IPTV Technologies and Deployment Challenges

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Outline

What is IPTV?

Market Drivers

Triple Play/IPTV – A Quick Introduction

Technology Enablers

Network Transport Architectures

Challenges

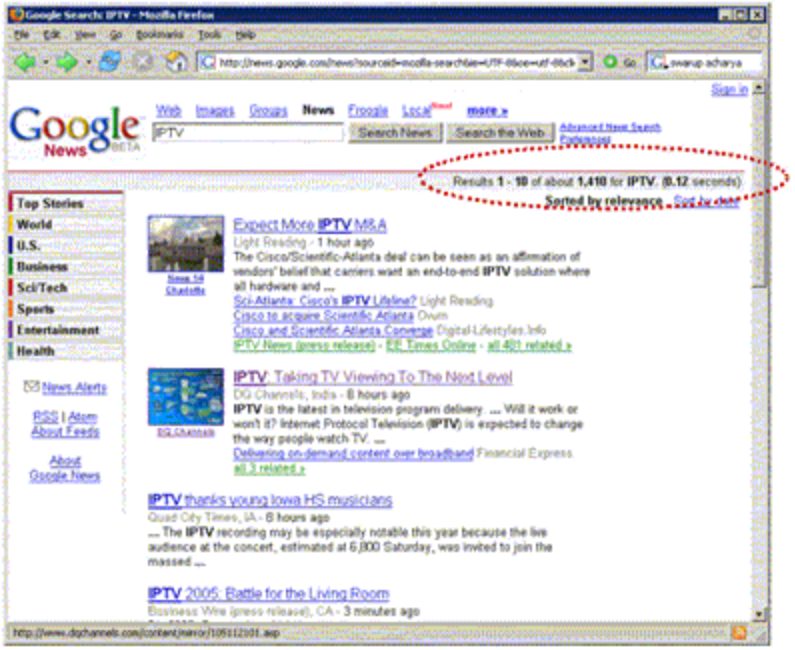
Competitive Threat

IPTV Vendors and Service Provider Strategies

Conclusion

IPTV Buzz

Its pouring IPTV in the press..



Unmanaged IPTV

Video over Broadband data network, or, Internet

- "Broadband Television", Or, "TV over Internet"

Two options:

- Video over PC
  - E.g., AOL TV service In2TV
- Video on TV (requires special set-top box)
  - E.g., Akimbo, DaveTV

Best-effort service for streaming/live broadcasts

- Providers have no control over the access network

Available since the early Internet days

Managed IPTV

The IPTV buzz is really around Managed IPTV

- TV service from Telcos (or, Cable Cos)

Service over "managed" access network

- Service provider controls access equipment outside or, even, inside the home
- Multiple access technologies --- DSL, Cable, FTTx

Service, quality guarantees from provider

TV on PC may also be offered

- e.g., Time Warner trials

Telco IPTV: TV from Telecom Providers

Traditional telecom providers starting video services

- Well publicized trials, M&As
  - E.g., Siemens-Myrio, Cisco-Scientific Atlanta

In US, two very different approaches:

- RF over Fiber (similar to Cable network)
  - Verizon's FiOS
- IPTV over hybrid fiber, DSL
  - SBC, Bell South

Even greater activity in the international market

- Asia Telcos undisputed IPTV leaders, Europe follows
- Bell Canada, FastWeb, PCCW (Hong Kong)

More details on specific deployments later in tutorial

Market Sizes

Market analysis points to significant revenue and customer growth over next 5 years

Global growth prediction (MRG., Inc, Aug 2004)

Year	Subscription Forecast (Millions)	Revenues
2004	2.1	$685M (Europe + Asia: 56%)
2008	27	$15B (Europe + Asia: 80%)

Lightreading.com 2010 forecast: 65M customers, $21B Telco equipment investment.

IPTV Market Drivers

Declining Voice Business

Voice revenues are the Telco cash cow

However, steady erosion from VoIP and wireless

Forecasts show year-over-year revenue drop for North America (Yankee Group, 2004)

Year	Consumer ($ B)	Business ($ B)
2003	74.4	62.2
2004	69.8	59.9
2005	65.4	57.9
…		
2007	57.2	54.0

VoIP Attack!

