Modern networks have evolved into very complex entities. To be effective, a significant amount of time and resources must be devoted to network research, testing, engineering and maintenance to insure functionality, interoperability, scalability, evolution, and economy of scale. Without this research, a poor design or choice of technologies or products could lead to the introduction of an inadequate network infrastructure within an enterprise. The end result is network instability or the lack of sufficient resources to accommodate user needs. Ultimately, this scenario would require a network redesign. As such, it is paramount that these networks must continually evolve in response to end user needs using a managed methodology that is technically sound, aligned with available human resources, and is fiscally responsible.

The campus network known as ISUnet is an example of such a modern network. ISUnet has become quite complex as it has evolved over the years in support of end user needs. And, the process of managing change has been invoked over and over again to support the evolution of this model. This document defines the need for evolving the network model for ISUnet once more and the forces that dictate this action.

2 – Forces of Change

ISUnet is a strategic resource for Illinois State University. Faculty, staff, and students depend upon the services provided by this network as much as they do for telephone and electrical service. Despite the growing complexity of ISUnet, it must continue to evolve with enhanced scalability and reliability. Otherwise, the services that it provides to the University community will not be able to meet current and future expectations as demands increase. Since the conception of ISUnet in the late 1980s, it has evolved dramatically. To continue to satisfy the expectations of our users, the infrastructure of this network will need to continue to evolve to meet the ever-growing needs of the University.

From the beginning days of ISUnet, the University required a basic set of services that included resource sharing, mainframe emulation, and basic Internet services (such as mail and file transfer). As time passed, newer applications emerged including more powerful Internet services (such as the web, network news, and on-line chat sessions), peer-to-peer networking, streaming multimedia (such as Real, QuickTime, and WinMedia), distributed services, client-server, the debit card system, and document imaging. Today, even newer applications are driving network growth including file sharing services (such as Napster, iMesh, and so on), software distribution (such as Ghost, SMS, and others), and video on demand (such as Real, QuickTime, and WinMedia). In the near future, even newer applications such as directory systems (such as NDS or ADS), desktop video conferencing, and voice over IP will continue to drive volume. These additional requirements, along with more users actively using these services over broadband connectivity have had a substantial influence on the growth of this network.

In the last couple of years, some of these new applications and services that have appeared on ISUnet dictate the need for fast ethernet connectivity. As part of the migration from desktop token ring to switched ethernet, server farms have emerged. These server farms have been based upon fast ethernet connectivity for each server. The requirements for desktop fast ethernet are not far behind.

Along with new applications, the number of users actively using electronic services on ISUnet continues to grow. At the same time, the amount of resources that an individual user is consuming is on the rise. In every conceivable way, ISUnet continues to experience dramatic growth as the result of end user consumption.

In the areas of remote access and Internet connectivity, demand has increased at a substantial rate. By October 2000, dialup volume grew by more than 10% over the previous year. The demand for Internet services has more than doubled between the spring 2000 semester and the spring 2001 semester. This increase has occurred even with the introduction of rate shaping technologies on ISUnet to manage the volume generated by applications such as Napster, iMesh, Hotline, and so on.

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There are three locations on campus where ResNet service is currently available: 1) Smith House in Watterson Towers, 2) west campus (Haynie -Wright-Wilkins), and 3) south campus (Atkin-Colby-Hamilton-Whitten). These three networks have the capacity to service over 3,000 students. By the fall semester of 2001, east campus (Hewett-Manchester) will be brought online with an additional 1,700 potential users. Watterson is tentatively scheduled to go online by the fall semester of 2002 with 2,200 potential users and central campus (Walker-Dunn-Barton) is tentatively scheduled to go online by the fall semester of 2003 with 800 potential users.

The number of active users in the residence hall networks has more than doubled from the spring 2000 semester to nearly 1,700 active computers by February 2001. Growth projections for the fall 2001 semester are that the total number of ResNet users will again double to over 3,000 active computers with the addition of networks going online in Hewett-Manchester during the summer 2001 semester. Based upon past growth, the number of students actively using ResNet by the fall 2002 semester could be as high as 6,000. Since ResNet users on ISUnet consume approximately 75% of the total network volume at peak times, this growth is significant.

Since 1999, the University has partnered with Verizon (then GTE) for offering ADSL (Asymmetric Digital Subscriber Loop) connectivity to off-campus affiliated faculty, staff and students. The number of these broadband ADSL users has increased substantially over the last year. Between January 2000 and January 2001, the number of ADSL subscribers has doubled to over 400 users. At the same time, several new Greek House networks were introduced in 2000. Several more are being planned for 2001.

