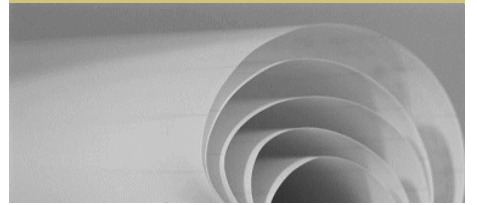


**PROVIDING PROFITABLE
MULTI-SERVICE BUSINESS ACCESS
IN TELCO NETWORKS.**



HOW NEXT GENERATION SDH USED IN MULTI-SERVICE,
TECHNOLOGY-INTEGRATED SOLUTIONS BRINGS NEW,
EXCITING AND REVENUE GENERATING SERVICES TO BUSINESS
CUSTOMERS.

THE ACCESS NETWORKING ENVIRONMENT TODAY

The Business customer's requirements for Telco networking services are changing fast. Speed requirements are increasing. Customers want on-demand bandwidth with high availability and on a large variety of network interfaces. Customers want new services quickly, so service activation times are decreasing.

In the effort to offer their customers a complete, multi-service access networking solution, Telcos are looking for access solutions that enable them to leverage their existing core networks to deliver advanced Carrier Class Ethernet and IP services for business customers over

- metropolitan areas,
- regional networks,
- long distance Links and
- campus / Industrial areas.

Cost effective access networks have always been an important issue for Telcos. Today, access is often the most costly part of an operator's total network operation.

In today's strained business climate, more than ever, it is essential for Telcos to make the most out of existing network base. The Telco investors demand quick return on investments (ROI), and generally limit the Telcos possibilities for making fundamental changes or upgrades to the core networks.

SDH AND ITS PLACE IN ACCESS NETWORKS

SDH is going to play a most important role in the future of business customer access. It is widespread, and is the most commonly used transport network in Europe, Africa and South America. It is thus essential to find a way to leverage this enormous investment when reaching out over the access gap with new services to business customers.

Telcos thus look for solutions and equipment that enable them to use their existing SDH networks as a basis for "Next Generation Access Network" or NGAN.

High-speed business data connections are sought after both in larger towns and in rural areas.

The Telcos, thus, needs an access solution that is both highly scalable in POP size and highly flexible in the interfaces and services to be implemented at each site. This means that the solution and the equipment is scalable and can be used to build both large to mid-sized Metro access networks, and at the same time the equipment has the granularity to be used in smaller scale in rural areas.

This type of new solutions and equipment enables the Telcos to deliver high quality, high-speed "transparent LAN" services both locally and over transport network distances, by only marginally complementing existing SDH- and IP infrastructure with multi-service access equipment. All this to realize all-in-one, flexible broadband service bundles for businesses both in towns and in rural areas.

It is essential to accomplish all this while still keeping the traditional and highly revenue-generating TDM services integrated in the same access network solution. Most of the revenue that finance the new network build-out still comes from these TDM services.

THE NEW SERVICES

ETHERNET RULES THE DAY

Ethernet data transport is the most sought after Telco service for business customers today. Operators must find an economical way to deliver a wide range of connection speeds to their customers, ranging from one Megabits/s on Fast Ethernet, via 10 and 100 Mb. to Gigabits/s.

Medium sized Business customers require connection speeds from a few Mb/s to 100 Mb.

The connection speeds are expected to grow rapidly, and the Telcos need flexible equipment that lets them change the connection speed or provide dynamic bandwidth over time of day in an easy way, and without visiting the customer or changing the equipment installed at the customer site.

Larger customers look for Gigabit connections:

- To concentrate router traffic between larger corporate sites.
- For transport of storage-site data between computer centres and for backup and disaster recovery.

Both customer-categories look for high quality and high availability point-to-point and point-to-multipoint Ethernet connections over transport distances.

STORAGE SERVICES

Demand for transport of data traffic over data-storage interfaces is growing steadily. Typical interfaces requested are Gigabit Ethernet, ESCON/FICON and FireChannel. These are used, MOST OFTEN, to connect storage centers for disaster recovery.

These transport services are the most sensitive to latency, and SDH-based "clear channel" point-to-point connections provide some of the lowest latencies available. With less than 50 ms protection switching time, SDH networks provide very reliable connections.

SPIN-OFF CONNECTIONS FOR OTHER SERVICES

As DSLAMs concentrators for DSL services are migrating from ATM to IP backbone interfaces, it becomes cost-effective to use both multi-service metro and rural access networks to consolidate this type of traffic. This especially facilitates further build-out of "fill-in" DSLAMs in rural areas where the cost of reaching the subscribers has been prohibitive until now.

