VOLUME 1, SECTION 2.3: APPROACH TO NETWORX ARCHITECTURE, CONVERGENCE, INTEROPERABILITY, AND EVOLUTION

2.3: APPROACH TO NETWORX ARCHITECTURE, CONVERGENCE, INTEROPERABILITY, AND EVOLUTION [M.2.2.2(D)]

Level 3 built its network with an emphasis on convergence, interoperability, scaling, and evolution. Over time, our IP focus has been validated by the growing dominance of IP and our ability to both coverage services over a single network and create new offerings quickly. Level 3 has implemented innovative solutions that promote service and operational flexibility.

Level 3 continuously incorporates new technologies as part of maintaining and enhancing our high-performance communications network. Introducing new leading-edge technologies in the customer environment requires close coordination among all affected parties. We will apply a disciplined approach when introducing new technologies on the [redacted] program, including pre-planning, laboratory testing, interoperability testing, and formal joint change management processes.

2.3.1 Approach for Integrated Access

To provide integrated access to locations that support customer applications with different performance requirements, Level 3 is proposing options [redacted]

[redacted] During

[redacted]

Level 3 will also support the Government's requirement to deliver Service Enabling Device (SED) IP router equipment with capabilities to support end-to-end CoS functions, with the same multiple CoS options.

Multiprotocol Label Switching (MPLS) is the primary interoperability engine in the Level 3 Network, supporting greater link speeds and enabling interoperability with a wider range of current and future services. The Level 3 Network provides the solution for multi-service environments with an architecture that delivers availability, CoS, multiple VPNS, and security through a single interface.

MPLS technology enables a wide range of Layer 2 and Layer 3 interoperability at speeds ranging from sub-T1 to OC-48. MPLS-supported CoS features result in class of service options that will deliver current and future voice, video, and latency-sensitive services.

[redacted]

2.3.2 Overall Network Architecture and Benefits

[redacted]

Network was designed and built from the “ground up” as a single, consistent, high-performance platform. [redacted]

In 2006, Level 3 announced the formation of a Metro Markets Operating Group toward the goal of offering customers local access alternatives, and the acquisition of multiple metro/regional network service providers to expand metro network coverage.

All of the services Level 3 is proposing to make available to Government agencies through [redacted] are delivered over this secure, robust, and highly scalable network.

2.3.2.1 THE LEVEL 3 NETWORK ARCHITECTURE

From its inception, the Level 3 Network was designed to provide first-class communications services to our customers. With this strategy in mind, we developed an architecture that is optimized for high availability, continuous

upgradeability, performance, and security (see Figure 2.3-1). Completed in 2001, the Level 3 Network being offered to Government customers is one of the world's newest and most advanced communications platforms. At present, the network spans [redacted] intercity route miles (additional miles will be available to Networx customers as integration of assets resulting from recent acquisitions proceeds) and enables us to offer services to Government agency customers in major markets across the United States and Europe. It serves a substantial number of the world's largest and most sophisticated communications companies, including inter-exchange carriers, local phone companies, European public telephone providers, cable operators, ISPs, wireless companies, content providers, media and entertainment companies, and Government agencies

Leveraging this physical infrastructure, we deployed the most advanced electronic and optical technology available. This enables us to deliver to the Government a focused set of high-performance services.

[redacted]

The Level 3 Network was the first international network in the world built to be continuously upgradeable and fully optimized for IP. Because the network was constructed with multiple conduits, Level 3 can deploy new generations of optical fiber and equipment far more quickly and economically than its competitors—a critical capability in an era of rapid technological change. Government agency needs will continue to be met as both usage and technology change.

Redundancy and resiliency are critical to the proper operation of any network. The Level 3 Network is designed for no single points of failure and is robust enough to function without impairment when network problems do occur. If a problem does arise, Level 3 mobilizes people, systems, and processes designed and dedicated to quickly and efficiently restore service. The Level 3 Network includes a redundant hardware path that is always available in the event of equipment or circuit failure.

Government access to higher-level services such as IPS, PBIP-VPNS, NBIP-VPNS, and VOIPTS is ensured by Level 3 through our use of MPLS technology. [redacted]

Figure 2.3-2: The (3)Enterprise solution leverages the reliability, flexibility, and upgradeability of the other service layers

2.3.2.1.1 Physical Infrastructure

Level 3 started construction of its network in 1998. Construction teams working exclusively to Level 3's exacting designs built the entire Level 3 intercity network and all of the company's metropolitan networks in North America and Europe.

