INTEGRATING NEW TELECOMMUNICATION SERVICES INTO THE BROADBAND NETWORK

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ABSTRACT

The cable television industry is just beginning the process of interconnecting disparate headends within a geographic region. The primary economic drivers relate to the existing core business and tend to be "broadcast" in technical configuration. This paper assumes that Synchronous Optical Network (SONET) standards are deployed as the transmission backbone network. The focus will be on the integration of likely new services into this digital platform. Three general areas will be addressed:

1) Telephone and related applications
2) Entertainment video (new applications)
3) Multimedia

The regional network will provide the primary core for this examination, although some discussion of integration into the RF residential network will be discussed.

INTRODUCTION

The cable television network architecture has been driven by the on-going requirements to deliver new services. Until recently, this evolution has been restricted to the residential network and the need to broadcast more NTSC channels in a point-to-multipoint configuration. The future seems dominated by opportunities involving:

- Interactivity
- Interoperability
- Broadband digital transmission

For the cable television operator, the implications associated with these new opportunities are enormous. While positioning for the future is essential, today's core business still revolves primarily around broadcast video entertainment services. The challenge is to leverage today's current business while positioning the network to be capable of handling future telecommunications requirements. This task has been made more difficult due to the reduction in expected core business cash flow through recent government regulation; however, the urgency continues to be elevated by the growing group of pending competitive threats to the cable television industry.

As fiber optics dramatically changed the residential network from a "tree and branch" structure to a fiber/coaxial "star-bus" architecture, the perception grew that cable television's broadband platform would provide the most cost effective and flexible solution for the future. Cable operators in 1994 are defining "foundation" elements of the network, such as passband, node size and migration strategies, while more complex issues (e.g. modulation format, set-top interoperability) are reviewed. It is critical to define these foundation elements (physical layer) in order to move the process forward. In similar fashion, the regional interconnect must define common elements to ensure future migration into non-broadcast services.

SONET AS THE REGIONAL INTERCONNECT FOUNDATION PLATFORM

It is beyond the scope of this paper to review how SONET will be technically configured to provide cost effective video transport for the cable television business today. There are several papers available for review on the subject.[1]. The critical issue for this discussion is that the regional interconnect should be designed today with the full expectation of being the transport layer for a variety of future applications. Interoperability between networks and each network element should be constant themes in planning the digital transmission platform. SONET standards represent several important advantages:

- SONET is a well defined, open standard assuring interoperability between vendors and networks;

- SONET intrinsically provides critical features such as ring configuration, drop and insert, drop and pass, etc.;

- SONET is the defined physical transport layer for Asynchronous Transfer Mode (ATM), which will become the interoperability standard for wide area network (WAN) and multimedia applications;

- SONET will facilitate interconnection to the public switched telephone network for new applications such as competitive access and interactive residential services;

- SONET provides a defined operational support protocol (TL1) and the potential to integrate network operations and support systems.

There are many challenges related to interoperability as the regional network develops. Cable operators will generally be looking for greater efficiency through network integration and consolidated operations. Proprietary systems in the regional interconnect or the residential network may offer short term capital savings but will quickly become impossible to manage as discrete elements. Many new applications will become virtually impossible to offer cost effectively through a patchwork network.

What are these opportunities and how will they be integrated into the SONET platform? Following the "convergence" model, this paper will examine three areas:

- Telephone
- Entertainment Video
- Multimedia

APPLICATIONS

Telephone

SONET was initially developed to operate within the public switched telephone network (PTSN). Telephone applications will grow out of the embedded base of equipment based on the North American Digital Hierarchy Standards (DS-N), in addition to SONET. Figure 1 shows the basic granularity of each.

Virtual tributary (VT) channels will be used to map DS-1 to SONET. The VT channels at various rates will be important for "mapping" digital applications to the SONET frame at optical carriers, OC-1 or OC-3. Equipment to digitally convert individual voice channels and multiplex the digital equivalent (DS-0) to higher level is well established in the PTSN; the PTSN also has a sophisticated switching infrastructure in place.

The cable operator, seeking incremental revenue opportunities, will utilize the regional SONET platform as leverage to extend the scope of the "telephone" opportunities. The two most often discussed applications are commercial business applications (competitive access) and residential telephony (voice and video).

