K-20 NEXT-GENERATION NETWORK ARCHITECTURE RECOMMENDATIONS

Approved by the K-20 Network Board March 14, 2006
EXECUTIVE SUMMARY

The contracts for transport that support the K-20 Educational Telecommunications Network (K-20 network) and Department of Information Services’ (DIS) statewide backbone network expire on June 30 2007. Further, the telecommunications industry and associated technologies have advanced a great deal since the original 1996 network architecture and design. A technology and architecture update is needed for the K-20 and DIS statewide networks. The K-20 Educational Network Board and the Director of DIS have asked that a technology refresh be incorporated into the upcoming transport acquisition process.

The K-20 Educational Network Board created a Technology Subcommittee on September 7, 2005 to support this architecture development effort. A core working group of Network Technical Steering Committee (NTSC) members, Department of Information Services, K-20 Program Office, and University Washington staff was created by the Technology Subcommittee to develop the new architecture. The purpose of the working group was to conduct an architecture refresh and network redesign in preparation for the upcoming transport acquisitions process. This document details the recommended architecture developed by the K-20 Technology Subcommittee core working group. The plan does not cover acquisition strategies or detailed design.

The core working group started the process by collecting the sector business requirements for the K-20 network sectors, the State Governmental Network (SGN) and Intergovernmental Network (IGN) users. The business needs for the users were very similar. The K-20 and government users needed:

- Cost-effective and reliable network services throughout the state.
- Network services that can scale to meet increasing throughput needs.
- Access to a wider range of Ethernet (and other) last mile services for connecting institutional networks to the statewide backbone network.
- Affordable business continuity and disaster recovery solutions.
- A highly secure network for conducting both e-commerce and institutional financial computing transactions.

The K-20 network sectors needed the following additional features:

- Ability to dynamically increase (or decrease) bandwidth on a situational basis to support their institutional needs, yet keep their networking costs as low as possible.
- Ability to dynamically create short-term, ultra high-speed (10Gbps+) network links between research and educational (R&E) institutions.
- Ability to more easily create links between multiple government research institutions within the state and university partners in nearby states like Idaho, Montana, and Oregon.
- Ability to more easily use partner transport services including wave (lambda) services that can be provided at very cost-effective rates.
The working group determined that the following make it difficult for the current network to meet the users’ business needs:

- The current network is synchronous optical network (SONET) based and any Ethernet services have been added in an ad hoc basis. This makes adding end-site Ethernet services time-consuming and problematic for the network operators.
- The current network is built as a system of individual automatic protection switching (APS) SONET paths between statewide node sites. The network is highly reliable but more complex than it should be to provision and operate; this has resulted in problems during upgrades to equipment or carrier services.
- The network is not able to easily take advantage of new regional optical networks (RONs) that provision Dense Wave Division Multiplexing (DWDM) that allow more efficient use of scarce fiber optic resources throughout the state. Unless wave technologies are taken advantage of, the unit cost of transport for the network will begin to rise.
- The original managed network aggregation points (nodes) for the network were designed to optimize the reliability of, and keep the costs as low as possible for a time division multiplexed (TDM) DS1/DS3/SONET network. The advent of Ethernet services throughout the state is changing the dynamic of appropriate aggregation points.

The K-20 core working group therefore has determined that the following statewide architecture will meet the business requirements for the K-20 network sectors and government users of the statewide network:

- Upgrade the node sites to next-generation equipment that allows the network to more easily aggregate Ethernet and TDM network traffic.
- Obtain DWDM waves throughout the state and as appropriate, use optical waves for network transport. It is anticipated that the unit cost for transport would be lowered in the upgraded network through the use of wave technology.
- Connect more aggregation points throughout the state to increase Ethernet access and to also increase access opportunities and capacity to R&E partners. The recommendation is to investigate Bellingham, Wenatchee, Tacoma, Aberdeen, Boise, Portland, and Tri-Cities, for example, as additional aggregation or connection sites to enhance the current statewide network architecture. More sites could be added as needed during detail design.
- Optimize the node sites so that the network is not made up of a grouping of point-to-point circuits, but rather each node is a location where traffic can be easily dropped off and/or added for passage across the state. The network will be managed more cost-effectively and with less chance for human error.

The above recommendations will provide the state with an infrastructure and network that will easily scale to meet the anticipated growth and more sophisticated networking needs of the K-20 network sectors and state users for at least the next ten years.

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1 Please note that these deficiencies are due to the current age and the limited capabilities of the telecommunications industry in 1996 when the network was originally conceived and designed.
SECTION 1: INTRODUCTION

1.1. Purpose

The contracts for transport that support the K-20 Educational Telecommunications Network (K-20 network) and Department of Information Services’ (DIS) statewide backbone network expire on June 30, 2007. Further, the telecommunications industry and technologies have advanced a great deal since the original architecture and design of the network in 1996. The K-20 Educational Network Board and the Director of DIS therefore have asked that the current K-20 Network and the DIS statewide backbone network undergo an architecture refresh and network redesign as part of the new acquisitions process.

The purpose of this document is to detail the next-generation-network (NGN) architecture update for the K-20 Educational Telecommunications Network. As an integral part of the document, the underlying business needs of the educational sectors and key proposed architectural features of the NGN for K-20 are documented. The key foundational needs of the DIS statewide backbone network, State Governmental and Inter-Governmental Networks (SGN/IGN), are also presented in parallel to show that the NGN will serve all state public communities.

The K-20 Network Architecture Plan will serve as the foundation for the development and evolution of the technical design and procurement of transport and equipment for the NGN K-20 and DIS’ statewide backbone network.

1.2. Scope

The scope of this document is limited to an architecture plan that provides a leveraged statewide architecture for K-20 and DIS. The plan does not cover acquisition strategies or detailed design.

1.3. Approach

The approach to the plan’s development consists of six principal activities:

<table>
<thead>
<tr>
<th>Past K-20 Strategic Plan</th>
<th>The K-20 Board approved a K-20 Educational Telecommunications Strategic Plan on July 9, 2004 that provides an updated vision for the K-20 Network.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-20 Board Creates Subcommittee for Technology</td>
<td>The purpose of the Subcommittee, created on September 7, 2005, is to define K-20 sector requirements, develop a new network design, and develop a high-level procurement and implementation schedule.</td>
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</tbody>
</table>
### K-20 Business Requirements

Representatives from the K-20 sectors met on October 14, 2005 to discuss and refine the educational community's business requirements with respect to the K-20 network. The draft results of that discussion are incorporated in Appendix A of this document.

### Working Group

A core work group (NTSC, K-20 Program Office, UW, and DIS) was formed to develop a recommended architecture plan. This document is the result of their efforts. Appendix D contains the names of the team members.

### NTSC Review & Approval


### K-20 Board Review & Approval

The K-20 Network Board approved the NGN Architecture document on March 14, 2006.

### ISB Review

The Information Services reviewed the NGN Architecture on March 16, 2006

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**1.4. Organization of this Document**

Sections 1 and 2 provide background for this document. Section 3 provides the detailed analysis used to formulate the architecture. Section 4 provides the proposed reference architecture and nodal layout for the NGN network. Section 5 provides a set of next steps. Section 6 provides supporting documentation in appendices. A detailed Glossary of Terms in included in Appendix G.
SECTION 2: BACKGROUND

2.1. Current Network Backbone

The current K-20 network and DIS statewide backbone network is primarily a traditional synchronous optical network (SONET) using carrier provided time-division-multiplexing (TDM) services. The network backbone comprises separately provisioned, automatic protected switching (APS) SONET rings between DIS node sites located throughout the state. Local institutional DIS and K-20 end-sites are connected via TDM access circuits (DS1, DS3, SONET) and Ethernet to the appropriate backbone node. Figure 1 depicts a logical view of the current, statewide backbone network.

Regional traffic is aggregated onto larger inter-nodal backbone SONET circuits for transport throughout the state. The backbone network reduces costs for the state since these large-scale circuits on the backbone cost less on a unit basis compared to local circuits. The network is highly redundant and resilient and has worked well for the state and its end-users.