Cable Multiple System Operators (MSOs) and Independent VoIP providers *(e.g. Vonage)* offering residential and enterprise voice services

- Attractive w/ *Call-waiting, Caller-Id* etc. for < $30

VoIP subscriber growth predictions (Yankee group):

Year	US (Thousands)	Global (Thousands)
2004	565	997
2005	1791	2992
....		
2009	17091	31404

Higher ARPU in Video Business

Customers also willing to pay more for video

Surveys show compared to voice spending alone (~$50/month), ARPU for:

- Voice + Data: 2x Voice
- Voice + Data + TV/Video: 4x Voice

By offering Pay-per-view and Video-on-Demand, TV providers also expecting to grab share of the video rental market (e.g., Blockbuster)

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Bundling Offer:
Triple Play – Voice, Video & Data

- Bundling of services enables lower package price
  - Translates to reduced cost for customers
  - Drives higher ARPU on the customer base by selling multiple services
- Lowers customer churn
  - *Cox Communications* reported reduction *50%* reduction in customer churn (Instat/MDR 2003)
- Allows operational efficiencies from the integration of OSS systems
- Reselling partnerships with Satellite a stop-gap triple-play offer

So, Why Now?

- Telcos have to defend their territory
  - Survival, no longer a matter *choice*
- FCC's unbundling relief to ILECs for Fiber to the curb deployments
  - Clears the regulatory uncertainty holding the fiber deployment by RBOCs
- DSL advances *(ADSL, ADSL2+, VDSL)*
  - Higher bit rate, better reach
- Mature video standards *(MPEG-4 H.264)*
  - Halved bandwidth requirements

Telco Fight Back..

Bell South CTO Bill Smith (Lightreading.com, 7/15/2005):

"From a competitive perspective, voice over IP has been a very good vehicle for cable companies to come in and attack our core business. I think IPTV may be an equally good opportunity for us to go in and attack their core business."

But, no illusions about the rocky road:

- VoIP: 8 Kbps, 3min (avg call), IPTV: 6+Mbps, 24x7
- Consumer VoIP entry as 2nd line
  - *Only one TV service* into the home (i.e., quality is key!)

IPTV: Challenges and Opportunities Galore!

Triple Play/IPTV—A Quick Introduction

Basics

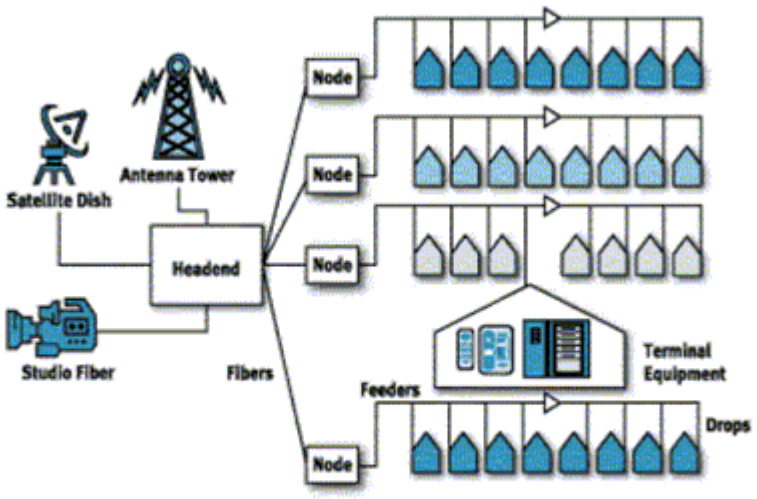
Triple-play refers to delivery of voice, video and data over a single pipe

- Quadruple-Play: T-play + Wireless offer

IPTV is digitally encoded video switched and delivered over managed IP infrastructure

Access network could be *xDSL*, Fiber-to-the-Home *(FTTH)*, Fiber-to-the-Node *(FTTN)*, Fiber-to-the-curb *(FTTC)*

