

V I D E O O V E R D S L

Enabling the Telecommunications Industry to
Deliver Advanced Video Services

White Paper



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Foreword

Great change has grasped the telecommunications industry. In a relatively short period of time, telephony service providers around the world have found themselves in a position where they are compelled to make significant changes in business strategy in order to continue to grow, in the face of fierce competition and regulatory uncertainty. A component of such a strategic shift being adopted by a growing number of forward-thinking carriers is to extend the portfolio of services they provide to include video delivery. Yet, to do this requires not only a considerable investment in their network infrastructure, but also an entry into the largely unfamiliar territory of content acquisition and distribution.

Fortunately, this predicament coincides with a time of unprecedented technological advancements, of which many are aimed specifically at the delivery of video over telephony networks. To name a few, ADSL has provided the highly anticipated 'big pipe' to consumers' homes. Rapid advancements in video compression technology have significantly reduced the bandwidth requirements for digital-quality video transmission. And standards for video transmission over networks are making rapid progress, thanks to a remarkable level of global cooperation between carriers and vendors. As a result, the marketplace for software and equipment from servers to storage to set-top boxes is bustling with competition.

Experts from throughout the video-over-DSL value chain have collaborated to author a white paper aimed at helping telecom providers begin to explore this topic, with a comprehensive look at the business opportunities and technical challenges of video delivery over DSL from a telecom perspective. Note that their participation is a reflection of their interest in providing information about the video over DSL landscape and not an indication of any business relationships between them.

The paper begins with a look at the driving factors behind the rapid evolution of this industry. It introduces some of the opportunities and inherent advantages telcos have over competing video delivery systems such as cable and satellite. The paper then gives an overview of the market conditions, including the regulatory and competitive environment, market trends and forecasts, a sample revenue case, and results from an actual deployment. Enabling technologies and architectures are described. Finally, the paper presents an in-depth discussion of what is entailed in sourcing and delivering content: acquisition, aggregation, transport, and processing.

The contributors welcome feedback and questions regarding the contents of this paper. Feel free to contact the editor, David Benini at Aware, Inc., at DBenini@Aware.com.

1 The Broadband Challenge and Opportunity

For nearly a century, the telecommunications industry (telecom) has built vast networks that have allowed people to quickly and easily communicate with one another. In return, telecom receives three primary revenue streams:

- A monthly “dial tone” subscription giving customers access to the network, allowing them to make local phone calls,
- A “transaction” fee called long distance collected each time a customer wanted to communicate with someone far away,
- Charges for hosting and delivering enhanced services related to telephony and data, such as voice-mail and calling line ID.

Until recently, these core revenues—combined with a monopolistic environment—constituted a healthy business. But the 1990s were a difficult time for telecom, with deregulation, the Internet, and significant advances in technology all causing tumultuous change.

Affordable bandwidth and improved technologies—coupled with consumers’ insatiable demand for entertainment and information—has been a double-edged sword for telecom. While they have empowered competition, they have also created a significant market opportunity. To take advantage, telecom must move beyond connectivity alone and exploit the new business models services that broadband is enabling. The cable industry’s multi-billion dollar upgrade effort to compete with the direct broadcast satellite (DBS) operator’s channel and pay-per-view (PPV) advantage has also enabled them to offer high-speed Internet, entertainment on demand, telephony, and interactive television (iTV) services.

The value of a network is largely proportional to its bandwidth, and today’s network decisions will determine tomorrow’s services and revenues. By postponing, reducing, or eliminating plans to upgrade the network, telecom operators may improve their corporate earnings near-term, but at the expense of long-term value. As web destinations add rich, bandwidth-consuming media to their sites, and more customers participate in high bandwidth applications, the local access provider will ultimately be forced to increase capital spending on the network to provide a sufficient level of service. A key question on the minds of the telecoms is, “Will customers be willing to pay for increased access fees to finance this expenditure?” The answer depends on telecom’s ability to compete. With a multitude of competitors challenging traditional telephony revenues and battling for control of the consumer, now is the time for a forward-thinking telecom to become a first-mover. The race for broadband leadership is still wide open, but to survive, telecom must act now.

The early years of the 21st century will quickly see residential broadband consumers demanding more than just high-speed access to narrowband content and services. A single home will have multiple users using a variety of multimedia services and appliances. The average home today has 2.7 televisions, and second computers account for nearly 70% of new PC purchases. Tomorrow’s broadband customer expectations will be high, with their benchmarks being the competitive services offered by providers such as DBS, cable companies, ISP’s, CLEC’s, and web-based “portal” companies like Yahoo!. But not one of these industry players is currently able to provide an integrated solution for today’s broadband homes. The envisioned model will include affordable telephone, digital interactive television, and Internet access, but to be competitive and differentiable long-term, it will also need to deliver the following benefits to the service provider:

- Control of the customer contact, relationship, and experience
- One bill, branding, and bundling capability
- The ability to deliver a wide range of interactive, customized, personalized, and local content to multiple devices in the home and the office Control service look and feel

Despite increasing competition, telecom still maintains a strong position in the local access and long distance markets, and has made great strides in the high-speed Internet access market. However, with television a cornerstone device in the home, winning the broadband battle requires that telecom must deliver advanced video services as part of a bundled package to win consumers hearts and wallets. In much the same manner as competitors have encroached on telephony services, telecom can use advanced technology to quickly counter the cable industry's first-mover advantage in this area.

The benefits to telecom operators prepared to deliver integrated broadband solutions for today's customers are clear: increasing market share, increasing subscribers, increasing penetration, customer knowledge, and relationships leading to strong financial performance and market leadership. As it turns out, telecom is well positioned to deliver and win.

1.1 Telecom's Competitive Advantage

The following sections explain how the combined strength of a DSL last mile, fiber backbones, IP based networks, and web technologies will enable telecom to be a service innovator and become the channel of choice in broadband. Employing these technologies along with its reputation for service, quality, and relationships, will provide telecom a unique competitive advantage in the areas of product leadership, operational efficiency, and customer intimacy.

1.2 The DSL Technology Advantage

DSL holds various advantages over cable or satellite broadband connections, the most prominent being that it leverages the current telecommunications infrastructure to deliver its services. In other words, telephone companies can use the world's nearly 750 million existing copper wires to deliver affordable high-speed remote access to the Internet, corporate networks, and on-line services over ordinary phone lines. As such, DSL provides the means to deliver next-generation broadband services over existing networks, enabling a quick time-to-market advantage. Today, a mere 40% of homes in the U.S. and Canada are equipped for high-speed Internet over cable service. Satellite service is even more sparse. It requires each new customer to install a satellite dish in their home or office, as well as phone line connections for high-speed Internet. Two-way satellite Internet access is in very early stages of deployment.

Another important DSL is that it provides phone companies with the ability to offer a dedicated, private, and secure channel of communications between the consumer and the service provider. This data travels along the customers' own lines, unlike cable telephone and modem services, where the line is shared. Cable uses a bus technology; thus, all traffic is routed on one single pipeline. As additional users log on, service becomes slower and slower. Because DSL provides a dedicated line, other users accessing service do not affect transmission speeds. A dedicated line also means that specific amounts of bandwidth can be allocated, enabling quality of service (QoS). DSL is the only broadband medium that can offer true QoS.

Based on the current architecture, DSL offers far more flexibility than either cable or satellite. This is due to the fact both cable and satellite communications were originally invented to send information, not receive it. Perhaps the most important (and often overlooked) architectural feature of DSL-based networks is how well suited they are for carrying IP and ATM traffic, thus future-proofing DSL technology for decades to come.

1.3 The Fiber/DSL Architecture Advantage

At first glance, there appears to be many last-mile options for the telecom broadband network. However, the acquisition of cable assets, overbuilding with hybrid fiber/coaxial (HFC) or deploying a DBS/DSL combination have proven to be very expensive. VDSL affords plenty of bandwidth, but its limited reach as compared to ADSL tends to relegate it primarily to fiber-to-the-neighborhood (FTTN) and multi-dwelling unit (MDU) applications. Although fiber-to-the-home (FTTH) is a possible end state, it remains decades from broad deployment.

Combining ADSL with a fiber backbone is an attractive alternative. Advantages afforded by this architecture include:

- carriers can harvest sunk costs in outside copper plant and builds on existing fiber rollouts
- carriers can use a reliable copper wire infrastructure that reaches into every home and office (unlike cable or DBS)
- long-term value by future-proofing the network,
- the network grows in the right direction of pushing fiber further towards the home
- Future-proofs the customer by installing an ATM- or IP-enabled CPE, thus ensuring that CPE investments remain compatible as applications migrate to fiber-based delivery. The ability for telecom to move a customer to an FTTH technology will be transparent to a DSL customer with IP enabled CPE, but not to DBS customers who have a dish and receiver, or cable customers with existing digital or analog set-tops.
- a “pay as you grow” model that permits both tactical and strategic broadband network investments that can best match business and market requirements.

DSL’s private wire delivers dedicated bandwidth to individual homes and is currently the most robust last mile technology delivering broadband applications. With the proper backbone and DSLAM architecture, its star topology will ultimately deliver a wider range of content and applications due to the location of the “edge of the network,” as compared to the ring topology of cable, or broadcast topology of DBS. For example, combining DSL’s point-to-point nature with IP allows a unicast VoD solution to be delivered to one home, broadcast video to another using multicast, and a pay-per-view movie to yet another home across the street. An additional advantage of DSL over the ring topology of cable is that it allows for a more effective OSS process, where individual customers can be easily isolated for troubleshooting.

Issues surrounding DSL loop length and bandwidth are disappearing as technology matures and video compression techniques improve. These improvements will help increase the range of future broadband services that telecom will offer. Service delivery issues are also diminishing as knowledge, skills, and delivery tool sets are improved.

1.4 The Web and IP Advantage

Building on a DSL and fiber network topology, telecom can increase its competitive advantage through the use of a combination of web and IP technologies. Together, they bring standards, interoperability, authoring and development tools, delivery platforms, commodity priced software and hardware, and developer support.

Unlike cable or DBS, telecom lacks a legacy of non-IP-based CPE in the home that are incapable of delivering leading edge interactive services. Customers will have to be upgraded as new services are developed and marketed, creating a huge entry barrier to increasing customer net present value (NPV). With over 38 million of these set-top boxes already installed in the US, cable and DBS have a multi-billion dollar upgrade problem, creating an opportunity for telecom to enter these markets with leading edge service.

Telecom can also extend the tools that offer delivery and tracking solutions for online advertisers to include all content and commerce offered on their network where anything that is IP based can be tracked, searched, measured and targeted using solutions from many vendors. As these innovations continue, telecom broadband IP networks are better positioned to harvest the technology. While the benefits of this approach are many, some of the most important involve:

- Growing industry support for IP as evident from accelerating investment and innovation
- Intelligent IP networks, statistically multiplexed for efficiency, fault-tolerant by definition, and efficient in the transfer and distribution of multi media types. IP has proven that it is scalable and can provide QoS using proper network planning or newer technologies such as DiffServ and MPLS.
- Using IP also allows telecom to utilize a common security and authentication model to deliver multiple services to multiple devices.
- Ability to leverage new content solutions as well as offer efficiencies for improving the distribution, interactivity and presentation of traditional media, including video. Telecom will have the ability to exploit and participate in new media business models as new and existing content creators embrace IP.
- The unicast and multicast capabilities of the "IP network spectrum" allow telecoms to best match the profile of the application being delivered.

In summary, there is a compelling opportunity for telecom to deliver services beyond what DBS or cable can offer. As telecom deploys other access technologies such as fiber, the use of IP as the delivery mechanism ensures that service delivery of these applications can continue without requiring a rebuild.

1.5 The "One Network, One Wire, One Bill, One Strategy" Advantage

Using a single technology infrastructure for delivery of all broadband applications—including video—means cost-effective delivery and a less complicated access network. It also means that investments required for video delivery can complement investments already being made by telecom for the high-speed Internet access network. It is a unique situation where common network infrastructures, OSS, and business processes can be used for all applications and services being delivered to residence and business. The efficiencies of a common infrastructure in the areas of training, tools and technology will reduce costs and improve service.

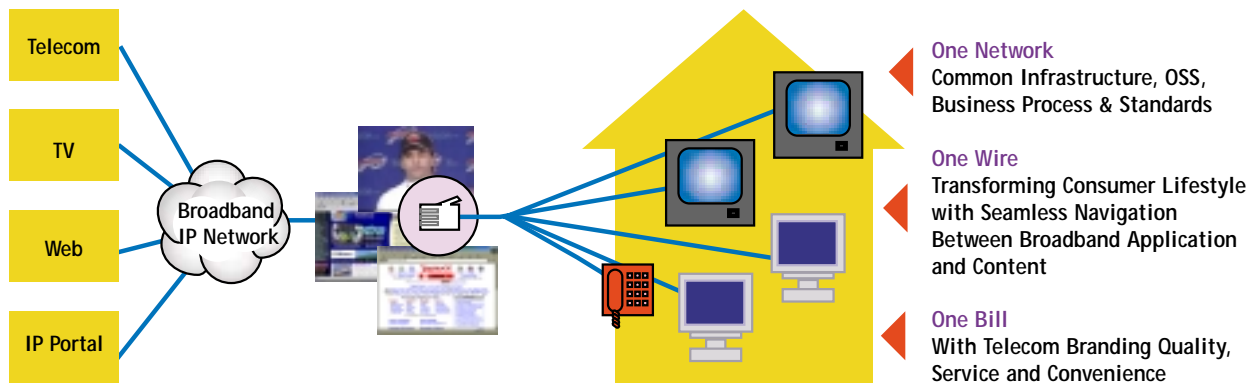


Figure 1. One network, one wire, one bill

Combining telecom broadband IP networks, multimedia, and last-mile connections into customers' homes will significantly reduce operations costs. The "always on" nature of broadband—coupled with the smart IP network and CPE—will allow telecom to extend OSS elements right into the customer home, providing a powerful "endpoint" in the OSS ecosystem for intelligent service monitoring, remote diagnostics, alarm generation and fault management. This capability allows the IP network to proactively implement fault management and error recovery processes before customer service is affected.

For the end customer, telecom can use the presentation power of video and "always on" multiple appliance access to extend "enterprise knowledge" such as OSS tools and business process into the home and make the customers themselves a part of their OSS strategy. Delivering "e-care" elements such as trouble reporting, status inquiry, online Information and help, communication and collaboration tools can minimize requirements for live agent contact while improving customer service.

1.6 The Telecom Relationship Advantage

Another important telecom asset is their relationship with residential and business customers. Unlike any other industry, telecom has direct access to a customer base that is nearly 100% of the population for marketing new broadband services. Telecom possesses strong brand awareness and important market information. It is key for telecom to leverage their current position and to extend the relationship benefits to partners by using its broadband network and services as an intermediary that can deliver both customers and an audience. The ability of telecom to control the "start screen" of its broadband TV and PC customers is a huge competitive advantage.

Telecom residence and business customers depend on the reliability of the telephone company, its services and its network. Unlike cable and DBS, telecom has a history of delivering 99.999% reliable network services. Studies indicate a consumer preference to receive multimedia services from the phone company. Telecom already has the attention of its customer base and transacts with them on a monthly basis, making the process familiar and comfortable.

2 The Marketplace

2.1 Regulatory Environment

The regulatory environment in the U.S. involves several levels of federal, state, and local government agencies. The Federal Communications Commission (FCC) established the Cable Services Bureau to implement and enforce the Cable Television Consumer Protection and Competition Act of 1992. The Bureau acts to promote competition in a converging communications marketplace, and plays a significant role in monitoring and evaluating the deployment of broadband technologies. It is responsible for enforcing several mandates, including television broadcast signal carriage, commercial leased access, program access, over-the-air reception devices, and open video systems. The Bureau is also responsible for resolving appeals of local rate orders issued by franchising authorities and addressing issues concerning the computation of the franchise fee.

Before launching a television distribution operation, a registration statement signed by an authorized representative of the "cable television" company must be submitted to the Secretary of the Commission for each community to be served. The television distribution company may begin operation as soon as they have filed their registration statement; however, if violations of the rules are subsequently discovered or other conditions not satisfactorily met, then a cease and/or desist order may be issued.

A variety of laws and regulations for cable television exist at the state and local level in the U.S. Some states, such as Massachusetts, regulate cable television through a state commission or advisory board established for the sole purpose of cable television regulation. In other areas of the country, cable is regulated by local governments, such as city cable commissions, city councils, town councils, or a board of supervisors.

The Communications Act requires that a new cable operator may not provide service without a franchise and establishes several policies relating to franchising requirements and franchise fees. The Communications Act authorizes local franchising authorities to grant one or more franchises within their jurisdiction. A local franchising authority may not, however, grant an exclusive franchise, and may not unreasonably withhold its consent for new service. Franchising authorities may charge the cable operator a fee for the right to operate a cable system in the franchise area, but it cannot exceed five percent of the annual gross revenue.

When planning a competitive television service offering, the best approach is to investigate the regulatory conditions that apply in the locations where service will be deployed to ensure that the appropriate approvals/licenses are obtained.

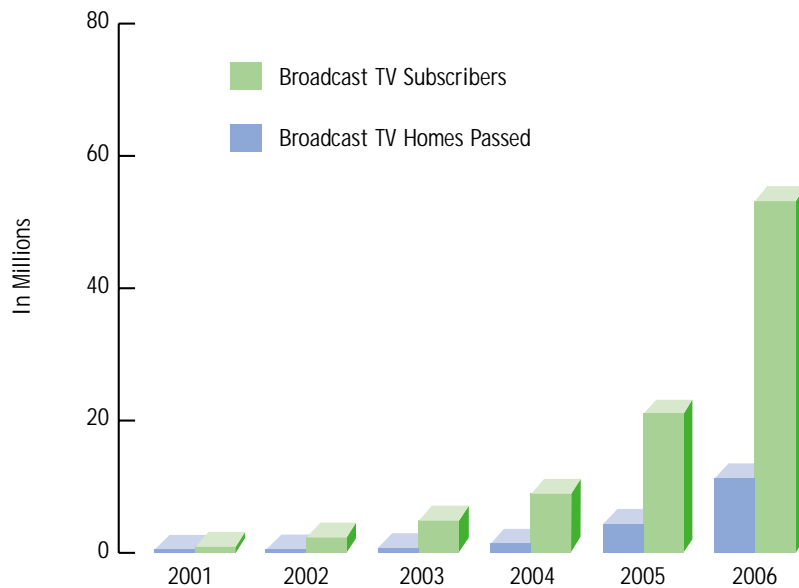
2.2 Market Environment

Telephone companies (telcos) are actively examining the best way to deliver video services to residential customers. The telco may be an Incumbent Local Exchange Carrier (ILEC) which already serves a territory, a Competitive Local Exchange Carrier (CLEC) which rents lines from the ILEC or overbuilds the existing network with their own, or a utility, which uses its rights of way to put in their own network thereby becoming a CLEC. Telcos are feeling pressured from several sides in the race to offer customers a full service network:

- Cable operators have spent billions over the past several years upgrading their networks to enable digital video, high-speed Internet access, and telephony.
- Small independent ILECs need to find new services to increase revenue as their fees from long distance fall.
- CLECs are stealing business customers with their voice and data offerings.
- In many countries deregulation is forcing the telephone companies, who also owned cable networks, to sell one of their networks. In order to continue to offer their former customers video services, they are looking at video over DSL.
- Utilities are looking to increase profitability by leveraging their direct customer relationships by adding additional services to their traditional power delivery.

