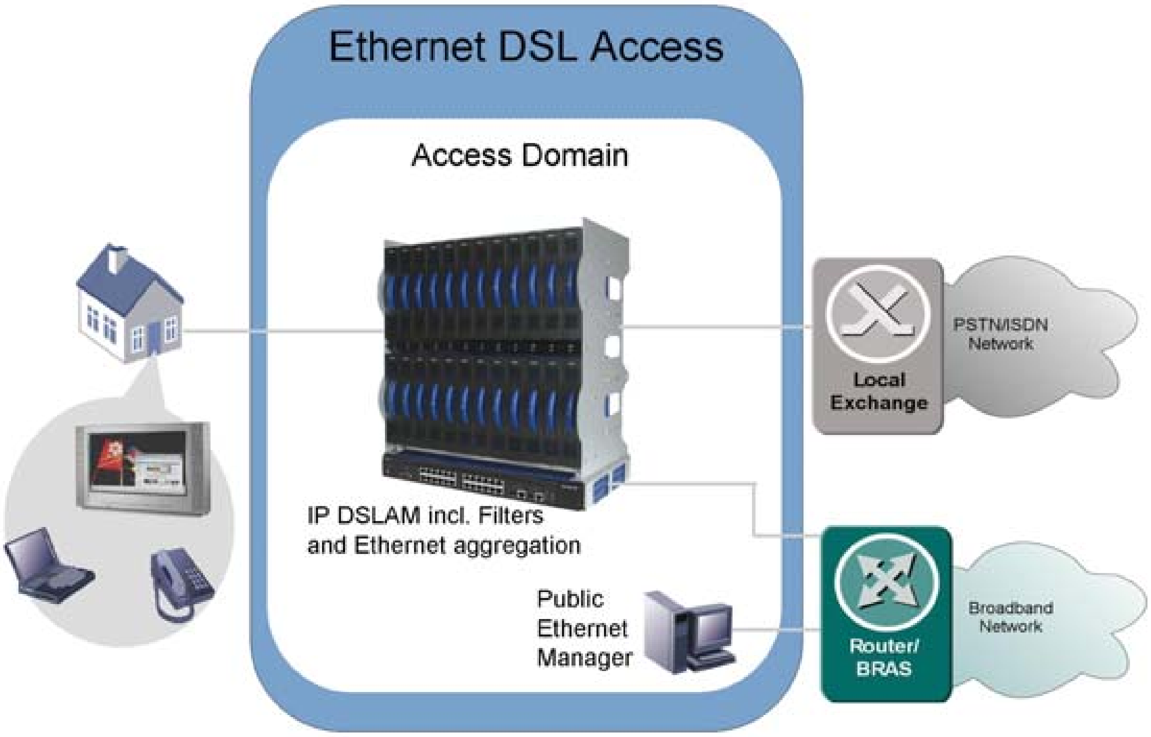
System Overview

EDA



ERICSSON

System Overview

EDA

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Contents

1 Introduction to this Guide

This guide is intended to provide the reader with an overview of the EDA system and concept. The guide describes the different elements forming an EDA network, and how they interact in order to constitute a versatile and flexible ADSL access network.

The guide may be read without prior knowledge of EDA and the technologies used, but to fully understand the system function the reader should be familiar with the basics of IP (Internet Protocol) technology.
The guide can be printed on a monochrome printer, but illustrations are easier to understand if a color printer is used.

1.1 Revision History

The guide is valid for EDA 2.2 R2A. Other product versions, with functions not described in this guide, may be available.

1.1.1 This revision (C)

The following changes have been made:

- Minor changes section 4.2 on page 26.

1.1.2 Version B

The following changes have been made:

- Line bonding description added.

1.1.3 Version A

This is the first version based on *System Overview* 1/1551-HSC901 35/2 Uen B. The following changes have been made:

- ECN330 added.
- Section 6 on page 40 rewritten.
- New subrack solutions added

Version A was never publicly published.

2 The EDA Concept

The EDA system can be tailored to a wide range of access scenarios, depending on the actual requirements to function and performance. Performance requirements are about for example the number of end-users that the access system can handle, and the bandwidth allocated to the end-users. The functional requirements are more versatile, covering for example which IP services to support, how to ensure security and privacy, and how to provide options for service selection.

Both performance requirements and function requirements will often vary significantly from one access scenario to another. Consequently, the EDA system is designed to allow adaptation to almost any possible scenario.

The demand for broadband access to homes and small businesses is rapidly increasing these years. Several technologies have been developed to meet this demand - one technology is DSL (Digital Subscriber Line). In DSL the telephony copper lines between end-users and the local exchange are used for providing high-speed data access.

There are several types of DSL, characterized by a theoretical maximum data rate offered to the individual end-users. Today, the most common type is Asymmetric DSL (ADSL) in which the maximum data rates are approximately 8 Mbps downstream (to the end-user), and 1 Mbps upstream (from the end-user).

EDA is the product name for Ericsson's ADSL access system. The concept sets a new standard for implementing digital access systems in a fast, flexible and future-proof way. EDA solves the major problems faced by operators who want to go for mass-deployment of ADSL. These problems include the relatively large number of man-hours required to install, configure and manage traditional ADSL systems, the size and poor scalability of these systems, and the growing requirements to provide flexible unbundling of the local loop. The following summarizes the EDA concept:

- Complete ADSL concept providing Ethernet based access
- Ultra compact DSLAM
- Developed and optimized for easy deployment and maintenance
- Adaptable to any broadband access scenario and penetration rate
- Well suited for unbundling scenarios

2.1 ADSL Standards

The EDA system supports the following ADSL standards:

- ITU-T G992.1 Annex A (ADSL over POTS)
- ITU-T G992.1 Annex B (ADSL over ISDN)
- ITU-T G992.2 (ADSL Lite)
- ITU-T G992.3 Annex A (ADSL2 over POTS)
- ITU-T G992.3 Annex B (ADSL2 over ISDN)
- ITU-T G992.3 Annex L (Extended Reach)
- ITU-T G992.3 Annex M
- ITU-T G992.5 (ADSL2+) Annex A and B
- ITU-T G992.5 Annex L and M

Broadband Access over the Local Loop: Like traditional DSL systems EDA provides broadband access over the local loop copper wires. Traditional ADSL systems are based on a DSL access multiplexer (DSLAM), which terminates the ADSL protocol layer towards the end-user. The ATM connections running on top of the ADSL layer may be terminated locally in an access node, or they may be conveyed over an ATM backbone network to a remote Service Provider. New end-users obtain ADSL access through individual wires drawn from their position in the main distribution frame (MDF) to the DSLAM.

Transmission technology shift from ATM to Ethernet: With EDA the main transmission technology is shifted from ATM to Ethernet. Compared to ATM, the Ethernet technology is superior on important areas like scalability, simplicity and equipment cost.

IP all the way: EDA deploys an “IP all the way” system supporting integrated high-speed always-on triple play services (data, video and voice) and supports more advanced services such as multicasting. EDA also provides an innovative solution for base band telephony.

2.2 The EDA System – Basic Principle

The basic principle of the EDA System is illustrated below in Figure 1 on page 4.

The end-users are connected to the EDA network through the IP DSLAM. The IP DSLAM is connected to an aggregation node, which provides layer-2 Ethernet switching and subsequently connects the end-users to various IP services through the EDA access network. The EDA system is managed by the EDA Management System called Public Ethernet Management (PEM).

The EDA system supports base band POTS, base band ISDN and telephony over IP. Telephony over IP, and one base band telephony, either POTS or ISDN, may coexist within a single EDA system and each end-user can be allowed to access any of the applications, including all in parallel. The EDA system can interface to any local exchange. The IP DSLAM separates ADSL signals from base band signals, and base band signals (telephony) are sent to the local exchange.

The EDA system can be extended to create different types of multi-service network architectures. For example by adding a broadband remote access server (BRAS), authentication, authorization and accounting (AAA) can be provided. Please note that neither BRAS nor telephony over IP is part of the EDA solution.

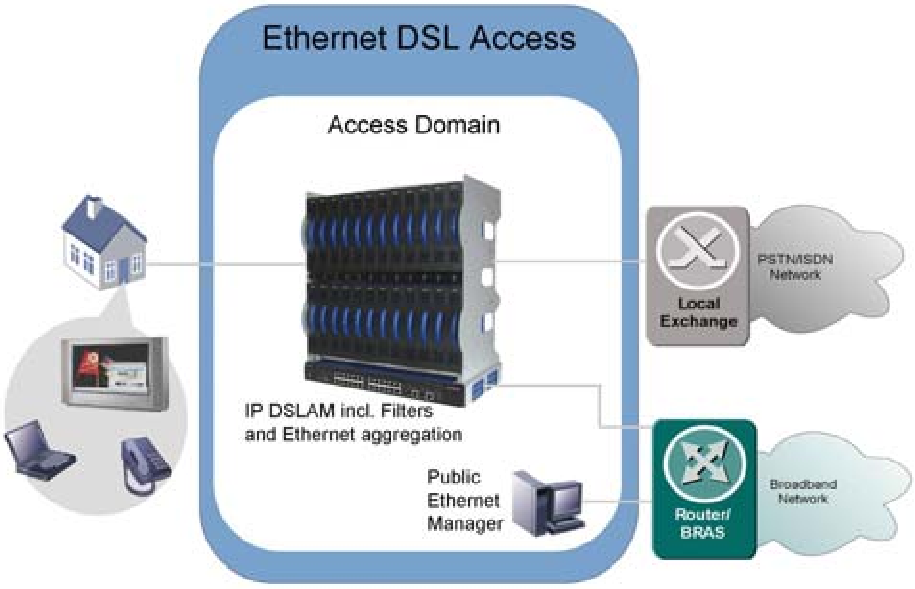


Figure 1 The EDA Concept Basic Principle

2.2.1 The IP DSLAM

The IP DSLAM is the cornerstone in the EDA system.

It converts and aggregates all incoming ADSL subscriber lines into a 100 Mbps Ethernet connection and as opposed to a traditional DSLAM system, the ATM layer in the ADSL protocol stack is terminated directly in the IP DSLAM. By using link aggregation the subscriber lines can be increased to 200 Mbps connections.

To ensure high security for end-users and EDA equipment the IP DSLAMs are capable of filtering the traffic in both upstream and downstream direction.

The Ethernet based access function provided by the IP DSLAMs can be extended to create different types of multi-service network architectures.

The EDA system is built around a number of different IP DSLAMS described in more detail in section 4 on page 13.

2.2.1.1 Line Bonding

The IP DSLAM enables bonding of lines in order to provide high or very high bandwidth to End-users. Line bonding is defining and using several twisted pairs copper wires as a one line. Up to six lines can be bonded, enabling a theoretical downstream bandwidth 132 Mbps. 44 Mbps can be achieved with two bonded lines (1.5 km or less). Figure 2 on page 5 illustrates a comparison of line bandwidths using ADSL, ADSL2+ and two bonded ADSL2+.

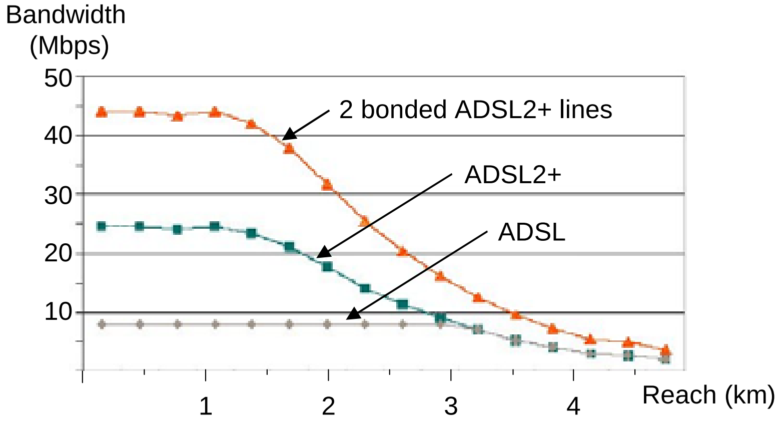


Figure 2 Line Bonding Utilization

2.2.2 The Aggregation Node

As shown in Figure 1 on page 4 the IP DSLAMs are connected to an aggregation node. Ethernet switches can be used as aggregation nodes and provide the capability to increase the LAN bandwidth because they allow for simultaneous switching of data packets between their ports. Furthermore, an Ethernet switch may be able to perform more advanced functions regarding traffic, such as prioritizing and separation.

A typical EDA switch used in an EDA system is the ESN310, which has 24 100 Mbps ports and two Gigabit Ethernet ports for the aggregated traffic towards the edge node. The ESN310 has built-in power over Ethernet and can thus supply the IP DSLAMS with –48 V power.

The Ethernet Controller Node and the EAN

Another type of aggregation node is the Ethernet Controller Node ECN, which also provides layer-2 Ethernet switching with built-in power over Ethernet, but has additional functions like automatic loading of software and configuration data into the connected EDA nodes. The ECN has a built-in node controller. It is a self-sustained IP DSLAM so to speak, composed of a number of IP DSLAMs (EDN312) connected to the ECN330/ECN320 either directly or through the EDA 8-port switch ESN108.

One of the key features of the EAN is the ability to act as a single node in the EDA network, and all the “embedded” IP DSLAMs are added or removed in a true plug-and-play way. The ECN330/ECN320 automatically registers the nodes and their ports making implementation, expansion and replacement of nodes very user-friendly and another advantage is, that network elements are maintained by the ECN330/ECN320.

This means that the EAN does not depend on the Public Ethernet Management system (PEM) when starting or restarting, and does not depend on a Domain Server during normal operation, and furthermore reduces the number of IP addresses necessary in the management network.

The ECN330/ECN320 and the EAN are described in further detail in section 4.1.4 on page 19.

2.2.3 The EDA Management System

The EDA management system provides the operator with a single aggregated management platform for the complete EDA system.

The EDA management system is called Public Ethernet Management (PEM). The management system is designed with scalability in mind, and scales from a single server solution, where all parts of the system are running on a central computer, to a fully distributed solution where different parts are deployed on multiple servers.

The Management Server contains the PEM servers and the database of the EDA system. The database contains all end-user and network configuration data. In a distributed configuration, the Management Server acts as a central point for operation and maintenance, providing the full view of the network.

PEM can be integrated through standard interface with an overlaying management system.

The management system is described in further detail in section 8 on page 68.

3 The EDA Access Network

The main objective of the EDA system is to support provisioning of IP services to end-users. The EDA system supports this through:

- Network Access
- Service Access

Network Access means providing access through the Access Domain.

Service Access means managing the end-users access to IP services.

The EDA system is mainly focused on providing network access, but it also provides several integrated service access solutions. In this way, the EDA system provides a complete IP service-enabling platform, which offers IP services such as Telephony over IP and Video over IP.

3.1 The Access Domain

An EDA network is divided into geographically separated Access Domains, as indicated in the principle illustration of the Access Network shown in Figure 3 on page 9, showing an EDA system where the network has been divided into three Access Domains. Each Access Domain is managed locally and has an interface to an operation and maintenance center that is the PEM. Furthermore the Access Domain has a Domain Server assigned to it. The Domain Server can be present in the Access Network in a physical sense but may also be installed on a Management Server.

Basically, the Access Domain is capable of conveying any network layer protocol, but the Internet Protocol (IP) is thought of as the absolute dominant layer-3 protocol used within EDA. The end-users can access IP services offered by different providers at their *Point-of-Presence* (PoP) through the backbone network.

The Ethernet within an Access Domain may span a single or multiple physical sites.

3.1.1 The Size of the Access Domain

An Access Domain has no theoretical size limit, but the practical size limits (due to IP DSLAMs start-up time, and limitations of the management system), are as follows:

The EDA system network may have up to 20 Access Domains. Each Access Domain can have up to 2,000 IP DSLAMs. The maximum number of end-users in the EDA system network is approximately 1000,000.

If the number of end-users exceeds the maximum, multiple EDA systems can be deployed.

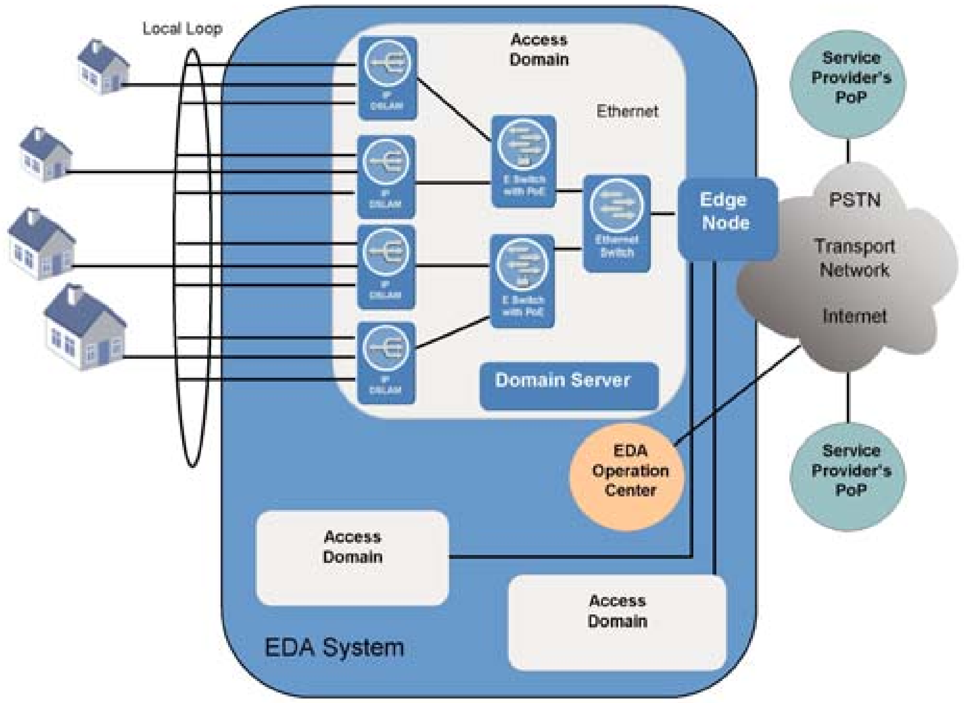


Figure 3 The Access Network

3.1.2 Domain Subnets and IP Networks

The Access Domain comprises one or more IP Networks each defined by a Network ID, a Subnet Mask and a Default Gateway, and comprises one or more Domain Subnets, see Figure 4 on page 10.

Each IP Network in the Access Domain is divided into a number of Domain Subnets. The Domain Subnet contains the network elements that are the EDA nodes like IP DSLAMs, FE-E1 converters, and EDA switches.

An IP range is defined in each Domain Subnet for network elements, which dynamically receives IP addresses from a DHCP Server. (Component of the Domain Server), unless the EDA network is based on the Ethernet Access Node (EAN), where the Domain Server function is an integrated part of the ECN330/ECN320.

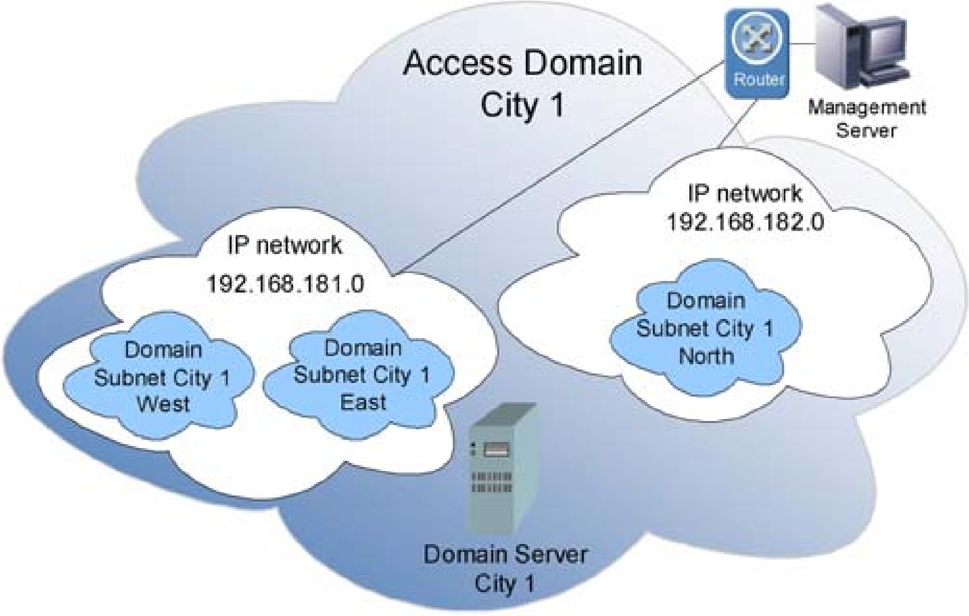
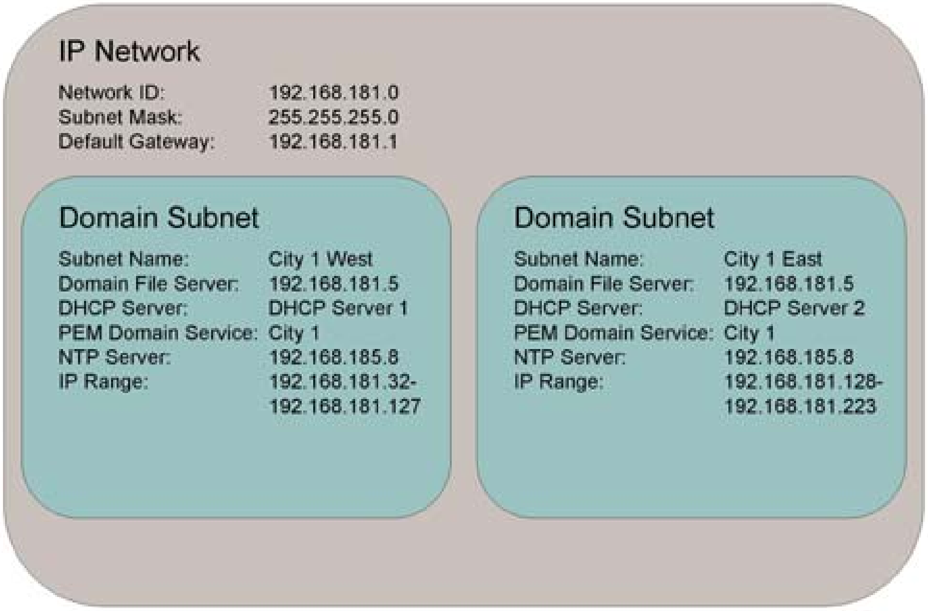


Figure 4 The Access Domain in the Access Network

The figure below shows that a Network ID, a Subnet Mask, and a Default Gateway, identify an IP network in the Access Domain.



IP Network

Network ID: 192.168.181.0
Subnet Mask: 255.255.255.0
Default Gateway: 192.168.181.1

Domain Subnet

Subnet Name: City 1 West
Domain File Server: 192.168.181.5
DHCP Server: DHCP Server 1
PEM Domain Service: City 1
NTP Server: 192.168.185.8
IP Range: 192.168.181.32-192.168.181.127

Domain Subnet

Subnet Name: City 1 East
Domain File Server: 192.168.181.5
DHCP Server: DHCP Server 2
PEM Domain Service: City 1
NTP Server: 192.168.185.8
IP Range: 192.168.181.128-192.168.181.223

Figure 5 IP Network and Domain Subnets

3.1.3 The Domain Server

An Access Domain is a logical network handled by a management system and defined by approved IP addresses. The components in an Access Domain are managed by a Public Ethernet Management (PEM) system through a Domain Server.

As shown in Figure 6 on page 12 the Domain Server is physically located in the Access Domain or on the Management Server, but for an EAN, which is shown to the right in Figure 6 on page 12, the Domain Server function is integrated in the ECN330/ECN320 controller node.
The Domain Server comprises a DHCP server, a Domain File Server, an NTP Server, PEM Domain Services, and HPOV clients.

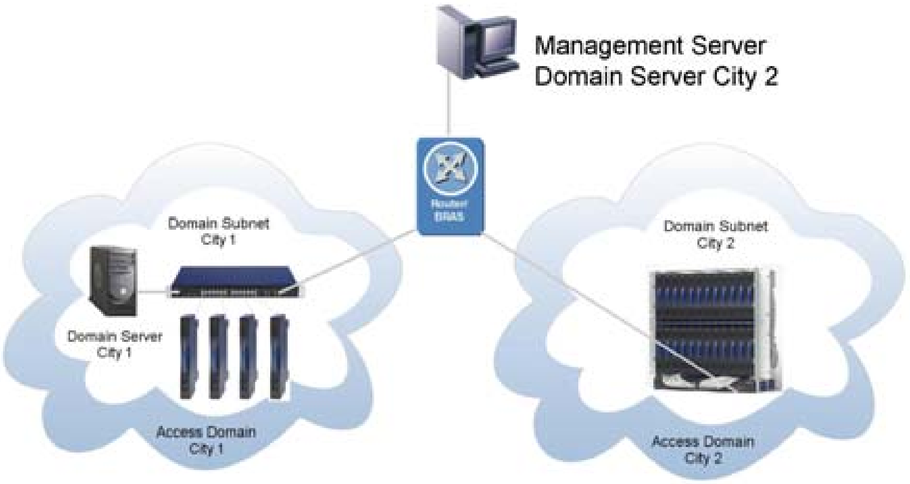


Figure 6 The Access Domain and Domain Subnets

The Domain Server City 1 is responsible for all network nodes in the Access Domain City 1.

The Domain Server for Access Domain City 2 is installed on the same computer as the Management server. This will typically be the case when the EAN is used as indicated in Figure 6 on page 12. Several Access Domains is only necessary in EDA deployment scenarios where the EAN is not used and the total number of end-users is high.

4 The EDA Components

The components of the EDA solution are described in further detail in the following sections.

The nodes or components in an Access Domain are all connected to the same Ethernet, which carries both end-user and management traffic. The EDA system is built on the following components, which can be combined to form a specific EDA solution:

- IP DSLAMs - EDN312 and EDN288
- Switches - ESN108, ESN310, ESN410 and ELN220
- Ethernet Controller Node - ECN320 (An ESN310 with built-in EDA Management Proxy (EMP) function) and ECN330 (A Layer 3 switch with built-in EDA Management Proxy (EMP) function)
- Subracks - Micro Subrack, Small Subrack, Medium 288 Subrack
- Cabinets - Outdoor Cabinet
- Converters - FE-E1 Converter (EXN104) and Ethernet Gateway EXN401/410
- Power Node - EPN102
- Management system - Public Ethernet Management system (PEM)

The components are described in more detail in the following.

4.1 The IP DSLAMs

The EDA solutions are based on IP DSLAMs, which are available in a 12-line, a 24-line version and a 288-line version. The IP DSLAMs are powered over the Ethernet cables and both data and power is conveyed in the same cable.

The IP DSLAMs can be aggregated in the network by using a 24-port switch ESN310, without built-in EDA Management Proxy. The IP DSLAMs can also be aggregated by the 24-port Ethernet Controller Node (ECN330/ECN320), in which case the EDA Management Proxy is used.

As opposed to many traditional DSLAMs the IP DSLAM also terminates the ATM layer used on top of the ADSL connections, thus interfacing directly to the switched Ethernet within the Access Domain. The IP DSLAM bridges between the switched Ethernet and the Ethernet at the customer premises, see Figure 7 on page 14.

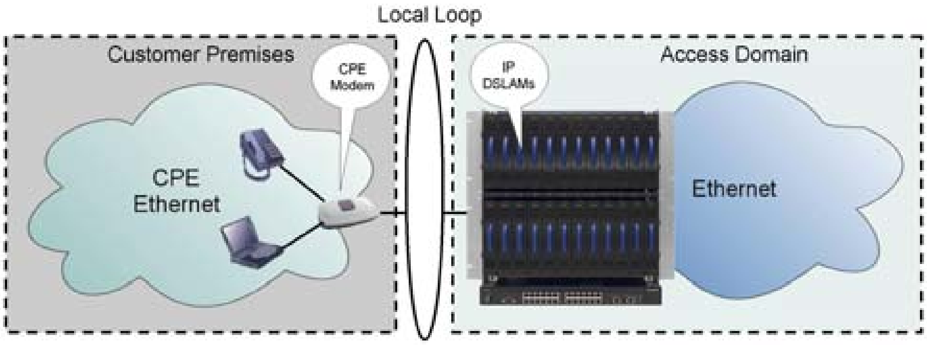


Figure 7 Bridging the Access Domain and the CPE Ethernet

The IP DSLAM terminates all end-user lines, and is able to provide high speed IP access to all end-users simultaneously. Installing the IP DSLAM at the Central Office, does not force the end-users connected to an IP DSLAM to have ADSL, which means that service activation of ADSL is done individually per subscriber line through the EDA Management System (PEM).

On the local loop each end-user has up to eight ATM Permanent Virtual Circuits (PVCs), depending on the CPE modem. Each PVC is individually configured with a maximum bandwidth and can be used for different Quality of Service scenarios.