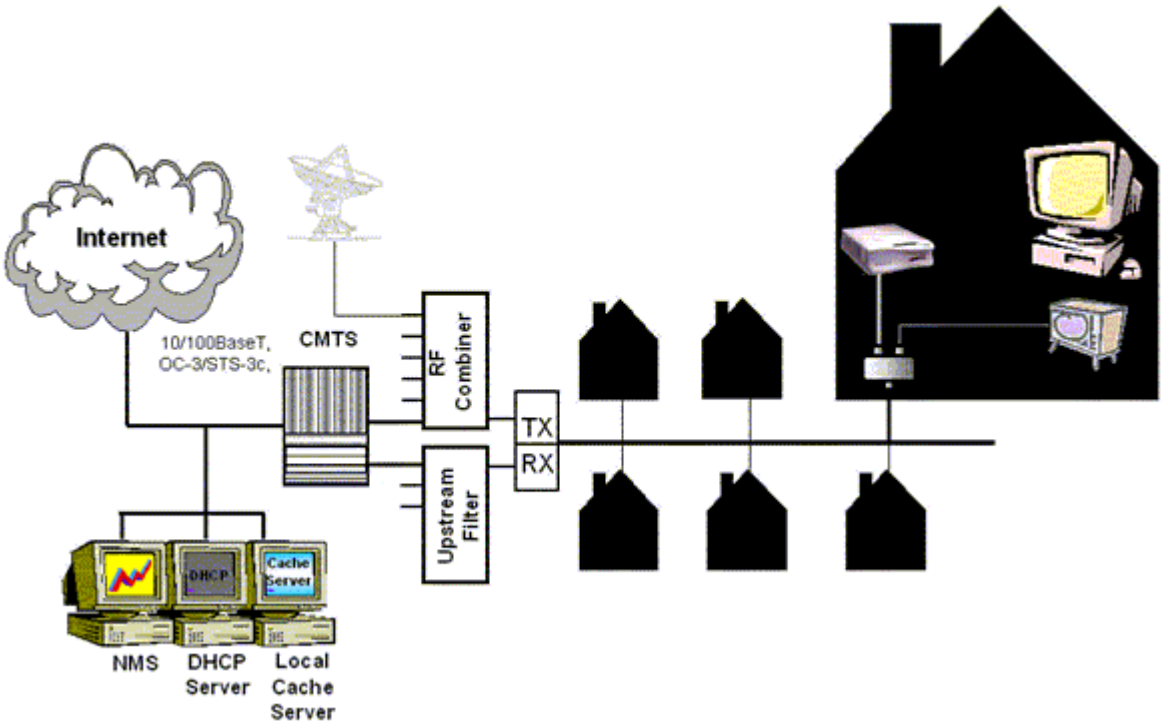
The Cable Plant Architecture



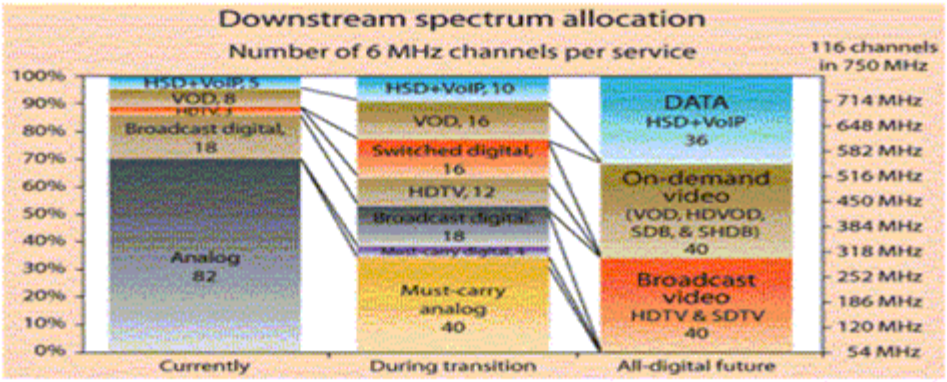
Today, most plants are HFC – Hybrid-Fiber Coax

- Fewer amplifications
- Two-way communication

Cable Modem/Data Architecture



Cable Spectrum



Downstream bandwidth is shared among all users in the loop (typically, ~ 500-700 households)

- About 4.5 Gbps total bandwidth
  - 40 mbps per 6Mhz channel

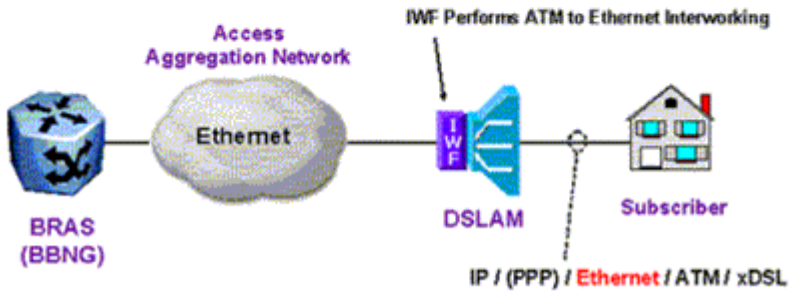
Data+Voice bandwidth to rise from 5% (today) to third of total