Once a telco decides to enter the video service business, the next step is to determine the type of network they will deploy. Since interoperability is key for telcos when purchasing equipment, they prefer to use standards-based approaches. ADSL is an international standard, and standards for VDSL and video delivery are in progress. Several telcos banded together to develop specifications to ensure interoperability between components of the video delivery infrastructure. The Full Service Access Network (FSAN) initiative is made up of 21 network providers from U.S., Europe, and Asia and equipment vendors, representing 310 million lines worldwide. FSAN's goal is to develop a uniform approach to delivery of video over DSL and overcome interoperability issues among equipment vendors. The network providers' buying power will ensure that equipment providers will tailor products to FSAN recommendations.

While video from many telcos is still in the lab, the number of telcos who have moved to commercial deployment has increased each year. As a group, the smaller incumbent telcos in North America continue to deploy video at a steady pace. The utilities and overbuilders have been active in Australia, Italy, and Scandinavia. However, reductions in capital expenditures continue to keep many large telcos on the sidelines. Market trials and commercial deployments have been delayed though RFIs and RFPs continue to be sent out to equipment vendors so that the telco will be ready to offer video when financial conditions improve. On the whole, we expect large gains in telco video deployment to come in 2004 and beyond.



Source: In-Stat/MDR, 5/02

Figure 2. Worldwide Telco Video Deployment

2.2.1 Entertainment on Demand vs. Broadcast Television

The decision of the type of video service to offer depends on the telco's current infrastructure, desired capital expenditure, and the revenue expectations. Entertainment-on-demand services are typically delivered to the TV over ADSL. The video is streamed through the set-top box in MPEG-4, MPEG-2, or a proprietary compression scheme. Instead of content from the local broadcast or cable network stations, subscribers receive a mix of content, such as movies on demand, old episodes of TV shows, music and news services.

While entertainment services over DSL are a way to increase the revenue from the copper infrastructure, they do not do much to halt the competition. Consumers still want their multi-channel TV, so an entertainment offering is not enough to kick DBS or cable out of the home. Additionally the monthly revenue from an Entertainment on Demand service is not nearly as high as that of broadcast TV.

The bandwidth for entertainment on demand should be high enough to offer DVD-quality for movies. As DVD penetration grows, consumers will be unlikely to accept anything less. The convenience of an on demand service will not outweigh lower quality with all subscribers. Those interested in future-proofing their networks should also note that within the next ten years, DVD-quality can be expected to reach the resolution of HDTV. DVD player manufacturers have already demonstrated the technology necessary to store and play back an HDTV-quality video on DVD. In North America, telcos wishing to offer broadcast TV will need to keep HDTV in mind as well. By 2006, 20% of households will have HDTV capable displays.

The biggest problem facing those who want to offer an entertainment on demand service is finding quality content at prices that fit their financial model. While the cable TV channels are consenting

to transmission of their content over a telco network, movie studios have been reluctant to release films for video-on-demand. Studios demand agreements that give them control and a large percentage of the viewing fee, as much as 70 to 80%. Without recent movie releases or a library of popular titles, subscribing to an entertainment on demand service is less appealing to the consumer, even though content providers are asking a steep price.

2.2.2 The Broadcast Television Market

Many telcos are interested in going after the proven revenue service, broadcast TV. Through 2001 we have seen small deployments of broadcast TV over DSL from small and medium size telcos, and those will continue. While 2002 will be another year of market and lab trials for RBOCs and PTTs, 2003 will see commercial deployment, with large numbers of homes being enabled for Broadcast TV in 2004 and 2005. By the end of 2006, over 50 million homes can be expected to be able to receive broadcast TV services from a telco.

Growth in subscribers will occur as the number of enabled homes grows and consumers realize they can receive video from their telco. When U.S. cable and DTH subscribers were recently asked if they would use their local phone company for TV services, 44% said they would. The percentage that said they would use their local phone company increased to 66% when asked for their decision if the TV service cost five dollars less per month than the competition. Consumers in the U.S. do not have any issues with purchasing TV services from the company that traditionally supplies voice and more recently data.

North America will be passed by Asia and Europe in telco video subscribers. By the end of 2006, In-Stat expects over 10 million homes will subscribe to video services from a telco, rather than the traditional cable or DTH provider.

2.2.3 The Entertainment on Demand Market

Many telcos who offer broadcast TV services will use entertainment on demand services as an additional source of revenue. It will also be another lure for subscribers. Therefore, the number of homes able to receive entertainment on demand will encompass those broadcast TV homes and many more. Many telcos offering high speed Internet access will look to entertainment on demand offerings to maximize the revenue from their existing DSL infrastructure. The lower bandwidth required for a video-on-demand service means a telco will be able to offer video without needing the more expensive network upgrade for broadcast TV. In some cases, the service will only be available on a PC, while others will enlarge the audience to TV viewers.

Telcos continue to have a problem making a business case for video on demand. As mentioned earlier, getting the right mix of content is tricky. If a telco wants to offer entertainment on demand to a TV, they need to offer subscribers a set top box. It takes a lot of downloading for just the set top box to pay for itself. A number of entertainment on demand services, both those up and running and those proposed, are now on shaky ground.

2.3 Sample Revenue Case

The rationale for telecom delivery of multiple voice, video and data services over a single network becomes clear when presenting the revenue case, as the revenues generated from video help offset downward pressures on traditional telephony and high-speed Internet access revenues. In three years, a telco can convert their \$86-per-month, two-appliance customer into a nearly \$124 per-

month, multi-service, multi-appliance broadband customer and extend a financial advantage to its customer by offering discounts on a bundled service package.

As depicted in Figure 3, the largest source of initial revenue will come from the delivery of video service. These services will allow operators to receive revenues from two wallets: those of merchants in the form of advertising, sponsorships and hosting and those of customers for subscription to applications and content. Starting in year one, these revenues also offset the predicted downward trend of Internet access subscription prices. Some highlights of the revenue opportunities are to:

- Deliver commerce applications with a strong local theme that tightly integrate content, advertising and commerce with compelling applications such as games, contests and short-form VoD applications.
- Extend customer service and brand, promote offline products and services and provide direct marketing channels.
- Augment TV programming & advertising to help prevent price competition by product differentiation
- Deliver on demand broadcast enhancement applications that complement regular TV & movie viewing such as video enabled TV & entertainment news, viewing guides, polls, & surveys, media planning & search tools
- Data mine TV viewing data to provide measurement of existing broadcast TV ad campaigns carried over the broadband IP network.
- Employ IP based digital ad insertion technologies to make use of the local cable avails in a more targeted and measurable manner.
- Amplify existing TV, radio and print advertising to deliver interactive versions of existing ad campaigns.
- Increase programmers' & advertisers' reach by delivering to multiple IP appliances.

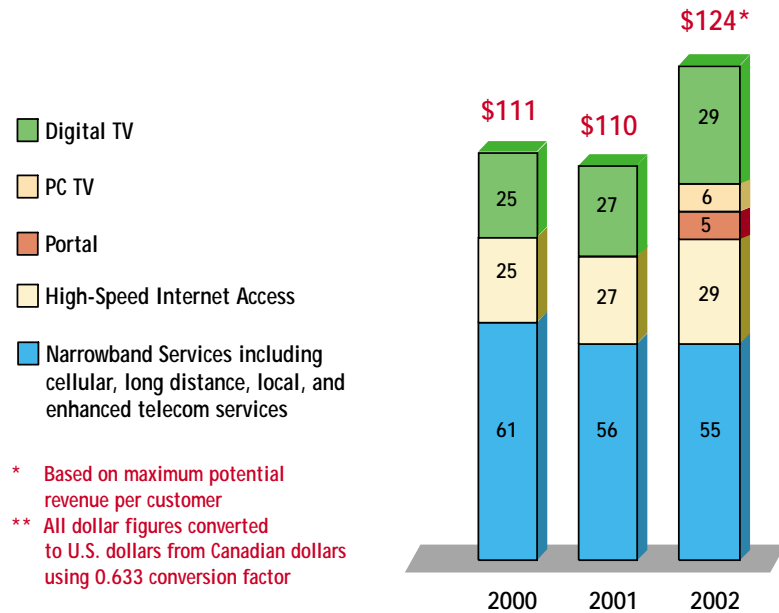


Figure 3. Sample Revenue Case

2.4 The Aliant Telecom Video Deployment

Aliant Telecom (TSE:AIT) is widely recognized as one of Canada’s most innovative telecommunications companies. With 10,000 employees, and a market capitalization of approximately \$4.5 billion, Aliant ranks in the top 10 technology companies, and top 100 publicly traded companies, in Canada. From its Canadian base, the Aliant group of advanced technology companies serves consumers and business customers worldwide. Aliant’s telecommunications division, which operates primarily throughout Atlantic Canada, is the region’s incumbent local exchange carrier (ILEC).

In the early ‘90s, significant changes to the telecommunications landscape forced Aliant to transform itself from a traditional telephone company into a multimedia service provider. They recognized that to succeed in this new role, research and development had to happen in an environment representative of consumers’ everyday experiences. So they built the LivingLAB™, which brings new technologies to market in a significantly reduced time frame by combining the power of customer feedback in testing phases, with industry partnerships and employee ingenuity. Over the years, the LivingLAB has become a cornerstone for technological advances and was key in transforming traditional telecom into a 21st century service provider.

One of the LivingLAB’s first breakthroughs resulted in the 1996 commercial launch of Vibe, making Aliant one of the first telcos in North America to provide high-speed Internet service on its all-fiber, all-digital network. Continued success followed in January 2000, when Aliant became the first company in North America to offer a commercial interactive digital television service, *VibeVision*™, over the same copper pair as *Vibe* service. With minimal marketing, *VibeVision* provided instant validation for the Aliant strategy when it increased the average incremental revenue per customer by \$22 (CAN \$35) per month while providing 56% of these customers access to the web for the first time. As the result of a successful bundled offer, 14.3% of *VibeVision* customers also took *Vibe*, the PC-based high-speed Internet service in addition to video. This increased the average incremental revenue to \$38 (CAN \$59.80) among this group.

Aliant has a four point broadband strategy:

- 1) Grow a large base of interactive TV (iTV) & high-speed Internet customers through aggressive, customer acquisition and retention campaigns, thus enabling commerce models.
- 2) Be a multimedia and content service provide by leveraging an Aliant branded service bundle with seamless integration of web, telephony, broadcast and relevant broadband content.
- 3) Lead customers to technology by providing leading edge broadband solutions using the customer's appliance of choice
- 4) Turn a customer service approach into our competitive advantage: 24/7, better service, low1er cost, one bill, self-serve.

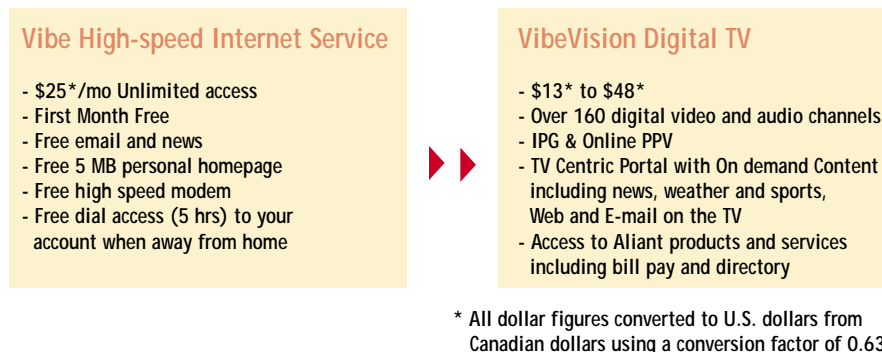


Figure 4. Aliant Service Offerings

In times of increased competition and convergence, Aliant Telecom continues to enjoy strong market share, increase subscribers, increase penetration, build strong customer knowledge and relationships, and achieve unprecedented financial performance. This is largely due to their ability to stay ahead of the curve in deploying new technology and services to their customer base.

3 The Architecture and Equipment

The architecture deployed by a telecom service provider to deliver video services will vary. A typical example is shown in Figure 5.

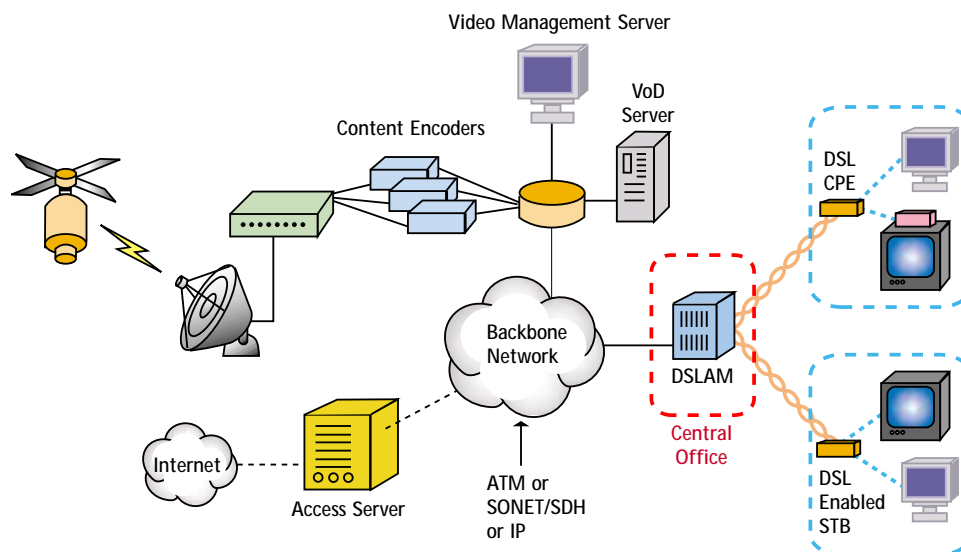


Figure 5. Video over DSL Architecture

In the access network, the asynchronous transfer mode (ATM) provides Layer 2 connectivity over DSL. Thus, each DSLAM is either an ATM multiplexer or a switch. As a result, video programs must be delivered in either MPEG-over-ATM format or MPEG-over-IP-over-ATM format. Although both technologies are currently available, the market appears to favor the Internet Protocol (IP) as the network layer delivery vehicle. While IP adds some overhead to the video stream, it greatly simplifies in-home distribution over Ethernet-compatible media. Also, more applications are available for IP, broadening its audience. Whether using MPEG over ATM, or MPEG over IP over ATM, the headend and transport networks are very similar. This combination of IP at Layer 3 and ATM at Layer 2 merges the power of IP for the application infrastructure and the quality of service capability so essential for video delivery.

3.1 Headend

The term “headend” originated in the cable industry, as each town or city required an aggregation point for television signals. The term is used to denote a location where content is aggregated for TV channels, VoD, t-commerce portals, Internet access, and so on. However, the location of the headend, and even whether it is centralized or distributed, is an architectural choice. Because the video content is delivered to the user over the ATM access network, content can be injected into the network at almost any location.

In the case of a broadcast TV service, video arrives from various sources over diverse media, including satellite, local off-air broadcasts and studios. If not already in MPEG format, content from these sources must be fed to an encoding platform to be converted into MPEG format. Each broadcast channel is usually encoded as a single program transport stream, and associated with a

specific channel ID. Given that the end-delivery network is ADSL, it is highly recommended that the output video signals should be “shaped” to optimize link utilization and ensure that the ADSL line is not over-loaded. Typically the output channels are delivered to an ATM network using either MPEG-over-IP-over ATM or MPEG-over-ATM encapsulation. In the IP scenario, IP multicasting is used to deliver the broadcast channels as broadcast TV is a perfect “one-to-many” application.

Interactive services, such as VoD and network-based time-shifted TV, are delivered from servers that store content in MPEG format and deliver a copy at the subscriber’s request. The server must be dimensioned for both the amount of content it must store and the number of active subscribers retrieving data. Either single large servers or multiple distributed servers can be used to meet this requirement. The trade-off is between transport costs, replicated server costs and management complexity. Other servers for a variety of video services may also be colocated at the headend. Aggregated bandwidth demands of larger servers may also favor many small, distributed servers.

The headend in a video-over-DSL architecture can be centralized or distributed. Since the content is distributed using IP and/or ATM, connectivity is very flexible.

3.2 Transport Network

The role of the transport network is to deliver the content from the headend(s) to the appropriate DSLAMs, or their attached switch/routers, in the access network. The network must transport two specific types of traffic: multicast and unicast, corresponding to broadcast and interactive services.

3.2.1 *Broadcast network*

Broadcast traffic is transported as IP multicast, ATM point-to-multipoint or a combination of the two. Traffic must be delivered to all DSLAM locations in the network, essentially emulating a cable service that delivers all channels at all locations. Given that the traffic is either IP or ATM, the choices for constructing the distribution network are ATM point-to-multipoint or IP multicast routed.

A good solution for an overlay network is to use ATM point-to-multipoint connections in an ATM switching environment. ATM is a stable and scalable technology with the proven ability to replicate high bandwidth data. This approach will work over almost any transport network, such as synchronous optical network/synchronous digital hierarchy (SONET/SDH), or dense wavelength division multiplexer (DWDM), and supports native MPEG-over-ATM and MPEG-over-IP encapsulation. The links that carry the broadcast channels can also be used to transport other data, such as interactive content. The downside to this multicast overlay approach is the increased cost of supporting multiple optical transport links and any intermediate ATM switches required to complete the point-to-multipoint tree. ATM switches attached to the DSLAMs are not included as extra costs, as these switches typically exist within the network.