The IP DSLAM is also able to make a Line Qualification Test in order to estimate the ADSL connection properties. The Line Qualification Test can be performed when the IP DSLAM is installed. The ADSL line does not have to be activated in order to perform a Line Qualification Test.

The IP DSLAM has a built-in Over Voltage Protection (OVP), which replaces the primary OVP typically mounted in the MDF and conforms to ITU-T K.20 and ITU-T K.21.

When the IP DSLAMs are aggregated using a non-EMP switch the IP DSLAMs are often referred to a stand-alone.
When the IP DSLAMs are aggregated using the EMP based ECN330/ECN320 they are often referred to as embedded nodes.

In order to clarify the concept of a stand-alone and embedded IP DSLAM the EMP and non-EMP solution is explained below.

4.1.1 The EDA Management Proxy (EMP)

EDA Management Proxy (EMP) is a built-in application in the Ethernet Controller Node ECN330/ECN320. EMP removes dependency of PEM servers during start-up and restart, and reduces the number of IP addresses needed in the management network as it defines the ECN330/ECN320 and its connected network elements as one logical node named Ethernet Access Node (EAN).

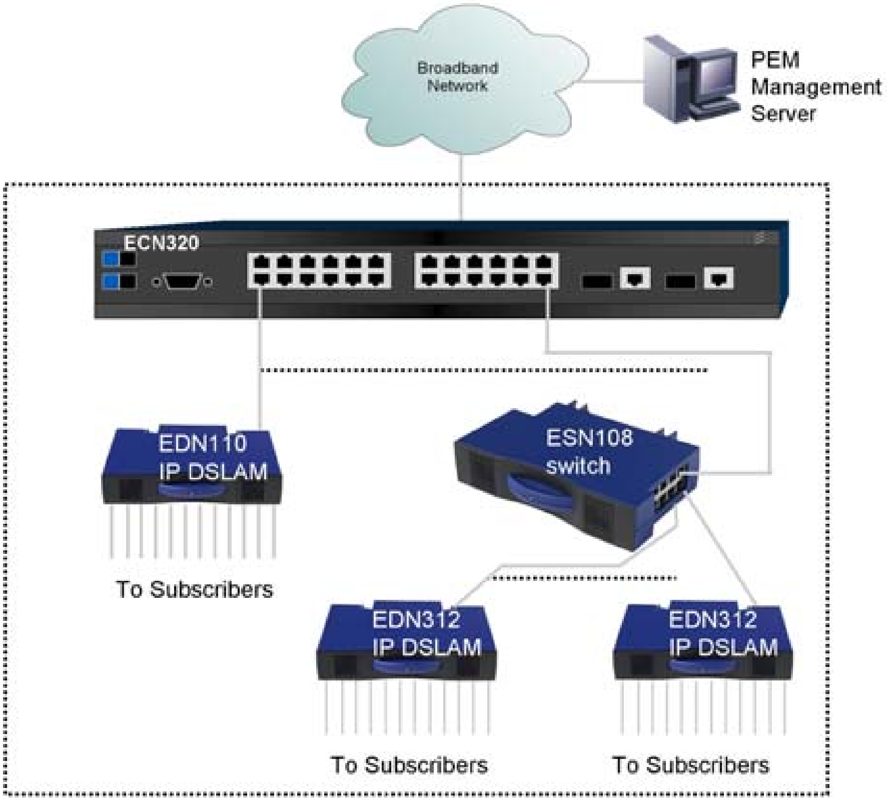


Figure 8 Example of an EAN

The EAN above shows a number of network elements connected to an ECN330/ECN320. The local IP addresses of the network elements are not visible in the management network, except for the IP address of the Ethernet Controller Node. The ECN330/ECN320 maintains the connected network elements using local IP addresses.

EMP makes the ECN330/ENC320 appear as one large IP DSLAM with one static IP address and up to 2016 end-users. This number of lines can be reached, if all ECN330/ECN320 downlink ports are used for aggregation of ESN108 switches, and the ESN108 switches each employ 7 electrical downlink ports, and if the EDN312 IP DSLAMs are used entirely. If the EDN312 IP DSLAMs are connected directly to the downlink ports of the ECN330/ECN320, then 288 ADSL lines will be available. This solution is achieved with the EDN288, which is described later. The EDN288 is referred to as an 288-lines IP DSLAM but should be thought of as an EAN with EDN312 IP DSLAMs.

The ECN320 benefits from automatic registration of all connected network elements and their ports, thus making implementation, expansion and replacement of nodes very user-friendly. Another advantage is, that network elements are maintained by their local EMP and do not depend on a Domain Server during normal operation.

The Domain Server is only used by the EAN for software upgrade, synchronization, and for SNMP commands.

The network elements are loaded with application software and a configuration file from the EMP. The load is done locally and not from the PEM management system, thus reducing management traffic in the network.

Characteristics of an aggregation node with EMP:

- Auto-registration of network elements
- Network element software and configuration files are distributed to the EMP
- One IP address per aggregation node

4.1.2 EDA Solution without EMP

The figure below, see Figure 9 on page 17, shows four IP DSLAMs and one 8-port Ethernet switch (ESN108) connected to an ESN310, which is an Ethernet switch without EMP. All six IP addresses of the network elements are visible to the management network and all six elements are maintained individually from PEM.

Each network element is registered manually in PEM.

The Ethernet switch ESN310 aggregates traffic in the Access Domain. The PEM Domain Server provides network elements in the Access Domain with application software and configuration data. The Domain Server is also responsible for alarm handling and network topology discovery.

The Domain Server co-operates with the Management Server, thus creating a distributed management system. SNMP trap filtering in the Domain Server reduces management traffic towards the Management Server. Automatic discovery of nodes in the Access Domain by the local Domain Server is another advantage of a distributed management system.

The number of maintenance IP addresses in the Access Domain can be quite high because every network element has its own IP address. The maximum number of maintained IP addresses per Domain Server is 2000.

Characteristics of an aggregation node without EMP:

- Manual registration of network elements
- Application software and configuration files are loaded from the Domain Server
- Discovery and trap filtering by the Domain Server
- Many IP Addresses in each Access Domain

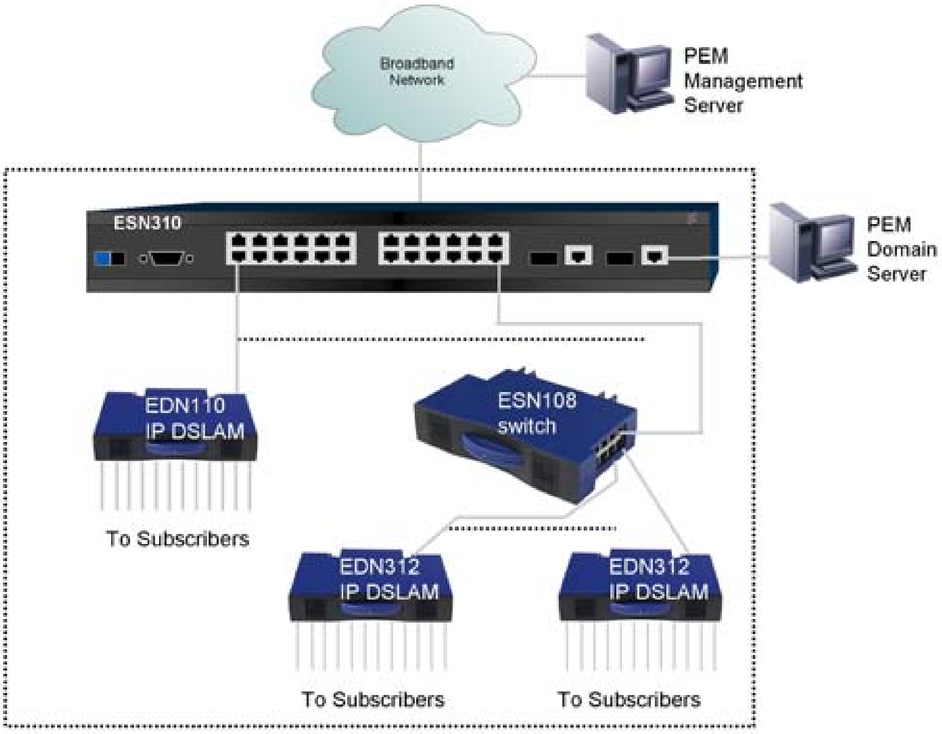


Figure 9 Solution without EAN

4.1.3 The EDN312 and EDN312x IP DSLAM

The 12-line IP DSLAM comes in two version, the EDN312 and the EDN312x both and available in different variants

- EDN312p – 12 lines with built-in POTS filter
- EDN312i – 12 lines with built-in ISDN filter
- EDN312e – 12 lines with built-in POTS filter and complies to ETSI standard.
- EDN312xp – 12 lines with built-in POTS filter, ADSL2+ facilities and two 100 Mbps Ethernet uplink ports, making it possible to use them in a link aggregation scenario.
- EDN312xi - 12 lines with built-in ISDN filter, ADSL2+ facilities and two 100 Mbps Ethernet uplink ports, making it possible to use them in a link aggregation scenario.
- EDN312xe – 12 lines with built-in POTS filter, ADSL2+ facilities and two 100 Mbps Ethernet uplink ports, making it possible to use them in a link aggregation scenario. Complies to the ETSI standard.

Redundancy and Aggregation Options (EDN312x only)

The EDN312x versions (EDN312xp, EDN312xi and EDN312xe) have two uplink ports, which EAN redundancy, and EDN312x link aggregation. EAN redundancy utilizes Rapid Spanning Tree, which can be setup in the ECN320. The two scenarios are described in further detail below in section 4.1.4 on page 19, but for a full understanding the reader is referred to the *EDN288 User Guide*.

There is no difference between the two uplink ports of the EDN312x. It does not matter which port is connected to which aggregation switch. The EDN312x draws power from one of the links. There is no indication and it is not possible to know which link supplies the power (applies also to the redundancy scenario).

Note: If the link that currently supplies the EDN312x is disconnected, or the power fails, the EDN312x will restart and draw power from the other link.

4.1.4 The EDN288 IP DSLAMs

With the 288-lines IP DSLAM Ericsson introduces the new and important concept of the Ethernet Access Node (EAN). In order to understand the function of the EDN288 it is important to understand the EAN concept, therefore the EAN is described in detail in the following.

The EDN288

The EDN288 is an EAN node, and available in the variant EDN288p and EDN288xp.

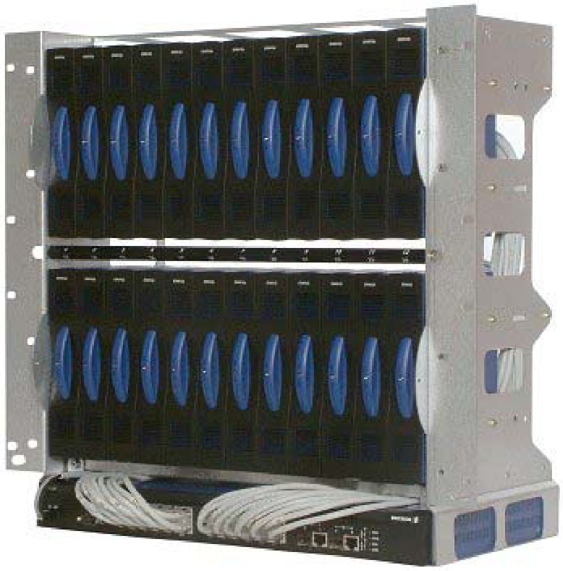


Figure 10 The 288-line IP DSLAM - EDN288

The EDN288p is a complete all-in-one system for 288 lines and consists of 24 12-lines EDN312p IP DSLAMs and an Ethernet Controller Node (ECN330/ECN320) fully cabled and assembled in a subrack prepared for installation in a standard 19” or ETSI cabinet, see Figure 10 on page 19.

The EDN288xp is similar to the EDN288p but supplied with 24 12-lines EDN312xp IP DSLAMs.

Furthermore the EDN288xp can be extended with an extra ECN330/ECN320, which makes it possible to enable EAN redundancy or link aggregation, depending on how cabling is performed. This is explained in more detail below.

EAN Redundancy

EAN redundancy is ensured by connecting the two Ethernet ports of the IP DSLAM to each ECN330/ECN320, as illustrated in Figure 11 on page 20. Redundancy requires enabling of Rapid Spanning Tree (RSTP) in both of the ECN330/ECN320.

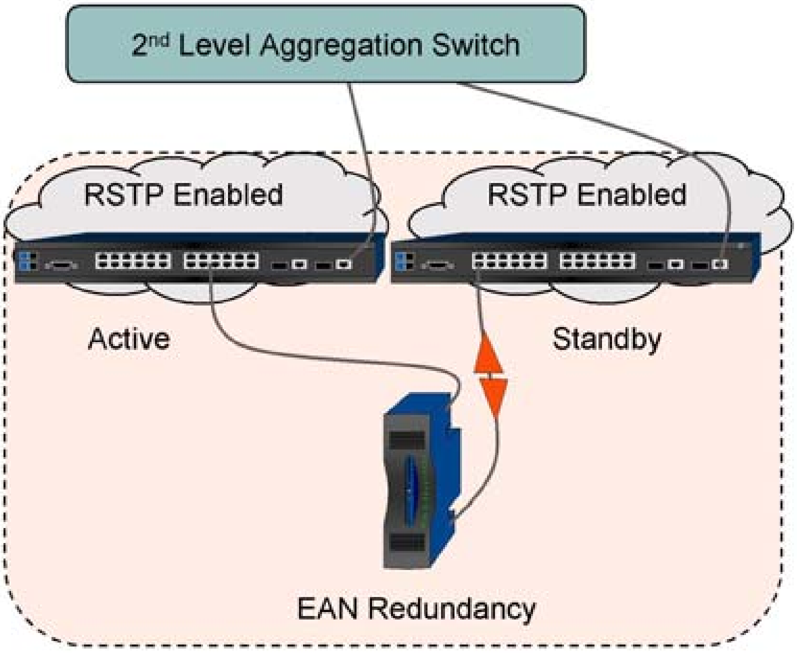


Figure 11 Cabling of Ethernet Cables for EAN Redundancy

EDN312x Link Aggregation

The two ports of the IP DSLAM can also be used to enable link bandwidth of 200 Mbps to a single EDN312x.

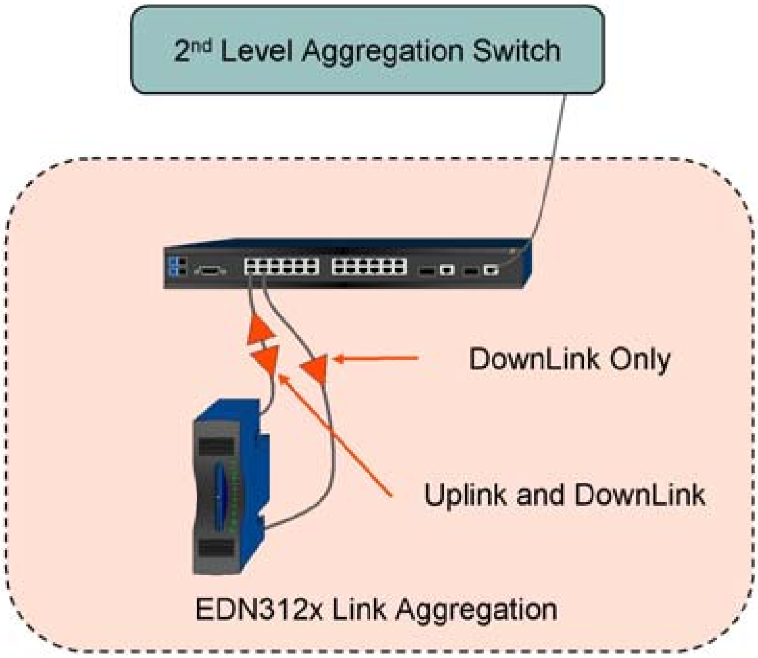


Figure 12 EDN312 Link Aggregation

Two ports of the ECN330/ECN320 can be joined to form one aggregated link. This is also called a trunk. By trunking two ports, the speed can be increased to 200 Mbps. The two uplink ports can also be grouped. There is a limitation though because the ECN330/ECN320 only supports up to 6 aggregated links.

This means that if the two uplink ports are grouped, only 5 downlink trunks can be created. If the extended EDN288x is cabled and configured to utilize the maximum number of aggregated links, this will result in two EANs with 144 end-user connections each (72 aggregated and 72 normal).

Connecting the single uplink IP DSLAMs to two ports will ensure PoE redundancy, as well as easy change of the aggregated devices without the need of changing the cabling on site.

When a link aggregation is selected as the link type of an EDN312x in PEM, both Ethernet connections will automatically be activated. As previously mentioned it is not possible to select more than six aggregated links for a single ECN330/ECN320.

The cabling is illustrated below in Figure 13 on page 22. The illustration shows how the IP DSLAMs in the upper row of the EDN288x are connected to the ECN330/ECN320. The IP DSLAMs in the lower row are connected to the lower ECN330/ECN320 the same way.

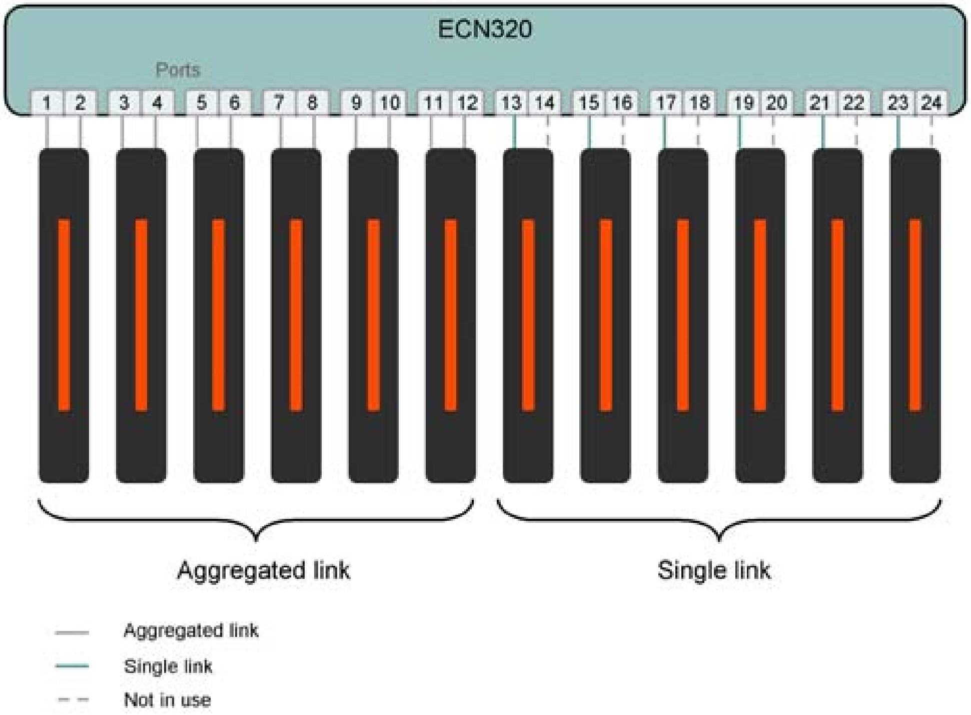


Figure 13 Cabling of Ethernet Cables for Link and PoE Redundancy

4.1.5 The ECN Aggregation Node

The heart of an EAN is a node controller, the *Ethernet Node Controller*, which is an integrated part of the ECN330/ECN320, which also functions as a 24 ports Ethernet switch.

Figure 14 The Ethernet Controller Node - ECN320

The switch part has Power over Ethernet capabilities and apart from the controller IP DSLAMs (EDN312), and ESN108 can be connected to it to form an EAN. Furthermore the optical switch ELN220 can be connected to it in order to support small remote sites using fiber optical connections. The embedded nodes may be installed as and when desired.

The Ethernet Node Controller of the ECN330/ECN320 manages all the embedded nodes. From a management point of view, the switch is also an embedded element, even though it is located and integrated in the ECN330/ECN320. All management of the embedded nodes is done through the Ethernet Node Controller, which is the only element communicating directly with the Public Ethernet Manager (PEM).

Using the *EDA Management Proxy* (EMP) function as described previously in section 4.1.1 on page 15, the Ethernet Node Controller forwards the communication to and from the embedded nodes. Note that only the management traffic goes through the Ethernet Node Controller. The end-user traffic is unaffected by the EAN structure.

The Ethernet Node Controller handles all functions of the Access Domain Server for the embedded nodes. Therefore the embedded nodes does not depend on the Access Domain Server, but the Access Domain Server must be running for the following reasons:

1. All communication with the ECN is SNMP based.

2. The Ethernet Node Controller gets new SW applications for the ECN from the Domain File Server when SW upgrade is performed.

3. The Ethernet Node Controller gets SW applications and configurations for the embedded nodes from the Domain File Server when the EAN is synchronized from PEM.

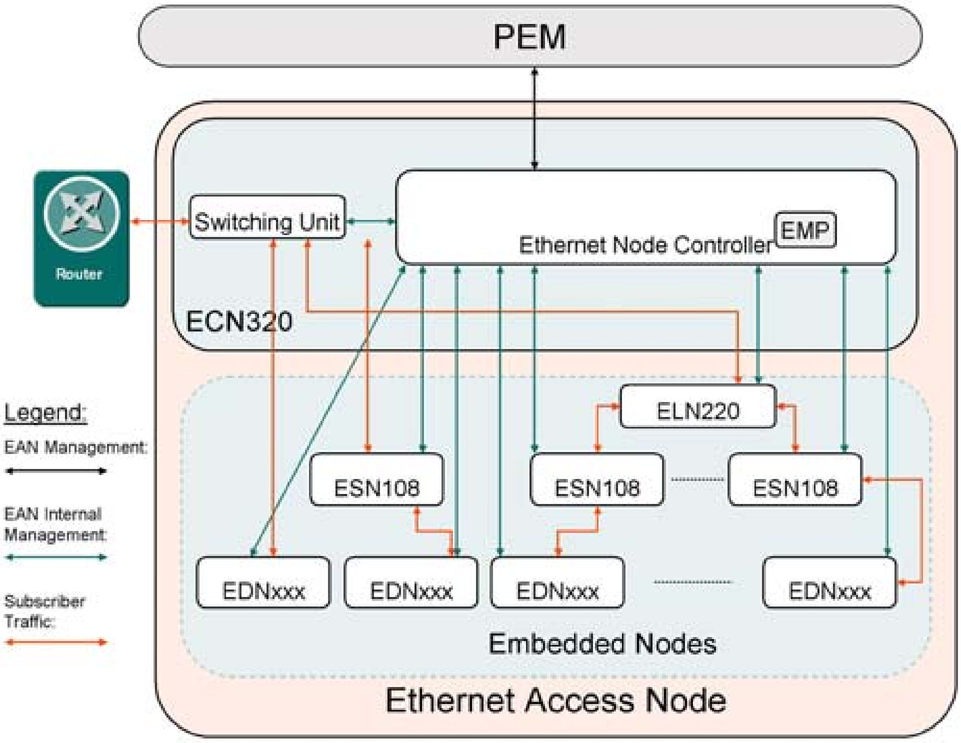


Figure 15   Ethernet Access Node Structure

The ECN320 contains 24 10BASE-T/100BASE-TX RJ-45 ports and two combo ports—10/100/1000BASE-T ports which operate in combination with Small Form Factor Pluggable (SFP) transceiver slots.

The ECN330 contains 24 10BASE-T/100BASE-TX RJ-45 ports and two combo ports—10/100/1000BASE-T ports which operate in combination with Small Form Factor Pluggable (SFP) transceiver slots and an additional electrical 10/100/1000BASE-T port.

The ECN330/ECN320 is used as the first and second level aggregation switch in the EDA network (second level with ESN108 or ELN220 as first level), while also supplying IP DSLAMs with DC power over the Ethernet connections.

It has two power supply ports which establishes power redundancy.

As well as its Power-over-Ethernet capabilities, the ECN320 provides comprehensive network management features, such as, multicast switching, virtual LANs, and Layer 2/3/4 CoS services that provide reliability and consistent performance for network traffic.

ECN330 looks very similar to ECN320, but ECN330 is built on an improved hardware platform supporting a number of advanced features like 4k VLAN, 16k MAC table, full link aggregation, and Layer 3 routing.

ECN330 also supports Layer 2 MPLS for tunneling and a number of redundancy protocols, e.g. Rapid Spanning Tree Protocol (RSTP), Multiple Spanning Tree Protocol (MSTP) and Ethernet Automatic Protection Switching (EAPS).

4.2 The EDA Switches

The EDA solution offers a suite of switches - two 1st level aggregation Ethernet switches (ESN108 and ESN310) with integrated Power over Ethernet functionality for powering the IP DSLAMs, and one 2nd level optical aggregation Ethernet switch (ELN220).

The ESN108 Switch

For small sites in areas with low subscriber density the EDA Ethernet switch, ESN108, fits very well, see Figure 16 on page 27.
The modularity of the switch is optimal for small sites with up to 96 lines and thus fits perfectly with a small pre-cables solution containing eight 12-port IP DSLAMs and one ESN108 aggregation switch for traffic uplink, see section 4.7 on page 37.

The switch offers 8-ports 100 Mbps Fast Ethernet downlink and 1 optical 100/1000Mbps Mbps aggregate (uplink) port. It has built in Power over Ethernet (PoE) used for distributing the power to the connected IP DSLAM through the downlink ports.

The ESN108 offers multicast loading of IP DSLAM software and multicast video streaming by use of IGMP snooping. Listening to Internet Group Management Protocol (IGMP) messages it builds mapping tables and associates forwarding filters. It dynamically configures the switch ports to forward multicast traffic only to those ports associated with multicast hosts.

The switch also offers port mapping filtering and is transparent for VLAN IDs. It is managed by the Public Ethernet Manager (PEM).

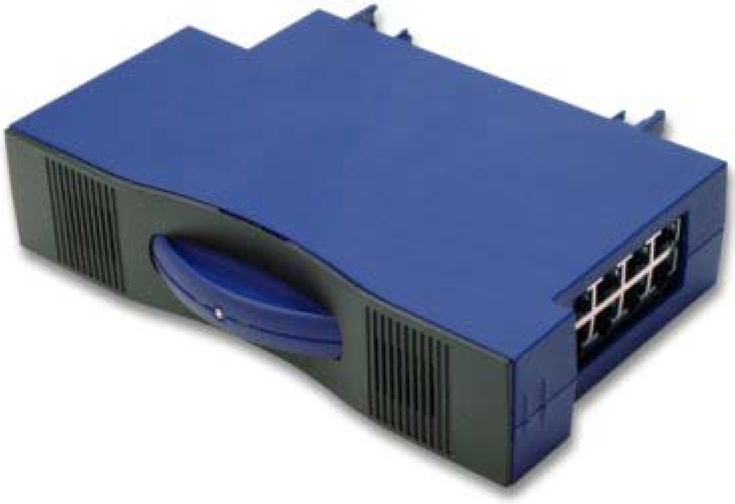


Figure 16 EDA Ethernet Switch (8 ports) with PoE - ESN108

The ESN310 Switch

The ESN310 is a switch specially designed for the EDA solution, see Figure 17 on page 27. The switch offers 24 ports 100 Mbps Fast Ethernet downlink ports. The uplink ports can be either 2 Gigabit (10/100/1000) Fast Ethernet ports or 2 Gigabit optical ports.

It has built in Power over Ethernet (PoE) and can be managed by the PEM.

The switch supports multicast loading of IP DSLAM software and multicast video streaming by use of IGMP snooping.

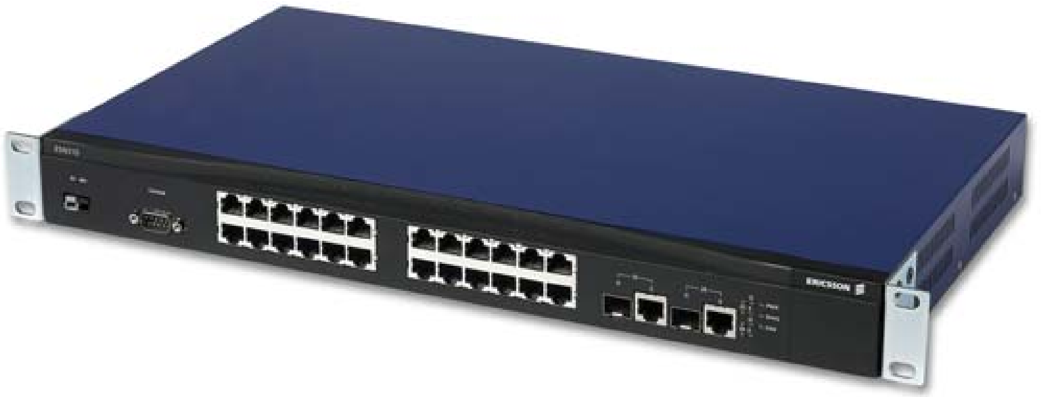


Figure 17 EDA Ethernet Switch (24 ports) with PoE - ESN310

The ELN220 Switch

The ELN220 switch shown in Figure 18 on page 28, is a 2nd level aggregation switch offering 24 optical ports for aggregation of the ESN108 and ESN310.