The design however, started in 1996 and implemented in 1998, is not optimal for support and especially for upgrade to higher speeds. The point-to-point nature of the backbone circuits forces traffic that travels from one end of the state to another, e.g., Spokane to Olympia, to be handled by node equipment at least three times. The level of traffic manipulation leads to less than preferred throughput levels and the potential for human error due to complex network configurations.

Figure 1 — Current Statewide SONET Network

![Diagram of Current Statewide SONET Network]
2.2. Current Nodal Equipment and Circuits

The current backbone network has inter-exchange carrier (IXC) circuits from 360 Networks, CenturyTel, and Qwest. The network circuits comprise a mix of SONET OC-3 (155 Mbps) and OC-12 (622 Mbps) circuits. The major network transport systems contain equipment from Fujitsu, Tellabs, Cisco, and Alcatel. The transport equipment has been highly reliable but some is nearly 10 years old. The current transport gear, due to age, is not able to support the latest optical networking innovations which can reduce network complexity and support ultra-high-speed circuits. Further, an estimated 20% annual growth in network bandwidth usage by K-20 sectors and DIS SGN/IGN users continues to strain the network’s ability to provide timely capacity upgrades for the backbone.

2.3. Current Ethernet Services

The state operates a 200 Mbps Ethernet ring that redundantly connects the Spokane, Seattle, Yakima, and Olympia Nodes. The Ethernet ring is provisioned as separate transport from the SONET network and is used to provide inter-nodal Ethernet transport for Ethernet-connected end sites. Currently the K-20 Network has approximately 40 sites connected via Ethernet access transport and has plans for another 90 sites in the next six months. DIS has approximately 15 sites connected via regional Ethernet access services and anticipates another approximate 50 end-sites moving to Ethernet over the next six months. The
The current network, however, is not optimized to support significant Ethernet growth and 
current Ethernet services are implemented in an ad hoc or “bolt-on” manner to the SONET 
network. The current network architecture is therefore less than efficient and more prone 
to errors in configuration and support than desired, and does not lend itself to high-speed 
Ethernet support on a statewide basis.
SECTION 3: BUSINESS NEEDS — FLOWS — THROUGHPUT


The K-20 sector representatives met on October 14, 2005 and developed a set of business IT needs/requirements for the K-20 Network. The formal results of that work are provided in Appendix A and summarized below:

1. **State Government Network (SGN) Access** -- Increasingly, K-20 subscribers have business needs to access statewide applications that require access through the SGN. Currently this requires a separate SGN circuit which is considered economically infeasible by most K-20 subscribers. The need is for a combination of technical solutions and policy changes to facilitate access while protecting the SGN. Similar issues exist with the Intergovernmental Network (IGN).

2. **Payment and Service Options** -- A general consensus exists that the singular approach to payment for K-20 subscribers does not work for all subscribers. For example, some K-20 users need a highly predictable, fixed set of charges for K-20 services while others greatly prefer the “pay for what you use” approach. Similarly, options within service offerings are greatly desired. For example, some users require a high level of business continuity assurance while to others, this may not be a significant need.

3. **Communications** -- All agreed that increased awareness and information is crucial. Many of those in positions of authority and decision making within K-20 subscriber organizations have little or no awareness of the value that K-20 brings to their respective organizations. Many perceive K-20 only as an expense item. Some institutions are increasingly viewing K-20 as a commodity that is no different from other transport/Internet alternatives. A statewide communication program is required. (Note: The K-20 Board Program Subcommittee has recognized this need and is including it as a part of its activities.)

4. **Business Continuity** -- As the number of educational business applications that rely upon K-20 has increased, the need for business continuity (i.e., protection against various types of disasters and other service interruption events) has become a significant business need.

5. **K-20 Purchases** -- A strong desire exists to have statewide convenience contracts for equipment, software, and services available for use by all K-20 subscribers. K-20-provided contracts have significant advantages to the K-20 subscriber community:
   - Individual entities save the high costs associated with conducting procurements
   - Overall prices are lower since K-20 can leverage the state’s buying power

6. **Best Practices Security Recommendations** -- One major goal of the K-20 Network is to enhance access between Washington’s educational sectors. All connected entities should ensure that overly broad security or “traffic management” policies do not inhibit educational use. Techniques such as firewalls, access lists, filtering, and bandwidth control should be carefully implemented to allow appropriate sector-to-sector interactions. Although security policies are the responsibility of each connecting institution, recommended “best practices” should be developed by
K-20 and communicated to all institutions, to ensure that legitimate educational uses of K-20 can be realized.

7. **Dynamic Bandwidth** -- K-20 subscribers want network bandwidth that varies according to instantaneous needs. The concept of a fixed amount of bandwidth—such as that provided by one or more T1 circuits—no longer meets the needs of the user community.

8. **Professional Services** -- K-20 subscribers need access to a consistent pool of technology professionals to help them make strategic and tactical technology decisions. The group agreed that such a pool would help to ensure that K-20 subscriber’s IT initiatives can seamlessly use available K-20 technologies.

9. **Possible K-20 Extension** -- The K-20 Network currently extends only to the school district boundary of K-12 schools, the main campus of community and technical colleges, and the headquarters of library systems. The group agreed that there is a need to understand the potential technical, operational, and cost implications of extending K-20 to individual schools and libraries.

10. **Voice over IP** -- There is an increasing need by some K-20 subscribers to utilize voice over IP (VoIP) as an integral part of the K-20 service. The largest need is to provide VoIP within a single organizational entity, such as a community college with its associated branch campuses.

11. **Increasing Demand** -- Utilization of the network is increasing in all of the educational sectors. This phenomenon has occurred even in institutions with declining enrollment.

12. **Potential Increased Redundancy** -- Some institutions have expressed a desire for redundancy in their access to the K-20 Network. In addition, it is recommended that multiple paths to the Internet and Internet2 should be examined for their potential technical, operational, and cost implications.

3.2. **SGN/IGN Business Needs**

The SGN/IGN business IT strategic goals can be summarized as follows:

1. **Use the IT infrastructure as a way to reduce costs by:**
   - Finding less expensive WAN technologies to provide ubiquitous IT infrastructure for the entire agency or educational institution, but at the same time reducing IT infrastructure’s overall contribution to the agency’s or institution’s bottom line.
   - Reducing the amount of time needed to support customers by providing enhanced Web-enabled customer support over the Internet, but at the same time still providing a satisfying customer experience.
   - Reducing development and support costs by using Web-enabled applications and using TCP/IP network delivery of those applications.

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• Increasing faculty/staff efficiencies by providing easy-to-use applications and ubiquitous network and data access throughout the agency/institution network.

2. **Use the IT infrastructure as a means of meeting legislatively mandated requirements by:**

   • Creating computerized applications that provide an efficient and speedy method of collecting required data in a secure and error-free manner.
   • Providing access to the above applications via the ubiquitous statewide network.
   • Providing security to the network in order to meet those mandated requirements, and providing a safe computing environment for all of the institution’s network computing users.

3. **Use the IT infrastructure as a means of enhancing the customer experience by:**

   • Providing universal network service coverage in the agency’s or institution’s domain of charge.
   • Providing sufficient bandwidth so that visual techniques like video on demand (VoD) can be used to supplement, or even become the principal delivery method of content to customers/students.

3.3. **Statewide Network Technology Flow, Performance, and Availability**

The working group also conducted an analysis effort to further refine the technology needs of the K-20 and DIS SGN/IGN user communities. Appendix E contains the detailed results of the analysis for flow, performance, and availability. The following summarizes the analysis results.