The same logic apply for connections to base stations for mobiles and Wireless LANs. The new generation SDH-based equipment makes it possible to share the cost of establishing a modern multi-technology rural network between several services.

NETWORKING REQUIREMENTS OF A MULTISERVICE ACCESS PLATFORM

AT THE CUSTOMERS PREMISES

IAD'S AT THE COSTOMER PREMISES

To address the exploding demand for last-mile bandwidth, new highly Integrated Access Devices (IAD) are needed. These are intended for building service-integrated, broadband access networks for operators serving enterprise customers, primarily via fibre and in some cases via radio.

One single IAD situated at the customer premises can handle all communication needs on a single fibre connection, connecting to the customers

- LAN-LAN connections (point-to-point and point-to-multipoint)
- Voice over IP applications
- Internet access
- PABX and
- legacy leased lines

These units can deliver Ethernet to one or more customer(s) using Fast or Gigabit Ethernet interfaces. They also deliver storage interfaces like ESCON and Fibre Channel.

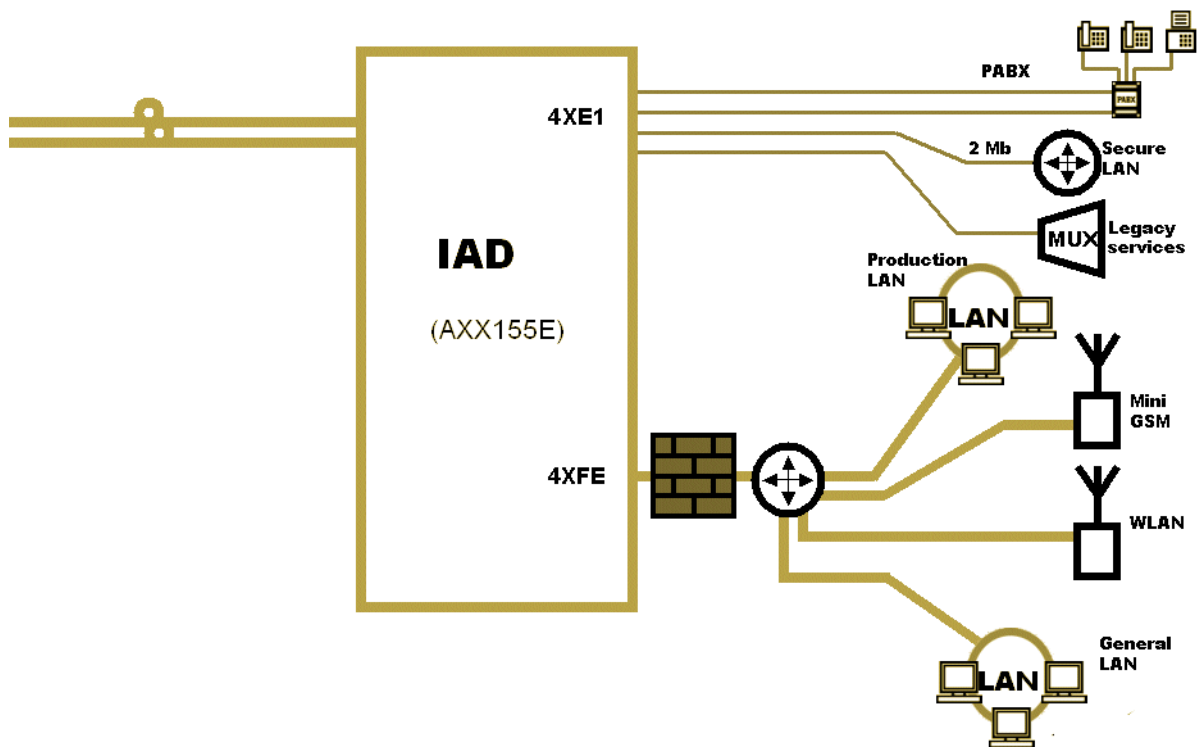


Figure 1. Connecting a Business Customer with multiple services on a single fiber

Interoperability with other operators, equipment from other vendors and different networking technologies like SONET is solved through mapping protocols like GFP (Generic Framing Procedure), and signalling schemes such as Virtual Concatenation (VC) and Link Capacity Adjustment Scheme (LCAS).

IN THE POP

WHERE ACCESS MEETS CORE

Having established new and cost-effective service-integrated access networks, the next challenge is to sort and groom the traffic reaching the core in a way that efficiently leverages the variety of already existing core networks.