It has 2 Gigabit Ethernet uplink ports, and can be managed through PEM.

The ELN220 can be used as an embedded node in an EAN and is then connected to the optical uplink port-25 of the ECN320. The main purpose is to support small remote sites through fiber optical connections.

The scenario is illustrated below in Figure 19 on page 29.

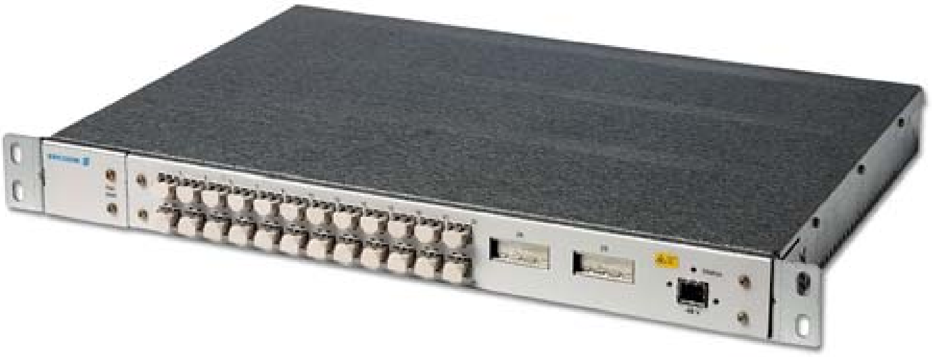


Figure 18 Ethernet Switch (24 optical ports - ELN220)

The purpose of the ELN220 switch is to support small remote sites through fiber optical connections. The ELN220 switch has 24 optical ports, which can be connected to the optical uplink port of the 8-port ESN108 switch. This means that up to 24 ESN108 switches can be connected to the ELN220, thus making it possible to support up to 24x8x12=2304 remote end-users.

As indicated by the illustration in Figure 19 on page 29 the 12-line IP DSLAM EDN312 is used in this scenario. The ECN320 has 24 downlink ports, which can be connected to for example 24 12-lines IP DSLAMs locally and thus the total supported end-users will be extended with 288 local end-users.

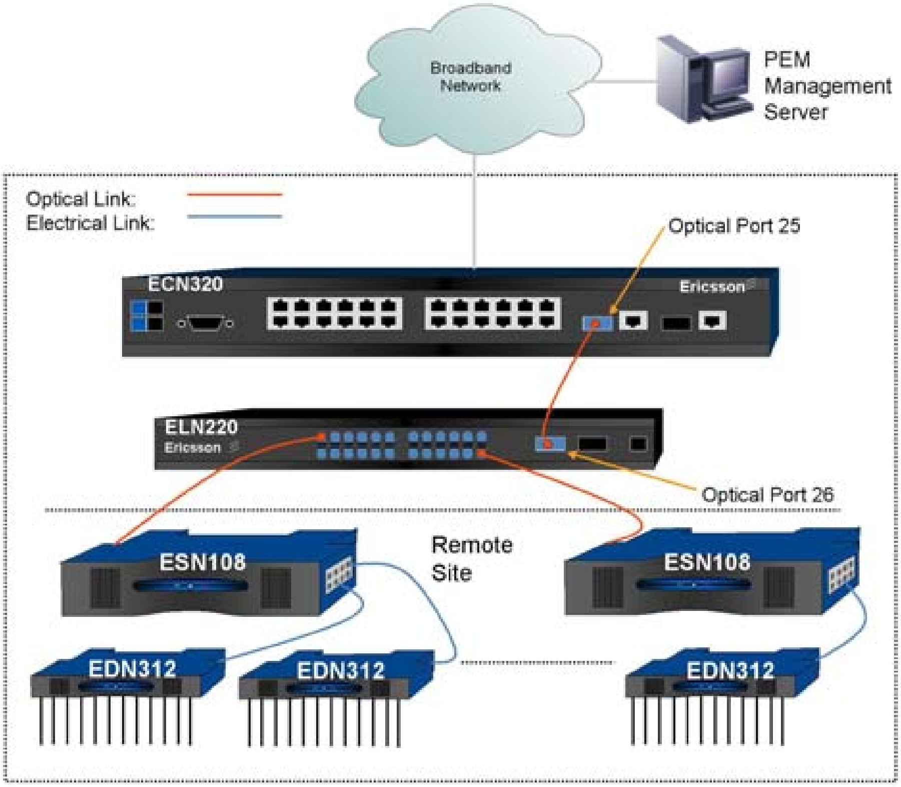


Figure 19 The ELN220 as an Embedded Node in the EAN

The ESN410 Switch

The ESN410 is a layer-3 Gigabit aggregation switch for the EDA solution, primary for network configurations that require some type of routing functionality. This means that it supports IP routing with the ability of routing at layer-3. Furthermore it has comprehensive network management functions such as Spanning tree protocol for standard bridging, GVRP for VLAN configuration, SNMP, RMON and Web management.

The switch is seen as a second level aggregation switch for the ECN320 and the ESN310. It has 12 1000Mbps ports, 4 of which are Ethernet combo ports for either RJ-45 cables or connection to fiber cables through a SFP connector.

The switch is manageable through a Command Line Interface (CLI) and through SNMP.

The ESN410 is prepared for 19” rack mounting and has built-in fan units that can be replaced without service interception.

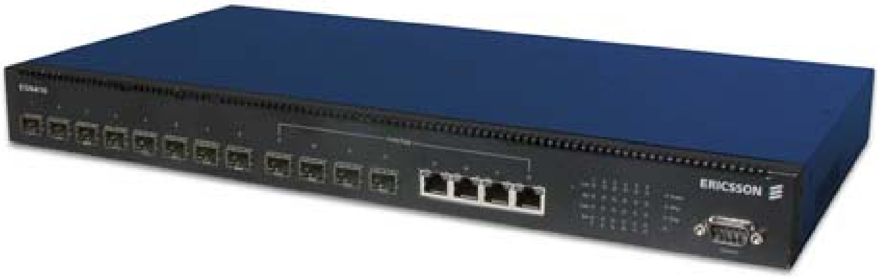


Figure 20 The ESN410 Layer-3 Gigabit Switch

4.3 The EDN424 HDSL IP DSLAM

The EDN424 is a 24-port IP DSLAM in the EDA solution. EDN424 is an environmental hardened, 1U high mini-DSLAM that aggregates 24 SHDSL lines to one 100 Mbps Ethernet. Design flexibility enables the EDN424 to be mounted as rack, wall or vertical positioned units inside an existing closure.

Downlink and Uplink ports

EDN424 offers 24 SHDSL downlink ports, each supporting symmetrical bandwidth of up to 2.3 Mbps for single pairs and 4.6 Mbps in 4-wire mode. Future upgrade will enable 5.7 Mbps per pair according to SHDSL.bis. The uplink aggregates the 24 ports to 100 Mbps Ethernet. Management.

The Public Ethernet Manager (PEM) is the element manager for EDN424. A customized management VLAN is terminated in the EDN424 to enable remote management of the unit. The northbound interface of PEM offers generic interfaces, such as CORBA and SNMP, enabling use of the same provisioning and management system already employed in the operator’s network.

Services

EDN424 enables the operator to offer a wide range of services:

- Telephony over IP (ToIP) to the end-users
- Data services as either fixed bandwidth or bandwidth on demand, with the possibility of using the existing PPP authentication

- Small Medium Enterprise (SME) services, such as video conferencing, LAN to LAN, VPN services to the enterprise over the existing copper

The SHDSL loops provide flexibility in the deployment schemes. The loops can be delivered individually in single port SHDSL customer premises. Other deployment options include 4-wire mode for longer reach or higher bandwidth.

Security

EDN424 ensures a secure network by offering VLAN according to IEEE 802.1Q. In future upgrades of EDN424 it will be possible to form up to 12 IMA groups with 2 to 18 ports per group. This feature makes it possible to differentiate the service by offering different symmetrical bandwidths up to more than 40 Mbps. Up to eighteen copper pairs are required to offer this service.

Figure 21 The EDN424 HDSL IP DSLAM

4.4 Ethernet Power Nodes

For EDA solutions where the IP DSLAMs are not powered by an EDA switch or where a Fast Ethernet to E1 converter is used, Ethernet Power Nodes can be applied. The Ethernet Power Node is available, EPN102, Figure 22 on page 32.

The Ethernet Power Node, EPN102, is able to supply two devices with power, but only one IP DSLAM. It is used for small sites for powering an IP DSLAM and a Fast Ethernet to E1 converter (FE-E1). A typical scenario is shown in Figure 24 on page 34.

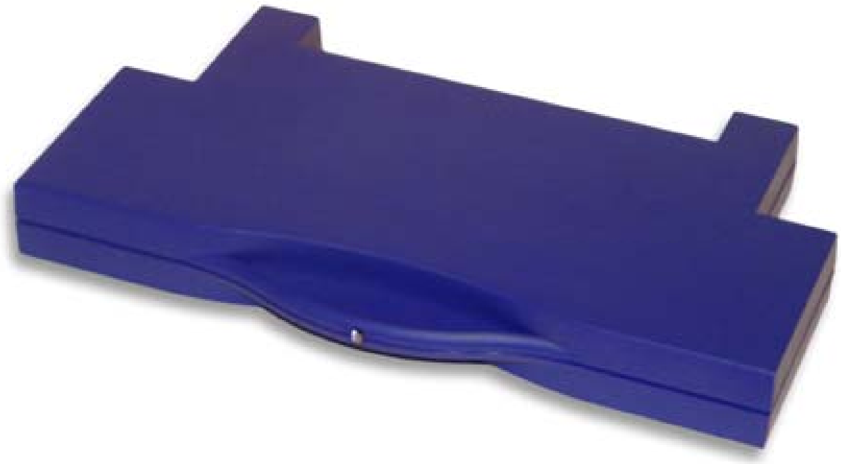


Figure 22 Ethernet Power Node - EPN102

4.5 The EDA Converters

For small site solutions the EDA system offers two types of converters, the FE to E1 converter (EXN104) and the Ethernet gateway (EXN401/410) for bridging the Ethernet and the ATM network.

4.5.1 The FE to E1 and T1 Converter

The Fast Ethernet to E1 converter (EXN104) is a small-managed converter developed for EDA rollout where no Ethernet uplink is available, see Figure 23 on page 33. The FE-E1 converter is intended for installation of the EDA solution at small sites with a few IP DSLAMs, see Figure 24 on page 34.

Figure 23 Fast Ethernet to E1 and T1 Converter - EXN104

A cost-effective solution to this problem is to transport the Ethernet traffic through vacant E1 lines using the FE-E1 converter. For a small site either remote or at the CO the typical PoE box is an EPN102.

Furthermore the converter can be setup to transport the Ethernet traffic through T1 lines. The converter is default setup to run in E1 mode, but can be configured to run in T1 mode as well. One important difference between running E1 and T1 is the data transfer speed, which for an E1 line is 2.048 Mbps and for a T1 line is 1.544 Mbps.

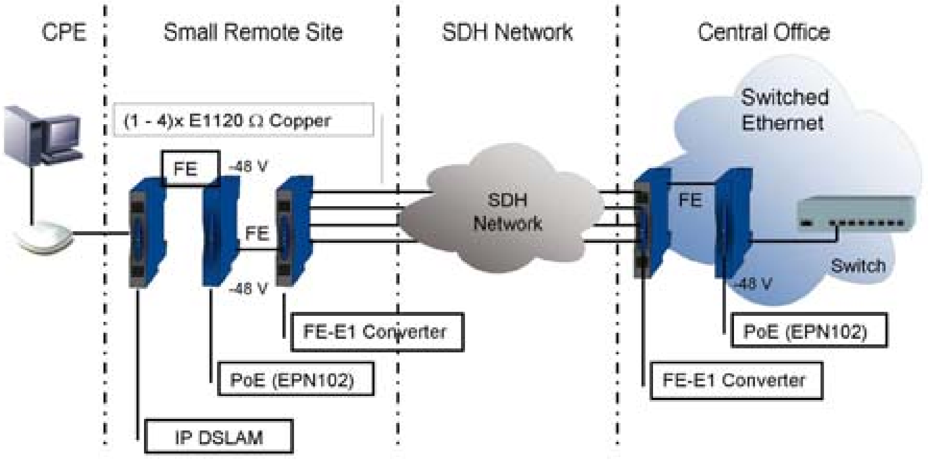


Figure 24 Fast Ethernet to E1 or T1 Converter in a Small Site Solution

4.5.2 Ethernet Gateway

The EXN401/410 is a small 1U easy-installable Ethernet to ATM STM-1 gateway developed to facilitate re-use of existing legacy ATM core networks. Ethernet traffic from a Fast or Gigabit port is encapsulated according to RFC2684 bridged mode onto ATM AAL5 PVCs according to traditional ATM DSLAM installations, see Figure 26 on page 35.

EXN401/410 provides a unique possibility to implement Ethernet-based broadband access networks while re-using the existing ATM core infrastructure such as ATM core interfaces and routers.

The EXN401/410 series supports the migration of broadband access networks from traditional ATM over SDH/Sonet to cost-efficient Ethernet, while preserving the quality of service and service availability.

Figure 25 The Ethernet Gateway EXN401/410

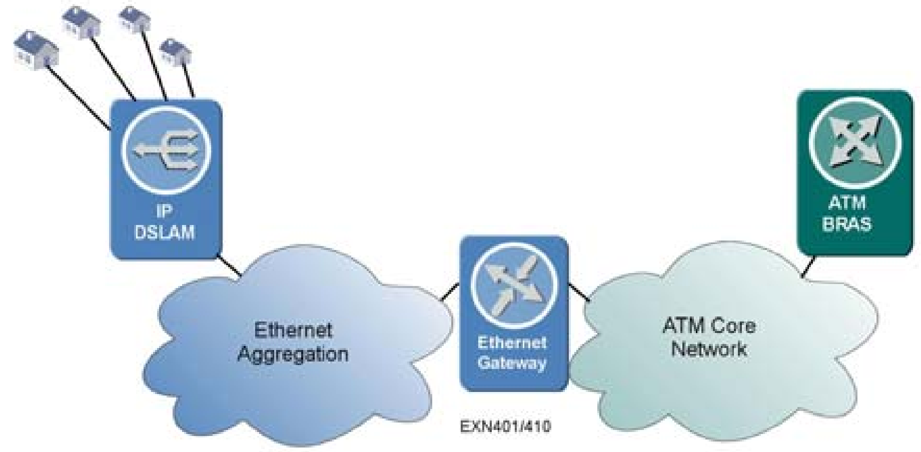


Figure 26 Migration from Ethernet to ATM through EXN401/410

4.6 Remote Powering

Remote powering is a concept for distributing DC power over existing twisted pairs. Remote powering is typically used in broadband applications, where telecom equipment located close to the end-user requires power. What makes remote powering attractive is the independence of local power utilities and centralized back-up systems (batteries). The system consists of a Remote Power System at the Central Office and a converter at the Remote Site. The design of the system is based on safety standards IEC 60950-21, IEC 60950-1, and GR 10989-CORE.

At the Central Office the Flatpack Remote Power Systems are designed for remote powering of telecom equipment, and provide ±190 V DC from a 48 V DC source. The power system consists of a 2HU Flatpack Mini PRS chassis, 19” or 21” (ETSI) wide. This chassis houses up to two DC/DC converters and VA limiters (24 channels).

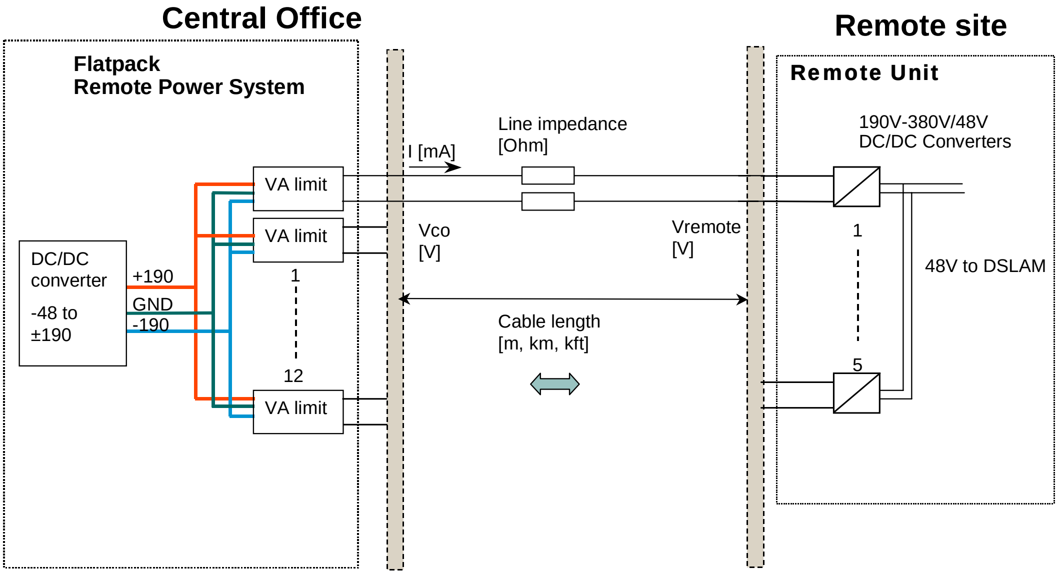


Figure 27 Block diagram for the remote powering

Figure 27 on page 36 shows a block diagram of the remote powering system.

The DC/DC converter is a 1500-watt step up converter which provides ±190 V DC from a traditional –48 V DC source. The VA limiter distributes the ±190 V DC and provides a safe power distribution over existing twisted pairs, protecting the Remote Feeding Circuits (RFT) from over-voltage, over-current, and leakage current to ground. The VA limiter has 12 individual outputs of up to 100 W each (RFT-V).

The converters at the remote site consist of parallel DC/DC converters that terminate the twisted pairs being fed from the Central Office. The converters incorporate high-energy surge protection and one specifically designed to work with a limited power source (VA limiter) and fed over a high-impedance line. The modules can be paralleled to meet the power requirement at the Remote End.

4.7 The EDA Subracks and Cabinets

Subracks are available in various sizes and configurations adapted for different solutions. An overview of available pre-cabled subracks and cabinets is shown below in Table 1 on page 37.

Table 1 Overview of Subracks and Cabinets

Name	Description	Capacity/ end-users
Subrack/36	Subrack based on 2x12-line IP DSLAMs and the 8 port switch (ESN108)	12-36
Subrack/96	Subrack with 8x12-line IP DSLAMs and one 8-port switch	96
Subrack/144	Subrack with 12x12-line IP DSLAMs and one 24-port Ethernet Controller Node (ECN330)	144
Subrack/288	2 rows with each 12x12-lines IP DSLAMs and one 24-port switch (ESN310) or an Ethernet Controller Node (ECN320 or ECN330) with EDGE plugs	288
Outdoor Cabinet	8x12-lines IP DSLAMs and one 8-port switch (ESN108)	96

5 Customer Premises Equipment

The termination of the ADSL connection at the customer premises may be performed in various ways, depending on the type of access protocol and the customer's type of equipment. Since EDA is based on Ethernet, some part of the Customer Premises Equipment (CPE) must provide termination of this layer.

The following possibilities exists:

1. The Access Domain Ethernet may be bridged by the modem towards a local physical Ethernet. The modem terminates the ADSL and ATM layers. Hosts are connected to the modem via the local Ethernet.

2. The Access Domain Ethernet (and lower layers) may be terminated by the modem, turning it into a combined ADSL modem and IP router. Typically, hosts are connected to the router via Ethernet.

3. The modem may terminate only the ADSL layer, and convey the Access Domain Ethernet and ATM layers over USB towards the host. Thus the Ethernet layer is emulated within the host.

The CPE equipment protocol termination is shown in Figure 29 on page 39.

The EDA concept is able to operate with any standard CPE modem complying with the ADSL standards. In Figure 28 on page 38 a CPE modem from Ericsson is shown: The HM310dp is an efficient and high-performing broadband router, using the ADSL2 Annex M technology.

Figure 28 Ericsson Modem HM310

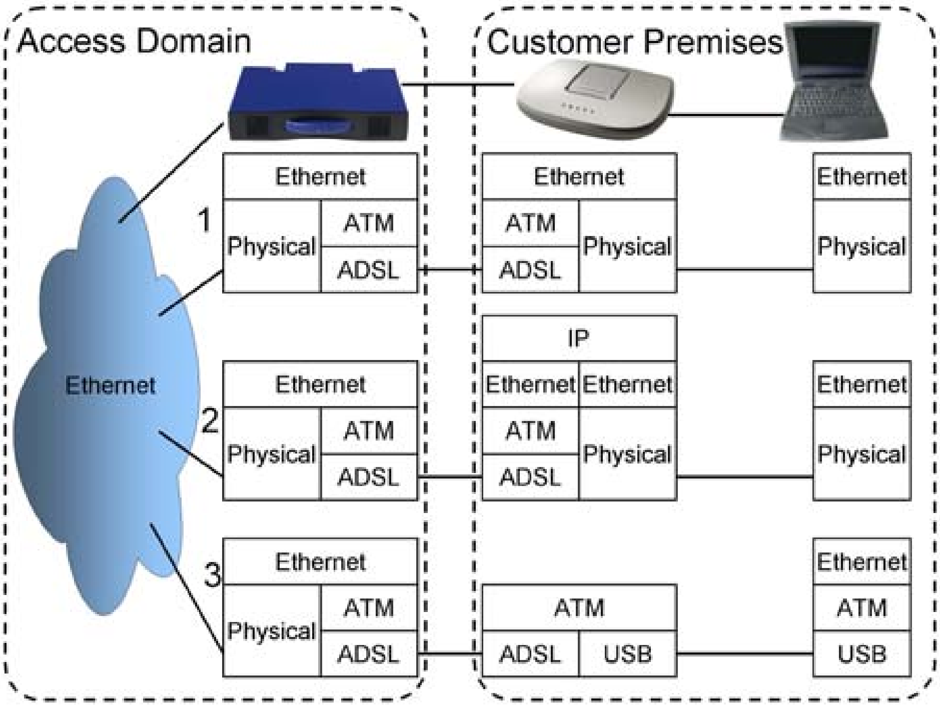


Figure 29 CPE Equipment Protocol Termination

Some ADSL modems are able to operate in either bridged or routed mode. A bridging modem requires a minimum of configuration, but does not provide any security for hosts connected through it.

A routing modem, on the other hand, often provides means for enhancing the security, for example by firewall and NAT function. If telephony is required, the CPE should provide a POTS interface to legacy telephones.

6 EDA System Services

EDA is a versatile and flexible system, and can be designed to fit various requirements regarding service access, network architecture, and network performance. Furthermore the EDA system solution can be adapted to various requirements regarding scalability and redundancy.

This section gives an overview of the services that can be provided by the EDA system.

6.1 The EDA Services

An *EDA Service* is a set of rules and properties, which defines how traffic is handled to and from an End-user through the aggregation network. A Service always has a Service Identifier that defines how to identify traffic of the specific Service.

The EDA Service should not be confused with a service offered by Service Providers as for example Internet connection, IP Telephony, IP video services and so on. The EDA Service defines properties such as associated VLAN, PVC, CPE Access Method and more. Thus the Service Provider provides the **contents** of the service, while the EDA Service provides the **means to access** the contents, with a defined bandwidth. The Quality of Service is the part of the rules, which defines the desired transport quality with respect to for example packet loss and delay.

The rules are applied to each frame, thus enabling the End-user to reach specific Service gateways or servers, and with the desired quality.

A key requirement of an access network is to impose **service access constraints**, that is, ensure that access is allowed only to services for which the End-user is authorized. In traditional broadband access network, this task is ensured by a Broadband Remote Access Server (BRAS). The BRAS is a single node through which all traffic must flow. The BRAS is located at the border between the aggregation network and the application servers or external network like the Internet.

Figure 30 on page 41 depicts a traditional access network scenario, where a BRAS controls what End-users can access. The aggregation network in itself imposes no constraints, but only transport all the End-user traffic to and from the BRAS.

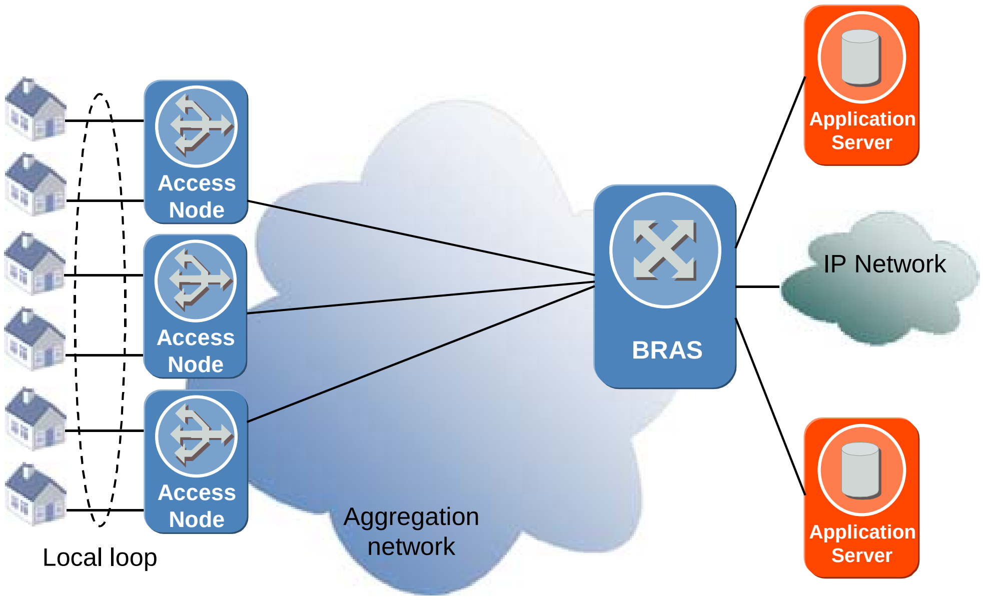


Figure 30 Traditional BRAS Controlled Access

Figure 31 on page 41 illustrates a multiple edge access network scenario. In this scenario it is the access nodes and aggregation network that must impose the restrictions on the End-user traffic.

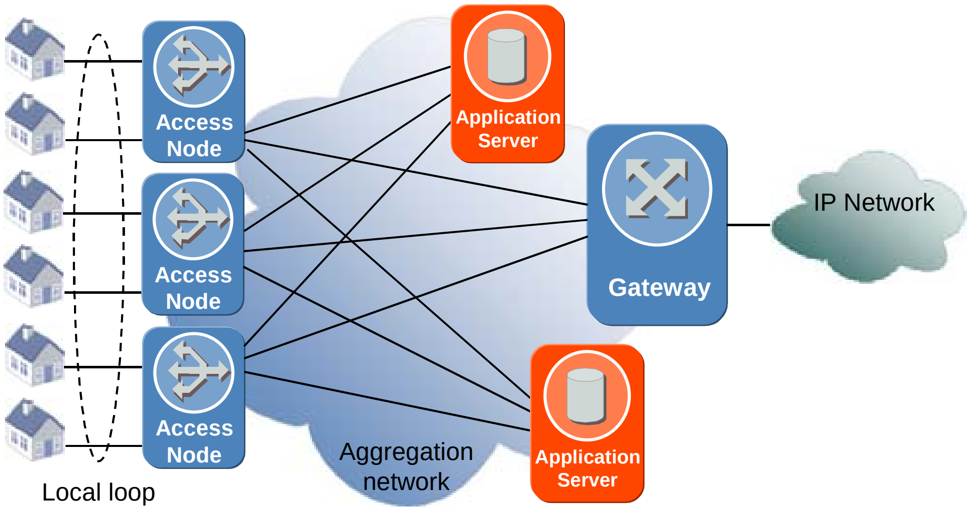


Figure 31 Multiple Edge Access

These EDA Service rules or definitions are implemented in the Access Node as a virtual switch that does the following on each frame:

- Inspection and identification of the service to which the frame belong
- Classification
- Filtering
- Modification
- Forwarding

In the Access Domain aggregation network, the rules are implemented as VLANs with a specified classification, configured throughout the network.

Figure 32 on page 42 depicts an EDA Service Access example. The lines between the virtual switches and the Service VLANs illustrate allowed connections.