3.3.1 **Flows**

   The current and anticipated future network flows are presented in Figure 3. A network flow is a set of network traffic (application, protocol, and control information) that have some common attributes, such as source/destination address, information type, performance, routing, or some other end-to-end information. It is important to understand flows (current and future) so that the network is properly designed to accommodate end-user traffic flow needs.
3.3.2 Performance

The flows contain the following types of traffic with unique performance needs:

- K-20 Internet (Best Effort)
- K-20 Internet2\(^3\) (traffic to and from the Abilene backbone network) (Best Effort)
- K-20 Video (Low-Latency/Delay, Guaranteed Bandwidth)
- K-12 Financial and Administrative (Guaranteed Bandwidth)
- Higher Education Research & Engineering (R&E) (Guaranteed Bandwidth)
- Community and Technical College (CTC) Computer Information Services (CIS) Financial and Administrative (Guaranteed Bandwidth)
- CTC CIS Disaster Recovery (DR) and Business Continuity (BC) (Guaranteed Bandwidth)
- State Governmental Network (SGN) Internet (Best Effort)

\(^3\) Internet2 is consortium of 200+ higher education and research institutions connected via the Abilene backbone network.
• SGN HQ Application (Guaranteed Bandwidth)
• SGN Agency-to-Agency (Guaranteed Bandwidth)
• SGN State Application (multi-agency access) (Guaranteed Bandwidth)
• SGN Video (Low Latency/Delay, Guaranteed Bandwidth)
• SGN IP Telephony (Low Latency/Delay, Low Jitter, Low Dropped Packets)
• Inter-Government Network (IGN) Internet (Best Effort)
• IGN State Application (Guaranteed Bandwidth)
• IGN Video (Low Latency/Delay, Guaranteed Bandwidth)
• IGN IP Telephony (Low Latency/Delay, Low Jitter, Low Dropped Packets)

3.3.3 Availability Needs

Network availability means that the network users are able to perform their normal day-to-day tasks within a timely manner. The network user and applications\(^4\) have a wide range of availability needs that the network must support ranging from 8x5 (8 hours a day, 5 days a week) to 24x7 (24 hours a day, 7 days a week, 365 days a year). Network architecture must take into account the application availability needs of the users and the costs associated with increased operational availability. The end result of the amalgamation of all the user availability need across the state is that the statewide backbone must be available on a continuous availability basis (24x7x365). [The unit cost of continuous availability lowers as more user traffic is aggregated into the backbone.]

3.3.4 Statewide Network Throughput Needs

The user’s network traffic throughput needs grow approximately 25% per year. The current daily average throughput usage of the network is approximately one Terabyte (1x10\(^{12}\) bytes) per day. If current trends continue, the network will need to support at least 2 Terabyte per day of traffic by 2010. The current SONET network (OC-12 and lower) would not be able to support such sustained levels of network usage. The following figure depicts the anticipated throughput growth needs for the statewide network.

\(^{4}\) Note that availability needs vary on a case-by-case basis by application. While E-911 service should be available on a 24x7 for all institutions seldom do office productivity tools need to be available on a 24x7 basis.
Figure 4 — Projected Daily Throughput Needs of Statewide Network

Terabyte (TB) = $1 \times 10^{12}$ bytes
or 1 trillion bytes

Total Daily Throughput (TB)
Statewide Network

~2 TB per Day

~1 TB per Day

2005

Year

2010

IGN

SGN

K-20
SECTION 4: ARCHITECTURE

4.1. Current Architecture Issues

The working group determined that the current architecture has the following issues that need to be dealt with in the refresh/redesign process:

1. The current network is not as efficient as it could be for the provisioning and upgrade of statewide transport.

2. The current design does not adequately support the use of NGN optical wave lambda (λ) technologies.

3. Because of issues 1 and 2, the current network will not cost-effectively scale to support the anticipated growth and business needs of the K-20 and SGN/IGN sectors.

4. The current node site placement in the state does not meet all of the needs of the K-20 and SGN/IGN users and their anticipated traffic flows for R&E, IP telephony, IP video, and disaster recovery/business continuity traffic.

5. The current node site equipment does not easily allow partners to be incorporated into the network.

4.2. Fundamental Architecture Precepts

The working group condensed recommended enhancements to the statewide backbone architecture into the following fundamental precepts:

1. The statewide backbone network, if it is going to be shared, must be highly flexible and allow dynamic provisioning of circuits including end-points and bandwidths throughout the network.

2. The SGN/IGN network has very strict availability and security requirements (including E-911 life-safety and other first-responder traffic) that DIS must continue to support. The network, especially the SGN, must be able to be provisioned in a continuous availability mode (neither outages nor maintenance are visible to users).

3. For K-20, especially in the higher education R&E portion of the K-20 Network, the current SONET based infrastructure does not meet the K-20 sector’s needs for very high-speed circuits needed for testing and research. The R&E institutions need wavelengths or wave (lambdas) technologies available to them now so that very high-speed and disruptive testing can occur. Such technologies are necessary to allow the higher education R&E institutions to apply for and win educational research grants.

The team believes that once the three preceding precepts and baseline traffic throughput and flow needs are met by the statewide network architecture, the network will scale to support K-20 and SGN/IGN users for the next ten years.
The following table develops, in more detail, the architectural goals the team has agreed to, and the affect or benefit to K-20 and SGN/IGN users:

**Table 2 — K-20 and DIS Architecture Goals for NGN Design**

<table>
<thead>
<tr>
<th>Goal</th>
<th>Description</th>
<th>Affect/Benefit to K-20/DIS</th>
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</table>
| 1    | Base infrastructure for the statewide NGN network should be based on wavelength (lambda) technologies | 1. Allows the network to be constructed with common layer-1 infrastructure thereby bringing economies of scale to the state during procurement and support processes.  
2. Allows network designers to easily create logically separate networks between subscribers with fundamental different business missions.  
3. Provides the most growth potential per unit of equipment and transport procured. Growth can easily be accommodated by adding another wavelength (\(\lambda\)) to an already existing fiber infrastructure rather than having to depend upon the carriers to provision and/or find another circuit to meet growing network needs.  
4. Removes the artificial network visibility constraints imposed by current carrier practices at the SONET level. Allows DIS to more easily design and manage robust layer-1 SONET protection schemes independent of carrier participation. |
| 2    | Base infrastructure should enable wide flexibility for partners to provide circuits for the statewide network | 1. Allows the network design team to ensure that the architecture will have appropriate levels of reliability by allowing the team to design and implement combinations of engineering route diversity and redundancy into the network.  
2. Allows more partners to procure and provide transport between node sites for the statewide network. Increases the number of routes and reduces the costs of the routes that can be provided by the network. |
| 3    | Base infrastructure should provide both wave optical add/drop support and multi-service provisioning platforms (MSPP) | 1. Allows the network operators to easily provision and manage wave-based, subscriber networks and allows the state to find the most cost-effective transport for wave services throughout the state.  
2. Allows the network operators to maximize wave technology usage throughout the state, in order to augment network availability and throughput capacity.  
3. Allows the network operators to support layer-2/3 with layer-1 technologies that meet subscriber’s business needs. |
### Goal Description & Affect/Benefit to K-20/DIS

<table>
<thead>
<tr>
<th>Goal</th>
<th>Description</th>
<th>Affect/Benefit to K-20/DIS</th>
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<tbody>
<tr>
<td>4</td>
<td>More secondary transport (access) Ethernet aggregation points will be added throughout the state.</td>
<td>1. Supports the K-20 and DIS expanding needs for Ethernet-connected end-sites throughout the state.</td>
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<td></td>
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<td>2. Enhances the network’s ability to support increased intra-regional collaboration.</td>
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<td></td>
<td></td>
<td>3. Decreases the issues when Ethernet vendors are required to maintain layer-2 continuity across the entire state.</td>
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<tr>
<td></td>
<td></td>
<td>4. Provides support for DIS and K-20 to substantially increase the number of Ethernet-connected end-sites in a cost-effective and manageable manner.</td>
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</table>

### 4.3. Recommended NGN Reference Architecture

The recommended K-20/DIS NGN reference architecture will be based on wave lambda (λ) technology. The recommended network will have wave facilities added at all current node sites (Seattle, Spokane, Vancouver, Yakima, and Olympia). The network would potentially build more aggregation points throughout the state to increase Ethernet access and to also increase access opportunities and capacity to R&E partners.