Figure 2.3-3: The (3)Enterprise solution physical layer

The majority of the Level 3 Network is a multi-conduit, fully upgradeable network, enabling it to be more adaptable to future technological changes than existing and less-flexible networks (see Figure 2.3-3). Level 3 created one of the most scalable, cost-effective, and state-of-the art optical networks in existence. Few providers own the amount of available fiber infrastructure that Level 3 owns. Consequently, few can offer the Government a Networx solution as accommodating of future customer growth. Level 3's complete network ownership translates into having control over the consistency, scope, and timeline of future network evolution.

Figure 2.3-4: The Level 3 Network
[note: updated maps of the Level 3 Network are provided in Appendix A of this Technical Volume]

At present, the Level 3 North American network is composed of [redacted] route miles of Level 3-operated, intercity terrestrial fiber (additional miles will be added as integration of assets resulting from recent acquisitions proceeds). [redacted] There are acres for expansion at intercity sites, and there is room for equipment expansion in the gateway cities as well. These facilities were designed to enable Level 3 to quickly take advantage of any new generations of fiber and equipment and pass the savings on to our customers. Other network providers who did not plan properly will be forced to engage in massive construction efforts to take advantage of new fiber technology. In

addition, the lack of real estate assets in other provider networks limits their ability to grow as their customers' bandwidth needs expand.

Our multi-conduit approach illustrated in Figure 2.3-5, enables us to rapidly upgrade and expand our network, passing the benefits of superior technology on to our customers. Furthermore, each successive generation of fiber and optoelectronics offers the opportunity to lower unit costs and accommodate more user applications. By leaving most of our conduits open to future generations of fiber, we enable all of our customers to take advantage of even greater cost-performance ratios in the future.

Figure 2.3-5: Level 3's North American buried conduit architecture

[redacted]. By deploying the most efficient fiber and replacing it in pre-deployed spare conduit when new generations of superior fiber are available, Level 3 reduces the need for amplification and other equipment. This reduces the cost of running the network, and the savings are passed to Level 3 customers.

[redacted] Also residing in our physical infrastructure are 70 CONUS facilities totaling nearly [redacted] million square feet of space. Level 3 is

one of the largest collocation providers in the world, and we are offering Collocated Hosting Services to Networx customers, a description of which is provided in Section 4.3 of this volume.

2.3.2.1.2 Optical Wavelength Core Layer

The first level of technology applied to the fiber network is the dense wave division multiplexing (DWDM) network, as illustrated in Figure 2.3-6). A description of this network is provided below.

Figure 2.3-6: The (3)Enterprise solution optical wavelength layer

[redacted]

Level 3 expects the majority of new IP and transport service instances to take advantage of the [redacted] deployment.

Optical Wavelength Service will enable a new generation of lower cost interfaces with simplified management.

As part of our [redacted] proposal, Level 3 is offering Optical Wavelength Service over dense wave division multiplexing (DWDM). This offering is described in Section 3.9 of this volume.

2.3.2.1.3 SONETS Core Layer

The next application on the network is the Synchronous Optical Network (SONETS) layer, which provides a protection scheme for private lines riding the DWDM network (see Figure 2.3-7).

With SONETS to enhance survivability, the basic plan uses self-healing rings (SHR). [redacted]

Figure 2.3-7: The (3)Enterprise solution SONETS service layer

[redacted] other fiber

[redacted] The SONETS standard recovery time for this type of “protection switching” is less than 50ms, with no noticeable disruption in service to the customer. This is commonly referred to as a “head-end bridged, tail-end switched” configuration.

[redacted] he SONETS standard recovery time for this type of “protection switching” takes place in around 50ms, with no noticeable disruption in service to the customer. The physical length of the ring and the number of switching nodes determine the recovery time. Under normal operation, data travels only the minimum distance to the destined traffic node.