Commercial Applications

Competitive access is currently a $300 million dollar business annually.[2] It is limited primarily by individual state regulation and economics. Generally, competitive access involves bringing business customers directly to their long distance carriers, instead of utilizing the local exchange carrier (i.e., the local telephone company). The economic issues center around the cost to serve the majority of the access universe. Only about seven percent of the total access revenue universe involves large businesses while most of the access fees come from residential customers and smaller businesses, a much larger market. But the cost to reach these small customers is difficult to justify in light of the revenue generated. The cable operator will enjoy a competitive advantage if the SONET backbone network is in place and justified through core business applications (Figure 2).

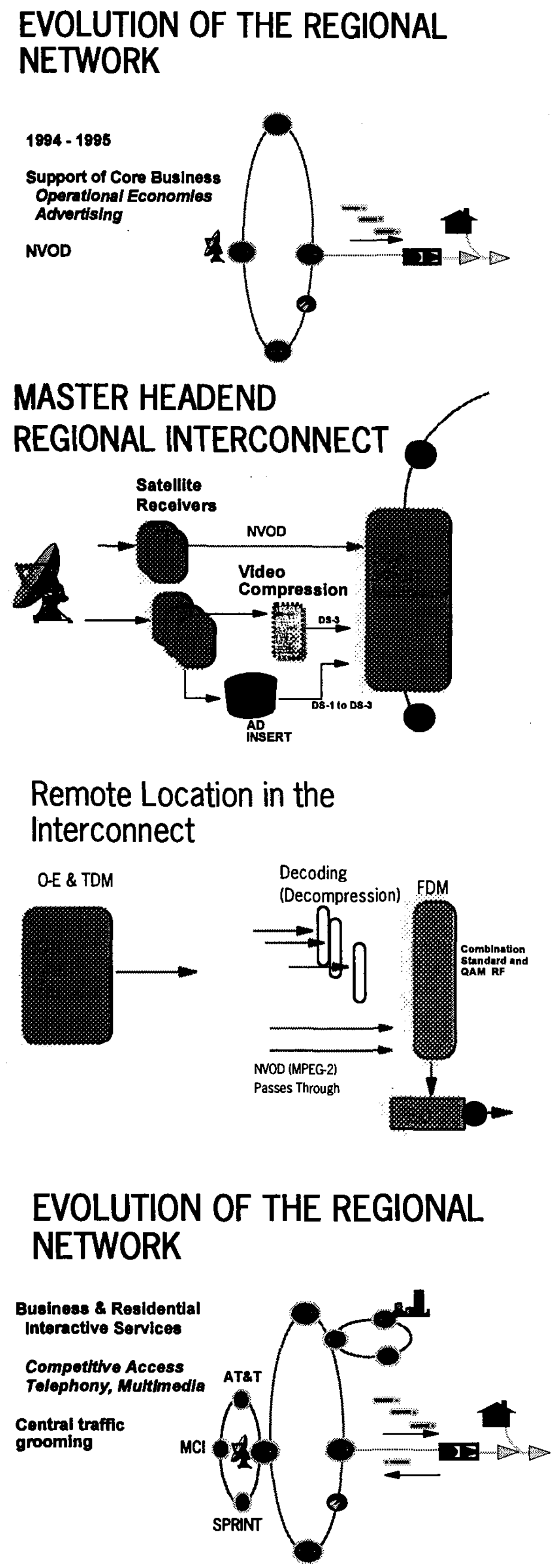


Figure 2

The marginal cost to serve smaller customers will be lower and, thus, the universe of potential customers will be greater. Even more importantly, digital switching and grooming equipment, when needed, will be deployed across the entire region. Some access providers have made significant inroads into providing switched services, as opposed to "dedicated routing" of circuits from the customer to the long distance carrier. This is controlled by regulation, but the general trend toward deregulation is clear.

The SONET regional backbone will facilitate economies of scale by spreading the costs of the switch, or any large centralized signal processing component, across the entire base. For example, the Class 5 switch is a multi-million dollar investment, a difficult piece of equipment to cost justify by a single cable system. Standard time division multiplexing (TDM) hardware will be used to process the signals on and off the SONET backbone in the remote locations (Figure 3).