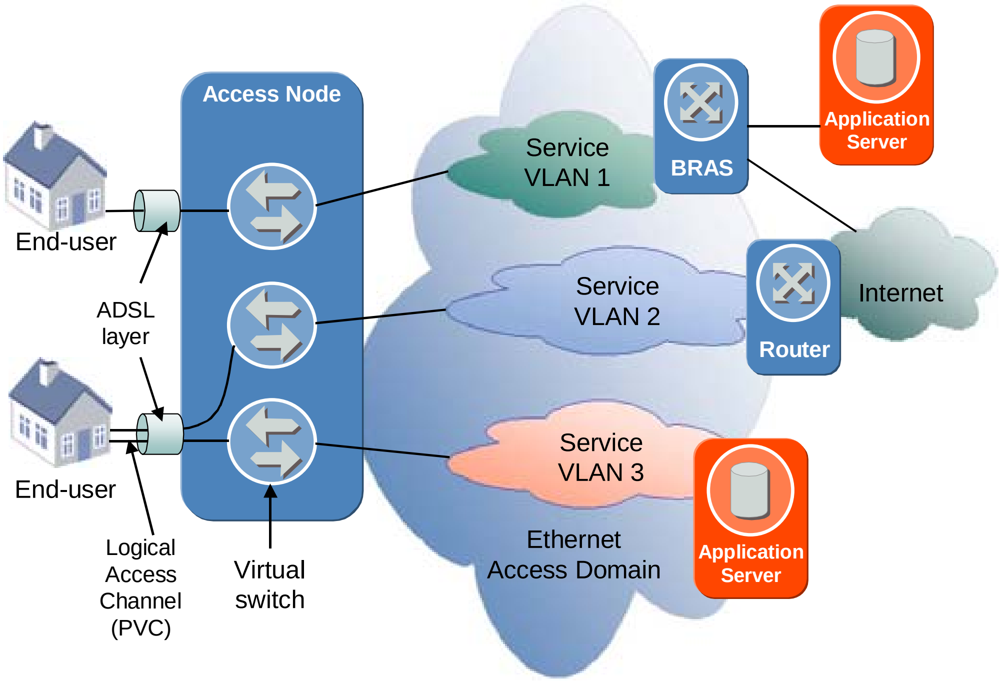


Figure 32 EDA Service Access

As Figure 32 illustrates, EDA Access network support both BRAS and multiple edge access scenario. The basic service identifier is a PVC (denoted as logical access channel in Figure 32). A virtual switch controls the traffic for each PVC in the network. It is important here to remark that the virtual switch is automatically configured when a service is assigned to an End-user. The Service VLAN1 in Figure 32 illustrates an EDA Service that contains two provider services that might have different QoS demands. The Ethernet in the Access Domain is capable of treating different frames with different QoS classification differently. The EDA Service allows for different **CoS** (Class of Service) **flows** with different QoS through the same PVC thus ensuring differential treatment of traffic through the DSL connection even if only one PVC is used.

A Service VLAN can also be used to create layer-2 connections to other End-users, either locally or across a transport network, creating a Transparent LAN Service (TLS).

The traffic to the End-user is identified by the PVC that it came from or was destined to. Since a Service VLAN is a property of the Service, there is a one to one traffic mapping between PVC and VLAN. However, it is also possible to add a parameter to the PVC as the Service identifier. It is possible to use Ethertype information and to create a service where the traffic from one PVC is mapped to two VLANs (and two gateways) according to the Ethertype (PPP or IP). Figure 33 on page 43 illustrates this scenario.

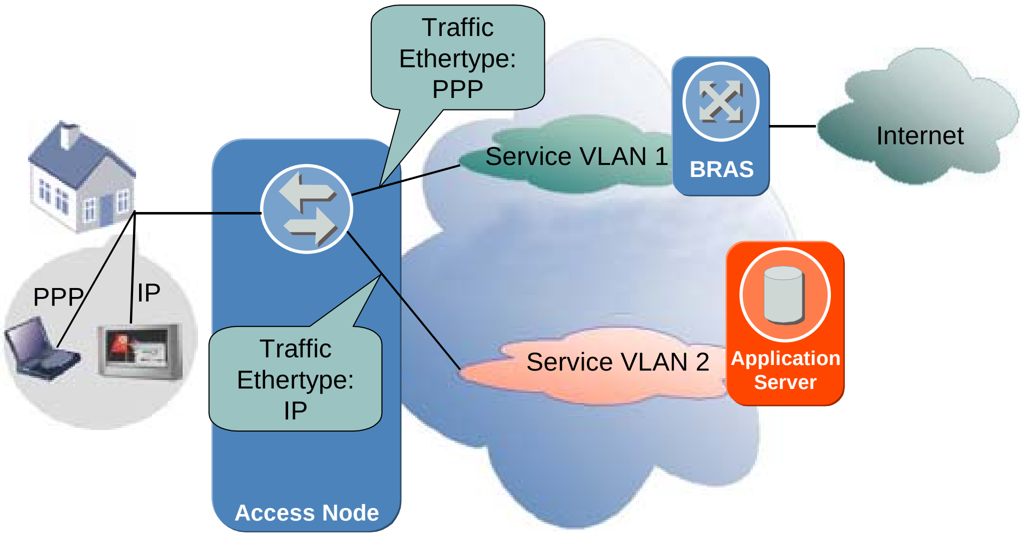


Figure 33 Traffic Mapping to Two VLANs

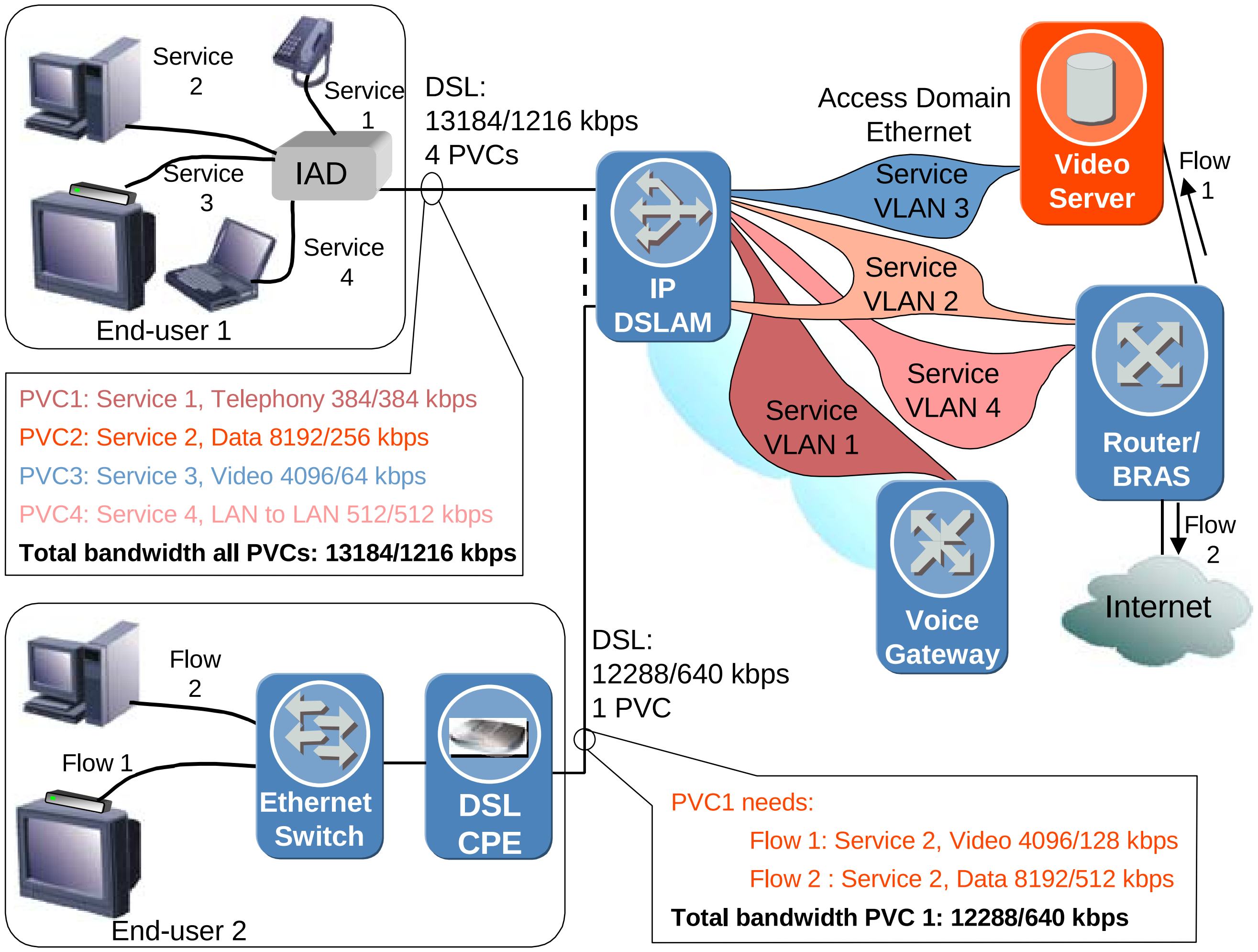
In practice, this scenario is done by creating two Service Configurations, and using the same PVC for both.

6.1.1 Bandwidth Control

The bandwidth control in EDA is done in several layers:

1. The DSL layer by setting the overall bandwidth for the DSL connection
2. The ATM layer by setting the bandwidth for each PVC
3. The Ethernet layer by applying traffic policing

Figure 34 on page 44 illustrates an example of the bandwidth control principle.



PVC1: Service 1, Telephony 384/384 kbps
PVC2: Service 2, Data 8192/256 kbps
PVC3: Service 3, Video 4096/64 kbps
PVC4: Service 4, LAN to LAN 512/512 kbps
Total bandwidth all PVCs: 13184/1216 kbps

PVC1 needs:
Flow 1: Service 2, Video 4096/128 kbps
Flow 2 : Service 2, Data 8192/512 kbps
Total bandwidth PVC 1: 12288/640 kbps

Figure 34 Bandwidth Control with Services

Two End-users are shown in Figure 34 on page 44. The DSL configuration is set for the total bandwidth of the entire customer services combined. End-user 1 has four EDA Services, which gives a total bandwidth demand of 13184 kbps downstream, and 1216 kbps upstream. The bandwidth for each PVC is set individually, and the DSL bandwidth is set to the total amount of all PVCs bandwidths together.

End-user 2 has one EDA service (single PVC) that contains two CoS flows: high priority for video and low priority for data. The bandwidth needs for the PVC is 12288 kbps downstream and 640 kbps upstream. It is not possible to configure the bandwidth of each CoS flow individually.

The DSL bandwidth can also be set to less than the sum of the services bandwidth. In this case, the bandwidth of the services will decrease according to the priority of each service, when simultaneously used services demand more than the available DSL bandwidth.

The control of the upstream bandwidth for each service should be done by the CPE modem. The IP DSLAM supports Integrated Local Management Interface (ILMI) for the configuration of the CPE modem. If the CPE modem does not support ILMI, the IP DSLAM can force upstream policing. No matter how the CPE modem is configured, the total upstream bandwidth can never exceed the DSL upstream bandwidth.

The bandwidth of the EDA Services can be changed on the fly. In order to be able to do that, the DSL bandwidth must be set to the highest requested bandwidth. That means that there might be situations where the DSL bandwidth is larger than the sum of all the PVCs bandwidths. If there is no total control over the configuration of the CPE modem PVC upstream bandwidth, it is possible to impose policing in the Ethernet layer in the IP DSLAM. The policing can be imposed per PVC, CoS flow or both. Please note that policing, unlike shaping, discards packets if the specified bandwidth is exceeded even in short periods.

6.1.2 CPE Access Methods

When the End-user is to receive an IP based service, the Customer Premises Equipment (CPE) must be configured with IP settings such as IP address, subnet mask and default gateway. The way in which the equipment receives these settings is called Access Method. The Access Method is an attribute of an EDA Service, and when the Service is assigned to an End-user, the CPE can only use that specific Access Method. The following Access Methods can be used:

- *DHCP* - Dynamic Host Configuration Protocol, which means that the IP address of the CPE is set dynamically by the Service Broker's DHCP server.

- *Static IP address* - The CPE equipment is assigned a static IP address or IP address range (that is, DHCP or PPP cannot be used).

- *Transparent LAN* – When LAN-to-LAN transparency is used, all filtering in the IP DSLAM for the subscriber is disabled, and broadcast is allowed. If any filtering or protection is desired, it must be done in the Edge Node or CPE.

- *PPP over Ethernet* – The CPE can only use PPPoE to access the network.

- *PPP over ATM* – Only PPPoA can be used by the CPE. The IP DSLAM will convert the PPPoA from the CPE to PPPoE.

- *PPP Automatic* – The IP DSLAM will automatically sense the access method (PPPoE or PPPoA) used by the CPE.

- *Static IP over ATM* – This method is used for IPoA access (RFC2684R) with end-user equipment by using a static IP address.

- *Dynamic IP over ATM* – This method is used for IPoA access (RFC2684R) with end-user equipment requesting dynamic IP address assignment via DHCP.

6.1.3 Transparent VLAN Service

The transparent VLAN Service (TVLS) is realized by using VLAN stacking, also called QinQ. QinQ is a method used for allowing multiple VLAN tags in a single Ethernet frame. The VLAN transparency and QinQ function has no relation to the End-user Access Method. Note that the use of QinQ is not mandatory.

QinQ is used for the following reasons:

- To be able to preserve an existing tagging of the traffic from the End-user or a sub-provider.
- To enable the re-use of the VLAN IDs, thereby extending the amount of used VLANs above 4096.

The QinQ can be used with any Access Method. Figure 35 on page 47 illustrates the QinQ principle.

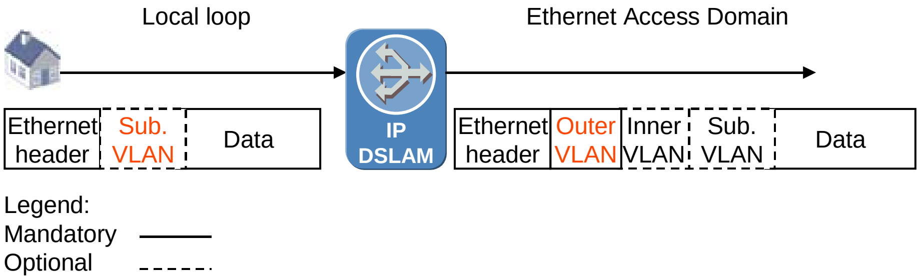


Figure 35 Using QinQ in EDA

When a frame from the End-user reaches the Access node, one (outer) or two (inner and outer) VLAN tags are added to the frame. The frame is sent into the Access Domain Ethernet where the outer VLAN tag is used as the VLAN ID, priority and Ether type. When the frame leaves the Access Domain both VLAN tags are removed (either by an IP DSLAM or by a router. However, the node can read the inner VLAN tag and use the information further if so required.

Figure 36 on page 48 illustrates one way of using the QinQ for VLAN per End-user, while using the same VLAN for a service.

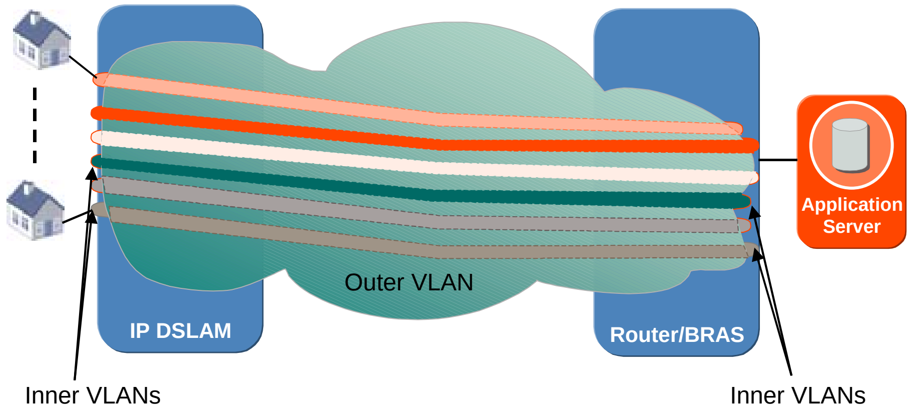


Figure 36 VLAN per End-user

In the example in Figure 36, each user is assigned a different inner VLAN. The End-users are thus layer 2 separated, since the IP DSLAM (terminating and acting upon the inner VLAN) will not allow direct layer 2 traffic between the two End-users. The Router or BRAS terminates both VLAN tagging, but acting only on the outer VLAN, and therefore supplying access to the application server for all the End-users.

Figure 37 on page 48 illustrates another example of using QinQ, this time for Multiple Server Access through the same Service.

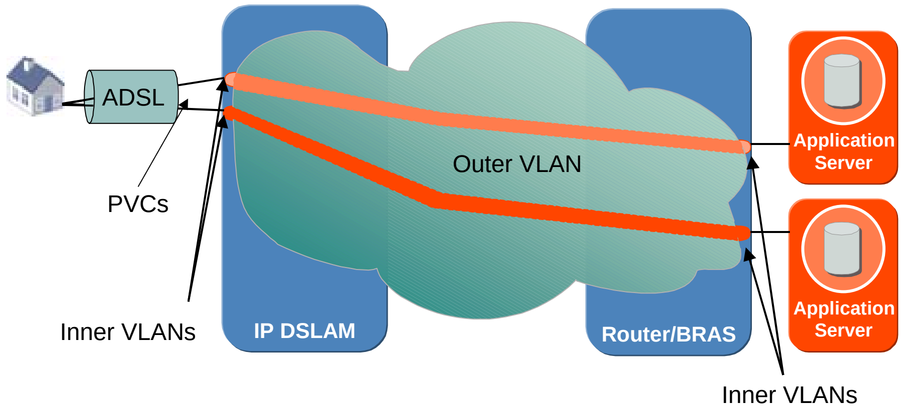


Figure 37 VLAN per Server

In the example in Figure 37, different PVCs of the same End-user are assigned with two different services using the same outer VLAN, but different inner VLAN. When the VLAN tagging is terminated by the Router or BRAS, traffic from one inner VLAN will be forwarded to one application server, while the traffic from the other inner VLAN will be forwarded to the other application server.

The IP DSLAM supports up to five VLAN tags (including the two it can add), in order to enable QinQ of frames that where QinQ is already used. If a frame already contain four tags, and the IP DSLAM should add two tags, the frame will be discarded.

The IP DSLAM supports two types of QinQ:

- IEEE 802.1Q (Ether type 8100)

- VMAN (Ether type 8A88) VLAN stacking defined by Extreme Networks.

The two QinQ types cannot be mixed within the same service. The inner VLAN can be changed individually for each End-user PVC, that is, different End-users can have different inner VLANs for the same service.

6.2 Quality of Service

Quality of Service (QoS) of a network deals with the ability of the network to provide transport services suitable for the applications using the network. There are three main parameters that affect the quality of the transmission:

- Packet loss – packets of information that get lost in the network and do not reach the receiver
- Delay – the time it takes for a packet to traverse through the network from the sender to the receiver
- Jitter – variation in the delay within the same traffic flow

Table 2 illustrates different requirements that different services have:

Table 2 QoS Requirements of different Service Types

	Packet loss	**Delay**	**Jitter**
Video	Very sensitive	(Not) sensitive	Not sensitive
Voice	Not sensitive	Sensitive	Very sensitive
Data	Not sensitive	Not sensitive	Not sensitive

The Very sensitive adjectives in Table 2 indicate which parameter will cause the perceived quality of the application using the transport to deteriorate. Not sensitive means that as long as the deterioration is reasonable (there is no definite definition for limits), the perceived quality will not be changed.

Video applications – As long as the video is only streaming video, only the packet loss is important for the perceived quality. Delay will only affect the time elapse when changing a channel. However, if the video service is interactive video, the delay becomes more important, and should be kept at a time that is acceptable as response time.

Voice applications – Such applications like telephony, are very sensitive, especially to delay and jitter. The jitter is especially important since voice packets may arrive in the wrong order if they have different delay length. Buffering the packets can help this, but the buffer will then increase the delay. Loss of packets can be handled by a telephony application without substantial service deterioration, provided that the loss is limited to a small fraction of the packets, and that the packets are not lost in bursts.

Data applications – Such as Internet surfing, using the TCP/IP protocol stack, are generally not very sensitive, neither to packet loss nor delay.

Interactive gaming however, is more sensitive to large packets losses and unacceptably long delays.

Loss of packets is rare within the EDA access network, unless the loss is caused by capacity limitations. In that case it tends to occur in bursts.

Consequently, in order to provide the transport service required for Telephony over IP there are two main requirements for the QoS function. One is to minimize the delay of voice packets, the other to minimize the influence of capacity limitations on voice packets.

In a network carrying a mixture of real-time applications and data packets, delays are mainly imposed on voice packets when they have to wait for transmission of often-longer data packets.

The Quality of Service in EDA is ensured by classifying packets and handling their transmission through the network according to the classification of each packet.

6.2.1 Traffic Classification

The classification of the traffic is done by the edge nodes in the network.

The Access nodes (IP DSLAM or POTS line board) tag upstream frames with classification tags (also called p-bit), determined by the origin of the frame. A frame generated internally by the Access node is tagged with the management priority tag. A frame originating from an ATM PVC is tagged with the priority tag defined for that PVC or the CoS flow within the PVC by the operator.

The classification tags included in downstream frames may originate from a voice gateway or a Service Provider’s PoP or it may be a result of a conversion performed at the edge of the EDA network. Figure 38 on page 52 illustrates the classifying nodes in the network.

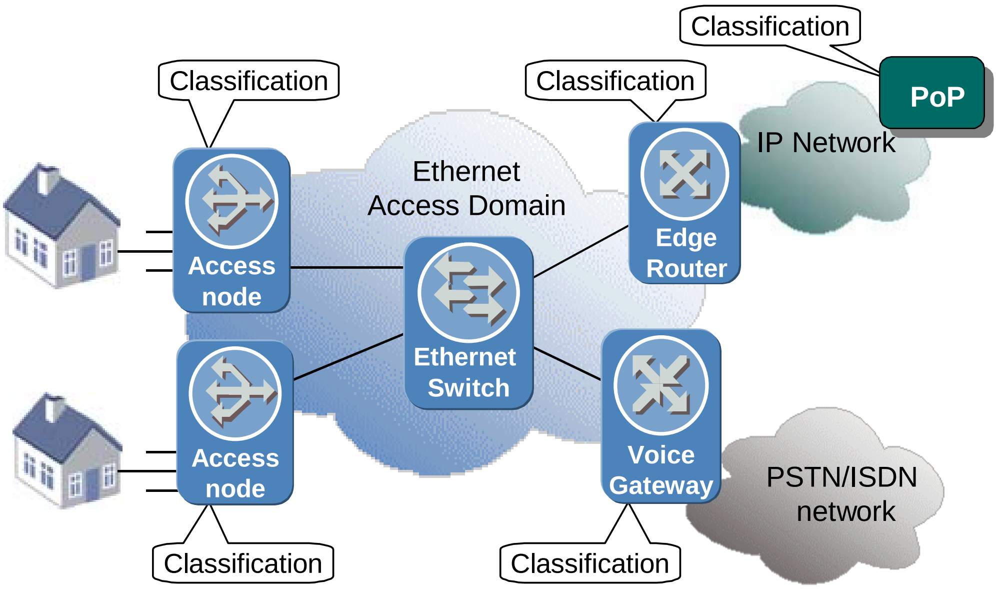


Figure 38 Traffic Classification in an EDA Network

6.2.2 Traffic Handling

The principle of differentiated services is that every single switch or router, as an autonomous unit, decides the order, in which packets or frames are forwarded on the transmission link. The decision is based on the classification (p-bit) of the packet or frame, and the QoS policy.

The differentiated services implementation used in the Ethernet is according to the IEEE 802.1Q specification, specifying 8 values using three bits, the so called p-bit. The p-bit value indicates the classification of the frame.

Figure 39 on page 53 illustrates the operation of a differentiated services based forwarding process of a network element using two priority levels (Classes of Service), one for voice and one for data.

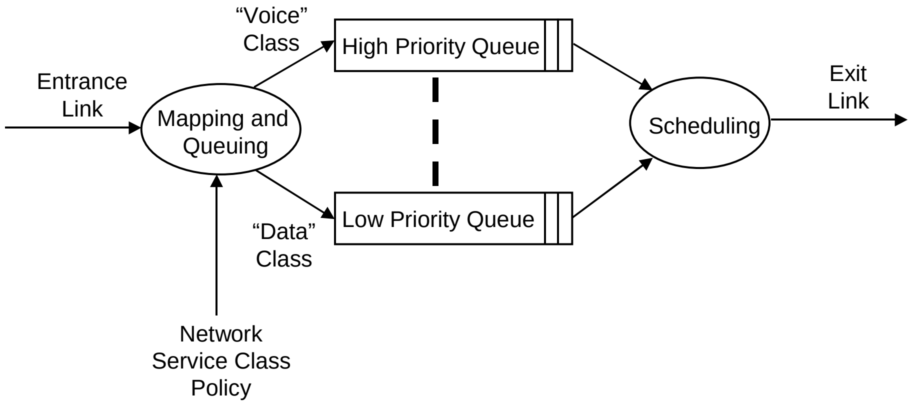


Figure 39 Differentiated Services in an Ethernet Switch

When a frame is received, the mapping and queuing process determines by examining the header, the destination port and the queue in which the frame will wait to be sent. The decision of which queue to use is based on the classification of the frame.

The scheduling process, submits the queued frames for transmission. Different algorithms can be used for emptying the different queues. For example, Strict Priority, Weighted Round Robin, Deficit Round Robin (DRR), or Modified Deficit Round Robin (MDRR). These algorithms are further explained in section 6.3.1 on page 57.

The EDA access network uses as default a queue for network control, one for voice, one for video and one for data. The default transport service and traffic type for each classification is shown in Table 3 on page 53. All units within the Ethernet Access Domain conform to the IEEE 802.1Q specification.

Table 3 Ethernet QoS Mapping in EDA

Classification (p-bit)	**Priority**	**Traffic Type**
7	Highest	Management
6	Higher	Voice (Telephony over IP only)
5	High	Video
0 - 4	Best Effort	Data

6.2.3 QoS Implementaion

The Quality of Service functions (mapping and queuing, scheduling) are implemented in different places in the EDA network in different ways. The implementation in the aggregation part of the network (switches and routers) is less demanding since it is expected that the ratio of available bandwidth compared with the traffic is greater than in the Access nodes (DSL lines).

In the Access Domain Ethernet the QoS functions are implemented as described in this section. On the DSL lines, the QoS functions are implemented based on the ATM native PVCs, or Ethernet like mechanism in a single PVC, or a combination of both. These mechanisms are further explained in section 6.3 on page 56.

6.2.4 QoS in IP Based Network Sections

Within routed parts of the network, that is, when EDA traverses an IP network in order to reach a remote Service Provider’s PoP, differentiated services is used on the IP level. The principle of the forwarding process of a router is similar to the process in an Ethernet switch.

Within IP networks various standards for priority tag indication exist, using DiffServ Code Point (DSCP) fields within the IP header. The tags used to indicate specific services within these fields also differ from network to network. Therefore mapping must be performed within the edge nodes in order to adapt to the priority tags used in the specific network.

6.2.5 Delay Imposed on Telephony over IP

There are two contributors to the delay imposed on voice packets:

- The interacting functions (decoding and encoding of analog information).

- The network itself, queues in network devices and physical distance (no matter how fast the connection is, one bit of information has a definite speed).

Figure 40 on page 55 illustrates the definition of the delays.

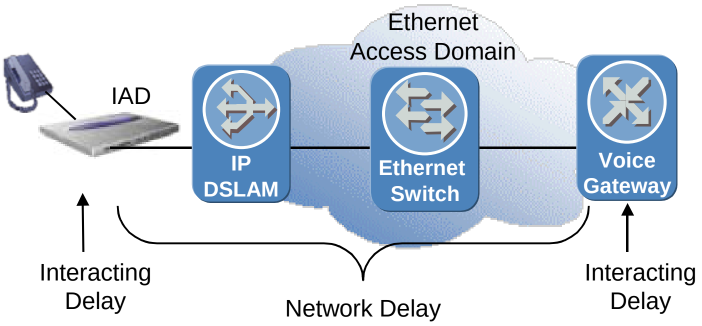


Figure 40 Delay Contributors

Delay Imposed by the Network

Due to the QoS measures implemented throughout the network the total one-way delay is kept on a minimum for Telephony over IP frames.

The EDA Ethernet Access Domain, including the ADSL line, introduces delays that vary with the bandwidth provisioned for the ADSL line and with the amount of competing Telephony over IP traffic to or from the same IAD, (when two or more lines on the same IAD are involved in calls). Table 4 on page 55 shows examples of theoretical maximum one-way delays introduced by the Ethernet Access Domain (up to 8 aggregating switches). These examples are based on strict priority scheduling and ATM based QoS (multiple PVCs).

