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SECTION 7
NETWORK EDGE INFRASTRUCTURE

7.1 CE SEGMENT ATTRIBUTES

The Customer Edge (CE) Segment may consist of a single Local Area Network (LAN) or a Campus Area Network (CAN), or it may be implemented as a Metropolitan Area Network (MAN) in certain locations. The boundary for the CE Segment is the CE Router (CE-R At Base/Post/Camp/Stations (B/P/C/S) that Support a Combatant Command (COCOM), all UC traffic associated with the COCOM will be routed through a COCOM-owned Tier 1 CE-R, directly to Defense Information systems Agency (DISA) Service Delivery Node (SDN) Provider Edge (PE) Tier 0 Routers. Other traffic on the B/P/C/S will be routed through the CE router owned by the B/P/C/S. The Customer Edge Segment is connected to the Network Core Segment by the Network Edge Segment, which is a traffic-engineered bandwidth (IP connection) that connects the CE-R to an SDN.

The CE Segment has the following attributes:

- LANs Configured to Meet Mission, Performance, and Affordability. At the CE, the design has a LAN that is designed with a mix of Assured Services and non-Assured Services LANs (ASLAN) based on availability, redundancy, and backup power tailored for an organization's missions and affordability. Performance requirements with respect to quality of service (QoS), security, and network management are the same for ASLANs and non ASLANs.
- Session Admission Control. The Session Controllers (SCs) use an Assured Services Admission Control (ASAC) technique to ensure that only as many user-originated sessions (voice and video) in precedence order are permitted on the traffic-engineered access circuit consistent with maintaining voice quality, so that on at least 95 percent of the voice sessions, the quality rating expressed as Mean Opinion Score (MOS) is as follows:
  - Fixed to Fixed Assured Voice 4.0.
  - Fixed to Fixed Non-Assured Voice 3.8.
  - Fixed to Deployed Assured Voice 3.6.
  - Deployable to Deployable Assured Voice 3.2.
- Session Preemption. Lower precedence sessions will be preempted on the access circuit to accept the SC setup of a higher precedence level outgoing or incoming session establishment request.
- Traffic Service Classification and Priority Queues. In terms of the CE-R queuing structure, traffic will be assigned to the higher priority queues by a UC defined service class as described in Section 3, Auxiliary Services.
- Multiprotocol Label Switching (MPLS) and MPLS Virtual Private Networks (VPNs). Can be implemented in the ASLAN but cannot be extended to the Defense Information Systems Network (DISN).

7.2 B/P/C/S UC DESIGN

The military B/P/C/S-level design is flexible, depending on whether or not the location uses Enterprise services. The design may consist of an SC complex that may consist of a redundant SC, or several SCs in an array or cluster arrangement, in a LAN, CAN, or MAN structure. The LAN, CAN, or MAN design may be tailored to a single building or an entire base structure with varying degrees of robustness tailored to individual user and building mission requirements. Off-base connectivity to the long-haul DISN network infrastructure is provided through the Session Border Controller function. Interface to the local commercial telephone network is provided through a Media Gateway (MG) function within an SC per local interface requirements. It is a Military Department (MILDEP) responsibility to design and fund the base infrastructure design to meet their organizational mission, performance and affordability requirements.

7.3 SC DESIGNS – VOICE

Figure 7.3-1, B/P/C/S-Level Voice over IP SC Voice Designs, shows examples of three possible configurations for connecting multiple SCs on a B/P/C/S to the DISN SS. A single SC per B/P/C/S or participation with a regional Enterprise SC is the preferred affordable solution for fixed locations. Tactical deployments may be best served by treating the Tactical Theater as a region with multiple SCs as shown in Case 3. The Unclassified CE (U-CE) Routers are dual homed (not illustrated in figure). At the top of the figure, the first case shown is when multiple LANs, each with its own SC and U-CE Router, connect via separate access circuits to the DISN WAN. Each SC would have its own traffic-engineered access circuit bandwidth, which can support the predetermined number of sessions (called a Budget in the figure). The limitation of this first case is that sessions from one SC on the base to another SC on the base must traverse the DISN SS to connect to the other SC. Should base connection to the DISN SS be lost, then sessions from one base SC to the other on-base SC could not be established. In addition, if one of the SCs was not using all its traffic-engineered bandwidth (Budget A), a second SC (Budget B), could not use the unused bandwidth of the other SC (Budget A).

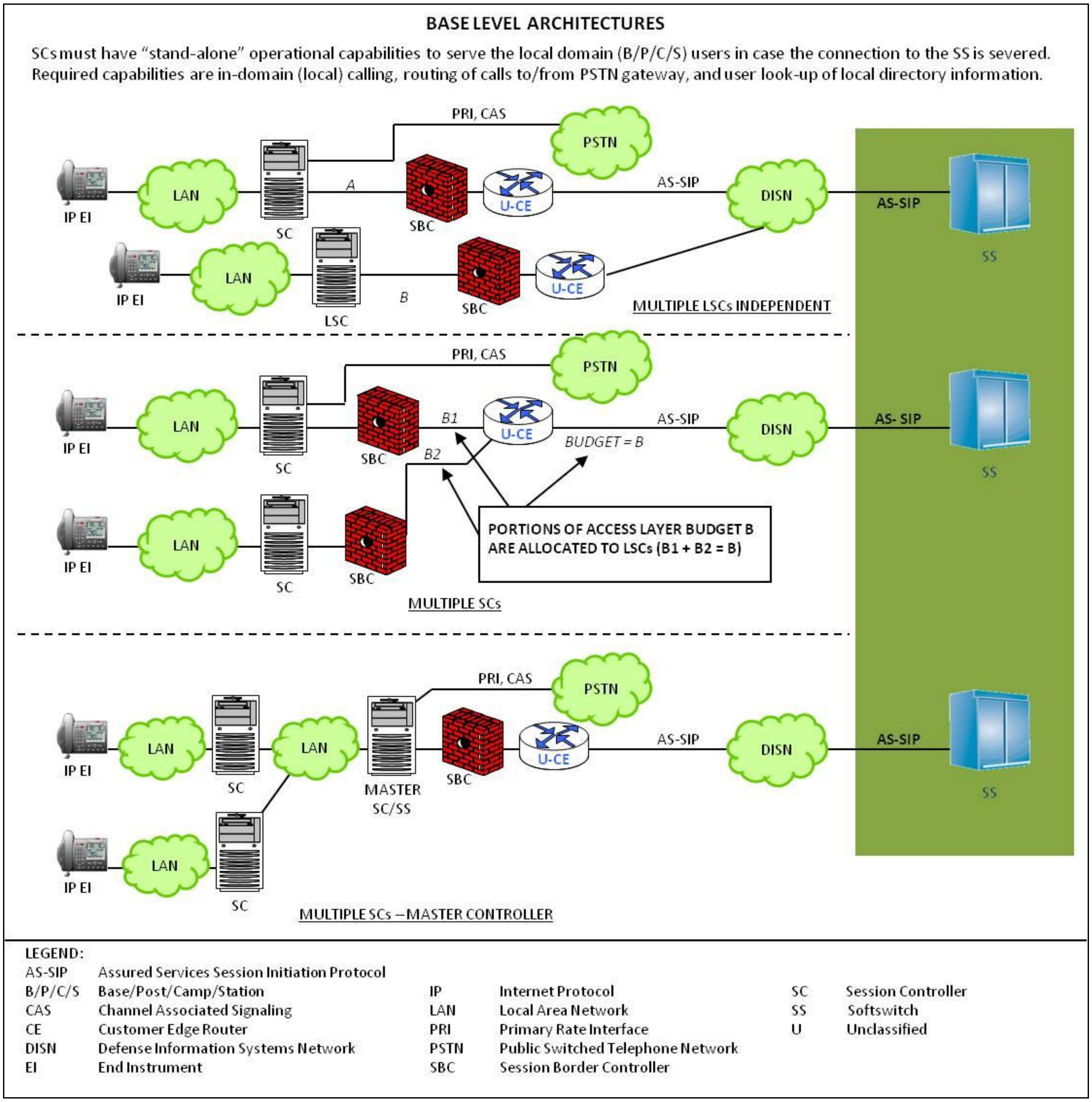


Figure 7.3-1. B/P/C/S-Level Voice over IP SC Designs

The second case, shown in the middle of the diagram, allows sessions to be established through the U-CE Router when connection to the DISN WAN is lost. Naturally, the access bandwidth connecting the common U-CE Router to the DISN WAN would need to be the sum of the traffic-engineered bandwidth for each individual SC (i.e., B = B1+B2). Again, if one SC is not using all its budget/bandwidth, the other SC cannot use the unused budget/bandwidth. For one SC to establish a session to the other SC, without access to the SS, then each SC must contain the directory information of all SCs on the base.

The third case, shown in the lower part of the figure, solves these limitations of being able to use all the WAN access circuit bandwidth, and the establishment of on-base sessions without the need for DISN WAN connection or access to an SS.

The third case requires the design and implementation of an SC array or cluster concept where a master SC, as shown in the figure, has a master directory of all users on the base. Under this arrangement, service order activity at one SC will be reflected automatically at all SCs in the array or cluster, including the master SC. Only the first case will be specified in detail in the Unified Capabilities Requirements (UCR) 2013. The other two cases will require custom engineering of the base design to ensure interoperability and acceptable performance between the various on-base SC arrangements and vendors.

Some general rules to follow with respect to a Master SC (MSC) and Subtended SCs (SSCs) are as follows:

1. End instruments served by an MSC are treated like EIs served by SSCs.
2. The MSC adjudicates the enclave budget between the SSCs.
3. Either of the following two methods is acceptable:
   a. Method 1: the master always ensures the highest priority sessions are served (up to the budget limit of the access link) regardless of the originating SSC, for example:
      (1) If the ASAC budget is 30.
      (2) Each SSC (3, total) allowed 10 voice sessions (3 budgets).
      (3) The MSC performs preemptions to ensure higher precedence sessions succeed.
      (4) The MSC blocks ROUTINE precedence sessions from any SC after the access link budget is met.
   b. Method 2: the Master maintains a strict budget for SSCs, for example:
      (1) If the ASAC budget is 30.
      (2) Each SSC (3, total) with each allowed 10 sessions.
      (3) Does not use unfilled SC budget to service above ROUTINE precedence sessions from another SSC.
   c. All SCs directly connect to an E911 Management System (EMS) to permit MILDEP support of the U.S. Cyber Command (USCYBERCOM).
   d. The MSC is not required to provide an aggregated Network Management (NM) view of the SSCs.
   e. MSCs and SSCs communicate using AS-SIP and/or proprietary signaling protocols if SCs are from the same vendor:
      (1) All signaling destined external to the enclave passes through the MSC.

(2) Allows multiple vendors within the enclave or a single vendor integrated solution.

f. Each SC maintains two budget counts as follows:

(1) Intraenclave (based on local traffic engineering and not associated with the access link budget).

(2) Interenclave (ASAC controlled by each SC).

g. It is desired that connections to the PSTN only be through the MSC (simplifies location services).

h. When an SSC directly connects to the PSTN (exception situation, not desired), then only EIs of the SSC can originate and receive calls from that PSTN PRI/Channel Associated Signaling (CAS) trunk.

i. The MSC is the only connection to enclave TDM infrastructure (simplifies location services).

The choice of the B/P/C/S SC configurations is dependent on the size of the B/P/C/S. Very small bases will have only one SC so these configurations are not of concern. Larger B/P/C/Ss are most likely to have multiple circuit switches to replace, and might try to set up the SC connections like their circuit switches, which would lead to the undesirable configurations that do not use master SCs. Only the master configuration is recommended.

7.4 SC DESIGNS – VIDEO

Figure 7.4-1, B/P/C/S Video over IP SC Designs, illustrates the SC designs for video services. An SC is a call stateful AS-SIP signaling appliance at the B/P/C/S that directly serves IP video-capable EIs.