While new applications emerge and the number of users that actively use the services that we provide increase, another phenomena is occurring: the evolution of the desktop computer. Below is an excerpt from an article in a recent edition of PC Computing magazine that describes the next generation desktop computer processor called the P4 (Pentium 4) from Intel:

“Intel's first all-new chip architecture since the Pentium Pro bowed in 1995 has a few tricks up its sleeve. Aimed at workstation professionals, business power users, and home PC enthusiasts, the Pentium 4 debuted at speeds of 1.4 GHz and 1.5 GHz, with the ability to scale much higher in the future (the Pentium III architecture, by contrast, had a viable upper limit of 1 GHz.). A 20-stage pipeline (double that of the PIII) increases processor frequency and hence performance. The rapid-execution engine can execute arithmetic instructions in half a clock cycle, effectively doubling the core frequency and reducing latency for those functions. A 400-MHz system bus (the PIII had a 133-MHz front-side bus) enables transfer rates of 3.2 Gb/s. Advanced transfer cache optimizes data transfer to the processor core. Enhanced floating-point and multimedia unit accelerates processor-intensive tasks such as streaming video, voice recognition, video and audio encoding, and image processing.”

In a nutshell, the emerging generation of desktop and server computers has broken the conventional bandwidth barrier. These new products can drive data rates beyond 10Mb/s of ethernet at the desktop. This is a barrier that older desktop systems have not been able to effectively break due to system bus limitations. Depending upon the application, these new processors can even drive volume beyond 100Mb/s. And, these new processors enhance the ability of these platforms to effectively deliver those applications that are capable of consuming this volume. These products are available today and are becoming less expensive as the cost to manufacture decreases. They will begin to enter service this year in increasing numbers and eventually begin to create an impact on the total volume of traffic on ISUnet. The drive to put Windows 2000 on the desktop within ISUnet will accelerate the introduction of these processors within our environment.

All of these issues impact the scalability of a network core network model. The aggregate volume as the result of the introduction of more bandwidth intense applications, more users using them, and faster processors capable of driving them are the real challenges of scaling ISUnet into the future.

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3 – What is ISUnet?

ISUnet is the network system that provides the University community with access to campus and Internet based electronic services. Virtually every department on campus depends upon these services for daily operations. Many departments cannot function without connectivity to these services.

The infrastructure of ISUnet is composed of four classes of network electronics: 1) access switch, 2) group switch, 3) edge switch, and 4) core switch. Each class of network switch provides a specific function within the ISUnet network model.

Access: An access switch (also known as a workgroup switch) is used to provide desktop connectivity. Currently, there are approximately 200 access switches in production on ISUnet within 70 buildings. Access switches deployed between 1996 and 1998 on ISUnet provide 10Mb/s ethernet of dedicated bandwidth to the desktop. Access switches deployed after 1998 on ISUnet have 10/100 bandwidth auto-sensing and can provide either 10 or 100Mb/s of dedicated bandwidth to the desktop. Due to the limitations of the existing core, 100Mb/s ethernet (also known as fast ethernet) is only available at this time for servers.

Group: A group switch (also known as a building switch) is used to connect multiple access switches together within a building if needed. Technologies such as fast ethernet, fast etherchannel (inversely multiplexed fast ethernet), and gigabit ethernet are used to interconnect these switches. Currently, there are approximately 20 group switches on ISUnet.

Edge: An edge switch (also known as a distribution switch) is used to connect multiple group switches together using fast ethernet, fast etherchannel, and gigabit ethernet uplinks over fiber. Like a group switch, an edge switch can also provide connectivity for multiple access switches within the same building. An edge switch also serves as the routing engine between networks and provides connectivity into the network core.

Core: A core switch is used to construct the network backbone. In the case of ISUnet, there are four ATM core switches. Each core switch has an OC-12 (622Mb/s) ATM connection to the other core switches within the mesh. In addition, each edge switch is connected to two core switches using OC-12 ATM connectivity. In this model, one path is active and the other is backup. If the primary path is unavailable, the backup path can be used to continue to provide connectivity in the event of an outage.

4 – The Core Upgrade Project of 1997

At the conception of ISUnet in the late 1980s, the network core also known as a CAN (Campus Area Network) was based upon token ring technologies using a single point of exchange. This model was enhanced over the years with newer forms of token ring technology. However, the design did not fundamentally change. In order to introduce other forms of desktop technologies, a fundamental change in this design was needed.