IP multicast capable routers can also be used to distribute the broadcast TV channels if IP is the network layer chosen for the service. If an existing IP network provides the required capacity and performance for multicast replication, then it might be feasible to add broadcast television streams. The end delivery encapsulation is ATM, so the IP multicast streams must be encapsulated into ATM virtual circuits for the final leg of the journey. To ensure high-quality video, the IP network must also be properly engineered to deliver quality of service.

3.2.2 Unicast network

In contrast to broadcast requirements, interactive services require a bi-directional network. Given the constraints of the access network, this is best provided by ATM virtual circuits, supporting either a native ATM encapsulation or IP-over-ATM. Given the wealth of applications that are easily supported by IP, such as web browsing, t-commerce, VoD, and network games, it is likely that IP-over-ATM will dominate. As mentioned earlier, the ADSL access network is well suited to point-to-point IP architectures. Many different architectures can be employed for a unicast network, including: existing broadband remote access servers (BRAS), ATM switches/routers (combining functions), and IP cards within the DSLAM connected to routers. The final choice will depend on the performance, capacity and subscriber concurrency requirements, and on budgetary constraints.

Unicast and broadcast services can be delivered over the same network infrastructure. For example, the ATM concentrator nodes that aggregate the DSLAMs support both point-to-multipoint and point-to-point virtual circuits. Bi-directional, interactive traffic over ATM point-to-point virtual circuits can be aggregated at either a BRAS or router, depending on the service requirements. These routing devices located within central offices can then be connected to a data center over the same optical transport medium that delivers the broadcast traffic.

3.3 Access Network

The DSLAM is the last element in the access network before the subscriber's home, and is thus the vehicle for delivering video services. It is responsible for switching the video channels delivered to the subscriber. Providing integrated multicast switching within the DSLAM offers the best performance and price mix for the delivery of broadcast services. As channel changing is performed at the first point of entry in the access network, this approach meets the need for rapid channel changes. Furthermore, if the integrated DSLAM performs this function, then there is no need for an external box, so the cost is reduced. To meet the performance requirements, the DSLAM should support multicasting in hardware.

The key requirement of the switching device is wire speed replication of a single stream of content to potentially hundreds or thousands of subscribers at the same time, depending on the number of DSLAMs terminated. Such system requirements are likely to limit the products available to fill this role. Note that the uplink from the DSLAM/DLC to the switching device will constrain the number of video subscribers supported by the DSLAM when all content channels are treated as unicast from the switching device onward.

The strength of the ATM access network lies in its use of virtual circuits. Unicast interactive traffic must also travel through the DSLAM, so both multiple virtual circuits and quality of service guarantees need to be available within the DSLAM to support both broadcast and interactive services concurrently.

A single subscriber might require multiple services, each of which is best served by a unique device. For example, high speed Internet access traffic might best be delivered via a BRAS (broadband remote access server), which provides a rich feature set for accounting, hypertext markup language (HTML) redirect and service selection. However, the VoD service might best be provided by a high end ATM switch/router that offers very high capacity forwarding and strong quality of service (QoS) features.

3.3.1 Access Architectures

There are various ways telcos configure their access network. Their architectures typically take into account 1) their existing infrastructure, and 2) how close to the home fiber is already deployed. A fiber infrastructure is sometimes employed due to reach limitations of DSL. In these cases, outside plant transport solutions must be utilized. An example are RAMs (remote access multiplexers), which are usually DSLAMs as small as 1 RU that provide DSL connectivity from a nearby indoor or outdoor cabinet. A RAM can be located at street cabinets, DLC cabinets, basements or other nearby locations that are provided with fiber termination. The majority of worldwide video over DSL deployments can be characterized as one of the following:

- Central-office based – delivers the signal over existing copper phone lines directly connecting homes to the central office. No installation of fiber or optical equipment is required.
- Fiber-to-the-node or neighborhood (FTTN) - delivers the signal over fiber from the central office to a node in the neighborhood. The signals are then sent over the copper twisted pair using DSL to the home.
- Fiber-to-the-curb (FTTC) - delivers the signal over fiber from the central office to the street outside the residence and from there, over copper via DSL. In a multiple dwelling unit, this may be fiber to the basement (FTTB).

3.3.2 Advanced DSLAM Features

Several key technologies must exist in the access equipment and infrastructure to provide broadcast video and entertainment on demand services. Many of these technology enablers must be supported in the DSLAM providing DSL transport.

Today, video channels today require approximately 3 to 4 Mbps per MPEG-2 channel, though improvements in compression technology reduce this requirement on a monthly basis. For now, this is the bandwidth requirement needed to achieve high-quality video with CD-quality audio typical of today's digital satellite TV offerings. In North America, there is a general requirement to provide at least two simultaneous channels to each home served, or a minimum of 6 Mbps of bandwidth. This puts a very high requirement on the DSLAM for non-blocking bandwidth. On a system supporting 240 users, for example, a non-blocking backplane bandwidth of 3.6 Gbps per DSLAM is necessary, and when moving to denser DSLAMs (480 users) a non-blocking backplane bandwidth of 7.2 Gbps per DSLAM would be required.

In addition to backplane bandwidth, multicasting is a key requirement of video networks. Research shows that in an arbitrary video networks servicing 500 TV channels to 200 users, up to 80% of the users will all be watching the same six channels at the same time. If multicasting is not employed, huge amounts of redundant data reside on the core network. With multicasting, these redundant flows are collapsed down to a single set of flows, maximizing network throughput and freeing up precious bandwidth for other applications. The figure below illustrates the bandwidth efficiencies gained using multicasting.

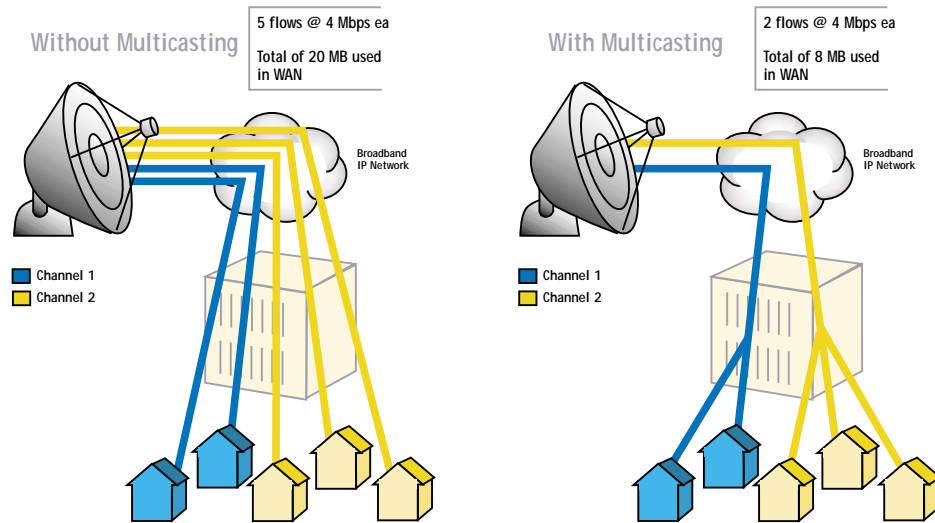


Figure 6. Video Without/With Multicasting

For the delivery of hundreds of simultaneous broadcast and unicast channels, the DSLAM must also be equipped with the appropriate network interface to support the required bandwidth. This bandwidth is especially required when dealing with high-density DSLAMs (i.e. 480 users) which also utilize aggregation, cascading and subtending capabilities. In such cases the interface toward the ATM network should be able to support a total bandwidth of up to two STM-4 links which enables to support over 250 channels of 4 Mbps each.

3.3.3 DSL Line Codes

DSL is a physical layer technology that expands the useable bandwidth of regular copper phone lines. There are different ‘flavors’ of DSL such as ADSL and VDSL. Each uses different features and characteristics that optimize bandwidth for different applications. Generally speaking, DSL presents a tradeoff between bandwidth and reach; the shorter the phone line, the higher the data rate achievable.

Standard-compliant G.dmt ADSL (asymmetric digital subscriber line) provides up to 8 Mbps downstream and up to 768 kbps upstream to subscribers out to about 8,000 feet from the central office. Data rates decline with distance to customers up to 18,000 feet away. ADSL is the most widely deployed DSL technology, with tens of millions of DSL subscribers worldwide.

VDSL (very high data rate digital subscriber line) allows data rates up to 56 Mbps, both symmetrically and asymmetrically, with corresponding maximum reaches ranging up to 4,500 feet. Standards for both single and multi-carrier VDSL line codes are still in progress and are expected to be finalized in the near future. The primary applications for VDSL are for business and residential multi-tenant units, fiber-to-the-neighborhood deployments, and Ethernet-over-copper applications.

Several recent technology trends are making it increasingly attractive for carriers to use their deployed ADSL infrastructure to deliver video services. Improvements in compression technology as well as DSL performance are increasing the data rate and reach of standard-compliant ADSL, making it viable to deliver two or more channels of video to customers out to 12,000 feet and further using existing ADSL equipment. These improvements present a means for carriers to

deploy a central office-based, ADSL video delivery system, which can potentially cost less than a fiber-based deployment, and significantly improving the business case for video over DSL.

An example of such developments is new chipset firmware now available which increases the data rates of existing ADSL chipsets to over 11 Mbps: enough to offer two channels of digital-quality video using MPEG-2 compression, high speed Internet access, and traditional voice services, all over a single telephone line. This "FastADSL" firmware can be loaded into existing chipsets without requiring a hardware design change. If a chipset not equipped with FastADSL is detected at either end of the link, then the chipsets automatically engage in a standard-compliant G.dmt mode.

3.4 Home Network

Once the video-over-DSL channel is terminated at the subscriber's premises by a DSL modem, content must be distributed to the set-top box so that it can be viewed on the television. This is typically done via Ethernet, which can also connect to the PC. When the video is encapsulated as MPEG-over-IP-over-ATM, there are more options for in-home distribution. A variety of Ethernet-compatible networks are available and under development, including: wireless Ethernet, wired Ethernet, Home Phonenumber Networking Alliance (HomePNA) and powerline technologies.

Obviously, networks that do not require new in-home wiring are very attractive as they considerably reduce the cost of home installations and "truck rolls". Wireless LAN technology is one of the most promising emerging technologies for rapid home installation. The DSL modem becomes an integral part of a broadband home gateway, which supports home links, such as wireless LAN, to communicate with IP devices in the home. A television set-top box could be one of these devices, so the IP video stream is directed from the home gateway to the set-top box. This is possible using the IEEE 802.11a and 802.11b standards, which can support up to 52 Mbps and 11 Mbps respectively; sufficient to supply several remote set-top boxes and PCs. The modem must support multiple IP addresses to meet the multiple service demands of the home, Internet access, multiple TVs and service management.

3.4.1 *The Set-top box*

The Set-top box (STB) plays a crucial role in the delivery of entertainment and video services over DSL. For a host of reasons, the STB decision is a vital one. The STB represents a substantial portion of the capital investment needed to launch a service. The STB sits in the customer's home, so if the box fails to work properly, it's the thing that the customer can point to and complain about.

The set-top can also be relatively expensive to install or replace. If an engineer is needed to install the unit, the costs to deploy services quickly mount up. Changing out the product, be it replacement or an upgrade to the physical hardware, in the past has meant the cost of the new equipment plus the cost of a service call.

From a service provider's point of view the 'life cost of ownership' of the STB is a key metric. This includes the actual cost to buy the product from the STB vendor, but also the cost to install, manage, and upgrade. The challenge for the STB provider is to lower the life cost of ownership, as well as to increase the revenue-generating potential of the product.

From a revenue generation perspective, there are a number of approaches to designing the product. Essentially, the more services a product supports, the more revenue-generating potential it has. For example, if a set-top allows someone to play a game, while a different person is paying for a Video on Demand (VOD) movie, then the average revenue per user (ARPU) will grow. If a service provider understands what services the consumer is willing to pay for, the STB vendor can help by educating the service provider about the cost implications of adding functionality in the STB.

In practice, each market is different, so there is typically not a one-box-fits-all product that can be built today. Some providers may feel that offering a video on demand and broadcast TV service over DSL is the optimum mix for their customers. For other operators, given their local conditions (i.e. networks, regulatory environment, consumer price expectation for services, acceptance of internet and digital TV), this simple set of services is not enough to make the business case profitable in the right timeframe. For these, services such as time-shift TV and personal video recorder (PVR) functionality, gaming, two-way video services such as video telephony, enhanced messaging and additional telephone lines (delivered using Voice over IP) provide the incremental revenue needed to make it all worthwhile.

This difficulty is compounded by the fact that within a market, some customers want few services while others want many. For the service provider, managing multiple STBs on the same network--each delivering different services--is a challenge if each box is based upon a different architecture (processors, operating system, application layer, security solution etc.) The challenge can be summarized as trying to provide a STB that has enough functionality to handle the services that the customer is willing to pay for, without having to pay for something that only a few will fully exploit.

From a cost perspective the cost-versus-revenue equation can be swung in the positive direction in a number of ways. First, the longer the STB can work effectively in the home, supporting new and innovative services, the lower the cost-per-month to deploy the product. High-speed processors help to achieve this. Additionally, the more features that can be added without requiring a truck roll to the home will impact the equation positively. Smart alternatives include allowing software features and applications to be added remotely or hardware upgrades to be added by the consumer (for example, with a PC card sent through the mail) expands the capability and lifespan of the product.

By integrating more and more of the home equipment into the STB, the total cost of equipment in the home can be reduced quite dramatically. For example, by integrating the DSL modem and adding home networking functionality, the total costs are significantly reduced when compared to the cost of a modem and a STB purchased separately. Home networking technologies that make use of the telephone wiring or power lines are reaching the capabilities and price points needed to present solutions to in-home networking. Wireless data technologies such as 802.11 and others will remove the wiring issue altogether.

Given all of these challenges, a picture of an ideal STB begins to materialize, which should include:

- A range of products that target each operator's business model optimally
- Product variants based on the same architecture to allow operators to add multiple variants within the same network or even the same home based on individual consumer needs.
- Support for 'basic' services such as VOD but also advanced services such as gaming, time-shift TV and PVR, video telephony, enhanced messaging and home networking

- Support for multiple simultaneous revenue generating services
- Support for low-bit-rate video such as MPEG-4
- Allows software features and services to be downloaded by the operator
- Can be installed by the consumer
- A high-speed processor that will perform well for years
- Support for home networking to allow services to be delivered easily around the home
- Low cost!

Today's STBs tackle all of these challenges. Several available STBs include a number of variants, from the most cost-effective product supporting video on demand, browsing, and broadcast TV, to the most advanced that include hard disk drive for PVR, VoIP, low bit rate video support, and the ability to drive two independent TV's from the same STB. Because all the variants are based upon the same architecture, an operator can mix and match products within the same network or in the same home. The integrated modem version can be coupled with home networking technologies such as HPNA or 802.11 to make service distribution easy.

Self-install capability removes the need to send an installation engineer to the home, and software features, applications and services can be upgraded remotely. Future hardware-based functionality can be added using the PC card upgrade slot, and the card could be sold through retail outlets or sent through the mail for the consumer to install.

3.5 Software

3.5.1 Service Administration

The service administration system allows service providers to define and configure client programming packages and customer profiles, as well as integrate with existing systems such as billing and operational systems. It also enables service providers to define service regions, classes of service and customized channel or program lineups. A subscriber provisioning service manages customer accounts and related activities and enables:

- Accounts to represent more than one subscriber
- Subscribers to have more than one STB
- Subscribers to be assigned to a geographic area
- Subscribers to store channel criteria and password
- Service providers to store billing data
- Subscribers to be assigned a defined class of service

The channel packaging feature allows the service provider to offer subscribers flexible packages to meet market opportunities and business objectives. This includes the ability to offer an unlimited number of channels, create packages and assign pricing to channel packages and pay per view programming.

3.5.2 Operations

The operations component provides the services and software required to distribute and manage digital television programming and IPG information.

The Interactive Program Guide data import and IPG multicast services manage the collection and provisioning of programming data and distribution to the subscribers. Updates of the IPG data are multicast continuously as they take place.

Connect services distribute and manage the client profiles that enable subscriber access to broadcast service resources, including the management of client profiles composed of a boot image, network addresses, software patches, persistent storage, client and client mask.

Headend content management service gives service providers the capability to configure and automate changes required in regular program lineups. This includes the assignment of content to data streams and channel numbers. It also works with third party solutions that deliver simulcast, blackouts, program substitution, emergency broadcast and backup of content streams.

The event collection service collects all events generated by the distribution services, including collection of events from the client and back-end system events and alarm counter monitoring events for exceeded thresholds.

- Remote diagnostics and cold start of STB
- Provides ability to remotely communicate with a client device using SNMP protocol
- Used for diagnosing a client device
- Uses administration interface to provide diagnostic functions such as:
 - Viewing current status
 - Viewing key indicators (signal quality)
 - Pinging the client device
 - Remotely restarting the client device

3.5.3 Set-top Client

The Set-top Client supports a STB and television combination. This can include an intuitive IPG (Interactive Program Guide) for viewing current and future programming information and for pay-per-view selections. It also includes information banners that provide detailed program information when a new channel is selected – even during commercials.

4 The Content

4.1 Acquisition and Aggregation

Content is everything intended to be transmitted or retransmitted. Sourcing is the act of contracting to legally obtain the content in a specific manner from a specific location. There are two distinct issues that are sometimes linked and confused, and both must be considered and addressed:

1. Content is owned by someone. Permission is needed to view it and to transmit it, and it will probably cost you money. As a general rule, content will cost you \$11 to \$18 per subscriber per month for basic or extended basic service, not including premium channels. For example, you should be able to get an extended basic line-up of over 50 channels for around \$11 per month plus transport fees by going through a cooperative. A wholesaler might charge around \$18 per month for well over 100 channels, including transport but not including premium channels such as Encore and Starz.