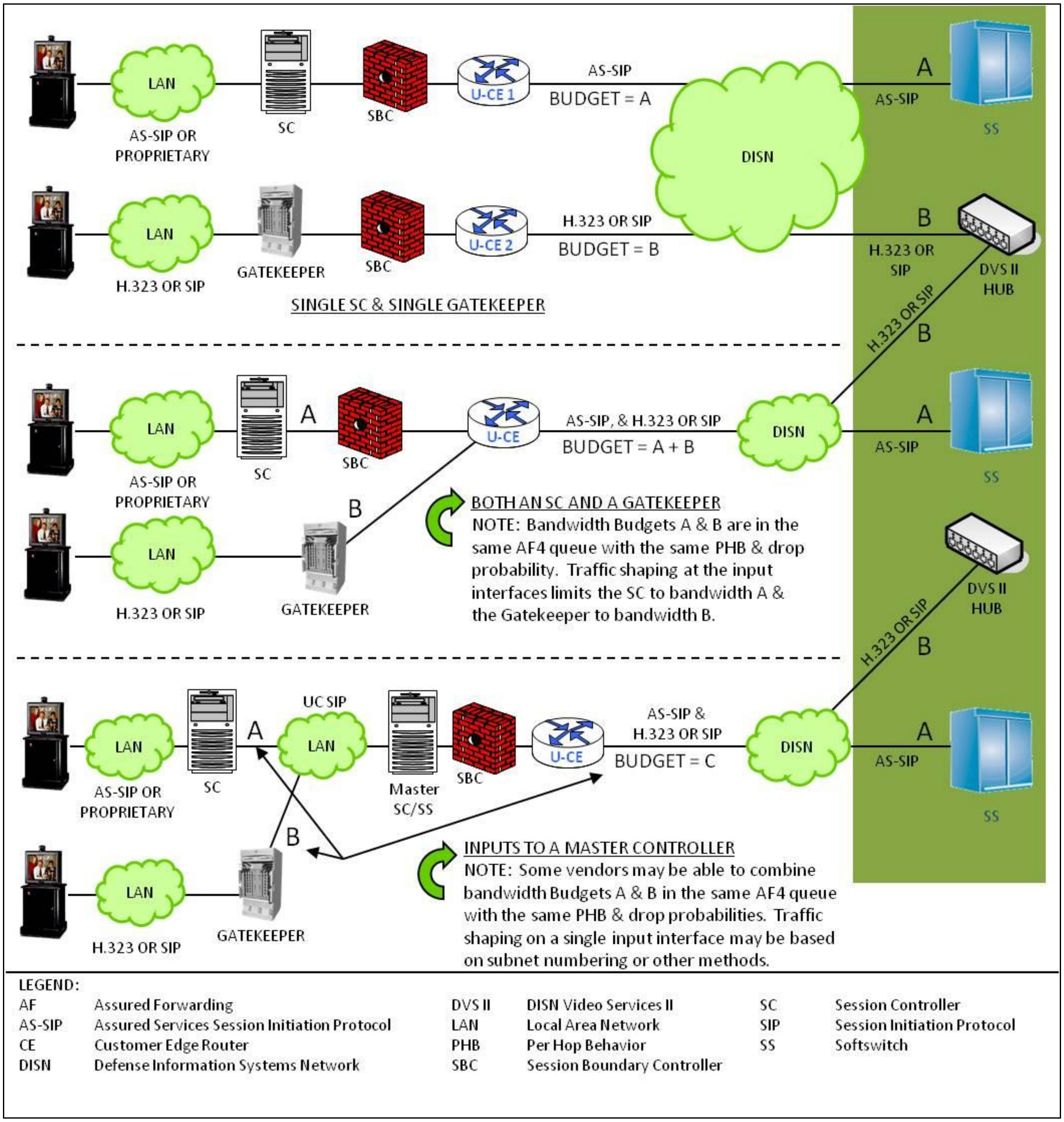


Figure 7.4-1. B/P/C/S Video over IP SC Designs

The design may consist of one or more physical platforms. On the trunk side to the WAN, the SC uses AS-SIP signaling. A Gatekeeper is an appliance that processes calls to the WAN using H.323 or SIP signaling. If the SC or Gatekeeper interfaces to the PSTN or to legacy B/P/C/S TDM appliances, it must also support PRI and CAS using its MG and MGC. All SCs provide PBAS via AS-SIP/ASAC for IP and for TDM trunks (where equipped).via its Media Gateway using the T1.619a protocol.

Figure 7.4-1 shows examples of three possible configurations for connecting multiple video-capable SCs and Gatekeepers on a B/P/C/S to the DISN SS.

The first case is, shown at the top of the figure, where multiple LANs, one with its own SC and U-CE Router, and another LAN with a Gatekeeper and U-CE Router that connect via separate access circuits to the DISN WAN. The SC and the Gatekeeper would each have its own traffic-engineered access circuit bandwidth, which can support the predetermined number of sessions (called a Budget in the figure). The limitation of this first case is that sessions from the SC or Gatekeeper on the base will not be able to communicate with each other because of the different signaling protocols in use by each. However, the SC and the Gatekeeper each will have separate bandwidths that act independently to each other.

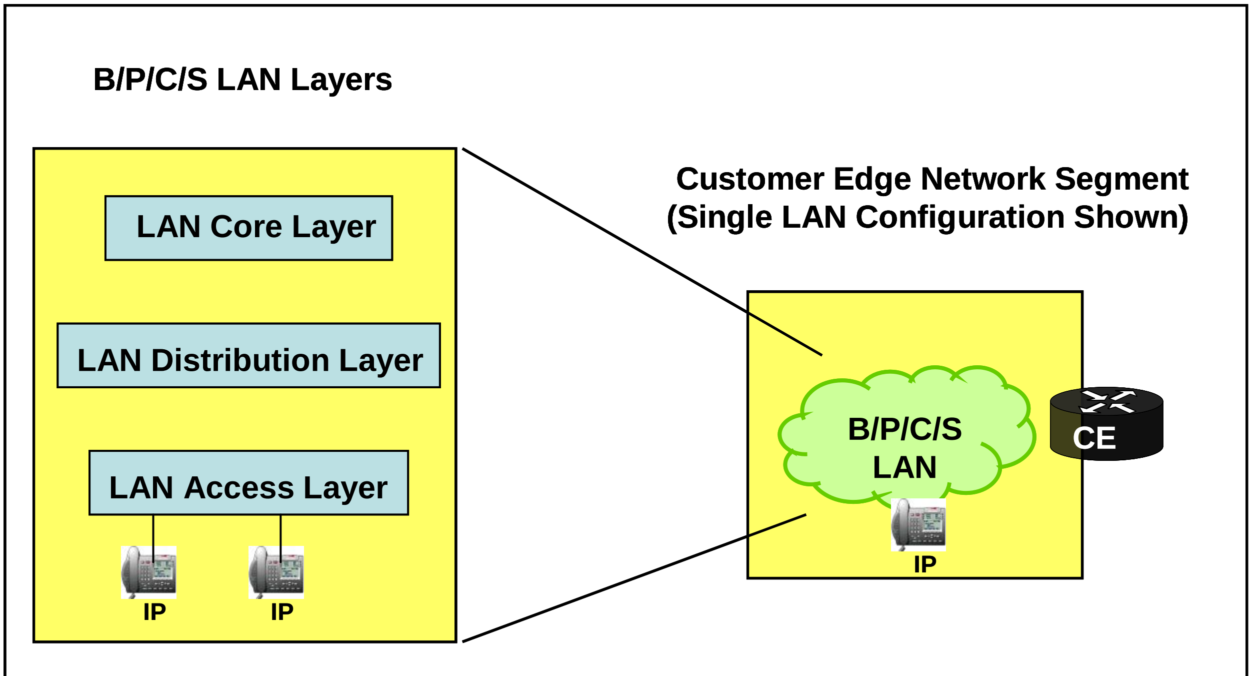
The second case, shown in the middle of the figure, allows sessions to be established through the U-CE Router. In this case, both the SC and the Gatekeeper will act independently as described in the first case, but both will connect to the same U-CE Router. However, the SC video call and the Gatekeeper video call will connect to separate ports on the U-CE Router. Naturally, the access bandwidth connecting the common U-CE Router to the DISN WAN would need to be the sum of the traffic-engineered bandwidth for the SC and Gatekeeper (i.e., A+B). Although each router port processing video calls acts independently in the AF4 queue, both customer calls must be treated equally if and only if the H.323 traffic is traffic engineered and controlled. This assumes that the AF4 queue is sized to meet the aggregate demand of the AS-SIP video teleconferencing (VTC) traffic and the H.323 Gateway-controlled traffic. If the H.323 traffic is not traffic engineered and controlled, then it goes into a different queue (i.e., the preferred data queue).

The third case requires the designation and implementation of an SC array or cluster concept as described for the voice design in Section 7.3, SC Designs–Voice.

With regard to the Gatekeeper interworking with the MSC or Softswitch (SS) in the third case, some vendors may be able to manage the SC-originated video call in addition to the Gatekeeper-originated call. In this case, the MSC or SS will manage Budgets A and B to make a more efficient use of Budget C. Although the SC video EI and the Gatekeeper EI will still not be able to communicate with each other (unless a H.323/AS-SIP Gateway is used) because of different protocols used, the MSC or SS will be able to process the calls into Budget C efficiently in the AF4 queue. All video calls leaving the MSC or SS must be treated equally only if the H.323 traffic is traffic engineered and controlled. This assumes that the AF4 queue is sized to meet the aggregate demand of the AS-SIP VTC traffic and the H.323 Gateway-controlled traffic. If the H.323 traffic is not traffic engineered and controlled, then it goes into a different queue (i.e., the preferred data queue).

7.5 LAN AND ASLAN DESIGN

The LAN consists of the Core, Distribution, and Access Layers, which all reside in the Customer Edge Segment of the E2E Global Information Grid (GIG) network reference. A high-level illustration of the three LAN Layers is provided in Figure 7.5-1, B/P/C/S LAN Layers and Relationship to Customer Edge Segment. The figure depicts a traditional three tier LAN infrastructure. This is not to be interpreted that all LANs must be comprised of three tiers. The B/P/C/S LAN infrastructure may contain more or less tiers based on network engineering frameworks. The B/P/C/S LAN infrastructure must be composed from Approved Products List (APL) products. The number of tiers and composition (core, distribution, or access) is left to the discretion of the services.



LEGEND
B/P/C/S Base, Post, Camp, Station
CE Customer Edge Router
IP Internet Protocol
LAN Local Area Network

Figure 7.5-1. B/P/C/S LAN Layers and Relationship to Customer Edge Network Segment

7.5.1 Overview of LAN General Design and Requirements

To provide cost-effective LAN solutions that meet mission requirements for all users served by a LAN, two types of LANs are defined; they are ASLANs and non-ASLANs. The LANs will be designed to meet traffic engineering and redundancy requirements, as required by applicable mission needs. The ASLANs and non-ASLANs may be designed to use any combination of the layers and functional capabilities, shown in Figure 7.5-2, LAN Layers. Multiple layers may be combined in a single switch or router (i.e., router acts as Distribution and Access Layers).

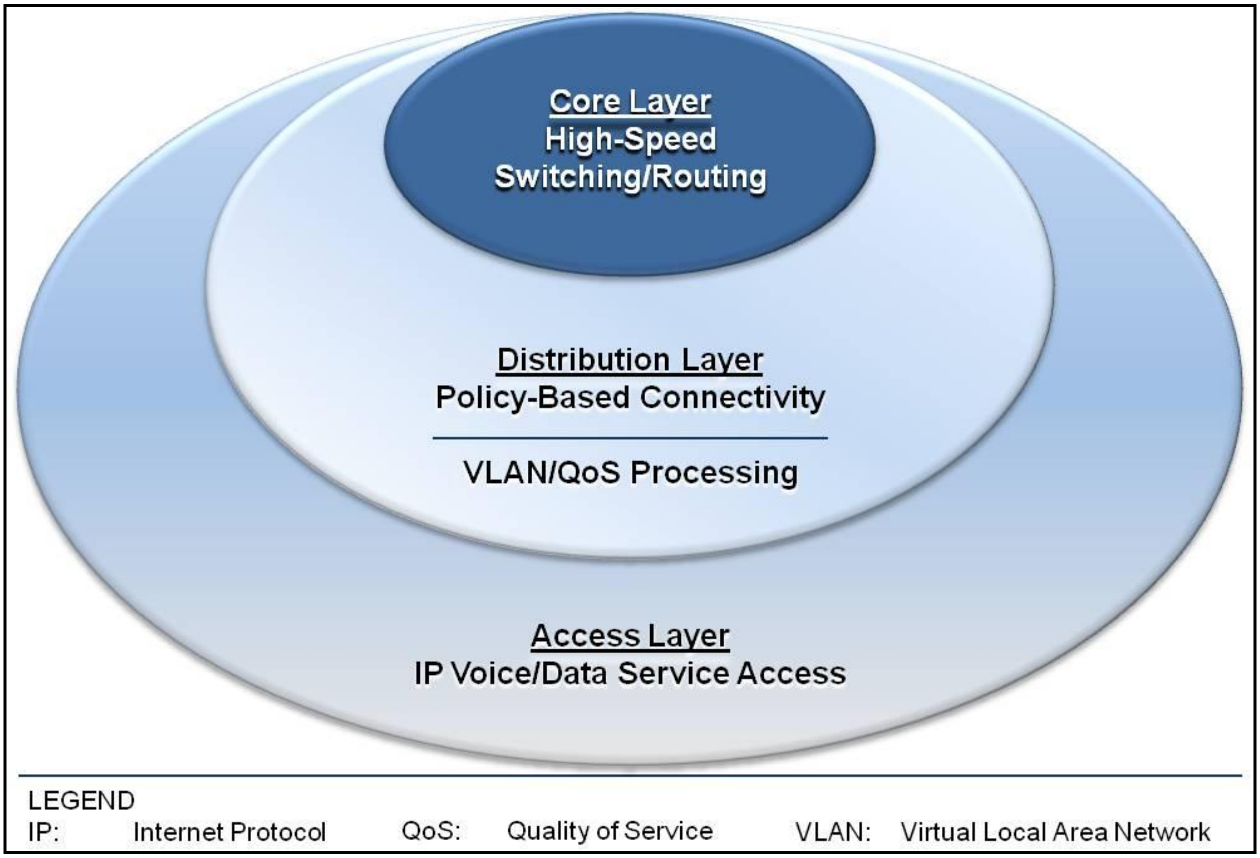


Figure 7.5-2. LAN Layers

The three LAN Layers are as follows:

1. Access Layer. The Access Layer is the point at which local end users are allowed into the network. This layer may use access lists or filters to optimize further the needs of a particular set of users.

2. Distribution Layer. The Distribution Layer of the network is the demarcation point between the Access and Core Layers and helps to define and differentiate the Core. The purpose of this layer is to provide boundary definition and is the place at which packet manipulation can take place.

3. Core Layer. The Core Layer is a high-speed switching backbone and is designed to switch packets as fast as possible.

Figure 7.5-3, Representative B/P/C/S Design and Terminology, illustrates a typical B/P/C/S LAN design. The LAN design and requirements refer to LAN products in terms of the Core, Distribution, and Access Layer products. These products are often known by other names such as Main Communication Node (MCN), Area Distribution Node (ADN), and End User Building (EUB) switch.