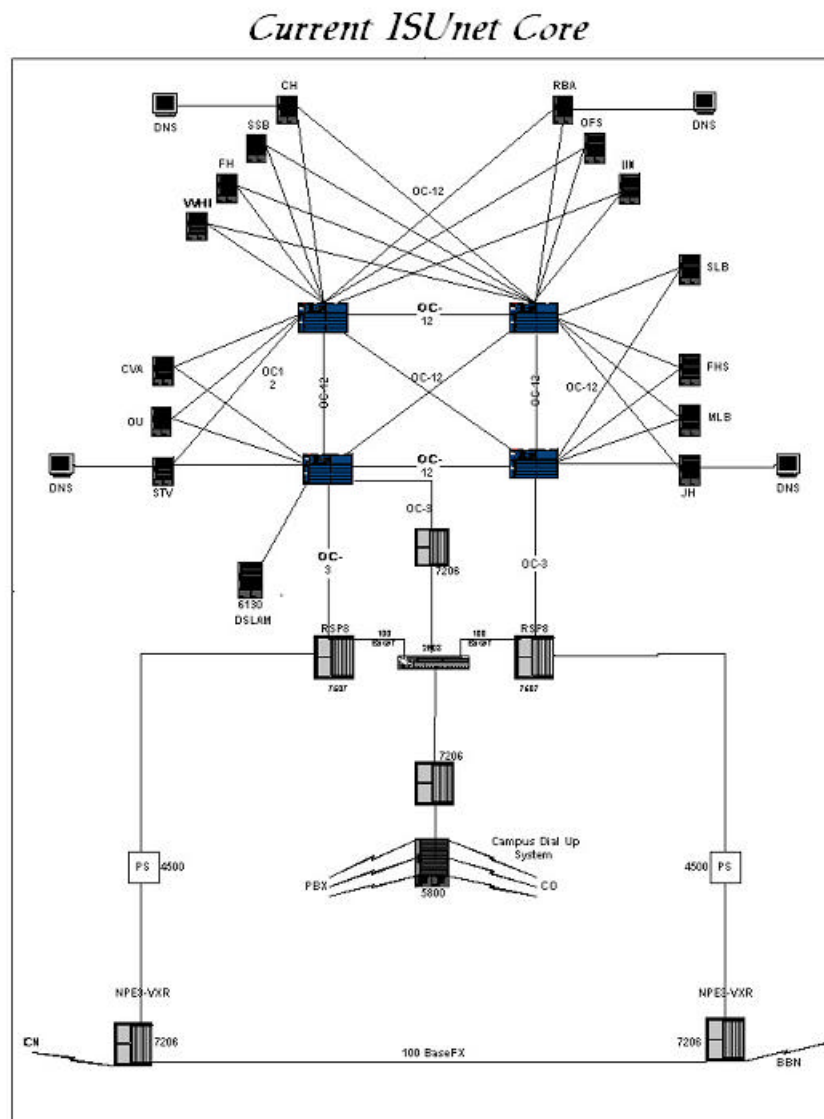
In 1997, the ISUnet core was completely redesigned to facilitate the introduction of and migration to switched ethernet at the desktop. This model was based upon ATM (Asynchronous Transfer Mode) and ethernet technologies but also focused on the integration of legacy token ring connectivity. The Catalyst 8540 MSR was the ATM core switch in this model and the Catalyst 5500 series served as the edge switch in this project. These products are manufactured by Cisco Systems and became the University standard to enhance product integration throughout ISUnet.

This newer model also introduced the concept of a distributed core for survivability. As a result, four core switching centers were created within the network backbone. In addition to survivability, this new model allowed the network core to scale more effectively than the original model. There were many related activities that surrounded the ATM core project of 1997. As such, it wasn't completed until early 2000.

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Despite the introduction of a new ATM core on ISUnet in 1997, the old token ring core remained in use in select environments on campus where token ring at the desktop was still in use. Although many token ring networks were integrated into the new core, smaller token ring networks or networks that had a need for native SNA (mainframe emulation) remained on the older core. However as more and more users migrated from token ring to switched ethernet, elements of the old network core were taken out of service. Today, very little of the old token ring core remains in use. The old token ring core will be phased out at the same time that desktop token ring support is discontinued on December 31, 2001.

Below is a diagram that represents that current network core.



5 – Why Now?

In 1997, the ISUnet core was redesigned to support the introduction of switched ethernet throughout campus. Prior to this date, token ring was the dominant desktop technology on ISUnet. The revised model was based upon the premise that desktop connectivity would not exceed 10Mb/s. As such, a network core consisting of an ATM OC-12 (622Mb/s) mesh could manage the aggregation of switched ethernet at the desktop throughout campus. Since desktop fast ethernet did not yet exist (although it had been proposed), it

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was not a major part of this design. At the time, ATM was the only technology that had the promise of scaling beyond 100Mb/s so it was the right choice at the time to construct a high performance mesh.

Today, the requirements are in the process of changing. As described earlier, there are many factors of change that are beginning to stress the ATM core model deployed in 1997. As such, it is appropriate to re-evaluate this design and look at how it can be enhanced. Because of the distributed design introduced in 1997, the degree of change to evolve beyond the limitations of ATM will be far less substantial than the change that occurred as the result of migrating from the original token ring core that predates ATM.

