A common access platform which is based on a scalable distributed architecture with integrated data capabilities to support asynchronous transfer mode (ATM) and time division multiplex (TDM) traffic. The platform is capable of serving multiple remote terminals with a significant increase in ATM and TDM traffic capacities. Furthermore, the platform is expandable by connecting a primary bank which includes ATM and TDM fabrics with one or more secondary banks through one or more stackplane buses. The traffic capacity of the common access platform can be flexibly scaled up or down by adding or subtracting secondary banks from the platform. The stackplane bus provides modularity for interconnections between the primary and secondary banks.
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COMMON ACCESS PLATFORM

CROSS-REFERENCE TO PROVISIONAL APPLICATION

This Patent Application claims the benefit of Provisional Application No. 60/096,956, filed August 18, 1998.

FIELD OF THE INVENTION

The present invention relates to telecommunications. More particularly, the present invention relates to a distributed telecommunications switching system and method.

BACKGROUND

Telecommunications switching systems have been developed for transporting asynchronous transfer mode (ATM) and time division multiplex (TDM) traffic with limited traffic capacities. A typical digital switching system usually has a fixed rate subscriber bus capable of supporting TDM traffic only at a fixed bit rate. Furthermore, the traffic capacity can be increased only with conventional point-to-point time slot interchange connections which would limit the modularity and expandability of the system.

SUMMARY OF THE INVENTION

The present invention provides a common access platform which is based on a scalable distributed architecture with integrated data capabilities to support asynchronous transfer mode (ATM) and time division multiplex (TDM) traffic. The platform is
capable of serving multiple remote terminals with a significant increase in capacity over a conventional access platform. In accordance with the present invention, a communications system which is capable of providing voice, video and data communications roughly comprises a time division multiplex (TDM) fabric, an asynchronous transfer mode (ATM) fabric connected to the TDM fabric, an ATM cell bus connected to the ATM fabric, and a variable rate subscriber bus connected to the TDM fabric.

In an embodiment, the system according to the present invention further comprises an interworking gateway connected between the TDM fabric and the ATM fabric. The variable rate subscriber bus is capable of accepting multiple TDM subscriber bus line cards or line units which operate at a variety of bit rates. In an embodiment, the system further comprises a synchronous transport signal (STS) access controller connected to the TDM fabric.

The ATM cell bus is capable of accepting multiple ATM line cards or line units. The ATM fabric is capable of supporting different modes of ATM fabric. In an embodiment, the ATM fabric is capable of managing ATM traffic based upon a variety of ATM service parameters such as class of service (CoS) or quality of service (QoS) parameters in an ATM cell mode. The ATM fabric is also capable of supporting an ATM packet mode or frame relay mode.

The common access platform according to the present invention is a scalable system which includes at least a primary bank comprising both ATM and TDM fabric. The system can be expanded by connecting one
or more secondary banks to the primary bank through one or more stackplane buses. In an embodiment, the stackplane bus comprises a plurality of ATM and TDM interfaces. The traffic capacity of the common access platform according to the present invention can thus be flexibly scaled up or down by adding or subtracting secondary banks from the platform. The stackplane bus provides modularity for interconnections between the primary and secondary banks.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with respect to particular embodiments thereof, and reference will be made to the drawings, in which:

Fig. 1 illustrates a Common Access Platform High-Level Concept according to the invention.

Fig. 2 illustrates a 2-Row Common Access Platform Shelf.

Fig. 3 illustrates a 1-Row Common Access Platform Shelf, with all full-height line units.

Fig. 4 illustrates the high-level architecture of a Common Access Platform, showing the backplane and stackplane bus concept.

Fig. 5 is a Functional Diagram and shows the major interfaces within Common Access Platform.

Fig. 6 illustrates 4 small line size applications of the Common Access Platform.

Fig. 7 shows the DSLAM Configuration of the Common Access Platform.

Fig. 8 shows Special Services Options in the Common Access Platform.
Fig. 9 illustrates Universal Line Frame Configuration with Internet Redirect in the Common Access Platform.

Fig. 10 illustrates Universal Line Frame with STM Transport in the Common Access Platform.

Fig. 11 illustrates Universal Line Frame with ATM transport in the Common Access Platform.

Fig. 12 illustrates Universal Line Frame with FR transport in the Common Access Platform.

Fig. 13 illustrates Universal Line Frame with IP routing in the Common Access Platform.

Fig. 14 illustrates Platform Transport interfaces in the Common Access Platform.

Fig. 15 illustrates the relationship of the Common Access Platform to a Litespan® system.

Fig. 16 shows a Residential User to ISP, PPP use of the Common Access Platform.

Fig. 17 illustrates a Remote LAN Access using PPP use of the Common Access Platform.

Fig. 18 compares a TDM mode of the Common Access Platform with a Frame Relay capable Common Access Platform.

DETAILED DESCRIPTION

5. System Architecture

5.1 High-Level Concept

At the high level, the new common access platform is based on a scalable, distributed architecture with
integrated data capabilities. It serves multiple remote terminals (significantly more than Litespan\textsuperscript{®} today), greater intelligence is placed on the line or transport card reducing the complexity and cost of the common elements, and modular shelves are interconnected with a buss or "Stackplane" rather than the point-to-point TSI connections today.

The system architecture is conceived to have an integrated ATM and TDM capability. Narrowband and other TDM based traffic use the system TSI, while all data traffic is transported-internally in ATM format. All adaptation to frame and other data services takes place on the interface cards. The system also allows for TDM adaptation to ATM and other types of data for applications such as circuit emulation, voice over ATM, voice over frame, and voice over IP. The transport interfaces are DS1 (T1/HDSL), DS3, and SONET. DS1 transport cards may be physically the same as DS1 service cards. Fig. 1 illustrates the New Common Access Platform High-Level Concept.

5.2 COT, HDT and RDT Configuration

The shelf is 6U high and can be divided into two rows. In this configuration, it can accept Litespan\textsuperscript{®} legacy TDM and ATM ADSL cards. It is expected that this shelf configuration be used in small NGDLC applications. Fig. 2 illustrates the 2 Row New Common Access Platform Shelf. As used herein, ALU is an Alarm Unit, AUX is an Auxiliary Unit, LU is a Line Unit, NCP is a
Nodal Control Processor, PS is a Power Supply, and TRAN is a Transport or Gateway Unit.

Specific features of the new platform are:

- Bank: 6 U tall / 2 Litespan® Line Cards high
  - 128 Narrowband line with quad-cards (ANSI)
  - 192 Narrowband lines with hex-cards (ETSI)

- Channel Bank Slots: 32 Universal
  - Subscriber Bus: 2 to 16 Mb/s
  - Assignable TDM capacity
  - Accepts all existing Litespan® channel cards (including ADLU)
  - Accepts quad-DS1 and OLU cards

- Cell Bus: 25 MHZ x 8 bus to 8 channel slots
  - 200 Mb/s capacity
  - Cell mode used for all traffic

- Transport: 4 Slots with subscriber bus
  - Cell bus 100 MHZ, point-to-point
  - 800 Mb/s capacity
  - SONET/SDH bus, 100 MHZ, point-to-point
  - OC-12/STM-4 capacity

- AUX Slots: 4 slots with subscriber bus
  - 2 RGU
  - 1 MTAU
  - 1 ALU Alarm Unit
-7-

√ Common: 2 Power Supplies
2 Processors
Stackplane interface at 800 Mb/s for up to 9 banks (2,000 NB lines)

5.3 Universal Line Frame and DSLAM Configuration

Full height cards are provided for ULF and central office data applications where high-density is required for POTS and a larger size line card facilitate advanced data capabilities. See Fig. 3, 1-Row New Common Access Platform Shelf, with all full-height line units.