Table 4 Maximum Imposed Network Delay

ADSL Line Capacity	**One Active Call**	**Two Active Calls**
640 kbps	8 ms	10 ms
384 kbps	10 ms	13 ms

Note that setting interleave to more than zero will add a substantial delay to the network delay.

Delays Imposed by Interacting Functions

The delays imposed by the interacting functions of the voice gateway and the IAD depend on the length of voice packets, and the type of the voice gateway and IAD used.

As can be seen from Table 4, the maximum one-way delays imposed on Telephony over IP traffic at 384 kbps and one call, by the EDA is approximately 10 ms. Even with extra delay from the voice gateway and IAD in the order of 30 ms, the total delay will be approximately 40 ms.

Such small delays are in contrast to other VoIP based systems, often imposing one-way delays of 100 ms or more, and they are very close to what can be achieved with ATM based systems implemented according to the BLES model (Broadband Loop Emulation Service), as recommended by the DSL Forum.

The delay figures for Telephony over IP can also be validated in a comparison with the recommended acceptable one-way delay of less than 150 ms, as specified by ITU.

Due to propagation delay a transatlantic call from San Francisco to London, or any call over a distance of approximately 10,000 km, would introduce a delay of the order of 50 ms. A call that both originates and terminates at EDA Telephony over IP subscribers would consequently experience a total one-way delay of approximately 130 ms (40+50+40 ms). This is well below the recommended value of 150 ms.

6.3 QoS and Bandwith Control in the IP DSLAM

Like the rest of the EDA network, differentiated services are also used to prioritize transmission on the ADSL line. However, on this line the prioritization is not sufficient to ensure low latency.

The bandwidth of the ADSL line is often significantly lower than the capacity of other links in the system. Due to low transmission capacity, considerable time is used to transfer a video or voice-carrying frame over the ADSL line. Transmission of a number of large data frames may also cause long delays for real time service traffic if QoS mechanisms are not imposed.

Two techniques are used to secure adequate QoS for different service types on the ADSL line:

- Using different ATM PVCs with different service classes
- Packet based queuing which ensures different treatment of Ethernet frame according to their classification (the packet based queuing is described in further details in section 3 on page 59)

The two techniques coexist and are always active. Note that the IP DSLAM can only ensure the QoS on the downstream direction. QoS handling in the upstream direction must be done in the CPE.

In cases where the IP DSLAM is overloaded with traffic, it must be ensured that the high priority packets are always processed first. This is done using an overload protection mechanism that is always active. In order to be able to limit the traffic from an End-user, policing can be applied on the traffic per PVC, per CoS flow or both. Figure 41 on page 57 illustrates the QoS and bandwidth control mechanisms in the IP DSLAM.

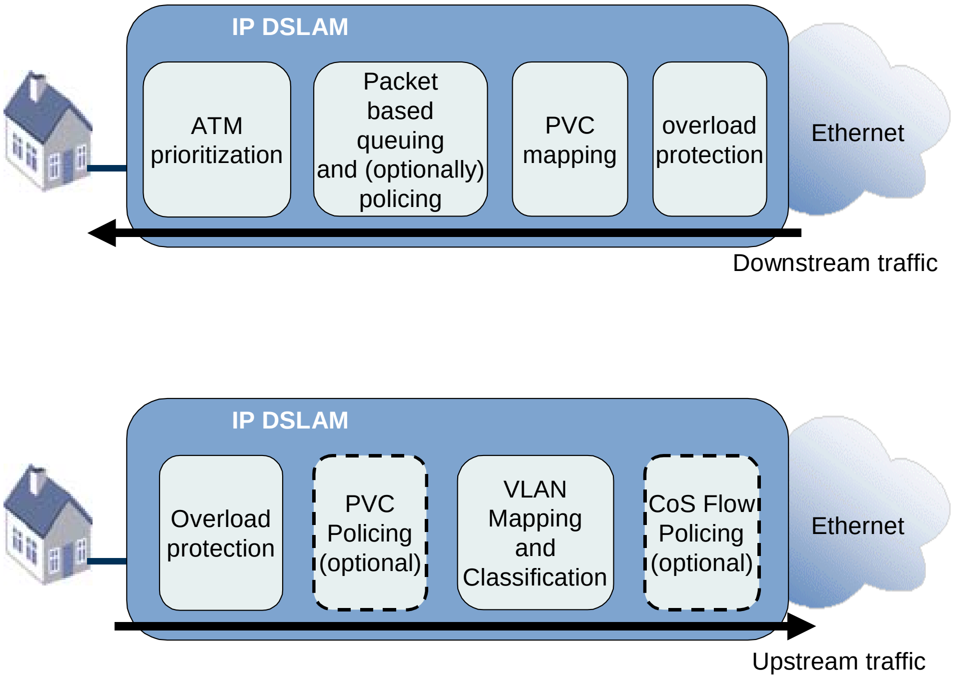


Figure 41 QoS and Bandwidth Control Mechanisms

The policing imposed by the IP DSLAM is not a traditional policing. Traditional policing discards all packets that exceed the configured bandwidth. However, this property is very unfortunate for TCP traffic, which is a burst traffic by nature, and has a self-adjusting mechanism. The EDA policing therefore, allows the operator to configure an extra bandwidth (burst size) that will be allowed to pass for a short period of time.

Since there are different mechanisms in the upstream and downstream, they will be explained separately.

6.3.1 Downstream Mechanisms

Figure 42 on page 58 illustrates the flow of the traffic in the downstream direction.

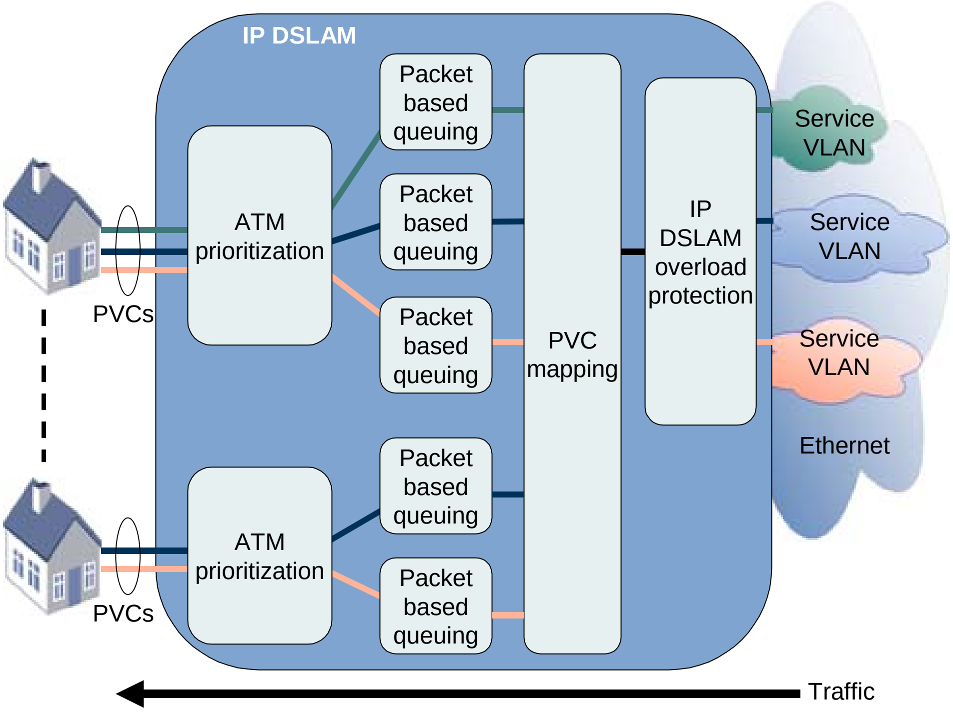


Figure 42 Downstream QoS Mechanisms

The traffic from the Ethernet will go through the following processes:

1. Overload Protection

The overload protection is only in use if there is more than one packet waiting to be processed. There are four queues in the IP DSLAM downstream overload protection. They correspond to the following classification classes:

Table 5 Overload Protection Queues

Queue	Priority	Classification Class
1	Highest	7
2	High	6
3	Medium	5
4	Low	0 - 4

Note the same four queues are used for all traffic coming from the Ethernet. Strict priority is used in the scheduling of the overload protection.

2. PVC Mapping

The Service of the packets is identified and the packets are sent towards the packet queuing of the designated PVC.

3. Packet Based Queuing

The packet based queuing enables treating different traffic contents on the same PVC by transmitting high priority traffic before lower priority traffic. This is done in three steps:

1 Sorting the packets in up to four different queues (a queue for each CoS flow) according to their classification.

2 Applying policing on each CoS flow (optional)

3 Emptying the queues by sending the packets according to a schedule that defines how these queues are emptied.

Figure 43 on page 60 illustrates the packets based queuing principle with an End-user that has two services (on two PVCs). One service contains only one CoS flow. That is, there is only one QoS definition for all the traffic in that service. The other service contains four CoS flows. Frames in this service will be treated according to their classification. That means that higher priority frames will be sent by the traffic scheduler before lower priority frames (according to the scheduler algorithm) for further processing. Prioritizing between the two services after the packet based queuing, is done in the ATM prioritization, according to the ATM Class of Service of each PVC.

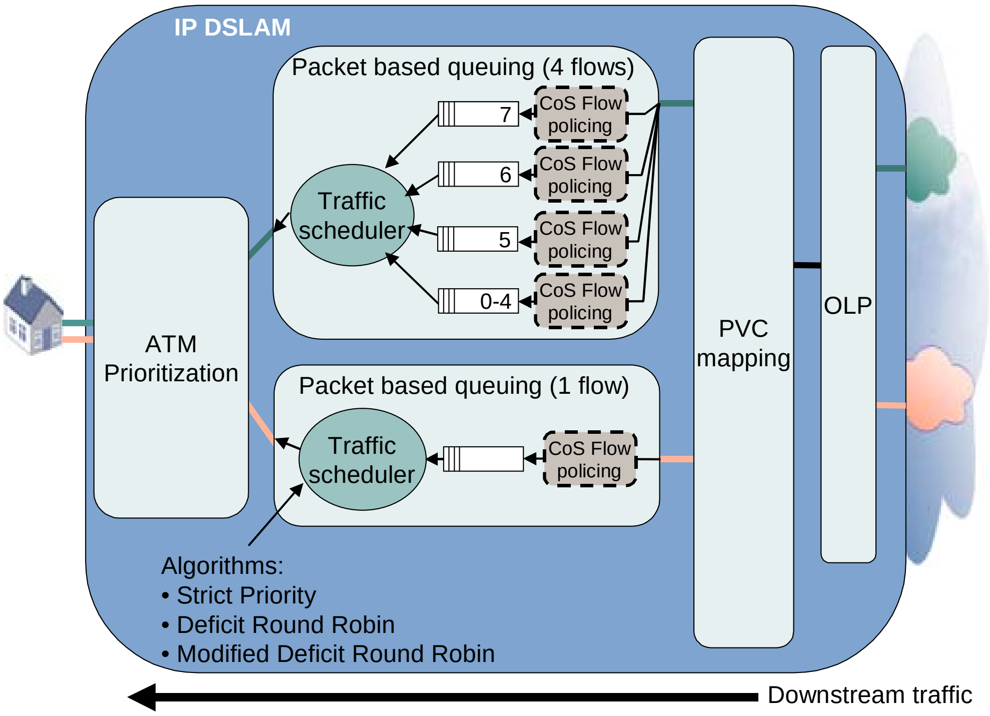


Figure 43 Packet Based Queuing

The buffer for the queues can contain up to 128 Ethernet frames per End-user. The buffer allocated to each queue is dynamic. If there is no more available buffer and new traffic arrives, frames from the lowest priority will be discarded in order to make place for higher priority frames.

As illustrated in Figure 43, if only one CoS flow is defined in a service, the frames will be placed in a queue that will be emptied right away by the traffic scheduler.

The traffic scheduler can use the following algorithms when emptying the queues:

- Strict Priority - The queues are processed by strict priority order. As long as there are packets in a higher priority queue, packets in a lower priority queue will not be sent. Queue 1 is the highest priority and queue 4 is the lowest.

- Deficit Round Robin (DRR) - The queues are serviced by weight in terms of bytes transmitted from each queue. The weights are fully operator configurable. The queue numbers has no importance when DRR is used, only the weight of each queue.

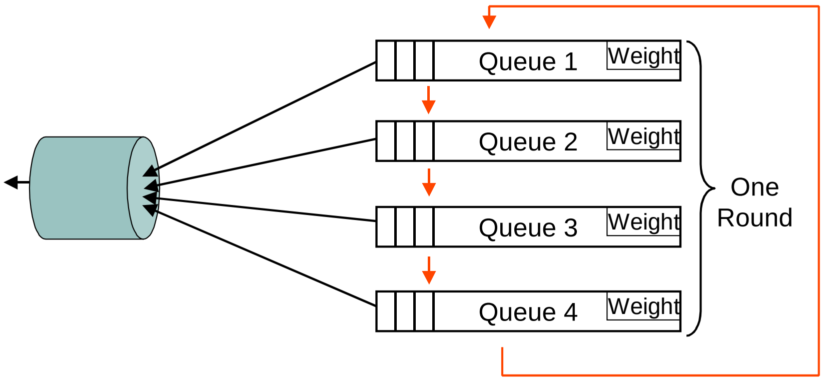


Figure 44 Deficit Round Robin

- Modified Deficit Round Robin (MDRR) - The highest prioritized queue (queue 1) is processed first and next the remaining queues are processed by weight as for Deficit Round Robin. The weights are fully operator configurable. Note that when MDRR is used, queue 1 has no weight since there is strict priority between queue 1 and all the other queues (meaning that queue 1 will always be emptied when serviced).

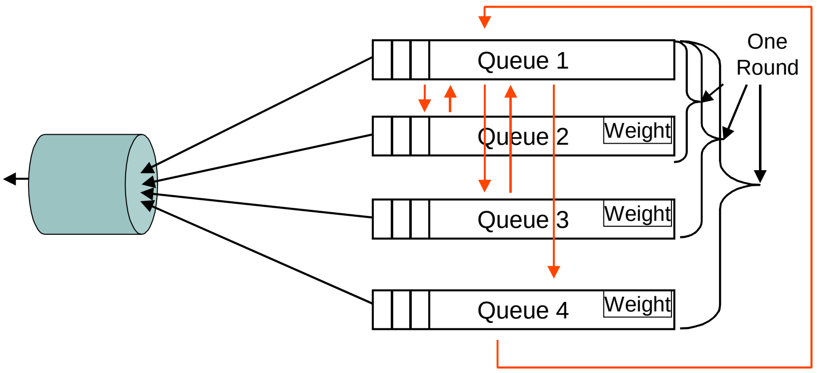


Figure 45 Modified Deficit Round Robin

DRR and MDRR weight is given in Bytes per round. The weight defines the number of bytes that can be sent from a specific queue in one round. This way the relative bandwidth of a CoS flow with relations to other QoS flows can be defined. When a queue is serviced, an Ethernet frame is the smallest unit (whichever size the actual frame has) that can be sent. If the frame waiting in the queue is larger in size than the weight for the specific queue (for example if the frame is 1500 bytes and the weight is 1000 bytes) then the frame will not be sent in the first round. The unused bytes that could have been sent in this round will be summed to the bytes in the next round. At that time the allowed bytes will be 2000, and therefore the frame

(1500) will be sent. The remaining 500 bytes (if there is no frame with less than 500 bytes waiting in the queue) will be summed with the weight of the next round again. When a queue is completely empty, any unused weight is deleted (not summed with the weight of the next round).

Line Overload Situations

Line overload situation, is a situation when the traffic coming downstream to a specific line is much larger than the bandwidth configured on the DSL line (typically UDP traffic). In this case, the queues for the line will be filled, since the IP DSLAM is not allowed to send more than the configured bandwidth, and at the end, packets will have to be discarded.

As part of the IP DSLAM’s QoS mechanism, the discarded packets will be of the lowest classification, by a mechanism according to the following rules:

When the queues are filled, and a new packet arrives, it will be mapped in order to identify its destination line, PVC and its classification. After it is identified, the IP DSLAM evaluates if there is a lower classification packet waiting to be sent according to the “discard rules”. If there is, the lower classified packet will be discarded and the new packet will be put in a queue, otherwise the new packet will be discarded. The “discard rules” are based on three levels (most important first):

1. ATM class

2. Scheduling mechanism and queue number

3. Length of the queue

The IP DSLAM evaluates each level and if there is more than one queue in the level, it will use the next level. Table 6 on page 63 show the order in which the IP DSLAM will determine from which queue a packet will be discarded. The IP DSLAM will start from the top and stop as soon as a queue that is not empty is found, and discard the last packet from that queue.

Table 6 Discarding Evaluation Steps

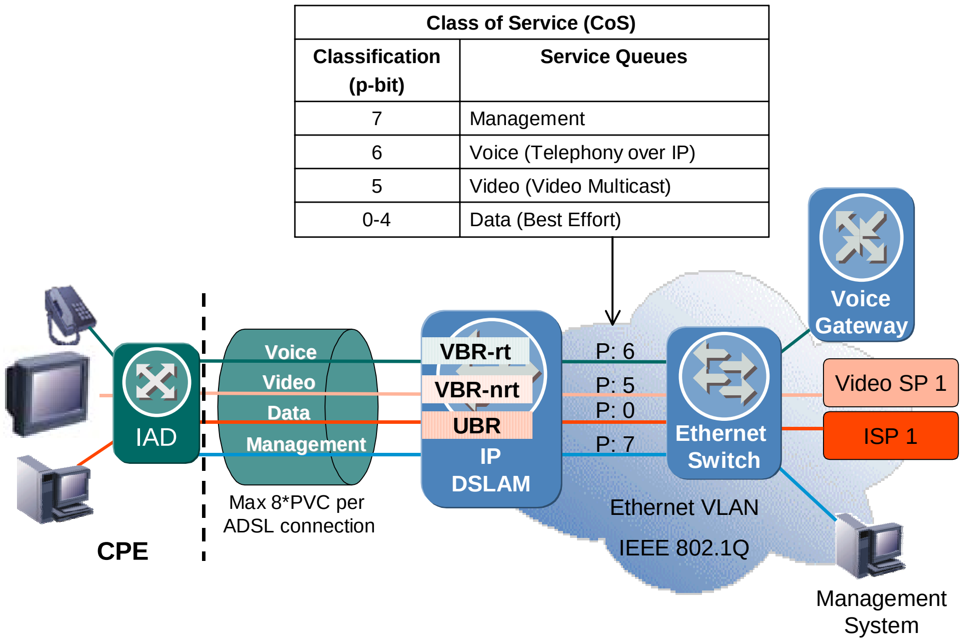
Step	Evaluate
1	UBR: Strict priority queues 4
2	UBR: Strict priority queues 3, MDRR queues 2-4, DRR queues 1 – 4, PVC with one CoS flow only
3	UBR: Strict priority queues 2, MDRR queues 1
4	UBR: Strict priority queues 1
5	VBR-nrt: Strict priority queues 4
6	VBR-nrt: Strict priority queues 3, MDRR queues 2-4, DRR queues 1 – 4, PVC with one CoS flow only
7	VBR-nrt: Strict priority queues 2, MDRR queues 1
8	VBR-nrt Strict priority queues 1
9	VBR-rt: Strict priority queues 4
10	VBR-rt: Strict priority queues 3, MDRR queues 2-4, DRR queues 1 – 4, PVC with one CoS flow only
11	VBR-rt: Strict priority queues 2, MDRR queues 1
12	VBR-rt: Strict priority queues 1
13	CBR: Strict priority queues 4
14	CBR: Strict priority queues 3, MDRR queues 2-4, DRR queues 1 – 4, PVC with one CoS flow only
15	CBR: Strict priority queues 2, MDRR queues 1
16	CBR: Strict priority queues 1

If more than one queue is found in the same step, a packet from the longest queue (largest number of packets) will be discarded.

4. ATM Prioritization (Native ATM QoS)

Measures have been taken to ensure that the full bandwidth provisioned for the ADSL line is utilized during transmission of voice frames and that voice frames can be transmitted as soon as they arrive and are available for transmission. These measures are based on standard ATM QoS mechanism, see Figure 46 on page 64.

Note that there will only be management traffic on the ADSL line if Interim Local Management Interface (ILMI) is used to control the CPE. In this case the management traffic will use a hidden UBR PVC (a ninth PVC if eight other PVCs are used for End-user traffic).



Class of Service (CoS)	
Classification (p-bit)	**Service Queues**
7	Management
6	Voice (Telephony over IP)
5	Video (Video Multicast)
0-4	Data (Best Effort)

Figure 46 Service Mapping and QoS in EDA

QoS in the ATM network uses the following features to ensure the fastest possible transmission of voice traffic over the ADSL line:

- Priority and service classes
- Segmentation
- Burst allowance

Priority is implemented by creating Permanent Virtual Circuits (PVCs) for voice, video and data on each ADSL line. Each PVC is like an open connection in a traditional circuit switched network.

Voice PVCs are configured with the service class **VBR-r**t (Variable Bit Rate real-time). The service class requires strictly controlled delays and delay variations, but not necessarily a constant bandwidth. It is characterized by Peak Cell Rate (PCR), Sustainable Cell Rate (SCR) and Maximum Burst Size (MBS) / Burst Tolerance (BT).

The Peak Cell Rate defines the maximum bit rate (kbps) that may be transmitted in the PVC. The Maximum Burst Size/Burst Tolerance is the number of cells or maximum time for which data may be transmitted at the Peak Cell Rate. The PCR and MBS or BT thus defines what is called burst allowance. The Sustainable Cell Rate is an upper limit for the average cell rate that may be transmitted in the PVC.

Video services are configured with service class **VBR-nrt**. This service class is suitable for non-real-time “burst” applications requiring service guarantee from the network. It is also characterized by PCR, SCR and MBS.

Data services are configured with the service class **UBR** (Unspecified Bit Rate). UBR is used for non-real-time, “burst” applications, which tolerates delays and packet loss and is often referred to as a “Best Effort” service.

Segmentation is a native feature of ATM, dividing the ADSL traffic into small cells, each containing 48 bytes payload, as opposed to Ethernet frames of up to 1500 bytes.

Burst allowance , which is defined by the Peak Cell Rate (PCR), and Burst Tolerance (BT) or Maximum Burst Size. The Burst Tolerance is the maximum time for which the PVC may transmit data at Peak Cell Rate. Limiting the Burst Tolerance to the size of a voice frame (per used POTS port), and allowing the voice PVC to use maximum capacity, ensures maximum QoS. The IAD maps only data coming from the POTS ports into the voice PVC, thus ensuring that the bandwidth configured for voice is always available.

6.3.2 Upstream Mechanisms

Upstream traffic is considered less critical from the Access network point of view. The most critical link – the DSL link is controlled by the CPE in the upstream direction. It is assumed that the uplink from the From the Access Node can easily handle any traffic coming from the slower DSL line. Still, an overload protection similar to the one in the downstream direction, but which is based on the ATM service classes, secures the upstream traffic. Other policing and classification mechanisms are also used. Figure 47 on page 66 illustrates the different QoS mechanisms on the upstream direction.

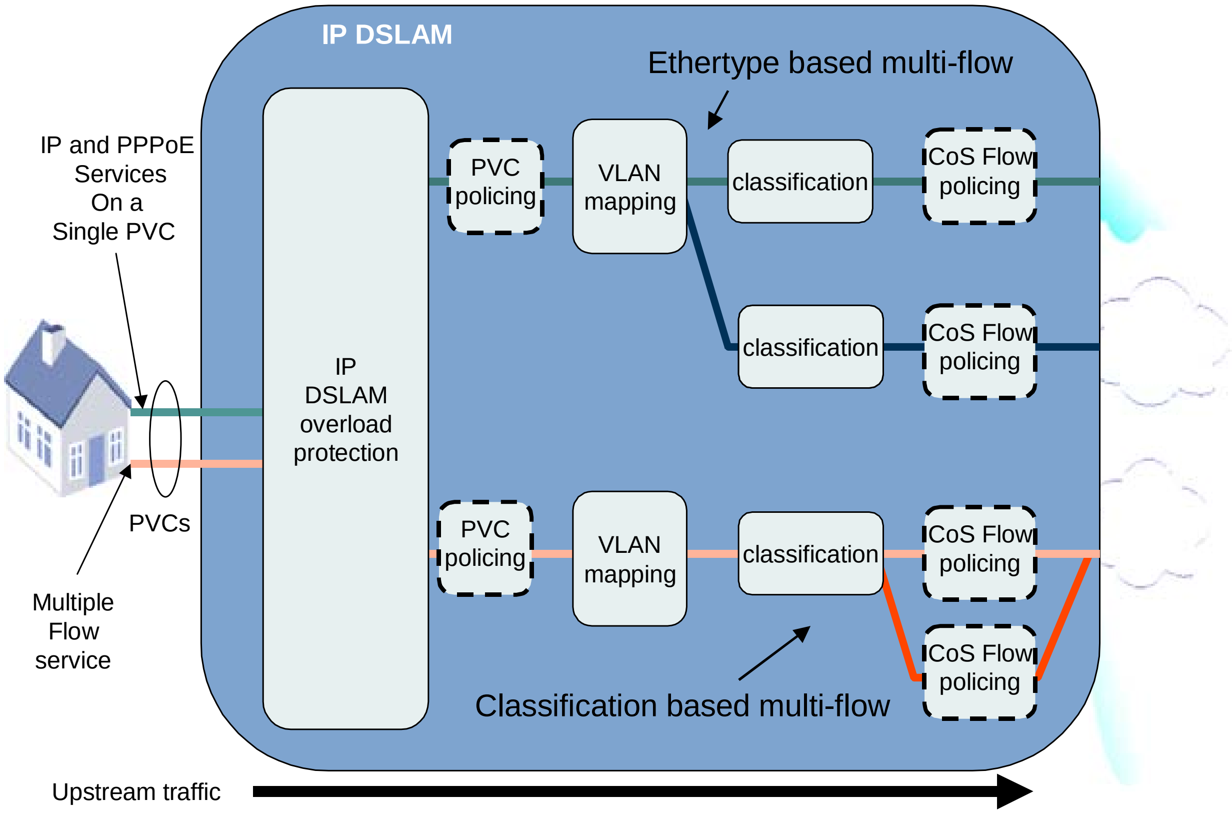


Figure 47 Upstream QoS Mechanisms

The upstream mechanisms work in the following steps:

1. Overload protection

The overload protection is only in use if there is more than one packet waiting to be processed. There are three queues in the IP DSLAM upstream overload protection. They correspond to the following ATM classes:

Table 7 Overload Protection Queues

Queue	Priority	Classification Class
1	High	VBR-rt
2	Medium	VBR-nrt
3	Low	UBR

Note the same four queues are used for all traffic coming from the DSL line. Strict priority is used in the scheduling of the overload protection.

2. PVC policing

Discards frames if the traffic from the End-user on that PVC exceeds the configured bandwidth. This policing discards frames randomly. This policing is optional and is configured per service.

3. VLAN mapping

Maps the frames to VLANs. The mapping is done on basis of the PVC from which the frame came from, or the PVC and Ethertype (IP or PPPoE) – if there are two services with two VLANs defined with that same PVC.

4. Classification

Sets the p-bit for the frame. The classification is based on one of the following:

- PVC
- PVC and Differentiated Services Code Point (DSCP) value (comes from the End-user)
- PVC and Ethertype

The method and the values of the conversion are defined when the service is created.

5. CoS flow policing

Discards frames if the outgoing traffic for that CoS flow exceeds the specified bandwidth. This policing is optional, and is configured per service.

7 System Maintenance

The EDA system does not require any scheduled maintenance apart from backup of the PEM. The only parts that should be replaced from time to time are the fans of the IP DSLAMs and switches. For a more detailed description of how to maintain the EDA nodes please see the specific user guide and installation guide.

8 Telephony and Multimedia Services

When migrating from analog line to ADSL, the EDA System supports the different telephony solutions as well as multimedia solutions:

- Base band POTS
- Base band ISDN
- Telephony over IP
- Multimedia services such as video over IP

Base band POTS is traditional analog telephony, supplied by a local exchange, in the frequency band below the DSL frequency spectrum, see Figure 48 on page 69.

Base band ISDN is traditional ISDN telephony, supplied by a local exchange, in the frequency band below the DSL frequency spectrum, see Figure 48 on page 69. Note that the ISDN upper frequency is approximate since the frequency depends on the coding).