At the Central Office or at the Telco POPs (Point of Presence), a scalable and cost-effective solution is required that allows the Telcos to groom and sort all the different traffic types coming out of a modern multi-service access network into traditional, mixed backbone networks:

- PDH
- ATM
- SDH
- IP

Great advantages can be achieved in this field by further combining SDH and IP functionality in the same equipment solution. Access traffic to be terminated in each of the legacy networks may be processed in and connected in directly from the access equipment. Mechanisms to oversubscribe the core while still meeting the customer-specific Service level Agreements should be available.

This assures efficient use of the backbone networks, and thus may postpone costly core network upgrades.

RADIO AS AN ALTERNATIVE TO FIBRE

Traditionally, high-speed microwave radio-links have been intended for trunk networks, and the prices have been prohibitive in most access applications. Today, low-cost point-to-point radios play several important roles in business access networks.

- They enable the operator to deliver services on short notice.
- They solve the problem of connecting business customers where fibre digging is not possible or impractical.
- They provide digging-free back-up circuits for customers requiring protected connections, and connect locations where there is no fibre available or where the fibre is used for other purposes.

Typical downtown access distances range from 5 to 20 km. Connection speeds up to 155 Mb/s are available at prices that easily fit most business cases.

THE FUTURE ROLE OF GENERIC FRAMING PROCEDURE (GFP), VIRTUAL CONCATENATION (VC), LINK CAPACITY ADJUSTMENT SCHEME (LCAS) AND MPLS.

A set of powerful, emerging mapping protocols and signalling standards will play an important role in releasing the full potential of SDH in multi-service access. Most notably by automating many of the circuit provisioning processes.

GENERIC FRAMING PROCEDURE - GFP

GFP is an international IEEE standard for mapping packet-based services into time-division, circuit oriented networks, most notably for mapping into SDH virtual containers. GFP is used in two important modes, Transparent and Framed.

Transparent Mode (GFP-T)

This mode is used to deliver a single connection (single channel) into a transmission system.

Transparent mode has the lowest latency, and its most common use is for transport of point-to-point traffic from fixed-rate storage interfaces such as ESCON and Fibre Channel, as these have fixed transmission windows and thus are sensitive to delays.

Gigabit Ethernet is an alternative interface for such connections.

Framed Mode (GFP-F)

This mode opens up the possibility for several Ethernet and other packet-based channels of different speeds to be multiplexed into a single SDH container. The channels may also come from different customers.

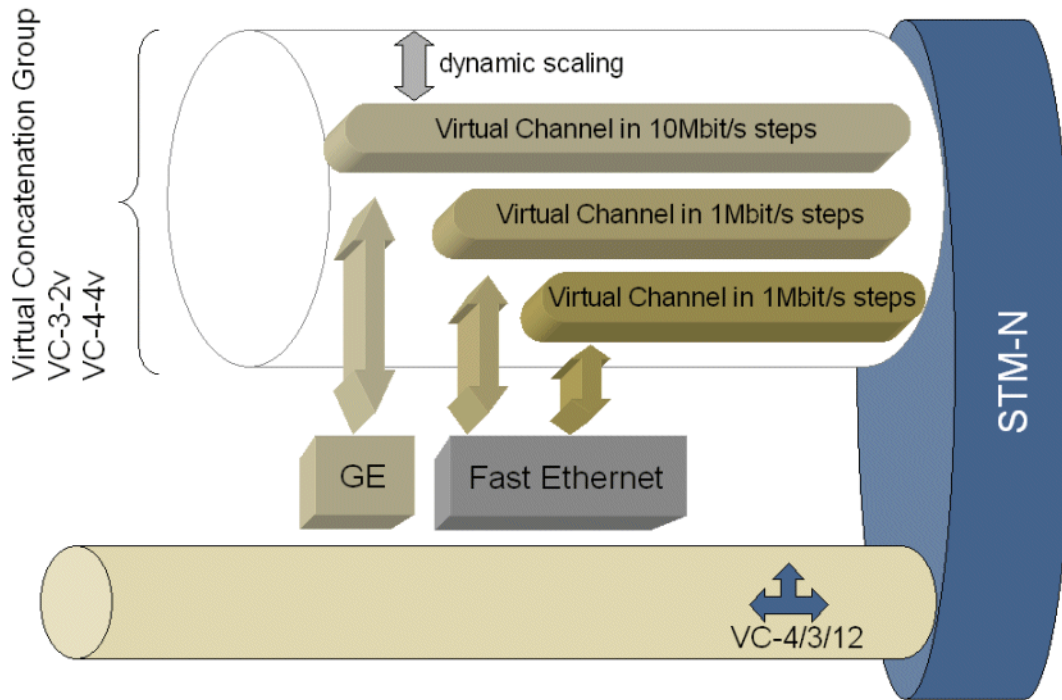


Figure 2. Generic Framing Procedure used to multiplex several packet channels into a common SDH virtual container.