Figure 2.3-8: Normal operation of UPSR and BLSR rings

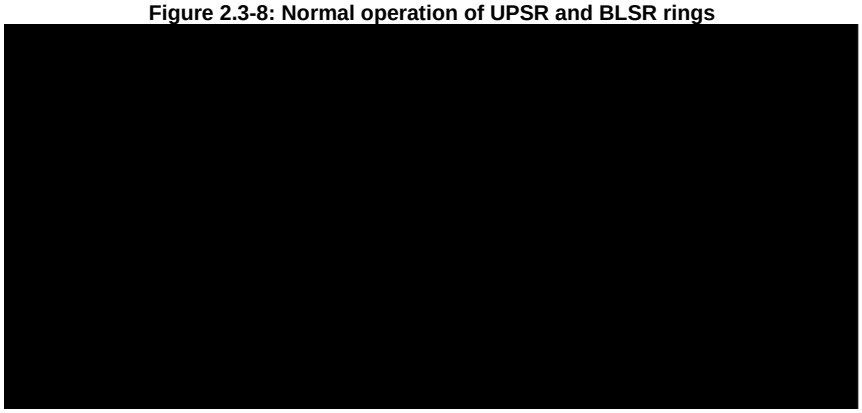

Figure 2.3-9: Protection operation of UPSR and BLSR rings

As part of our (3)Enterprise proposal, Level 3 is offering SONETS and SONET-based services to Networx customers.

Descriptions of these offerings are provided in Sections 3.4 and 3.6 of this volume.

2.3.2.1.4 MPLS Core Layer

The next layer of the network is the MPLS network. The MPLS core layer (see Figure 2.3-10) rides on [redacted] Gbps wavelengths on the Optical Wavelength Core network and enables a variety of higher-level services including IPS, NBIP-VPNS, PBIP-VPNS, VOIPTS, and elements of Managed Network Services (MNS).

Figure 2.3-10: The (3)Enterprise MPLS core layer

Level 3 is taking advantage of MPLS technology, in combination with the previously described physical and wavelength multiplexed architecture, offering Government agency customers the most forward-looking network for technological evolution, convergence of voice, video and data services, and interoperability with current and future critical-mass communication technologies.

Level 3 was the first major carrier to deploy MPLS across its network backbone [redacted] MPLS has proven to be a cost-effective, secure, and scalable core technology.

Level 3 perceives a compelling level of industry investment directed toward IP technology, with the result being that the IP industry continues to drive innovation in protocols, applications, and equipment. MPLS innovation continues at a fast pace, adding advanced Operations, Administration, and

Maintenance (OAM) capabilities and new protocols for supporting multiple VPN services.

The Level 3 Network architecture that includes MPLS can be considered the leading technology for combining voice, data, and video applications on a single, converged network. Convergence is supported with solid performance in the areas of class of service, inherent resilience, and alternative path features, and a wide range of speeds and interface methods at Layers 2 and 3. MPLS, as implemented with industry leading equipment and the Level 3 Network, results in lower overall monthly service charges for customers due to fewer service instances lower administration staff costs, and greater leverage of router, switch, and hub resources.

MPLS is the primary interoperability engine in the Level 3 Network, supporting high link speeds and enabling interoperability with a wide range of current and future services. Level 3's MPLS-based network provides the solution for multi-service environments with a network architecture that delivers availability, CoS, multiple VPNS, and security through a single network interface.

MPLS technology enables a wide range of Layer 2 and Layer 3 interoperability at speeds ranging from sub-T1 to OC-48. Layer 2 options support customer deployment of Layer 2 circuits over an MPLS-enabled backbone, including signaling, with examples of popular services including [redacted] MPLS-supported QoS (quality of service) features result in CoS options that will deliver current and future voice, video, and latency-sensitive services. Interoperability testing reports from groups such as Isocore, a technology validation group working in next generation IP and optical networks, confirm the viability and emerging

maturity of MPLS for a wide range of service classes, including differentiated support of voice, video, data, and multicast services.

2.3.2.1.5 IP Core Layer

The next layer of the network is the IP network, which provides the Internet Protocol service. The IP core layer is built upon the Level 3 MPLS network (see Figure 2.3-11).

Figure 2.3-11: The (3)Enterprise IP core layer

[redacted]

Figure 2.3-12: Optimal mesh protection switching vs. traditional SONETS ring protection

There are multiple layers within the Level 3 IP backbone network. At least two network elements at each layer at each IP network site are deployed in the Level 3 Network design. This is critical for any network to achieve a high reliability requirement.

The Level 3 backbone routers are connected directly to the long-haul dense-wavelength-division multiplexing (LH-DWDM) equipment. In traditional networks, IP elements are commonly connected, via add-drop multiplexers (ADMs), to SONETS gear. The Level 3 IP backbone network is MPLS over lambdas (DWDM). As such, there are fewer network elements connecting IP to its underlying transport. The benefits are simplicity of design, fewer network components, reduced chance of equipment failure, and improved network cost-effectiveness.

As part of our [redacted], Level 3 is offering Internet protocol service to Networx customers. A description if this offering is provided in Section 3.1 of this volume.

