NEW CARRIER CLASS ARCHITECTURE BUSTS BANDWIDTH BLUES

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Abstract

Network operators are on the burgeoning edge of providing interactive video, data and voice services. In offering these technologically advanced services, operators are in search of an enabling platform to deliver quality of service and reliability for interactive applications.

This paper explores optical network platforms and their ability to provide broadband operators with the technologies needed to take advantage of their unique position to deliver interactive video, data, and voice services, previously associated only with today's most advanced telecommunications systems. Discussions will offer new solutions allowing operators to deliver the bandwidth advantages of optical networking closer to subscribers' homes.

THE OPPORTUNITY

Broadband network operators have spent the past few years transitioning their networks from one-way analog entertainment to multimedia interactive networks. Voice and data services have been scaled to reasonable volume, and video has been expanded from analog to include digital -- and now interactive digital video services. Unlike other telecommunications network transitions, this transition has been fueled by a clear willingness to pay for new services by the users.

Now, however, the very success of these new offerings is leading to more demands by customers for bandwidth intensive services. The first generation of technologies used to build these interactive networks will not be adequate as the bandwidth growth pushes these technologies beyond their breaking points.

A number of new technologies are fortunately becoming available to enable significant bandwidth capacity increase to be engineered in a cost effective manner.

CURRENT NETWORK LIMITATIONS

With approximately one percent of U.S. households currently using voice services on HFC networks, four percent using data, and less than one percent using video-on-demand, the cable industry is still in the very early stages of interactive deployment. However, it is clear that a number of impediments to high volume ramp currently exist. Beginning with voice services, the use of circuit switched technology requires a unique conversion device at each user's home, and coupled with network powering demands, has lead most network operators to forego the voice opportunity until voice can be integrated with the data network.

For data services, the industry has transitioned from proprietary systems to DOCSIS 1.0 and is currently preparing to move to DOCSIS 1.1-based networks. Cost of deployment has come down significantly via the standardization process, and with DOCSIS 1.1, capability will move beyond best efforts data to include managed data and voice services.

A key issue however is users future expectations on data rates. Current market pricing for CMTS functionality is typically in the $500 per megabit forward and $1,000 per megabit reverse capacity. For this reason, networks are typically engineered for less that 20 kb/s usage bit rate per home passed. The "bursty" nature of data, low penetration levels, and current usage rates, enable a relatively high data rate to be typically delivered. As more users turn to streamed data, whether for audio or especially video, average bit rates per user will climb dramatically. Current CMTS architectures will have great difficulty scaling to meet this demand. Furthermore, lack of ability to transport high numbers of multiplexed analog upstream paths has caused operators to deploy CMTS systems in hubs rather than headends. This results in strain on hub space as data rates grow and a need for an independent baseband digital transport network in parallel with the HFC transport to carry the traffic back to the internet POP.

Another key issue with data going forward is the nature of user demand. It is likely that a small subset of users, consisting of SOHO and telecommuters, will demand and be willing to pay for a massive increase in bandwidth -- into the 10 Mb/s range. The dilemma is finding these customers, servicing them without knowing a payoff and coping with the inevitable churn – all while not penalizing the cost of servicing the rest of the customer base.

Unlike business users, who can justify a dedicated fiber deployment, these high-end residential customers require a network which can overlay fiber rate bandwidth for deployment as needed.

Finally, for video services, operators must either increase their network transport capacity to move video streams from a central point, or distribute video servers throughout their network. The distributed server model is viable for content which is common to most users, e.g. “top-ten” movies. Some operators however, already see an opportunity to bring a much wider array of content to the on-demand or personalized model. To enable this business model the cost per stream of optical transport required needs to continue downward in cost.

THE SOLUTION – NEW CARRIER CLASS ARCHITECTURE

To address these issues, operators require two broad capabilities. First, they require improvements in transport capability to enable carriage of all types of multimedia information reliably and cost effectively between their network locations, whether headend or hub. Included in this transport requirement is the ability to consolidate and transport many reverse path signals, which multiply as fiber goes deeper into the network.

Secondly, the ability is needed to target significant amounts of interactive bandwidth to residential users, including an ability to serve a small percentage of ultra high capacity users cost effectively.

Transport

Operators have traditionally used separate transport networks for voice, data, and video, resulting in inefficiency and a lack of ability to scale independent of shifts in service volumes. Many networks were designed to allow 1550 nm analog optics to be used for video transport. As networks grew, and digital technology came down in cost, many operators shifted toward use of digital video transport, initially using proprietary encoding, and more recently using SONET based systems, such as Scientific-Atlanta’s PRISMA DT OC 48 digital transport system. The use of SONET technology allowed video, voice and data to be carried on a single network. As more and more traffic becomes packet based, however, a channeled data transport system becomes inefficient.