Specific features of the new platform are:

√ Bank: 6 U tall / 2 Litespan® Line Cards high
384 Narrowband line with 24-line cards (ANSI)
240 Narrowband lines with 15-line cards (ETSI)
24 Tip / Ring per slot

√ Channel Bank Slots: 16 New Platform
Subscriber Bus: two at 2 to 16 Mb/s
Assignable TDM capacity
Accepts new high-density NB line cards
Accepts new data cards

√ Cell Bus: 25 MHZ x 16 bus to 8 channel slots
400 Mb/s capacity
Cell mode used for all traffic
(including Frame)
Resource card (FR, IP Router, etc),

\[\text{Transport:} \quad 4 \text{ Slots with subscriber bus}\]
\[\text{Cell bus 100 MHz, point-to-point}\]
\[800 \text{ Mb/s capacity}\]
\[\text{SONET/SDH bus, 100 MHz, point-to-point}\]
\[\text{OC-12/STM-4 capacity}\]

\[\text{Aux Slots:} \quad 4 \text{ slots with subscriber bus}\]
\[2 \text{ RGU}\]
\[1 \text{ MTAU}\]
\[1 \text{ ALU Alarm Unit}\]

\[\text{Common} \quad 2 \text{ Power Supplies}\]
\[2 \text{ Processors and resource cards in LU}\]
\[\text{slots}\]
\[\text{Stackplane interface of 800 Mb/s for up}\]
\[\text{to 9 banks (2,000 NB lines)}\]

5.4 High-level Architecture

Fig. 4 illustrates the high-level architecture showing the backplane and stackplane bus concept.
Fig. 5 is a Functional Diagram and shows the major interfaces within the new platform.

5.5 Software Architecture
The new platform provides the ability to address issues with the current Litespan® software architecture. The following are items that are considered in the development of the software architecture.

The use of an "off-the-shelf" real-time operating system. The ability to purchase software packages and easily port them into the new system is enhanced by using an off-the-shelf operating system. Also, the ability to purchase software development tools and testing tools can increase productivity and reliability. Most software packages are developed to work with the standard operating systems, which include pSOS, VxWorks, and VRTX. Wind River Systems' VxWork is being used in new Litespan® line cards, so it is a likely choice.

The reuse of the Litespan® line card software. The goal of the new platform is to reuse the Litespan® line cards, this includes the line card firmware. This implies that the same Litespan® line card message interface are used.

The TL1 messages syntax is the same as Litespan®. A TL1 interface is needed to interface to the new system. Many of the TL1 commands currently supported in Litespan® will need to be available on the new platform. To maintain a consistent interface and to leverage much of the work that has been done with the OSS, Litecraft and AMS, the front end of TL1 can be
ported over to the new system, though the back end may change in the new architecture.

The ability to manage the system using embedded TL1, CMISE, and SNMP. - Narrowband needs to be managed by TL1 and legacy interfaces, GR-303 needs CMISE for management through switch interfaces, and Data Services need SNMP. Each interface is able to migrate to support all services over time. The new platform therefore has multiple management interfaces.

Line cards with their own FLASH can receive a new image downloaded directly from AMS (Access Management System).

More intelligent Line cards. - It is an objective to be able to release line cards independently from the main software load. More intelligence in the line cards might enable this objective.

Command and Alarm history logs. - To be able to historically browse events that happen when the system is not on line with AMS or other OSS, the ability to retrieve the history is provided.

GR303 DSET software - DSET is the leader in regards to GR-303 interface software toolkit. Much development and testing effort has gone into the Litespan® GR303 interface using the DSET software. That knowledge and effort is reused in the new platform.
Service State Models - There are several service state models in existence with TR-1093, TR-303 CMISE, SNMP and the Litespan® model. The new platform's service state model captures all the service state models requirements.

New features - the same philosophy discussed above of either porting existing work or using off-the-shelf code is utilized for the new features such as ATM, Frame Relay, IP, V5, etc.

6. Network Configurations

6.1 System Configurations

This new platform has the following functions for both ANSI and ETSI versions:

a) Scalable POTS DLC cost effective at 100 lines with linear system cost increase up to 2,000 lines,

b) Broadband Channel Bank functionality for the new platform and LS-2000,

c) Standalone DSLAM for all xDSL-based advanced data services,

d) Universal Line Frame taking the function of the Class 5 switch line interface while adding data capabilities and Internet redirect for up to 2,000 lines,
e) VoIP gateway in ULF and CPE applications.

6.2 Scalable POTS NGDLC

The system has the following key capabilities:

- Scalable system in increments of 128 lines up to 2,000 lines,
- Banks may be daisy chained locally, extended optically, or over T1/HDSL facilities to multiple remote nodes (number of remotes can be more than Litespan® today).
- Can use existing Litespan® cards specifically the Special Services plugs. Although the systems can use Litespan®'s POTS cards, a higher-density POTS card is also available for the system,
- Full set of feeder interfaces:
  a) Metallic (T1, HDSL)
  b) Optical (OC-3, OC-12)
  c) Add-drop and UPSR capabilities
  d) Branching tree with up to 4 branches per node
- Concentration on metallic interfaces,
TR-8, DS1-based GR-303, asynchronously mapped STS-1, and byte-synchronous OC-3 GR-303 switch interfaces. A system can optionally be used in the central office to function as a COT supporting TR-57 interfaces,

Remote management capability over SONET DCCs (OSI) and Ethernet (TCP/IP),

SNMP, TL1 and CORBA management interfaces,

MLT and PGTC test interfaces capability with communications channels to test heads located in systems connected to the HDT. Integrated test systems within the HDT (many small operators do not have PGTC or MLT test systems). It is likely to be compatible with test systems of the operator's choice (e.g. Hekiminan) and may even need to have some level of integrated functionality.

Fig. 6 illustrates 4 small line size applications of the new common access platform. With any of these small system configurations, special services are provided through n x DS0 as is ISDN support. The four applications are described as follows:

A. Direct TR-08 interfaces from the local-Class 5 switch to a Remote Digital Terminal (RDT) via electrically fed T1 or HDSL.
B. TR-08 interface from the local Class 5 switch to a Host Digital Terminal (HDT) with concentrated metallic links to subtending RDTs, again over HDSL.

C. Fiber-fed HDT from an existing CO based fiber multiplexer feeding subtending RDTs by either fiber or metallic links.

D. Central Office Terminal (COT) with either TR-57, TR-08 or GR-303 switch interfaces feeding multiple HDT and RDT groups.

6.3 Broadband Channel Bank (BCB)

The Broadband Channel Bank concept supports the new and preferred access network architecture for a fiber-to-the-node topology. This pulls the distribution fiber back from the fiber-to-the-curb model to a position serving up to 500 homes. Distances from node to home are typically less than 3,000 feet allowing "full service network" features to be offered via VDSL. With these distances, up to 26Mb/s data rate can be supported. VDSL has several advantages over ADSL at these distances which include: higher speeds, lower power, multiple services on the same drop (voice, data and video), and opportunities for business services such as native LAN.

In addition to the residential model of multiple services (voice, data and video), a FTTPN topology within a business park or business condominium allows the operator to offer enhanced data service such as
native LAN and ATM UNIs without stringing fiber directly to the business building. From the FTTN, VDSL can run at symmetrical data rates of 6, 13, and 26 MB/s which extends the capabilities of traditional T1 over HDSL.

This BCB will support the existing LS-2000 RDT configuration and can be remoted from the existing BFB as a standalone broadband channel bank within a CLE environment or street cabinet acting as a large ONU. In either configuration (new platform or subtending LS-2000/BFB), the BCB has a small ATM fabric and accepts VDSL line cards in addition to all other line cards.