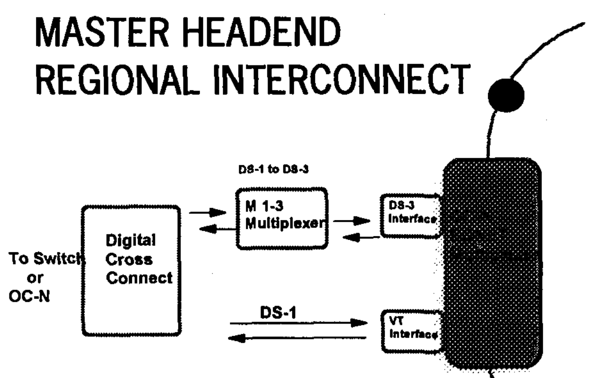


Figure 3

As traffic on the network increases, concentration equipment, such as digital crossconnects will be utilized.[3] Eventually, remote switching modules can be employed at critical remote sites to manage traffic more efficiently. The critical theme will be to use processing hardware only when transmission efficiencies justify the capital expense. This is an elegant model for incremental, revenue-justified growth.

Residential

The same infrastructure used for commercial customers will extend to residential telephone customers; however, the aggregation of residential telephone circuits through the RF fiber/coax network is not within the scope of this paper. Several systems are available for this purpose and most have the ability to offer multiple line, dynamic digital bandwidth (N x 64) and a range of features that will facilitate not only voice telephone but a variety of new services to the home.

The function of the residential system will be to aggregate circuits at the headend and present a standard interface to the next level in the network. This will typically be the DS-1 rate (Figure 4).

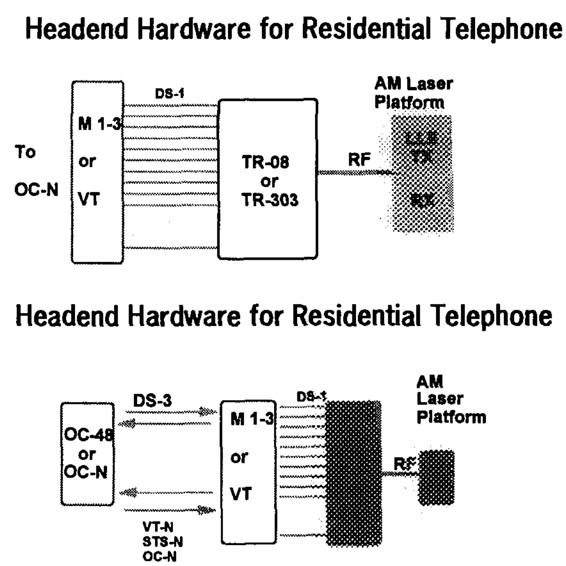


Figure 4

Figure 4 demonstrates circuit roll up DS-1 to DS-3 to SONET (STS-1 to STS-3c to OC-3). The SONET backbone network will back haul traffic to the master headend for further grooming. This may involve cross connections to a dedicated path such as an inter-exchange carrier or local exchange carrier. As in the "commercial" example above, switching may also be a possibility at the master location.

Using the SONET regional infrastructure for traditional telephone services is straight forward. Dynamic bandwidth applications, such as video telephone, will pose little additional technical burden on the transport network. The rest of the public network, especially the imbedded base of switches and asynchronous equipment may represent a bottleneck outside the regional inter-connect. Evolving PSTN standards such as TR-303, which defines many of the switch interface and dynamic bandwidth protocols, will take time. The evolutionary pace for the cable operator will not be governed by an imbedded base in the regional interconnect as long as the correct fundamental elements are put in place from the outset.

Entertainment Video

The specific focus of this paper will be on the delivery of near video-on-demand (NVOD) and video-on-demand (VOD) services through the SONET regional network. Assuming that MPEG-2 is received at the master location, the function of the regional network is to transport that information to the remote locations. Since NVOD implies broadcast services, each headend will receive the same information and will broadcast either in a digital format or an analog scrambled format to the subscriber through the RF fiber/coax network. Regardless of the RF transport, the implications for the regional network remain the same. The satellite transponder will deliver 30 Mbps to 45 Mbps to the master headend. At this time, MPEG-2 compatibility with ATM is undefined. This is not a severe problem until VOD and interactive requirements emerge. The data stream could be mapped to the SONET frame directly, although this would be inefficient. The 30 Mbps rate would need to be "bit stuffed" to match the payload size of the STS-1 frame. The more likely solution is to utilize SONET virtual tributaries to "container-ize" the transponder output and then map that output to the SONET frame. The granularity requirements suggest VT-6 (6 Mbps virtual tributaries) should be optimal. Once the digital information is retrieved at the remote site, two possibilities exist:

1) Digital RF modulation and transport to a digital set-top at the subscriber's location.