DSLAM

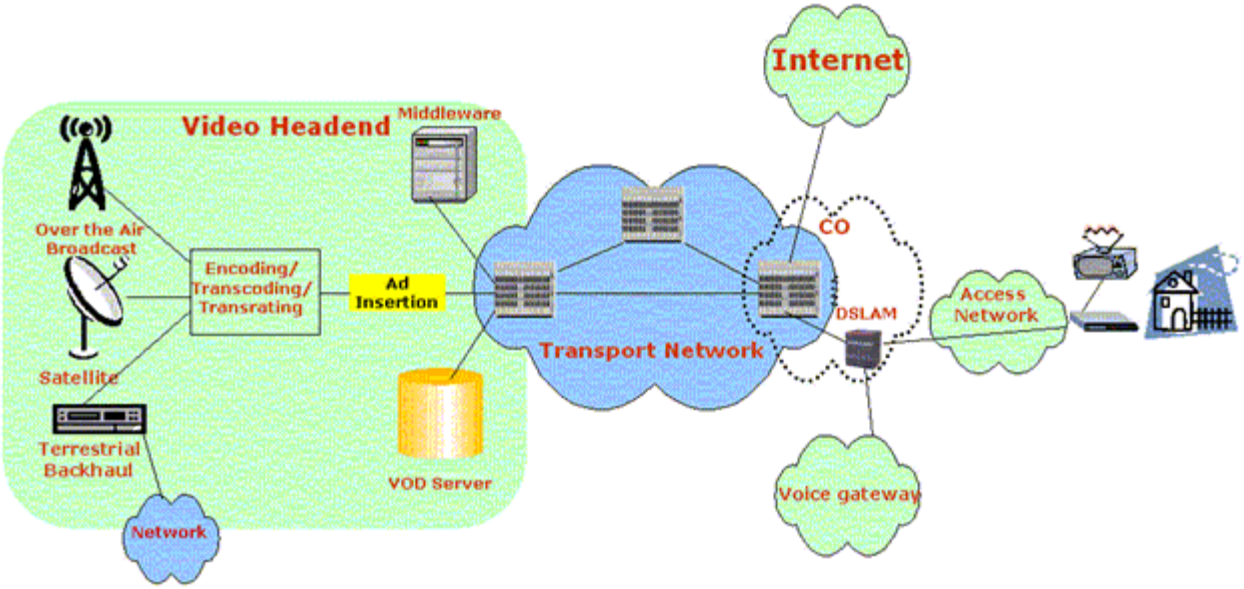
Digital Subscriber Loop Access Multiplexer key element of the DSL access network

Interfaces between DSL line on customer side and the transport network

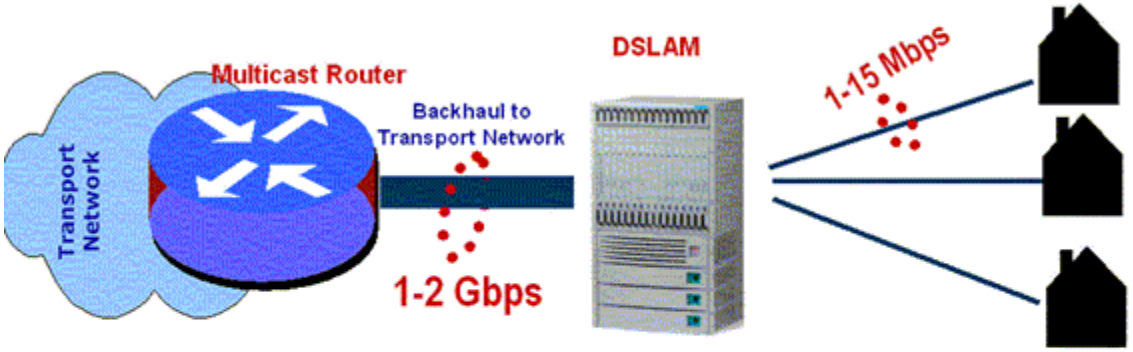
DSLAMs migrating from ATM-based to IP/Ethernet-based backhaul



IPTV Reference Architecture



DSL Bandwidth Limitations



DSL pipe to customer is dedicated

- Not shared like CATV

However, today, DSL copper loop and the DSLAM backhaul have lower bandwidth

- Key to different approaches in IPTV and CATV

Implications of Lower Bandwidth

DSLAM Backhaul

Determines "size" of channel lineup

- Video + Voice + Data carried over backhaul
- Assuming 60% of 1Gbps = 600 Mbps for video
  - @ 6Mbps per channel ≅ 100 channels simultaneously per DSLAM

DSL Line Bandwidth

Determines the number of "simultaneous" channels one can watch

- Determines how many TVs in the home can get service
  - 20 Mbps downstream @ 6Mbps per channel → 3 channels/TVs

This is the primary driver for switched video

⇨ No longer a "broadcast" TV model

So What, For End-User?