6.4 DSLAM Configurations

DSLAMS are data only access devices traditionally delivering high-speed service via ADSL for Internet access. Within the context of the new common access platform, this generic DSLAM delivers data services via any variation of xDSL such as SDSL, HDSL and VDSL in addition to ADSL-full-rate (G.DMT) and ADSL-Lite (G.Lite). Additionally, higher-rate UNIs are supported.

The DSLAM shelf may be:

a) a single standalone shelf,

b) part of a multi-shelf DSLAM system,
c) a dedicated data services shelf within an NGDLC system,

d) or a device that terminates a derived voice channel riding with the xDSL data stream as either voice over ATM, voice over IP, or other coding method and presents these voice channels to a switch interface.

In addition to the traditional dial-up and ADSL Internet access, other high-speed data services include:

- lease line access with n x DS0 in a TDM mode,
- Frame Relay up to DS3 rates in a packet mode,
- ATM up to OC-3c rates in cell mode,
- and Frame to ATM service interworking.
- Future IP based service may be offered using a datagram mode.

Fig. 7 shows the DSLAM Configuration.

Specific value added data functions provided within the access network are Frame Relay aggregation, Frame Relay concentration, and Frame Relay to ATM interworking. As illustrated below, these functions simplify the network design. Economies of scale are provided by reducing the number of network elements
(such as D4/D5, DCS 1:0 and fiber terminals), reducing the number of dedicated links between data network and the access network, and providing by consolidation of switch ports (from many low-speed to a few high-speed ports), and additionally provides a common management platform for all data services.

Fig. 8 shows Special Services Options.

The system has the following DSLAM capabilities:

- Supports Litespan® DMT and G.Lite cards with and without POTS, ISDN (IDSL applications), T1, HDSL, SDSL, and DDS interfaces,

- Full height cards with the following densities: a) 6 line per card for full-rate DMT and b) 12 lines per card for G.Lite, c) 12 line HDSL, d) 24 line SDSL, e) 24 line ISDN,

- Frame Relay over the following service interfaces: full-rate DMT, G.Lite, ISDN, T1, HDSL, SDSL, and DDS,

- Following network interfaces for frame relay: DS1, DS3,

- FR aggregation and concentration,

- ATM over the following service interfaces: full-rate DMT, G.Lite, IMA (inverse multiplexing of ATM) and HDSL,
-18-

- Following network interfaces for frame relay: IMT (inverse multiplexing over DS1), DS3, OC-3 with migration path to OC-12,

- ATM multiplexing and switching with PVCs and SVCs,

- TDM based transport over the following service interfaces: ISDN, T1, HDSL, SDSL, and DDS,

- IP routing for PPP/ATM and,

- Provides PPP aggregation and redirect at DSLAM,

- Multi-10BaseT and FR interfaces for unbundling,

- Provides ATM/FR interworking,

- IP routing in DSLAM,

- Voice over ATM and IP gateway

25 6.5 Universal Line Frame Configuration

Universal Line Frame concept is an extension of the narrowband local Class 5 switch line interface. The ULF provides the analog termination for the subscriber drop and provides concentrated GR-303 interface to the local switch. In addition it provides fast Internet access with ADSL/DSLAM function,
Internet redirect for the legacy dial-up modems, and VoIP gateway. The Internet redirect feature has the ability to offload the local switch from supporting long hold times associated with data calls to the public Internet. Call control for narrowband and data is under the direction of the Connection Control system as described later.

The following are the narrowband capabilities of the ULF:

- √ Supports high-density POTS card with 24 lines per card. Up to 16 cards or 384 lines are supported per bank.

- √ The POTS interface is LSSGR compliant in Gain, SRL, and ERL specifications for non-loaded drops.

- √ Up to 2,000 lines (6 banks) is to be supported in 7-ft bay.

- √ The system also supports high-density ISDN cards (24 lines per card) and DS1 cards (12 per card).

- √ Provides GR-303 interface to switch over DS1s, asynchronous STS-1, and byte-synchronous OC-3.

- √ Voice over ATM or IP gateway.

- √ Up to 4 VRDTs per node for unbundling.
The following are Internet redirects capabilities of the ULF for voiceband modem calls:

- Redirects Internet voiceband calls on a per call basis under the control of the external connection control system

On a call is originated, the system sends it over the GR-303 interface to the Class 5. The class 5 makes an LNP query through SS#7 system and determines that the call needs to be redirected. The connection manager is connected to both the class 5 and the SS#7 system. The connection to the class 5 is to build a database correlating GR-303 CRVs and physical bank/slot/channels on the Litespan®. The connection to the SS#7 is to receive the redirect information. Once it has been established that the call is to be redirected to an ISP, the connection manager issues a command over a TMC-like link between the connection manager and the system (for the Litespan®, the interface is over an X.25 link to minimize development efforts. A TMC-like interface may be best for the new system. It may be possible to eliminate the correlation table of CRVs and physical slots in the connection manager if TMC-like datalink channel is used.
Redirected data calls are placed over DS1s or SONET interfaces to ISP.

Fig. 9 illustrates Universal Line Frame Configuration with Internet Redirect.

The following are data capabilities of the system:

- Multiplex ATM cell traffic onto an inverse multiplexing (IMA) interface with up to 12 DS1s, DS3, or STS-1 within an OC-3/12 payload, and OC-3/12c

- Aggregate and concentrate frame relay traffic over a DS1, DS3, or STS-1 within an OC-3/12

- Aggregate PPP links within a DS1, DS3, or STS-1 within OC-3/12 payload

- Directs IP traffic over DS1, DS3, STS-1 within an OC-3/12 payload and directly over SONET OC-3/12C

- ATM adaptation for voice over ATM and circuit emulation applications.

- Voice over Frame Relay termination

- VoIP gateway functionality for Voice over IP applications

- ATM/FR network and service interworking
Ability to place different type of traffic on STS-1s with a SONET interface

Ability to place different type of traffic on DS1s on a multi-DS1 interface card

SNMP based management system
When the new platform interfaces with the transport system via TDM or STM interfaces, an external multiplexer such as a SONET terminal may be used by the network operator. This arrangement provides a simple solution and transparency of service to the transport network, but requires the new platform to map all services via the STM interface and bandwidth usage is not optimized

Fig. 10 illustrates Universal Line Frame with STM Transport.

ATM transport has a similar effect to STM only interfaces. TDM based and other services must be adapted to ATM within the new platform before being presented to the transport network.

Fig. 11 illustrates Universal Line Frame with ATM transport.

Frame Relay transport is based on a TDM structure with n x 64 kb/s channels. This transport interface does not allow for high bandwidth services such as ATM and is the most limiting of all interfaces.

Fig. 12 illustrates Universal Line Frame with FR transport.
The IP interface facilitates a variety of service classifications. One such service interface is the
possibility of ADSL unbundling on a per subscriber basis. This application requires the new platform to provide IP routing and Layer 3 processing. The same concept can be used with the Internet redirect application.

Fig. 13 illustrates Universal Line Frame with IP routing.

In conclusion, the new platform supports all types of transport interface and is both effective and efficient for the services described herein. Fig. 14 illustrates the New Common Access Platform Transport interfaces.

6.6 CLE and CPE Configurations

Customer Located Equipment (CLE) can take the form of small to medium sized RDT sub-systems located on customer premises supporting high-density application for high-rise and multi-tenant buildings. With the short loop lengths from these systems, higher data rates are possible with VDSL or even direct Ethernet connections. For smaller line densities, the BRX or other ONUs can be deployed for the same but smaller function of a RDT.