2) Decompression of the video; reassembling of the baseband signal, including scrambling information and BTSC audio; RF modulation to an analog set top at the subscriber's home.

The key point is that digital set-tops are not a prerequisite for implementation of NVOD services if regional distribution is efficient. The MPEG-2 compression standards should enable between 10 and 15 NTSC programs per STS-1 frame. The expensive encoding component of the MPEG-2 process will not be duplicated in the region. Satellite reception, SONET mapping and decompression at either the remote headend or the subscriber's home will provide a very cost effective initial deployment strategy.

Multimedia (High Speed Data/LAN Interconnect)

Data communications in the regional interconnect will develop initially from point to point applications (e.g. user location to inter-exchange carrier) or point to multipoint service (e.g. broadcast teleconferencing or application like NVOD and advertising insertion as described above). Switching, bridging and routing functions will grow out of this "provisioned circuit" business.

The end user applications will drive the evolution of the multimedia network configuration. The business LAN environment has already begun the process of moving from a mainframe, or centric, environment to a distributed, or network-centric, environment. This direction has been driven by the application, decision-support vs. production[4], as well as the rapid development of computing hardware. For years, software programmers have been told that processing power will double every two years and the relative cost will decline by half in that same time frame. With such an equation to work with, it is no wonder that software processing, storage and memory requirements have increased exponentially. Software complexity usually translates into user simplicity and/or increased utility.

High-speed data applications will be driven from two directions:

1) Wide area network (WAN) connection of local area networks (LAN) will likely involve interactive ATM transport through the SONET regional platform and the RF broadband residential network.

2) Applications driven by the imbedded telephone infrastructure will emphasize North American Digital Standards such as DS-0, DS-1, N x 64, etc. This will involve new applications such as video teleconferencing and high speed data communications to the home, in addition to more traditional voice and data applications.

The existing public switched telephone network is designed around the North American Digital Standards as described in (2) above. There is still concern over the impacts of latency in ATM voice transport, particularly through the public switched telephone network that has been optimized for time division multiplexing and analog technology. It is likely that new applications requiring bandwidth below 1 Mbps transmission will evolve from the DS-0 and N x 64 world.

ATM holds great promise for the future and will likely become the wide area network transport standard. SONET provides a well defined physical transport layer at the DS-3 and STS-3c levels. ATM granularity will reach the DS-1 level soon and the "promise" is that ATM will ultimately support N x 64 and voice applications. This would represent a smooth transition for the SONET regional interconnect, given the physical transport definition between ATM and SONET.

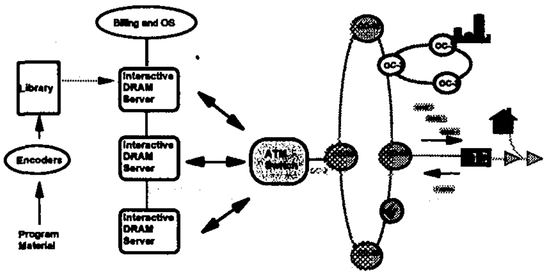
ATM would enable the network provider to offer packet services and thus move into the "retail" side of the competitive transport business. Instead of one 155 Mbps circuit for one customer, many customers and locations would share a single 155 Mbps ATM connection, paying for bandwidth as it is utilized.

ATM is still not a complete standard. Virtual connection oriented ATM, the ability to create short term circuits for ATM traffic between two or more locations, is not yet available as a final standard. Other issues, such as latency, need to be resolved for isochronous telecommunications. However, ATM could be very important in the long run for network connectivity and dynamic digital bandwidth services.

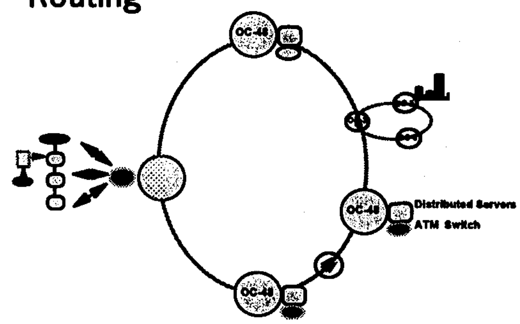
The regional interconnect based on SONET standards will provide cost effective multimedia transport for ATM and the North American Digital Standards protocol. Other bridging, routing and gateway functions between dissimilar and similar LANs can be accomplished. The transport network provider may want to define either an ATM, SONET, or NADS interface to the network. It would be extremely difficult to manage various network bridging hardware for the many local area network configurations (e.g. TCP\IP, SNA, Ethernet, etc.).