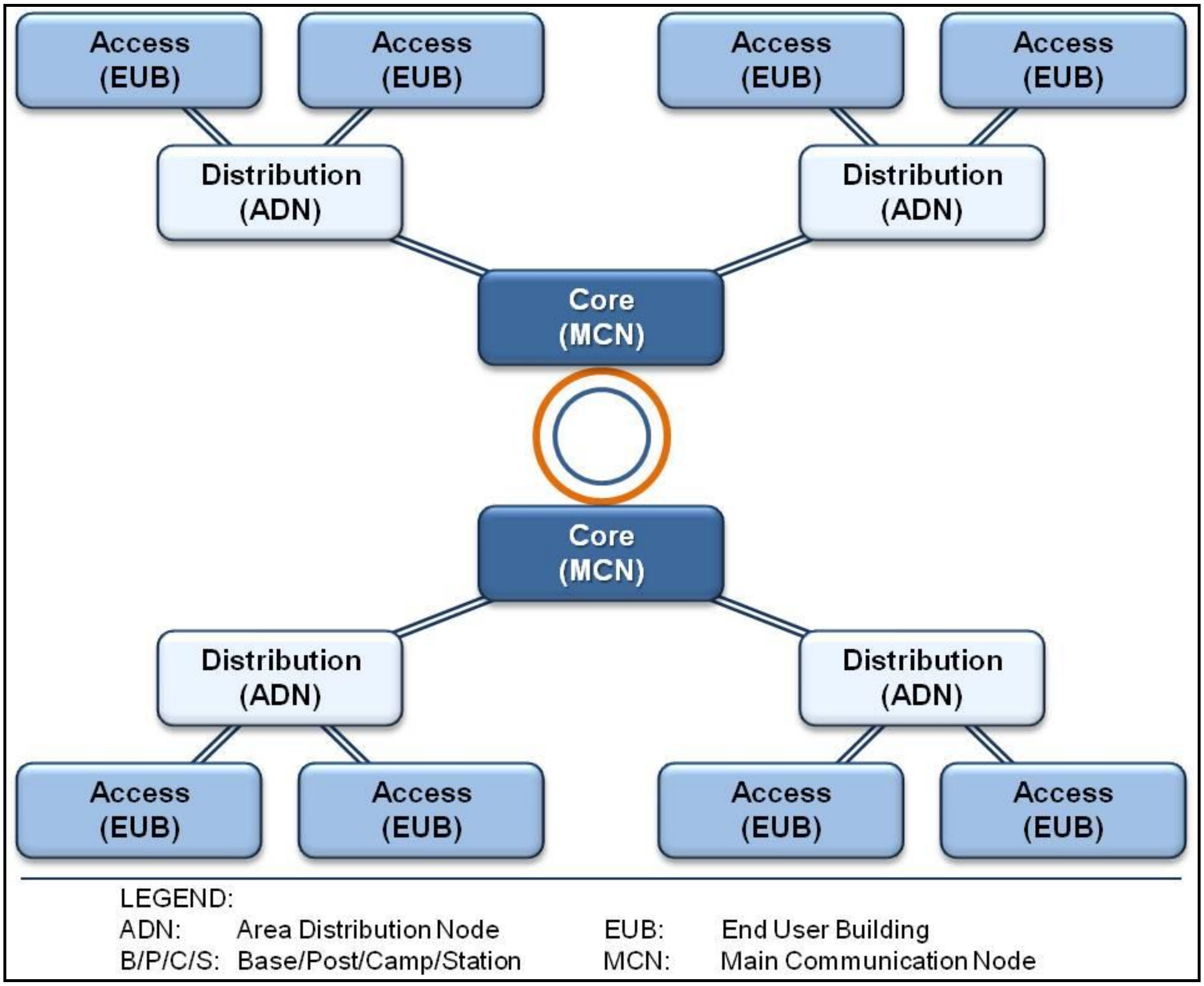


Figure 7.5-3. Representative B/P/C/S Design and Terminology

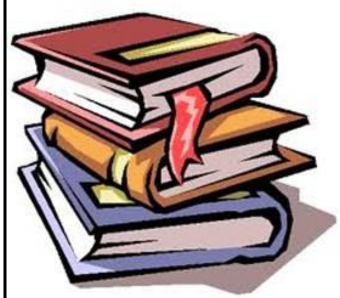
Within the LAN, the terminology used to reference traffic at each specific Open System Interconnect (OSI) layer is shown in Table 7.5-1, OSI Layer Control Information Name.

Table 7.5-1. OSI Layer Control Information Name

OSI LAYER	CONTROL INFORMATION NAME
Application Presentation Session	Data
Transport	Segment
Network	Packet
Data Link	Frame
Physical	Bit
LEGEND OSI: Open System Interconnect	

7.5.2 LAN Types and Mission Support Summary

The principal LAN requirements are summarized in Figure 7.5-4.



LAN
UCR/UCTP

Requirements

- QoS
- Meet Voice, Video, and Data Performance
- Packet Loss, Jitter, Latency Measured
- Support Service Classes and Precedence Mapped Into DSCPs
- Commercial, Medium, and High Availability/Backup Power Tailored to User Mission
- VLAN for Voice, Video, Data Peripherals
- Network Management of LAN

LEGEND
DSCP: Differentiated Services Code Point
LAN: Local Area Network
QoS: Quality of Service
UCTP: Unified Capabilities Test Plan
VLAN: Virtual Local Area Network

Figure 7.5-4. LAN Requirements Summary

Two types of LANs are ASLAN and non-ASLAN, depending on the type of missions and users served by a LAN. ASLANs support assured services while non-ASLAN need not meet assured services requirements. ASLANs provide enhanced availability and backup power as compared to Non-ASLANs. As a result, they are more robust and more costly. The two LAN types and three categories along with user classes are illustrated in Figure 7.5-5, Three Categories of LANs Tailored to Mission Needs.

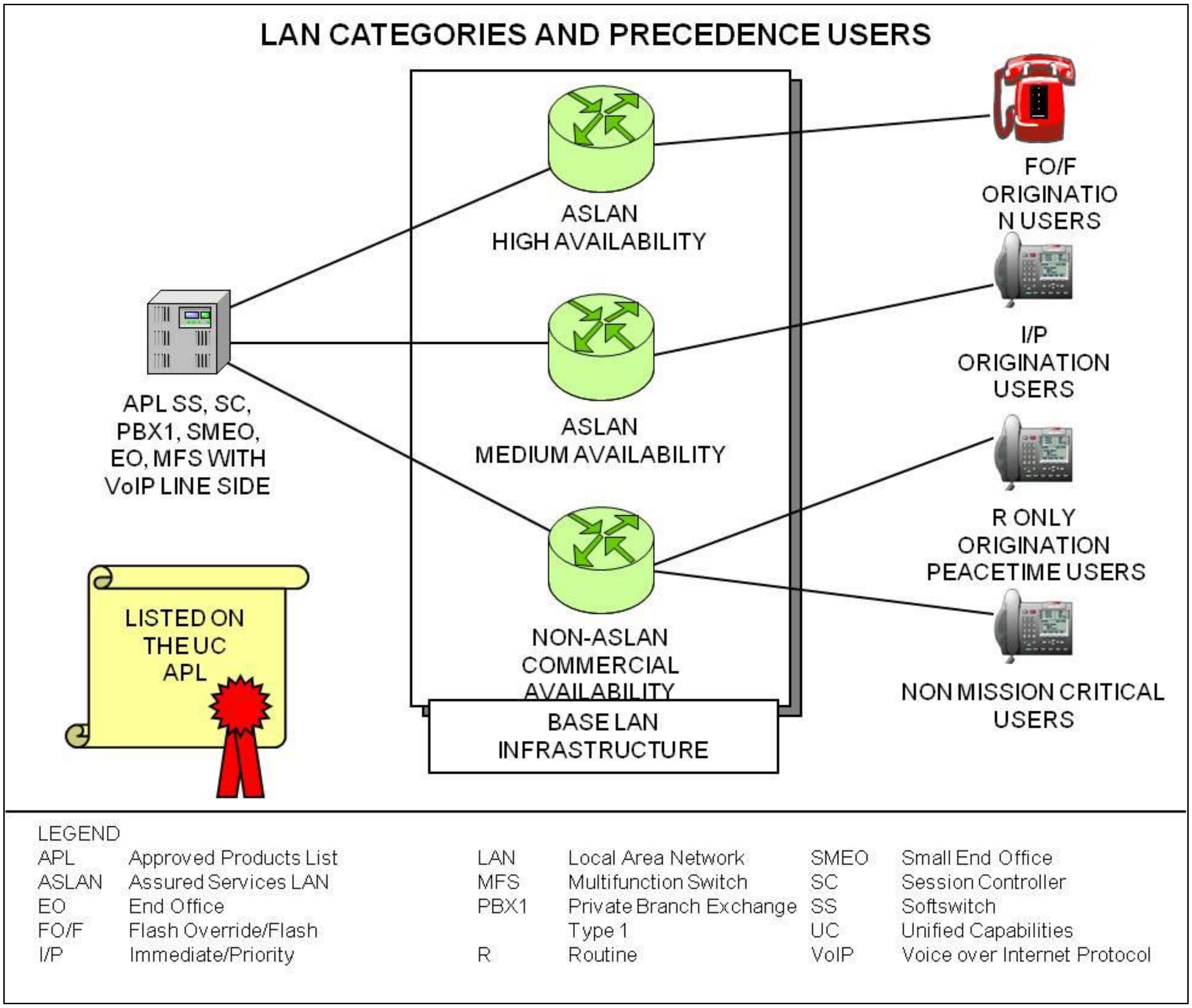


Figure 7.5-5. Three Categories of LANs Tailored to Mission Needs

Table 7.5-2, LAN Requirements Summary, shows the requirements needed based on subscriber mission category. Note that in addition to subscriber requirements, mission critical functions that do not originate or receive precedence traffic must also be supported since these functions must continue in time of crisis. Requirements are defined, as necessary, for the user, while Permitted allows other user types to be served (such as a user that is authorized FLASH OVERRIDE and FLASH precedence is required to be served on a High Availability ASLAN, and other users are permitted on the same LAN). Not Permitted means that the user must not be served (such as a user that is authorized FLASH OVERRIDE and FLASH precedence cannot be served by a Medium Availability ASLAN or non-ASLAN). Not required are requirements that do not have to be met for some users (such as requirements for diversity, redundancy, and power backup that are not required for users that only have ROUTINE precedence).

Table 7.5-2. LAN Requirements Summary

LAN REQUIREMENT ITEM	USER PRECEDENCE ORIGINATION AUTHORIZATION			
	F/FO	I/P	R	NOT MISSION CRITICAL
ASLAN High	R	P	P	P
ASLAN Medium	NP	R	P	P
Non-ASLAN	NP	NP	P	P
ASF	R	R	R	NR
Redundancy (with diversity)	R	R	NR	NR
Battery Backup	8 hours	2 hours	NR	NR
Single Point of Failure User > 96 Allowed	No	No	Yes	Yes
GOS p=	0.0	0.0	0.0	Note 1
Availability	99.999	99.997	99.9	99.8
NOTE 1: GOS is discretionary and shall be determined by DoD Components.				
LEGEND				
ASF: Assured Services Features	I/P: IMMEDIATE/PRIORITY	P: Permitted		
ASLAN: Assured Services LAN	LAN: Local Area Network	R: Required		
F/FO: FLASH/FLASH OVERRIDE	NP: Not Permitted	R: ROUTINE		
GOS: Grade of Service	NR: Not Required			

An ASLAN that supports users authorized IMMEDIATE/PRIORITY (I/P) is classified as a Medium Availability ASLAN. An ASLAN that supports users authorized FLASH/FLASH OVERRIDE (F/FO) is classified as a High Availability ASLAN.

Installing ASLAN in all buildings may result in a fiscally untenable cost. Therefore, the actual LAN implementation will vary from base to base depending on building or facility locations, installed cable plant, and the location and type of missions being performed within the various buildings on the base.

ASLAN requirements for a Military installation can be determined by performing a site survey to identify the specific locations (buildings) that require a High, Medium, or non- ASLAN capabilities. Examples of buildings with mission critical functions include but are not limited to the following:

> Buildings with LAN core nodes, reachable nodes that extend services into, e.g., Theater, network operations and security centers, network control centers , command posts, battle staff, Core nodes including connectivity between the core nodes (i.e., the LAN backbone) must be high availability. If the backbone is not a high availability ASLAN, nothing else can be high availability.

Figure 7.5-6, An Example of a Potential CAN With a Mix of Mission and Non-Mission-Critical Users, is an example of a LAN with a mix of organizations with different Mission and Non-Mission-Critical Users that combines the LAN capabilities illustrated in Figure 7.5-2, Three Categories of LANs Tailored to Mission Needs. It shows a LAN at a location involving multiple buildings and types of mission users and how connectivity redundancy and the backup power time requirement of eight, two, or zero hours are met in a cost-effective manner.