6.7 Relationship and Interface with Existing Litespan®

The new common access platform interworks with several of the existing Litespan® assemblies:
Channel Bank Assembly (CBA) has a replacement Bank Control Unit (BCU) that provides the interface to the internal "stackplane" bus architecture of the new system. This functions in a similar method to that of the existing Litespan® TSI link. In this application, the CBA is interconnected via a point-to-point arrangement since the legacy CBA does not allow the stackplane to flow-through to the next shelf.

Broadband Fiber Bank (BFB) is maintained as the high-density optical distribution assembly for Fiber-to-the-Node and Fiber-to-the-Curb applications feeding BRX or ONU-48/96. Like the CBA, the BFB has a replacement ATM Fiber bank Interface Unit (AFIU) that provides the interface with the internal "stackplane" bus architecture of the new system. In this application, the BFB interconnects with the stackplane and provides the flow-through connection to other banks.

BRX is maintained as the fully integrated Optical Network Unit (ONU) providing narrowband and broadband service drops. The BRX is either fed directly from the new common access platform or by a BFB.

Access Management System (AMS) functions as the element manager layer with the necessary software enhancements for the new common access platform. The AMS therefore provides access management for both Litespan® and the new system.
Broadband Channel Bank functionality is added to existing Litespan®-2000 and Litespan®-2012 systems with the new common access platform connecting to the legacy Litespan® TSI interface. For this application, the new platform has a special control interface to proxy the TSI signal and control information. Additionally, the new common access platform (BCB function) has the ability to feed a number of BRX type ONUs along with the high-speed data services (xDSL up to VDSL). Typically, the BCB is used at a RT site in a Fiber-to-the-Node or Fiber-to-the-Building application where the subscribers are within 3,000 feet.

Fig. 15 illustrates the New Platform Relationship to Litespan®.

7. Operations Environment

7.1 Operations Introduction

As the telecommunications industry moves toward the utilization of the existing copper wire-based access network with xDSL technology (specifically the ADSL family) for fast-data access services, a reasonable assumption is that the Legacy OSS (Operations Support Systems) that manage the traditional copper loop-based services will continue to be used. Meanwhile, the network equipment manufacturers are developing support systems for data
services and access products at the Element Management Layer. An important decision must be made to determine how to utilize both the data-based Access Network EMS (Element Management System) running SNMP and the existing or legacy narrowband OSS and surrounding procedures to speed up new service deployment and migrate the operations environment to a TMN-based model.

7.2 Strategic Value of the AMS

Operations are the glue that has the ability to bind together many dissimilar functional groups within the RBOC structure. In a typical telco operations organization there are distinct workforces for DSO-based Special Services, DS-1-based IOF including DCS and fiber, DLC and OSP, and VF-based message services. This segregation of job functions is strictly controlled by union contract and results in a separation of services on network elements. For example, message services and OSP can reside together but specials cannot be on the same bank as message. The IOF group manages IOF and fiber facilities. When a service has to be provisioned through different functional areas, a service contract will be written between the unions that allow one of them to assume responsibility. Usually the workforce with the cheaper rate will be chosen to show a "cost reduction". Additionally, each grouping of network elements administered by a specific workforce has its own OS interface.
When a multi-functional platform such as Litespan® is used for integrated services as illustrated below, again separate workforces are involved. However, unlike the scenario above where the functional groups have responsibility over physically separate network elements, the Litespan® solution does not offer the same physical separation. A strategic solution to the non-physical separation problem that faces the RBOC when they choose to use Litespan® for integrated services is through the AMS. Logical partitions can be created within the software structure of AMS and Litespan® that provides each workforce with its own and physically separate workstation and access to the integrated platform. The new platform amplifies the situation. It contains DLC functionality that is managed with legacy OSS, SNMP managed DSLAM and data capabilities, SONET-based management, and a management system for Internet redirect.

The RBOC's arbitrary restrictions above do not apply the new operator or CLEC.

In conclusion, the following operations capabilities are included with the appropriate narrowband or data feature set.

√ OSI-based management over SONET DCCs

√ 10BaseT using TCP/IP with TL.1 messages to legacy OSs
√ SNMP for DSLAM and data (ATM, FR, IP) functions

√ FTAM for file transfer

√ Q3 with TCP/IP and CORBA for the AMS northbound interface

8. End-to-End System Requirements

10 8.1 TDM, Narrowband/Wideband

TDM based services are supported internally by the TS1 matrix very much like Litespan® today. An enhancement to the database structure allows a greater number of remote terminals to be supported. A typical application that applies to the small scalable concept would use a GR-303 switch interface group across multiple remote nodes. These small nodes (100 to 200 lines) may be fed via a branching tree or a ring topology. However, two embodiments support TDM transport between nodes. These are: mapping the DS0 traffic to VTI.5 payloads and allocating a fixed amount of OC bandwidth to TDM with the remainder for ATM. The drawback of this approach is that the bandwidth of the transport is not used efficiently if few TDM channels are in use. A more efficient mode and simpler system implementation from a software perspective is to convert the TDM traffic to ATM and run in a circuit emulation mode. This approach allows for dynamic bandwidth allocation between TDM and ATM of the OC link. The key differences are from a configuration standpoint.
The advent of a GR-303 STS-1 Class 5 switch interface imposes an asynchronous VT mapping structure on the SONET transport. The primary application for the STS-1 switch interface is to feed multiple remotes via a fiber ring without requiring a COT. Therefore, a VT mapped payload between nodes would permit the new platform to interface directly with the switch are participate in the fiber distribution ring but with a relatively inefficient bandwidth for mixed TDM and ATM traffic. When the new platform node-to-node links are transported via circuit emulation, the new platform can no longer participate in the ring unless a ring within a ring is provisioned.

Therefore, two nodal interfaces are foreseen: one being the bandwidth-optimized circuit emulation mode, the other being a VT mapped transport specifically for the STS-1 switch/ring interface.

8.2 ATM Traffic Considerations (Cell Mode)

When considering the service that is supported by the new platform, we have to also consider how they are supported by the ATM infrastructure. Four basic ATM modes exit for the new platform:

- Native ATM UNI (Typically T1, DS3 and OC-3c)
- Inverse Multiplexed ATM (an emerging service of multiple lower rate T1s multiplexed together at the new platform to form an aggregate bandwidth of typically between 4 and 12 T1s).
• ATM over ADSL (not a true ATM service, but the defacto method of delivering data service via ADSL)

• Frame to ATM interworking.

The basic ATM elements of service are defined as: a) Class of Service (CoS) which specifies which type of service or application that can be provided, b) Quality of Service (QoS) specifies how well a given service will perform, and c) Traffic Management which is the umbrella under which both QoS and CoS is specified.

8.2.1 Basic ATM Elements

8.2.1.1 Class of Service

0 CBR  constant bit rate
0 rt-VBR  real-time variable bit rate
20 0 nrt-VBR  non-real-time variable bit rate
0 UBR  unspecified bit rate
0 ABR  available bit rate
0 GFR  Guaranteed Frame Rate

8.2.1.2 QoS Parameters

• Peak Cell Rate (PCR), Cell Delay Variation Tolerance (CDVT)

• Cell Delay Variation (CDV)

• Sustained Cell Rate (SCR)
-31-

- Burst Tolerance / maximum burst size (MBS)
- Minimum Cell Rate (MCR)
- Cell Transfer Delay (CTD)
- Cell Loss Ratio (CLR)

8.2.1.3 Traffic Management
- Connection Admission Control
- Usage Parameter Control
- Selective Cell Discarding
- Traffic Shaping
- Explicate Forward Congestion Indicator
- Resource Management using Virtual Paths
- Frame Discard
- Generic Flow Control
- ABR Flow Control

8.2.2 Class of Service Characterization

For the five classes of service identified above in 8.1.1, they each are affected by various transmission factors and are assigned a priority within the network:

<table>
<thead>
<tr>
<th>Service</th>
<th>Network Priority</th>
<th>Tolerance to Cell Variation</th>
<th>Tolerance to Cell Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBR</td>
<td>1</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>VBR-rt</td>
<td>2/1</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
-32-

<table>
<thead>
<tr>
<th>Service</th>
<th>PCR</th>
<th>CDVT</th>
<th>CTD</th>
<th>CLR</th>
<th>SCR</th>
<th>MBS</th>
<th>MCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBR</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>=PCR</td>
<td>1</td>
<td>=PCR</td>
</tr>
<tr>
<td>VBR-nrt</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>=SCR</td>
</tr>
<tr>
<td>VBR-nrt</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>=SCR</td>
</tr>
<tr>
<td>ABR</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Opt</td>
</tr>
<tr>
<td>UBR</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>UNI</td>
</tr>
</tbody>
</table>

Class of Service Network Priority

*Note: CBR always carries the highest network priority with UBR being the lowest. However, VBR and ABR priority may be negotiated.