GFP ensures interoperability between equipment from different vendors, and between Telcos.

GFP mapping allows transport of Ethernet and other packet services (like RPR) between different Telcos, and even across continents. A GFP-based Ethernet connection may originate in Europe on SDH and be terminated in the US coming out of a SONET network.

Virtual Concatenation (VC)

Virtual Concatenation is an end-node concatenation scheme that allows a number of lower speed virtual containers to be concatenated and assembled, to create a bigger logical container, typically to match the speed requirements of a specific customer. Virtual concatenation is possible for all container-sizes from VC-12 to VC-3 and VC-4.

Virtual concatenation works over unmodified traditional SDH. Some of the containers may travel through the SDH network with different container designations than what they started out with, - and some even over different links. Only the end nodes are aware which of the containers that are being concatenated for a specific customer connection.

While traditional Contiguous (fixed) Concatenation, provide coarse steps of bandwidth, VC (especially combined with GFP) enables provisioning of bandwidth in small increments and on demand. Virtual Concatenation thus assures maximum Ethernet/IP throughput in an SDH network.

With Virtual Concatenation, large data channels can also be routed over older networks that do not support large contiguous channels.

Link Capacity Adjustment Scheme (LCAS)

LCAS is a two-way signalling protocol to synchronize the re-sizing of transmission links when the bandwidth of one or more of the VC's running on a link are changed.

While it is beneficial to use Virtual Concatenation alone, LCAS brings further advantages as bandwidth demand changes over time for already established connections, LCAS enables changes in a single connection running over a link to be made without disrupting other traffic on the link as such, thus protecting SLA's agreed with each customer using the link. This takes place without manual intervention.

Resilient Packet Ring (RPR)

RPR started out as a packet-oriented transport service with a concept that required another new and separate network. RPR allows statistical multiplexing of traffic, but still includes the concept of protected rings with low recovery times, and with traffic travelling in both ring directions during normal operation. It also includes the concept of closed user groups connecting across an RPR network.

The ability of GFP to map RPR frames into SDH opens up the possibility to transport this service over existing SDH connections.

Multiprotocol Label Switching (MPLS)

MPLS is intended to expedite the routing and forwarding of IP traffic over core networks.

MPLS relieves the core network elements of inspecting IP packets in detail. All packets are inspected and labelled for quick transport all the way to their destination by the edge router receiving the traffic from the customer. MPLS ensures the customers SLA, facilitates traffic engineering, and is independent of core network topology.

This is a typical edge-node or POP function, and this signalling capacity should be available in access concentrators/consolidation units close to the core networks. On smaller sites, where cost and equipment size is at its most important, it is an advantage to have this functionality as an integral part of the access solution.