Further, in detail, the recommendation is to investigate Bellingham, Wenatchee, Tacoma, Aberdeen, Boise, Portland, and Tri-Cities, for example, as additional aggregation or connection sites to enhance the current statewide network architecture. More sites could be added as needed during the detailed design. The NGN system would then examine opportunities to build, add, or purchase wave facilities at the Tri-Cities region and in Bellingham, Pullman, Tacoma, Boise, Idaho and Portland, Oregon, as well as at the current node sites.

Figure 5 provides a topological view of the architecture that meets the previously listed recommendation. The network will continue to leverage procured SONET services in those parts of the network where wave services are not attainable.

**NOTE 2:** The proposed architecture enables or supports the entire set of 2004 Updated K-20 Technical Goals and Objectives provided in Appendix C.

**NOTE 3:** The proposed architecture enables or supports the entire set of K-20 Technical Standards (2004) listed in Appendix F.
The needed flexibility in the recommended network will be provided via MSPP implemented at the nodes and fronted by customer premise equipment (CPE) or WDM equipment on fiber optic networks.

MSPP is designed to handle very high-speed (100+ Gbps) switching between connecting networks and to multiplex significant levels of circuits on and off larger and smaller circuits. The recommended MSPP and the WDM infrastructure will allow K-20 and DIS to easily aggregate their customer traffic, with differing business requirements, onto a common layer-1 wave infrastructure with separate layer-2 and -3 networks. The technology will also allow DIS to continue to leverage current investments in SONET carrier circuits until it is cost-effective and/or possible to move to wave-based transport. The MSPP equipment will also allow DIS to continue to leverage its investment in Multiprotocol Label Switching (MPLS) infrastructure. Figure 6 provides a schematic view of such a provisioned node site.

**NOTE 4:** The MSPP and WDM system can be a single device or a system consisting of several devices.

**NOTE 5:** Regional and inter-nodal transport will be handled in the nodes via the most manageable and cost-effective manner possible which may have transport bypassing the MSPP in certain scenarios.
4.4. **NGN Architecture Benefits**

The recommended architecture in Section 4.3 meets the business and technology needs of the K-20 and SGN/IGN communities in the following manner:

<table>
<thead>
<tr>
<th>Category</th>
<th>Architecture Benefits</th>
</tr>
</thead>
</table>
| **Reliability and Availability** | - The architecture ensures that all network traffic has a redundant path to use for reaching any location on the network.  
- Reliability is further enhanced due to the reduction in the complexity of building paths statewide which reduces the chance of human error.  
- High quality equipment provisioned in redundant modes helps to ensure continuous availability. |
<table>
<thead>
<tr>
<th>Category</th>
<th>Architecture Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>￭ The network can easily accommodate new transport partners being added to the network to enhance, upgrade, or add to the network’s capacity and reach.  &lt;br&gt; ￭ The network can be easily configured to allow on-demand bandwidth provisioning to meet users’ needs for such services. &lt;br&gt; ￭ The increase in regional Ethernet aggregation will provide more opportunities for network users to upgrade, as needed and can be afforded, to faster Ethernet access services.</td>
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<tr>
<td>Scalability</td>
<td>￭ The use of wave lambda (λ) technology provides the network with simpler growth strategies. Since less physical infrastructure is involved, additional carrier and other partner services can be easily added to the network.  &lt;br&gt; ￭ Wave technologies allow 10G and even 40G services to be provisioned on the network enhancing the network’s ability to support continued growth in throughput levels.</td>
</tr>
<tr>
<td>Cost-Effectiveness</td>
<td>￭ The unit cost of the network should decrease since more efficient wave technologies can be deployed. (Note that since network usage is growing at 25% per year, the absolute cost of the network will likely not decrease.)  &lt;br&gt; ￭ The unit cost of managing the network should decrease since the node equipment layouts will be more efficient and easier to manage.</td>
</tr>
<tr>
<td>User Community Business Needs</td>
<td>￭ Clearly meets the K-20 Technical Goals and Objectives provided in Appendix C.  &lt;br&gt; ￭ a. Leverages partnerships  &lt;br&gt; ￭ b. Scalable and cost-effective  &lt;br&gt; ￭ c. Interconnections to other institutions  &lt;br&gt; ￭ d. Supports network multimedia and video  &lt;br&gt; ￭ Meets the ability of DIS to support MPLS for the SGN and IGN customers and their security needs.  &lt;br&gt; ￭ Will meet the continuous availability needs of state government.  &lt;br&gt; ￭ The network allows the state to continue to leverage a common transport infrastructure continuing to meet one of the founding principles of the K-20 Educational Telecommunications Network.</td>
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SECTION 5: ACTIONS

5.1. NTSC and DIS Next Steps

1. Review this document with DIS Director and Chair of the K-20 Educational Network Board.
2. Review and seek approval for this document with the Network Technical Steering Committee.

5.2. K-20 Board Next Steps

Review and seek approval with K-20 Board.

5.3. ISB Next Steps

Present architecture to ISB.

5.4. K-20 Technology Subcommittee Core Working Group Next Steps

Develop detailed design and acquisition/procurement documents.
2. Introduction and Purpose

K-20 is in the process of defining a network architecture and associated network design for the next generation of the K-20 Network. A vital element of this process is to ensure that the design satisfies the business requirements of the educational community (i.e. K-12, Community and Technical Colleges, Public Baccalaureates, Independent Baccalaureates, Public Libraries). An important component of the process was to solicit from each of the three principal educational sectors (K-12, Community and Technical Colleges, Public Baccalaureates) their business needs for K-20 as they are currently able to identify them.

A meeting was held on October 14, 2005, in Tacoma where the business needs of these sectors were presented. Sector representatives were:

- K-12: Marty Daybell
- CTC: Mike Scroggins
- Baccalaureates: Terry Teale

The results are summarized in Section 3 of this document.

Once the business needs of the three principal educational sectors are documented, other K-20 participants will be asked to review the needs to ensure that their requirements are met within this framework. The final document will be presented to the NTSC and K-20 Board for review and approval.

3. Current K-20 Strategic Plan

The K-20 Strategic Plan was approved by the K-20 Board on July 29, 2004. This plan lists principal strategic goals, principal IT needs, and provides a summary of needs of the K-20 participants. The goals and needs contained in the K-20 Strategic Plan were reaffirmed by the group at the October 14, 2005 meeting.

The summary of K-20 needs, as contained in the K-20 Strategic Plan, is shown below for reference.

“Taken as a whole, the top four K-20 needs for the five-year period 2004–2008 can be summarized as follows:

- **Continuation of Current K-20 Capabilities:** The currently-provided functional capabilities of the K-20 Network must continue to be available to the user community.
Maintenance of High Performance Standard: Much of K-20’s success is attributable to the high standard of reliability and throughput provided by the network. One of the reasons users stay with K-20 is that they can depend upon its high standard. Maintaining this standard is a cornerstone of K-20 needs.

Flexible Bandwidth to User Sites: As user needs change, K-20 must be able to provide the user site with associated bandwidth. Inherent within this requirement is the need for progressively higher bandwidths as user applications and uses of the K-20 Network continue to grow. Bandwidth improvements should be provided on a timescale of days rather than weeks (or months).

Increased Use of IP-Based Video: Over the next several years, there will be a highly discernable trend from ISDN-based (H.320) video to IP-based (H.323) video. Within five years, the need will likely approach 100% IP-based video. Since this technology lends itself to a far more cost-effective distribution within a campus/school district environment, a logical consequence will be that K-20 access points will require significantly higher data rate transmissions.

The group consensus upon additional needs that have been identified since the issuance of the Strategic Plan are outlined in Section 3.


1. State Government Network (SGN) Access -- Increasingly, K-20 subscribers have business needs to access statewide applications that require access through the SGN. Currently, this requires a separate SGN circuit which is considered economically infeasible by most K-20 subscribers. The need is for a combination of technical solutions and policy changes to facilitate access while protecting the SGN. Similar issues exist with the Intergovernmental Network (IGN).