Since 1998, 10/100 ethernet access switches have been introduced on ISUnet as switched ethernet continued to displace token ring as the preferred desktop technology. These switches are connected to a group or edge switches with fast ethernet, fast etherchannel, or gigabit ethernet uplinks. Because of the scalability concerns of the existing ATM OC-12 mesh, fast ethernet is not available for desktop connectivity.

At the same, the prevalence of STP (Shielded Twisted Pair) cabling on campus limits where fast ethernet can be provided. STP is the original cabling standard for ISUnet designed to support token ring connectivity. Although specialized jack adapters (called baluns) can be used with STP cabling to offer switched ethernet connectivity, there is no economical equivalent solution for fast ethernet. As such, fast ethernet connectivity on ISUnet will require UTP (Unshielded Twisted Pair) cabling (category 5 or higher). The category 5 (also known as UTP-5 or cat 5) has been part of the cabling standard for ISUnet since January 1996. It is estimated that approximately 50% of the campus cabling plant is UTP-5. Since all new cabling (construction, remodels, or new jacks) are based upon UTP-5, the amount of fast ethernet capable cabling available on campus increases continuously. Considering the amount of new construction (ie: College of Business) and remodels (ie: ResNet, Schroeder, Moulton, Julian, and Milner) underway, the percentage of fast ethernet capable cabling on campus will continue to dramatically rise.

To aggregate a group of access switches on ISUnet serving a large number of desktop fast ethernet users will require a core mesh beyond what can be provided with OC-12 (622Mb/s). An obvious solution is to upgrade to OC-48 (1.248Gb/s) within the existing mesh. Although such modules exist in the C8540 products, they do not within the C5500 series edge switch products. Because the existing OC-12 modules in the C5500 series do not support load balancing, the fast fastest aggregate volume to and from any edge switch would be less than 600Mb/s (OC-12 minus the ATM payload tax). Cisco has indicated that they will not be developing ATM modules beyond OC-12 in either the C5500 or C6500 series edge switch products. This means that the only means for scaling this model is dramatically increasing the number of edge switching centers. This is not a very cost effective approach.

The other issue relating to aggregation surrounds the capacity of the C5500 series switch. This product is currently serving as the edge switch platform in the ISUnet inventory. This switch is limited by a 3.6Gb/s backplane and the affiliated routing engine known as the RSM (Route Switch Module) is limited to an aggregate volume of 400Mb/s. These limited volumes will prevent the aggregation of high speed, non-blocking transport between access switches through the network backbone.

At the same time, QoS (Quality of Service) techniques have begun to emerge within the IP (Internet Protocol) world. QoS has traditionally been a major feature of ATM that has distinguished it from ethernet. However, only native ATM applications could exploit these technologies. This promise never happened. As such, vendors have focused on enhancing TCP/IP with QoS support so that applications could be managed qualitatively with new or existing applications.

Another challenge for ATM was the lack of support for IP multicast. This technology allows for the efficient replication of directed broadcasting across a large network. Examples of applications that would be enhanced by IP multicast include broadcast video and software distribution. There is no effective mechanism for constructing an IP multicast model on ISUnet using LANE (Local Area Network Emulation) over ATM. In 1997, a solution entitled MARS (Multicast ATM Relocater Server) was expected to solve this problem but the technology never emerged. As such, IP multicast has never been deployed.

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To address these limitations, newer high-performance switches have emerged on the market. However, these products are based upon gigabit ethernet technology and not ATM. The price point for these new gigabit products is significantly less than a comparable ATM solution. As such, the market has begun to favor the use of gigabit ethernet technologies within a backbone core mesh over the last 12 months. The result is that most development dollars are being focused into gigabit ethernet technologies by all of the major hardware manufacturers. This is the future of core switch technology. ATM still has a role but it has officially lost the battle of the core.

In response to growing requirements factored in with the realization of the limitations of ATM, a new core model for ISUnet was researched. Current gigabit ethernet technology provides the headroom needed to accommodate the growing requirements of the University and sheds the restrictions of ATM that has prevented some technologies from being introduced. Gigabit ethernet solves the current problems of backplane aggregation, IP multicast support, uplink aggregation, routing throughput and so on. For these reasons, gigabit ethernet became the foundation for this revised model. More importantly, the development of faster, more scalable gigabit solutions are in progress including 10Gb/s connectivity.

Desktop fast ethernet connectivity throughout campus cannot happen on ISUnet without a gigabit core. This is a mathematical fact. Since desktop fast ethernet connectivity is a technology that can be driven by emerging applications and processor platforms, it is only a matter of time before it becomes dominant just as switched ethernet has since 1996. Fast ethernet will eventually require the network core to evolve. It is better to manage a proactive migration than a reactive upgrade.