2. Transport is how you get the video stream into your facility. The people to contact regarding transport may be the same people who license content, but not necessarily. Just because you are paying a transport company to get convenient program feeds into your facility doesn't mean you have permission to view or retransmit it.

In general, one or more of four provider methods will provide content:

1. Working "direct" by contacting and contracting with each content provider and then providing a capital-intensive set of satellite dishes to download the various program streams from their respective sources.
2. Working through a cooperative, such as the National Cable Television Cooperative (the NCTC) to contract for content.
3. Working with an aggregator such as AT&T's Headend in The Sky (HITS) for the transport and then contracting with each of the content providers or a cooperative to get permission to access the program material.
4. Working with a wholesaler, such as S Squared Entertainment (S²), WSNet, or 4Com.

Content Provider Type	Content	Transport
Direct	X	
Co-op such as the NCTC	X	
Aggregator such as HITS		X
Wholesaler such as S ² or WSNet	X	X

Figure 7. Table of Provider Services and Charges

What these four provider types supply and get paid for is summarized in Figure 7. The elements not supplied by the provider are the responsibility of the service provider. Combining of providers makes sense, such as joining the NCTC for content and contracting with HITS for efficient transport of aggregated program streams.

4.1.1 Content Provider Types

4.1.1.1 Direct

The direct method of obtaining content is by contacting and contracting with each content provider. There are three sources of programming content:

- broadcast or local networks (including PEG channels),
- cable networks and
- movie production studios.

Some service providers wishing to distribute video programming contact and contract with each of the organizations in each of these categories to gain the rights to redistribute programming. This can be a labor intensive process.

Programs from broadcast networks such as ABC, NBC, CBS, and other local broadcasters are referred to as "off-air" channels. Redistributing off-air programs requires the telco to do the following:

1. Contact and contract with the local broadcast affiliate to obtain authorization to redistribute the programming. There will probably be no charge to redistribute these signals.
2. Acquire and install the antennas to capture the signal.
3. Acquire and install receivers/demodulators to process the signal.
4. Acquire and install encoding equipment to digitize the signal for transmission over digital TV systems.
5. Acquire and install multiplexing equipment to integrate the acquired signal into the transmission system.
6. Discuss the rights to play or substitute the advertisements currently embedded in the programming as part of the negotiations with the broadcaster.

Cable networks such as Discovery Communications, Bravo Network, MTV Networks Company and Trinity Broadcasting Network typically provide content to cable operators and also provide programming to alternate emission methods for a fee. Alternate emission methods include direct broadcast satellites (DBS) and full-service networks. There are over four hundred cable networks, and many of them distribute more than one channel. Service providers wishing to go directly to the cable networks for programming need to identify each channel contact and negotiate a contract with each of the appropriate networks. Compounding what could be a big task is the basic fact that many cable networks would rather not deal directly with service providers with fewer than 20,000 subscribers. Payment to networks is typically on a monthly basis for the number of subscribers who receive the programming. The cost for the right to receive and distribute cable network programming usually ranges from a few cents to a few dollars per subscriber per month. Some content is free. Some networks, such as shopping and some religious channels, compensate service providers monetarily for carrying their programming.

In many cases the telco will get access to a number of channels by contracting with one network. For example, the channel line-up of Discovery Networks (a unit of Discovery Communications, Inc.) is comprised of twelve distinct feeds on four satellites.

When dealing directly with the cable networks, the telco will have to design your acquisition system to receive many signals from potentially many different satellites or sources. This means you will need very large satellite receiving dishes and/or a number of dishes and antennas.

Programming from production studios such as Columbia, Disney, and Paramount is usually film movies for cinema release, broadcasters, and cable networks. Their content can be used as pay-per-view programming on a set "pay-per-view" time schedule or in an entertainment on demand manner. Distribution of production studio content is very tightly controlled with respect to when it can be shown (time of day and calendar days), how it may be encoded, what programming it may be shown adjacent to, and how and where it is stored.

Production studios take a proactive approach to discouraging illegal copying and distribution of their content. They have strict rules enabling them to maintain possession and control of their intellectual property. They are particularly concerned with digitally encoded programming since stealing of an encoded copy would enable the thieves to make an unlimited number of high-quality copies without generational quality losses.

In addition, the timing of movie presentation by market and method is controlled by a complex marketing procedure called "windows." The production studios make their money by managing presentation windows. The first time window is usually the theater release window, followed by the airplane entertainment window, followed by the hotel release window, etc. Third parties can manage much of the details involved in presenting movies for you. For example, software is available that monitors the encoding, distribution, reception, onsite processing and network equipment required to distribute production studio content according to the content owner's requirements.

If you want to distribute production studio content to your customers, you would need to contract with each studio for rights to redistribute the movie, a process that is neither quick nor trivial. You may have to digitize the movie from videotape before being able to distribute the movie via a digital medium. Typically, you would have to ensure that the copyrights will be protected, account for the number of times the movie was shown on a monthly, subscriber basis within the studio's time window, and pay the studio a share of the revenue gained from the subscribers.

4.1.1.2 Cooperatives

Cooperatives enable member service providers to get excellent pre-negotiated rates on content and greatly simplify the contract process with the content owners.

NCTC, the National Cable Television Cooperative, is an organization of independent cable television companies serving more than 12 million cable subscribers throughout the United States. Through joint purchasing and negotiation, the NCTC functions similar to a multisystem operator (MSO), taking advantage of volume discounts offered by programming networks, hardware manufacturers, and other providers. This results in significant cost savings for members purchasing these products and services. Currently, NCTC member companies save an average of \$4 to \$8 per subscriber per year on programming costs relative to what they would pay for content by going directly to the content providers. Although the NCTC maintains confidentiality regarding pricing, the savings appears to be in the 3% to 5% range.

The NCTC is a not-for-profit, member-operated purchasing organization that negotiates and administers master affiliation agreements with cable television programming networks, cable hardware and equipment manufacturers, and other service providers on behalf of its member companies. In many instances, members with relatively few subscribers pay the lowest cost available to them anywhere and get access to content that they might not otherwise be able to obtain.

The primary advantages of contracting for content through the NCTC are that it saves time and greatly decreases contract administration. Unlike contracting directly with each content provider, members no longer have to deal with confusing programming invoices or the distribution of separate checks to individual networks. Each month, members pay the co-op by check or pre-authorized draft and the co-op pays each network on behalf of participating members.

Contracting directly with each content provider and network can be a considerable amount of work. Service providers who join the NCTC have no need to execute full network affiliation agreements. When members participate in an agreement, they only need provide information on a sign-up form and return it to the NCTC. The co-op then notifies the network for the member.

The NCTC provides for contracts and payment to the content providers but does not provide the aggregated digital programming line-up. Transport of the video content remains the responsibility of the service providers. Many service providers choose to contract for content through the NCTC and to get the program content delivered via an aggregator.

4.1.1.3 Aggregators

Aggregators of television signals aid in the delivery of the content in a very efficient and low cost manner but do not provide the legal right to redistribute actual content or programming. Based on agreements between programmers and television distribution operators, an aggregator will receive television signals from multiple content sources (programmers), statistically multiplex them together and transport the multiplexed signals via satellite to the service provider. Aggregators typically charge a fee for this service known as a transport fee, which typically ranges from \$0.005 to \$0.025 per channel per subscriber per month. Fees are discounted based on the number of channels carried. Some programmers charge no fees for transport. To calculate transport fees, you must have a specific channel line-up and know the number of subscribers.

4.1.1.4 HITS

HITS is AT&T's Headend in The Sky and provides a complete array of digitally compressed programming feeds, minus the basic line-up, for a comprehensive programming strategy that helps address service providers' needs in an efficient manner. The industry term "tier" is used for any group of programs or offerings within a service type. Using this terminology, HITS provides little of the standard "basic" tier and the entire "extended basic" tier.

HITS refers to AT&T's programming line-up as digital tier programming. Digital tier programming includes services like ESPN Classic, ESPN2, and the History Channel. HITS doesn't provide basic services like CNN, TBS, A&E, and ESPN. HITS is defined as a digital transport entity created to provide turnkey digital tier programming to digital headends requiring programming in addition to "basic cable". Although not a complete channel line-up, HITS aggregates a large number of channels on one satellite and greatly simplifies the acquisition of these signals.

HITS provides two basic types of service of value to FSN operators:

1. Digital programming transport.
2. Launch Support, which helps a system manage the digital activation within an eight-week time frame and educates the operator on critical digital processes, allowing for quick marketplace deployment.

HITS is not a programming solution for consumer distribution. By contracting with HITS, you will require at least one full-time employee to work with HITS in an administrative and technical authorization role. This administrative effort will probably be less than if you use the direct method of obtaining content by contracting with each of the individual content providers. A less labor-intensive alternative would be to use HITS aggregated content in combination with NCTC's contract offerings. A number of service providers have seen this as a good combination.

4.1.1.5 Wholesalers

Wholesalers of programming content offer both the content and transport of the signal from the program creator to the service provider. Wholesalers have entered into contracts with the content owners to redistribute programming. The wholesaler receives television signals from multiple content sources (programmers), statistically multiplexes those signals, and transmits them to the service provider. The price of content from a wholesaler may be higher than obtaining programming from originators or through a cooperative with transport from an aggregator. With wholesalers, service providers will receive content sooner, reduce administrative overhead, and pay a consolidated bill to the wholesaler.

4.1.2 Channel Lineup Development

With the deployment of any broadcast television solution comes the task of developing a content programming strategy that provides consumers with a compelling service offering giving them the choice, control and convenience they expect. The content programming task can be especially complex and difficult for new entrants into the broadcast television business.

The programming aspect involves licensing available broadcast services and creating content packages (or tiers) that are competitive in the serving area and provide customers with the value and choice they want. The programming is a critical component of the service since the access to compelling content will be a key driver for new subscribers. Content transport focuses on the delivery mechanism the service provider uses to retrieve broadcast programming from the cable networks and forms part of the overall headend development process. This section of the document provides a comprehensive overview of programming for a cable system, including a detailed review of the content acquisition process.

Cable services are often provided in tiers. A **tier** is a category of cable service or services provided by a cable operator for which a separate rate is charged by the cable operator. There are four types of cable services: basic service, cable programming service, Premium (per-channel), and per-program (pay-per-view) service, described here.

Basic service is the lowest level of cable service a subscriber can buy. It includes, at a minimum, all over-the-air television broadcast signals carried pursuant to the must-carry requirements of the Communications Act, and any public, educational, or government access channels required by the system's franchise agreement. It may include additional signals chosen by the operator. Basic service is generally regulated by the local franchising authority (the local or state entity empowered by Federal, State, or local law to grant a franchise to a cable company to operate in a given area).

CNN, ESPN, A&E, TLC, and off-air broadcasters (NBC, CBS, ABC, FOX, and PBS) are also carried in basic service.

Cable programming service includes all program channels on the cable system that are not included in basic service, but are not separately offered as per-channel or per-program services. Pursuant to a 1996 federal law, the rates charged for cable programming services tiers provided after March 31, 1999 are not regulated. There may be one or more tiers of cable programming service. Examples include: CNN/SI ESPN News, Discovery Science, etc.

Premium (Per-channel) or per-program services include those cable services that are provided as single-channel tiers by the cable operator, and individual programs for which the cable operator charges a separate rate. The local franchising authorities or the Commission does not regulate these services. Examples include: HBO, Showtime, Starz!, iN Demand, etc.

4.1.2.1 Revenues and Rights

Along with regulatory requirements, there are issues and concerns that originate with the owners of programming that must be factored into the channel lineup development. The two biggest issues that are of concern to the programmers are **revenues** and **rights**.

Program and content owners make their money in two ways from affiliation payments (from cable companies, direct-to-home (DTH), and other service providers distributing the programming to end customers) and advertising. The cable television industry has built a model over time, with the cable companies still being the dominant player in the market. Any model that threatens either of these two revenue sources or potentially changes the payments that come from the large cable companies poses a large threat to the programmer's viability. This is important for a new entrant to keep in mind when negotiating carriage, price, and length of term with programming owners. Any change or concession made to a new entrant must be considered in light of the larger picture, and a determination made about how the incumbent companies will react, and how the revenue stream will be affected.

New entrants to the television business are generally looking for a way to differentiate their service; most are digital services with interactive components. All of these factors open the door to things like "pick-and-pay" pricing models for customers, new interactive revenue streams, and channel lineup development that is more flexible than current services in the market. Programmers typically are threatened by ideas that threaten the status quo.

Another related concern that programmers have, which is indirectly tied to both revenue and/or advertising, is the carriage and placement of a channel in the lineup. Carriage concerns relate to the number of customers that will subscribe to the service. If a channel is being proposed for carriage in a optional tier by a new entrant, for example, instead of basic where it is currently carried by the incumbent(s), then the program has the potential to be viewed by less customers, thus reducing the advertising and subscription based revenue.

To minimize the potential for revenue loss, some programmers will try to negotiate contracts that tie their lineup placement with other well-known services. For example, many new services will try to negotiate carriage in a package with A&E, TLC, etc.

The other major concern expressed by most programmers is the issues of "rights". Each programmer sources, negotiates, and pays for, specific rights to distribute content. Depending on the type of content, programmers obtain the right to distribute content during specific time

windows, and for a pre-determined number of “plays.” This issue will become important if a service provider is approaching a broadcaster/programmer to provide services that involve storing/replaying their content, or altering the scheduling of the programming in any manner. For example, services that record programming for the customer, and allow him/her to replay the content at a later time, will be an issue for many content owners.

If a program distribution undertaking wants to provide programming to the end customer in any manner that violates the rights that the program owners have negotiated with their studios/content owners, the program owners will generally not allow them to do so. With sports and movie rights in particular, the dollar values paid to acquire the programming rights are very large. Anything that puts the programmers in a situation where they don’t honor the rights they have negotiated and contractually agreed to will be disallowed.

4.1.3 Competitive Landscape

By understanding the competitive landscape of the market to be served, a new video services operator can develop a programming package that provides subscribers with more choice and control, thereby creating customer value and helping to differentiate their service offering. Competitive analysis of the incumbent cable operator’s channel line-up is a key component to package creation. It is important to understand the packages being offered and the pricing strategy so that a compelling and competitive alternative can be created for subscribers. From a competitive perspective, cable systems with 54 channels or more serve more than half the US subscribers (57% as of October 1999). New service providers need to ensure their offering provides a compelling volume of content to compete with incumbent cable operators and Direct Broadcast Satellite providers. It can be noted that although the majority of systems (58%) only offer 30-53 channels, the majority of subscribers (57%) are served by systems with 54 or more channels.

Another component to examine during the package creation process is the penetration of the top networks, as this will provide some indication of the channels customers tend to prefer. The following table outlines the top twenty cable networks based on the number of subscribers.

Figure 8. Top-20 Cable Networks Ranked by Number of Subscribers¹

Network Programming	Subscribers	Affiliates
TBS Superstation	78,000,000	11,668
Discovery Channel	77,400,000	10,884
USA Network	77,181,000	12,500
ESPN	77,115,000	12,017
C-SPAN	77,000,000	7,047
CNN (Cable News Network)	77,000,000	11,528
TNT	76,800,000	10,637
Nickelodeon/Nick at Nite	76,000,000	11,788
FOX Family Channel	75,700,000	13,818
Lifetime Television (LIFE)	75,000,000	11,000
TNN	75,000,000	14,382
A&E	75,000,000	12,000
The Weather Channel	74,000,000	12,763
MTV: Music Television	73,200,000	9,176

¹ “Cable Television Developments” - Spring/Summer 2000 Volume 24, Number 1 - National Cable Television Association.

Network Programming	Subscribers	Affiliates
CNN Headline News	72,446,000	7,039
QVC	72,175,994	7,511
The Learning Channel (TLC)	72,000,000	6,401
CNBC	71,000,000	5,000
American Movie Classics	71,000,000	4,100
VH-1 (Music First)	68,300,000	5,040

4.2 Transport and Provisioning

Transport is the process of getting the audio and video content streams into your facility. Provisioning is the process of preparing the content for distribution through your emission system. Content is available as analog and digital video and audio. It can come in as the original “baseband” analog audio and video TV transmission, as a high frequency L-band signal from a satellite dish, or as an aggregated feed from a regional digital headend over a wide area network (WAN) connection. After reception at your digital headend, the content may be analog baseband or a multiplex of digital signals. This section describes how each of the content types is usually obtained, how it is provisioned, and how it is handed off to your emission hardware for retransmission.

Content can be obtained off-air via an antenna or downlinked from a satellite as analog or digital video, digital audio or received from a regional digital headend via a wide area network. Receivers and demodulators are used to get the signal into baseband video or digital video and audio MPTS. Encoders and demultiplexers then provide an SPTS that is encapsulated as an ATM stream and sent to the emission equipment. In this manner, virtually any content can be provisioned for emission on a full-service network.

4.2.1 Off-air Local Channel Content

Local station content, primarily commercial television, is typically captured “off-air” by placing an antenna on a tower.

Local channel content from the antenna is a modulated composite video signal.² The signal is first sent through a demodulator, which is essentially a commercial TV tuner. The demodulator retrieves and recovers the video and audio information transmitted on their respective carrier frequencies. Output of the demodulator is baseband composite analog video and analog audio.

² In North America the NTSC composite video signal is 4.2 MHz maximum in a 6 MHz bandwidth.

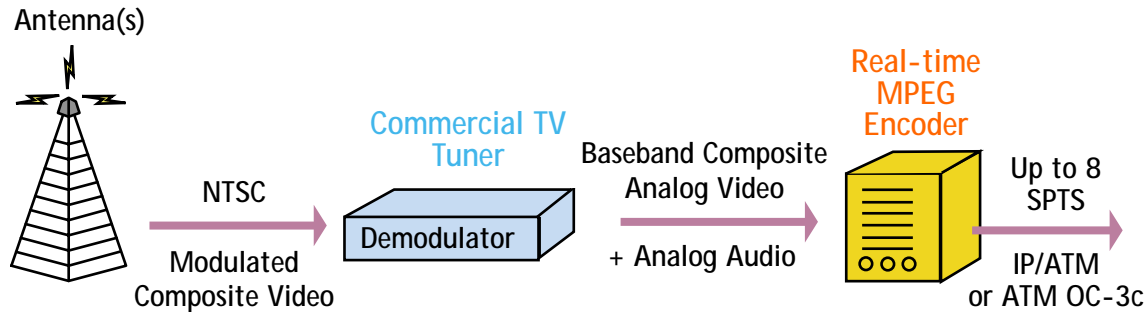


Figure 9. Typical Off-air Local Channel Content Provisioning Chain

The baseband video and audio is then input into a real-time encoder to process it into MPEG-2 transport streams. Output of the encoder for each program stream (channel) is typically a separate MPEG-2 4:2:0 single program transport stream (SPTS). Professional encoders for distributing program material for telco and MDU transmission typically encapsulate the SPTS into a line protocol such as ATM cells on an OC-3 fiber interface. The ATM streams then go to a video concentrator to aggregate the signals to OC-12 or other high-speed optical connections for hand-off to the access network equipment.