2.3.2.1.6 Ethernet Layer

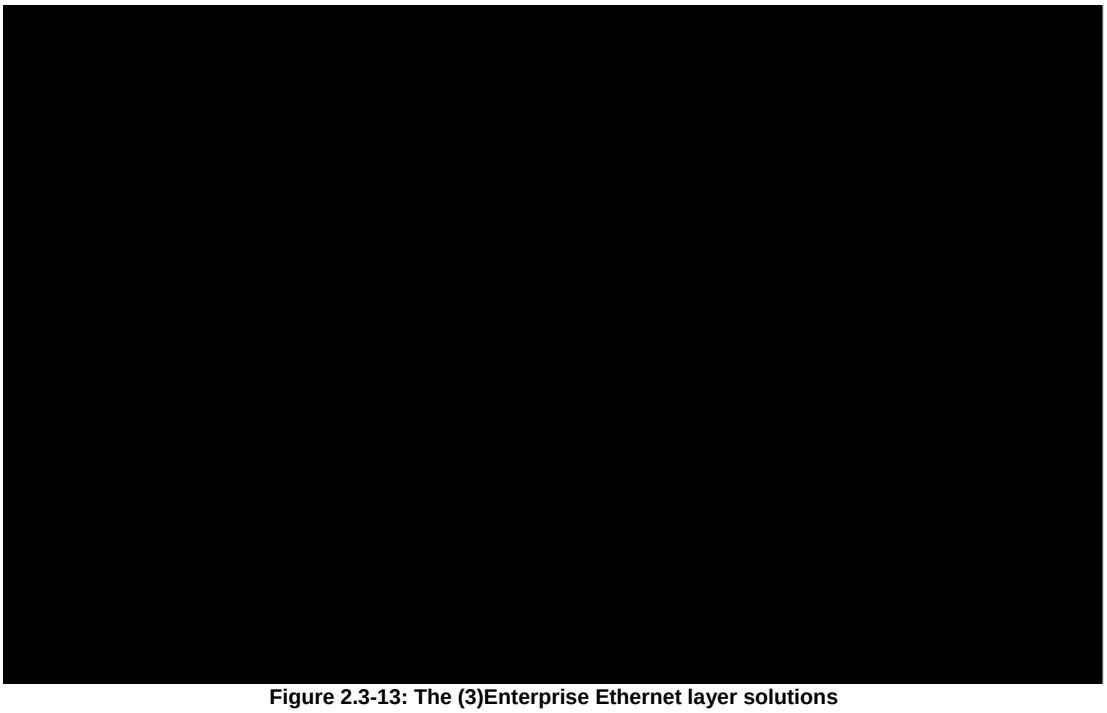

Figure 2.3-13: The (3)Enterprise Ethernet layer solutions

E-LAN Layer

[redacted] It is composed of the same routers that provide the PE services for the IP VPNS. In addition to IP VPNS, these routers also provide Layer 2 Ethernet tunnels over the network based on the pseudo-wire drafts from the IETF. This layer provides the E-LAN services provided to the Government.

The E-LAN layer encapsulates Ethernet frames that enter the network with an MPLS label that describes their destination and CoS level on the network. The Level 3 MPLS backbone then routes these MPLS encapsulated Ethernet frames to the proper destination on the network. Each Ethernet frame can receive a different CoS treatment in the backbone based on the settings in the MPLS label. A customer's Ethernet service is logically

separated from the others by imposing unique labels describing only the customer's tunnel. Since this is not an IP-based service, there can be no transfer of traffic between the Ethernet network and the Internet network. This pseudo-wire design provides traffic isolation equivalent to ATM or Frame Relay networks. The traffic isolation is equivalent to that provided in our IP VPNS.

As part of our ([redacted], Level 3 is offering E-LAN service to Networx customers. A complete description of this offering is provided in Section 3.5 of this proposal volume.

E-Line Layer

The E-Line layer (see Figure 2.3-13) runs on top of Level 3's SONETS and OWS layers. It is provided though an ADM with Gigabit Ethernet user-to-network interface (UNI). The line side of the ADM is an [redacted] signal. For protected E-Line service, the line side of the ADM is protected as for all SONETS services. Protection is provided as for other SONETS-based transport services, and has similar restoration time (< 100ms).

For unprotected E-Line service, the ADM is connected to a single wavelength (OWS) with no protection. It is composed of the same ADMs that provide PLS, SONETS and OWS.