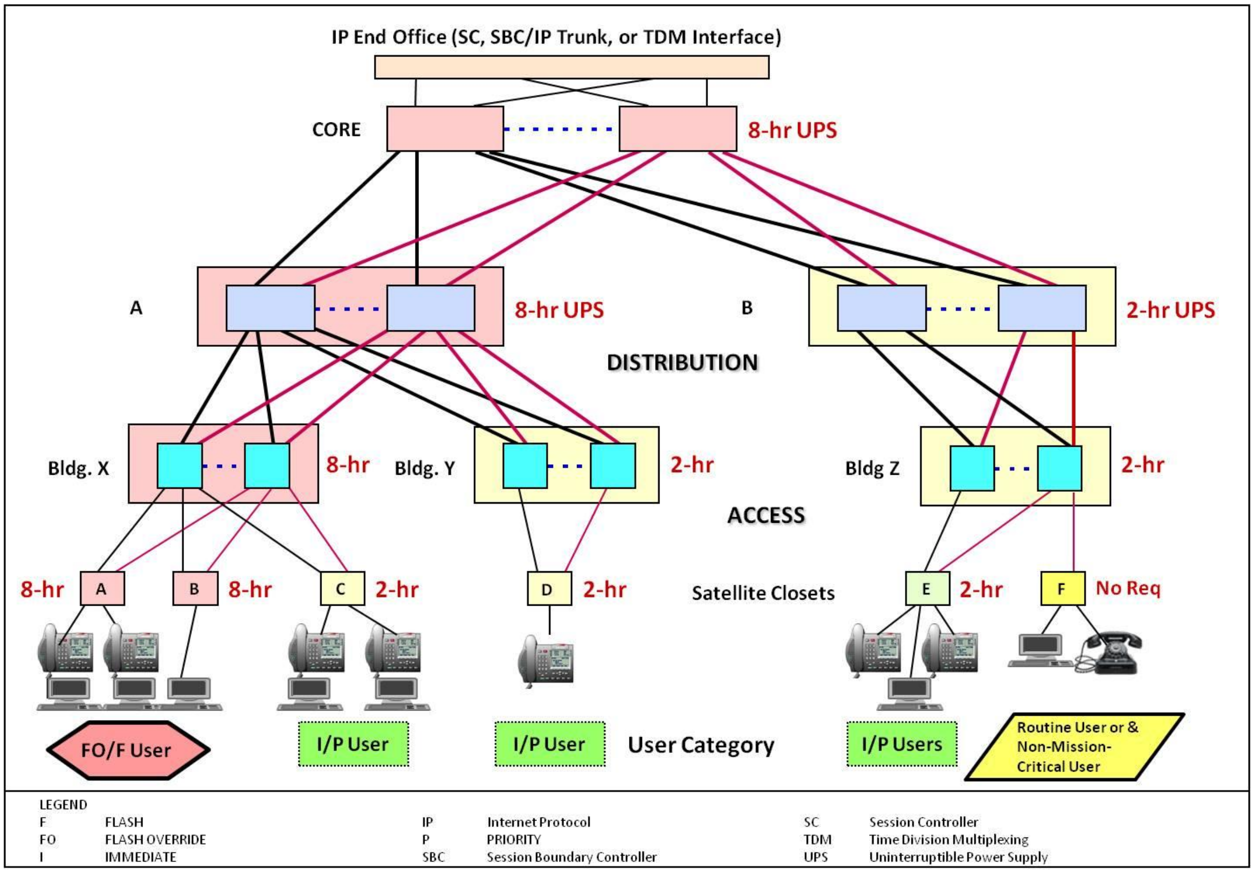


Figure 7.5-6. An Example of a Potential CAN With a Mix of Mission and Non-Mission Critical Users

7.5.3 Wireless LANs

Wireless networks may support IMMEDIATE/PRIORITY (I/P), ROUTINE (R), and non-mission critical users, but shall not be used to support F/FO users.

The use of wireless in the LAN as a bridging function shall not increase latency by more than 10 ms for each bridging pair. This is calculated based on the end-to-end requirements to support assured services users. Since the wireless bridge may be implemented within the ASLAN. It may process assured services voice. Thus the need to keep end-to-end latency below the prescribed 220 ms was considered. The use of wireless via an access point shall not increase LAN latency by more than 15 ms. Wireless access pints are not used to provide assured services voice. Therefore end-to-end latency for non-assures services voice is increased to 250 ms.

Given the possibility of having access points at either end, a budget of 15 ms for the access point was derived.

The WABs may support F/FO calls, I/P, and non-mission critical calls. All calls must meet other specified performance requirements for these users.

7.6 END-TO-END LAN PERFORMANCE REQUIREMENTS

End-to-end performance across a LAN is measured from the traffic ingress point (typically, the LAN Access product input port) to the traffic egress port (typically, the LAN Core product port connection to the CE Router). Metrics are based on best estimates for the DoD environment calculated through lab and operation testing.

7.6.1 Voice Services

7.6.1.1 Latency

The ASLAN shall have the capability to transport voice IP packets, media and signaling, with no more than 6 ms latency E2E across the network as measured under congested conditions. Congested condition is defined as 100 percent of link capacities (as defined by baseline traffic engineering. The latency shall be achievable over any 5-minute measured period under congested conditions.

7.6.1.2 Jitter

The ASLAN shall have the capability to transport voice IP packets E2E across the network with no more than 3 ms of jitter. The jitter shall be achievable over any 5-minute measured period under congested conditions. Congested condition is defined as 100 percent of link capacities (as defined by baseline traffic engineering.

7.6.1.3 Packet Loss

The ASLAN shall have the capability to transport voice IP packets E2E across the network with packet loss not to exceed configured traffic engineered (queuing) parameters. Actual measured packet loss across the network shall not exceed 0.045 percent within the defined queuing parameters. The packet loss shall be achievable over any 5-minute measured period under congested conditions. Congested condition is defined as 100 percent of link capacities (as defined by baseline traffic engineering.

7.6.2 Video Services

7.6.2.1 Latency

The ASLAN shall have the capability to transport video IP packets with no more than 30 ms latency E2E across the network. Latency is increased over voice IP packets because of the increased size of the packets (230 bytes for voice packets and up to 1518 bytes for video). The latency shall be achievable over any 5-minute measured period under congested conditions. Congested condition is defined as 100 percent of link capacities (as defined by baseline traffic engineering.

7.6.2.2 Jitter

The ASLAN shall have the capability to transport video IP packets E2E with no more than 30 ms of jitter across the network. The jitter shall be achievable over any 5-minute measured period under congested conditions. Congested condition is defined as 100 percent of link capacities (as defined by baseline traffic engineering).

7.6.2.3 Packet Loss

The ASLAN shall have the capability to transport video IP packets E2E with packet loss not to exceed configured traffic engineered (queuing) parameters across the network. Actual measured packet loss across the network shall not exceed 0.15 percent within the defined queuing parameters. The packet loss shall be achievable over any 5-minute measured period under congested conditions. Congested condition is defined as 100 percent of link capacities.

7.6.3 Data Services

7.6.3.1 Latency

The ASLAN shall have the capability to transport prioritized data IP packets with no more than 45 ms latency E2E across the network. Latency is increased over voice IP packets because of the increased size of the packets (230 bytes for voice packets and up to 1518 bytes for data). The latency shall be achievable over any 5-minute measured period under congested conditions. Congested condition is defined as 100 percent of link capacities.

7.6.3.2 Jitter

There are no jitter requirements for preferred data IP packets.

7.6.3.3 Packet Loss

The ASLAN shall have the capability to transport prioritized data IP packets E2E with packet loss not to exceed configured traffic engineered (queuing) parameters. Actual measured packet loss across the LAN shall not exceed 0.15 percent within the defined queuing parameters. The packet loss shall be achievable over any 5-minute period measured under congested conditions. Congested condition is defined as 100 percent of link capacities (as defined by baseline traffic engineering).

7.7 INFRASTRUCTURE NETWORK MANAGEMENT REQUIREMENTS

ASLAN Network managers must be able to monitor, configure, and control all aspects of the network and observe changes in network status. The infrastructure components shall have an NM capability that leverages existing and evolving technologies and has the ability to perform remote network product configuration/ reconfiguration of objects that have existing DoD GIG management capabilities. The infrastructure components must be able to be centrally managed by an overall Network Management System (NMS). In addition, both NMS (RMON2) and Management Information Base II (MIB II) shall be supported for Simple Network Management Protocol (SNMP). In addition, if other methods are used for interfacing between infrastructure products and the NMS they shall be implemented in a secure manner, such as with the following methods:

- Secure Shell 2 (SSH2). The SSH2 Protocol shall be used instead of Telnet because of its increased security. The LAN products shall support Request for Comments (RFC) 4251 through RFC 4254 inclusive.
- HyperText Transfer Protocol, Secure (HTTPS). HTTPS shall be used instead of HyperText Transfer Protocol (HTTP) because of its increased security as described in RFC 2660. The infrastructure products shall support RFC 2818.

7.7.1 Configuration Control

The ASLAN Configuration Control identifies controls, accounts for, and audits all changes made to a site or information system during its design, development, and operational life cycle (DoD Chief Information Officer [CIO] Guidance IA6-8510 IA). Infrastructure components shall have an NM capability that leverages existing and evolving technologies and has the ability to perform remote network product configuration/reconfiguration of objects that have existing DoD GIG management capabilities. The NMS shall report configuration change events in near-real-time (NRT), whether or not the change was authorized. The system shall report the success or failure of authorized configuration change attempts in NRT. NRT is defined as receiving configuration control updates within 5 seconds of querying the status (polled) or within 5 seconds of changes being sent from the monitored device (pushed) Configuration change, excluding transport time.

7.7.2 Operational Changes

The ASLAN infrastructure components must provide metrics to the NMS to allow them to make decisions on managing the network. Network management systems shall have an automated NM capability to obtain the status of networks and associated assets in NRT 99 percent of the time (with 99.9 percent as an Objective Requirement). Near-real time is defined as receiving operational changes within 5 seconds of querying the status (polled) or within 5 seconds of receiving status changed (pushed), excluding transport time. Specific metrics are defined in NMS

Sections 2.17, Management of Network Appliances, and 2.18, Network Management Requirements of Appliance Functions.

7.7.3 Performance Monitoring

All ASLAN infrastructure components shall be capable of providing status changes 99 percent of the time (with 99.9 percent as an Objective Requirement) by means of an automated capability in NRT. An NMS will have an automated NM capability to obtain the status of networks and associated assets 99 percent of the time (with 99.9 percent as an Objective Requirement) within 5 seconds of querying the status (polled) or within 5 seconds of receiving status changes (pushed) from the monitored device. The NMS shall collect statistics and monitor bandwidth utilization, delay, jitter, and packet loss.

7.7.4 Alarms

All ASLAN infrastructure components shall be capable of providing SNMP alarm indications to an NMS. Network Management Systems will have the NM capability to perform automated fault management of the network, to include problem detection, fault correction, fault isolation and diagnosis, problem tracking until corrective actions are completed, and historical archiving. This capability allows network managers to monitor and maintain the situational awareness of the network's manageable products automatically, and to become aware of network problems as they occur based on the trouble tickets generated automatically by the affected object or network. Alarms will be correlated to eliminate those that are duplicate or false, initiate test, and perform diagnostics to isolate faults to a replaceable component. Alarms shall be reported as TRAPs via SNMP in NRT. More than 99.95 percent of alarms shall be reported in NRT. NRT is defined as receiving alarm changes within 5 seconds of querying the status (polled) or within 5 seconds of receiving alarm changes (pushed) from the monitored device.

7.7.5 Reporting

To accomplish GIG E2E situational awareness, an NMS will have the NM capability of automatically generating and providing an integrated/ correlated presentation of network and all associated networks.

7.8 ENGINEERING REQUIREMENTS

7.8.1 Copper Media

Cabling used for the ASLAN shall not be lower than a CAT-5 performance (see Table 7.8-1, Cable Grade Capabilities). The CAT-5 cable specification is rated up to 100 megahertz (MHz) and meets the requirement for high-speed LAN technologies, such as Fast Ethernet and Gigabit Ethernet. The Electronics Industry Association/Telecommunications Industry Association (EIA/TIA) formed this cable standard that describes performance the LAN manager can expect from a strand of twisted pair copper cable. Along with this specification, the committee formed the EIA/TIA-568-B standard named the "Commercial Building Telecommunications Cabling Standard" to help network managers install a cabling system that would operate using common LAN types, like Fast Ethernet. The specification defines Near End Crosstalk (NEXT) and attenuation limits between connectors in a wall plate to the equipment in the closet. Wires used for interconnecting LANs using Digital Subscriber Line (DSL) Access Devices and DSL Concentrators should not be lower than a CAT3 performance (see Table 7.8-1, Cable Grade Capabilities). Actual implementations depend on existing wiring infrastructure.