2. Payment and Service Options -- A general consensus exists that the singular approach to payment for K-20 subscribers does not work for all subscribers. For example, some K-20 users need a highly predictable, fixed set of charges for K-20 services while others greatly prefer the “pay for what you use” approach. Similarly, options within service offerings are greatly desired. For example, some users require a high level of business continuity assurance while, to others, this may not be a significant need.

3. Communications -- All agreed that increased awareness and information is crucial. Many of those in positions of authority and decision making within K-20 subscriber organizations have little or no awareness of the value that K-20 brings to their respective organizations. Many perceive K-20 only as an expense item. Some institutions are increasingly viewing K-20 as a commodity that is no different from other transport/Internet alternatives. A statewide communication program is required. (Note: The K-20 Board Program Subcommittee has recognized this need and is including it as a part of its activities.)

4. Business Continuity -- As the number of educational business applications that rely upon K-20 has increased, the need for business continuity (i.e., protection against various types of disasters and other service interruption events) has
become a significant business need. Additional analysis is required in order to define the extent and nature of protection that is required.

5. **K-20 Purchases** -- A strong desire exists to have statewide contracts for equipment, software, and services available for use by all K-20 subscribers. K-20 provided contracts have significant advantages to the K-20 subscriber community:

- Individual entities save the high costs associated with conducting procurements
- Overall prices are lower since K-20 can leverage the state’s buying power

6. **Best Practices Security Recommendations** -- One major goal of the K-20 Network is to enhance access between Washington’s educational sectors. All connected entities should ensure that overly broad security or “traffic management” policies do not inhibit educational use. Techniques such as firewalls, access lists, filtering, and bandwidth control should be carefully implemented to allow appropriate sector-to-sector interactions. Although security policies are the responsibility of each connecting institution, recommended "best practices" should be developed and communicated to all institutions, to ensure that legitimate educational uses of K-20 can be realized.

7. **Dynamic Bandwidth** -- K-20 subscribers want network access bandwidth that varies according to instantaneous needs. The concept of a fixed amount of bandwidth, such as that provided by one or more T1 circuits, no longer meets the needs of the user community.

8. **Professional Services** -- K-20 subscribers need access to a consistent pool of technology professionals to help them make strategic and tactical technology decisions. The group agreed that such a pool would help to ensure that K-20 subscribers’ IT initiatives can seamlessly use available K-20 technologies.

9. **Possible K-20 Extension** -- The K-20 Network currently extends only to the school district boundary of K-12 schools, the main campus of community and technical colleges, and the headquarters of library systems. The group agreed that there is a need to understand the potential technical, operational, and cost implications of extending K-20 to individual schools and libraries.

10. **Voice over IP** -- There is an increasing need by some K-20 subscribers to utilize voice over IP (VoIP) as an integral part of the K-20 service. The largest need is to provide VoIP within a single organizational entity such as a community college with its associated branch campuses.

11. **Increasing Demand** -- Utilization of the network is increasing in all of the educational sectors. This phenomenon has occurred even in institutions with declining enrollment.

12. **Potential Increased Redundancy** -- Some institutions have expressed a desire for redundancy in their access to the K-20 Network. In addition, it is recommended that multiple paths to the Internet and Internet2 should be examined for their potential technical, operational, and cost implications.
APPENDIX B — STRATEGIC BUSINESS NEEDS FOR SGN/IGN CUSTOMERS

The following is excerpted from the *Network Architecture Assessment, January 2004, DIS, pp. 7-8*:

The business IT strategic goals can be listed as follows:

- **Use the IT infrastructure as a way to reduce costs by:**
  - Finding less expensive WAN technologies to provide ubiquitous IT infrastructure for the entire agency or educational institution but at the same time reducing IT infrastructure’s overall contribution to agency or institution’s bottom line.
  - Reducing the amount of time needed to support customers by providing enhanced, Web-enabled customer support over the Internet, but at the same time still providing a satisfying customer experience.
  - Reducing development and support costs by using Web-enabled applications and using TCP/IP network delivery of those applications.
  - Increasing faculty/staff efficiencies by providing easy-to-use applications and ubiquitous network and data access throughout the agency/institution network.

- **Use the IT infrastructure as a means of meeting legislatively mandated requirements by:**
  - Creating computerized applications that provide an efficient and speedy method of collecting required data in a secure and error-free manner.
  - Providing access to the above applications via the ubiquitous statewide network.
  - Providing security to the network in order to meet those mandated requirements and providing a safe computing environment for all of the institution’s network computing users.

- **Use the IT infrastructure as a means of enhancing the customer experience by:**
  - Providing universal network service coverage in the agency’s or institution’s domain of charge.
  - Providing sufficient bandwidth so that visual techniques like video on demand (VoD) can be used to supplement, or even become the principal delivery method of, content to customers/students.
APPENDIX C — 2004 UPDATED K-20 TECHNICAL GOALS AND OBJECTIVES

1. Establish an open, interconnected network architecture and infrastructure with full interoperability of Internet services, interactive video capabilities, audio, video, and multimedia distribution and overall transport, which seamlessly interconnects, maintains, and builds upon appropriate existing network resources and commitments.

2. Ensure backbone design, topology, and infrastructure which efficiently and reliably provides adequate bandwidth at and among network nodes, and to designated sites, which can be cost effectively augmented and extended to meet future growth and performance requirements, and which facilitates real-time, demand, and hybrid access and delivery mechanisms. This foundation ensures scalability to accommodate the future needs of K-20 members.

3. Internet Access - Provide high quality and pervasive Internet access within and between the educational sectors, and to the dramatically growing array of state, regional, national, and global learning and teaching resources, library, bibliographic, and other learning materials which are Internet (e.g., World Wide Web) based.

4. Interactive Video Capabilities - Provide appropriate open standards based interactive video codec and switching infrastructure as well as transport capabilities which permit flexible selection of private and public network transport options. Design enables appropriate selection among the varying modes of high and low speed services, small and large classroom to classroom and/or person to person interactions, point to point or multipoint and conference multi-site distribution, and circuit switched or packetized video so that educational institutions have the industry standard range of approaches from which to choose in creating flexible and cost effective programs ‘right sized’ to meet diverse and evolving program objectives.

5. Network Multimedia and Packetized Video Capabilities - Enable network multimedia and packetized video serving and distribution over the terrestrial inter-nodal infrastructure. The Internet design incorporates both high speed multimedia servers and native multicasting to support the distribution of audio/video material in real-time from sources on a global, national, regional, statewide, or local scale. In order to support these types of Internet based services, the network provides for differentiated bandwidth allocation on the basis of quality-of-service requirements.

6. Interoperability and Compatibility - Ensure interoperability of Internet, interactive video, multimedia and other capabilities, and hence full opportunities for sharing across the entire system and also with other open standards based educational infrastructures and resources elsewhere throughout the region and globally.

7. Interconnections to Other Institutions - Ensure open access to and from other institutions and systems to enable broad inter-institutional cooperation, access, and resource sharing including schools and colleges, libraries, government, businesses, and other educational networks, etc., which are not part of the State of Washington's publicly funded educational systems. Incorporate regional Internet inter-exchange point.
8. Scaleable, Extensible and Granular Designs - Design to enable orderly and cost-effective upgrade and expansion of the system and system components.

9. Standards Based Design - Open standards based architecture, firmly rooted in relevant education, telecommunications, and computer industry standards.

10. Interoperability with Public Switched Network - Seamless interconnectivity with and use of the public switched network.

11. Evolutionary Path - Ensure a flexible mainstream evolutionary path enabling use of industry standard components and following market driven technologies appropriate to education.