8.2.3 ATM Service Attributes

Each ATM class of service has defined or negotiated attributes and is measured against them:

<table>
<thead>
<tr>
<th>Service</th>
<th>PCR</th>
<th>CDVT</th>
<th>CTD</th>
<th>CLR</th>
<th>SCR</th>
<th>MBS</th>
<th>MCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBR</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>=PCR</td>
<td>1</td>
<td>=PCR</td>
</tr>
<tr>
<td>VBR-nrt</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>=SCR</td>
</tr>
<tr>
<td>VBR-nrt</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>=SCR</td>
</tr>
<tr>
<td>ABR</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Opt</td>
</tr>
<tr>
<td>UBR</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>UNI</td>
</tr>
</tbody>
</table>

4.0
<table>
<thead>
<tr>
<th>GFR</th>
<th>Yes</th>
<th>Yes (TCP Timeout)</th>
<th>Yes (Frame Loss)</th>
<th>Yes (MTU Size &amp; Min PR)</th>
<th>Yes (MTU Size &amp; Min FR)</th>
</tr>
</thead>
</table>

ATM Service Attributes

Note 'is User Defined

8.2.4 ATM "Goodput" Factors

Goodput is a measure of ATM cell traffic efficiency through the system fabric. The use of large buffers, per VC queuing, fair-weighted queuing, and packet discard methods, all system performance as discussed below:

Large Buffers: allows switches to hold traffic without loss until congestion passes. The best buffer size is a balance between large buffers that reduce cell loss and small buffers which lower frame delay and system cost.

Per VC Queuing: allows a switch to independently hold the cells without impacting other connections.

Fair-weighted Queuing: is a mechanism for fairly servicing all virtual connection queues destined to a particular outgoing link while providing each with the requested QoS. Weighting applies to the switches
ability to assign priority to certain service categories requiring low cell loss and low delay.

Packet Discarding: drops whole packets and not just individual cells to relieve congestion. The Packet represents the higher-layer application like TCP/IP. A corrupt cell in a TCP/IP packet would result in the client equipment rejecting the whole packet and requesting a retransmission, which results in further congestion, and a greater chance of more cells being discarded.

8.2.5 ATM Requirements
The tables presented have mapped the ATM attributes against the services previously defined in form of:

* R is a requirement that is supported
* NA is not a requirement
* 0 is optional based on a customer implementation
* xxx is a value

The services are defined as:

* HSIA-R High-speed Internet Access - Residential
* HSIA-B High-speed Internet Access - Business
* RLANE Remote Local Area Network Emulation
* SOHO Small Office, Home Office
* DVB Digital Video Broadcast
* ITV Interactive Television
<table>
<thead>
<tr>
<th>Requirement</th>
<th>HSI A-R</th>
<th>HSI A-B</th>
<th>RLAN NE</th>
<th>SOHO</th>
<th>DVB</th>
<th>ITV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Path Grooming</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Virtual Circuit Policing</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Virtual Path Policing</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Virtual Circuit Traffic Shaping</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Virtual Path Traffic Shaping</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Virtual Circuit Based Buffer</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General ATM Requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement</th>
<th>HSIA-R</th>
<th>HSI A-B</th>
<th>RLAN E</th>
<th>SOHO</th>
<th>DVB</th>
<th>ITV</th>
</tr>
</thead>
<tbody>
<tr>
<td>F4 Flows</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>F5 Flows</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Operations, Administration and Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement</th>
<th>HSIA-R</th>
<th>HSI A-B</th>
<th>RLAN E</th>
<th>SOHO</th>
<th>DVB</th>
<th>ITV</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBR</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>VBR-nrt</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
8.3 PPP and Layer 2 Tunneling

The following is a description of the L2TP Access Concentration (LAC) functionality for the new platform. The purpose of L2TP tunneling is to group multiple PPP session and transports them over a layer 2 network to a particular destination. This allows the end users to use the widely deployed PPP protocol while eliminating the need for the access equipment to fully terminate the PPP sessions. It is an alternative being proposed within the Standards Forums in place of CPE devices using ATM interface with Q.2931 signaling.
and the access network functioning as a signaling node.

The following are the functions of the LAC:

5
* LAC looks for PPP session establishment messages

* LAC determines destination based on users domain name

10
* LAC encapsulates PPP session into pre-existing L2TP Session or generates new L2TP Session if one does not exist

15
* LAC Terminates up to 2,000 VCs or 2,000 drops

* LAC Terminates Client based ATM now Frame Relay in the future

20
* LAC Terminates Network based ATM/Frame Relay/Leased Line

* QoS for LAC currently UBR only in the near future ABR

25
* In the future the LAC terminates Q.2931 Signaling generated from up to 2,000 clients with multiple VCs per Client and multiple QoS's per client.

30
Fig. 16 shows Residential User to ISP, PPP.
Virtual Private Networking appears as a standard Internet access connection to the new platform. The Client initiates a standard PPP session with the access system with the Client sending packets destined to the IP address of the corporate network. The LAC initiates a tunnel above that IP layer with traffic at this layer that may or may not be encrypted based on the client/corporate policy (see below). The client now has to manage multiple network logins but this is common practice to provide the security demanded by most corporate networks.

Fig. 17 illustrates Remote LAN Access using PPP.

8.4 Packet Mode (Frame Relay)

Frame Relay combines the statistical multiplexing and port sharing features of X.25 with the high speed and low delay characteristics of TDM circuit switching. Defined as a "packet-mode" service, Frame Relay organizes data into individually addressed units known as frames rather than placing it into fixed time slots. This gives Frame Relay statistical multiplexing and port sharing characteristics.

Only a few Layer 2 functions, the so-called "core aspects," are used, such as checking for a valid, error-free frame but not requesting retransmission if an error is found. Thus, many protocol functions already performed at higher levels, such as sequence numbers, window rotation, acknowledgments and supervisory frames, are not duplicated within the
Frame Relay network. These functions are not necessary when the communications infrastructure provides near zero bit error rates. Essentially Frame Relay is a data link protocol that can transport upper layer multi-protocol traffic.

The new platform is based on two switching fabrics namely TDM and ATM. Numerous TDM capable line cards exist for Litespan® today. Thus it makes sense to leverage the existing line cards when it makes sense. For Frame Relay access T1, DDS and BRI are common rates. These line-cards all exist for the TDM fabric. In the T1 case a fractional T1 transport may be provisioned and the Litespan® system may be provisioned to groom the DS0s. Thus it makes sense to use these line cards for the drop side interface to the Frame Relay Client.

8.4.1 Frame Relay Features

For the new platform there are two types of Frame Relay products. They are:

* Type 1, supporting Frame Relay circuit aggregation
* Type 2, supporting Frame Relay circuit concentration

Fig. 18 compares a TDM mode new platform (top half of diagram below) with a Frame Relay capable new platform (bottom half of diagram). This configuration supports the Type 1 with low-speed TDM, and Type 2 for Frame Relay processing and higher-speed UNIs.