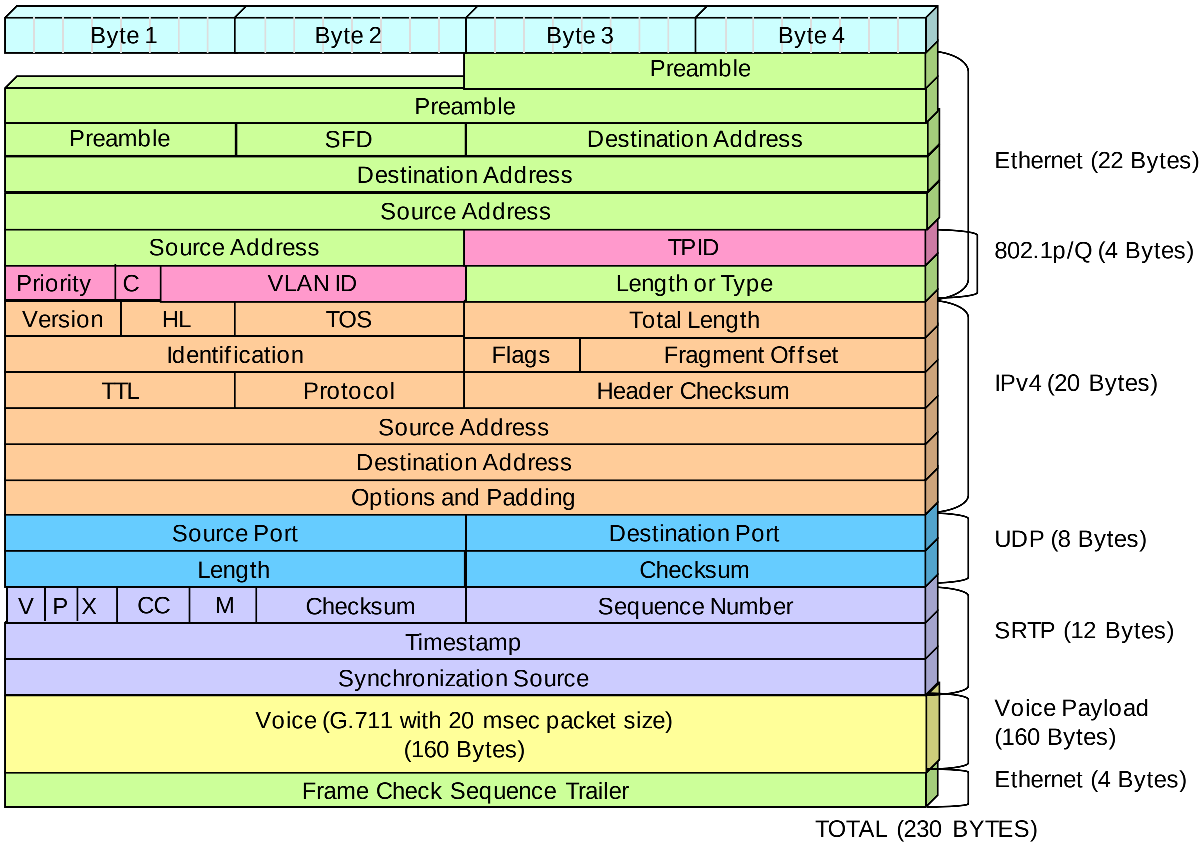
Table 7.8-1. Cable Grade Capabilities

CABLE NAME	MAKEUP	FREQUENCY SUPPORT	DATA RATE	ASLAN COMPATIBILITY
CAT-3	1 twisted pair of copper wire– terminated by RJ11 connectors	16 MHz	Up to 10 Mbps	DSL (see Section 7.8, DSL Requirements)
CAT-4	2 twisted pairs of copper wire – terminated by RJ45 connectors	20 MHz	Up to 16 Mbps	DSL (see Section 7.8, DSL Requirements)
CAT-5	4 twisted pairs of copper wire – terminated by RJ45 connectors	100 MHz	Up to 1000 Mbps	1000Base-T, 100Base-TX, 10Base-T
CAT-5e	4 twisted pairs of copper wire – terminated by RJ45 connectors	100 MHz	Up to 1000 Mbps	10Base-T, 100Base-TX, 1000Base-T
CAT-6	4 twisted pairs of copper wire – terminated by RJ45 connectors	250 MHz	1000 Mbps	10Base-T, 100Base-TX, 1000Base-T
LEGEND				
ATM: Asynchronous Transfer Mode		Mbps: Megabits per second		T: Ethernet half-duplex
Base: Baseband		MHz: Megahertz		TX: Ethernet full-duplex
CAT: Category		RJ: Registered Jack		

7.8.2 Traffic Engineering

7.8.2.1 Voice Services

ASLAN bandwidth required per voice subscriber is calculated as 102 Kbps (each direction) for each IP call (for IPv4). This is based on G.711 (20 ms codec) with IP overhead as depicted in Figure 7.8-1, Voice over IP Packet Size, (97 Kbps for Ethernet IPv4) plus 5 Kbps for Secure Real-Time Transport Control Protocol (SRTCP).



NOTE: Diagram does not show the 4-byte SRTP authentication tag (recommended in RFC 3711 and the optional 4-byte SRT MKI (Master Key Identifier) field. When processing an incoming packet the appliance must process the packet properly whether the 4-byte SRTP authentication tag is present or not present, and whether the 4-byte MKI Field is present or not. See RFC 3711 Section 3.1 for detailed processing requirements.

LEGEND

ID	Identification	SFD	Start Frame Delimiter	TTL	Time to Live
IPv4	Internet Protocol Version 4	TOS	Type of Service	UDP	User Datagram Protocol
msec	Milliseconds	TPID	Tag Protocol Identification	VLAN	Virtual Local Area Network
RTP	Real Time Protocol				

Figure 7.8-1. Voice over IP Packet Size

Based on overhead bits included in the bandwidth calculations, vendor implementations may use different calculations and hence arrive at slightly different numbers. IPv6 adds an additional 20 bytes in the IP header (40 bytes instead of 20 bytes). The increase of 20 bytes to 250 bytes increases the IPv6 bandwidth to 110.0 Kbps. This calculation includes a 12-byte Ethernet Interframe gap and the SRTCP overhead.

Bandwidth in the LAN shall be engineered IAW Section 6.10 of the UC Framework

Table 7.8-2. LAN VoIP Subscribers for IPv4 and IPv6

PRODUCT	LINK TYPE	LINK SIZE	# MISSION CRITICAL VOIP SUBSCRIBERS (ASLAN)	# R AND NON-MISSION CRITICAL VOIP SUBSCRIBERS (NON-ASLAN)
Core	IP Trunk Link	10 Mbps, 100 Mbps 1 Gbps, and 10 Gbps	96[1]	50, 500, 5000, and 50,000
	IP Trunk Link Pair	10 Gbps	25000[3]	50000
	IP Trunk Link Pair	1 Gbps	2500	5000
	IP Trunk Link Pair	100 Mbps	250	500
	IP Trunk Link Pair	10 Mbps	25	50
	IP Subscriber (voice only)	10 Mbps	1[4]	1
	IP Subscriber (converged)	100 Mbps	1[5]	1
Distribution	IP Trunk Link	10 Mbps, 100 Mbps 1 Gbps, and 10 Gbps	96[1]	50, 500, 5000, and 50,000
	IP Trunk Link Pair	10 Gbps	25000	50000
	IP Trunk Link Pair	1 Gbps	2500	5000
	IP Trunk Link Pair	100 Mbps	250	500
	IP Trunk Link Pair	10 Mbps	25	50
	IP Subscriber (voice only)	10 Mbps	1[4]	1
	IP Subscriber (converged)	100 Mbps	1[5]	1
Access	IP Trunk Link	10 Mbps, 100 Mbps 1 Gbps, and 10 Gbps	96[1]	50, 500, 5000, and 50,000
	IP Trunk Link Pair	10 Gbps	25000	50000
	IP Trunk Link Pair	1 Gbps	2500	5000
	IP Trunk Link Pair	100 Mbps	250	500
	IP Trunk Link Pair	10 Mbps	25	50
	IP Subscriber (voice only)	10 Mbps	1[4]	1
	IP Subscriber (converged)	100 Mbps	1[5]	1

NOTES:

1. All trunks must be link pairs to meet assured service requirements. For single links, number of users is limited to 96 because of single point of failure requirements.
2. Link pairs may also include link aggregation. The link pair may use stand-by links or load balancing mechanisms. Regardless of method, the total number of subscribers per link pair (both links) is limited to the number of subscribers listed above.
3. For the converged network, voice traffic was engineered not to exceed 25 percent of total utilization.
4. The minimum link for VoIP subscriber is 10 Mbps.
5. For subscribers that share voice and data (converged), minimum recommended bandwidth for the link is 100 Mbps.

LEGEND

ASLAN: Assured Services LAN IP: Internet Protocol LAN: Local Area Network

PRODUCT	LINK TYPE	LINK SIZE	# MISSION CRITICAL VOIP SUBSCRIBERS (ASLAN)	# R AND NON-MISSION CRITICAL VOIP SUBSCRIBERS (NON-ASLAN)
C2: Command and Control	IPv4: IP Version 4	Mbps: Megabits per second		
Gbps: Gigabits per second	IPv6: IP Version 6	VoIP: Voice over IP		

4. No single point of failure within the ASLAN can cause a voice service outage to more than 96 users. It should be noted that a single point of failure for more than 96 subscribers may exist if 96 or less are IP telephone subscribers (i.e., 50 data, 20 video, and 50 IP telephony = 120 subscribers). Based on the previous constraints, the recommended number of voice subscribers based on available link sizes is shown in Table 7.8-2.

7.8.2.2 Video Services

The amount of video bandwidth required over the ASLAN varies depending on the codec and other features that are negotiated at setup. Unlike voice, video over IP is not a constant rate. Video packets may range in size from hundreds of bytes up to 1500 bytes. Table 7.8-3, Video Rates and IP Overhead, lists the common video rates and associated IP overhead. Video bandwidth shall be engineered IAW bandwidth provisioning considerations provided in UCF Section 6.10, Bandwidth Provisioning Considerations.

Table 7.8-3. Video Rates and IP Overhead

VIDEO STREAM BANDWIDTH	IP OVERHEAD	TOTAL IP BANDWIDTH
128 kbps	32 kbps	160 kbps
256 kbps	64 kbps	320 kbps
384 kbps	96 kbps	480 kbps
768 kbps	192 kbps	960 kbps
2 Mbps	0.5 Mbps	2.5 Mbps
4.5 Mbps	1.125 Mbps	5.625 Mbps
6 Mbps	1.5 Mbps	7.5 Mbps
LEGEND		
IP: Internet Protocol	kbps: Kilobits per second	Mbps: Megabits per second

UCR 2013, Section 7, Table 7.3-2, Maximum Number of EIs Allowed per WLAS, lists the bandwidth available based on an engineered solution of 25 percent allocation of the bandwidth to video. Unlike voice, video does not have the single point of failure requirements. Thus, the capacity or available bandwidth on a link pair is based on the aggregate total, not one half used in the voice calculations. Table 7.8-4.

Table 7.8-4. Video over IP Bandwidth

ASLAN PRODUCT	LINK TYPE	LINK SIZE	# VIDEO OVER IP BW	# 384 KBPS SESSIONS
Core	IP Trunk Link	10 Gbps	2.5 Gbps	5000
	IP Trunk Link	1 Gbps	250 Mbps	500
	IP Trunk Link	100 Mbps	25 Mbps	50
	IP Trunk Link	10 Mbps	2.5 Mbps	5
	IP Subscriber (video only)	10 Mbps	1	NA
	IP Subscriber (converged)	100 Mbps	1	NA
Distribution	IP Trunk	10 Gbps	2.5 Gbps	5000
	IP Trunk	1 Gbps	250 Mbps	500
	IP Trunk	100 Mbps	25 Mbps	50
	IP Trunk	10 Mbps	2.5 Mbps	5
	IP Subscriber (video)	10 Mbps	1	NA
	IP Subscriber (converged)	100 Mbps	1	NA
Access	IP Trunk	10 Gbps	2.5 Gbps	5000
	IP Trunk	1 Gbps	250 Mbps	500
	IP Trunk	100 Mbps	25 Mbps	50
	IP Trunk	10 Mbps	2.5 Mbps	5
	IP Subscriber (video)	10 Mbps	1	NA
	IP Subscriber (converged)	100 Mbps	1	NA

NOTES
1. All trunks must be link pairs to meet assured service requirements. For single links, number of users is limited to 96 because of single point of failure requirements.
2. For the converged network, voice traffic was engineered not to exceed 25 percent of total utilization.
3. The minimum link for VoIP subscriber is 10 Mbps.
4. For subscribers that share voice and data (converged), minimum recommended bandwidth for the link is 100 Mbps.
5. Link pairs may use stand-by links or load balancing (e.g., link aggregation). Number of subscribers is calculated as not to exceed the link pair capacity listed above regardless of the method implemented.

LEGEND

ASLAN: Assured Services LAN	IP: Internet Protocol	Mbps: Megabits per second
BW: Bandwidth	kbps: kilobits per second	NA: Not Applicable
Gbps: Gigabits per second		

7.8.2.3 Data Services

The ASLAN will be traffic engineered to support data traffic IAW bandwidth provisioning considerations provided in Section 6.10.

7.8.3 VLAN Design and Configuration

The Virtual LANs (VLANs) offer the following features:

- Broadcast Control. Just as switches isolate collision domains for attached hosts and only forward appropriate traffic out a particular port, VLANs refine this concept further and provide complete isolation between VLANs. A VLAN is a bridging domain, and all broadcast and multicast traffic is contained within it.
- Security. The VLANs provide security in two ways:
  - High-security users can be grouped into a VLAN, possibly on the same physical segment, and no users outside of that VLAN can communicate with them.
  - The VLANs are logical groups that behave like physically separate entities; inter-VLAN communication is achieved through a router. When inter-VLAN communication occurs through a router, all the security and filtering functionality that routers traditionally provide can be used because routers are able to look at Layer 3 information.

Two ways of defining a VLAN are as follows:

1. Port-Based. Port-based VLANs are VLANs that are dependent on the physical port that a product is connected to. All traffic that traverses the port is marked with the VLAN configured for that port. Each physical port on the switch can support only one VLAN. With port-based VLANs, no Layer 3 address recognition takes place. All traffic within the VLAN is switched, and traffic between VLANs is routed (by an external router or by a router within the switch). This type of VLAN is also known as a segment-based VLAN (see Figure 7.8-2, Port-Based VLANs).

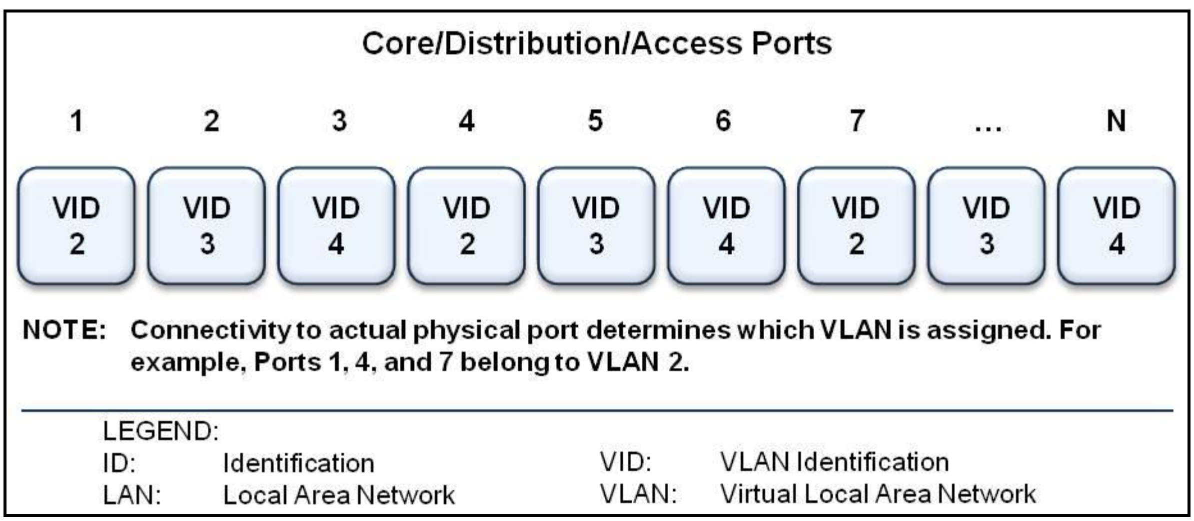


Figure 7.8-2. Port-Based VLANs

2. Institute of Electrical and Electronics Engineers (IEEE) 802.1Q. VLANs can be assigned by end products in accordance with (IAW) the IEEE 802.1Q VLAN ID tag.