In early 2000, plans were being made to research a replacement for the C5500 series edge switch. As such, the replacement of several C5500 series switches was budgeted for FY01. This project was to take place upon the successful completion of the evaluation of a C6509 on campus. This product would also be used as the edge switch in all future residence hall network projects. At the time, the future of the C8540 ATM core switch was unclear. Once these limitations became evident, the project was altered to focus on the replacement of the four C8540 ATM core switches. As a result, this project is fully funded as part of the unending upgrade

The C6509 currently being evaluated is the first generation gigabit core switch developed by Cisco. It has a backplane capacity of 24Gb/s and a routing engine called the MSM (Multilayer Switch Module) that could manage volumes greater than 1Gb/s. In December 2000, the 256Gb/s backplane module and MSFC2 (Multilayer Switch Feature Card 2) routing engine for the C6500 started to ship. These new modules greatly enhance the scalability and performance of the C6509 gigabit ethernet core switch.

During the fall semester of 2000, a revised network core model was developed for ISUnet. This new model included four C6509 switches (with the enhanced backplane and routing modules) that would displace four existing C8540 ATM core switches. Two of the C8540 switches would be retained to provide connectivity to service provider networks. This model was presented to Cisco to determine if any financial opportunities were available for the project. In response, Cisco proposed an aggressive trade in budget for two of the C8540 ATM switches. This offer will expire by March 2001.

Fortunately, deploying gigabit ethernet within the ISUnet core will not be a dramatic change from the existing design. The fiber currently used to interface among core switches and edge switches can be re-used for gigabit connectivity. All edge switches in production currently have gigabit ethernet modules to support the connectivity of gigabit attached access or group switches. This conversion can be done transparently with the core switch upgrades complete by the end of the summer.

If the offer is accepted, the intent is to displace the C8540 ATM core switches on ISUnet with C6509 gigabit core switches during the summer of 2001, introduce the first production C6509 edge switch with the new Hewlett-Manchester ResNet network by August 2001, and begin the displacement of existing production edge switches after token ring has been formally removed. Although these changes do not represent major changes in the core network model, it will take time and resources to displace these switches throughout the core.

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In summary, requirements have reached a point where time is now critical to begin the introduction of gigabit technologies in the core now. Much research has already been done in support of this project. Resources are available to fund this project. The opportunity to maximize trade in value for the C8540 from Cisco is also important. To meet our objectives and take advantage of opportunities, this project must begin now.

6 – The Gigabit Core Model for ISUnet

In response to the evolving needs of our users, the ISUnet core model has been revised to propose the introduction of gigabit technologies, wirespeed routing, IP based QoS (Quality of Service), and define a revised role for ATM to provide service provider connectivity. This model maximizes our current investment in infrastructure products while introducing additional technologies to enhance our existing model to support growth and emerging requirements.

To build this new gigabit model, the four existing C8540 ATM switches must be displaced with gigabit switches within the ISUnet core. This change allows all edge switches to use gigabit ethernet to connect to the network core as an alternative to OC-12 ATM. With the introduction of routing within the core switch, network traffic will be load balanced over multiple interfaces between core and edge switches concurrently. This configuration greatly increases the scalability of connectivity from core switch to core switch and core switch to edge switch.

The product that has been selected for the task of displacing the C8540 ATM core switch on ISUnet is the Catalyst 6509. This switch (with the appropriate modules) can support up to ninety 1Gb/s ports and can route more than 100 million pps (packets per second). The C8540 (the class of ATM core switch deployed on ISUnet within the 1997 core upgrade project) is capable of 40Gb/s of non-blocking backplane volume. The C6509 is capable of 256Gb/s of non-blocking backplane volume which represents a six-fold increase in throughput over the C8540. We began evaluating the C6509 in our lab during the summer of 2000. We are confident that it will satisfy our needs as we implement this new model.

Once the C6509 core switches have been introduced into production, two of the C8540 ATM switches will be left to remain within the core to be used to interface with service provider networks. For now, this includes the ICN (Illinois Century Network). In the future, this will include the Internet 2 and Ge nuity.

Once the ATM core switches have been displaced, the next step in enhancing the core model is by replacing the campus edge switches over a period of three years. This activity ensures that as desktop fast ethernet is introduced on ISUnet that adequate capacity is available within the network core to manage the aggregate volume of traffic between switching centers. To accomplish this task, existing C5500 series edge switches must be displaced with gigabit switches capable of wirespeed routing and highspeed backplane aggregation. The C5500 series are only capable of 3.6Gb/s non-blocking backplane volume and are therefore inadequate platforms for providing the aggregation for a large number of gigabit uplinks for access or group switches used for providing desktop fast ethernet connectivity. In addition, the routing engine within the C5500 series platform is only capable of 400Mb/s. This limitation prevents inter-vLAN routing from scaling to support desktop fast ethernet connectivity on campus.