12. Leverage Public and Private Partnerships.

13. LeverageExisting State and Local Resources.
### APPENDIX D — K-20 BOARD TECHNICAL SUBCOMMITTEE WORKING GROUP

**Table 4 — Board Technical Subcommittee Working Group**

<table>
<thead>
<tr>
<th>Member</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brad Jordan</td>
<td>University of Washington</td>
</tr>
<tr>
<td>Connie Michener</td>
<td>K-20 Program Office</td>
</tr>
<tr>
<td>Frank Leeds,</td>
<td>Seitel Leeds &amp; Associates, NTSC Industry Representative</td>
</tr>
<tr>
<td>Geoff Lakeman,</td>
<td>University of Washington</td>
</tr>
<tr>
<td>Michael Partlow</td>
<td>Department of Information Services</td>
</tr>
<tr>
<td>Ron Kappes</td>
<td>Department of Information Services</td>
</tr>
<tr>
<td>Steve Paulson</td>
<td>University of Washington</td>
</tr>
<tr>
<td>Tom Carroll</td>
<td>K-20 Program Office</td>
</tr>
</tbody>
</table>
### APPENDIX E — K-20 AND SGN/IGN FLOWS, PERFORMANCE, AND AVAILABILITY

Table 5 — SGN/IGN Flows, Performance, and Availability

<table>
<thead>
<tr>
<th>Sector/Site Approximate Bandwidth</th>
<th>Current Flows</th>
<th>Future Flows</th>
<th>Performance Needs</th>
<th>RMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTI — Real-Time-Interactive, GB — Guaranteed Bandwidth, BE — Best Effort, RMA — Reliability, Maintainability, Availability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-12 &gt; 15 Mbps</td>
<td>Internet IP Video ISDN Video</td>
<td>Disaster Recovery/Business Continuity (DR/BC)</td>
<td>RTI GB BE</td>
<td>High 10x5</td>
</tr>
<tr>
<td>K-12 NxDS1, &lt; 15 Mbps</td>
<td>Internet ESD Data Centers IP Video ISDN Video</td>
<td>Consolidated Data Center (CDC), DR/BC</td>
<td>RTI GB BE</td>
<td>High 10x5</td>
</tr>
<tr>
<td>K-12 DS1</td>
<td>Internet ESD Data Centers IP Video ISDN Video</td>
<td>CDC DR/BC</td>
<td>RTI GB BE</td>
<td>High 10x5</td>
</tr>
<tr>
<td>K-12 Consolidated Data Center</td>
<td>N/A</td>
<td>To 276 districts throughout state</td>
<td>GB</td>
<td>Continuous</td>
</tr>
<tr>
<td>Educational Service Districts</td>
<td>Internet Districts IP Video ISDN Video</td>
<td>Intra-regional – ESD to districts (content) Video on Demand (VoD)</td>
<td>RTI GB BE</td>
<td>High 12x7</td>
</tr>
<tr>
<td>CTC &gt; 15 Mbps</td>
<td>Internet IP Video ISDN Video</td>
<td>CIS Consolidated Data Center (CCDC) Intra-regional</td>
<td>RTI GB BE</td>
<td>High 12x6</td>
</tr>
<tr>
<td>CTC &lt; 15 Mbps</td>
<td>Internet IP Video ISDN Video CCDC</td>
<td>Intra-regional</td>
<td>RTI GB BE</td>
<td>High 12x6</td>
</tr>
<tr>
<td>BACC ~ 45 Mbps+</td>
<td>Internet Internet2 Inter-Sector IP Video ISDN Video, Research &amp; Education (R&amp;E)</td>
<td>Out-of-state partners (Idaho, Montana, Oregon, Alaska), Tri-Cities Region, VoD</td>
<td>RTI GB BE</td>
<td>High 24x7</td>
</tr>
<tr>
<td>BACC ~ NxDS1</td>
<td>Internet Internet2 Inter-Sector IP Video ISDN Video Research &amp; Education (R&amp;E)</td>
<td>VoD</td>
<td>RTI GB BE</td>
<td>High 24x7</td>
</tr>
<tr>
<td>Libraries ~ 10 Mbps</td>
<td>Internet N/A</td>
<td>BE</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Sector/Site Approximate Bandwidth</td>
<td>Current Flows</td>
<td>Future Flows</td>
<td>Performance Needs</td>
<td>RMA</td>
</tr>
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<td>----------------------------------</td>
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</tr>
<tr>
<td>Libraries N x DS1</td>
<td>Internet</td>
<td>N/A</td>
<td>BE</td>
<td>Medium</td>
</tr>
<tr>
<td>SGN – DS1, Frame Relay</td>
<td>Internet</td>
<td>IP Video</td>
<td>RTI</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Branch Access to Agency HQ Applications Agency to State Apps (Oly) Intra-Regional DR/BC Secure Extra-Net VPN</td>
<td>IP Telephony VoD</td>
<td>GB</td>
<td>24x7</td>
</tr>
<tr>
<td>SGN Ethernet (Rate-Limited)</td>
<td>Internet</td>
<td>IP Video</td>
<td>RTI</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Branch Access to Agency HQ Applications Agency to State Apps (Oly) Intra-Regional DR/BC Secure Extra-Net VPN</td>
<td>IP Telephony VoD</td>
<td>GB</td>
<td>24x7</td>
</tr>
<tr>
<td>SCAN DS1</td>
<td>Node to Node CO to Node Site to Node</td>
<td>IP Telephony</td>
<td>RTI</td>
<td>Continuous Availability</td>
</tr>
<tr>
<td>IGN – DS1, Frame Relay</td>
<td>Internet</td>
<td>IP Video</td>
<td>RTI</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Local to Local</td>
<td>IP Telephony VoD</td>
<td>GB</td>
<td>12x7</td>
</tr>
<tr>
<td>IGN Ethernet (Rate Limited – FE/GE)</td>
<td>Internet Local to Local Local to State</td>
<td>IP Video</td>
<td>RTI</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Local to Local Local to State</td>
<td>IP Telephony VoD</td>
<td>GB</td>
<td>12x7</td>
</tr>
</tbody>
</table>

RTI — Real-Time-Interactive, GB — Guaranteed Bandwidth, BE — Best Effort, RMA — Reliability, Maintainability, Availability
# APPENDIX F — K-20 TECHNICAL STANDARDS (2004)

## Table 6 — K-20 Technical Standards (2004)

<table>
<thead>
<tr>
<th>Category</th>
<th>Technical Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internet/Intranet Services</strong></td>
<td>TCP/IP-based Internet backbone infrastructure.</td>
</tr>
<tr>
<td></td>
<td>Open Internet routing protocols, including either open shortest path first (OSPF), intermediate systems – intermediate systems (IS-IS), or multitypology IS-IS for internal routing and border gateway protocol version 4 (BGP-4) for external routing among participating organizations.</td>
</tr>
<tr>
<td></td>
<td>Minimum SNMP v2 for network monitoring and management, with a focus on supporting SNMP v3.</td>
</tr>
<tr>
<td></td>
<td>Internet multicast support: protocol independent multicast sparse mode (PIM-SM), MBONE, and source specific multicast (SSM).</td>
</tr>
<tr>
<td></td>
<td>MPEG 1 &amp; 2 based compressed video and audio for Internet demand video and broadcast distribution.</td>
</tr>
<tr>
<td></td>
<td>World Wide Web (WWW) based server infrastructure, including Harvest style information caching servers for improving WWW performance and minimizing Internet backbone utilization costs.</td>
</tr>
<tr>
<td></td>
<td>Differentiated services (DiffServ) quality of service (QoS) for packetized multimedia applications that require low latency or guaranteed bandwidth transport characteristics.</td>
</tr>
<tr>
<td></td>
<td>ITU, IETF, and ANSI based standards.</td>
</tr>
</tbody>
</table>
APPENDIX G — GLOSSARY OF TERMS

-A-

**Abilene Network** – The Abilene Network is an Internet2 high-performance backbone network that enables the development of advanced Internet applications and the deployment of leading-edge network services to Internet2 universities and research labs across the country. The network has become the most advanced native IP backbone network available to universities participating in Internet2.

**Access Link** – Refers to the telecommunications service that connects the user institution and networks to a larger backbone network typically at a backbone Node. See also Last-Mile.