7.8.4 Power Backup

To meet UC requirements for assured services, ASLAN equipment serving F/FO and I/P users must be provided with backup power. The ASLAN must meet the power requirements outlined. The following requirements for emergency power systems (EPSs) are bare minimum requirements. An EPS may be any combination of uninterruptible power source (e.g., batteries) or auxiliary power (e.g., generator) that it will provide near-instantaneous protection from input power interruptions. These requirements should be increased following the guidance in Telcordia Technologies GR-513-CORE to meet site operational requirements and extenuating characteristics of the application environment. Figure 7.8-3, ASLAN UPS Power Requirements, illustrates a typical arrangement of how the minimum power backup requirements can be met.

- F/FO. The ASLAN must provide an 8-hour backup capability in the event of primary power loss to F/FO user. Any ASLAN product, Core, Distribution, or Access, that supplies service to the F/FO user must have an 8-hour uninterruptible power supply (UPS).
- I/P. The ASLAN must provide 2-hour backup capability in the event of primary power loss to I/P users. Any ASLAN product, core, distribution, or access that supplies service to the I/P user must have a 2-hour UPS.
- R or Non-mission critical. R or non-mission critical users may lose telephony service in the event of a power failure. Commanders who are relying on voice communications to fulfill their responsibility for safety and force protection must take the above into account when implementing VoIP.

  NOTE: Backup Power (Environmental). Environmental systems (including but not limited to heating, ventilation and air conditioning) required to sustain continuous LAN equipment operation shall have backup power. Backup power may be provided by the same system used by the LAN or a separate backup system.

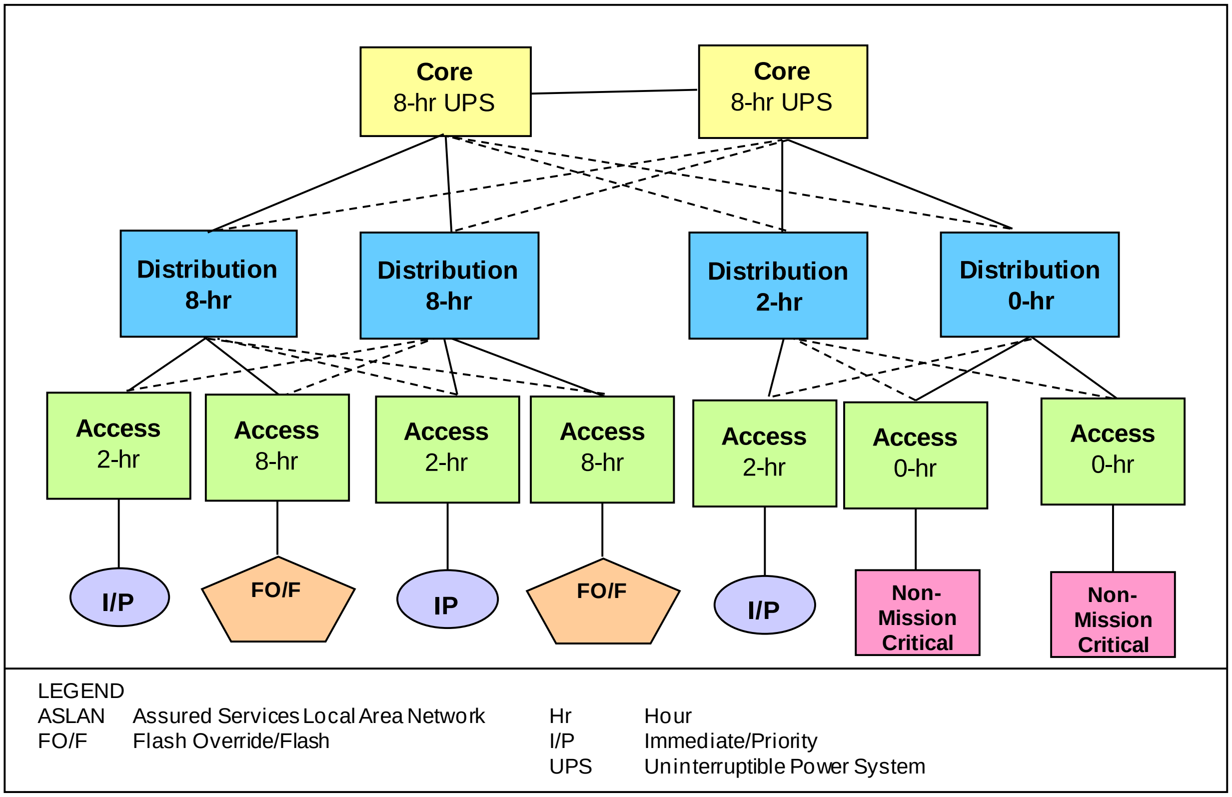


Figure 7.8-3. ASLAN UPS Power Requirements

7.8.5 Availability

The terms reliability, resiliency, and availability are sometimes used interchangeably. However, although all three terms are related to the concept of high availability, it is important to note the differences in terminology. Reliability is the probability that a system will not fail during a specified period of time. Resiliency is the ability of a system to recover to its normal operating form after a failure or an outage. Availability is the ratio of time that a service is available to total time.

Availability can be expressed as mean time between failure (MTBF) and mean time to repair (MTTR), and expressed in mathematical terms as:

Availability = MTBF/(MTBF+MTTR)

MTBF is tied to the reliability of the system, while MTTR and resiliency are closely related. Thus system availability increases as the reliability and/or resiliency of the system is increased. Availability is typically expressed in percentage of time the system is available or in downtime per year. The two methods of expressing availability are equivalent and related as shown in Table 7.8-5, Methods of Expressing Availability.

Table 7.8-5. Methods of Expressing Availability

NUMBER OF 9'S	AVAILABILITY	DOWNTIME PER YEAR
1	90.0%	36 days, 12 hrs
2	99.0%	87 hrs, 36 mins
2 (non-AS)	99.8%	17 hrs, 31 mins
3	99.9%	8 hrs, 46 mins
4	99.99%	52 mins, 33 secs
5	99.999%	5 mins, 15 secs
6	99.9999%	31.5 secs
LEGEND hrs: hours	mins: minutes	secs: seconds

The ASLAN has two configurations depending on whether it supports F/FO or I/P users. The ASLAN shall have a hardware availability designed to meet the needs of its subscribers:

- F/FO. An ASLAN that supports F/FO users is classified a High Availability ASLAN and must meet 99.999 percent availability to include scheduled maintenance.
- I/P. An ASLAN that supports I/P users is classified as a Medium Availability ASLAN and must have 99.997 percent availability to include scheduled maintenance.

The non-ASLAN shall provide an availability of 99.8 percent to include scheduled maintenance. R users who originate ROUTINE-only precedence calls but terminate any precedence level may be supported on a non-ASLAN, but the non-ASLAN must support Multilevel Precedence and Preemption (MLPP) for the R users. F/FO or I/P users shall not be supported on a non-ASLAN.

The methods for calculating reliability are found in Section 2, Session Control Products.

7.8.6 Maintainability

The following information is proved as an engineering guideline:

Maintainability is described in MIL-HDBK-470A as:

> "The relative ease and economy of time and resources with which an item can be retained in, or restored to, a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair. In this context, it is a function of design."

Operational availability is similar to inherent availability but includes the effects of maintenance delays and other non-design factors.

The equation for operational availability, or Ao, is:

$$Ao = MTBM/(MTBM + MDT)$$

where MTBM is the mean time between maintenance and MDT is the mean downtime.

(NOTE: MTBM addresses all maintenance, corrective and preventive, whereas MTBF only accounts for failures. MDT includes MTTR and all other time involved with downtime, such as delays. Thus, Ao reflects the totality of the inherent design of the product, the availability of maintenance personnel and spares, maintenance policy and concepts, and other non-design factors, whereas availability reflects only the inherent design.)

When acquiring products for the ASLAN, maintainability of the products must be taken into consideration. Based on the need to meet operational availability for F/FO and I/P users, it is recommended that all ASLAN components have maintenance contracts in place that can replace key components in 24 hours or less.

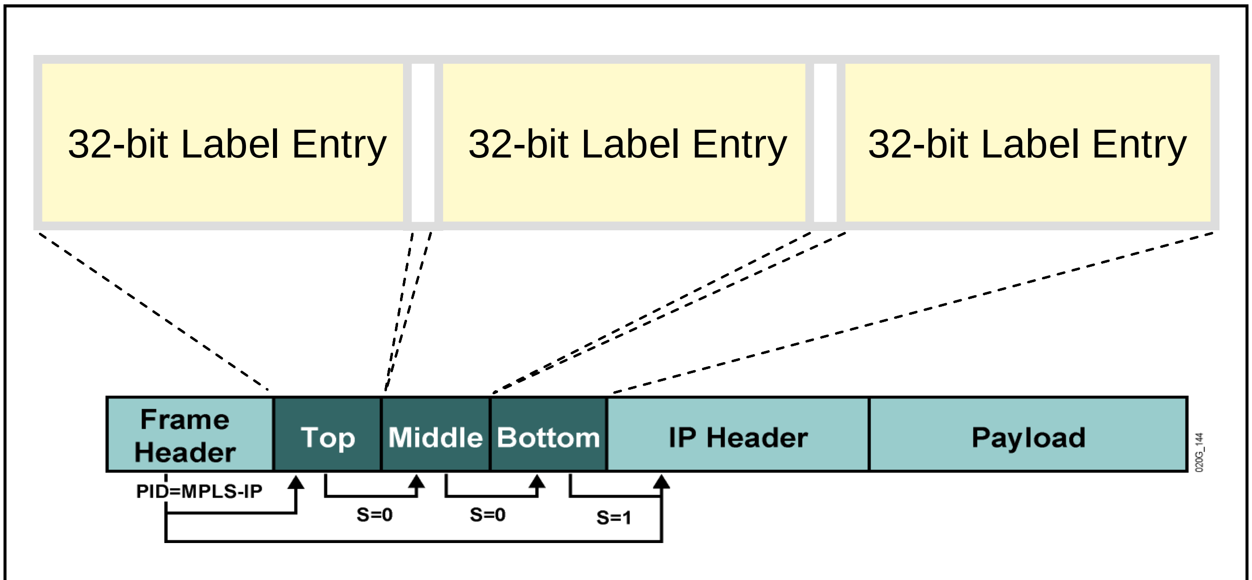
7.8.7 MPLS Background

Traditional IP packet forwarding uses the IP destination address in the packet's header to make an independent forwarding decision at each router in the network. These hop-by-hop decisions are based on network layer routing protocols, such as Open Shortest Path First (OSPF) or Border Gateway Protocol (BGP). These network layer routing protocols are designed to find an efficient path through the network, and do not consider other factors, such as latency or traffic congestion. Multiprotocol label switching creates a connection-based model overlaid onto the traditionally connectionless framework of IP routed networks. Multiprotocol label switching works by prefixing packets with an MPLS header, containing one or more "labels," as shown in Figure 7.8-4, MPLS Header, and Figure 7.8-5, MPLS Header Stacking. These short, fixed-length labels carry the information that tells each switching node how to process and forward the packets, from source to destination. Labels have significance only on a local node-to-node connection. As each node forwards the packet, it swaps the current label for the appropriate label to route the packet to the next node.

00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Label																				Exp			S	TTL							

LEGEND:
EXP Experimental Functions
S Stack Functions
TTL Time to Live

Figure 7.8-4. MPLS Header

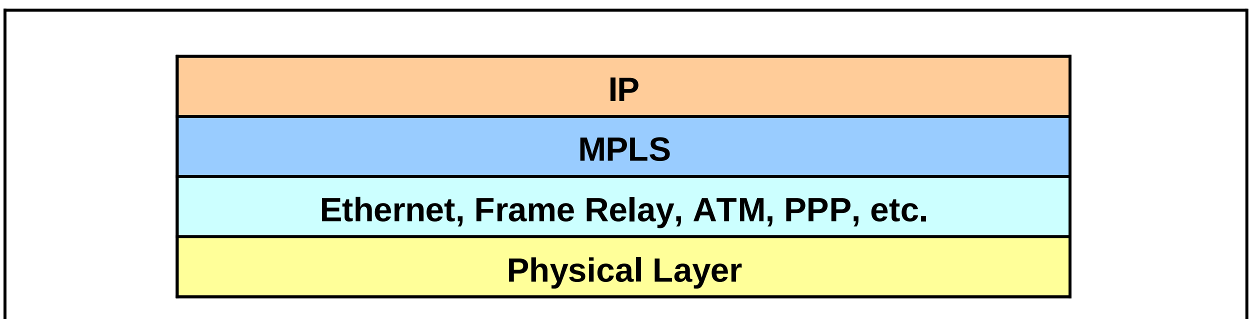


LEGEND

IP	Internet Protocol	PID	Protocol Identifier Data
MPLS	Multiprotocol Label Switching	S	Stack Function

Figure 7.8-5. MPLS Header Stacking

Multiprotocol label switching relies on traditional IP routing protocols to advertise and establish the network topology. Multiprotocol label switching predetermines the path data takes across a network and encodes that information into a label that the network's routers understand. The MPLS operates at an OSI layer that is generally considered to lie between traditional definitions of Layer 2 (Data Link Layer) and Layer 3 (Network Layer). Figure 7.8-6, MPLS OSI Layer, illustrates the OSI Layer position of MPLS.