4.2.2 Satellite Program Content

4.2.2.1 Analog Video and Music Content

Many networks still have analog content and are in the process of migrating to digital signals. Satellite receiving antennas (dishes) are used to capture the analog satellite content. The antenna's low noise block (LNB) feeds contain a number of transponders's payloads. Each transponder contains one analog program that is typically encrypted for security. In the process of receiving the signal from a satellite, both the incoming satellite frequency band and the LNB local oscillator frequency are injected into a mixer circuit where the two signals beat ("heterodyne") to produce the intermediate frequency (IF) band. The IF band contains all the information present in the original satellite band. The process of producing the IF signal is called block downconversion.³

The L-band signal from the antenna is carried to the digital headend where an analog receiver converts the IF (1 – 1.5 GHz) single program into composite analog video baseband video and analog audio. The receiver also decrypts the encrypted security codes. Typical receivers are called integrated receiver decoders (IRDs). Output of the IRD is baseband composite analog video and analog audio.

³ Long, Mark E. *The Digital Satellite TV Handbook*. Newnes Press: Boston, 1999: p. 79.

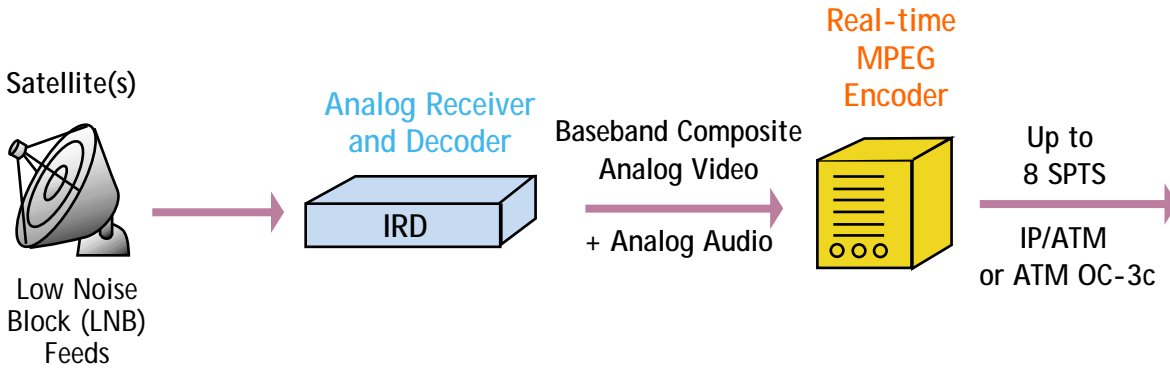


Figure 10. Analog Video and Audio Content Provisioning Chain

The baseband video and audio is then input into a real-time encoder to process it into MPEG-2 transport streams. Output of the encoder for each program (channel) is typically a separate MPEG-2 4:2:0 Single Program Transport Stream (SPTS). Professional encoders for distributing program material for telco and MDU transmission typically encapsulate the SPTS into ATM cells on an OC-3 fiber interface.

The ATM streams then go to a video concentrator to aggregate the signals to OC-12 or other high-speed optical connections for hand-off to the access network equipment.

4.2.2.2 Digital Video and Music Content

There is also a substantial amount of video content that has already been compressed into MPEG-2 format. The content providers are gradually migrating to compressed digital format due to substantial efficiency gains related to leasing the satellite transponder. A single program (channel) of analog content consumes a complete transponder for its transmission. In contrast, MPEG-2 compressed content can be multiplexed on the transponder. Typically, you will find between eight and fifteen channels multiplexed together on one transponder to create a multiprogram transport stream (MPTS).

There are two primary scenarios for receiving compressed digital format from satellites: direct-feed content and aggregated content.

4.2.2.3 Direct-purchase of Content

Direct content providers of digital program material lease transponder space on a satellite. Program streams (channels) are uplinked "directly" to a satellite in an ala Carte manner enabling service providers to pick and choose with great flexibility. Content providers may uplink single content channels as one or more program streams per transponder. Figure 11 shows four content providers each uplinking one or more program streams on each of four transponders. By coincidence, the third and fourth content providers are both uplinking content to the same satellite, but on different transponders. As the service provider, you would need up to three satellite receiving antennas to simultaneously get the content from all four content providers. Each of the antennas would require its own hardware in your digital headend. If you were to receive 100 channels of programming from perhaps thirty content providers, you would need a lot of large satellite dishes.

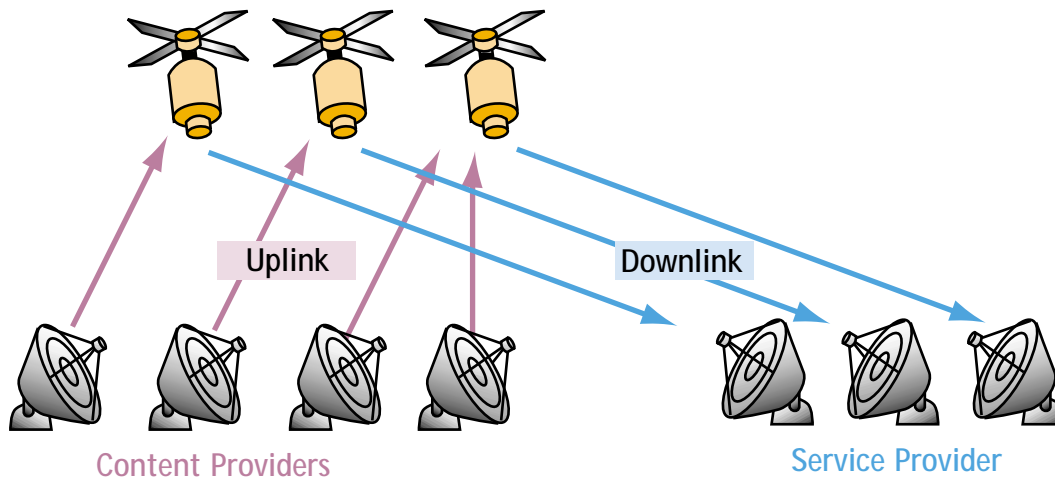


Figure 11. Diagram of satellite feeds for direct purchase of content

This discussion assumes that only one or two program streams per transponder is required. If the content provider is supplying a transponder full of digital streams that you need, the discussion under Aggregated Content, below, is better suited to your needs.

Satellite receiving antennas (dishes) are used to capture the digital satellite content. The antenna's Low Noise Block (LNB) feeds contain a number of transponders' payloads. Each transponder contains one to twelve program streams as an MPTS, each typically either encrypted for security or sent "in the clear". This example assumes that the telco only wants to access and redistribute one of the program streams.

The L-band signal from the antenna is carried to the digital headend where a digital IRD or IRT receiver converts the IF multiprogram transport stream (MPTS) into analog audio and video programs after having been tuned to the one you need.

The receiver also decrypts the encrypted security codes. The IRD outputs two types of signals for MPTS input:

1. A single channel of baseband composite analog video and four channels of analog audio.
2. A single channel of digital video as a single program transport stream (SPTS) with a MPTS of digital audio via DVB-ASI serial data over coax.

For the case where you want to use the IRD's single channel of baseband composite analog video, the video and audio is input into a real-time encoder to process it into MPEG-2 transport streams. Output of the encoder for each program stream (channel) is typically a separate MPEG-2 4:2:0 single program transport stream (SPTS). Professional encoders for distributing program material for telco and MDU transmission typically encapsulate the SPTS into ATM cells on an OC-3 fiber interface.

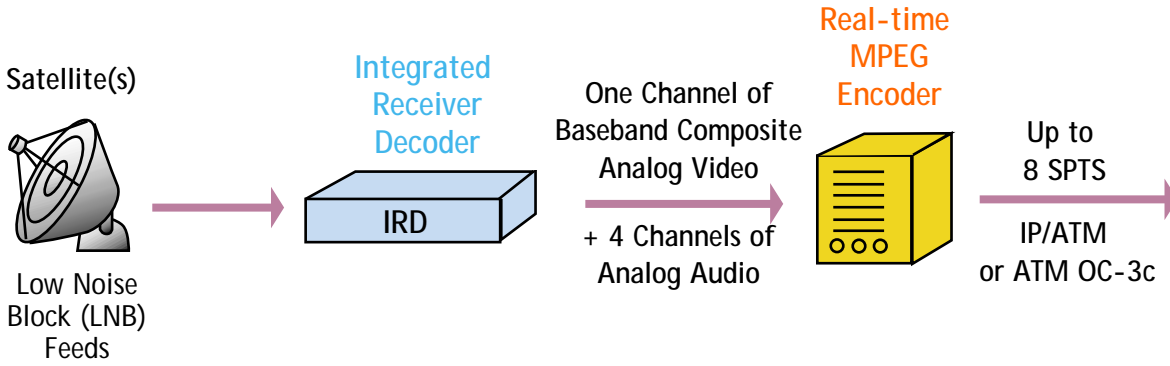


Figure 12. Single Channel Direct-Feed Content Provisioning Chain

The ATM streams then go to a video concentrator to aggregate the signals to OC-12 or other high-speed optical connections for hand-off to the access network equipment.

For the case where you want to use the IRD's single channel of digital video as a single program transport stream, follow the instructions in the next section for aggregated content.

4.2.2.4 Aggregated Video Content

Aggregators, wholesalers, and some networks place as much content as possible on the satellite transponder, typically getting twelve program streams into a multiprogram transport stream. There are a number of efficiencies to using aggregated content, not the least of which is that a single satellite dish can access up to twenty-four transponders, each with up to twelve program streams. Of course, the content you need may well be spread across a number of satellites.⁴

Satellite receiving antennas (dishes) are used to capture the digital satellite content. The antenna's low noise block (LNB) feeds contain a number of transponders' payloads. Each transponder contains one to twelve program streams as an MPTS, each typically either encrypted for security or sent "in the clear". For aggregated content we assume that you will want to access and redistribute a number of the program streams.

⁴ An excellent source for finding which content providers own or lease each transponder on each satellite, the type of content feed, encryption type, and all the necessary specifics of the satellite is the *Phillips Satellite Transponder Guide* available in North American and other editions. For information on this publication, which is updated every two months, contact Phillips Business Information, Inc., 1201 Seven Locks Road, Suite 300, Potomac, MD 20854, telephone: (301) 340-1520. Outside the U.S., contact International Press Publications, Inc., 90 Nolan Court #21, Markham, Ontario, Canada L3R 4L9, telephone: (905) 946-9590.

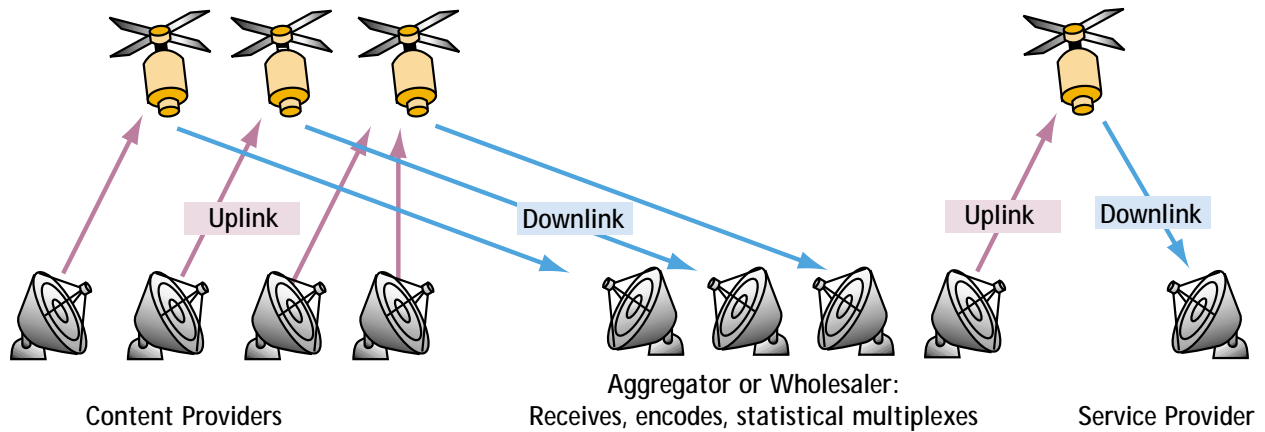


Figure 13. Diagram of satellite feeds for acquiring content from an aggregator or wholesaler

Viewing Figure 13, the transport role of an aggregator or wholesaler becomes clear. Instead of you, the service provider, needing to buy and install all the satellite receiving antennas to downlink your content from the very many satellites on which it was uplinked, the aggregator has done that for you. The fee you pay the aggregator covers their capital and maintenance costs of the satellite receiver farm and whatever grooming they do in the area of encoding or statistical multiplexing. In exchange for this fee, you gain in possibly needing only one satellite dish to download the multiplexed signals.

The L-band signal from the LNB of the satellite dish is carried to the digital headend where a digital receiver converts the IF multiprogram transport stream (MPTS) into a decrypted MPTS. Typical receivers are IRTs (integrated receiver transcoder), and a satellite multiplex decrypter (SMD). Output of the IRTs and SMD are decrypted multiprogram transport streams (MPTS) in DHEI format or DVB-ASI format.

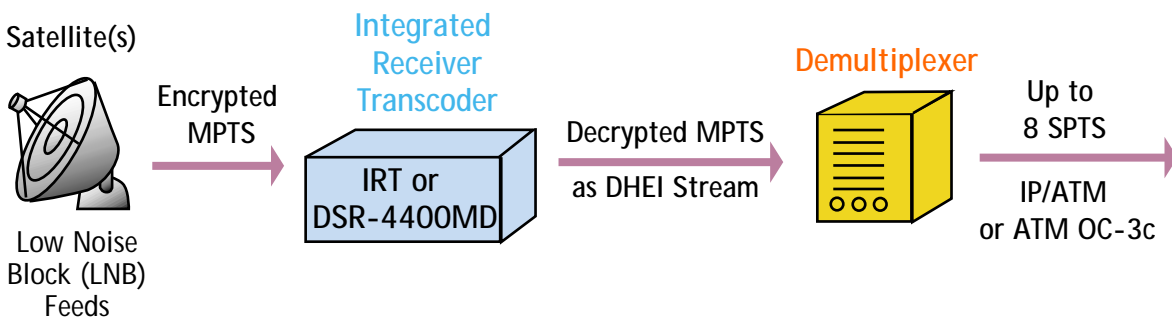


Figure 14. Aggregated Video Content Provisioning Chain

The MPTS of up to twelve multiplexed program streams is then fed into a demultiplexer, which breaks up the MPTS multiplex into single-program transport streams (SPTS) which can then be retransmitted, spliced with advertisements, or deleted.

There are some caveats regarding the bandwidth of each SPTS. For the content to be processed and distributed through the operator's emission architecture, the content must be "well behaved," which means the bit-rates of the video streams can't grossly exceed the payload capacity for the emission architecture.

If the MPEG-2 data rates are grossly above the rates that the emission architecture can handle and too large to address, then recoding of the signal is required. An IRD is installed to transform the content into baseband video and audio. This baseband video and audio is then input into a real-time encoder to process it into MPEG-2 transport streams.

The demultiplexer then encapsulates the SPTS into ATM cells on an OC-3 fiber interface. The ATM streams then go to a video concentrator to aggregate the signals to OC-12 or other high-speed optical connections for hand-off to the access network equipment.

4.2.2.5 Aggregated Music Content

Aggregators and wholesalers deliver audio program content in the same manner as video program content. Two companies that aggregate audio are Music Choice and DMX. Music Choice currently multiplexes forty-five music “channels” as an MPTS on one transponder. DMX when downloaded off HITS places three to thirty music channels per transponder on five transponders. Receiving audio is very similar to receiving video. The audio is simply an MPTS on one or more transponders.

Satellite receiving antennas (dishes) are used to capture the digital audio content along with video content. Each transponder typically contains three to forty-five audio program streams as an MPTS, each typically either encrypted for security or sent “in the clear”.

The L-band signal from the satellite dish is carried to the digital headend where a digital receiver converts the IF multiprogram transport stream (MPTS) into a decrypted MPTS. An IRD, IRT or SMD may be used. Often an IRD is used since it is the least expensive. In digital headends also receiving video feeds, using an IRT often makes sense. Output of the IRD, IRT or SMD is a decrypted multiprogram transport stream (MPTS) in DHEI format.

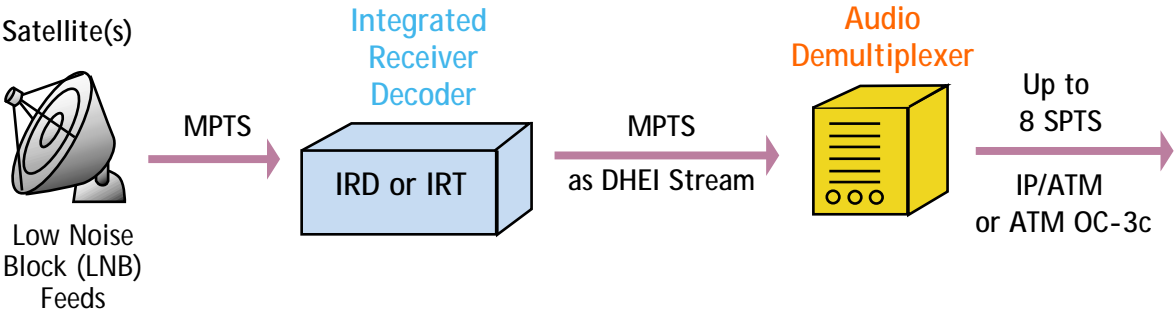


Figure 15. Aggregated Audio Content Provisioning Chain

The MPTS of up to fifty multiplexed audio program streams is then fed into a demultiplexer, which breaks up the multiplex into single-program transport streams (SPTS) that can then be retransmitted. To retransmit all of the audio channels currently available on the five DMX transponders, two demultiplexers are required. The demultiplexer then encapsulates the SPTS into ATM cells on an OC-3 fiber interface. The ATM streams then go to a video concentrator to aggregate the signals to OC-12 or other high-speed optical connections for hand-off to the access network equipment.

