Delivering Video over DSL

Telecom service providers have recognized the revenue potential of providing high speed data services to their traditional POTS customers and have traditionally responded by deploying ADSL DSLAMs in Central Offices (COs). They are also beginning to address the nearly one half of customers served by remote terminals. The growth in high speed data has been a welcome addition in the face of flagging POTS revenues. However, the full potential of ADSL is only now beginning to be realized. ADSL's dedicated broadband link to the home provides the opportunity to offer additional revenue-generating broadband services, including broadcast and interactive video services.

Service providers are under increasing pressure, not only to increase revenue per subscriber, but also to protect their subscriber base. Cable companies have reached beyond their traditional video business and deployed data services to a large number of customers. Cable companies are now expanding their offerings to include telephony, making it even more attractive by bundling video, high speed data and POTS services together on a single bill.

For service providers, the bottom line is the ability to cost-effectively deliver a complete range of competitive services to all users—whether served by Central Offices (COs) or by remote terminals. While many COs now house DSL equipment, remote sites are running Digital Loop Carriers (DLCs) originally designed to provide narrowband services. Outdated architectures don't meet the needs of video, requiring outdated cards to be swapped out and replaced with makeshift fixes. The result is unacceptable levels of service and a forklift upgrade if demand grows beyond the most minimal of levels. Overlaying the POTS equipment with DSL equipment may enable some ability to provide high speed data and video, but it requires manual activation to turn-up each customer. The operational expense of truck-rolls to activate service makes the business case unsustainable.

To effectively provide a complete suite of broadband services, in addition to the legacy POTS services, service providers have begun to deploy Broadband Loop Carriers (BLCs). The CN 1000™ BLC from CIENA combines the functions of a traditional DLC system, a video-enabled DSLAM and a packet-ready Media Gateway. It provides the logical next step in loop carrier evolution by addressing the operational inefficiencies and broadband capacity limitations of prior generations of access network equipment.

CIENA®

The CN 1000 BLC has been designed from the ground up to enable profitable delivery of broadband services. Fundamentally, the CN1000 provides POTS and standards-compliant ADSL on every pair, which eliminates the need for truck-rolls to the remote terminal to activate services. To profitably enable Video over DSL, the CN 1000 integrates features that are essential for a scalable solution, eliminating the need for additional equipment in the access network and permitting fully software-provisionable service activation.

The CN 1000 is based on open, standards-based interfaces and protocols, allowing CIENA to partner with best-in-class companies and the requisite products for a comprehensive, competitive video delivery solution. Complete interoperability is assured by working closely with leading vendors of video headend hardware and software, service switches and Customer Premises Equipment (CPE). By leveraging the expertise and experience of each partner, CIENA is able to create a cohesive video solution utilizing subsystems of the highest performance and with the most advanced features. This methodology eliminates the compromises inherent in a one vendor approach and results in a tailored end-to-end solution that provides the richest video experience to the subscriber.

Service Offerings

There are two forms of services considered in this paper: broadcast television and Video On Demand

Broadcast Television

This is traditional television service. Broadcast content is generally acquired via satellite, off-air antenna, or through a landline video transport connection to local or remote studios such as a T3. Pay-per-view and staggercast may also be considered broadcast services that are additional requirements on access and billing.

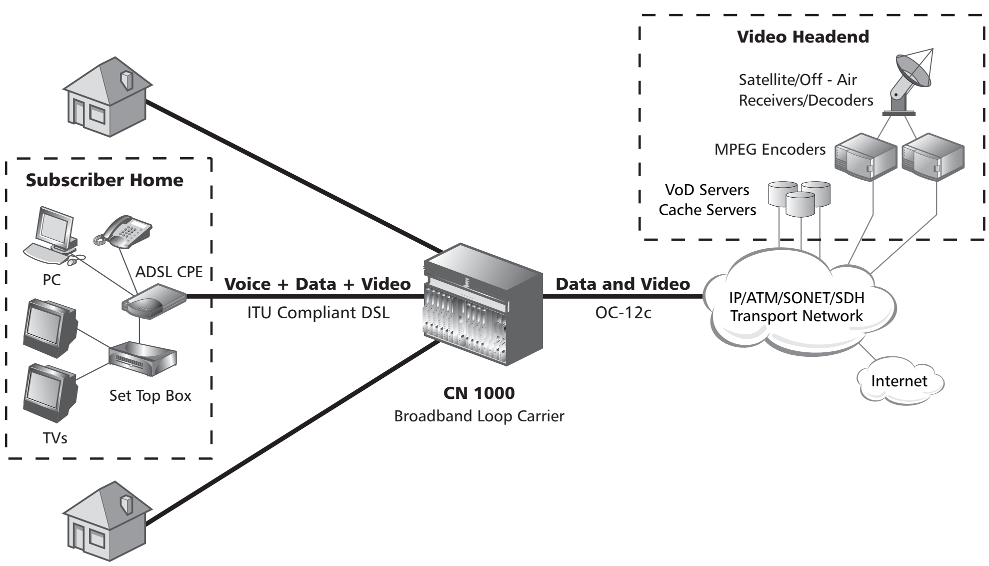

Figure 1 Video over DSL Network: An example of a typical video network employing Broadband Loop Carriers