LEGEND:

ATM	Asynchronous Transfer Mode	MPLS	Multiprotocol Label Switching
IP	Internet Protocol	PPP	Point-to-Point Protocol

Figure 7.8-6. MPLS OSI Layer

7.8.8 MPLS Terminology

Definitions of terms can be found in Appendix C, Glossary and Terminology Description.

7.8.9 DoD LAN MPLS Operational Framework

The previous ASLAN sections detail requirements up to and including the Core LAN router devices. To interconnect Core or Distribution ASLAN routers on a B/C/P/S, transport technologies, such as MPLS, can be used. Figure 7.8-7, ASLAN MPLS Operational Framework, depicts DoD's ASLAN MPLS implementation. This section does not address WAN requirements for use of MPLS with the DISN backbone.

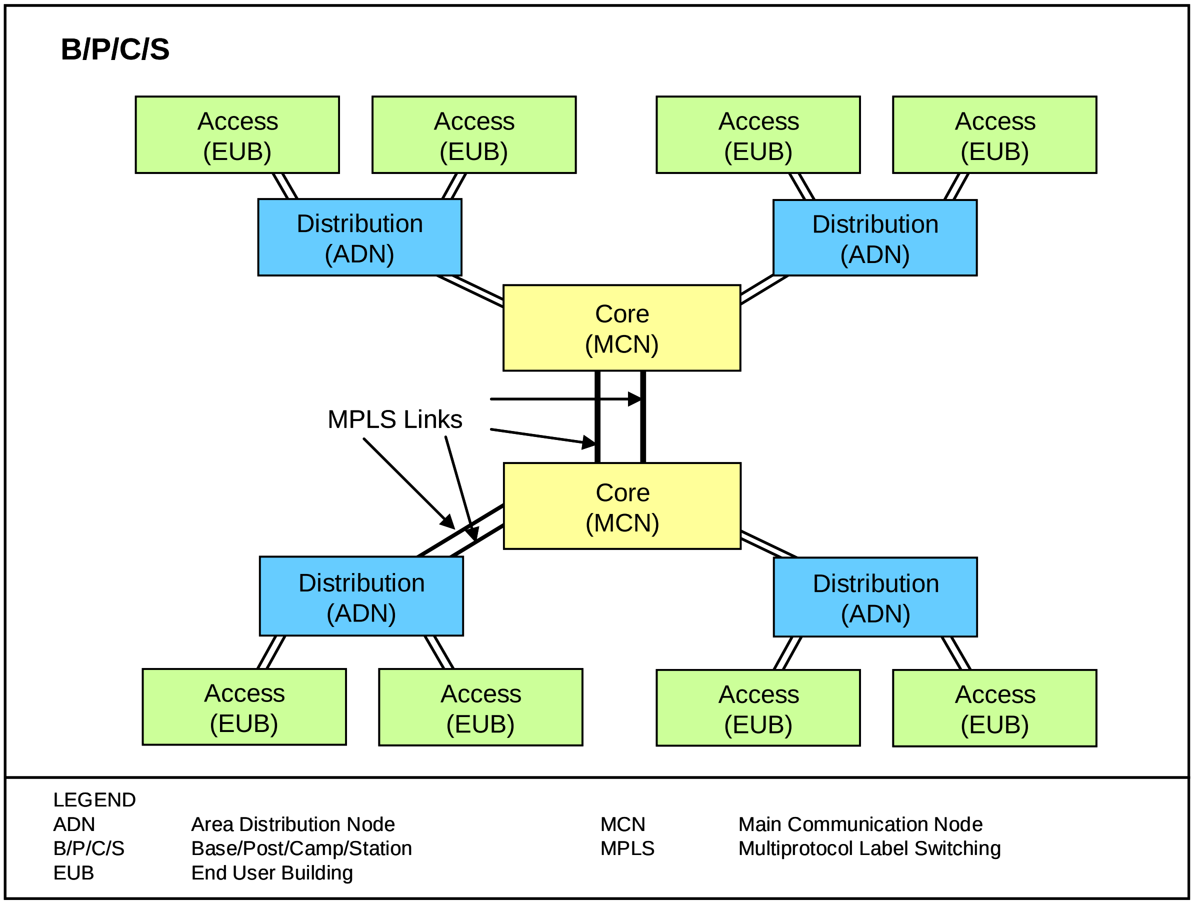


Figure 7.8-7. ASLAN MPLS Operational Framework

7.8.10 Primary Application Support

DSL is primarily used at military facilities to provide Local Area Network (LAN) interconnection. As such, the primary DSL functions that support this application are as follows:

- Symmetrical bandwidth (available with some DSL access technologies).
- Use of DSL repeaters to provide an extended range of operation.
- Point-to-Point configurations.
- Point-to-Multi-Point configurations.

7.8.11 DSL Overview

DSL uses existing twisted-pair telephone lines to transport high-bandwidth data, such as multimedia and video, between endpoints. The term xDSL covers a number of DSL technologies. Those that are standards-based are shown in Table 7.8-6, ITU DSL Standards Overview.

Table 7.8-6. ITU DSL Standards Overview

VERSION	STANDARD	COMMON NAME	DOWNSTREAM RATE	UPSTREAM RATE	INITIALLY APPROVED IN
High Bit Rate DSL (HDSL)	ITU G.991.1	HDSL/2/4 (multi pair)	1.5-2.0 Mbps	1.5-2.0 Mbps	1998
ADSL	ITU G.992.1	ADSL (G.DMT)	6.144 Mbps	640 Kbps	1999
ADSL	ITU G.992.2	ADSL Lite (G.Lite)	1.5 Mbps	0.5 Mbps	1999
ADSL	ITU G.992.1 Annex A	ADSL over POTS	6.144 Mbps	640 Kbps	1999
Very High Speed DSL (VDSL)	ITU G.993.1	VDSL	52 Mbps	16 Mbps	2001
ADSL2	ITU G.992.3 Annex J	ADSL2	8 Mbps	800 Kbps	2002
ADSL2	ITU G.992.3	ADSL2	8 Mbps	800 Kbps	2002
ADSL2	ITU G.992.4	Splitterless ADSL2	1.5 Mbps	0.5 Mbps	2002
Single Pair High-Speed DSL (SHDSL)	ITU G.991.2	G.SHDSL (single pair)	2.3 Mbps	2.3 Mbps	2003
ADSL2+	ITU G.992.5	ADSL2+	24 Mbps	1.3 Mbps	2003
ADSL	ITU G.992.1 Annex B	ADSL over ISDN	12 Mbps	1.8 Mbps	2005
ADSL2	ITU G.992.3 Annex L	RE-ADSL2	5 Mbps	0.8 Mbps	2005
VDSL2	ITU G.993.2	VDSL2	100 Mbps[1]	100 Mbps[1]	2006
ADSL2+	ITU G.992.5 Annex M	ADSL2+M	24 Mbps	3.3 Mbps	2008
NOTE: VDSL2 supports transmission at a bidirectional net data rate (the sum of upstream and downstream rates) up to 200 Mbps.					

Many of these DSL technologies support both analog voice services and high-bandwidth digital data services (which may include UC VoIP and Video over IP services). In this case, different frequency bands are used on each twisted-pair copper telephone line for the analog voice service and the digital data service.

7.8.11.1 DSL Bonding

Wire bonding solutions provide a method for combining multiple copper DSL connections (with the same or different bit rates) together into a single, aggregate connection. This technology is extremely valuable when support for high-speed services must be provided. Bonding can allow delivery of high-bandwidth services even when the bandwidth of individual DSL connections is relatively low.

Three DSL bonding standards are defined in Table 7.8-7, DSL Bonding Standards.

Table 7.8-7. DSL Bonding Standards

ITU-T STANDARD	DESCRIPTION
G.998.1	ATM-based multi-pair bonding: A method for bonding of multiple DSL lines to transport an ATM payload beyond the rate/reach capability of a single DSL loop. This protocol allows the bonding of 2 to 32 pairs and supports dynamic removal and restoration of pairs without human intervention.
G.998.2	Ethernet-based multi-pair bonding: Provides a method for bonding of multiple DSL lines for Ethernet transport. This recommendation builds on IEEE 802.3ah-2004 Ethernet in the First Mile (EFM) methods, and extends Ethernet transport over multiple xDSL technologies, including ADSL.
G.998.3	Multi-pair bonding using time-division inverse multiplexing: Details a method for bonding DSL lines using Time-Division Inverse Multiplexing (TDIM). This recommendation uses IEEE 802.3ah handshakes for pair discovery, parameter negotiation, and setup. It also allows the hitless addition and removal of pairs (i.e., without any service disruption) and the fast removal of a pair upon pair failure.

7.8.12 Ethernet in the First Mile Over Copper (EFMCu)

Ethernet in the first mile (EFM) is known as IEEE 802.3ah and defines Ethernet in the access network, i.e., first or last mile. EFMCu defines interfaces over voice-grade copper with optional multi-pair aggregation or bonding transmission.

EFMCu allows for deployment of resilient symmetrical Ethernet Access links over existing voice-grade copper infrastructure, providing an economical alternative to fiber and a solution where only voice-grade copper infrastructure exists.

There are two standardized EFMCu technologies:

- Long reach 2BASE-TL, delivering a minimum of 2 Mbps and a maximum of 5.69 Mbps over distances of at least 2700 m, using standard G.SHDSL.bis technology over a single copper pair.
- Short reach 10PASS-TS, delivering a minimum of 10 Mbps over distances of at least 750 m, using standard VDSL technology over a single copper pair.

7.8.13 DSL-Based ASLAN Interconnection Operational Framework

DSL or EFMCu connections are used to provide ASLAN interconnection in the Network Edge Segment. Either can be utilized in cases where voice-grade wiring is the only choice for linking ASLANs in different buildings within a military base. DSL or EFMCu utilization within a base is described in the following sections.

7.8.13.1 Point-to-Point Interconnection of ASLANs

Figure 7.8-8, Point-to-Point LAN Interconnection, illustrates the simplest scenario for DSL use on a military base is for basic point-to-point LAN interconnection. This can be used for connectivity within an ASLAN, or for connectivity between ASLANs on the same base. It makes use of Unshielded Twisted Pair (UTP) copper phone cables for connectivity.

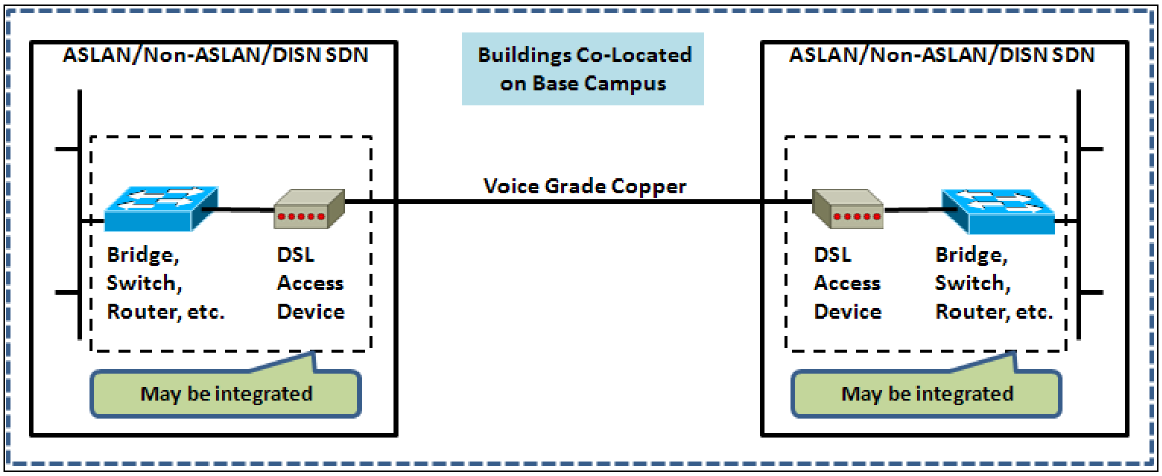


Figure 7.8-8. Point-to-Point LAN Interconnection

At each location is a DSL access device which contains a DSL line interface (on the voice-grade copper side) and typically an Ethernet physical interface (on the LAN side). At a minimum, the DSL access device supports data bridging between its two sides, but it may have additional functionality built in, such as LAN switching and IP routing.

7.8.13.2 Point-to-Multipoint Interconnection of ASLANs

As illustrated in Figure 7.8-9, Point-to-Multipoint Interconnection Concentration, a more complicated scenario for DSL use on a military base is for point-to-multipoint LAN interconnection. This can be used for aggregating connectivity of ASLANs to a single or multiple core locations within the same base. It also makes use of UTP copper phone cables for connectivity.