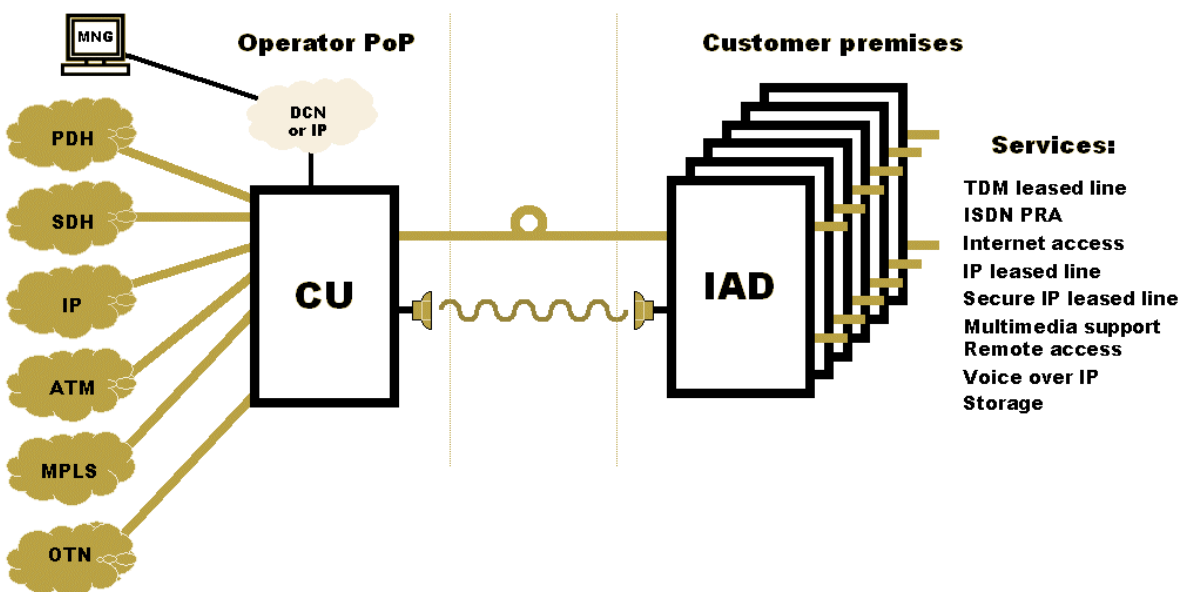


Figure 3. Grooming off MPLS traffic from an access domain into MPLS-enabled IP network.

AXXESSIT's ADVANTAGE USING THE NEW MAPPING AND SIGNALLING SCHEMES

GFP, RPR and proprietary mapping standards will all be present at the same time both in

Metro access networks and in rural access networks; - together with MPLS, VC and LCAS.

Together they will more or less remove today's provisioning times for SDH-based connections, and to a large extent, automate provisioning processes.

The advantage of the AXXESSIT solution is that allows the combined flexibility of the packet-oriented 1 Mb/s granularity when performing the GFP framing, while at the same time leveraging all aspects inherent of the fine-grained SDH resolution of VC-12s.

AXXESSIT has been a market leader in the field of efficient utilization of SDH links right from the formation of the company.

The AXXESSIT solution allows Telcos to extract MPLS-bound packet traffic from an SDH access domain (Metro or rural) from customer sites far out in the network, and to concentrate this traffic on dedicated Fast or Gigabit Ethernet interfaces going into MPLS-enabled routers in the POPs.

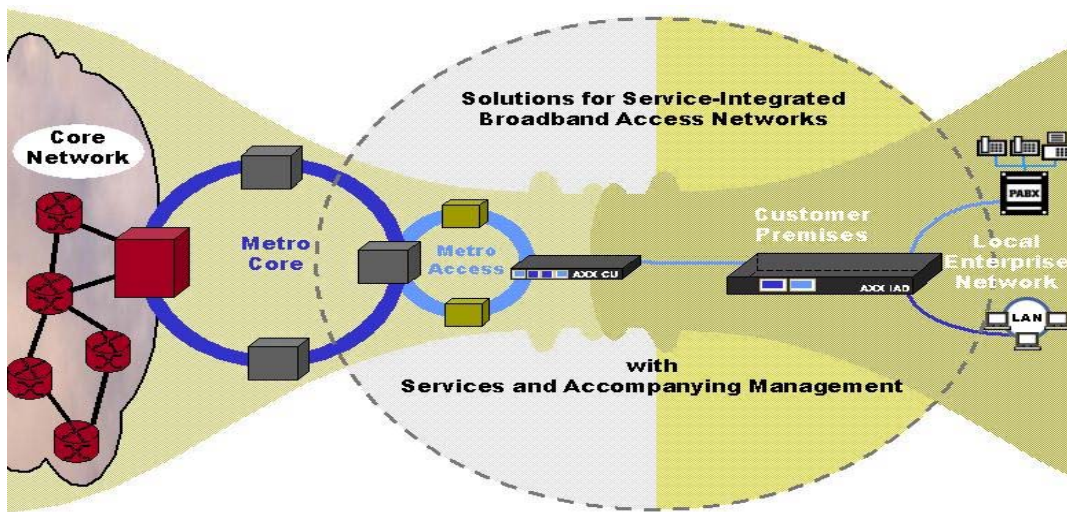
Again, AXXESSIT's ability to combine standardized framing, fine SDH granularity and integrated layer 3 IP functionality in the same equipment makes the AXXESSIT solution stand out in the crowd.

In addition, The AXXESSIT solution enables advanced and market leading point-to-multipoint solutions to connect multiple sites of corporations by transporting Ethernet connections directly over SDH.

All this allows the Telco both to offer a flexible service to the customer, and to utilize the transport network as efficiently and economically as possible.

AXXESSIT HAS THE SOLUTION THAT LETS YOU ACHIVE YOUR GOALS FOR ACCESS NETWORKING

THE AXXESSIT NETWORK SOLUTION OPENS UP THE ACCESS SPEED BOTTLENECK, AND HELPS YOU IN GETTING THE SERVICES ACROSS THE LAST MILE



GETTING ETHERNET AND STORAGE SERVICES INTO SDH.