4.2.3 Features and Benefits of the Approaches

This section discusses the various combinations of contracting for content and transporting it to your digital headend. Note that what is expressed as a strength or weakness may be just the opposite for a given environment.

The five scenarios to be discussed are:

1. **Direct contract with no aggregator:** Here you contract with the network or content owner for each program feed and design a system for getting the content feed into your digital headend.
2. **Using a cooperative for contracting with no aggregator:** Here you join a co-op to get good pricing and efficiency in contracting but continue to design a system for getting the content feed into your digital headend.
3. **Direct contract with an aggregator:** Here you contract with the network or content owner for each program feed but use the services of a content aggregator to simplify getting the content feed into your digital headend.
4. **Using a cooperative for contracting with an aggregator:** Here you join a co-op to get good pricing and efficiency in contracting and then use the services of a content aggregator to simplify getting the content feed into your digital headend.
5. **Use of a wholesaler for contracting and aggregation:** Here you go to a one-stop wholesaler who handles all the contracting for you, makes getting the feeds to your digital headend relatively easy and hands you a single bill each month.

4.2.3.1 Direct Contract with No Aggregator

As a technically proficient entrepreneur, you may feel that the best procedure for your situation and possibly the only way to guarantee that the job will get done right is to do it yourself. If you believe that and if you have enough subscribers to cover your up front costs, then this route might be for you.

You will need to identify the appropriate person to call and contact each network or owner of the program content and request permission to acquire their signal and retransmit it to your subscribers.

When contacting the content provider, be it a network or otherwise, one of your employees needs to be prepared to:

- Locate the appropriate resource at each content provider – They need to know whom to call at each network and their phone number. In general, most content providers are responsible for more than one program feed, such as The Discovery Channel, Animal Planet, and The Learning Channel.
- Describe your telephone company, its business plan, its cable plant, and the number of subscribers – This is sometimes difficult for a telco when talking to the content types. You guys speak different languages.
- Ascertain the content provider's satellite alignment and assignments, channel assignment, etc. – The point here is that you are asking for permission to use a specific piece of content available on one transponder of very many satellites circling the globe, and you need to state which one you want permission to access. If you are given permission, decryption codes will

be uploaded by the content provider to the satellite so that your digital headend equipment can decrypt the signal. You need to know precisely which signal you plan to access.

- Negotiate legal documents acceptable to both parties – This may be as simple as a standard network contract or could involve both of your lawyers. And yes, this has to be done for each and every content provider.
- In addition, you should plan to:
- Budget the appropriate personnel and resources – Plan on a minimum investment of at least six months by a full time employee for a 100-channel total offering. This process can get involved and is unfortunately not a part-time task.
- Obtain pricing and cost information – Remember that the typical cable network is familiar with contracts dealing with millions of subscribers. If you hope to negotiate a special discount, keep in mind that you might need over 100,000 subscribers to qualify.
- Assemble a dedicated staff to work through the start-up process of receiving the signals.

The benefit of directly dealing with programmers is that your telco will own the contract and could negotiate to receive promotional information and programs from the programmer. You should be aware that the same programs can be downlinked from different satellites. The same program is priced differently based on satellite, encryption scheme, coding, etc. A little research will go a long way.

You need a good resource for finding the right person to call at each content provider. We suggest the *International Satellite Directory*, which lists all the content providers and contact information as well as information about the satellites transmitting the content.⁵

On the transport side, if you elect to acquire each piece of content yourself without using an integrator, you may require a large number of satellite receiving antennas (dishes) and wind up real-time encoding a number of program streams. If you do not choose to use a content aggregator, you are looking at the most capital intensive of the alternatives. But, if you negotiate favorable contracts and have enough subscribers, you can wind up with the greatest return in the long run.

4.2.3.2 Using a Cooperative for Contracting with No Aggregator

If contacting and negotiating with thirty or more networks and content providers is seen as a hassle, then joining a cooperative, such as the NCTC (the National Cable Television Cooperative) could be right for you. This section describes working through the co-op for the rights to retransmit content but still has you building the infrastructure and getting the satellite dishes to acquire all the signals.

This alternative requires the same number of satellite receiving antennas (dishes) as does the “direct contracting with no aggregator” discussed in the previous section.

The NCTC is a cooperative holding distribution contracts for multiple programmers. The Organization was created to address second tier franchise cable programming issues:

⁵ *International Satellite Directory*. Volume 1 is The Satellite Industry, Volume 2 is Satellite Systems and Operators. Published as a set of two books annually for around \$400 by Design Publishers, 800 Siesta Way, Sonoma, CA 95476, U.S.A. Telephone (707) 939-9306. Email: <http://www.satnews.com>.

- **Inability to negotiate due to lack of subscriber volume.** – You won't be able to negotiate a custom package from the content providers, but you will get the NCTC quantity discount.
- **Contract and legal complexities with a small staff.** – The NCTC has a standard contract that you will probably find acceptable. You could still have someone review and possibly renegotiate, but this would probably not be quickly accomplished. The NCTC has a small staff to keep expenses down, so don't expect to get a lot of quick attention from them.
- **The NCTC is NOT a transport solution.** – With the NCTC you will be contracting only for the right to retransmit content. You must still acquire and transport the signal.

NCTC member companies save on per-subscriber per-month programming costs. In addition there are savings on hardware and equipment that system operators purchase on a regular basis. You will still require full-time employees to support contracts on all video services. With the NCTC, the telco must still make the arrangements for the downlink from the appropriate satellites.

4.2.3.3 Direct Contract with an Aggregator

In this approach, you would again need to contact and contract with each content provider from whom you wish to gain carriage rights. In addition, you would contract with an aggregator, such as HITS, for the aggregation of the content. In this way, you would own the contract for the content and receive the digital feed from HITS. You could possibly have a more simple acquisition system and satellite receiving antennas than by receiving all the signals without aggregation. As a rule, your capital expenses for the digital headend should be much smaller with this alternative since you will require fewer satellite dishes and be doing far less real-time encoding (HITS does it for you).

4.2.3.4 Using a Cooperative for Contracting with an Aggregator for Transport

A popular solution for telcos is to join a cooperative for simplicity in contracting and contract with an aggregator for easy transport of the content. This combination results in a decreased number of required satellite receiving antennas (dishes), a very low number of expensive real-time encoded channels, and a relatively quick time to market.

By contracting for content through the NCTC and arranging for transport through HITS, you may be able to receive programming within about eight weeks. You would complete the standard NCTC contract, map the channels according to the HITS line-up, and receive project management support from HITS in coordinating the efforts amongst HITS, the NCTC and the content providers. Monthly, you would receive one consolidated invoice from the NCTC for content and another from HITS for transport of the signal. Your digital headend would receive a digital signal from HITS and potentially have a simpler acquisition system configuration.

The following pros and cons of using a cooperative like the NCTC for content and an aggregator like HITS for content transport have been mentioned in the previous discussions, but not in this combination. For detailed comments on each, please refer back to "Pros of Content Contracting through a Cooperative" and "Pros of Using an Aggregator to Obtain Content Signals":

4.2.3.5 Use of a Wholesaler for Contracting and Aggregation

Using a wholesaler for all the content provider contracting and transport of the signal to your digital headend requires the fewest number of satellite receiving antennas (dishes) and real-time

encoder channels. This results in the lowest up front capital expenditure and also possibly the fastest route from concept to retransmission of entertainment content.

Contracting with a wholesaler, such as S², WSN^{et}, and others for content is the least labor-intensive route for a service provider such as you. You would have one point of contact for content and transport, “24 x 7” technical support, and a digital signal which does not require encoding. You would be responsible for authorization, authentication, and accounting of subscribers but would only have one monthly invoice. A possible downside is that since you will be dealing with the wholesaler and not the content owner, you would have no contact with the programmers. You would also have to adjust to work within the parameters of the wholesaler’s distribution guidelines.

For many telcos, the wholesaler route is a very feasible approach to contracting for and obtaining content to retransmit.

Figure 16. Summary of Pro and Cons – Content Contract and Transport Approaches

	Pros	Cons
Direct Content Contracting	<ul style="list-style-type: none"> ▫ Direct contact ▫ Ability to negotiate marketing support 	<ul style="list-style-type: none"> ▫ Slow to market ▫ Resource intensive ▫ Individual contract negotiations ▫ Risk of rejection ▫ Individual billing ▫ Individual reporting ▫ Poor chance for volume discount
Contracting through a cooperative	<ul style="list-style-type: none"> ▫ Standard Contracts are accepted by content providers ▫ Volume discounts ▫ Consolidated billing ▫ Speed to market ▫ Deployment cooperation with HITS ▫ Marketing and launch support ▫ Centralized subscriber reports 	<ul style="list-style-type: none"> ▫ Limited channel line-up might require contracts with additional programmers ▫ Limited promotional support ▫ Must be a cable operator ▫ Probably need a full-time employee to manage relationship ▫ Decide on transport system
Using an aggregator	<ul style="list-style-type: none"> ▫ Enables partnership with today's major players in digital cable. ▫ Optimize overall system bandwidth. ▫ Twelve video services in the space of a single 6 MHz analog channel. ▫ 140+ channels aggregated. ▫ launch support. 	<ul style="list-style-type: none"> ▫ HITS is an AT&T company ▫ HITS maps channel assignments ▫ HITS charges a transport fee ▫ Basic tier content is not available
Using a cooperative and Aggregator	<ul style="list-style-type: none"> ▫ Standard Contracts are accepted by content providers ▫ Volume Discounts ▫ Consolidated billing ▫ Speed to market ▫ Marketing and launch support ▫ Centralized subscriber reports ▫ Enables partnership with today's major players in digital cable ▫ Optimize overall system bandwidth. ▫ Twelve video services into the space of a single 6 MHz analog channel ▫ 140+ channels aggregated ▫ Launch support 	<ul style="list-style-type: none"> ▫ Limited channel line-up would require contracts with additional programmers ▫ Limited promotional support ▫ Must be a cable operator ▫ Probably need a full time employee to manage relationship ▫ HITS is an AT&T company ▫ HITS maps channel assignments ▫ HITS charges a transport fee ▫ Basic tier content is not available
Using a wholesaler	<ul style="list-style-type: none"> ▫ Single source ▫ Digital signal ▫ Large number of channels 	<ul style="list-style-type: none"> ▫ Programming costs ▫ Transport fee ▫ Bandwidth.

	Pros	Cons
	<ul style="list-style-type: none"> ▫ Single invoice ▫ 24 x 7 technical support ▫ Some launch support ▫ Speed to market 	<ul style="list-style-type: none"> ▫ No direct support from programmers

4.3 Processing

This section of the document covers the two basic solutions for processing content through the headend:

- 1) encoding of base-band signals (see Figure 9 and Figure 10) and
- 2) transcoding of digital feeds (see Figure 14 and Figure 15).

The technology selection for transport is dependent on the content programming decision and should be made once a high-level programming plan and channel line-up has been developed. It is important to note that carriers should expect to receive local services in analog format and cable signals in either an analog or digital format.

4.3.1 Reception

The multiple television programs and real time content distributed by the service provider must first be received at the headend. These content services can arrive in a multitude of different formats. Each format requires different technology and solutions to accomplish reception and processing to insure compatibility with IP and pure ATM broadband solutions. The range of content formats can be divided into two main groups: **uncompressed** and **compressed**.

4.3.1.1 Uncompressed Formats

Uncompressed formats include all analog and some digital formats. The significant issue with uncompressed formats is the requirement of encoder technology to create a bandwidth-efficient service. The requirement of an encoder may add significant cost to providing the service.

Reception of traditional analog formats is still very common, especially for local program sources. Analog sources require technology for reception and signal processing. For the traditional headend, signal processing of analog signals occurs after reception and before broadcasting. For the IP Broadband headend, the focus is on video compression technologies such as encoders, multiplexers, and transcoders. Due to the importance of digital compression technology for the IP Broadband headend, signal processing of analog signals is better grouped into the functionality of reception. The goal of signal processing in the IP headend is restricted to converting all analog signals to baseband signals as a common analog input format to digital video encoders.

Each analog feed needs to be evaluated to determine the appropriate equipment required to receive and to convert the service to baseband. Great care should be taken for the design and implementation of reception of analog services. Reception is the most critical stage for insuring picture quality. Analog signals are very susceptible to noise insertion, generational loss and signal degradation. Any video/audio artifacts introduced at this stage can be considered to impact picture quality twice. First, the encoder spends valuable bits attempting to faithfully encode the unwanted

video/audio artifacts. Second, the spent bits are not available to contribute to overall picture quality. The types of equipment necessary to accomplish reception include satellite dishes, microwave antennas, antennas for off-air TV and FM radio signals, low noise amplifiers, video filters, demodulators, etc.

Baseband audio/video describes the common signal formats of NTSC, PAL and SECAM with associated audio (stereo or mono). These formats define a single A/V (audio/video) program (or channel) and can be composite, S-video, or component signals with one or two channels (L and/or R) of audio. Component requires three conductors or cables to carry the luminance component (Y) and two color components (Cb and Cr). S-video requires two conductors to carry the luminance (Y) and combined color information (Cb/Cr). While, composite requires a single conductor (video cable) to carry the combined luminance and color information as per the NTSC, PAL or SECAM standards.

Digital feeds such as SMPTE 259M-C and ITU-R BT.601 may also be received from contribution or studio sources. These formats can either be fed directly to encoders or must first be converted to baseband.

Successful encoding in a production environment ensures that noise and interference do not happen. Noise (analog artifacts) severely impacts the quality of the encoding process. The encoding engine will attempt to faithfully encode all noise artifacts. The encoded analog artifacts represent negative aspects of the picture quality. The bandwidth spent on these artifacts cannot be used for encoding the actual content (positive aspects) represented in the original video feed. Effectively, this situation represents a portion of the costly bandwidth actually working against the final picture quality.

If reception design cannot rule out noise insertion then the video has been compromised. In this situation, filtering is necessary to improve the S/N prior to the encoding process. This approach can ensure that the compression performs well but at the expense of softening the video (lowering resolution). Basic horizontal and vertical filtering is offered on a range of encoder products. Today, however, most of these encoders are configured with their filters turned off, as setting the filters for effective reduction of variable noise has not proven effective in practice.

If the quality of the received feeds is in doubt, consider using encoder products that employ sophisticated dynamic noise filtering prior to the encoding process. The best solutions would involve noise filtering that is MPEG-aware.

4.3.1.2 Compressed Formats

An ever-widening range of compressed digital video formats may need to be considered, ranging from contribution formats (such as MPEG-2 HP@ML 4:2:2) to distribution formats (such as DVB-ASI and ATSC or MPEG-2 MP@ML 4:2:0). The array of possible contribution and distribution formats can be received through ever increasing methods as well: QPSK, QAM, DWDM, RF, SONET, SDH, ATM and any future means capable of carrying digital video with sufficient bandwidth. For distribution formats (such as MPEG-2 MP@ML) consider the actual parameters of each individual program in order to determine if the service is a candidate for digital turn-around.

Evaluate compressed digital feed type to determine the appropriate equipment required to receive the service. This may require satellite dishes, antennas, demodulators, descrambling, conditional access provisioning, demultiplexers, and decoders, etc.

The headend strategy for compressed digital video can be handled in a similar manner as uncompressed video. Compressed digital video can be decoded to baseband and presented to digital video encoders. This is known as the “decoder-encoder cascade.” This method permits easy baseband splicing and ad insertion. The encoder provides full control of the parameters of the resulting stream, making this an easy solution to implement. When large bit-rate reductions are required, this method is better than re-quantization.

Negative impacts of this method are 1) the cost of decoding and encoding technology and 2) the fact that the original encoding information is lost when decoded to baseband. The headend encoder must make new encoding decisions based on the decoded baseband signal. This results in a significant degradation of picture quality known as generational loss.

4.3.2 Compression

The name MPEG is an acronym for Moving Picture Experts Group, a group formed under the support of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). The MPEG standards define the syntax for specifying the coded representation of A/V information “for digital storage media and digital video communication and specifies the decoding process.”

There are currently three different MPEG standards: MPEG-1, MPEG-2 and MPEG-4. Target data rates and applications distinguish them. MPEG-1 is intended for intermediate data rates of 1.2 to 1.5 Mbps appropriate for the target applications of CD-ROM and VideoCDs. MPEG-2 is intended for higher bit-rates of 3 to 15 Mbps, appropriate for broadcast distribution of commercial interlaced standard definition television (SDTV). MPEG-4 is now targeted for very low to high bit-rates appropriate for applications ranging from Internet and mobile to broadcast distribution of SDTV with and without interactivity.

Broadcast distribution uses syntax for digital audio that includes MPEG-1 Layer 2 (ISO 11172-3) and Dolby Digital™ coding AC-3. Digital video is commonly distributed using MPEG-2 MP@ML 4:2:0 (ISO 13818-2) syntax. These video and audio elementary streams are packetized in the “so-called” Packetized Elementary Stream (PES) sub-layer, defined in Part 1 of the ISO/IEC 13818 standard (MPEG-2). The audio and video PES packets are further multiplexed with in the Transport Stream packet layer. The Transport Stream packet layer and the PES packet sub-layer together form what is referred to as the Transport Stream system layer (ISO 13818-1).

4.3.3 Encoding

Uncompressed feeds, both analog and digital, must be processed by an MPEG encoder to lower the bandwidth before transmission over a service provider’s infrastructure, and to make it compatible with the decoder in the STB.

Real-time broadcast encoders are available that accept analog baseband and serial digital video, and analog or digital audio. These devices compress inputs and output a broadcast-ready multiplexed MPEG-2 transport stream. The stream quality depends upon the quality of the encoder design, the chosen stream parameters, and the quality of the received feeds.