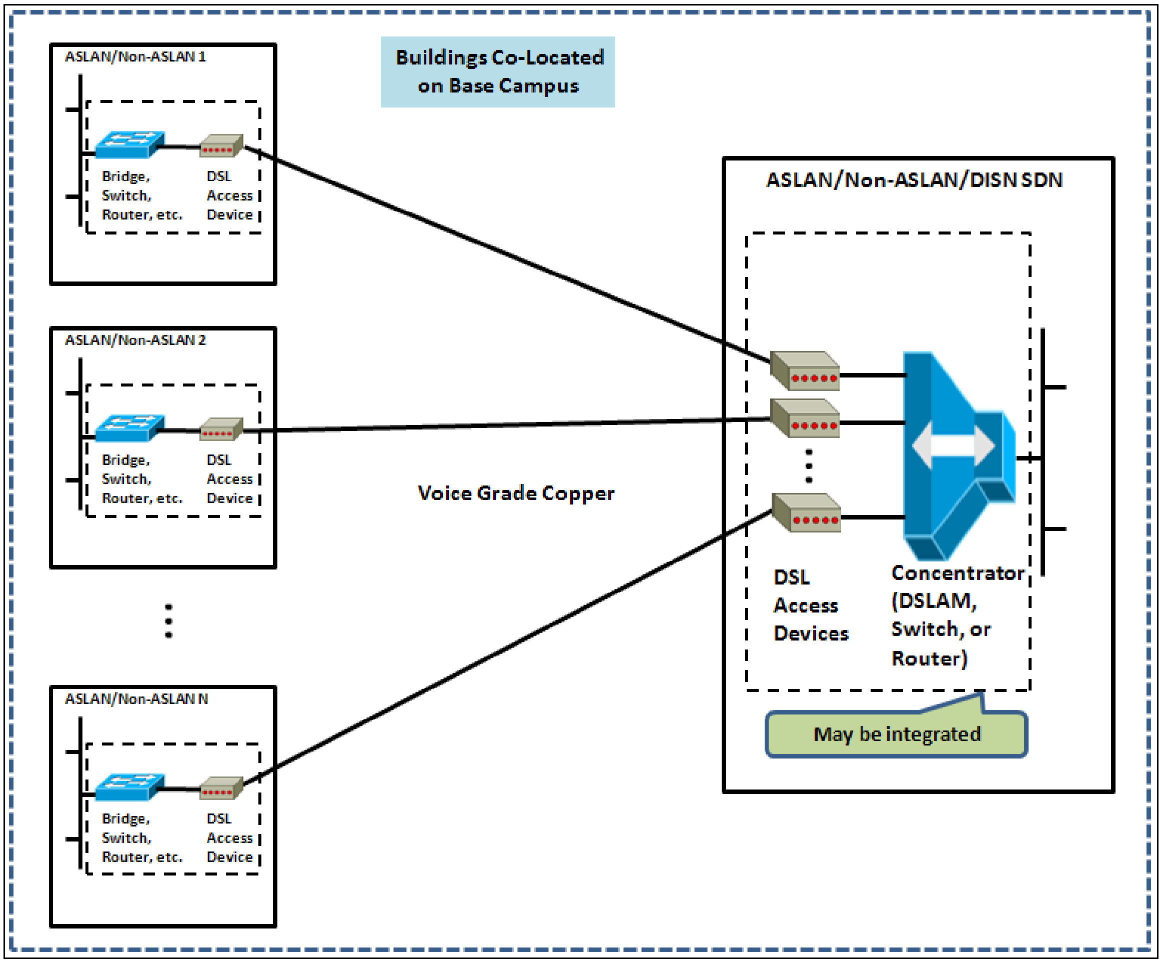


Figure 7.8-9. Point-to-Multipoint Interconnection Concentration

In this scenario, a Concentrator handles connectivity for multiple ASLAN locations and then aggregates traffic that is destined for remote destinations. Typically, the Concentrator is a DSL Access Manager (DSLAM), a Bridge, or a Router, all of which have advanced functionality to support switching or routing of IP packets between local ASLANs, and forwarding/routing of IP brackets between local DSLAMs and remote destinations.

DSLAMs can support a very large amount of interfaces (e.g., multiple 19 inch/23 inch racks of equipment that support hundreds of access interfaces), or they can be very small, mini-DSLAMs that support less than one hundred access interfaces.

7.8.13.3 DSL Repeaters

There may be situations where the distance between two ASLANs is too long to support a single DSL connection. In this scenario, a solution could be to use multiple DSL wire hops to bridge the link. While the total distance may be too great for a single DSL transmitter/receiver pair, cascading two separate DSL links may provide the solution. In this case, a DSL repeater could be used to amplify the DSL signal at a midpoint in the total link to provide enough amplification to drive the signal over the total link length. The application of a DSL repeater to extend the signal distance is shown in Figure 7.8-10, DSL Repeater Provides Extended Distance.

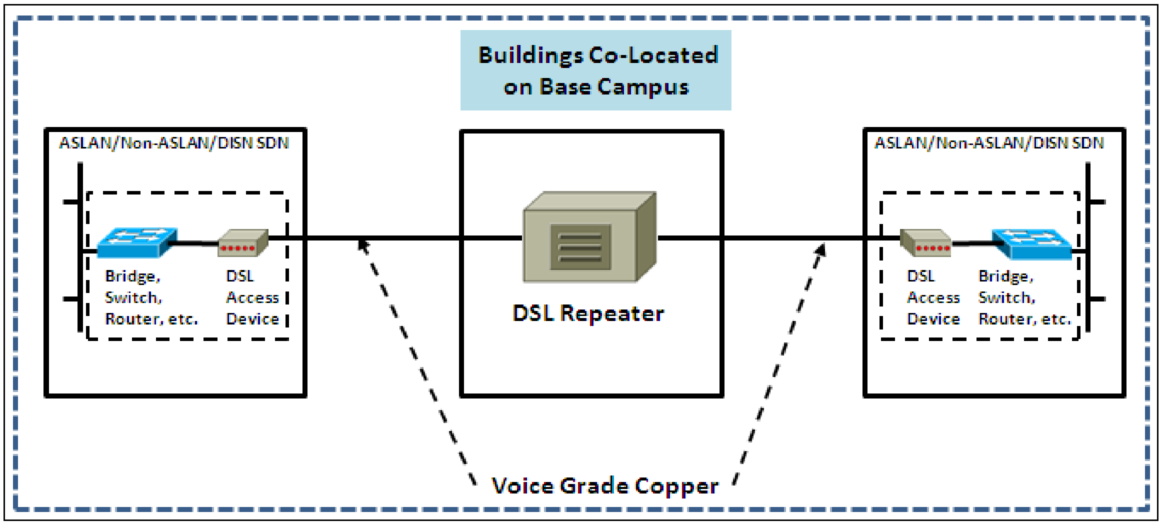


Figure 7.8-10. DSL Repeater Provides Extended Distance

Use of a DSL repeater provides extended distance/speed between DSL endpoints.

7.8.13.4 DSL Support for Analog Voice and Voice over IP (VoIP)

DSL Access Device, Concentrator, and Repeater products can also be used to carry both Analog Voice and VoIP services over existing voice-grade copper links. In this case, the Analog Voice is carried over the link using the pre-existing Analog Voice frequency band, and the VoIP is carried over the link using the separate frequency bands that the DSL products use for IP data service. A Base configuration supporting Analog Voice, IP Data, Voice over IP, and Video over IP with DSL Modems, a DSLAM, and a UC SC, is shown in Figure 7.8-11, Base Configuration Supporting Analog Voice and VoIP using DSL Modems and a DSLAM.

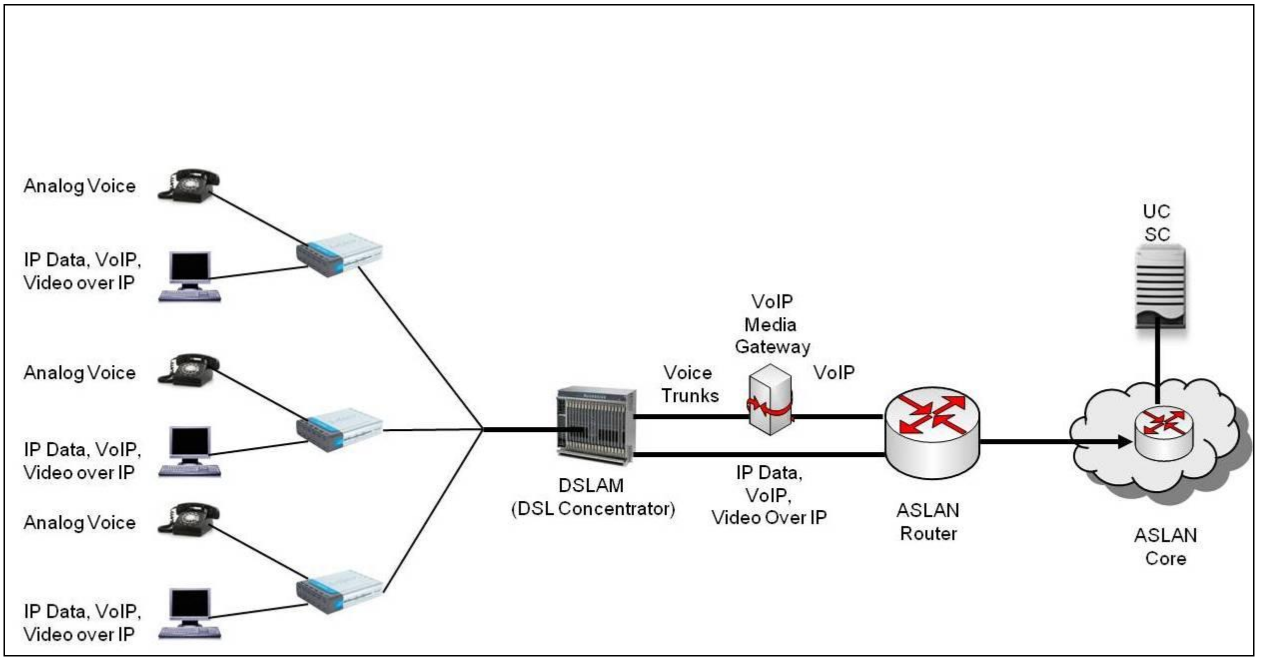


Figure 7.8-11. Base Configuration Supporting Analog Voice and VoIP Using DSL Modems and a DSLAM

In the above configuration, the Analog Voice, VoIP, and Video over IP Services are all provided by a UC SC and its associated VoIP Media Gateway on the Base. The Media Gateway provides conversion between Analog Voice service and UC VoIP service in this case. For VoIP and Video Over IP services, the DSLAM also needs to be interoperable with the ASLAN Router and the UC SC, based on the ASLAN Router requirements in this section and the SC requirements in Section 2.

On Bases that are not equipped with an SC and a Media Gateway, the Analog Voice service can be provided by an End Office or Private Branch Exchange (PBX) on the Base. When a UC SC and VoIP Media Gateway are located at the Base, the DSLAM and the MG can be interconnected using either individual analog lines (e.g., Unshielded Twisted Pairs) or by an Integrated Services Digital Network (ISDN) PRI, that multiplexes the analog lines onto one or more T1 facilities. In this case, the DSLAM also needs to be interoperable with the MG ISDN PRI requirements in Section 2, Session Control Products.

It is also possible for the DSLAM and the VoIP Media Gateway to be integrated into a single product. In this case, the DSLAM side of the product needs to meet the Concentrator requirements in this section, and the MG side of the product needs to meet the MG requirements in Section 2, Session Control Products. Support for integrated DSLAM/MG products is not required.

7.8.14 References

The following References were used in the DSL Requirements Section:

G.991.1 ITU-T Recommendation G.991.1, "High bit rate digital subscriber line (HDSL) transceivers," 1998.

G.991.2 ITU-T Recommendation G.991.2, "Single-pair high-speed digital subscriber line (SHDSL) transceivers," 1998.

G.992.1 ITU-T Recommendation G.992.1, "Asymmetric digital subscriber line (ADSL) transceivers," 1999.

G.992.2 ITU-T Recommendation G.992.2, "Splitterless asymmetric digital subscriber line (ADSL) transceivers," 1999.

G.992.3 ITU-T Recommendation G.992.3, "Asymmetric digital subscriber line transceivers 2 (ADSL2)," 2009.

G.992.4 ITU-T Recommendation G.992.4, "Splitterless asymmetric digital subscriber line transceivers 2 (splitterless ADSL2)," 2002.

G.992.5 ITU-T Recommendation G.992.5, "Asymmetric digital subscriber line (ADSL) transceivers – Extended bandwidth ADSL2 (ADSL2plus)," 2009.

G.993.1 ITU-T Recommendation G.993.1, "Very high speed digital subscriber line transceivers (VDSL)," 2004.

G.993.2 ITU-T Recommendation G.993.2, "Very high speed digital subscriber line transceivers 2 (VDSL2)," 2006.

G.998.1 ITU-T Recommendation G.998.1, "ATM-based multi-pair bonding," 2005.

G.998.2 ITU-T Recommendation G.998.2, "Ethernet-based multi-pair bonding," 2005.

G.998.3 ITU-T Recommendation G.998.3, "Multi-pair bonding using time-division inverse multiplexing," 2005.

I.361 ITU-T Recommendation I.361, "B-ISDN ATM layer specification," 1999.

I.363.5 ITU-T Recommendation I.363.5, "B-ISDN ATM Adaptation Layer specification: Type 5 AAL," 1999.

RFC 1990 K. Sklower, B. Lloyd, et al, "The PPP Multilink Protocol (MP)," August 1996.

802.1D IEEE Standard for Local and Metropolitan Area Networks: Media Access Control (MAC) Bridges, June 2004.

802.1Q IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks, 2003.

802.3 IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, 26 December 2008.

802.3ab	IEEE Standard for information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications: 1000BASE-T Gbit/s Ethernet over twisted pair at 1 Gbit/s (125 MB/s), 1999.
802.3ah	IEEE Standard for information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks, 2004.
802.3i	IEEE Standard for information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications: 10BASE-T 10 Mbps (1.25 MB/s) over twisted pair, 1990.
802.3u	IEEE Standard for information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications: 100BASE-TX, 100BASE-T4, 100BASE-FX Fast Ethernet at 100 Mbps (12.5 MB/s) w/auto-negotiation, 1995.
802.3z	IEEE Standard for information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications: 1000BASE-X Gbit/s Ethernet over Fiber-Optic at 1 Gbit/s (125 MB/s), 1998.

7.9 REGIONAL ASLAN

Regional ASLAN designs are used where a local service enclave covers a large geographical area. Regional ASLANs typically consist of a single security enclave. Regional ASLANs use a centralized Enterprise SC (ESC) with redundancy and automatic failover of an EI to a “backup” SC, high-speed links with MPLS at the LAN core layer, and remote MGs.