Quick return on investment is assured as a single, low cost device is cost-effective to introduce at the customers premises already when delivering speeds like 2 - 10 Mb/s to a single customer.

Traffic mapping protocols like GFP, Virtual Concatenation and similar will assure interoperability and efficiency for long distance connections.

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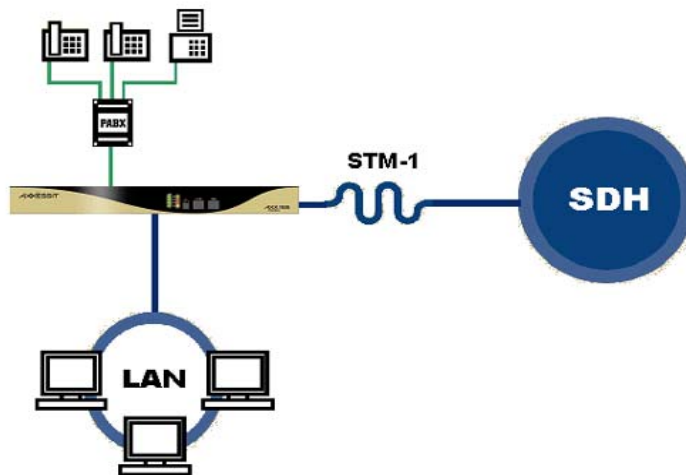


Figure 4. Example of combined fibre access for broadband and high-speed mixed Ethernet /TDM services for business customers using the AXXESSIT AXX155E Integrated Access Device.

AXX155

The AXX155 is an Integrated Access Device (IAD) in the AXXESSIT Rainbow family to provide real broadband solutions (2Mbit/s or higher). This new product will aid the converging process from circuit-switched to packet-switched services. AXX155 combines IP- and TDM-traffic in a cost effective way, by running IP-along with TDM-channels inside an SDH-frame that can easily be carried across the network. The bandwidth of the IP-channel is configurable up to 100Mbit/s true "wire speed". The AXX155 is designed to facilitate interfacing with IP and TDM equipment from other vendors. All interfaces are based on open standards

AXX155E

The AXX155E is an Integrated Access Device for use in fibre optic networks. The AXX155E combine IP- and TDM-traffic, by running IP-along with TDM-channels inside an SDH STM-1 frame structure that can be easily carried across the network. The bandwidth of the IP-channel is configurable up to 136 Mb/s. The IP part of the AXX155E consists of a L2/L3 switch.

Each E1 interface, up to 12, is mapped into separate VC-12 containers while the Ethernet traffic is mapped into a configurable number of linked VC-12 containers.

The AXX155E has a slot for plug-in modules supporting different features e.g. upgrade to four WAN ports on the aggregate side or a VPN accelerator. The WAN module gives the possibility to allocate bandwidth per LAN port both for point-to-point and point-to-multipoint applications.

GIGABIT ETHERNET

The demand for Gigabit Ethernet customer access is steadily increasing, and is supported by most of AXXESSIT network elements and modules.

RADIO AS AN ALTERNATIVE TO FIBRE

Lacking fibre all the way to the customer?

Consider the AXXESSIT range of radio-links to reach your customer fast and without cable digging.

Typically, the AXXLINK155 is a point-to-point microwave radio delivering trunk radio quality at access distances and at access-network prices. Combined with IAD's from the AXXRAINBOW family you may deliver high-speed, multi-service access at places that are otherwise difficult to reach.

CONSOLIDATION AND GROOMING IN THE ACCESS NETWORK

In the operator's network, AXXESSIT establishes a portfolio of highly versatile consolidation units (CUs). The CUs fit into the network in the metro access area and connects to metro core networks. They can also be used as high-end IADs in large businesses or in sites accommodating several smaller businesses.

A wide variety of roles can be taken by the AXXESSIT CUs, including terminal multiplexer, add/drop multiplexer (ADM), non-blocking cross-connect (DXC), layer 2 packet switch, layer 3 wire-speed packet router and any combinations.

The CUs can aggregate traffic from a wide variety of sources and interface with numerous kinds of core or metro core networks. Both TDM and packet traffic technologies are implemented. With the CUs, the network operators can easily build full-service access network infrastructures (FSAN infrastructures) accommodating all variants of voice, data and video services, from business and residential users. Mobile networks as fixed networks are accommodated.