A newly emerging optical transport technique, known as Resilient Packet Ring (RPR), enables an IP-based infrastructure to carry both packet and constant bit rate traffic with the resiliency of SONET based systems and the QOS capability of ATM networks, while eliminating much of the cost and complexity of these technologies. These new IP-over-fiber networks, currently being standardized in the IEEE 802.17 working group, are now entering field trials in MSO networks. They show excellent promise to enable operators to consolidate their existing piecemeal networks over a single network and scale up as traffic increases, independent of service mix. More details of this key network technology can be found at this conference in the paper by Greg Hardy, entitled “IP Transport Technology in the Primary Ring Network.”

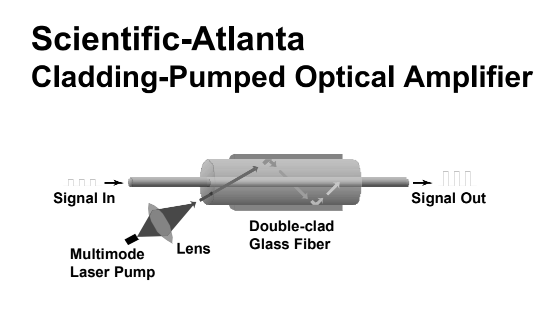

Figure 1.

For those operators using analog video transport, two key enhancements to 1550 nm technology are enabling ongoing improvements in capacity and cost effectiveness of both the headend to hub and hub to node access networks.

The introduction last year of QAM optimized 1550 nm transport has enabled operators to lower the cost of VOD and cable modem transport, and scale sufficient capacity on existing fiber via DWDM counts of up to 24 wavelengths per fiber. Through the use of software selectable pre-distortion operators can enjoy external modulation performance at direct modulation price structures, enabling both a full QAM loading and full distance reach, thereby lowering the cost of VOD stream transport to within the range required for pricing in the typical VOD business case.

A second key enhancement to the 1550 nm optics tool kit has been the recent introduction of a cladding pumped optical amplifier. This technology, as illustrated in Figure 1, utilizes a double clad, all glass ytterbium-erbium-doped fiber to deliver previously unreachable output levels while using highly reliable, extremely low cost technology. Amplifiers using this technology with 27dBm of output power, configured as 8x 17dBm outputs are currently being deployed by a number of operators. The theoretical limit of this technology is 35dBm. By utilizing this technology for the broadcast or common element of the spectrum, operators can cost effectively extend the fiber deeper and deeper into the network.

The last key technology being utilized by operators to enhance their networks for high capacity interactive service traffic is baseband digital reverse (bdr). By using Time Division Multiplexing and combining up to four independent reverse path signals and 24 channel DWDM, 96 independent reverse channels can be transmitted on a single fiber. The quality of the transmission can now be engineered by varying the number of bits per sample. This process eliminates a key weakness in HFC networks: the upstream choke point.

Access

Utilizing the above advances in optical transmission, in both the forward and bdr-based reverse, it is now economically possible to take the fiber all the way to the last active device, producing the so-called "passive HFC" network. Boosting the RF level of the launch amp, made feasible through the elimination of the subtending RF amps, produces additional efficiency.

Given the short coax runs these passive nodes produce, the possibility is raised of running dark fiber in parallel with the coax, for any new construction. By doing this, full service operators can selectively service the needs of the high bandwidth users, by enabling the fiber, and ultimately migrate more and more users over to the fiber as bandwidth needs grow. More details on the operational aspects of this approach can be found in a companion paper by Don Sorenson entitled "Transition Strategies: Synchronizing Deep Fiber Baseband Access Network Design with Advanced HFC Infrastructure."

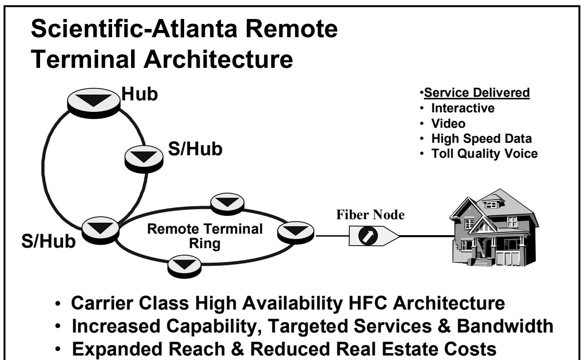

Figure 2.

The provisioning of those dark fibers raises a final issue to be considered, however. Even if fibers have been provided to every termination, an aggregation point needs to be provided deeper in the network than today's typical hub in order to manage fiber counts.

Transport-Access Connection – The RT Architecture

To address this issue, it is proposed to locate a new network element, the Remote Terminal, deep in the network. This location, connected through a fault tolerant ring to a primary headend or hub, enables groups of fiber deep nodes to be aggregated for distribution of required forward and reverse bandwidth as interactive service traffic grows. This architecture is illustrated in Figure 2.

The RT cabinet is a sited similar to a power supply or splice cabinet. The RT eliminates the need for costly real estate and hub building construction. For maximum efficiency, a hardened optics platform such as the PRISMA II chassis, eliminates the need for costly environmental controls in the cabinet.

Summary

The RT architecture, using all of the new technologies cited in this paper, enables operators to overcome the limitations of first generation interactive HFC technology. By effectively scaling all the way to FTTH, this architecture enables broadband operators to keep pushing the bandwidth limits as they provide increasing value to their customer base.

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