The E-Line layer encapsulates Ethernet frames that enter the network in SONET STS-1 frames. The circuits are provisioned end to end, just as in the case of PLS, OWS or SONETS. The E-Line service can be provisioned on a per STS-1 basis. Thus the service is incremental in 50 Mbps increments. The latency is fixed and dominated by the path length, since this is not a switched or routed service. Each E-Line service is unique, private and isolated from all others just as in ATM, Frame Relay, SONETS, PLS or OWS. Since this is not

an IP based service, there can be no transfer of traffic between the Ethernet network and the Internet network.

As part of our [redacted] proposal, Level 3 is offering E-Line service to Networx customers. A complete description of this offering is provided in Section 3.5 of this proposal volume.

2.3.2.1.7 IP VPN Core Layer

The next layer of the network is the IP VPNS, which provides the NBIP-VPNS and a component of Level 3's VOIPTS service. [redacted]

[redacted]

Figure 2.3-14: The (3)Enterprise IP VPN layer solution

NBIP-VPN services utilize labels that the MPLS service attaches to the IP packets that enable routers to distinguish packet destination. Each provider edge (PE) router uses VPN Routing and Forwarding Tables, which provide separate tables containing routing information for each VPN service instance.

Since each instance has its own routing table, an agency's traffic is logically separated from all of the other customers on the network. The Level 3 design provides traffic isolation equivalent to an ATM or Frame Relay network implementation. Each customer is logically separated from the other customers.

As part of our (3)Enterprise proposal, Level 3 is offering NBIP-VPN service to Networx customers. A description of this offering is provided in Section 3.2 of this volume.

2.3.2.1.8 IPSec Encryption Tunnels

Customer traffic is further protected as it travels over the Level 3 NBIP-VPN layer through the use of IPSec-encrypted tunnels. [redacted]

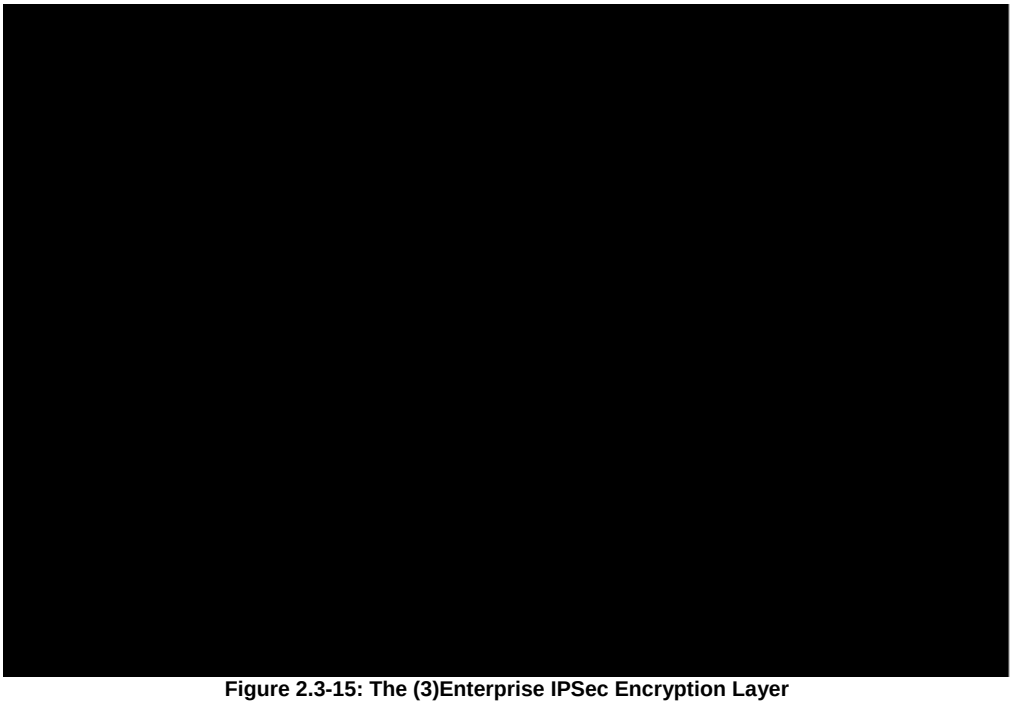

Figure 2.3-15: The (3)Enterprise IPSec Encryption Layer

[redacted]

2.3.2.1.9 VOIPTS Application

Another application enabled by the Level 3 Network architecture is voice-over IP transport. This service uses IP VPNS using IPSec to transport voice traffic over the MPLS backbone (see Figure 2.3-16). This service is a great example of multiple layers of the network coming together to provide a leading-edge and reliable service to the Government.