THE AXXEDGE CONSOLIDATION UNIT

The AXXEDGE is as small as 1U in physical size, but it is probably the most powerful unit in the industry, comparing size, flexibility and prize.

Traffic interfaces range from 2Mb to STM-16 in the TDM/SDH domain, and from 10 through 100 Mb/s to Gigabit for Ethernet, IP and storage-network interfaces.

The internal, non-blocking SDH cross-connect has a capacity of 64 x 64 STM-1s, covering all granularities from VC-12 to VC-3 and VC-4.

The internal full duplex and non-blocking IP switch has an unprecedented capacity of 20 Gb/s.

AXXEDGE has four generic slots for plug-in of service/traffic modules. The specific capacities and features of the AXXEDGE are decided by the selection of service modules plugged in at any time.

Several AXXEDGE units may be stacked at the same location, allowing true Pay-as-you-grow build-up of access network nodes.

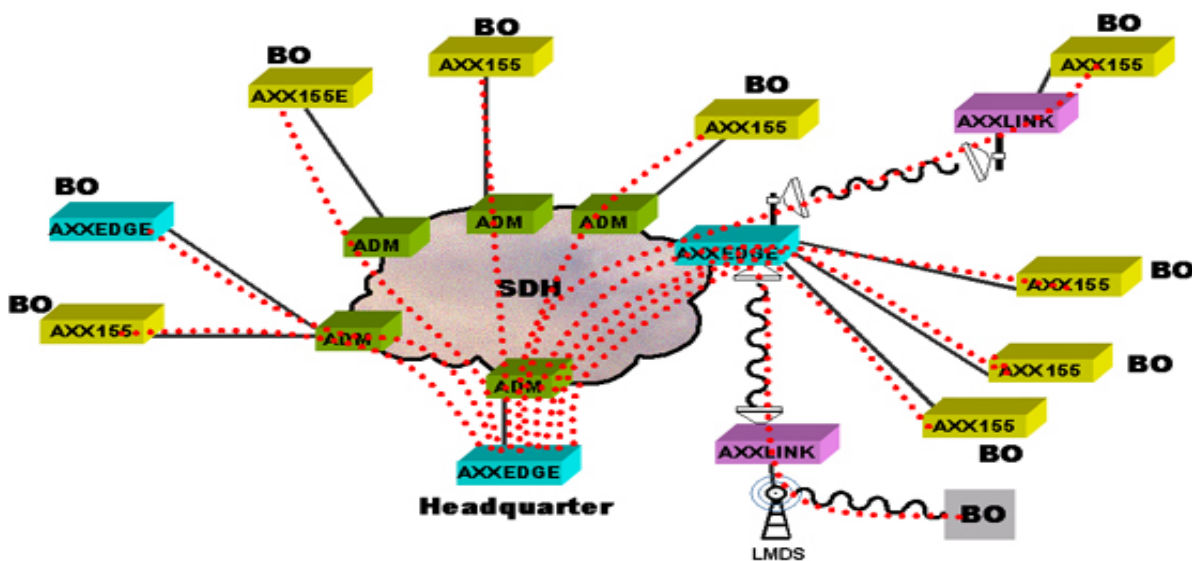


Figure 5. AXXEDGE Consolidation Unit in several roles

Right hand side:

Consolidating mixed Ethernet /TDM traffic in a local area.

Left hand side:

Building longer distance "clear channel" multiservice access routes from a business' branch offices (BO) into headquarter. The AXXESSIT solution and network elements allows for connections through fibre or point-to-point radio, - and even as termination points for LMDS systems.

NETWORK MANAGEMENT SOLUTIONS.

The new and emerging signalling standards described elsewhere in this paper will automate substantial parts of the actual service activation and circuit provision tasks, and may actually be among the factors that relieves the operators of the vast amount of work required today, and that will reduce today's long manual provisioning times.

Still, network management systems will have increased importance in running the day-to-day business in the new and more dynamic networking environment;

The tasks of

- service activation
- SLA verification
- protective measures
- billing of dynamically provisioned connections
- statistics
- traffic engineering measures

will all be important parts of modern network operations.

New and emerging mapping and signalling standards for vendor and Telco interoperability will put new demands on communication between management systems, and having open and well standardized interfaces to your management solutions will become crucial to avoid vendor lock-ins.

The AXCESSIT advantage

Efficient and stable operation of an access network and of the services running on it relies heavily on a well-developed Network Management system.

Running a multi-service and multi-disciplinary access network, with real-time remotely controlled service activation makes this even more important.