The product that has been selected for the task of displacing the C5500 series edge on ISUnet is also the Catalyst 6509. This product represents a seventy-fold increase in throughput over the C5500 series switch. In addition, the MSFC2 (Multilayer Switch Feature Card 2), which is the routing engine for the C6509, offers a ten-fold increase in routing throughput over the RSM (Route Switch Module) combined with the NFFC2 (NetFlow Feature Card 2) module in the C5500 series switch. Because it will take up to three years to displace these switches, MLS (MultiLayer Switching) will be enabled to enhance the routing performance on the C5500 series using the existing NFFC2 enabled supervisor engines.

In preparation for the introduction of a new gigabit core, changes will be made within the network VTP (Virtual Trunking Domain) model. VTP is used to announce vLAN assignments from server to client

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switch. At this time, there are fifteen isolated VTP domains on ISUnet separated by ATM. Before ATM has been displaced, each VTP domain will be renamed to prevent VTP announcement conflicts.

Existing C5500 series group switches also need to be displaced with gigabit switches during this project. The product that has been selected for this task is the Catalyst 3508. This switch has eight gigabit ethernet ports and a 32Gb/s backplane. There are already several C3508 switches on ISUnet serving as group switches. This project will take a couple of years to complete.

As the C6509 is introduced as an edge switch, routing patterns within the network core will be altered. In the existing ATM core model, traffic is switched (bridged) between switches on the same vLAN (Virtual LAN). In the revised model, all traffic will be routed as it passed from core switch to core switch or core switch to edge switch. This model enhances the scalability of the core by allowing traffic to be load balanced more effectively among core and edge switches. It also enhances the survivability of the new model by reducing the amount of time it takes for switches to dynamically redirect traffic past failed links.

At the same time, an IP multicast model will be begin deployment on ISUnet. Using the existing 7500 series edge routers as RP (Rendezvous Points), PIM (Protocol Independent Multicast) using sparse mode will be deployed on all C6509 core and C5500 and C6509 edge switches. MSDP (Multicast Source Discovery Protocol) will be used to exchange multicast sources between RP.

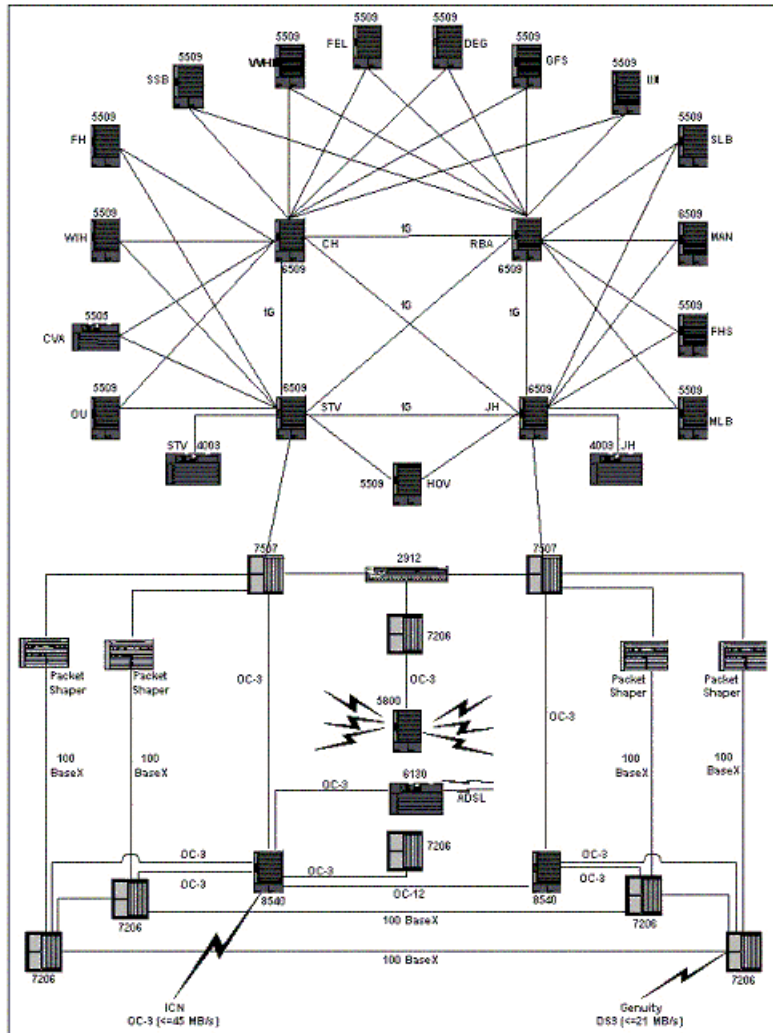
Sometime during the process of introducing the C6509 as an edge switch on ISUnet, QoS (Quality of Service) policies will be introduced to manage select Internet applications and the integration of voice, video, and data over IP. These policies will coincide with those QoS policies that have been introduced to manage Internet traffic volume earlier.