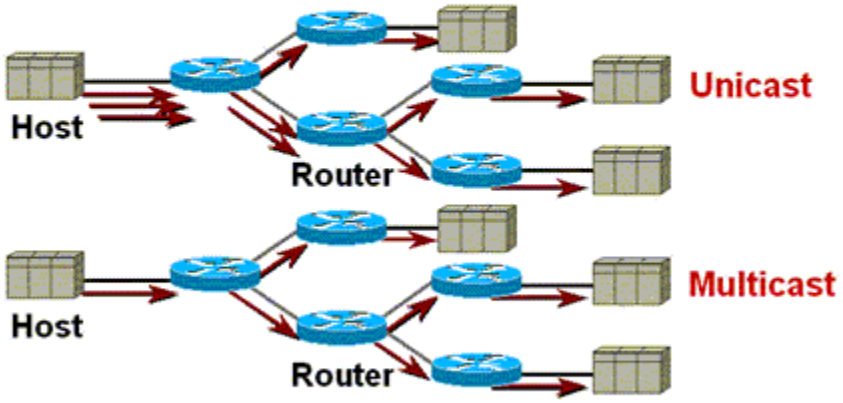
For the user, a few differences from Cable TV:

1. Need for a Set-top Box
   - TVs designed for analog broadcast, not needed for basic Cable
2. User experience differences – channel flipping
   - Time, Scalability
3. Program recording
   - DVR, Network PVR

Multicast

Core technology driving IPTV

First large-scale commercial use



Key requirement: Packet “replication” at appropriate routers

IPTV and Multicast

For IPTV deployments with switched video:

- Every channel maps to a multicast address

Flipping to a new channel implies "joining" the multicast group corresponding to the channel

Channel #	Multicast Address
1	239.192.1.1:1234
2	239.192.1.2:1234
.....	
48	239.192.1.69:1234

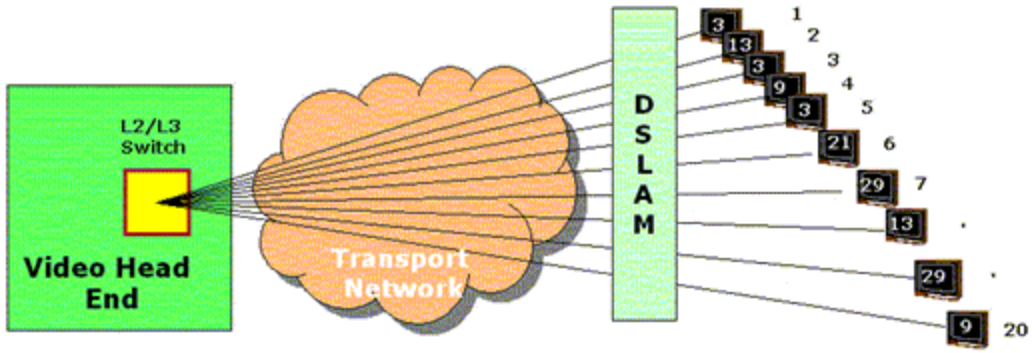
Multicast IGMP

IGMP: Internet Group Management Protocol

Multicast protocol between hosts (set-top box) and router

- How hosts inform routers about group membership
  - IGMP “join”
  - IGMP “leave”
- Router solicits group memberships from directly connected hosts
  - IGMP membership “query”