Figure 2.3-16: The (3)Enterprise VOIP transport layer

As described in Section 3.3 of this volume, Level 3 is offering VOIPTS to (3)Enterprise customers.

Figure 2.3-16a: The (3)Enterprise Managed Security Services Layer

2.3.2.1.10 Managed Security Services

Level 3 will support the GSA's Multi-Tier Security Profiles (MTSP) initiative in accordance with Tier-2 – Protected Service specifications. [redacted], the Level 3 MTSP Tier 2 solution includes the Help Desk function specified for Tier 1 service, and additional technical and management components to support security needs of Sensitive but Unclassified (SBU) mission functions and information. Our Managed Tiered Security Service (MTSS) offering will provide a vehicle for agencies to order individual managed security services a la carte or in a bundle. The components include:

- Anti-Virus Management Service (AVMS)
- Managed Firewall Services (MFS)
- Agency-Dedicated Help Desk

- Intrusion Detection and Prevention Services (IDPS)
- Incident Response Service (INRS)
- Packet Filtering
- Premises-Based IP VPN Services (PBIP-VPNS)
- Proxy Server
- Secure Managed Email Service (SMES)
- Security Certification Support
- Security Maintenance
- Vulnerability Scanning Service (VSS)

Agencies will gain efficiencies and cost savings through service bundling, versus ordering any of the Managed Security Services a la carte. In addition, there is defense in depth: by having redundant layered security, achieved through service bundling, agencies will be assured of multiple safeguards for their systems.

Section 5.0 of this volume describes Level 3's Managed Security Services offerings.

Figure 2.3-16b: The (3)Enterprise Storage Services Layer

2.3.2.1.11 Storage Services

In partnership with Unisys Corporation, Level 3 will provide a full-range of Storage Services (SS) to Government agency customers.

The Level 3 team's storage services offering will provide Government agencies with three types of services:

1. Backup and Restore (BBKUP&R) to enable an Agency to backup copies of Agency data to contractor's data centers to be securely stored.
2. Network Attached Storage (NAS) to enable an Agency to securely store and have continuous access to its files from contractor's data centers.

3. Storage Area Networks (SANs) to enable an Agency to securely store and continually access its data from contractor's data centers.

Our offering is also designed to provide agencies with additional services such as, but not limited to, assessment and development of Agency storage strategy, engineering and detailed design, and support of Agency Continuity of Operations (COOP).

Section 4.6 of this volume describes Level 3's Storage Services offering in detail.

2.3.2.2 BENEFITS OF THE LEVEL 3 ARCHITECTURE

Level 3's network is built on the following cornerstones of a high-quality communications network:

[redacted]

Our network has been painstakingly designed to include diversity at all levels to avoid single points of failure. While other networks contain spurs and laterals that isolate segments, the Level 3 Network is designed with complete redundancy in mind (see Figure 2.3-17).

Figure 2.3-17: The Level 3 Network is designed to ensure complete redundancy

Within the supporting transport network for the IP backbone, we plan for 100% restoration of a worst-case single fiber cut. Within the Level 3 Gateways, planned capacity considers full redundancy in the case of a single

router failure. Government agency customers can rely on the availability of the Level 3 Network.

Level 3 designs and upgrades its IP backbone such that when any circuit reaches [redacted] utilization during the peak busy hour for five days in a row, the circuit is immediately upgraded. This policy enables Level 3 to guarantee our Government customers latency, availability, and minimal packet loss even in worst-case failure scenarios.

Level 3 performs advanced planning for upgrades using a process that combines capacity forecasting and real-time network monitoring. The company tracks historical performance and forecasts expected traffic growth. Level 3 uses this information to plan capacity upgrades and order equipment. In addition, real-time usage is measured using network utilization statistics to ensure that lit capacity exceeds current customer requirements in both normal and fail-over usage modes.

Many networks fail to meet the architectural requirements of a rapidly changing future. The ability to upgrade long-haul fiber and customer equipment out to the farthest edge of the network determines how well an infrastructure can evolve and leverage new technologies.

The (3)Enterprise customers will be able to take advantage of the benefits of superior technology because our multi-conduit approach enables us to rapidly upgrade and expand our network. Each successive generation of fiber and optronics offers the opportunity to lower unit costs and accommodate more user applications. By leaving most of our conduits open to future generations of fiber, we enable our customers to take advantage of even greater cost-performance ratios in the future.