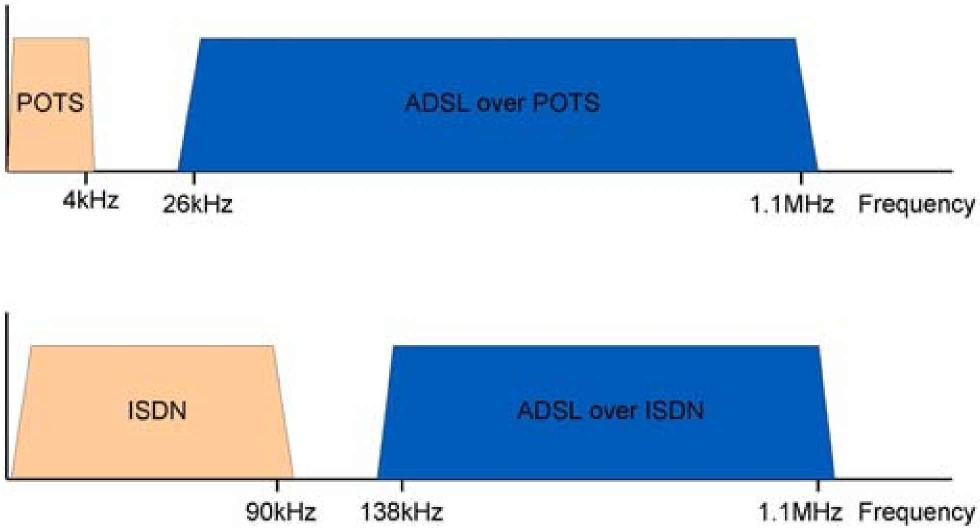


Figure 48 Base band POTS and ISDN Frequency Separation

Telephony over IP (ToIP) is a Voice over IP (VoIP) based carrier class telephony application. The voice is transmitted in data packets, together with other data packets, but with higher priority. It can be used for replacement of POTS, and supports legacy telephony services including supplementary services (Class 5 services). Services are supported with the same functions as in local exchanges.

Multimedia services are supported using basic EDA data access. There is however no higher priority, and the multimedia services are treated as data applications.

All applications (that is Telephony over IP, Multimedia services and one base band telephony either POTS or ISDN) may coexist within a single EDA system and each subscriber can be allowed to access any of the applications, including all in parallel. It should be noted, that while base band POTS and ToIP are perceived by the user as high quality telephony, the multimedia is perceived as lower quality.

8.1 Baseband POTS and ISDN in EDA

EDA innovatively supports base band telephony deployment based on generic filter/splitter functionality, which separates low frequency analog speech from high frequency digital ADSL information. A POTS/ADSL splitter must be deployed at the Customer Premises as well as within the Central Office (CO) site. The data traffic is delivered into the Ethernet switch. The base band solution is recommended when an existing narrowband (PSTN/ISDN) is updated to a broadband connection (ADSL) and the existing narrowband infrastructure is maintained.

EDA offers IP DSLAM and splitter/filter combinations with either integrated filters or external filters, as described below.

8.1.1 Baseband Solution with Integrated Filter

The 12-line IP DSLAM EDN312 has built-in base band POTS or ISDN filter, which simplifies installation compared to an external filter. The EDN312 IP DSLAM is shown in Figure 49 on page 71 and for an example please see the EDN288 solution illustrated on Figure 10 on page 19.

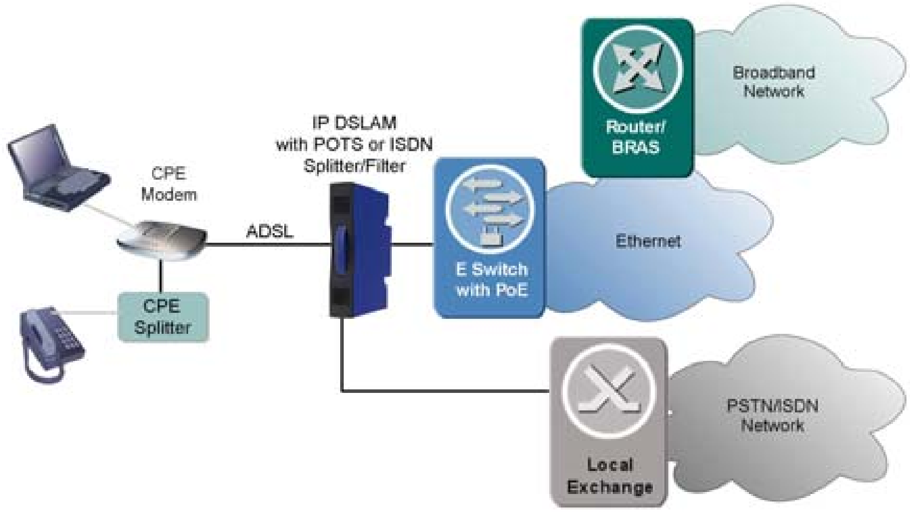


Figure 49 Base band Solution with Integrated POTS/ISDN Filter

8.1.2 Baseband Solution with External Filter

The 10-line IP DSLAM EDN110 supports a variety of external mechanical POTS low-pass filters and one combined ISDN splitter + low-pass filter solution. Connected to the IP DSLAM, the POTS low-pass filter complies with ETSI recommendations. In the network, the POTS filter is placed on the network side of the IP DSLAM between the IP DSLAM and the exchange, as shown in the figure below.

In Figure 50 on page 72 the EDA implementation of base band POTS is illustrated with a filter inserted between the IP DSLAM and the local exchange. This is only necessary when using the 10-line IP DSLAM.

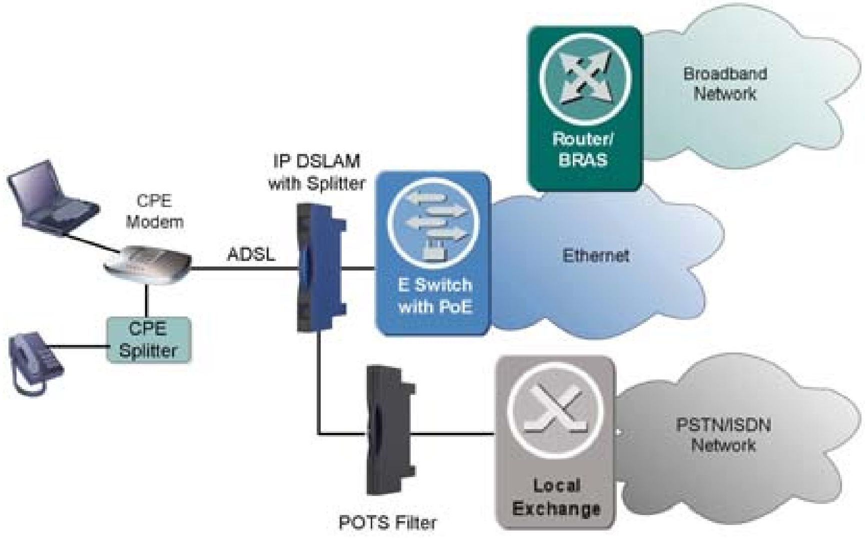


Figure 50 Base band Solution with External POTS Filter

8.1.3 Baseband Solution with External ISDN Filter

When implementing base band ISDN a splitter/filter is used and placed before the IP DSLAM as shown in Figure 51 on page 73. Connected to the IP DSLAM, the combined ISDN splitter/low–pass filter complies with ETSI recommendations. In the network, the combined ISDN splitter/low-pass filter is placed the same way as a traditional ADSL splitter – on the end-user side of the IP DSLAM - connecting directly to the ADSL line, to the IP DSLAM and to the local exchange, as shown below.

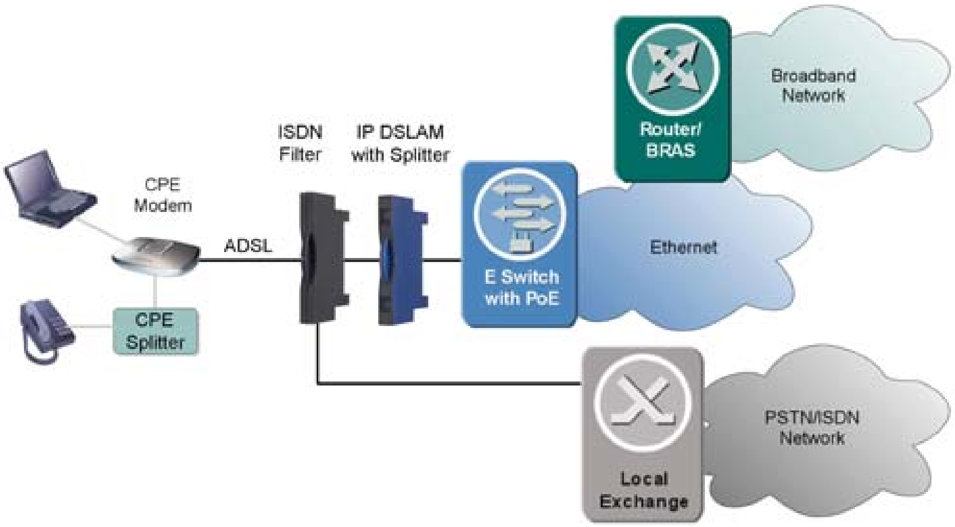


Figure 51 Base band Solution with External ISDN Filter

8.2 Telephony over IP

Telephony over IP (ToIP) is a Voice over IP (VoIP) based application, intended to supplement or replace traditional POTS. The function and quality as perceived by the subscribers, is identical to traditional POTS.

Charging is performed entirely in the local exchange. Consequently the same charging and billing systems can be used independently of the subscriber connection method, base band POTS or ToIP.

The Telephony over IP deployment is simple to implement, and gives the full advantage of the EDA System. There is no need to consider existing equipment (such as existing local exchange), and there is no need for a technician to work at the customer premises, since no installation of splitter and filters is required. This solution is especially advantageous in new subscriber installation, since half of the MDF (equipment part) is not needed. Subscriber aggregation is done in an Ethernet, eliminating the need for a PSTN line per subscriber

Telephony over IP is implemented by combining the ETSI TIPHON architecture of H.323 VoIP with the ETSI Access Network architecture, using the V5.2 protocol standard, see Figure 52 on page 74.

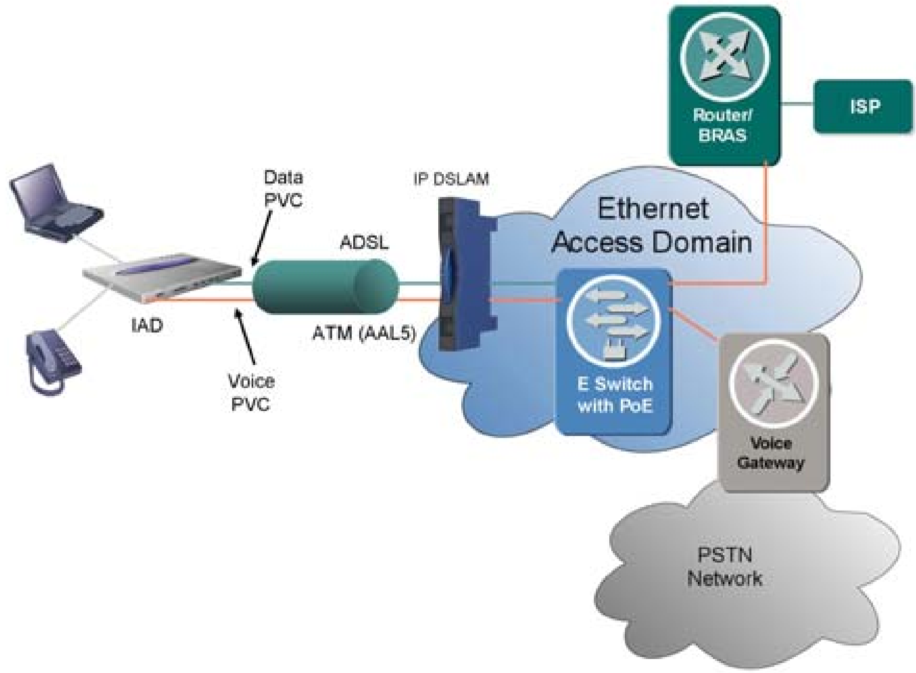


Figure 52 Telephony over IP Architecture

Telephony over IP is based on an H.323 to V5.2 voice gateway (VoGW), connected to a local exchange. H.323 signaling is used between the subscriber's Integrated Access Device (IAD) and the voice gateway while V5.2 signaling is used between the voice gateway and the local exchange. The use of V5.2 signaling enables utilization of existing class 5 services available in the local exchange, in the same way as done in circuit switched networks with Remote Sub Systems (RSS). The voice gateway just prolongs the services supported by the exchange over the packet-based network, using H.323 signaling. Consequently, with Telephony over IP it is possible to support all class 5 services[1].

The use of V5.2 and H.323 constitutes a very flexible architecture. The voice gateway may be connected to an exchange physically located at a site within an EDA Ethernet Access Domain, or to a centralized exchange system, covering several Ethernet Access Domains with a voice gateway each.
If the broadband network between the Ethernet Access Domains provides QoS capabilities to support Telephony over IP, the voice gateways may also be centralized. The location of the voice gateway and the local

[1] With the single exception of Private Metering

exchange is limited only by capacity and capabilities of the packet based and/or circuit switched networks. Figure 53 on page 75 shows possible locations of local exchanges and voice gateways.

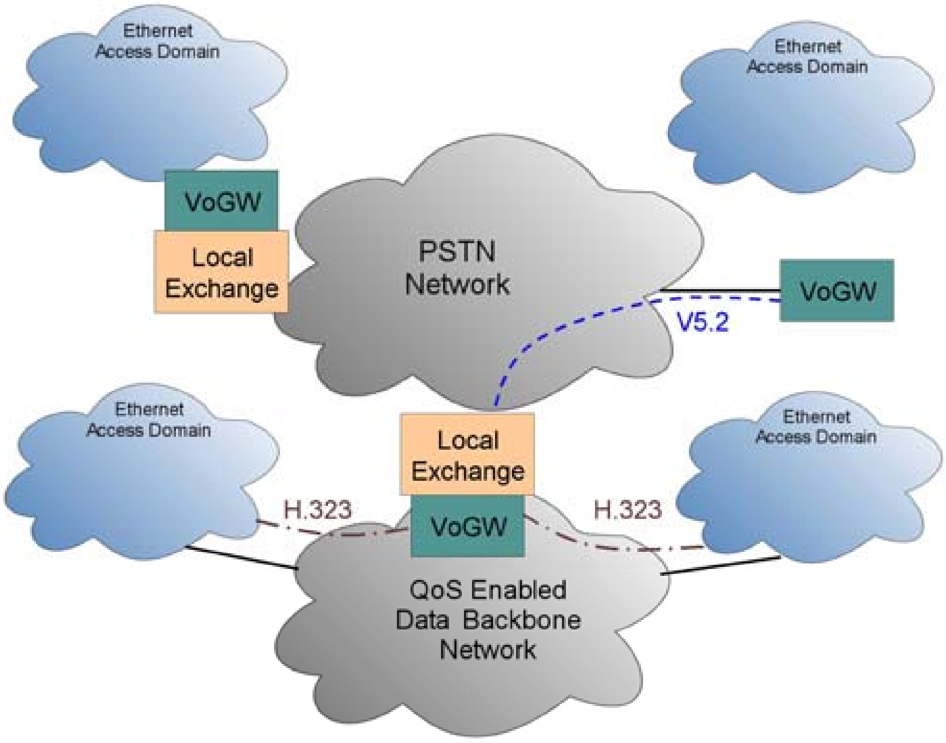


Figure 53   Locations of VoGW and Local Exchange

8.2.1 Quality Considerations

Reliability

Telephony over IP in EDA provides highly reliable telephony service, implemented on carrier grade HW platforms.

Speech Path

ToIP is provided with full 64kbit/s G.711 coding with packet loss concealment (lost packet regeneration). Differentiated services, packet fragmentation and other measures are implemented to ensure low latency and jitter throughout the EDA network. The result is a voice quality similar to normal POTS and capable of carrying DTMF, Fax and legacy modem signalling. For more detailed information on how QoS is provided in EDA (see section 8.5 on page 78).

Call Signaling

Call establishment timing has been optimized and is comparable to design objectives as specified for digital exchange equipment.

8.2.2 Capacity

Providing G.711 ToIP requires 170 kbps per voice channel each way (with 10 ms voice packets). However, VoIP can be provided at lower speed, if POTS comparable quality is not required.

8.2.3 Security

Identification of a subscriber accessing the VoGW is based on the subscriber’s IP address. In order to ensure correlation between this IP address and the IAD, measures have been taken to restrict access to the Telephony over IP network, whether this network is separated from the data network by VLAN or by forced forwarding.

When access to the Telephony over IP network does not include a PPPoE connection, access to the network can be limited to equipment with known IP address, configured in the IP DSLAM for the specific voice PVC. A filter in the IP DSLAM thereby prevents address spoofing.

8.3 Multimedia Services

Multimedia services comprise high-quality video applications over IP. Video over IP is based on standard protocols, independent of type of access as long as IP and sufficient capacity can be provided to the home. However, the network must support IP multicasting in order to distribute broadcast programming such as live TV, premium channels, Pay Per View (PPV), and Near Video on Demand (NVOD).

A solution for Video over IP consists of the following main parts:

- Customer Premises Equipment (CPE) - A Set-top Box
- Network platform - A broadband IP access and backbone network supporting IP multicast and Quality of Service (QoS)
- Service platform - Contains the servers and systems that implement and deliver the broadcast and interactive TV services to the end-users.
- Content creation platform - Providing the tools and processes needed to create and maintain the service offerings of the service platform.

Increasing demands for streaming and broadcast video services in high quality make demands on the bandwidth. In order to save bandwidth the EDA system provides IGMP multicast for video streams in both the IP DSLAM and the aggregation layer. Using IGMP snooping saves Ethernet bandwidth. Requests from one end-user for video are detected by the switch, which connects the end-user to an already active stream to another end-user. This is illustrated in Figure 54 on page 80.

8.3.1 Quality

The EDA solution enables a multi-service access scenario in which all end-users are able to access different services simultaneously. The Quality of Service is ensured by Ethernet prioritization and ATM QoS mechanisms.

The Ethernet Access Domain elements conform to the IEEE 802.1Q specification, which specifies the priority tag for video services to 5). The upstream Ethernet traffic is tagged with the corresponding priority information, and downstream traffic is de-tagged and mapped to a PVC corresponding to the priority value.

The ATM QoS mechanisms are described further in section 6.3.1 on page 57.

8.3.2 Security

The recommended way for the EDA solution is to separate services using VLAN technology as specified in IEEE 802.1Q. A VLAN for video traffic such as TV broadcasting or pay per view can thus be created, see Figure 63 on page 102.
Other security mechanisms are described in more detail in section 9.4 on page 88.

8.4 Telephony Deployment in EDA

Whether base band POTS or Telephony over IP should be used to provide telephony services depends on the specific EDA deployment scenario. Both applications are capable of providing first line telephony, that is, they can provide reliable telephony with the range of services supplied by existing POTS telephony implementations.

Telephony over IP provides a number of independent phone lines on a single local loop, emulated on the ADSL link in order to provide derived telephony services. Telephony over IP may consequently be used to supply additional lines to customers, either alone or in combination with base band POTS. In the latter case more lines per subscriber can be supported, one as base band POTS more as Telephony over IP, (the number depends on the IAD used).

8.5 Broadcast Handling

Within the Ethernet parts of the EDA network special attention must be paid to the amount of broadcast traffic generated.

Basically, Ethernets are broadcast networks. In principle, a frame transmitted from one unit may reach the ports of all other units. The learning switches used in EDA limits the amount of broadcast traffic. However, broadcast traffic cannot be totally prevented.

Especially in networks with links of different capacity there is a risk of overloading the low capacity links. What appears to be just a few percent of overhead on a Gigabit Ethernet link may impose a heavy load on a link with less bandwidth.

In EDA, the IP DSLAMs act as ARP proxies and as filters, thereby preventing broadcast traffic originated in the Central Office parts of the Ethernet Access Domain from reaching the ADSL line. Only traffic destined for known addresses is allowed.

EDA also provides an opportunity to divide the physical Ethernet into virtual sections distinguished by VLAN ID’s. Thereby the broadcast traffic can be isolated and limited to the amount of traffic generated within each VLAN.

8.6 Multicast Handling

The EDA system supports IP multicasting, which is especially suitable for multimedia services in order to avoid overloading the network for example if more end-users receive video over IP simultaneously.

Multicasting actually means that a network node sends a packet addressed to a special group address. Nodes that are interested in this group register to receive packets addressed to the group. IP multicasting is a method to utilize the available bandwidth in an effective way. Instead of broadcasting all packets only one multicast packet is transmitted. The switches and routers will transmit the packet to the members of the multicast group only. When using IGMP snooping the switch listens to IGMP messages to build a mapping table and associate forwarding filters. It dynamically configures the switch ports to forward IP multicast traffic only to those ports associated with multicast hosts.

In this way the IP multicast technology:

- reduces the total traffic load in the network by eliminating unnecessary traffic.
- only requested broadcasts is transmitted downstream
- only one downstream to several listeners

In the EDA network multicasting groups can be established, so that video transmissions are sent only to the members of the multicast group. The IGMP protocol handles packet inspection to ensure that the packet is transmitted to the multicast group members only. This is also called IGMP snooping. This is illustrated in Figure 54 on page 80,.

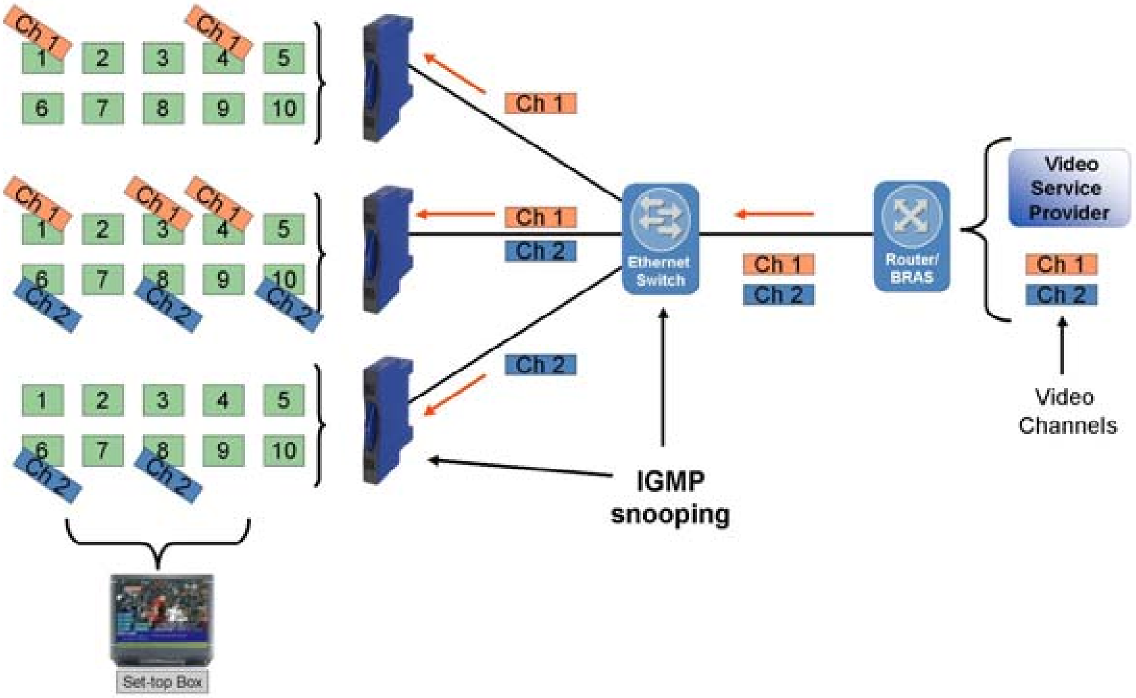


Figure 54   IP Multicasting using IGMP Snooping for Video Services

The EDA system can prevent end-users from unauthorized access to Multicast services using Multicast Whitelist.

The number of simultaneous multicast streams to an end-user can also be limited.

9 Security

The ability to protect communication systems and information from various types of attacks has become increasingly important over the last years. Since the advent of the Internet, hackers have become more and more skilled and are today equipped with numerous tools to perform a multitude of different attacks on data networks. The number of attacks per day has increased dramatically and is ever increasing.

In general, all IP networks are susceptible to attacks from both external and internal parties. The attacks can have many forms, including information theft, denial-of-service attacks, and corruption of programs or information. Thus, a number of threats are facing an EDA system.

9.1 EDA Security Issues

The EDA concept is based on Ethernet technology as a common data-link layer (layer 2) and IP as the typical common network layer. Thus, in addition to the general IP network threats, security issues are imposed by the use of Ethernet as the common layer 2 technology within an Access Domain. Sharing a broadcast media to convey management traffic as well as traffic for all subscribers requires the system to provide countermeasures to ensure privacy and integrity of the transported data.

Consequently, the EDA concept includes mechanisms to handle any type of attack on the system, including attacks on EDA system entities (i.e. equipment within the Access Domain), on subscriber equipment, and on the data conveyed via the EDA network.
The mechanisms, which can be used to improve security, are:

- Layer 2 separation to force the upstream traffic to go through a router using PPP, VLAN or Forced Forwarding technique.

- Using DHCP Relay Agent Information Option (Option 82) to authenticate the end-user.

- Filtering of IP frames in the IP DSLAM in order to filter out broadcast traffic, verify source MAC and IP addresses of upstream traffic, limit destination addresses and frame types in both directions.

- Using Virtual MAC addresses to prevent MAC spoofing

Security risks to subscribers (for example viruses) are not considered the responsibility of the EDA system.

9.2 PPP, VLAN and Forced Forwarding

9.2.1 PPP (Point to Point Protocol)

Using PPP, sessions are created between the clients and the BRAS. The IP DSLAM does not take active part in handling the PPP sessions.

Being able to recognize and verify the identity of a subscriber enables the Service Provider to deliver the exact service that the subscriber is entitled to. Furthermore, to perform charging of service usage the identity of the service user must be known to the system. The usual way of recognizing a subscriber is by a unique combination of username and password or DHCP Relay Agent Information Option (Option 82). The subscriber must present these login credentials before access to services is granted.

The Point-to-Point Protocol (PPP) is widely deployed for providing dialup access to an Internet service provider via an analogue modem. With PPP a point-to-point connection that can convey a packet-oriented network layer protocol (for example, IP) is created between the subscriber’s equipment and the service provider’s access server. The access server constitutes the Service Providers Point-of-Presence (PoP). To establish a PPP session the subscriber usually must login with username and password to get access. These login credentials are typically verified towards a server with subscriber profile information, for instance a RADIUS server. In case of successful login the subscriber is equipped with network configuration data, for example an IP address, a subnet mask, and a default gateway.

PPPoA is also supported and is converted to PPPoE.

The subscriber’s PPP client may be located in the CPE modem or at the subscriber’s PC. It is possible to start multiple PPP sessions over the same DSL connection, for instance from different PCs connected to the CPE LAN. In this way it is possible to access different services simultaneously.

PPP in EDA is implemented according to the standard for PPP over Ethernet (PPPoE). The standard supports the presence of multiple broadband access servers (BRAS) on the same Ethernet, for example representing individual service providers. Via the PPPoE client the subscriber is presented with a list of available BRAS servers to choose from.

After the BRAS have obtained the username and password from the subscriber, it is sent to the RADIUS server in an access request.

The contained subscriber password is encrypted using a “secret” shared between the RADIUS client and server. The RADIUS server can accept or reject the authentication request. Alternatively, the RADIUS server may wish to perform authentication directly towards the subscriber, before validating takes place. If the authentication request from the subscriber is acknowledged, the RADIUS server may provide subscriber profile information such as IP address, subnet mask, compression parameters, MTU, and more.

9.2.2 VLAN Technique

The VLAN technology can be used to create separate logical networks within a LAN like the Access Domain Ethernet. The VLAN principle is useful for separating the traffic through the Access Domain Ethernet. The separation can be based on different criteria depending on the reason to separate the traffic.

VLAN can be used for layer-2 separation. Assigning an individual VLAN to each subscriber, will force all communication through a router. The maximum of VLANs is defined by the IEEE802.1Q as 4096, which may be exceeded in larger access scenarios. Alternatively, VLANs may be defined for a group of users, to create for instance a virtual corporate network, or a group of on-line gamers.

A basic use of VLAN for separation of traffic types has been devised, in order to enhance the security of the EDA system. With this scheme the following VLANs are defined:

- ***The Management VLAN***. This VLAN is used for all operation and maintenance purposes, for example SNMP messages, routing information, and DHCP messages regarding the IP DSLAM.

- ***The Subscriber Data VLAN***. This VLAN is used to convey the traffic that gives subscribers access to the data backbone.

- ***The Subscriber Voice VLAN***. This VLAN conveys all traffic pertaining to the IP Telephony function.

- ***The Subscriber Video VLAN***. This VLAN conveys all multimedia traffic such as video over IP.

Figure 55 on page 84 illustrates the use of the VLANs mentioned above.