**Automatic Protection Switching (APS)** – A technique where a transmission system can detect a failure in a working facility (working circuit) and switch automatically to a standby system (protect circuit).

**Availability** – The relationship between the frequency of mission-critical failures and the time to restore service. This is also known as operational availability. Availability is typically managed by the service provider in one of three modes; high availability, continuous operation, or continuous availability.

**Backbone** – The backbone network is an important architectural element for building enterprise networks. It provides a path for the exchange of information between different LANs or sub-networks. A backbone can tie together diverse networks in the same building, in different buildings in a campus environment, or over wide areas. Generally, the backbone’s capacity is significantly greater than the capacity of the individual networks connected to it.

-B-

**Bandwidth** – A measure of the theoretical capacity of one or more network devices or communications links in a network (system). See also *Capacity*.

**Best-Effort (BE)** – Network services where there is no control over how the network will satisfy service requests and there are no guarantees associated with this service. See also *Guaranteed Bandwidth*.

**Business Continuity (BC)** – The overarching and ongoing processes whereby an institution prepares its IT infrastructure and services to reduce the impact of a disaster or major failure so that the institution’s major line of business can continue. Disaster recovery is one part of business continuity.

-C-

**Capacity** – Either a measure of a network or system’s ability to transfer information (voice, video, data or combinations of these) or the anticipated throughput needs for information transfer in the system. Capacity is typically measured in Kbps, Mbps, or Gbps.

**Carrier** – A term for a telecommunications service provider who provides digital transport services. See *IXC*. See *RBOC*. 
Channel – A communications path or the signal sent over that path. Using multiplexing, several channels can be transmitted over a single medium (copper or fiber). In wavelength division multiplexing (WDM) technology, a channel is assigned to a specific wavelength, or lambda.

Continuous Availability – A characteristic of an IT service that minimizes or masks the effects of ALL failures and planned downtime to the user. Even scheduled maintenance should not impact the system users. The public switched telephone network (PSTN) backbone and the statewide backbone are examples of a networks that are constructed and supported to provide services with continuous availability.

Continuous Operation – A characteristic of an IT service that minimizes the or masks the effects of planned downtime to the user. Such a service may have a service level agreement that allows the provider to take the network down during scheduled maintenance windows of time (typically early morning and on weekends).

-D-

Dense Wave Division Multiplexing (DWDM) – An optical technology used to increase realizable bandwidth over existing fiber optic backbones by using separate light wavelengths to modulate (transmit) digital information through the fiber optic cable. A DWDM network might be created by a user by purchasing unlit or “dark” fiber optic cables via IRU and then “lighting” the fiber with DWDM equipment between multiple sites. The DWDM equipment typically has transponders that allow a wide variety of interfaces (Fast Ethernet, SONET OC-192, GE, or 10GE for example) to be deployed over separate waves via the fiber optic cables connecting the two DWDM systems. Sophisticated DWDM systems allow add/drop grooming of DWDM wavelengths.

Disaster Recovery/Business Continuity – The plans, procedures, and contingencies that enable an organization to set up, reconfigure, and continue to work after a disaster or during a major work disruption such as a power outage.

DS1 (Digital Signal Level 1) – A digital signal transmitting 1.544 million bits of information per second. A DS1 is composed of 24 DS0 (DS0 is 64 kbps) signals and can transport 24 voice channel equivalent circuits. T1 is an old AT&T trademarked name for a DS1 circuit.

DS3 (Digital Signal Level 3) – A digital signal transmitting 44.736 Megabits of information per second. A DS3 can be configured as a clear-channel or multiplexed to carry 28 DS1 signals.

DWDM – See Dense Wave Division Multiplexing.

-E-

Ethernet – The baseband LAN specification invented by Xerox Corporation and developed jointly by Xerox, Intel, and Digital Equipment Corporation. Ethernet networks use CSMA/CD and run over a variety of cable types at 10 Mbps. The IEEE 802.3 series of standards is very similar. See also Fast Ethernet; Gigabit Ethernet.
-F-

**Fast Ethernet** – Based on an extension to the IEEE 802.3 specification, Fast Ethernet offers a speed of 100 Mbps. It preserves many of the attributes of Ethernet, including frame format, MAC mechanisms, and MTU. See also Ethernet.

**Fault Tolerance** – The ability of a system to respond gracefully to an unexpected hardware or software failure. There are many levels of fault tolerance, the lowest being the ability to continue operation in the event of a power failure. Many fault-tolerant computer systems mirror all operations that is, every operation is performed on two or more duplicate systems, so if one fails the other can take over.

**Fiber** – The structure that guides light in a fiber optic system.

**Fiber Optics** – A medium for the transmission of information (audio, video, data). Light is modulated and transmitted over high purity, hair-thin fibers of glass. The bandwidth capacity of fiber optic cable is much greater than that of conventional cable or copper wire.

**Flows** – Sets of network traffic (application, protocol, and control information) that have some common attributes, such as source/destination address, information type, performance requirements, routing, or other end-to-end information. Flows also have directionality. Also known as traffic or data flows.

**Frame Relay** – Frame Relay is a WAN protocol that operates at the physical and data link layers of the OSI reference model. Frame Relay services are typically distance insensitive and attractive as access circuits due to lower costs. QoS is more difficult to implement on FR circuits as compared to DS1/DS3 or Ethernet services.

-G-

**Gbit** – An abbreviation for gigabit. A gigabit is equal to one billion bits.

**Gbps** – See Gigabits per Second.

**Gigabits per Second** – A measure of data transfer speed (a gigabit is equal to one billion bits).

**Gigabit Ethernet (GE)** – Standardized in IEEE 802.3z, GE is a both a LAN and WAN technology offering data speeds up to 1000 Mbps.. See also Ethernet.

**Guaranteed Bandwidth** – Network service where there is control and a service level guarantee that a specific application or flow will receive a fixed amount of bandwidth.

-H-

**High Availability** – A characteristic of an IT service that minimizes or masks the effects of IT component failure to the user.

-I-

**Indefeasible Right of Use (IRU)** – An agreement whereby one party (the “User”) obtains the right to use specified network facilities and/or fiber of another party (the “Grantor”).
Essentially it is a lease. The User is granted rights to use the facilities and/or fiber of the Grantor for a specified period of time.

**Infrastructure** – The underlying foundation or basic framework of a system or organization.

**Internet2** – Internet2 is a consortium being led by approximately 207 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet. Internet2 is recreating the partnership among academia, industry and government that fostered today’s Internet in its infancy. The primary goals of Internet2 are to:

- Create a leading edge network capability for the national research community
- Enable revolutionary Internet applications
- Ensure the rapid transfer of new network services and applications to the broader Internet community.

*See Abilene Network.*

**IRU** – *See Indefeasible Right of Use.*

**Interexchange Carrier (IXC)** – In the United States, Interexchange carrier (or IXC) is a legal and regulatory term for a telecommunications company, commonly called a long-distance telephone company, such as AT&T, MCI, and Sprint. It is defined as carriers which provide inter LATA (local access and transport area) communication. An IXC carries traffic (usually voice traffic) between telephone exchanges. Telephone exchanges are usually identified in the United States by the three-digit area code and the first three digits of the phone number. Different exchanges are generally in different geographic locations, such as separate central offices (COs, also called "wire centers").

-J-, -K-

-L-

**LAN** – *See Local Area Network.*

**Local Access and Transport Area (LATA)** – A term used in U.S. telecommunications regulation. It represents a geographical area of the United States under the terms of "the Modification of Final Judgment (MFJ) entered by the United States District Court for the District of Columbia in Civil Action number 82-0192 or any other geographic area designated as a LATA in the National Exchange Carrier Association, Inc. Tariff FCC No. 4." Generally, a geographical area as defined by the preceding sentence represents an area within which a divested Regional Bell operating company (RBOC) is permitted to offer exchange telecommunications and exchange access services.