The AXCESSIT Network Management suite span the range of:

- basic Craft Terminal software used locally or remotely to control single network elements.
- Powerful Element and Sub-network Management system for efficient 24x7 operation of the network elements and their domains

- Elaborate Network Management program suites including Connection Management, Network Topology, Service Activation and QoS monitoring features.
- A range of Mediation solutions to allow inter-working with the customers' existing and evolving management systems from any vendors.

The AXXESSIT Suite of management products is tailored for Access Network operations and is purpose-built to unleash the full potential of all of the multi-service network elements.

It relies heavily on open interfaces, and is designed ground-up in line with NGOSS standards and thinking.

A combination of generic tools that cover all aspects of the equipment capabilities, together with a selection of dedicated, task-specific tools, ensure that the user can work in an equally efficient and intuitive manner in both routine operations and ad-hoc tasks.

The AXXESSIT management solutions are designed to fulfill the exact level of requirements that an organization may have, both as stand-alone solutions and integrated as sub-systems of a multi-vendor management environment.

Due to their powerful, modular architecture and flexible information model, the AXXESSIT management packages may easily be integrated into your existing, specially developed network management system on request, even when proprietary standards and information models are used.

Use of the program packages is cost-efficient and scalable from single connections to large networks and with a flexible License Policy, allowing Pay-as-you-grow network build-out.

NEXT GENERATION SDH NETWORKS ARE AVAILABLE TODAY.

Leveraging existing SDH networks for delivery of new business customer packet based services

alongside the traditional TDM services is possible today by adding simple equipment at the customer premises and in Metro networks. The rapidly emerging new mapping and signaling schemes described will make SDH an even clearer choice for high speed, high quality packet/IP connections.

AXXESSIT is totally committed to delivering solutions and equipment that keeps its customers at the leading edge and prepared for gaining and keeping Business Customers.

OVERALL ADVANTAGES OF THE AXCESSIT ACCESS NETWORKING PLATFORM:

The above considerations imply tremendous advantages of the AXCESSIT solution, including:

- Reduced entrance costs for initial service deployment and in different geographical areas.
- Cost savings because of fine-grained scalability with accompanying improved ROI (Return On Investment) times and close alignment between investments and needs, anytime, anywhere.
- Cost savings caused by better utilization of bandwidth and infrastructures.
- Cost savings because less equipment is needed (prices, reduced stock of spare parts, etc.).
- Improved networks because of better flexibility in the network structuring and in general.

UNIQUE CHARACTERISTICS OF THE AXCESSIT NETWORKING SOLUTION.

Traditionally, implementation of service-integrated offers makes use of separate network and access equipment for each service. Recognition in the market of the cost, complexity and inflexibility of this approach has stimulated a popular vision of an all IP/optical network, accommodating all services.

AXCESSIT has devised a new suite of network elements from scratch, unrestrained by history, but still adhering strictly to established and relevant TDM and IP standards and network interfaces.

The result is a solution with the following unique combination of characteristics:

- Unprecedented port density.
- Today's entire packet interfaces in the same equipment as TDM interfaces.
- Small base modules (network elements) that can be used both stand-alone to form small nodes, and for building larger access network nodes.
- Modular architecture with generic, position-independent module slots.
- Fine-grained scalability.
- Flexible network element stacking.

- Unparalleled general flexibility.
- Both TDM and IP/packet technology implemented directly.
- Openness to standards, both for traffic mapping and signaling, and for management.
- Fine-grained bandwidth allocation.
- Simplicity.
- Fast return on investment.

To learn more, contact: AXXESSIT ASA at e-mail: info@axxessit.no

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ACRONYMS

ADM	Add-drop Multiplexer
ATM	Asynchronous Transfer Mode
DSLAM	Digital Subscriber Line Access Multiplexer
DXC	Digital Crossconnect
ESCON	Enterprise Systems Connection
FE	Fast Ethernet (100 Mb/s)
FICON	Fibre Connection (storage interface)
GFP	Generic Framing Procedure
GE	Gigabit Ethernet
IAD	Integrated Access Device (Customer Premises)
IP	Internet Protocol
LAN	Local Area Network
LCAS	Linear Capacity Adjustmet Scheme
MPLS	Multi Protocol Label Switching
NGAN	Next Generation Access Network
PDH	Plesiochronous Digital Hierarchy
POP	Point of Presence
RPR	Resilient Packet rings
SDH	Synchronous Digital Hierarchy
SLA	Service Level Agreement
SONET	Synchronous Optical Network
TDM	Time Divison Multiplexing
VPN	Virtual Private Network
WAN	Wide Area Network

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