Many experts predicted that, over time, optical technology and IP would evolve to include these networking attributes and that this would further increase the advantages associated with IP. These predictions have proven correct. The Level 3 Network design rationale was, and continues to be, based on this foresight. For example, Level 3 built an MPLS network that supports the various IP-based services such as IPS, PBIP-VPNS and NBIP-VPNS, and VOIPTS directly on a [redacted] Gbps wavelength network, choosing to rely on the various protection features offered by MPLS and IP. Most other service providers rely on SONETS-based networks.

As IP and optical technology improved, the elimination of extra “layers” of network and equipment represented a significant opportunity to lower the overall cost of service and, at the same time, increase operational efficiency. There are fewer network elements to manage and maintain. Level 3 designed its network to permit this evolutionary improvement to occur at a cost much lower, and at a faster deployment rate, than that of many of its competitors.

2.3.3 Evolution, Convergence, and Interoperability

The Level 3 Network architecture was designed based on the principles of silicon economics to enable continuous technological evolution. With a vision that the communications marketplace will be driven by exponential growth in bandwidth demand, fueled by Government and commercial adoption of Web- and Internet-based applications, and feature rich voice and video applications, Level 3’s business model and operational framework is a network of evolutionary agents and elements.

The world’s largest telecommunications carriers all continue to use Level 3 services, as do the [redacted] largest ISPs in the United States and the [redacted] largest European telecommunications carriers. Our success with these customers is based upon accurate assessment of communication technology

lifecycles, economics, and operational effectiveness, followed by timely deployment of emerging communication technology. These benefits will be available to the Government customers through [redacted].

Many networks fail to meet the architectural requirements of a rapidly changing future. The ability to upgrade long-haul fiber and customer equipment out to the farthest edge of the network determines how well an infrastructure can evolve and leverage new technologies. This ultimately determines how low costs can go.

The Smithsonian Institution cited the Level 3 Network as “the world’s first upgradeable international fiber optic network to be completely optimized for Internet Protocol technology, helping to stimulate the biggest change in communications technology in 100 years.”

The word “upgradeable” in the above sentence is especially important. Because improved fiber reduces the number of amplifiers and regeneration facilities needed along any given fiber route (thereby reducing maintenance requirements and the chance of failure), one key to maintaining the lowest unit cost is to stay on the most current generation of fiber.

New generations of fiber are expected to spawn every two-to-five years. With multiple conduits in the ground, new cables can be rapidly and cheaply blown through the next empty conduit using an air compressor, saving billions of dollars in carrier construction costs as fiber improves. Meanwhile, the old cable can be easily removed or used for additional capacity. This is the reasoning behind Level 3’s multi-conduit infrastructure, and Level 3 remains the only carrier to have installed more than one or two conduits everywhere throughout its core network.

To accommodate new technologies, Level 3 has established a state-of the-art, carrier-class testing laboratory at our corporate campus in Broomfield, Colorado. The laboratory supports architecture evolution with over [redacted] million invested in production network equipment and components, next generation and alternative architecture equipment and components, infrastructure components such as network management, and security and environmental systems. The facility covers 10,000 square feet with full carrier-class infrastructure that replicates the production environments of our major facilities of North America and Europe.

[redacted]

[redacted]

Level 3 Network Element Testing Process	
[redacted]	[redacted]

Level 3 Network Element Testing Process	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

2.3.4 Network and Service Improvements

Level 3 believes that over the course of the [redacted] acquisition, several new technologies will be adopted by carriers in support of increasing bandwidth, security, and application requirements. Continued adoption of Ethernet technologies, VoIP, and higher-capacity optical services are a few of the areas likely to drive change throughout the course of the acquisition. Level 3 intends to incorporate key technologies into its network "system" as the technologies evolve into carrier-class services, and Level 3 is poised to

deliver services to our customers that exceed service requirements and provide value.

[redacted]

[redacted]

Level 3 Service Development Process		
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Level 3 Service Development Process		
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

An example of how Level 3 handles change is through the evolution of our MPLS-based IP network. In 2001 when Level 3 was completing the construction of our next-generation network, the IP backbone was nearing the technological limits of current ATM technologies. Level 3's traffic was growing

so rapidly that ATM technologies in the backbone would soon become unmanageable, requiring a new technology or method to be introduced. Level 3 analyzed various solutions for network evolution and ultimately selected MPLS as our next-generation platform.

Level 3 worked closely with industry protocol forums to advance the technology and ultimately worked with vendors to ensure that the technology would scale in Level 3's infrastructure. The result is that Level 3 runs the world's largest MPLS-based network with service capable of exceeding the performance requirements of customers such as AOL, Yahoo, Microsoft, and Google.