Type 1 consists of multiple low-speed Frame Relay aggregated into a non-channelized high-speed
interface. An example is 24 x 64 Kb/s which are aggregated into a single non-channeled T1. This configuration in effect provides a rate adaptation function between the T1 and the low-speed drop side ports.

Type 2 is similar to Type 1, however, this mode permits the drop side bandwidth to exceed the DS1 bandwidth. An example would be 48 x 64Kbps are concentrated into one DS1. In this case the sum of the committed information rate (CIR) must be less than 1.536 Mb/s.

8.4.1.1 Physical Port Provisioning

Frame Relay aggregation and concentration interfaces are supported as follows:

Modes Supported for Frame Relay, Aggregation (TDM Mode)

<table>
<thead>
<tr>
<th>Drop Side</th>
<th>Network Side</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>56k x 27</td>
<td>1 x DS1</td>
<td></td>
</tr>
<tr>
<td>64k x 24</td>
<td>1 x DS1</td>
<td></td>
</tr>
<tr>
<td>56k x N</td>
<td>1 x FT1</td>
<td>Where Nx56k &lt; FT1</td>
</tr>
<tr>
<td>64k x N</td>
<td>1 x FT1</td>
<td>Where Nx64k &lt; FT1</td>
</tr>
<tr>
<td>128k x 12</td>
<td>1 x DS1</td>
<td></td>
</tr>
<tr>
<td>128k x N</td>
<td>1 x FT1</td>
<td>Where Nx128k &lt; FT1</td>
</tr>
</tbody>
</table>

Modes Supported for Frame Relay Concentration (Frame/ATM Mode)
<table>
<thead>
<tr>
<th>Drop Side</th>
<th>Network Side</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>56k x N</td>
<td>1 x DS1</td>
<td>Where sum of CIR &lt; DS1</td>
</tr>
<tr>
<td>64k x N</td>
<td>1 x DS1</td>
<td>Where sum of CIR &lt; DS1</td>
</tr>
<tr>
<td>56k x N</td>
<td>1 x FT1</td>
<td>Where sum of CIR &lt; FT1</td>
</tr>
<tr>
<td>64k x N</td>
<td>1 x FT1</td>
<td>Where sum of CIR &lt; FT1</td>
</tr>
<tr>
<td>128k x N</td>
<td>1 x DS1</td>
<td>Where sum of CIR &lt; DS1</td>
</tr>
<tr>
<td>128k x N</td>
<td>1 x FT1</td>
<td>Where sum of CIR &lt; FT1</td>
</tr>
</tbody>
</table>

Note: bonding may be required for 128kbps case.

10 8.4.2 Frame Relay Aggregation Module

The frame relay aggregation module comprises a new network side card. The drop side cards are existing Litespan line cards. The module is compatible with existing Litespan TDM drop side cards as necessary and with FT1, DDS, BRI, etc.

New Frame Relay Card:

20 Frame relay card with TDM bus interface
   T1 framer with 24 drop side HDLC controllers
   One network side HDLC controller
   Rate adaptation between drop and network

25 ports
   Management interface for provisioned frame relay PVCs
   Alarms and statistics for frame relay PVCs
This design approach limits the drop side to a maximum of 24 users per module. (Low-rate frame relay access such as 19.2 Kb/s is not supported)

8.4.3 Frame Relay Concentration Module

The frame relay concentration module comprises a new network side card. The drop side cards are existing Litespan line cards. The module is compatible with existing Litespan TDM drop side cards as necessary and with FT1, DDS, BRI, etc.

New Frame Relay Card:

- Frame relay card with TDM bus interface
- Granularity of drop side is NxDS0
- T1 framer with 48 drop side HDLC controllers
- One network side HDLC controller
- Rate adaptation between drop and network ports
- Packet buffers for concentration
- Packet policing and traffic management for PVCs
- Traffic management details
- Management interface for provisioned frame relay PVCs
- Alarms and statistics for frame relay PVCs

This design approach limits the drop side to a maximum of 48 users per module. (Low-rate frame relay
access management interface such as 19.2 Kb/s is not supported)

8.4.4 Frame Relay Module(s)

In an embodiment, the frame relay module roughly comprises:

(a) new drop side cards that interface with the system over the ATM fabric; and
(b) new network side cards that interface over the ATM fabric with the appropriate physical layer interface.

Frame Relay processing functions are located on a resource module (based on a multichannel HDLC controller) that can be added in a modular fashion to the system. A centralized gateway function between the TDM and ATM fabric is also provided in an embodiment. With a gateway, it is possibly to reuse existing TDM drop side cards. The gateway provides the inter-working function between TDM and ATM cards.

8.4.5 T3/E3 version

FR greater than T1 (T3/E3 also NxT1) rates over ATM fabric using cell switching

Drop side is PRI, BRI, FT1 with NxDS0
Network side is one HDLC T3 with 28 (aggregated) or up to 128 (concentrated) drop side HDLC controllers
Traffic management for PVCs
Network management/provisioning for PVCs
Statistics and alarms for PVCs

8.4.6 HSSI/V.35 version

FR greater than T1 (8 to 52 Mb/s) rates over ATM fabric using cell switching
Useful for co-located equipment
Drop side is PRI, BRI, FT1 with NxDS0
Network side consists of 1 HDLC HSSI/V.35
with 28 (aggregated) or up to 128 (concentrated) drop side HDLC controllers
Traffic management for PVCs
Network management/provisioning for PVCs
Statistics and alarms for PVCs

8.5 ATM/Frame Relay Interworking

Frame to ATM is becoming a common requirement at the edge of the network. Typically, an operator's network has an ATM core with several service level shells such as Frame Relay. Interworking between Frame and ATM can greatly streamline the network design and offer enhanced reliability due to the reduced number of network elements. The functions of ATM to Frame interworking are:
Frame Relay Forum and ATM forum interworking specifications for service and transport
Network side ports ATM format of DS3 and OC-3
System bus used is ATM
Drop side format is frame relay with many HDLC (up to 128 controllers) mapped to various physical ports PRI, BRI, FT1 with NxDS0, and xDSL
Network side consists of ATM AAL5 SAR controller
Traffic management/policing for PVCs
Network management/provisioning for PVCs
Statistics and alarms for PVCs

8.8 Transport Requirements

Transport functions are principally SONET based interfaces at the OC-3 and OC-12 rates with an upgrade path to OC-14. Concatenation is required for high-speed ATM streams. Both byte-synchronous and floating VT mapping is required. Configuration support required is follows:

Point-to-Point
Linear ADM
Two fiber path switched rings (UPSR)
SONET Phase II Compliance (GR-253)
Drop and Continue for Dual Homing
Synchronization status messaging
Stratum 3E
Full Performance monitoring
1+1 Optical facility protection
Full drop capacity of line rate
Full STS-1 and VT1.5 time slot assignment
Time slot interchange (DS0 grooming)
In-service upgrades to higher rates
Section DCC functionality (Transport, LAN, Drop Optics)
Byte Synchronous VT mapping
Asynchronous floating VT mapping

8.10 ETSI Requirements

ETSI product requirements are different from those of the ANSI market. Some of the key differences are:

Signal interfaces are based on a 2 Mb/s hierarchy vs. 1.5 Mb/s
There are 30 message channels vs. 24
Out of band signaling is used vs. robbed bit
Ring and line impedances are different
Physical mounting is 600mm vs. 23"
Depth is 300mm vs. 12" overall
Front cable access is required for all mountings
ITU and ETSI standards are enforced vs. ANSI and Bellcore
EMI limits are tighter and MUST be met
Safety requirements are more strict (the "CE" mark)
Connectors are different and by region
Management interfaces do not use TL.1
Each country may have unique requirements

The following are high-level ETSI functions.