Unicast TV Delivery

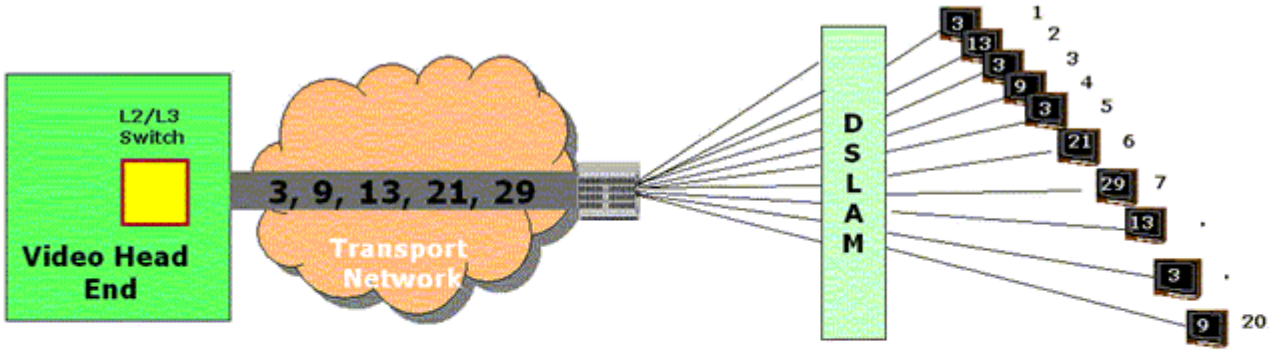


Assume: 5 channels
(3, 9, 13, 21, 29)

Potential bottlenecks:

- Transport network
- DSLAM backhaul

Router-based Multicast



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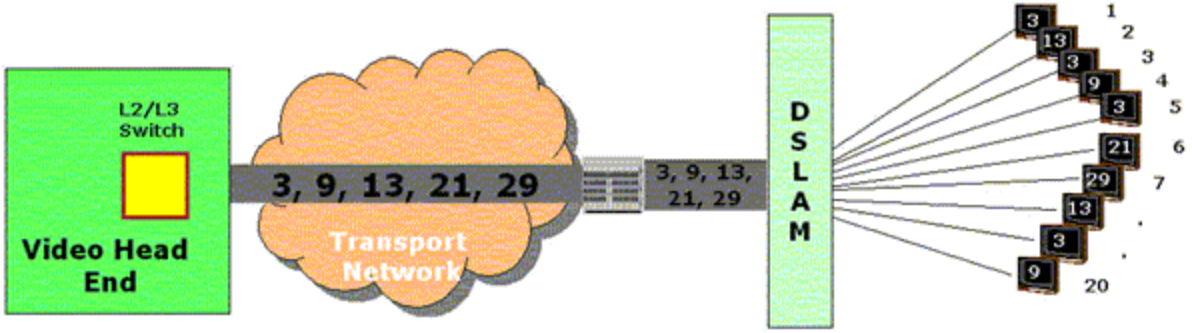
Potential bottlenecks:

- DSLAM backhaul

Lower Transport B/W, DSLAM bottleneck remains!

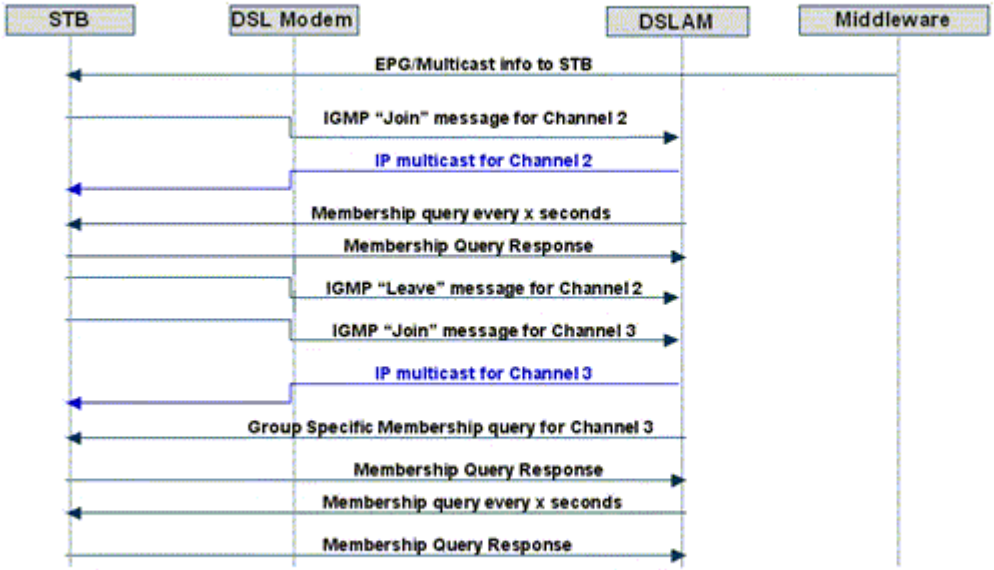
DSLAM-based Multicast



Assume: 5 channels
(3, 9, 13, 21, 29)

Most Efficient! Requires DSLAM Multicast Support!