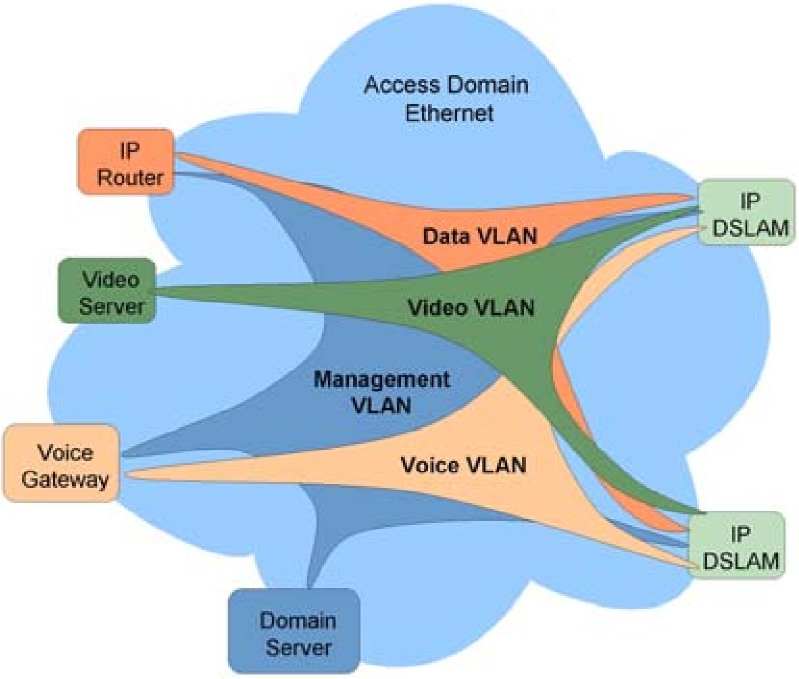


Figure 55 Separation of Traffic Types with VLANs

Each of these VLANs has a unique value (the VLAN ID) indicated by the VLAN tag.

Within the Access Domain the VLAN tag is included in the Ethernet frame, according to IEEE802.1Q, see Figure 56 on page 84.

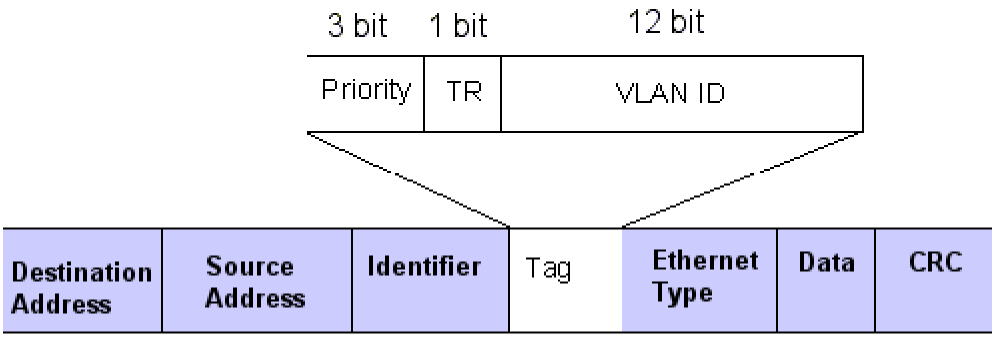


Figure 56 802.1Q MAC Frame with VLAN Tagging

In an IP DSLAM the VLAN IDs are used to direct the traffic to the appropriate PVC. The basic scenario in Figure 55 on page 84 is an example of assigning the voice VLAN ID to all voice PVCs, and the data VLAN ID to all data access PVCs.

Separating the traffic in this way is a security mechanism that prevents EDA subscribers from attacking the local Management System, or performing hacking attacks on the access equipment (IP DSLAMs, aggregation switches, routers, voice gateway).

Other schemes than the one illustrated in Figure 55 can be used for enhancing the security. For example, it is possible to dedicate a VLAN to a single subscriber, to provide for corporate access. The subscriber’s traffic is guaranteed logical isolation from the traffic pertaining to other subscribers.

VLANs may also be associated with different services or Service Providers. In this way traffic belonging to different service providers can be separated, and it constitutes a way of service selection. This is described more detailed in section 10.3.3 on page 99.

9.2.3 Forced Forwarding

Forced forwarding is an EDA-specific technique in which the subscriber is forced to use the router as default gateway for all upstream traffic. This is easily obtained by defining individual IP subnet for all subscribers. In that case a subscriber will automatically use the router for communicating with other subscribers, and the IP DSLAMs need only verify that the upstream traffic is indeed sent to the router’s MAC address, and not anywhere else.

Using a unique IP subnet per subscriber is considered problematic in a network of public IPv4 addresses, because it wastes a lot of scarce addresses. The minimum subnet takes up 4 addresses, but only one of these addresses can be assigned to a subscriber because the remaining 3 addresses are reserved[2]. A way of obtaining better address utilization is to have more subscribers in the same subnet, because there are still only 3 reserved addresses.

The apparent conflict between layer-2 separation and subnet sharing is solved by an ARP proxy function in the IP DSLAM. An EDA subscriber, who wishes to communicate with another subscriber in the same subnet, will issue an ARP request to get the destination MAC address. However, the ARP proxy will respond to the ARP request with the MAC address of the default gateway for the subnet. In this way the requesting subscriber will now forward its traffic via the default gateway, believing that it is in fact the other subscriber. For this mechanism to work properly the default gateway must be configured to accept and forward (or actually return) traffic between hosts within the same subnet, which is a procedure that is not the default behavior of a router. It is still necessary for the IP DSLAM to

[2] One address for the other peer of the network, one for the network itself, and one for broadcast.

verify that the upstream traffic actually uses the returned MAC address of the default gateway as destination address in subsequent frames.

The ARP proxy function implementing Forced Forwarding is an optional security feature that ensures layer-2 separation (rules for the Forced Forwarding are configurable through the management system). However, it is also a way to optimize the utilization of the downstream bandwidth. The ARP proxy will also respond to downstream requests so they will not take up bandwidth on the ADSL link. Finally, Forced Forwarding can be viewed as a way of associating subscribers with a given Service Provider, thus providing a simple method of service selection. This is described in more details in section 9 on page 81.

9.3 DHCP Relay Agent Information Option

In access scenarios where the end-users IP address is obtained by use of DHCP the EDA solution offers a feature to authenticate the DHCP request send from the end-user equipment.

To obtain an IP address the equipment at the end-user premises will send a DHCP request to a DHCP server. The IP DSLAM will insert an identifier in all DHCP requests from the end-user on a PVC basis. This allows the Service Provider to authenticate and control the rights for assigning IP addresses to the end-user. This function is known as DHCP Relay Agent Information Option (Option 82) according to RFC 3046.

Figure 57 on page 87 shows an end-user PC sending a DHCP request to obtain an IP address from a Service Provider (SP). The End-user Profile in the IP DSLAM has been configured through the PEM system to insert a unique Option 82 identification in the DHCP request. This identifier could for example be the end-users phone number of the ADSL line or a password, specified by the Service Provider.

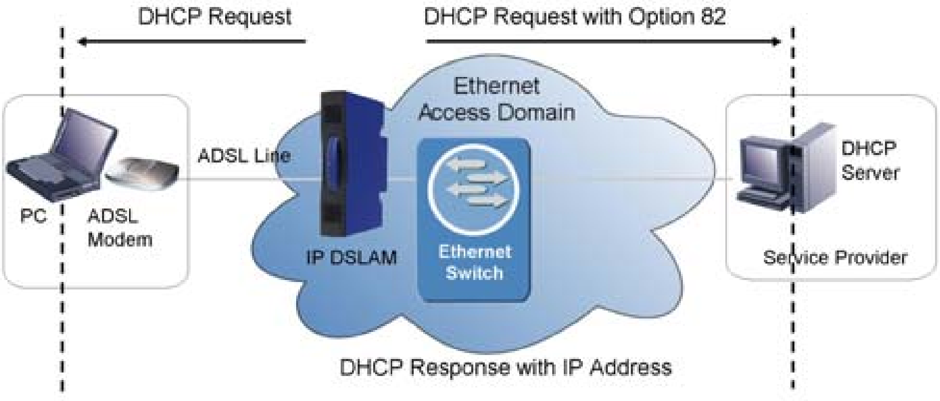


Figure 57 DHCP Request with Relay Agent (Option 82)

The Service Provider receives the DHCP request in the DHCP server and (based on the Option 82 identifier) authenticates the DHCP request. The DHCP server can then assign an IP address to the end-user according to the services offered by the ISP.

The EDA solution offers three different identification options to be used when DHCP Option 82 is enabled:

- String option - A string of up to 253 octets can be inserted

- Cisco option - A format specified by Cisco.

- Customer Number Format - A format specified automatically by PEM.

If the *String Option 82-identifier* option is selected a binary string of up to 253 octets will be inserted as sub-option 2 (Agent Remote ID).

The *String* Option complies with RFC 3046.

If the *Cisco Option 82 identifier* option is selected, the option 82 will be encoded in a Routed Bridge Encapsulation (RBE) format specified by Cisco.

The encoding is used by Cisco for a number of routers, which supports the relay agent information scheme.

With this configuration only the second sub-option, Remote Agent ID, is used. A total of 16 bytes are inserted, where the contents of each byte have been defined in advance.

Even though the Cisco configuration is used with routers, the encoding is still relevant for the EDA system, and the requirement from RFC 3046 concerning a global unique Remote Agent ID is still fulfilled.

The *Customer Number* will be an ASCII String using bytes x1, x2, x3 and so on. Since the IP DSLAM acts as a bridge and not as a router, a few deviations from RFC 3046 will be made:

If a DHCP request from a subscriber already contains an option 82 identifier the Ethernet packet is not discarded. The unique identifier is replacing the original to prevent spoofing of the DHCP request.

9.4 IP DSLAM Security Mechanisms

The bridging function of the IP DSLAMs virtually creates a common Ethernet covering both the Access Domain Ethernet and the CPE LANs. While this creates simple and flexible network architecture, it also introduces some potential security issues to be addressed by the EDA system.

The nature of a broadcast media like Ethernet implies that information is distributed to multiple entities connected to the media, including to some that are not intended as receivers. This may be acceptable in a corporate LAN environment, but in an access scenario like EDA, it must be possible to ensure that subscribers will only receive information that is explicitly intended for them. A key entity here is the IP DSLAM, which is able to perform filtering and other functions that ensure security and privacy.

9.4.1 Filtering

By introducing filtering in the IP DSLAM it is possible to control the traffic to and from EDA subscribers, thereby restricting the types of frames/packets forwarded by the IP DSLAM.

The filtering policy can be based on a wide set of rules. Consequently, the filter may be tailored to a specific deployment scenario, and it can be updated on the fly if a security risk is discovered after installation. The filters are configurable individually per PVC.

9.4.1.1 Broadcast

Broadcast traffic can in general be filtered out. This filtering will prevent subscribers from loading the network with broadcast traffic. Also, network information messages that are normally broadcasted on an Ethernet are not sent to the EDA subscribers. One example of exception is DHCP request from subscribers. These are needed to obtain the initial network configuration, for example an IP address, from a DHCP server. The DHCP request is forwarded only in the upstream direction, never to other subscribers.

9.4.1.2 Source MAC/IP Address

In order to prevent EDA subscriber from spoofing, the source MAC and IP address of upstream traffic can be verified as belonging to some allowed set of addresses. The IP DSLAM stores the valid combinations of MAC and IP addresses for each subscriber in a MAC table. The MAC table entries can be static or dynamic. Static entries correspond to a fixed IP address permanently assigned via the management system to a specific subscriber’s PVC. Dynamic entries are created based on the DHCP responses from the DHCP server. In order to maintain an updated picture of the MAC addresses and IP addresses in use, all subscribers must repeat their DHCP requests with a configurable interval (the IP address lease time). The MAC table entries will time out after a while. The exact time is configurable, but should be at least as long as the IP address lease time.

9.4.1.3 Destination MAC/IP Address

In order to prevent EDA subscribers from attacking EDA system nodes it is possible to filter out upstream packets towards those addresses, located in a given range. It is also possible to allow only limited destination addresses for the upstream traffic.

9.4.1.4 Ethernet Frame Type

It is possible to limit the acceptable frame types in both directions. Examples of acceptable frame types could be those carrying IP traffic. Examples of rejected frame types could be LAN routing protocols (NetBEUI).

9.4.2 Layer-2 Separation

IP Hosts connected to the same LAN can communicate directly with each other by knowing the other party’s MAC address. The way a host can see if the other party is on the same LAN is by looking at the subnet mask. If the other party's IP address is located within the same subnet, then the sender can obtain the destination MAC address by an Address Resolution Protocol (ARP) request.

The Access Domain Ethernet enables direct communication between EDA subscribers on layer 2. This can be considered an advantage in terms of efficiency, compared to the alternative of routing all communication via some IP router at the top of the Access Domain hierarchy. However, the direct communication enables subscribers to perform attacks that are normally not associated with a DSL access system. An example of this is manipulation of ARP tables in the CPE, with the purpose of intercepting traffic to and from the subscriber.

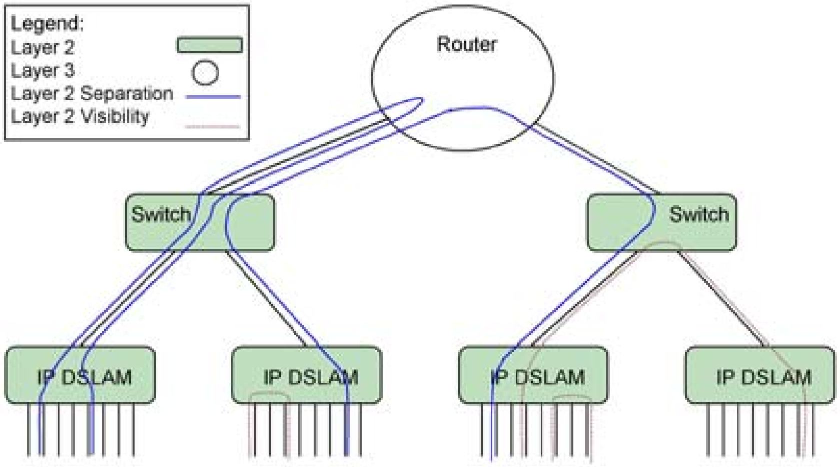


Figure 58 Layer 2 Separation and Visibility

Thus, in some access scenarios it is necessary to prevent direct layer-2 communication between subscribers. Instead, all traffic must be transmitted via an IP router, as indicated in Figure 58 on page 90.

Forcing the upstream subscriber traffic via a router can be done in different ways. The EDA System operates with four different methods: PPP, VLAN and Forced Forwarding.

Virtual MAC Address

To prevent MAC spoofing and to be able to uniquely identify an end-user in the EDA access system, the EDA solution offers the use of the function called virtual MAC address.

The basic principle of virtual MAC addresses is that the IP DSLAM performs address translation of MAC addresses. The IP DSLAM pre-assigns a number of potential MAC addresses to be associated with the real MAC address from the end-users equipment for example a PC or a STB (Set Top Box) for video service.

The IP DSLAM maps between the MAC addresses received from the end-users equipment and the locally administered MAC (Virtual MAC) address used in the Ethernet Access Domain.

For upstream traffic the source MAC address from the end-user is replaced with its corresponding locally administered address and just forwarded toward the aggregation switch. For downstream traffic the locally administered address is replaced with its corresponding end-user MAC address and forwarded towards the ADSL line.

In this way, it does not matter if multiple end-users equipment is configured with the same MAC address (spoofing); the addresses are never used within the Access Domain.

Virtual MAC addresses are statically assigned by the IP DSLAM and allow the operator to control and limit the number of equipment (PCs) the end-user is able to connect to the ADSL line (per PVC). It makes it possible to identify the end-users traffic in the EDA access network by looking at the virtual MAC address in the Ethernet frame, since this is traceable to the specific PVC on the end-users ADSL line.

The Virtual MAC is an optional feature to prevent MAC spoofing.

9.5 Encryption and Tunneling

The Access Domain interfaces to other data network that may be subject to hacking attacks. An attacker may intercept the traffic sent over the external network, or he may try to access the EDA system via that network.

To protect the EDA network and traffic from external attackers the communication via external networks can be protected. The keywords here are tunneling and encryption.

Between the Access Domain and remotely located service providers the traffic is sent in tunnels. For example, the PPP sessions may be tunneled to a remote service provider.

The communication between the Access Domains and the Operation Center can be protected using secure VPN connections.

Even if the EDA access node is considered secure the subscriber traffic may be snooped on the public Internet. A solution to this is VPN.

Encryption of subscriber traffic is generally considered outside the EDA scope.

9.6 Other Security Measures

General security measures should also be implemented in order to secure the network.

9.6.1 Management Security Policies

Another type of attacker is trusted personnel misusing their authority.
In this case nearly any threat is possible, because these people often have knowledge about security systems. However, one measure is to provide staff with strictly personal passwords to be used when logging into EDA equipment. This is supported by the EDA management system.

9.6.2 Network Monitoring and Intrusion Detection

An important tool in network security is the ability of monitoring and logging the activity on the network and within the entities. In this case, attacks can potentially be detected, or it is possible to backtrack an attack scenario to find the source of the attack, in order to prosecute attackers and take measures to prevent future successful attacks.

10 EDA System Design

10.1 System Design Approach

A wide range of different access scenarios can be designed to fit various requirements regarding service access functions, network architecture and network performance. Based on requirements to service selection, security, and services the function of the EDA System can be determined and optimized. Combined with requirements to network architecture and performance this can be used as the basis for designing the specific EDA System. Figure 59 on page 93 illustrates the system design approach.

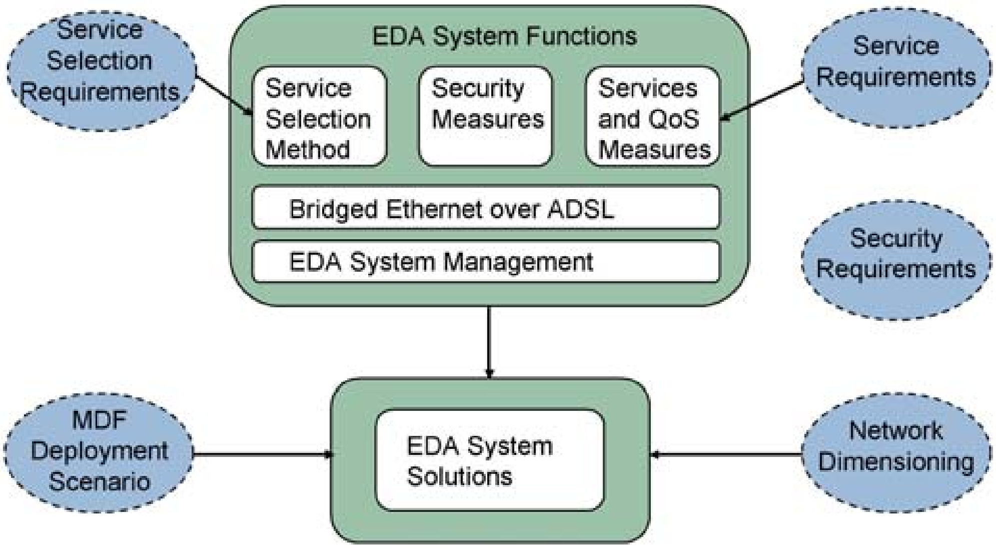


Figure 59 EDA System Design Approach

10.2 Determining the EDA System Functions

The basic EDA System functions are based on requirements to services, service selection, and security. The actual EDA scenario must provide these functions while observing the remaining system requirements such as the chosen MDF deployment scenario and the network performance requirements. The latter covers for example the number of subscribers, the bandwidth allocation policy, scalability options, and redundancy requirements.

The EDA System functions involve the following design considerations and choices:

- **Service Requirements -** Each service is connected to the end-user through a PVC and each PVC is connected to a VLAN through the IP DSLAM. The end-user can have up to 8 PVC connections.
    - Access to voice services can be offered and implemented as traditional base band telephony (POTS) or as high quality Telephony over IP (ToIP). Both services can be implemented and offered simultaneously.
    - Access to the Internet.
    - Access to a LAN (LAN to LAN).
    - Access to multimedia services, such as video.
- **Service Selection -** The EDA System allows each individual PVC to be configured to use one of the listed access methods to create associations between the end-user and the Services Provider:
    - DHCP - which means that the IP address of the end-user equipment is set dynamically by the Service Broker’s DHCP server.
    - Using PPPoE, where a PPP session is created towards a BRAS. This solution offers integrated options for authentication, authorization and accounting via RADIUS.
    - Using PPPoA, where the IP DSLAM converts the PPPoA user to a PPPoE user creating a PPP session as described above.
    - Static IP address, where the end-user equipment is assigned a static IP address.
    - Transparent LAN, which sets LAN to LAN transparency

- **Security Requirements -** Different security measures can be deployed in order to protect the EDA system and the end-users connected to it. Some of the security settings may overlap but can be activated simultaneously to improve the security.

  The following measures can be used:

  - Using PPP as access method can be used for verifying the identity of an end-user before granting access to the services. PPP sessions can be forwarded towards remote Service Providers using secure tunnels.
  - The IP DSLAMs can be configured to filter out unwanted traffic based on a variety of parameters.
  - VLANs can be used to create logically separate network within the Access Domain Ethernet. In this way different traffic types, as for example management traffic and subscriber traffic, are separated.
  - Using Forced Forwarding towards the Service Provider’s default gateway.
  - Using DHCP Relay agent configuration (Option 82) to authenticate end-users and to allow access to specific services.
  - Using Virtual MAC addresses to prevent MAC spoofing.

Although not all of the functions above are the responsibility of the Access Provider, the Access Provider creates the EDA network and functions that enables the services to be offered to end-users. For more detailed description of security measures please see section 9 on page 81.

10.2.1 Designing the Actual EDA System

In addition to function requirements and MDF deployment scenario, the total solution is influenced by a number of performance requirements to the system:

- The number of subscribers connected to the local exchange, and the expected DSL penetration forecast.
- The bandwidth allocated to individual subscribers, and the degree of aggregation.
- The requirements to different quality of service levels.
- The requirements to redundancy.

These requirements are the main input when dimensioning the aggregation network (the number of switches and the bandwidth required to connect them).

10.3 EDA Scenario Examples

The following examples of EDA scenarios are divided primarily according to the method used for service selection:

1. No service selection.
2. Using a BRAS.
3. Using a VLAN per service or super VLAN.
4. Using IP sub-netting combined with Forced Forwarding.
5. LAN-to-LAN transparency

10.3.1 No Service Selection

In some access scenarios it may not be required or relevant to use any form of service selection. The Access Domain merely provides unrestricted Ethernet access to one or more Edge Nodes (IP Routers and/or Voice Gateways). There is no authentication or authorization of subscribers. An example network is depicted in Figure 60 on page 97.

This scenario provides layer-2 visibility. This implies that peer-to-peer connections between EDA subscribers within the same IP subnet are possible. The advantages of such connections are a better usage of network resources and lower delay.

The drawbacks are potential security risks caused by the accessibility on layer 2.

While layer-2 visibility between subscribers is an implicit feature of this scenario, it is possible to protect the Access Domain equipment by using one or both of the following security mechanisms:

1. Traffic filtering in the IP DSLAM. Relevant options are:

    a IP/MAC address filtering

    b Broadcast filtering

c Non-IP-traffic filtering

2. Separating traffic types in different VLANs within the Access Domain, for example a separate VLAN for management traffic.

This access scenario imposes no limits to what IP services can be offered. However, unmanaged access to Telephony over IP service may be considered inappropriate due to the lack of security and charging options. Consequently, Figure 60 on page 97 illustrates the use of base band POTS instead.

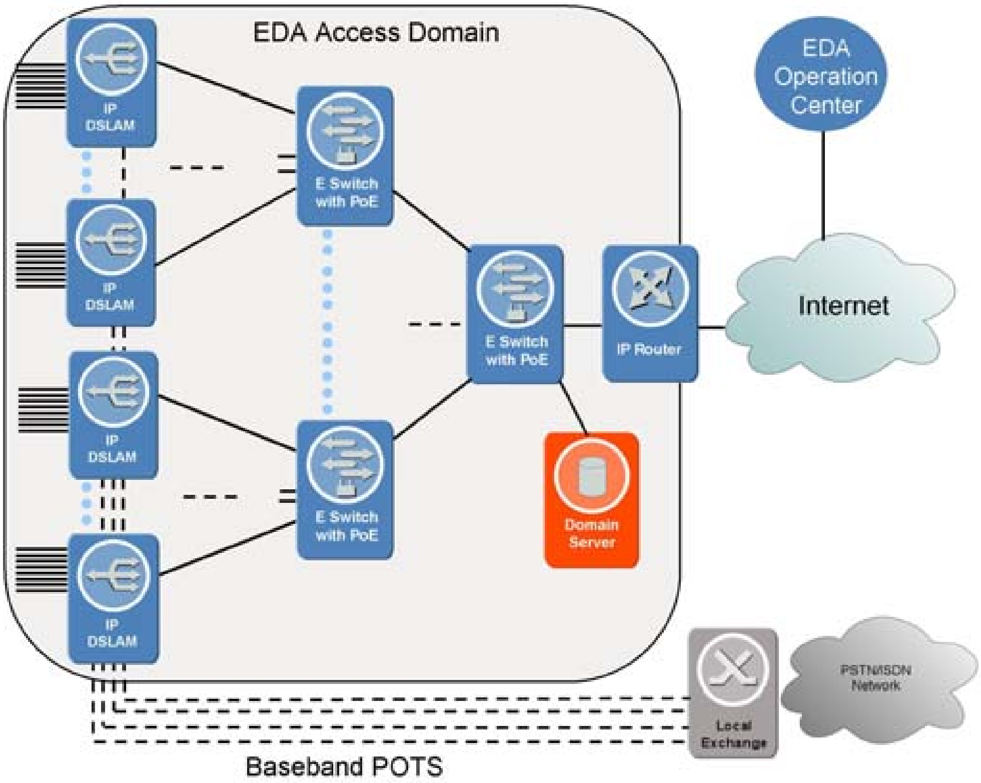


Figure 60 Base band POTS with and without Service Selection

10.3.2 Service Selection Using a BRAS

Service selection based on a Broadband Access Server offers a multitude of access functions integrated in a single entity.

End-user authentication is performed using either PPP or HTTP. In the first case, the subscriber initiates a PPPoE client on the CPE host in order to start a PPP session. In the other case, the BRAS presents a web page to the subscriber on which the login must be performed.

The use of PPP creates a kind of tunnel between the CPE and the BRAS. This provides an inherent level of security, because it creates layer-2 separation of the subscribers. Configuring the IP DSLAM filter to allow only PPPoE frames provides additional security.

The security level can be extended with the use of VLAN to separate traffic types within the Access Domain.

Multiple providers may each have a BRAS located within a single Access Domain. These BRAS servers may be separated in different VLANS, causing each subscriber to be able to reach only one BRAS, or the BRAS may be located within the same broadcast domain. In the latter scenario, a subscriber can access any of the BRAS servers, but must of course still perform a successful login in order to be authenticated by the BRAS.

It is possible to provide practically any IP service via the BRAS; however, IP multicast services to PPP-connected subscribers requires that the traffic is sent as unicast from the BRAS to each of these subscribers.

The Telephony over IP (ToIP) service offered by the Voice Gateway may also be accessed via the BRAS, thus requiring the ToIP client to perform a PPP-based authentication before being authorized to use this service. However, the use of PPP as encapsulation protocol for voice may not be optimal in terms of delay, Calculation of the extra delay, using a specific BRAS must be made before choosing this possibility.

An example of an EDA solution using a BRAS, and employing both data access services and Telephony over IP, is depicted in Figure 61 on page 99. The BRAS offers connectivity towards remote service nodes (ISP PoP) through tunneling of PPP sessions over a backbone network. The BRAS, acting as an ISP PoP, may also terminate the PPP sessions. For this purpose a RADIUS Server may optionally be located within the Access Domain (not shown in Figure 61 on page 99).

The Voice Gateway provides Telephony over IP function towards the PSTN. If the telephone calls are encapsulated using PPP sessions, they must be terminated in the BRAS before they are passed on to the Voice Gateway. In that case it may be more optimal (with respect to delay), to send the traffic directly from the BRAS to the Voice Gateway instead of via the upper aggregation switch.