Video On Demand (VOD)

Interactive TV, such as VOD, utilizes video servers to store digitized video content and provide that content to subscribers upon request. This allows the user to perform "trickplay" functions such as pause, reverse, and fast forward. Features such as network-based or Set Top Box (STB)-based Personal Video Recorder (PVR) are also possible, allowing the subscriber to control when and how the content is viewed.

From the perspective of the service provider, there are two types of service categories: those that serve many viewers simultaneously (i.e. broadcast TV, pay-per-view and staggercast) and those that serve a single viewer (i.e. VOD). In delivering broadcast TV and pay-per-view services, one must ensure that the networking infrastructure supports efficient multicast, as described later in this document. VOD on the other hand is essentially a point-to-point service, which requires a scalable network and headend solution.

Headend

The headend is the location where video content is acquired, managed and processed for distribution throughout the network. Broadcast television is acquired, encoded into MPEG format, and a transport stream for each channel is created with a unique channel ID. Content that is acquired already in MPEG-2 format may be transmuxed or transrated depending on the source. Buffering, scheduling, and shaping are then applied to the streams to ensure integrity of the video being transported to the end subscriber. Depending on the chosen architecture these can be done in an ATM or IP context since the data is now SPTS, or it can be done in an MPEG context. Encapsulation may be of the form of MPEG over ATM or MPEG over IP over ATM. The former introduces less overhead in the video stream while the latter provides additional flexibility within the network and in the subscriber's home.

Depending on the volume of data being transmitted over the backbone, the number of subscribers and the cost of transmission between geographically dispersed locations, the architecture of the headend may be centralized or distributed. In a centralized architecture, there is a single headend location feeding all subscribers. A distributed architecture may save transport costs by utilizing multiple headends, each serving its own locality.

The VOD servers may be centralized at the headend by scaling the size of the servers according to the number of active subscribers and the available content. As VOD penetration increases, a distributed architecture can lower transport costs by employing several smaller servers located throughout the network, each providing interactive content to local subscribers. Better VOD servers will also provide the capability of redirecting a user who wants a program not locally available off to another network VOD server.

Transport Network

The transport network carries the video content from the headend to the Broadband Loop Carriers and DSLAMs in the access network. A wide range of transport network options are possible: ATM, IP, Packet over SONET (PoS), Ethernet, Ethernet over SONET, and DWDM.

Service providers may want to consider the following criteria in selecting the network infrastructure:

Multicast Capability

Multicasting is key to providing an efficient and scalable video service. Without multicasting, the network is quickly overwhelmed by inefficiently carrying multiple copies of the same television channel to individual subscribers. With multicasting, only a single unique stream is required for each active channel, minimizing bandwidth requirements. The ideal place to perform the multicasting is on the access equipment, the closest point to the end subscribers. However, additional multicasting may be required within the transport network to optimize networking resources. There are economical and network planning arguments that drive this need. For example, when a single headend office is serving multiple localities (a centralized architecture), it is ideal for the transport network to support multicast. Without multicasting in the transport network, a point-to-point connection from the headend to every BLC or DSLAM that serves video customers would be required. In a distributed architecture, each headend serves its own locality and there may be no requirements for multicasting within the transport network.

Efficiency

It may not be cost-effective to statically configure all television and pay-per-view channels over the transport network. While popular channels may be watched by many viewers at all times, there may be a number of channels not viewed for substantial periods of time. Rather than delivering these channels at all times, service providers may want to consider a dynamic channel setup such as SVCs to manage network resources more efficiently.

Quality of Service (QoS)

Proper traffic management and conditioning is required throughout the network to ensure the QoS. Whether the underlying transport network is ATM or IP, it must be engineered to meet the real time and packet loss requirements needed for video. Most STBs are designed to handle some jitter, but they remain vulnerable to packet or cell loss. Therefore, predictability of the transport network is the key to meet the QoS objectives. Fortunately, QoS within the access network is not a major issue because standards-based ADSL equipment is ATM.