*NOTE 6: Under the terms of the MFJ, the RBOCs are generally prohibited from providing services that originate in one LATA and terminate in another. This is changing.*

**Local Area Network (LAN)** – A computer network that spans a relatively small geographic area. Most LANs are confined to a single building or group of buildings. However, one LAN can be connected to other LANs over any distance via telephone lines and radio waves. A system of LANs connected in this way is called a wide-area network (WAN). Ethernet, has
become the predominant LAN technology. See also Metropolitan Area Network; Wide Area Network.

**Lambda** – A single wavelength of light used to carry one or more data channels in a WDM or DWDM system over fiber optic cable. Also called a wavelength or wave.

**Last-Mile** – An industry term referring to the telecommunications infrastructure and service that actually physically connects the user’s network to the nearest carrier aggregation infrastructure like a central office or a metropolitan optical Ethernet aggregation point.

**Layer 1** – Layer 1 refers to the Physical Layer of the OSI (see Open System Interconnection) model. This layer conveys the bit stream electrical impulse, light or radio signal through the network at the electrical and mechanical level. It provides the hardware means of sending and receiving data on a carrier, including defining cables, cards and physical aspects. Ethernet and Frame Relay, for example, are protocols with physical layer components.

**Layer 2** – Layer 2 refers to the Data Link Layer of the OSI (see Open System Interconnection) model. At this layer, data packets are encoded and decoded into bits. It furnishes transmission protocol knowledge and management and handles errors in the physical layer, flow control and frame synchronization. The data link layer is divided into two sub-layers: The Media Access Control (MAC) layer and the Logical Link Control (LLC) layer. The MAC sub-layer controls how a computer on the network gains access to the data and permission to transmit it. The LLC layer controls frame synchronization, flow control and error checking.

**Layer 2 / Layer 3 Switching** – Layer 2/Layer 3 switching refers to the combined Layer 2/Layer 3 switch which has the capability of switching traffic at Layer 2 and routing traffic at Layer 3.

**Layer 3** – Layer 3 refers to the Network Layer of the OSI (see Open System Interconnection) model. This layer provides switching and routing technologies, creating logical paths, known as virtual circuits, for transmitting data from node to node. Routing and forwarding are functions of this layer, as well as addressing, internetworking, error handling, congestion control and packet sequencing.

-M-

**MAN** – See Metropolitan Area Network.

**Mbit** – An abbreviation for megabit. A megabit is equal to one million bits.

**Mbps** – See Megabits per Second.

**Megabits per Second** – A measure of data transfer speed (a megabit is equal to one million bits). Network transmissions are generally measured in Mbps.

**Metropolitan Area Network (MAN)** – A data network designed for a town or city. See also Local Area Network; Wide Area Network; and Campus Area Network.

**Multiprotocol Label Switching (MPLS)** – In computer networking and telecommunications, Multiprotocol Label Switching (MPLS) is a data-carrying mechanism,
operating at a layer below layer-3 and in parallel to IP. It is designed to provide a unified
data-carrying service for both circuit-based clients and packet-switching clients which
provide a datagram service model. It can be used to carry many different kinds of traffic,
including transport of Ethernet frames and IP packets. It also has a mechanism that allows
secure transport of IP packets for users over common IP transport.

**Multi-Service Provisioning Platform (MSPP)** – A next-generation SONET device that
typically supports multiplexing DS1 through OC-192 services and also allows a wide variety
of other traffic types (Ethernet for example) to be groomed to and from SONET backbone
networks which are typically being carried on separate lambdas in DWDM networks.
Typically the DWDM infrastructure is separate from the MSPP and WDM waves are either
customer provided via IRU fiber or by the carrier for carrier provided WDM services.

**Multi-Service Transport Platform (MSTP)** – A MSPP where DWDM capabilities are
directly integrated into the device.

**Node** – A logical and physically entity in a network where regional access traffic is
aggregated and placed on the backbone network. A node thus has connections to the end
user networks as well as to the backbone network. The Node contains a wide variety of
equipment such as routers, switches, SONET multiplexers, MSPPs, and may aggregate many
disparate types of access services (SONET, Ethernet, Frame Relay, DS1/DS3 etc.) and
multiple vendor services.

**OC3** – Optical Carrier transmission speeds, used in fiber optic networks conforming to
SONET standard. OC-3 is 155.52 Mbps.

**OC12** – Optical Carrier transmission speeds, used in fiber optic networks conforming to
SONET standard. OC-12 is 622.08 Mbps.

**OC48** – Optical Carrier transmission speeds, used in fiber optic networks conforming to
SONET standard. OC-48 is 2.488 Gbps.

**OC192** – Optical Carrier transmission speeds, used in fiber optic networks conforming to
SONET standard. OC-192 is 9.952 Gbps.

**Open System Interconnection (OSI)** – The OSI, or Open System Interconnection, model
is an International Organization for Standardization (ISO) standard that defines a
networking framework for implementing protocols in seven layers. Control is passed from
one layer to the next, starting at the application layer in one station, and proceeding to the
bottom layer, over the channel to the next station and back up the hierarchy. See also
Layer 1; Layer 2; Layer 3.

**Optical Transport Network (OTN)** – The transmission of information over optical media
in a systematic manner.

**OSI** – See Open System Interconnection.
R&E – A research and education (R&E) institution is typically an institute of higher learning (UW and WSU for example) or national laboratory where a large percentage of their network usage is devoted strictly to research. See Internet2

Real-Time-Interactive (RTI) – Network service where stringent controls enable the service provider to provide completely predictable and low levels of delay/latency, jitter, and % dropped packets. RTI service is mandatory for relatively fragile applications like voice over IP (VoIP).

Redundancy – A technique used in network architecture design to ensure that the number of single-points-of-failure (SPF) are minimized to increase network reliability. A designer, for example, might specify redundant power supplies in devices or a second carrier circuit to support an institution as part of the plan to build in redundancy for the device or network.

Regional Bell Operating Company (RBOC) – The Regional Bell Operating Companies (RBOC) are the result of the U.S. Department of Justice antitrust suit against AT&T. On January 8, 1982, AT&T settled the suit and agreed to divest (“spin off”) its local exchange service operating companies in return for a chance to go into the Internet services industry. Effective January 1, 1984, AT&T’s local operations were split into seven independent Regional Bell Operating Companies, or RBOCs. Qwest is the RBOC serving the state of Washington.

Route Diversity – A telecommunications standard that states that there must be at least twenty-five (25) feet of separation between a working and a protect path in a network.

Single-Point-of-Failure (SPOF) – A place in a network where there are no redundant components or systems available to support the network should a component fail in that location. Often power supply to an institutional network is feed through a single location and thus constitutes a SPOF for that institution.

SONET – See Synchronous Optical Network.

Synchronous Optical Network (SONET) – An interface standard developed by Bellcore (formerly Bell Laboratory) and widely used by the telecommunications industry for high-speed synchronous transport over optical fiber.

Terabyte (TB) – A trillion ($1 \times 10^{12}$) bytes of information. (A byte is equivalent to 8 bits.)

Transmission Control Protocol/Internet Protocol (TCP/IP) – The basic communication language or protocol of the Internet.

Throughput – The realizable capacity of the network or system given its current state of implementation/configuration, protocol efficiencies, and input/output (I/O) buffering latency. Very seldom is the network throughput equal to the network bandwidth.
**Topology** – The physical background “look” and the configuration of technology and information resident on a card, including the visible security features.

-U-, -V-

-W-

**WAN** – See *Wide Area Network*.

**Wavelength** – The distance between points of corresponding phases of two consecutive cycles of a wave. In DWDM systems, wavelength is also called lambda.

**Wavelength Division Multiplexing (WDM)** – A type of multiplexing developed for use on optical fiber. WEDM modulates each of the several data streams onto a different part of the light spectrum.

**Wide-Area Network (LAN)** – A computer network that spans a larger geographic area. While LANs are confined to a single building or group of buildings a WAN can be regionally distributed, nationwide or even international in scope. A WAN comprises two or more LANs that are connected via telecommunications services and infrastructure.

-X-, -Y-, -Z-