- 15 POTS per card
- 8 E1s per card
- SDH multiplexing hierarchy up to STM-4
- P-Mux functionality
- V5.1 and V5.2 switch interface
- 600 mm bank

A full list of ETSI and international industry requirements is provided in References and Related Documents below.

8.11 Network Synchronization

The following are the system synchronization requirements:

- Internal clock with Enhanced Stratum 3 holdover capability (ST3E)
- Ability to derive timing from BITS clock (CC and 1.544), DS1 interface on backplane, loop time from any SONET interface, and synchronization to traffic carrying non-SONET mapped DS1.
- Ability to distribute timing on optical interfaces and extract timing from an optical interface and distribute to a DS1 without going through the system clock.
Support SONET synchronization messages

8.13 Housing Requirements

A new series of cabinets and enclosures are low cost and existing cabinets are optimized for 2 or 4 new platform shelves. Technologies such as Heat Pipes (exchangers) and lexan polycarbonates are used. Generally for the traditional RBOC market, TR-487 defines the housing requirements. However, when new markets are entered such as the CLECs, the requirements may be relaxed.

9. Glossary of Terms

The glossary of terms listed below has been compiled to assist the reader with new concepts introduced within this document.

Fiber-to-the-Node/Curb/Home (FTTN, FTTC, FTTH)
Fiber-to-the-Node/Curb/Home defines the termination point of a fiber distribution feed to an optical network unit (ONU) where the service is then provided by copper twisted pair. ONUs are essentially small remote terminals served from an HDT. The above topology is covered by the umbrella term Fiber-in-the-Loop (FITTL). The key difference between FTTN/C/H is the location and number of subscribers served. The distance from the ONU to the subscriber is inversely proportional to the effective data rate over the copper pair. Typically FTTN serves hundreds of subscribers, FTTC serves tens of subscribers, and FTTH
serves units. FTTH is also known as FTTBuilding or Basement (FTTB).

Inverse Multiplexed ATM (IMA)
ATM service has been defined to function efficiently over broadband networks. Extending this broadband link to customers is however costly while a single T1 is not sufficient. One method known as' IMA uses multiple T1 (via HDSL) and is now widely used to support aggregate bandwidths between T1 and T3. Typically between 4 and 8 T1 are multiplexed together for an aggregate bandwidth of 6 to 12 Mb/s supporting native ATM UNI and LAN emulation.

L2TP Access Concentrator (LAC)
LAC is a device attached to the switched network fabric (e.g. PSTN, ISDN, ATM) or co-located with a PPP end system capable of handling the L2TP protocol. The LAC needs only the media over which L2TP is to operate to pass traffic to one or more LNS's. It may tunnel any protocol carried within PPP. The LAC is the initiator of incoming calls and the receiver of outgoing calls.

L2TP Network Server (LNS)
An LNS operates on any platform capable of PPP termination. The LNS handles the server side of the L2TP protocol. Since L2TP relies only on the single media over which L2TP tunnels arrive, the LNS may have only a single LAN or WAN Interface, yet still be able to terminate calls arriving at any LAC's full range of PPP interfaces (asynchronous, synchronous ISDN, V.120,
ADSL, etc.). The LNS is the initiator of outgoing calls and the receiver of incoming calls.

Point-to-Point Protocol (PPP),
5 The point-to-point protocol is commonly used for dial-in connections to the public Internet. PPP is a link layer protocol used on a point-to-point basis for control of the link (Link Control Protocol, LCP), network-layer control, authentication, and compression. These capabilities require a point-to-point relationship between peers such as client PC and network server. The Point-to-Point Protocol (PPP) provides a standard method for transporting multi-protocol datagrams over point-to-point links and is now used with ADSL.

Tunnel
A tunnel is defined by an LNS-LAC pair. The tunnel carries PPP datagrams between the LAC and the LNS. Many sessions can be multiplexed over a single tunnel. A control connection operating in-band over the same tunnel controls the establishment, release, and maintenance of sessions and of the tunnel itself. A tunnel is sometimes referred to as a control connection.

10. References and Related Documents

The documents referenced below are provided as a guide and reference for the platform. These documents are incorporated herein by reference. Additionally, a list of ETSI and international (non-ANSI) related documents
are provided to aid in the development of an international version of the platform.