Noise (analog artifacts) severely impacts the quality of the encoding process. The encoding engine will attempt to faithfully encode all noise artifacts. The encoded analog artifacts/noise represent negative aspects of the picture quality. The bandwidth (bits) spent on these artifacts cannot be used for encoding the actual content (positive aspects) represented in the original video feed.

Effectively, this situation represents a portion of the costly bandwidth actually working against the final picture quality. If the quality of the received feeds is in doubt consideration should be given to encoder products, which may employ sophisticated noise filtering prior to the encoding process.

Encoders can operate in standalone mode. However, many manufacturers offer remote systems for control of large broadcast encoding deployments. Depending upon the scale or size of the headend and the desired quality of service (value-add to carrier class), consider 7x24 products that offer network management and redundancy tools.

Encoder products typically offer different controls/parameters set by the manufacturer. Basic and common parameters of interest are as follows:

Bit Rate – A parameter of paramount importance, as it defines the bandwidth requirements of the service. It also has the greatest effect on picture quality given an encoder product. The stream/service bit-rate is the sum of audio bit-rate plus video bit-rate, plus system layer overhead.

Resolution – A parameter to be chosen carefully in conjunction with the chosen bit-rate. Increasing the horizontal and/or vertical resolution at lower bit-rates can lead to bit starving an encoder during difficult sequences resulting in visible macroblocks. However, low resolution settings at high bit-rates will likely result in a picture quality not reaching its full potential.

GOP structure – A parameter that determines the degree of compression. For a wide range of content and bit-rates between 1 and 4 Mbps, a GOP size of 15 to 30 and 2 B frames provides for effective compression.

Bytes per IP packet – A parameter for the IP environment that is important for achieving successful playback on the client. Some clients require large packet sizes to keep their IP stack from overloading. However, larger packet sizes can effectively create a source of network jitter and limit the agility of channel changers.

The following is a list of basic requirements for broadcast encoders:

- real-time
- MPEG-2 Transport (ISO 13818-1)
- MPEG-2 Video 4:2:0 MP@ML (ISO 13818-2)
- MPEG-1 Audio Layer 2 (ISO 11172.3)
- Closed Captioning EIA 608 (NTSC line 21)
- Ethernet 10/100 Mbps (NIC)
- IP (UDP/IP)
- IGMP v.2 (RFC2236 – IP multicast).

Other traits to consider when choosing an encoder product are:

- High reliability and supportability
- Hot standby or hot swappable modules/components
- Redundancy solutions

- Superior encoding (picture quality)
- Cost effective
- 19" rack-mountable and/or compact
- Centralized control through standardized network management tools
- In-service adjustment of MPEG parameters

Dual pass encoding involves the use of two encoders to create a single stream. The first encoder processes the uncompressed video using the chosen MPEG parameters. The statistics from this process, such as picture complexity, motion, scene cut detection, bit-rates, quantizer step, etc are collected and used to optimize the settings of the second encoder, which actually creates the product (stream). Alternatively, the second encoder may simply attempt to locate areas of the compression which may benefit from further transcoding. As these approaches are ideally performed over an entire Group Of Pictures (GOP) a significant delay equal to the GOP size is added to the encoding process.

4.3.3.1 Encoding of Baseband Signals

Baseband encoding can be used for all content possibilities since all content can be converted to baseband format. Off-air signals can be captured from an antenna and demodulated to baseband. Digital feeds can also be decoded to base-band and then re-encoded. For digital feeds, this solution is known as the "decoder-encoder cascade."

Figure 9 shows local channels captured from antennas off-air and demodulated to baseband combined with a decoder-encoder cascade. These analog signals are input to encoders. This arrangement provides the service provider with full control over the parameters of the resulting encoded stream. However, this solution also results in the encoding decision information of the source stream being lost, so some degradation in signal quality will occur.

4.3.3.2 Transcoding Digital Feeds

Compressed digital feeds can be captured and processed in the digital domain to create a compatible service stream. This approach is referred to as Digital Turnaround (DTA). DTA may be more cost effective than the decoder-encoder cascade solution. Depending upon the level of processing required, the effect on picture quality by the headend can be minimized or eliminated.

Ideally, a service provider does not want to be responsible for the picture quality of programming services. A service provider only profits on providing a service of content distribution. As a distributor, the service provider desires to be as transparent as possible with respect to picture quality. For services provided via DTA, the provider of the digital feed is responsible for picture quality.

The parameters of the incoming digital feed must be understood to accomplish Digital Turn-Around. Parameters could include codec (MPEG-2, Dolby Digital™ AC-3), resolution, modes and instantaneous bit-rate. Typically, the individual programs of MPTS are encoded as variable bit-rate (VBR). Given the constraints of the service providers infrastructure, the peaks of the unprocessed variable bit-rate SPTS may be increasingly.

In part, the applicability of the DTA solution depends on 1) the bandwidth requirements of the signal received, and 2) the transcoder's ability to reduce the required bandwidth using stream

optimization, requantization, and resolution change. Figure 17 illustrates DTA applicability as a variant of Figure 14.

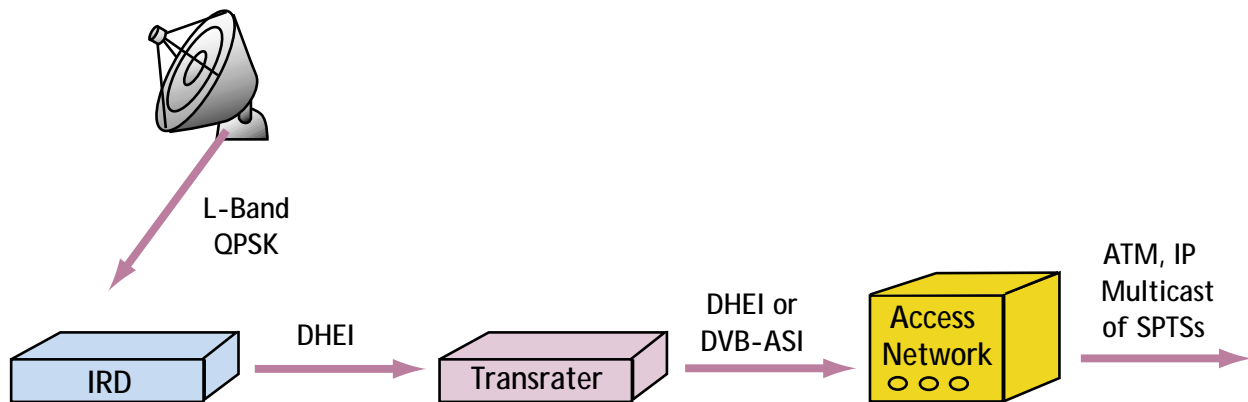


Figure 17. Digital Turnaround (DTA)

The strategy for a DTA solution is best suited for a smaller service provider that wants a transport solution providing the lowest investment costs. In most cases a hybrid DTA and full encode solution is required. The advantages and disadvantages of a DTA or a DTA/Full Encode solution include:

Advantages:

- Faster time to market
- Little up-front investment for headend equipment
- Proven experience in the content delivery industry

Disadvantages:

- Limited local content available in digital format (MPEG2)
- Inflated content and transport costs for larger service providers
- Limited control over the contractual obligations (i.e. bitrate, MPEG 4, etc.)

4.3.4 Monitoring and Redundancy

It is common practice to conduct quality assurance before distribution of any product. For digital video, this can be conducted before and during distribution and at a variety of levels. Four key testing levels can be defined for compressed digital video systems. The levels relevant to monitoring quality of service include video, digital signal compression, and digital signal formatting. Video monitoring is a requirement in the headend only. A local STB should be capable of accessing any program service stream. This is a useful debug tool, though it requires personnel to operate and confirm service health.

Codec monitoring or picture quality analyzers are products capable of determining the health (efficiency and effectiveness) of an MPEG-2 codec. These products are just becoming available and are currently targeted at the satellite and cable industries. Currently, these products only accept streams in ASI format. Because of this limitation, extra technology is currently required to integrate

these tools into the broadband headend. As the IP broadband industry grows, these products will likely become available with appropriate interfaces. This technology will provide automated and subjective measurement of the performance of the digital signal compression layer. Alarms generated from this equipment could be used for redundancy and live codec parameter modification. For digital turnaround, logs generated using this equipment can be used for confirmation of contractual obligations.

The health of the MPEG-2 transport stream (digital signal formatting) can be determined by products called DV protocol analyzers. These products conduct a real-time MPEG-2 transport stream analysis and verify the health of the Digital Signal Formatting layer. Monitoring at this layer ensures successful distribution of content and is therefore relevant throughout the service provider's infrastructure. Currently targeted at the satellite and cable industries, these products only accept streams in ASI format. This would currently require extra technology in IP broadband headends. This technology will provide automated and subjective measurement of the performance of the digital signal formatting layer.

To minimize service disruption to customers, redundancy and emergency planning strategies should be considered for all components of reception. Some components can be protected through automatic redundancy while some hardware must be manually replaced. Regardless, all components need to have a replacement strategy.

One-to-one redundancy means each component is backed up by a spare. This configuration provides the maximum assurance of uninterrupted service, though is the least commonly implemented due to cost and space requirements. N+1 redundancy means there is one backup component for a group of identical components. This is the most common implementation of component redundancy. N+2 redundancy means there are two backup components for a group of identical components.

4.4 Conditional Access

4.4.1 *The Piracy Problem*

Piracy of content has been a problem since the introduction of analog cassettes. With the advent of digital recording and transmission technologies, the threat of content piracy becomes an increasingly crucial concern for content owners and broadcast platform operators. New technology now makes it significantly easier for pirates to not only duplicate content but also distribute that content to a wide audience. A compelling example of the type of new technology that makes piracy easy and widespread is the wildly popular Napster peer-to-peer file swapping system. Despite the fact that the Recording Industry Association of America's (R.I.A.A) lawsuit forced Napster to shut down their service, the world has been shown how easy it is to pirate copyrighted content. Small, highly compressed audio files were the first example of a media that was easily pirated and distributed. The growth of broadband fiber optic networks and broadband connections to the home means that the piracy of much larger video files could be the next target of content pirates. Therefore, the implementation of a secure, IP-based conditional access (CA) system is critical if rights holders want to prevent the easy theft and redistribution of their content and services on IP networks.

4.4.2 The Importance of Conditional Access (CA) in Pay-TV Markets

Today, MPEG2-based video-on-demand (VOD) services are increasingly being offered by a number of cable multiple system operators (MSOs) around the world. These operators use their existing, proven, conditional access (CA) infrastructure to encrypt and provision their VOD streams.

In the United States, the providers of these VOD solutions must integrate with leading CA and STB providers, whose proprietary technology largely dominate the market. In other parts of the world where CA and STB vendors comply with the DVB standard, VOD solutions must comply to DVB standards in order to integrate their offering into a Pay-TV operators existing infrastructure.

However, in the telecom market where the delivery of IP-based video services is an emerging concept, there are no defined standards such as DVB, and there are no de-facto standards based on proprietary technology of well-established incumbent technology providers.

At the same time, it is important to note that one of the most difficult elements of being a Pay-TV operator is gaining access premium content. In order to entice consumers to pay for video content, it is imperative that Pay-TV operators offer content that is appealing, popular, and in-demand. The rights-holders of such content are typically the same organizations that already sell to the cable MSOs. These rights-holders often require that interested buyers pass stringent content protection requirements and provide valid proof that the transmission and reception of content is done in a highly secure fashion; otherwise the content community is not obliged to sell their content. This implies the need for a secure, reliable and proven conditional access system.

4.4.3 Conditional Access Basics

Conditional Access systems impose secrecy on a transport medium by encrypting the data stream, whether it is voice, video, data or a combination of the three, using a "service key" that changes every few seconds. This service key is itself encrypted and made available only to authorized subscribers and is transmitted using a "secure channel". It is the function of a Pay-Media Smartcard and Headend Encryptor to ensure that the keys or secrets used to make that "secure channel" remain secret.

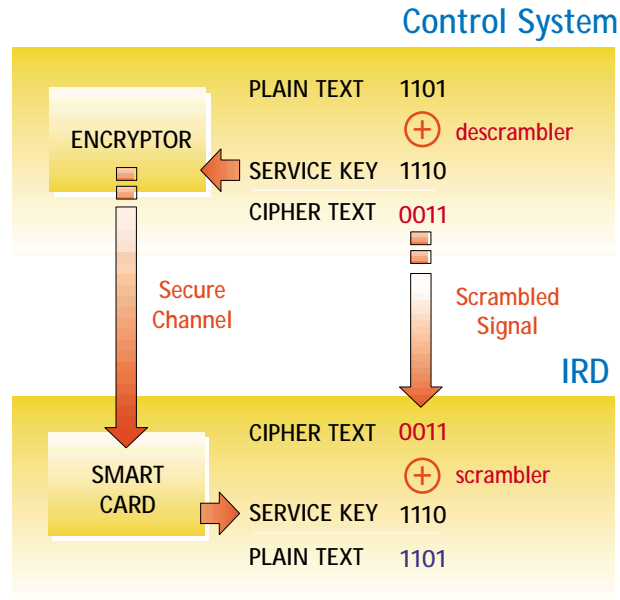


Figure 18. Conditional Access Illustration

For a Pay-Media system to remain secure over an extended period of time, it must continuously evolve to keep pace with technological advancements that aid content pirates. These include cryptographic analysis capability, microcircuit-probing tools and low-cost, high-performance microprocessor technology. For this reason, many operators favor renewable security elements over less secure security systems such as those that are embedded in the IRD or exist as software in the IRD. Many CA vendors use smartcard technology because it is believed that it represents the most effective balance between cost, operational convenience, and security.

Smartcard replacement can involve significant expenditure and potential disruption of service for an operator, so vendors make every effort to maximize the security of the system and maintain a close relationship with customers so that the life of the Pay-Media smartcard can be extended.

But security is more than just an issue of physical smartcard security; other key factors include:

- Overall CA system architecture and cryptographic integrity;
- Management of system keys and system secrets at the headend;
- Availability of cost effective technology for a piracy business;
- Intelligence gathering and monitoring of pirate groups;
- Legislative environment with respect to copyright and intellectual property;

4.4.4 Requirements for an IP VOD CA Solution

The previous section described the basic functionality and operation of a CA system. However, because CA systems were originally designed to operate in one-way broadcast (multicast) environments it is important to realize that the requirements for CA solutions in unicast environments are different.

4.4.4.1 All-Format Encryption and Standards

Encryption in a VOD system should be transparent to the underlying formats and protocols used to deliver the content. In the world of emerging technologies, and competing standards, the easiest

mechanism to deploy a secure, protected service is to remove dependencies between components, including the IP video streamer, the CA system, the transmission equipment, the middleware, and the client STB. It is even more important to choose a set of components that are based on industry standards where applicable, and whose technologies employ industry-standard software APIs for easy integration.

Session Based Encryption

Since VOD sessions are not pre-defined broadcasts that can be encrypted for all recipients, the CA system must be able to dynamically encrypt a stream and send out the appropriate entitlements to the receiver, this is known as session based encryption.

Massive Scrambling

Broadcast mediums typically have a fixed amount of a bandwidth with a fixed amount of products, which are grouped together to form packages. Therefore, the amount of throughput is usually fixed or varies only slightly. VOD on the other hand—especially in DSL networks—requires a system that can provide variable-bit-rate encryption and can scale up to support several hundred or even thousand concurrent streams and products. Thus, it is required that a CA system for such an environment be able to sustain high throughput rates for scrambling.

Unicast and Multicast

The system should be capable of supporting both unicast and multicast streams. Undoubtedly, multicast streams will be utilized to offer broadcast IP TV services, while unicasting capabilities will be required for VOD applications. Together this system will allow broadband operators to roll out a security system capable of up to handling millions of subscribers, with thousands of concurrent video streams.

Real-Time Encryption

Real-time encryption, which utilizes *key cycling*, is the most secure mechanism for the distribution of premium content over IP networks. It also permits easy trick play functionality in a secure manner without any costly format related integration.

Persistent Encryption

A critical element of any security solution is the ability to add value to securing content from the time of transmission to the time of viewing by the end user. The CA solution should fulfill the requirement to store content in insecure locations such as local loop exchanges, multi user dwellings and local storage devices in the home such as home gateways, PC's, and STB's. This ensures that content is safe from theft throughout the entire course of it's journey to the STB.

4.4.4.2 Authentication / Secure transaction

All telco networks are inherently two-way networks. This implies the need for a 2-way security protocol that can support return encryption to facilitate secure impulse purchase of services, as well as 3rd party transactions. Transactions can be secured end-to-end through a combination of both industry standard encryption technologies such as PKI and SSL in addition to the latest smartcard technology. Secure authorization, based on identification and authentication will be integrated in the smartcard in addition to support for multiple ID's per household. Open Internet

and 'walled garden' T-commerce applications will be supported (on-line banking, shopping), as well as on-line gaming, gambling, voting and betting.

4.4.4.3 Flexibility and Scalability

Any CA solution IP Networks should be designed to be flexible and scalable to meet the needs of diverse networks and operator requirements. The system can be applied in centralized and distributed networks. It should be designed to manage between thousands and multiple millions of subscribers, and to handle thousands of individually and simultaneously encrypted streams. The system can be utilized in a redundant configuration and scaled at any point in the network. The decryption software should be integrated into a wide variety of client receiver devices including but not limited to IP STBs and PC's.