In an attempt to enhance the survivability of critical servers located on the server farms in the Julian and Stevenson switching centers, HSRP (Hot Standby Routing Protocol) will be introduced. In the current model, the gateway for these hosts would be unreachable in the event that the edge switch that the server farm is attached to fails. Using HRSP, the gateway address would be dynamically applied to the alternate edge switch.

Below is a diagram that represents the revised ISUnet core model using gigabit technologies:

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Proposed ISUnet Gigabit Core



7 – The Continuing Need for ATM

The introduction of a new gigabit core does not mean that ATM will no longer be needed on ISUnet. ATM is essential to interface to our service provider networks and on-campus ADSL subscribers. ATM is also a requirement to obtain Internet 2 connectivity.

8 - Consultant Review

The fall 2000 semester witnessed dramatic increases in the consumption of Internet capacity for ISUnet. In response, newer hardware and software were introduced in an effort to attempt to respond to these needs. However, ISUnet experienced a great deal of instability with these newer products. Although these problems were eventually resolved, even newer hardware and software were introduced to manage this growth.

In an effort to validate this evolving model, a consulting engineer from Cisco was asked to review the ISUnet model from the fall 2000 semester. The goal of this review was to identify any obvious shortcomings of our current network model that contributed to stability problems encountered with Internet

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connectivity during the fall 2000 semester. Concurrently, this review was to validate the approach being developed to continue to enhance the campus network model to support the growth projected for the fall 2001 semester. The review accomplished both objectives and more.

The network review from Cisco not only discusses recommendations for Internet connectivity, it also recommends a migration strategy from ATM to a gigabit core. This recommendation supports a proposal developed last year to deal with corresponding growth within the network core. Below is an excerpt of this review relating to this project:

“In order to optimize the configuration and implementation of IP multicast, replacement of the ATM backbone with a Gigabit Ethernet solution, based on Catalyst 6500 switches is highly recommended. This will provide for a very scalable solution since the 6500 implements IP Multicast in hardware, and eliminating the Broadcast and Unknown Server (BUS) function found in LANE. The actual implementation of IP Multicast (RP selection, etc.) should be reviewed in detail. The migration to Gigabit Ethernet also provides for bandwidth scalability not available with ATM, by utilizing gigabit etherchannel or the forthcoming 10 Gigabit Ethernet standard.”

9 – Gigabit Core Implementation Plan

To implement the new gigabit core, several phases will be needed to provide a managed process for introducing this technology into ISUnet. This plan optimizes human resources within the networking group and minimizes the impact on the end user by focusing most of the work during major prescheduled network maintenance outage windows. Below is the proposed schedule:

Pilot (May through August): test proposed model in the Julian lab

Phase I (June): introduce C6509s in Cook and Redbird

Phase II (July): introduce C6509s in Julian and Stevenson

Phase III (August): remove ATM core switches

Phase IV (August 2001 through June 2003): begin deploying C6509s as distribution switches

Pilot: By this May, two or more C6509 core switches will begin being tested to model the new gigabit core described within this document in the JH 143 network lab. These switches will contain modules that provide 256Gb/s on the backplane, wirespeed routing and QoS (Quality of Service), and gigabit modules to construct a complete mesh. **In order to complete this project on schedule, equipment for the pilot project must be ordered from Cisco Systems by the first week of February.** At this time, Cisco is reporting a 90 day lead time in acquiring this product due to industry demand. If the pilot time line slips, Phase III of this project may not happen until December 2001. In addition, Cisco may not honor the trade in value of the C8540 past March.

Phase I: The first two C6509 core switches will be deployed in the Cook and Redbird switching centers. These switches will be deployed in parallel to the existing C8540 ATM core switches and connected to the collocated edge switches. These edge switches will then be disconnected from the ATM core. The new C6509 core switches will then be connected to the Julian and Stevenson edge switches using gigabit ethernet. This phase is tentatively scheduled to take place on June 10, 2001 during a prescheduled network maintenance outage.

Phase II: The last two C6509 core switches will be deployed in the Julian and Stevenson switching centers. As in Phase I, these switches will be deployed in parallel to the existing C8540 ATM core switches and will be used to provide connectivity for ethernet networks within these switching centers. At this point, all four C6509 core switches will be interconnected to construct a complete gigabit mesh. This phase is tentatively scheduled to place on July 15, 2001 during a prescheduled network maintenance outage.