IPTV Channel Flip Mechanism



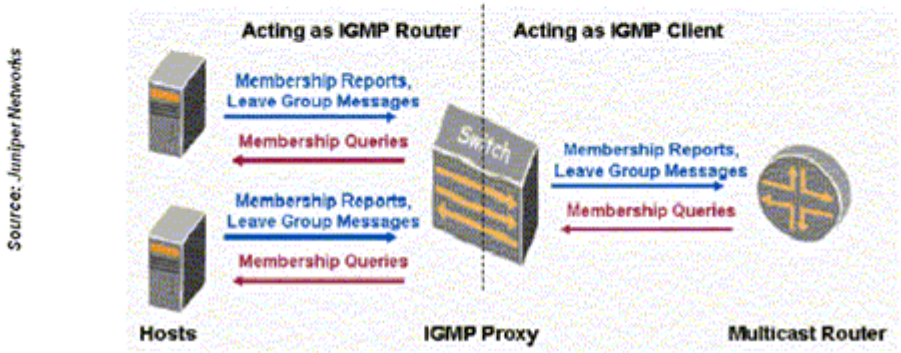
STB: Set-top Box

DSLAM Multicast Options: IGMP Snooping

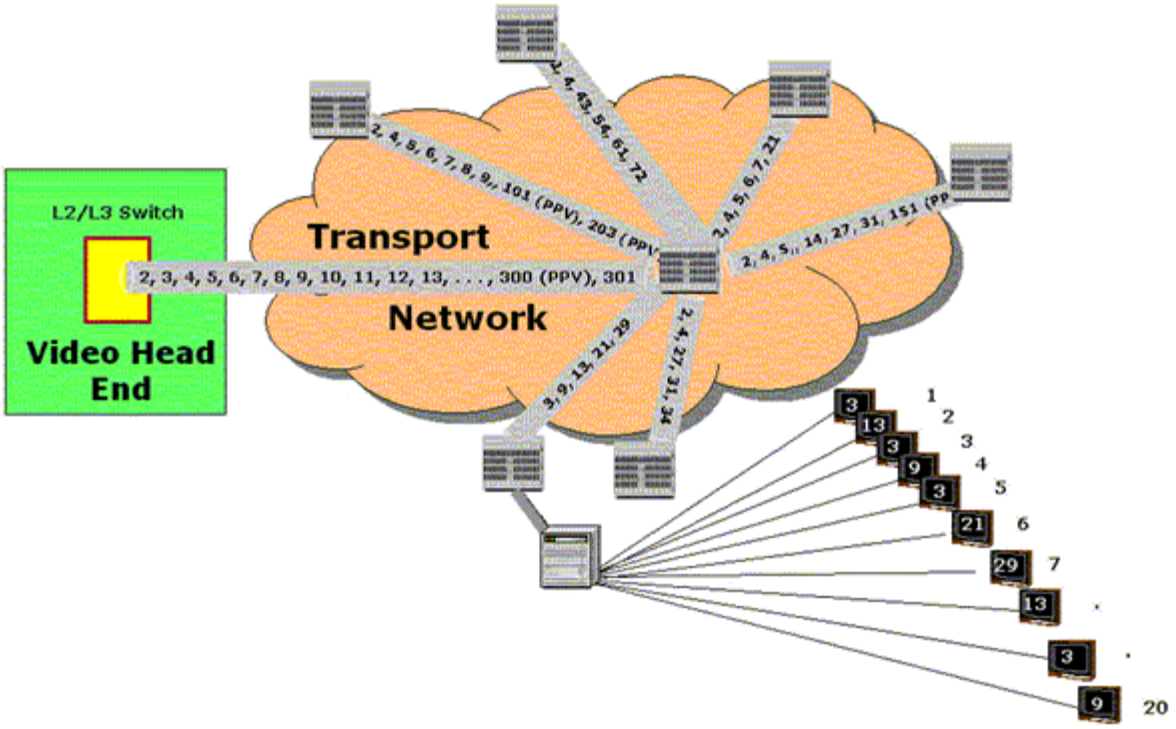
- DSLAM is transparent in the IGMP control path between STB and router
- It monitors IGMP joins/leaves and replicates to appropriate DSLAM port