ATM provides a very strong QoS capability within the network and has proven its scalability and dependability. ATM is a logical choice in that it was developed to simultaneously support a wide variety of traffic types including Internet data, Voice over Packet and video. Additionally, ATM may be carried over Dense Wavelength Division Multiplexing (DWDM) equipment and the large installed base of Synchronous Optical Network (SONET) equipment.

Service providers operating IP-based networks may take advantage of IP multicast capable routers and the flexibility of IP to introduce broadcast video. By properly engineering the network to meet the scalability requirements, IP can be used to deliver video. PoS provides the flexibility of IP, while leveraging existing SONET equipment. Because ADSL is based on ATM, encapsulation of the IP streams is still required.

Access Network

The CN 1000 Broadband Loop Carrier (BLC)

By combining the functions of a DLC and DSLAM, CIENA's CN 1000 BLC eliminates bulky and expensive splitters and cross connects. This integrated approach provides the highest density and allows for a much lower capital cost than legacy DLCs and remote DSLAMs while yielding enormous operational advantages.

To ensure a profitable video service, the service provider must address the operational challenges presented in turning up new services, especially when subscribers are served by remote equipment. Eliminating truck-rolls due to line-and-station transfers is important to create a positive business case for high speed data. With voice, DSL and video on every line, providing data and video services to a new customer served from a CN 1000 requires nothing more than a remote service activation. No truck-roll to the remote site is required, no card swaps are required and no cross connects are required. Coupled with an efficient STB delivery/installation methodology, a few simple keystrokes turn a traditional POTS customer into a video customer. The result is immediate service order activation and enormous operational cost savings, essential for profitability.

DSL Standards

The CN 1000 Broadband Loop Carrier uses CIENA's highly integrated core silicon technology to provide splitterless POTS + ADSL on every line. CIENA's technology is standards-compliant with ANSI and ITU standards and provides industry-leading interoperability with third party CPE modems. The rate-reach provided by ADSL ensures full coverage of the serving area and is an excellent match with the existing subscriber loops. The remote provides the perfect vehicle for delivering video services over ADSL. No restructuring or segmentation of the loop plant is required as the rate-reach capability maps very well to the CSA loops fed by remotes. However, the bandwidth requirements of video put increased pressure on the need for the highest performance ADSL. While 8 Mb/s is often quoted as the maximum downstream rate on ADSL, higher rates are achieved by supporting optional parameters within the standard such as S=__. The CN 1000 and many CPE already support this capability and can achieve rates greater than 10 Mb/s. This enables service offerings comprised of high speed data and 1 to 2 channels or DVD-quality video.

The standards bodies are now defining ADSL+. This technology will increase downstream rates further, with the potential of allowing 2-3 channels of video in addition to data. By building on the foundation of the current standard, backwards compatibility with the installed base of standards-compliant CPE can be achieved. Active involvement in defining the standard and silicon ownership means CIENA is able to quickly respond to the new standard and maintain leadership in performance and interoperability requirements. Even as DSL standards evolve, encoding technologies are improving rapidly. These offer the potential of allowing even 3 to 4 channels of video in addition to data in the foreseeable future. VDSL is also under definition in the standards bodies, with the potential to provide rates in excess of 26 Mb/s but only on loops limited to less than 4000 ft.

These reach capabilities do not map well to the existing carrier serving area and generally limit the applicability of VDSL to new build (Greenfield) deployments where remote terminals can be placed closer to the customer premise. ADSL/ADSL+ based approaches delivering 2-3 channels represent a complimentary solution that can address the majority of installed, remote plant that was designed to the original CSA guidelines. The VDSL standard is currently divided into two separate tracks; one based on CAP/QAM, the other on DMT. CIENA is actively pursuing VDSL development, with a focus on solutions built on the robustness of DMT-based technology.

Multicasting

The bandwidth requirements of video necessitate that distribution and transport be kept as efficient as possible. Multicast support at the network edge is critical to allow local replication of common video streams and avoid the tremendous costs associated with sending numerous identical copies of broadcast video content through the transport infrastructure. Legacy DSLAMs and DLCs without true video capabilities utilize co-located IGMP routers to achieve multicasting. The extra equipment increases costs and results in a solution that is not scalable. The DSLAM network interface remains a bottleneck, carrying redundant copies of video channels and severely limiting the number of addressable subscribers.