[redacted]

new IP and VoIP technologies that continue to expand Level 3's capabilities in both of those evolving technological areas. Level 3 is able to rapidly deploy these technologies because of its recently upgraded underlying network. The network system enables Level 3 to introduce new technologies rapidly at each layer of the network as the individual technologies mature into commercial platforms or protocols.

2.3.5 Interoperability and Mapping between IP Networks and PSTN

Level 3 has built a large Softswitch-based PSTN Edge network over the past seven years. As a large national CLEC, Level 3 has deployed close to 2 million ports of Local Interconnect trunks with Incumbent, Independent, and Competitive Local Exchange carriers. [redacted]

[redacted] All of today's ISUP trunks terminate into a Universal Port Media-Gateway which enables any given call to be originated or terminated as Voice or modem, determined on a call-by-call basis by the Media Gateway Controller (MGC). An illustration is provided in Figure 2.3-18.

Figure 2.3-18: High-level view of today's VOIP network connections

Call processing in the Level 3 Network is handled through centralized routing logic that associates call attributes (e.g., the called-party number) with PSTN and IP routing options. This routing logic can effectively map between PSTN and IP addresses at the carrier level.

Routing logic is provisioned into the Level 3 voice network through our OSS infrastructure based on a various information sources including negotiated interconnection arrangements and industry-standard databases like the LERG.

Level 3 was instrumental in the development of the "Softswitch" and was involved in founding the Softswitch Consortium. The VIPER Softswitch, a Level 3 proprietary softswitch developed in-house and supported by internal developers, supports more than [redacted] billion minutes a month. We are committed to investing in our Softswitch platform to deliver additional services. Level 3 owns and operates its own System Signaling 7 (SS7)

network with control of our own Signaling Transfer Points (STPs) and Signaling Control Points (SCPs). With the addition of Universal Port technology, Level 3 has enabled all of its media gateways to support VoIP.

Interoperability testing validates the interoperability between Level 3-provided VoIP services and the customer's IP voice application. Interoperability is a prerequisite for customers entering into a commercial agreement, ordering, provisioning, and going live on the production network.

The Level 3 Interoperability facility is a test lab that reflects the Level 3 VoIP services architecture. The Level 3 Interoperability Team and Sales Engineer will work closely with the (3)Enterprise customer's testing contact to conduct test cases to validate the call flows.

Test cases will be run against the Level 3 Interoperability facilities to assess passing and failure of each test case. There are approximately 60 test cases that address PSTN-to-SIP and SIP-to-PSTN call flows. Changes to software and hardware on the customer's systems need to be verified for continued interoperability.

Level 3 is aware of various industry efforts to create more standardized and centralized means of communicating VoIP handoff parameters to the carrier community (examples of these include ENUM and LERG-IP efforts). Level 3 is monitoring these efforts to ensure that any such mechanism facilitates secure, high-quality, carrier-to-carrier transactions. Several approaches are being discussed and prototyped in the industry, but no consensus has been reached, and commercial grade solutions are not available. Level 3 is periodically evaluating these mechanisms and will incorporate one or more of these into our route-provisioning and call-processing systems based on operational suitability, commercial requirements, and alignment with security and privacy needs.

2.3.6 Approach for IPv4 to IPv6 Migration

[redacted] Demand for this functionality has been seen predominantly in Europe. However, demand is expected to be rising in North America, and Japan and Asia have substantial IPv6 infrastructure deployed in both the Enterprise and Service Provider communities. [redacted]

At the present time, Level 3 is offering access to the IPv6 network [redacted]

[redacted]

Peering relationships are being developed, and Level 3 has a number of major IPv6 peers in Europe, North America, and Asia. Level 3 will continue to expand our peering relationships to maintain and increase IPv6 Transit capabilities.

[redacted]

[redacted]

Figure 2.3-19: Overlay tunnel configuration

[redacted]

[redacted]

The preferred routing protocol for the customer is Border Gateway Protocol (BGP). Due to the nature of the tunnels that are required to connect to the IPv6 platform, it is best to maintain an accurate routing table, add or removing routes based on customer reachability. Route maps are used to control and identify routes being lent from customers.

[redacted]

[redacted]

Figure 2.3-20: IPv6 over MPLS-enabled backbones enable IPv6 domains to communicate with each other over an MPLS IPv4 core network

[redacted]

[redacted]

[redacted]