Glossary

Aggregator	Aggregators of television signals aid in the delivery of the content in a very efficient and low cost manner but do not provide actual content or programming. Based on agreements between programmers and television distribution operators, an aggregator will receive television signals from multiple content sources (programmers), statistically multiplex them together and transport the multiplexed signals via satellite to the service provider. Aggregators typically charge a fee for this service known as a transport fee.
Asynchronous Transfer Mode (ATM)	A high bandwidth, controlled-delay fixed-size packet switching and transmission system. Uses fixed-size packets also known as “cells”. A communication mode capable of transmitting at very high speeds, typically from 155 Mbps to 622 Mbps. Provides on-demand, high-speed digital connections between service-provider servers and the broadband network.
Avail	Avails are set times defined by the networks for each of their channels in which the local service provider may insert local commercials. The networks have set times when the ads or commercials may appear and have inserted network advertisements in those places in case the service provider doesn’t have an ad to run. The networks do not charge for avails and each channel from each network has its own guidelines for avails, such as the time when they occur, the length available, etc.
Baseband	The original frequency span of the video and audio signals before they are modified for transmission or otherwise manipulated. Also, the form of the audio and video after the process of removing such modifications, since the signal can get “back to baseband”. The term is often synonymous with “analog”. For most entertainment video, broadband is the original native representation of the analog signal as audio (20 Hz to 20 kHz) and video (100 Hz to 4 MHz).
Bundling	The grouping of different services, such as offerings of voice, data and video. Bundling differs from Packaging, which is the grouping or “tiering” of the same service, such as two or three voice offerings, data offerings or video channel offerings.
Cable Networks	Programmers that grew to create and distribute multiple channels of programming over cable and satellite, but not as standard terrestrial broadcast stations available through rabbit ears, are known as Cable Networks.
C-Band	C-band – Frequencies in the 4 to 6 GHz range used both by terrestrial microwave links and for satellite links. The spectrum from 3.7-4.2 GHz is where satellite TV and other fixed satellite services are broadcast. C-Band was used for uncompressed video for the original satellite video services.
CBR (Constant Bitrate)	Constant Bitrate. A method of provide guaranteed levels of service and throughput in delay-sensitive applications, such as video. QoS class defined by the ATM Forum for ATM networks. CBR is used for connections that depend on precise clocking to ensure undistorted delivery. Contrast with VBR.
DBS	Digital Broadcast Satellite. Transmitting high power television signals directly to homes via satellite.
Demodulator	Device that performs the process of returning a modulated signal to its original form. Modems perform demodulation by taking an analog signal and returning it to its original (digital) form.
Demultiplexing	To separate two or more signals that were previously combined. Separating of multiple input streams that were multiplexed into a common physical signal back into multiple output streams.

DHEI	Digital Headend Expansion Interface, a proprietary General Instrument (Motorola) interface.
Digital Head-End	A central point of communications processing equipment that receives television and program audio content from various sources. The digital headend performs digitization and other content processing as necessary, and prepares the combined television channels for retransmission across telephone, IP, wireless and other networks.
Direct Broadcast Satellite (DBS)	Digital Broadcast Satellite also known in some areas as Direct To Home (DTH) satellite broadcast. The satellite transmission of TV programs directly to the consumers' home.
FCC	Federal Communications Commission. U.S. government agency that supervises, licenses, and controls electronic and electromagnetic transmission standards. The Federal Communications Commission has a tremendous role to play in creating fair rules for competition in this new era of broadband communication.
Full-service Network (FSN)	A system that provides home entertainment, voice telephony, and data services (including Internet access) across a single network. The full-service network (FSN) is a telecommunications infrastructure capable of providing all of today's known telecommunications applications as well as laying the foundation for future applications. This definition does not imply that the infrastructure is owned by one entity or that only one medium carries all applications.
HITS	HITS is AT&T's Headend in The Sky and is an aggregator that provides a complete array of digitally compressed programming feeds for a comprehensive programming strategy that helps address service providers' needs in an efficient manner. HITS programming feeds, offer service providers up to 12 digital signals in the space of one 6MHz analog channel.
IF (Intermediate Frequency)	Intermediate Frequency. In the process of receiving the signal from a satellite, both the incoming satellite frequency band and the LNB local oscillator frequency are injected into a mixer circuit where the two signals beat ("heterodyne") to produce the intermediate frequency (IF) band. The IF band contains all the information present in the original satellite band. The process of producing the IF signal is called block downconversion.
IRD	Integrated Receiver/Decoder, a General Instrument (Motorola) term. Digital headend equipment that receives satellite L-band QPSK signals and tunes to the selected transponder. Downconverts and demodulates bitstream from QPSK carrier. Typically converts a single video program stream into composite analog baseband video and analog audio. The output is an "in the clear" baseband video/audio signal suitable as input.
IRT	Integrated Receiver Transcoder, a General Instrument (Motorola) term. A device that receives and demodulates a satellite L-band QPSK signal, tunes to the selected transponder, and performs error detection and recovery of the satellite signal and decryption as required. The IRT then forwards the signal via Digital Headend Expansion Interface (DHEI) to downstream equipment. Downconverts and demodulates bitstream from QPSK carrier. The IRT then remodulates the data from QPSK to QAM for cable plant transmission in the RF mode.
Ku-Band (or K-Band)	Ku-band - The spectrum from 11.7-12.2 GHz where satellite TV and other fixed satellite services are broadcast. Also in North America the spectrum from 12.2-12.7 GHz where the small dish (18-inches) antenna DBS satellite systems operate. KU-band is typically used for compressed video services.
L-Band	Used loosely for satellite systems. This is the intermediate frequency (IF) output by the LNB.
LEC	Local Exchange Carrier. Local telephone company, providing connections between local points or to long distance carriers for extended connections. Examples are Pacific Bell in

California, Illinois Bell in Illinois, Verizon in Hawaii, etc.

Low Noise Block (LNB)	The LNB (Low Noise Block Downconverter) is the first stage in electronic reception for a satellite dish. This block is attached directly to the feed horn of the satellite dish. The LNB receives the incoming signal, amplifies it, bandpass filters it and mixes it with a signal from a local oscillator. The resulting IF (intermediate frequency) signal can then be sent over coax cable to equipment in the digital headend. The LNB sets the noise floor for the satellite receiving system.
May-carry	Stations the cable operator is allowed to replicate on to cable, but is not required to.
MDU	Multi-dwelling unit. Includes apartment buildings (both garden style and high rise), condominiums and town houses.
MMDS	Multi-channel Multipoint Distribution Service. A wireless access network technology that uses downstream microwave transmission.
MPEG	Motion Picture Experts Group. Standard for compressing video. MPEG-1 is a bit stream standard for compressed video and audio optimized to fit into a bandwidth of 1.5 Mbps. MPEG-2 is intended for higher quality video-on-demand and broadcast-to-the-home applications and is specified up to 15 Mbps but typically runs at data rates between 4 and 9 Mbps. MPEG-4 is a low-bit-rate compression algorithm initially intended for 64-kbps connections.
MPEG-2 4:2:0	A digital compression decoder standard devised by the Motion Picture Experts Group that uses a relatively sparse chrominance sampling (4:2:0) that is less resolved in the vertical dimension. This is visually acceptable in the consumer domain where there is no multi-generation cascading at low bit-rates. Targeted to set-top boxes and other consumer uses (such as DVD).
MPTS (Multi- Program Transport Stream)	Multi Program Transport Stream: A transport stream carrying multiple programs. The multi program transport stream is a multiplex of a number of single program transport streams (SPTS). See SPTS.
MSO	Multi-system operator. A major cable TV organization with franchises in multiple locations.
Multichannel Video Programming Distributor	<p>Multichannel video programming distributor (MVPD) is a term used in the Telecommunications Act. For the purpose of this paper, we use the more familiar term "service provider".</p> <p>A multichannel video programming distributor (MVPD) is any entity such as a cable operator, a telephone company, a multichannel multipoint distribution service (MMDS), a direct broadcast satellite service (DBS), or a television receive-only satellite program distributor, who makes multiple channels of video programming available for purchase by subscribers or customers.</p>
Multiplex Decrypter	The output tap providing that subset of the function of an IRT which is used by the M2-VMX (i.e. the demodulated and decrypted stream prior to re-encryption.) This function is now available as a stand-alone instrument from Motorola and is known as the DSR 4400MD.
Must-carry	As an alternative to requesting and receiving a retransmission consent, local commercial and noncommercial television broadcast stations may require a cable operator or full-service network that serves the same market as the broadcaster to carry its signal. A demand for carriage is commonly referred to as "must-carry."
MVPD	See "multichannel video programming distributor". For the purpose of this paper, we use the more familiar term "service provider".
NCTC	NCTC, the National Cable Television Cooperative, is an organization of independent cable television companies serving more than 12 million cable subscribers throughout the United

	television companies serving more than 12 million cable subscribers throughout the United States. Through joint purchasing and negotiation, the NCTC functions like a multi-system operator (MSO), taking advantage of volume discounts offered by programming networks, hardware manufacturers and other providers.
OC-12	A SONET-based fiber-optic User-to-Network Interface (UNI), either public or private, operating at 622.08 Mbps over single-mode and multimode optical fiber.
OC-3	A SONET-based fiber-optic User-to-Network Interface (UNI), either public or private, operating at 155.52 Mbps over single-mode and multimode optical fiber.
Open Video System (OVS)	Under the rules of the Telecommunications Act of 1996, a LEC or other entrant may provide video programming to subscribers, although the OVS operator must provide non-discriminatory access to unaffiliated programmers on a portion of its channel capacity.
Overbuilder	Overbuilders are usually facilities-based cable companies that install their own fiber-coax and build-out their own high-bandwidth networks to compete with local incumbent cable companies, telcos and entrenched DBS providers.
Packaging	Packaging is a term used by cable network programmers. It refers to the situation where you or the wholesaler negotiate with a network that produces multiple channels of content. In those negotiations, the network may require you, the service provider, to carry a package of channels, meaning more than the one channel you asked for. Packaging is the tiering of the same service, such as grouping a number of program channels, in contrast to Bundling, which is the grouping of different services.
Pay-per-view (PPV)	A variant of video delivery services and is the transaction permitting a viewer to receive authority to view a particular video event. The event may be live or recorded and is aired at prescribed times. In order to obtain the rights to view the event, the viewer must be authorized to receive such events; the provider of the event must authenticate the viewer can and has received the program and that the accounting or billing of the event has taken place.
PCO	Private Cable Operator. A private video system within a building or group of buildings, generally not going over public right-of-ways.
PEG	Public Access, Educational and Government. Usually used with respect to "must carry" content from these sources. Also referred to as PEGLO channels
PEGLO	Public, Education, Government and Local Origin. Usually used with respect to "must carry" content from these sources. Most people prefer to use the abbreviation PEG.
PES	Packetized Elementary Stream. An elementary stream that is divided into variable length packets. The header of each packet provides additional information to process the stream.
QoS	Quality of Service. For networks, Quality of Service (QoS) is the idea that transmission rates, error rates, latency and other characteristics can be measured, controlled, and, to some extent, guaranteed in advance. QoS is of particular concern for the continuous transmission of high-bandwidth video and multimedia information. Transmitting this kind of content dependably is difficult in public networks using ordinary "best effort" protocols. Asynchronous Transfer Mode (ATM) technology supports QoS levels.
QPSK (Quadrature Phase-Shift Keying)	A modulation technique based on phase modulation. Used in satellite systems that carry digital video. A digital modulation method that combines two carriers that are 90 degrees out of phase (in quadrature), resulting in four possible phase states.
Retransmission Consent	The permission to retransmit a commercial broadcast station's programming is commonly referred to as "retransmission consent" and may involve some compensation from the cable operator to the broadcaster for the use of the signal.
SPTS (Single Program	The single program transport stream contains different PES streams (see PES, Packetized

Transport Stream)	Elementary Stream), which all share a common time base. The different PES streams could carry video, different audio and perhaps data information, but all would be used with the same time base. An application for this would be a movie transmitted in different languages.
Telecommunications Act of 1934	An act to provide for the regulation of interstate and foreign communication by wire or radio, and for other purposes. The update and version of 1996 is the primary reference and controlling document for transmission of television and related signals in the United States.
Telecommunications Act of 1996	<p>The Telecommunications Act of 1996 is the first major overhaul of telecommunications law in almost 62 years. The goal of this new law is to let anyone enter any communications business -- to let any communications business compete in any market against any other.</p> <p>The Telecommunications Act of 1996 has the potential to change the way we work, live and learn. It will affect telephone service -- local and long distance, cable programming and other video services, broadcast services and services provided to schools.</p> <p>As a rule, individuals who feel they need to obtain and read the "Communications Act of 1996" really want to read the Communications Act of 1934 as updated and amended by the Communications Act of 1996. The official title of this document is "Telecommunications Act of 1996, Pub. LA. No. 104-104, 110 Stat. 56 (1996)."</p>
Tier and Tiering	A tier is a group of programs or offerings within a service type. Tiered program groupings are offerings such as "basic" and "extended basic" cable. Examples of tiered groupings would be "sports", "news and information", "family", "kids", etc. Tiering is the act of combining channels into a tiered group.
Title VI	Refers to part, or Title, six (VI) of the Telecommunications Act of 1996. Title VI covers Cable Communications.
VBR (Variable Bitrate)	Variable Bitrate. A method of giving each frame the optimum number of bytes, while still meeting set constraints, such as the overall data rate and the peak data rate. The bitrate varies and is not constant over time. VBR is a QoS class defined by the ATM Forum for ATM networks. VBR is subdivided into a real time (RT) class and non-real time (NRT) class. VBR (RT) is used for connections in which there is a fixed timing relationship between samples. VBR (NRT) is used for connections in which there is no fixed timing relationship between samples, but that still need a guaranteed QoS. Contrast with CBR.
Video Demultiplexing	The separation of the individual programs within a Multiple Program Transport Stream into individual Single Program Transport Streams.
Wholesaler	Wholesalers of programming content offer both the content and transport of the signal from the program creator to the service provider. Wholesalers have entered into contracts with the content owners to re-distribute programming. The wholesaler receives television signals from multiple content sources (programmers), statistically multiplexes those signals and transmits them to the service provider.

About the Contributors

Aliant/Innovatia

Headquartered in Atlantic Canada, Innovatia focuses on designing and commercializing Internet-based innovations. Innovatia accelerates the design, development and sale of applications to service providers worldwide through the LivingLAB innovation, research and development approach. Using IP technology, Innovatia provides a variety of advanced Internet-based open standard services for governments, enterprises and service providers, including interactive television, e-business solutions as well as Web-based knowledge services. For more information about Innovatia please visit www.innovatia.net. Innovatia is a wholly owned subsidiary of Aliant Inc. (TSE:AIT), one of Canada's top high-tech companies. Aliant provides integrated communications and IT solutions through subsidiaries operating worldwide.

Analog Devices

With revenues of \$772 million for the first quarter of fiscal 2001, Analog Devices is a leading manufacturer of precision high-performance integrated circuits used in analog and digital signal processing applications. The company is headquartered in Norwood, Massachusetts and employs approximately 9,800 people worldwide. It has manufacturing facilities in Massachusetts, California, North Carolina, Ireland, the Philippines, Taiwan and the United Kingdom. Analog Devices stock is listed on the New York Stock Exchange and the company is included in the S&P 500 Index.

Aware

Aware, Inc. designs, develops, licenses and markets DSL technology that enables broadband communications over existing telephone networks. Its solutions, including splitterless G.lite, full-rate ADSL, VeDSL™, Dr. DSL®, DMTflex(TM), and G.shdsl address central office as well as consumer electronics requirements. The company licenses its intellectual property and software to semiconductor manufacturers and equipment manufacturers who sell products incorporating Aware's technology. Aware also markets to systems companies to encourage them to design its technology into their products, and to service providers to encourage them to deploy new broadband services based on its technology. More information about Aware can be found at <http://www.aware.com>.

iMagicTV

iMagicTV (Nasdaq:IMTV and TSE:IMT) provides software products and related services that enable telephone companies and other service providers to deliver multi-channel digital television and interactive media services to their subscribers over a broadband network infrastructure. iMagicTV's software can be deployed over high-speed broadband networks including ADSL, VDSL, wireless, Ethernet and Fiber to the Home (FTTH) technologies. Incorporated in 1997, iMagicTV maintains its global headquarters in Saint John, New Brunswick, Canada, its European headquarters in Cambridge (United Kingdom) and its Asia Pacific headquarters in Singapore. The Company also has offices located throughout the United States in Raleigh, NC, Atlanta, GA, Dallas, TX and Denver, CO. For more information, visit <http://www.imagictv.com>.

Inovia Telecoms

Formerly ECI Telecom's Access Solutions Division, Inovia's technological excellence is derived from years of experience in the telecommunications market. Inovia's solutions for the multi-service access gateway market enhance the value of carriers' infrastructure to support robust, value-added services, including video channel streaming, multicasting, Video-on-Demand, Fast Internet and TV

Commerce. Suited for any network topology, Inovia's modular access gateway is the preferred solution for mass deployment by leading providers worldwide. Inovia has an extensive worldwide sales network, supported by subsidiaries in the U.S., Europe, Asia, and Latin America. Additional information about the company is available on Inovia's site: <http://www.inoviatele.com>.

In-Stat/MDR

In-Stat/MDR (<http://www.instat.com>) covers the full spectrum of digital communications research from vendor to end-user, providing the analysis and perspective that allows technology vendors and service providers worldwide to make more informed business decisions. In-Stat/MDR is a unit of Reed Business Information (<http://www.cahners.com>), a leading provider of critical information and marketing solutions to business professionals and a member of the Reed Elsevier plc group.

Irdeto Access

Irdeto Access is a company headquartered in Hoofddorp, Netherlands, specializing in designing, developing and marketing solutions for protecting content from unauthorized access. Irdeto Access provides affordable, secure, and user-friendly conditional access solutions for the pay media industry (both TV (DVB) and Internet (IP)). Internationally renowned for innovation, Irdeto Access was the first company to offer MPEG2/DVB Conditional Access, as well as the first to provide technology for securing IP scrambling and conditional access for the IP multicast and unicast environment.

Pace Micro Technology plc

Pace Micro Technology plc is a pioneer of digital technology for the home and has helped build the global market for pay television services. Using this expertise, Pace is evolving the set-top box into a sophisticated home gateway to enable revenue-generating services for TV and the networked home. Pace Americas office is based in Boca Raton, Fla., with its head office in West Yorkshire, England. Additional offices are throughout England, the U.S., France and Hong Kong. The company's shares are traded on the London Stock Exchange (PIC). For further information, please visit Pace's web site.

VideoTele.com

VideoTele.com is the single source supplier of Digital Headend solutions enabling home entertainment delivery via the broadband Internet. Building on 20 years of experience in video over telecommunications networks, VideoTele.com assists broadband providers with innovative products, strategic consulting and premier performance in system design, deployment and support. VT.c's Digital Headend solutions are used today at RBOCs, ILECs and CLECs, and VT.c is the number one provider of these products to Independent Operating Companies (IOCs). Headquartered in Lake Oswego, Oregon, VideoTele.com is a subsidiary of Tektronix, Inc. Additional information on the company can be found by accessing the VideoTele.com website at: <http://www.videotele.com>.

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