To support Video over DSL, the CN 1000 implements the IGMP protocol and performs downstream multicasting. While watching video, the user is allowed to browse the Internet and use the phone. The CN 1000 network processor strips the relevant IGMP messages from the data stream while other traffic continues to move upstream. The IGMP messages are then used to command the multicast engine to direct the appropriate video channels to the user. If the requested channel is not currently active, the CN 1000 obtains the video stream from the headend and provides it to the subscriber. By relying on open protocols such as IGMP, CIENA is able to ensure wide interoperability with existing IP-based STB and headend equipment. This allows CIENA and its partners to choose the optimal equipment to create an end-to-end solution fitting the varied requirements of each service provider. CIENA then performs end-to-end integration and testing of multi-vendor video solutions to ensure full interoperability.

Subscriber Premise

The equipment at the subscriber premise includes an ADSL modem, digital set top box and television(s) in addition to the phone and PC used for Internet browsing. Typically, the modem terminates the ADSL signal and distributes the IP packet to the STB over Ethernet. Some STB can terminate ADSL directly and provide a USB or Ethernet port for the user's PC, in addition to multiple connections to televisions over S-video+audio cables or over coax cable.

When the video is encapsulated as MPEG-over-IP-over-Ethernet-over-ATM, the modem terminates the ATM/ADSL connection, and distributes the video stream over Ethernet to the STB. The STB then decodes the MPEG signal and generates an NTSC signal compatible with standard televisions. The in-home distribution is very flexible and may take advantage of the ubiquitous nature of Ethernet. A wide range of in-home networking options are also available such as wireless Ethernet, powerline carrier and HomePNA. Note that in-home distribution may not be necessary for fully integrated STB that terminate the ADSL signal and directly connect to the television. The lack of ATM-based distribution technologies in the customer premise limits the range of choices

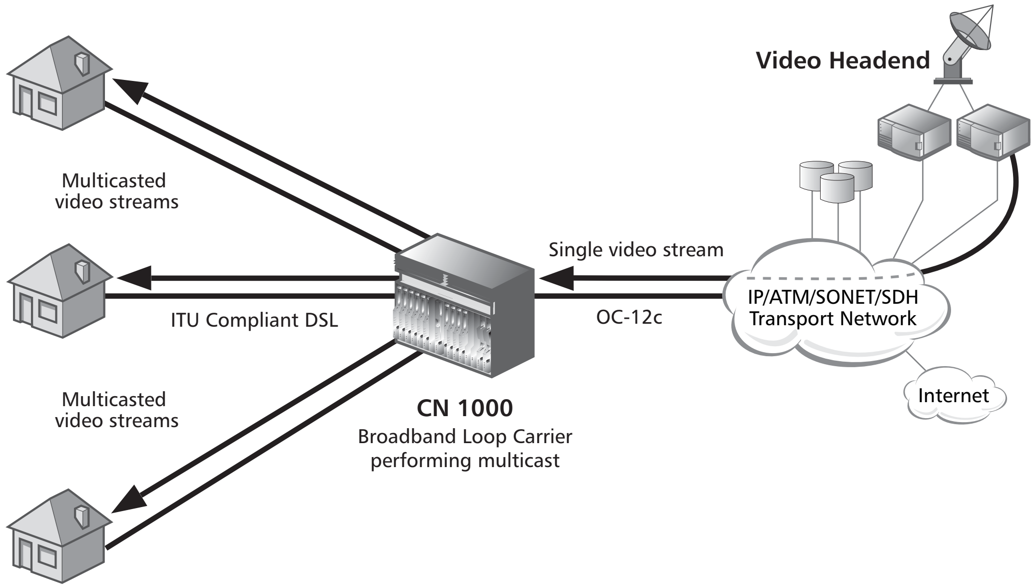

Figure 2 Network efficiency through multicasting

when MPEG-over-ATM encapsulation is used. Typically, the STB provides connections to the television(s), an Ethernet port for the subscriber PC and integrates the ADSL modem functionality internally.

To implement multicasting with an IGMP based video network, the STB must be IGMP-capable and interoperate with leading standards-based video servers.

Conclusion

ADSL provides a compelling and native ability to deliver video services, especially when deployed at remotes. Creating a video over ADSL service that is scalable and best-in-class requires multicasting and IGMP interpretation at the very edge of the network and requires equipment based on open standards and interfaces.

Introducing video not only counters the competitive threat of the cable companies, but also creates new revenue streams based on broadcast and interactive services. Ensuring profitability requires a broadband platform that reduces service deployment costs and operational expenses.

CIENA's integrated approach provides the ability to offer voice, data and video at a much lower capital cost than legacy DLCs and remote DSLAMs. With DSL on every line, service can be remotely activated without truck-rolls, card swaps, or line-and-station transfers, resulting in dramatically reduced operational costs.