1. ADSL Forum, TR-002, ATM over ADSL Recommendations.

2. ADSL Forum, TR-012, Broadband Service Architecture for Access to Legacy Data Networks over ADSL, Issue 1.


11. Acronyms

AAL     ATM Adaptation Layer
ABR     Available Bit Rate
ADSL    Asymmetrical Digital Subscriber Line
AMS     Access Management System
ANSI    American National Standards Institute
ATM     Asynchronous Transfer Mode
ATU-R   ADSL Termination Unit - Remote
BB      Broadband
BRX     Broadband Remote Transceiver
CAC     Connection Admission Control
CATV    Community Access Television (or Cable Television)
CBA     Channel Bank Assembly
CBR     Constant Bit Rate
CC      Composite Clock
CDV     Cell Delay Variation
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDVT</td>
<td>Cell Delay Variation Tolerance</td>
</tr>
<tr>
<td>CIR</td>
<td>Committed Information Rate</td>
</tr>
<tr>
<td>CLE</td>
<td>Customer Located Equipment</td>
</tr>
<tr>
<td>CLEC</td>
<td>Competitive Local Exchange Carrier</td>
</tr>
<tr>
<td>CLR</td>
<td>Cell Loss Ratio</td>
</tr>
<tr>
<td>CO</td>
<td>Central Office</td>
</tr>
<tr>
<td>CORBA</td>
<td>Common Object Request Broker Architecture</td>
</tr>
<tr>
<td>COT</td>
<td>CO Terminal</td>
</tr>
<tr>
<td>CPE</td>
<td>Customer Premises Equipment</td>
</tr>
<tr>
<td>CSU</td>
<td>Customer Service Unit</td>
</tr>
<tr>
<td>CTD</td>
<td>Cell Transfer Delay</td>
</tr>
<tr>
<td>DBS</td>
<td>Direct Broadcast Satellite</td>
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<tr>
<td>DCC</td>
<td>Data Connection Control</td>
</tr>
<tr>
<td>DCS</td>
<td>Digital Cross-connect System</td>
</tr>
<tr>
<td>DLC</td>
<td>Digital Loop Carrier</td>
</tr>
<tr>
<td>DSL</td>
<td>Digital Subscriber Line</td>
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<tr>
<td>DSLAM</td>
<td>Digital Subscriber Line Access Multiplexer</td>
</tr>
<tr>
<td>DSU</td>
<td>Data Service Unit</td>
</tr>
<tr>
<td>EMS</td>
<td>Element Management System</td>
</tr>
<tr>
<td>ERL</td>
<td>Echo Return Loss</td>
</tr>
<tr>
<td>ETSI</td>
<td>European Telecommunications Standards Institute</td>
</tr>
<tr>
<td>FITL</td>
<td>Fiber-in-the-Loop</td>
</tr>
<tr>
<td>FR</td>
<td>Frame Relay</td>
</tr>
<tr>
<td>FRS</td>
<td>Frame Relay Service</td>
</tr>
<tr>
<td>FSN</td>
<td>Full Service Network</td>
</tr>
<tr>
<td>FT1</td>
<td>Fractional T1</td>
</tr>
<tr>
<td>FTTC</td>
<td>Fiber-to-the-Curb</td>
</tr>
<tr>
<td>FTTH</td>
<td>Fiber-to-the-Home</td>
</tr>
<tr>
<td>FTTN</td>
<td>Fiber-to-the-Node</td>
</tr>
<tr>
<td>FVO</td>
<td>First Verification Office</td>
</tr>
<tr>
<td>GFR</td>
<td>Guaranteed Frame Rate</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>HDLC</td>
<td>High-level Data Link Controller</td>
</tr>
<tr>
<td>HDSL</td>
<td>High-rate Digital Subscriber Line</td>
</tr>
<tr>
<td>HDT</td>
<td>Host Digital Terminal</td>
</tr>
<tr>
<td>HDTV</td>
<td>High Definition Television</td>
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<tr>
<td>HFC</td>
<td>Hybrid Fiber-Coax</td>
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<tr>
<td>HSSI</td>
<td>High-Speed Serial Interface</td>
</tr>
<tr>
<td>IDSL</td>
<td>ISDN Digital Subscriber Line</td>
</tr>
<tr>
<td>ILEC</td>
<td>Incumbent Local Exchange Carrier</td>
</tr>
<tr>
<td>ILMI</td>
<td>Integrated Local Management Interface</td>
</tr>
<tr>
<td>IMA</td>
<td>Inverse Multiplexed ATM</td>
</tr>
<tr>
<td>IMT</td>
<td>Inverse Multiplexed T1</td>
</tr>
<tr>
<td>IOF</td>
<td>Inter-Office Facility</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>ISDN</td>
<td>Integrated Services Digital Network</td>
</tr>
<tr>
<td>ISP</td>
<td>Internet Service Provider</td>
</tr>
<tr>
<td>IXC</td>
<td>Inter-Exchange Carrier</td>
</tr>
<tr>
<td>L2TP</td>
<td>Layer 2 Tunneling Protocol</td>
</tr>
<tr>
<td>LAC</td>
<td>Local Access Concentrator</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LSSGR</td>
<td>Local Switched Services Generic Requirements</td>
</tr>
<tr>
<td>MBS</td>
<td>Maximum Burst Rate</td>
</tr>
<tr>
<td>MCR</td>
<td>Minimum Cell Rate</td>
</tr>
<tr>
<td>NB</td>
<td>Narrowband</td>
</tr>
<tr>
<td>NGDLC</td>
<td>Next Generation DLC</td>
</tr>
<tr>
<td>NIC</td>
<td>Network Interface Card</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operations, Administration and Maintenance</td>
</tr>
<tr>
<td>OC-n</td>
<td>Optical Carrier hierarchy</td>
</tr>
<tr>
<td>ONU</td>
<td>Optical Network Unit</td>
</tr>
<tr>
<td>OS</td>
<td>Operations Support</td>
</tr>
<tr>
<td>OSP</td>
<td>Outside Plant</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
</tbody>
</table>
PCR  Peak Cell Rate
PM  Performance Monitoring
PMO  Present Method of Operation
POTS  Plain Old Telephone Service
5  PPP  Point-to-Point Protocol
PPS  Point-to-Point Signaling
PSTN  Public Switched Telecommunications Network
PTT  Post, Telephone and Telegraph
PVC  Permanent Virtual Channel
10  PVP  Permanent Virtual Path
QoS  Quality of Service
RADSL  Rate-adaptive ADSL
RBOC  Regional Bell Operating Company
RF  Radio Frequency
15  RFP  Request for Proposal
ROBO  Remote Office, Branch Office
ROI  Return on Investment
SCR  Sustained Cell Rate
SDSL  Symmetrical Digital Subscriber Line
20  SNMP  Simple Network Management Protocol
SOHO  Small Office, Home Office
SONET  Synchronous Optical Network
SPR  Spare
SRL  Singing Return Loss
25  STM  Synchronous Transport Mode
STS-x  Synchronous Transport Signal-x (rate)
SVC  Switched Virtual Circuit
TCP/IP  Transport Connection Protocol for IP
TDM  Time Division Multiplexing
30  TL1  Transaction Language-1
TMN  Telecommunications Managed Network
TSI  Time Slot Interchange
The foregoing description of preferred embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in this art. In particular, and without limitation, any and all variations described, suggested or incorporated by reference in the Background section of this patent application are specifically incorporated by reference into the
description herein of embodiments of the invention. The embodiments described herein were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.
CLAIMS

What is claimed is:

1. A communication system capable of providing voice, video and data communications, the system comprising:

   (a) a time division multiplex (TDM) fabric;

   (b) an asynchronous transfer mode (ATM) fabric connected to the TDM fabric;

   (c) an ATM cell bus connected to the ATM fabric; and

   (d) a variable rate subscriber bus connected to the TDM fabric.

2. The system of claim 1, further comprising an interworking gateway connected between the TDM fabric and the ATM fabric.

3. The system of claim 1, further comprising a synchronous transport signal (STS) access controller connected to the TDM fabric.

4. The system of claim 1, further comprising a plurality of ATM line units connected to the ATM cell bus.
5. The system of claim 1, further comprising a plurality of subscriber bus line units connected to the variable rate subscriber bus.

6. The system of claim 1, wherein the ATM fabric is capable of managing ATM cell mode traffic based upon class of service (CoS) or quality of service (QoS) parameters.

7. The system of claim 1, wherein the ATM fabric is capable of supporting ATM frame relay mode traffic.

8. A scalable digital loop carrier (DLC) system capable of providing voice, video and data communications, the system comprising:

   (a) a primary bank, comprising:

   (i) a time division multiplex (TDM) fabric;

   (ii) an asynchronous transfer mode (ATM) fabric connected to the TDM fabric; and

   (iii) a synchronous transport signal (STS) access controller connected to the TDM fabric;

(b) a stackplane bus connected to the primary bank, the stackplane bus comprising a plurality of ATM and TDM interfaces; and
(c) a secondary bank connected to the stackplane bus, the secondary bank capable of providing ATM and TDM transport.

9. The system of claim 8, wherein the primary bank further comprises an ATM cell bus connected to the ATM fabric.

10. The system of claim 9, wherein the primary bank further comprises a plurality of ATM line units connected to the ATM cell bus.

11. The system of claim 8, wherein the primary bank further comprises a variable rate subscriber bus connected to the TDM fabric.

12. The system of claim 11, wherein the primary bank further comprises a plurality of variable rate subscriber bus line units connected to the variable rate subscriber bus.

13. The system of claim 8, wherein the ATM fabric is capable of managing ATM cell mode traffic based upon class of service (CoS) or quality of service (QoS) parameters.

14. The system of claim 8, wherein the ATM fabric is capable of supporting ATM frame relay mode traffic.

15. The system of claim 8, further comprising:
(a) an additional stackplane bus connected to the primary bank, the additional stackplane bus comprising a plurality of ATM and TDM interfaces; and

(b) an additional secondary bank connected to the additional stackplane bus, the additional secondary bank capable of providing ATM and TDM transport.

16. A network access node which provides access to both the ATM and TDM networks (such as a Litespan or a Millennium system), and a gateway function integrated into the network access node to allow narrowband services to/from the TDM network to be carried to/from subscribers via an drop which uses either ATM or DSL or both.
Data Services PMO (e.g. FR):

Customer CPE → TEST → D4/D5 Chnl Bk → OS → IOF → FOT → OS → 1:0 DCS → OS → Service (Frame, ATM, Message, TDM)

Data Service Simplification with the New Access Platform:

Customer CPE → TEST

Service Processing: TDM/ATM/FR Fabric

Transport: Fiber or Copper

Local Access Office

Service Office

Analog Line Frame Replacement.

Dial-up data calls managed on a per call bases from the Connection Control

TDM
FR
ATM
HITP
LAC
Class 5

Connection Control

NxDS1
STS-3
DS3

TDM STM

GR-303

Fig. 8

Fig. 9