Phase III: All existing C5500 series edge switches will be disconnected from each of four C8540 ATM core switches. Then, each edge switch will then be connected to a pair of C6509 gigabit core switches using gigabit ethernet. Then, the C8540 ATM core switches in the Redbird and Julian core switching

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centers will be removed. The C8540 ATM core switches in the Cook and Stevenson switching centers will remain to be used for connectivity to the ICN (Illinois Century Network) and on-campus ADSL. In the future, these switches will also provide connectivity to the Internet 2 and Verizon. This project is tentatively scheduled for August 12, 2001 during a prescheduled network maintenance outage.

Phase IV: The first C6509 will be deployed as an edge switch as part of the new residence hall network in Hewett-Manchester during August of 2001. During this phase, older group switches based upon the C5500 series switch should begin being displaced by the C3508. By the end of December 2001, all token ring networks on ISUnet will be disconnected. Once this has been completed, the process of replacing existing C5500 series edge switches with C6509 edge switches will begin. As each edge switch is displaced, wirespeed routing will be implemented. Up to four of these switches will be replaced during prescheduled network maintenance outages between January and July 2002. The remaining edge switches will be displaced between July 2002 and July 2004. As these edge switches are displaced, fast ethernet desktop connectivity can be offered where these switches are available within existing building networks.

10 – Then, Now and Beyond

Although much has happened to ISUnet since its inception, the reality is that it has evolved through a series of managed migrations as needs dictated action. In the early 1990s, growth on ISUnet defined the need to introduce multiprotocol routing. To support the increased volume of aggregate volume on the original token ring core, token ring switching was introduced. In 1995, ResNet introduced high density ethernet into ISUnet. Eventually, it evolved into switched ethernet. Once this technology became dominant over token ring, a phased migration strategy was developed to displace it. To support this migration, a new core model was introduced in 1997.

The ISUnet of today is the evolved product of the requirements that defined the past. Just as in the past, newer requirements are defining the need to continue to evolve it. The introduction of gigabit ethernet technologies as outlined in the document is the appropriate means for meeting these needs.

Beyond today, many new opportunities emerge with the evolved model we are preparing to deploy this summer. And with it, are newer challenges. It will be paramount to continue the displacement of the C5500 series edge switch with the C6509 as well the C5500 series group switch with the C3508. At the same time, additional edge switching sites may need to be created to manage volume. More and more STP cabling is being displaced with UTP cabling to support the ever-growing number of users that could obtain fast ethernet connectivity if they want it. Access switches such as the C1924 or C5500 deployed prior to 1998 will need to be displaced with 10/100 auto-sensing products. The limited introduction of gigabit ethernet connectivity for servers over copper will also become important.

To support all of this growth, the gigabit core mesh will need to continue to evolve. In the future, this can be done by upgrading to even faster backplane modules in the C6509 (a 512Gb/s switch module is in the works) and by introducing 10Gb/s technologies between core switches and among edge switches as needed.

The ISUnet Gigabit Core Project

1988	begin rollout of original ISUnet backbone
1989	
1990	
1991	deployment of STP cabling throughout campus
1992	
1993	start of multiprotocol router project, start of intelligent token ring hub project
1994	begin ResNet
1995	introduction of switched token ring, end of multiprotocol project, end of intelligent token ring hub project
1996	introduction of switched ethernet, introduction of UTP-5 cabling standard
1997	start of ATM core project
1998	begin token ring to switched ethernet migration
1999	no new token ring activations, introduction of off-campus ADSL
2000	end of ATM core project, start of Greek House networks, start apartment complex networks
2001	start of gigabit core project, introduction of UTP-6 cabling standard, introduction of desktop fast ethernet, emergence of wireless data service
2002	end of switched ethernet migration, token ring removed, introduction of gigabit ethernet for servers, introduction of 10Gb/s modules in core mesh
2003	complete ResNet on campus
2004	end of gigabit core project

11 - Conclusion

The health and usability of ISUnet greatly impacts the activities that occur at Illinois State University. To meet the needs of these activities, this network must evolve. Since requirements continuously change, it is only natural that the components of this network will need to be enhanced or replaced to support these needs. As a result, evolution of the network is a continuous process.

The project defined in this document does not represent a dramatic design change from the existing network model. The only real change is the displacement of ATM as a core technology with gigabit ethernet. The activities that surround edge switch upgrades need to occur regardless if ATM is displaced or not. However, desktop fast ethernet CANNOT happen without this project. Because the appropriate resources are available and opportunities are maximized, this project must begin NOW.

This document defines a very clear process for evolving the campus network model to meet the growing needs of the University. A substantial amount of research has taken place in the effort to develop this plan. However, more work lies ahead during the implementation phase of this project. Since complete implementation will up to three years, now is the time to begin this work. Once these projects are in motion, ISUnet will be able to offer enhanced services such as desktop fast ethernet, IP multicast, and eventually gigabit ethernet over copper. These services will position our users to maximize information technology as the University continues to enhance the services provided to our students, faculty, and staff.