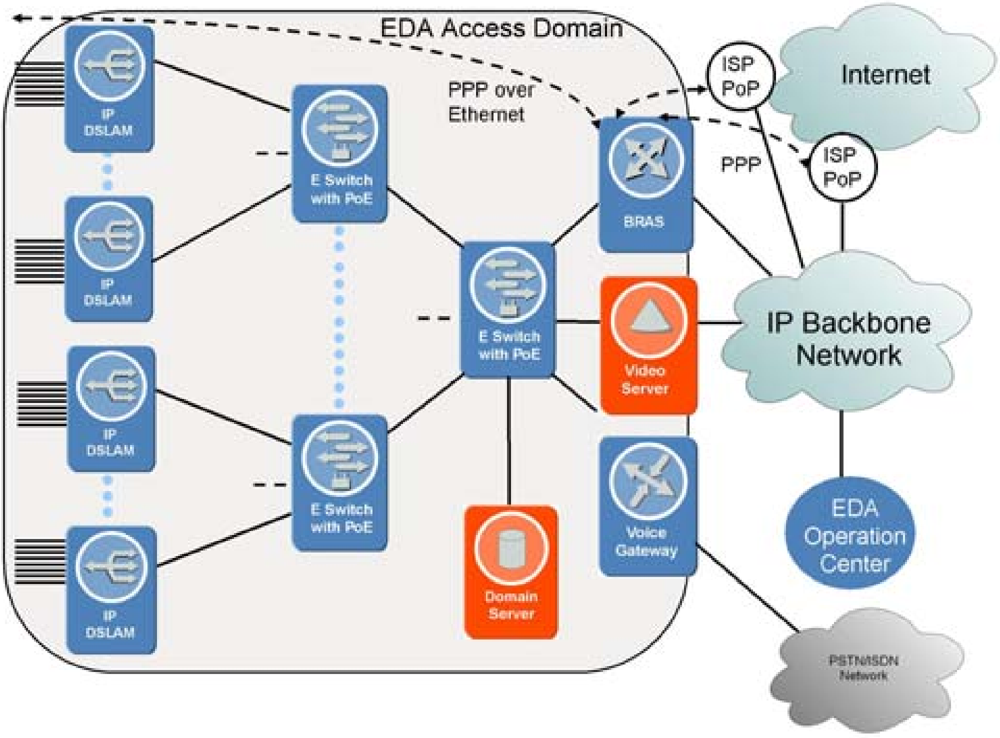


Figure 61 EDA Access Network Incorporating a BRAS

10.3.3 Service Selection Using VLAN

The VLAN technology may be used to separate the Access Domain between Network Service Providers, giving each Service Provider a logically separated access network with a unique VLAN ID. The Service Provider has the option of using a BRAS, or an IP router. Subscribers are associated to a specific Service Provider by configuring the association in the IP DSLAM between the PVCs and the Service Provider’s VLAN.

It is also possible to define different VLANs for specific services. For example, a Service Broker may have 10 unique VLANs used for different services offered to subscribers. One VLAN may provide best effort Internet access, while another may provide high quality access. Some VLANs may be used for providing certain contents, such as Telephony over IP, online games, TV broadcasting etc. This usage of VLAN still supports multiple Service Brokers within the Access Domain, the difference being that each can administer more than one VLAN. Figure 62 on page 100 illustrates a scenario with two Service Providers with their domains separated by VLAN. Both Service Providers offer data access via an IP router, whilst one of the Service Providers offers Telephony over IP via a Voice Gateway.

Four different VLANs are defined: One for system management traffic (VLAN1), one for the voice access domain (VLAN2), and one for each of the two data access domains (VLAN3, VLAN4). The IP DSLAMs map between PVCs and VLANs (magnified to the right in Figure 62 on page 100). Between the IP DSLAMs and the top-level switch all VLANs are present. At the top-level switch (magnified to the left in Figure 62 on page 100) the VLANs are mapped to physical ports, thereby controlling the subscribers' access to different Edge Nodes and preventing them in accessing the Management System.

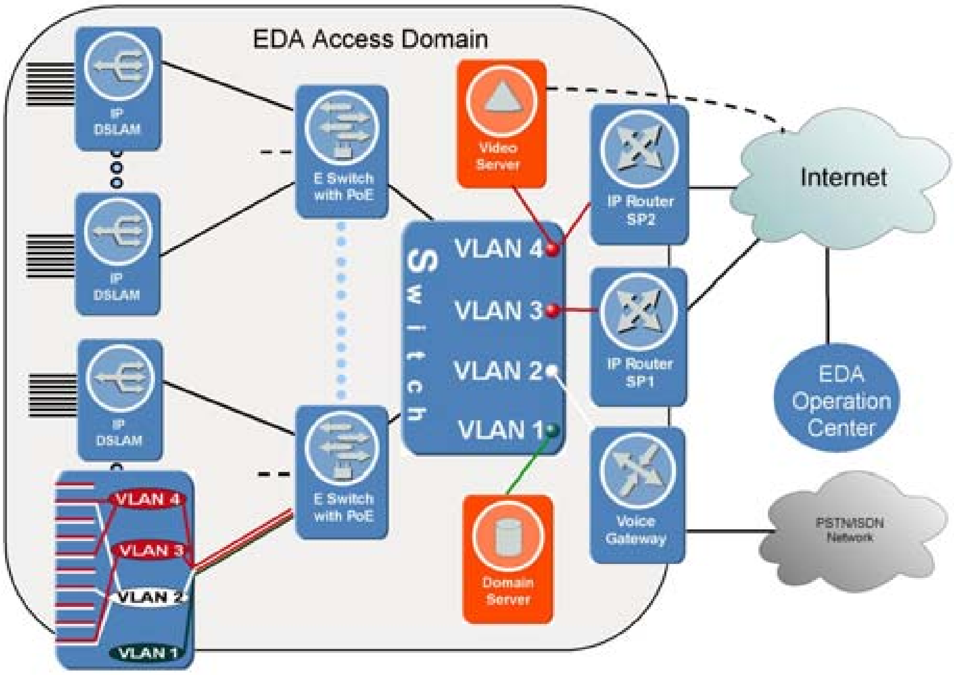


Figure 62 VLAN-based Scenario with Data Access Services and ToIP

Another way of using VLAN for service selection is by employing Super VLAN technology. With this method a unique VLAN is provided to each subscriber (or even to each PVC). Within the Edge Node a number of Super VLANs are defined, and each subscriber VLAN is associated with one of these Super VLANs. Each Super VLAN is associated to a certain Service Provider. The Super VLAN is grouping subscribers associated with this Service Provider.

The Edge Node creates tunnels between each Super VLAN and the Service Provider's PoP that is associated with the Super VLAN. A limitation with Super VLAN is that the maximum number of VLANs in any broadcast network is 4096.

All VLANs solutions except for the three VLANs scenario (Management, Data and Voice) have one drawback: each IP DSLAM and each top-level switch must be configured manually. The PEM does not support automatic configuration of VLANs, other than the three mentioned above, which are the default for the IP DSLAMs. The top-level switches have to be configured under all circumstances.

The various VLAN scenarios offer different levels of security. If VLANs are used to separate different services or service providers it is natural to define also a VLAN for management traffic. Still, the IP DSLAM filter must be used if layer-2 separation is required.

Layer-2 separation is achieved automatically when VLANs are assigned to individual subscribers, because traffic from one VLAN must pass an IP router (the Edge Node) to reach another VLAN.

10.3.4 Service Selection by Using Domain Subnets

VLAN divides the Access Domain in separated layer-2 domains. It is possible to associate a specific service or Service Provider with each layer-2 domain. It is also possible to perform a layer-3 separation of the Access Domain, and associate different Service Providers with each domain, by splitting the Access Domain into different subnets. Each subnet has a default gateway managed by a specific Access Provider. Different subnets may use the same default gateway.

EDA subscribers are always assigned to a subnet (and a default gateway) together with an IP address. Each EDA subnet may include one or more subscribers, depending on its size. Assigning individual subnets per subscriber is straightforward but can have some drawbacks regarding efficient use of IP addresses. Consequently, a typical requirement to address assignment is to have multiple subscribers share an IP subnet.

In order to provide layer-2 separation it is possible to use Forced Forwarding in the IP DSLAM. This ensures that subscribers within the same IP subnet cannot access each other directly on layer-2, but are forced via the default gateway.

Forced forwarding requires the use of a single destination (the default gateway) for upstream traffic. Thus, if Forced Forwarding is used together with Telephony over IP, the voice traffic must go through IP router acting as default gateway before it is passed on to the Voice Gateway.

10.3.5 Service Selection using LAN-to-LAN Transparency

LAN-to-LAN transparency enables the Service Broker to offer connections by use of VLANs without any filtering in the IP DSLAM. The connection is transparent for both tagged and untagged Ethernet frames. This allows services like Home office, where the IP address is assigned from the DHCP server at the office premises. Another service example is a VLAN for Home interconnections where a group of end-users wants to interconnect their LAN networks.

Figure 63 on page 102 shows the VLAN service for Home Office and Home interconnection.

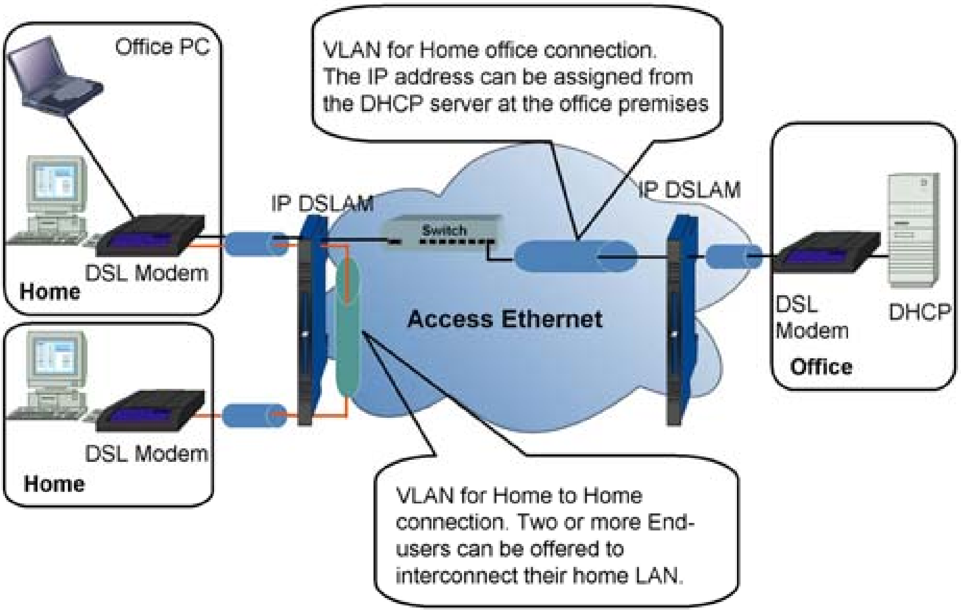

Office PC
VLAN for Home office connection. The IP address can be assigned from the DHCP server at the office premises
IP DSLAM
Switch
IP DSLAM
DSL Modem
Home
Access Ethernet
DSL Modem
DHCP
Office
DSL Modem
Home
VLAN for Home to Home connection. Two or more End-users can be offered to interconnect their home LAN.

Figure 63 VLAN Service for Home Office and Home Interconnection

When LAN-to-LAN transparency is used, all filtering in the IP DSLAM for the subscriber is disabled, and broadcast is allowed. If any filtering or protection is desired, it must be done in the Edge Node or CPE.

Interconnected LAN-to-LAN end-users may be located on the same IP DSLAM or different IP DSLAMs. They may use any mixture of DHCP obtained and static IP addresses.

10.4 Dimensioning the Network

An EDA access network is build around generic system elements that to a great extent adapt automatically to architectural changes in the network. It can therefore easily be extended to support increasing traffic and/or changed performance requirements.

10.4.1 Capacity of System Elements

All elements included with the EDA system are optimized to meet the capacity requirements of any ADSL access network.

The EDA IP DSLAM is capable of handling up to 8 Mbps downstream traffic and 1 Mbps upstream traffic on all lines simultaneously.

The EDA switches are capable of switching traffic between all ports at full wire speed.

10.4.2 Dimensioning an EDA Access Network

The capacity requirements of an EDA network depends on the following issues:

- The number of subscribers connected.
- The bandwidth provisioned per subscriber.
- The nature and combination of applications that must be supported.
- Service Level Agreements, that is, the service guaranties purchased by the subscribers.
- The subscriber’s traffic patterns.

A substantial concentration of traffic onto oversubscribed links is normally acceptable in an access network. However, a generally applicable ratio of over subscription cannot be given.

Glossary

AAA
Authentication, Authorization and Accounting

AAL5
ATM Adaptation Layer 5

Access Domain
A logical network handled by the OAM system and defined by the approved IP-addresses. One or more Access Domains makes up an EDA network, which is a switched Ethernet. An Access Domain is managed by one Collection Station.

Access Provider
The Access Provider owns the physical network, installs equipment and monitors network status and provides the basis for offering services to end-users.

Account Management
Account Management tracks usage of services in the network in order to handle billing or disable services for exceeded accounting limits. See also FCAPS.

ADSL
Asymmetrical Digital Subscriber Line

ARP
Address Resolution Protocol. A method for finding a host's Ethernet address from its Internet address. An ARP request is sent to the network naming the IP address; then the machine with that IP address returns its physical address so it can receive the transmission.

ARP proxy
A function, embedded in an Ethernet device, that answers ARP requests on behalf of other devices. Used in switching and bridging equipment to limit broadcast traffic. Using one machine to respond to ARP (Address Resolution Protocol) requests for another machine.The proxy machine routes transmission packets to the proper destination.

ARP requests
Requests, broadcasted within Ethernets in order to get MAC addresses to use for transmission towards known IP addresses.

ATM
Asynchronous Transfer Mode. A network technology that enables the transmission of data, voice, audio, video, and frame relay traffic in real time.

Backup Manager
A GUI client for handling backup of data in the PEM system.

Baseband Telephony
Traditional analog telephony as supplied from a local exchange. See also POTS.

Best Effort
A transport service, defined in IEEE 802.1Q and normally used for transfer of data when no special requirements to Quality of Service (QoS) are specified.

BLES
Broadband Loop Emulation Service. A method using ATM with AAL2 adaptation layer encapsulation, recommended by ATM Forum.

BRAS
Broadband Remote Access Server. A BRAS is a multi-service access node to manage IP service access for a large number of subscribers. See also VLAN.

Broadband
A transmission bandwidth higher than 2Mbps.

Burst Tolerance (BT)
The maximum time for which the source may transmit the PCR.

Carrier Grade
Designates highly reliable equipment intended for use in telecommunication (central office and backbone installations).

Cell
The unit of data, transferred as an entity through an ATM network. A cell has a fixed length of 53 bytes.

Central Office
Building with telecommunication equipment. Also referred to as CO.

Class 5 services
Telephony supplementary services, provided by a local exchange, as opposed to Class 4 services, provided by a PBX. Class 5 services are services like Call Hold, Call Forwarding, Call Waiting, Call Transfer, 3tpy and Conference Call.

CLIP
Calling Line Identification Presentation

CO
Central Office

Collection Domain
The network monitored by a Collection Station. In EDA identical with the Access Domain.

Collection Station
A Collection Station (CS) is a remote point in a distributed installation of HP OpenView Network Node Manager (NNM). Multiple Collection Stations can connect to a Management Station to form an NNM distributed system. When the HP OpenView NNM is installed on a server it is configured to be either a Management Station or a Collection Station.
The Collection Station software is installed on the Domain Server.

Configuration
A logical group of parameters with specific values. An operator can set a number of parameters in one operation. A Configuration can be compared to a profile or a template.

Configuration Management
Managing configuration of resources in PEM and the network elements, both in terms of viewing, setting and backing up configuration parameters. Examples are network engineering, software upgrading, managing end-users and services, backup/restore, discovery of new resources in the network and keeping an inventory list.

CPE
Customer Premises Equipment

CS
Collection Station

Database
The database contains all data related to the IP DSLAMs, subscribers, end-users and O&M Operators. The database is a standard SQL Sybase® database. A Network Management System (NMS) can retrieve data from the database through the NMS server.

DHCP
The *Dynamic Host Configuration Protocol* (DHCP) is an Internet protocol for automating the configuration of computers that use TCP/IP. DHCP can be used to automatically assign IP addresses, to deliver TCP/IP stack configuration parameters such as the subnet mask and default router, and to provide other configuration information such as the addresses for printer, time and news servers. In EDA the following counts:

Re. the CPE equipment, a DHCP server shall be available somewhere in the ISP-network to provide IP addresses for the IADs.
Re. the Access Domain/Domain subnet, there shall be access to an Access Domain DHCP server to provide IP-addresses for the Elements in the Access Domain/Domain subnet server.

DHCP server
Dynamic Host Configuration Protocol server. A configuration server, capable of configuring hosts with a variety of information required for their operation. In EDA there is one or more DHCP servers for each Access Domain.

Differentiated services
A priority based approach to providing transport services with distinct QoS in packet based networks. The differentiated services approach relies on each network element to invoke the network QoS policy hop-by-hop.

Domain Server
A Domain Server is a server computer that handles part of the network managed by PEM. The Domain Server will host an NNM Collection Station and a Domain Service (which links the application software to NNM), and probably also a DHCP Server and a Domain File Server.The DHCP Server and the Domain File Server can be installed on separate server computers.

Domain Service
Also referred to as PEM Domain Service has two functions:
Interface between NNM and the other EDA specific elements and interface between the EDA servers and the IP DSLAMs (a protocol converter between CORBA and SNMP).
There are two types of Domain Services: PEM Management Domain Service, and PEM Access Domain Service. The two types are identical; the name only refers to their placement in the EDA system.

DSL
Refers to D*igital Subscriber Lines*

DSL technologies use sophisticated modulation schemes to pack data onto copper wires. They are sometimes referred to as last-mile technologies because they are used only for connections from a telephone switch to a home or office, not between switches.

DSLAM
Digital Subscriber Line Access Multiplexer

DTMF
Dual Tone Multiple Frequency

Dual Latency
An ADSL option, enabling establishment of two separate physical channels with different characteristics on an ADSL line. The characteristics in question are bit error rate and delay, which are traded off against each other. Optimizing one deteriorates the other.

EAN
Ethernet Access Node

ECN
Ethernet Controller Node

EDA Core System
Mandatory parts of an EDA access system.

EDF
Ethernet DSL Filter

Edge Node
The node that connects the switched Ethernet of the EDA with the backbone network (can be either data network or telephony network).

EDN
Ethernet DSL Node comprises EDN110 and EDN312.

EMP
Ethernet DSL Node

End-user
An end-user is a consumer of services in the access network. The end-user is physically connected to the network and is uniquely identified in PEM. Services are given to and removed from end-users.

Engineering
Engineering is typically also referred to as Network Engineering. The work prior to the network goes into operation. (Engineering is not part of FCAPS).
Engineering includes: Network planning, (IP addresses, usage and location of Domain Servers), installation of equipment (switches, IP DSLAMs, servers), initial configuration of equipment (assigning IP addresses, subnet, defining management VLAN), "loading" equipment into the management system.
Once the Engineering is done and the equipment is ready to go into service, Configuration Management will take over. Engineering is executed by Network Managers.

EPN
Ethernet Power Node

Erlang
Erlang is a unit of measurement for telephony traffic. One Erlang corresponds to one telephony connection.

Ethernet Access Node

The EAN is a logical node built on the ECN320 switch with built-in EMP function. To create a EAN a number of ESN108 switches and 10-lines or 12-lines IP DSLAM are connected to the ECN320. The nodes are embedded in the sense that all management are done by the ECN320. The EDN288 IP DSLAM is an example of an EAN.

Ethernet Converter Node
Converter Node for Ethernet.

EDA
Official product name for the EDA product.

Ethernet Power Node
Power supply for Power over Ethernet (PoE) devices comprises EPN124 and EPN102.

EXN
Ethernet Converter Node

Fault Management
Fault Management (FM) covers the area of viewing and handling alarms coming from the PEM or the managed network. Also logging, filtering and correlating alarms are handled within this functional area.

FCAPS
The term covers different functional areas within the discipline of network management.

FE-E1
Fast Ethernet to E1 converter used for small sites in for example a back-to-back transmission solution.

Frame
The unit of data, transferred as an entity through an Ethernet.

FTP
File Transfer Protocol

G.711
The voice codec standard normally used for telephony in digital exchange equipment within the switched circuit network.

H.323
A suite of protocols, standardized by ITU for

use in multimedia applications, for example Voice over IP (VoIP)

HPOV
Hewlett Packard Open View - a term for packages used for viewing networks.

HTTP
Hyper Text Transfer Protocol

HUt
High Unit

IAD
Integrated Access Device - a generic term for various customer equipment.

IEEE
Institute of Electrical and Electronic Engineers

In-band Telephony
Means that the ADSL/IP also has voice (Voice over IP) transmission within the ADSL/IP signal. This is called Telephony over IP. See also Baseband.

Installation Manager
A GUI based manager for addition, replacement and removal of IP DSLAM and FE-E1 data from the system. The Installation Manager is a client of the Installation Server, and is installed on the Management Center. The Installation Manager is aimed at the Access Provider.

Installation Server
This server interfaces between the EDA GUI's, Database, IP DSLAM (through the PEM Domain Service) and NNM.

Interacting Function
Protocol converter function, embedded in gateways and IADs.

IP
Internet Protocol

IP DSLAM
The cornerstone in the EDA solution – a small, compact DSLAM (EDN108 and EDN110).

IP DSLAM port
A single DSL interface in the IP DSLAM (EDN108 and EDN110).

ISDN
Integrated Services Digital Network

LAN
Local Area Network

Latency
The amount of time it takes a packet to get to its destination.

Link Aggregation
Grouping parallel Ethernet links into a single logical link. Defined in IEEE 802.1 ad.

Load Sharing
A feature of Link Aggregation, distributing the load over the grouped links.

Local loop
The physical line traditionally used for POTS telephony, that is, the copper connecting subscribers to the central office installation.

LSA-PLUS 8/10
Notation of connector from KRONE. Available as LSA-PLUS 8 and LSA-PLUS 10 for mounitng on a Back-Mount frame.

LSA-Profile 8/10
Notation of connector from KRONE. Available as LSA-Profile 8 and LSA-Profile 10 for mounting on a Profile Rod or a Backmount frame.

LSA Filter
Compact POTS filter in a similar mechanical design as the IP DSLAM.

MAC
Media Access Control

MAC address
Media Access Control address. The physical address of a device connected to a network, expressed as a 6 byte hexadecimal number.

Management Center
Work Station (PC) used for running manager applications.

Management Domain
The network managed by a Management Station (also through Collection Stations).

Management Server
The core of the PEM, which contains the database, PEM application servers and HPOV Management Station.

Management Station
A Management Station is the central point in a distributed installation of HP OpenView NNM to which multiple Collection Stations can connect. When the NNM is installed on a server it is configured to be either a Management Station or a Collection Station.

MBS
Maximum Burst Size is the maximum number of cells for which the source may transmit the Peak Cell Rate.

MDF
Main Distribution Frame

MTBF
Mean operation Time Between Failures

NAT
Network Address Translation. A method that allows a multiple number of computers within a local network to connect to the Internet though one IP address.Network Address Translation can also act as a firewall by preventing outside computers from connecting with the local network, unless it is a connection initiated from within the local network.

Network Configuration Manager
The Network Configuration Manager is a GUI used for management of IP DSLAMs and their related servers (Domain File Server and DHCP Server). The Network Configuration Manager is a client of the Network Configuration Server, aimed at the Access Provider.

Network Configuration Server
This server interfaces between the GUI’s, database, IP DSLAMs (through the PEM Domain Service) and NNM

Network Operator
A Network Operator is an individual working in the Access Provider organization. The Network Operators are responsible for managing and maintaining the access network, for example installation of new equipment and alarm monitoring.

NMS
Short for Network Management System. An overlaying management system that can interact with the PEM through the North bound interface.

NNM
Short for Network Node Manager, an HPOV package for viewing a network topology, managing fault and performance data. Available as a collection station (CS) or Management Station (MS).

Operation Center
Center where Operation and Maintenance takes place.

Operator
An Operator is a person or an IT system that can access the PEM system. An Operator can log in to PEM and execute actions according to the security profile defined for the Operator. Operator roles can

be: Network Operator; Service Operator; Subscriber Operator.

OVP
Over Voltage Protection

Packet
A format in which data is transmitted over an IP network A packet contains the data itself as well as addresses, error checking, and other information necessary to ensure the packet arrives intact at its intended destination.

Peak Cell Rate (PCR)
The Peak Cell Rate is an ATM term which defines the maximum bit rate that may be transmitted from the source. In EDA it is the maximum capacity which the PVC is permitted to use.

PEM
Public Ethernet Manager. PEM is the management system solution for the EDA.

PEM Access Domain Service
PEM Access Domain Service is the PEM Domain Service installed on a Domain server.

PEM Application
All PEM specific SW developed by Ericsson.

PEM Domain Service
See Domain Service.

PEM Management Domain Service
PEM Management Domain Service is the PEM Domain Service installed on a Management server.

Performance Management
Performance Management (PM) is the area of tracking the usage of resources in the network, typically communication links. Often the objective is to support the capacity planning process and find bottlenecks in the system. Data can be collected and stored, and an Operator can extract the data and view them.

PoE
Power over Ethernet

Power over Ethernet
Power supplying devices through category 5 LAN cables.

PoP
Point of Presence which means the place where the Service Provider is present.

POTS
Plain Old Telephone Service.The standard analog telephone service.

PPP
Point to Point Protocol. A protocol for communication between computers using TCP/IP.

PPPoE
Point-to-Point Protocol over Ethernet. A small protocol for using PPP over Ethernet networks.

PSTN
Public Switched Telephony Network

Public Ethernet Access
Common term for EDA, FEA, TAG and PEM solutions.

PVC
Permanent Virtual Circuit. A point-to-point connection in the ATM layer.

QoS
Short for *Quality of Service.*

Retailer
A place where a subscriber can buy for example an ADSL solution.

RADIUS (RFC2138)
Remote Authentication Dial In User Service.

An authentication and accounting system used by many ISPs.

RSS
Remote Sub System

RSS filter
Compact clip-on POTS filter for the Ericsson

SDH
Synchronous Digital Hierarchy is the physical layer in the ATM network.

Security Manager
GUI used for PEM user's management.

Security Server
The Security Server interfaces between the Security Manager and the database.

Server
The term Server in the PEM can be either a robust computer with high specifications (as opposed to a workstation) or a SW application.

Service Broker
The Service Broker is the organizational entity supporting the access network with specific services, such as Internet or Video. The Service Broker will make agreements with a number of Service Providers, to be able to offer their services to end-users. Service Brokers are optional in PEM and the Access Provider can act as a Service Broker. How this is structured depends on customer preferences and organization.

Service Configuration
A Service Configuration is a setting of parameters defining a service to be offered through the access network. A Service Configuration is used as the basic template when applying the service to an end-user, and the defined parameters will be common to all end-users subscribing to the service. Parameter examples could be VLAN ID and priority.

Service Configuration Manager
The Service Configuration Manager is a GUI used for handling end-users and their IP services. The Service Configuration Manager is a client application of the Subscriber server.

Service Operator
A Service Operator is an individual working in the Access Provider organization. The Service Operators are responsible for service and Service Broker related issues within the Access Provider organization.

Service Provider
A provider of services also called content provider, for example Internet access service, contend services or firewall services. Service provider equipment may be located anywhere in the network.

SNMP
Short for *Simple Network Management Protocol,* a set of protocols for managing networks.

Spanning Tree
A protocol specified in IEEE 802.1Q, allowing links to be physically available but unused, until another link breaks. Spanning Tree creates a tree structure without loops and changes this structure in case of failure.

Status Manager
A GUI client shows the line status of the IP DSLAM (8 or 10 lines) and the FE-E1 converter (4 lines).

Subscriber Operator
A Subscriber Operator is an individual working in the Service Broker organization. The Subscriber Operators are responsible for handling service related issues for subscribers and end-users within the Service Broker organization.

Subscriber Server
This server interfaces between the GUI's,

database, IP-DSLAMs (through the PEM Domain Service) and NNM.

Sustainable Cell Rate (SCR)
The upper limit for the average cell rate that may be transmitted in the PVC.

TAG
Telephony Access Gateway

TCP
Transmission Control Protocol

TFTP
Trivial File Transfer Protocol

Time Synchronization Server
The Time Synchronization Server is used for setting the real time in the system elements. The real time is used for making the time stamps in log files and alarms, and in the IP DSLAM also for the Remote Storage. The Server is optional in the Domain Server, but there must be a Time Synchronization Server present in the system

ToIP
Telephony over IP

Transport service
A service, accessible for the users of a network, providing consistent and well defined transmission conditions in terms of for example throughput, packet loss and delay.

Unbundling
The process of enabling competitive carrier access to the local loop in order to liberalize the telecommunications market.

V5.2 multilink
V5.2, including the option of supporting more than a single E1 system

V5.2
A standard for Local Exchange and Network Access Node interconnection, using dynamic allocation of E1 timeslots as voice bearer media

VLAN
Virtual LAN. A method used to separate and group traffic within a physical LAN.

VLAN ID
A numerical value identifying a certain VLAN.

VoGW
Voice Gateway

VoIP
Voice over IP

VPN
Virtual Private Network. Secure communication between multiple networks or network devices using insecure public networks, such as the Internet.

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