The scope of multimedia services for the cable television operator will likely include content services in addition to transport (conduit) services. File servers may be employed initially for "broadcast" applications such as advertising insertion and NVOD. The same platform will support interactive services such as games and catalog shopping, two of the more discussed applications. Figure 5 demonstrates a decentralized approach to file servers. This has the advantage of reducing network traffic in the regional infrastructure and facilitating more truly interactive services. The tradeoff between distributed file servers and regional network bandwidth may reflect more of a migration than a design conflict. Meanwhile, reduced memory and processing costs tend to favor the distributed approach sooner, rather than later.

Centralized Server Overlay



Distributed Server and ATM Routing



Remote Headend Processing in Distributed Server Architecture

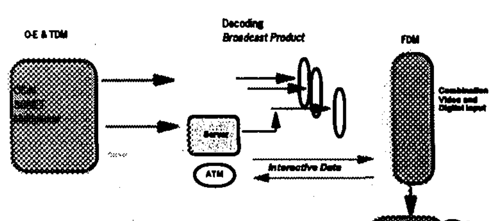


Figure 5

REGIONAL INTERCONNECT TRANSPARENCY

Transparency above the SONET regional interconnect will involve public switched telephone network (PSTN) standards and interface through the inter-exchange carriers' local "point of presence" and the local exchange carriers' central office. The PTSN interface will be defined in terms of evolving SONET and switch standards, such as TR-303, which define parameters of dynamic bandwidth in an N x 64 environment, among other things. This is reasonably straightforward, assuming a SONET regional platform.

Transparency below the regional interconnect involves seamless interconnection with the residential RF network, the fiber optic/coaxial hybrid that is today's cable television system. The time when proprietary formats could be tolerated has passed for the cable television industry. The need to adapt to evolving transmission standards becomes even more critical as high level elements, such as file servers and inter-network connectivity, become issues. Two digital formats will need to be supported at the residential network level initially:

- N x 64 -- DS-0
- ATM

RF delivery of digital signals will require further definition in terms of modulation format, contention rules, and mapping. In general, the fewer the variables within the network, the better for network efficiency and cost. The industry must work toward physical and data link layer definition (e.g., ATM, SONET, 16 VSB modulation) that will emphasize element strengths. For example, one 6 MHz carrier containing 40 Mbps of ATM cells, could represent several applications. Bandwidth would be dynamically assigned between applications or within the same application, such as the video compression rate based on program content. Working with selected standards will provider volume leverage for key network components.

CONCLUSION

By adhering to open architecture standards in the regional interconnect, new services will require incremental investments that will be proportionate with the new opportunities. This will bring many applications into focus that traditionally would not have been deemed financially viable. This is important, as most of the revenue from telecommunications today comes from small users, not large business. The marginal cost to serve small, more numerous customers must be low enough to make the business worthwhile. The cable industry has some significant bandwidth advantages in the residential network. The regional interconnect will leverage that advantage further while providing gateway access to virtually any service that is available on the public network.

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[1] C.J. McGrath, "Digital Technology for CATV Networks," AT&T Bell Laboratories, 1991.

Andy Paff, "Applications and the Evolving Regional Interconnect," Society of Cable Television Engineers Emerging Technologies Conference, 1993.

Andy Paff, "Evolution of the "SONET Regional Interconnect in the Cable Television Environment," SCTE Emerging Technologies Conference, 1994.

Stephen D. Dukes, "Photonics for Cable Television Design," Cable Television Laboratories, Inc., 1992.

[2] The Yankee Group, "CAP Market Update: Year of Transition", White Paper, Vol 7, No. 2, February, 1992

[3] Scott Nelson, "Moving Toward the Full Service Digital Network," Communications Technology, July 1993

[4] The McData Link, "How to Avoid Gateway Chaos in Multiprotocol Networks", Internal publication, McData, 1991