DSLAM Multicast Options:
IGMP Proxy

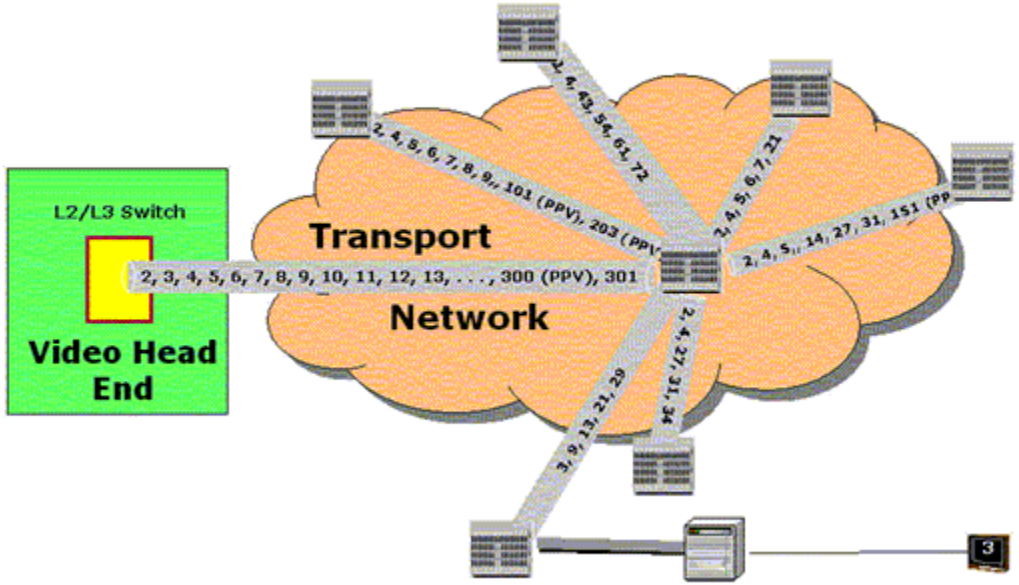
- DSLAM acts as an IGMP server to STBs and as an IGMP client to upstream routers
- DSLAM "hides" individual join/leave messages from STBs and forwards only first (join) and last (leave)



Multi-Level Multicast



Network Implications of Channel Flipping



Channel Flipping Impact

Latency key factor driving quality of user experience

- Minimizing flip latency critical

Other factors besides network determine latency

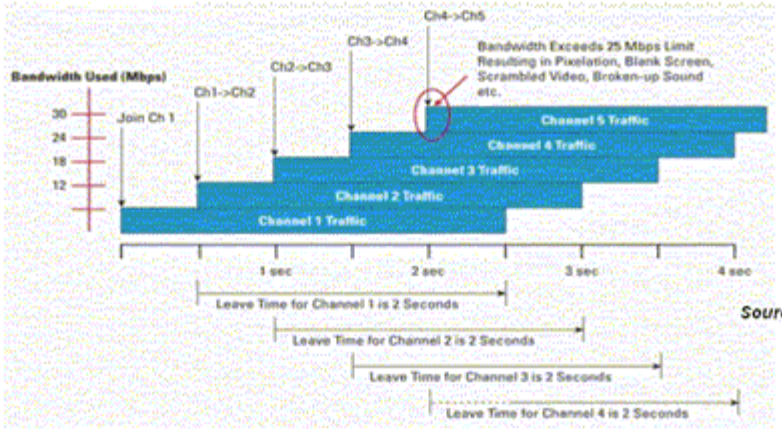
- More later in tutorial

More importantly for the operator, will the network scale?

Poor designed network can “freeze” at critical moments

- Overloaded DSLAM/Routers can loose IGMP messages
- Network has to be sized for worst-case scenarios
  - After popular TV programs end (e.g., Superbowl, Season finale of *Friends* series)

IGMP Leaves



Source: Cisco Systems

Let's assume:

25 Mbps bandwidth, MPEG-2 stream of 6 Mbps, user switching channels every 0.5 seconds, join latency 0.5 sec, leave latency 2sec

If Latency (join) < Latency (leave), system will glitch!

Novel IPTV Services

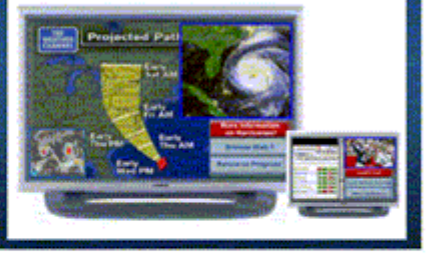
TV Caller ID with TV "Pause" Feature

Screen shows Caller ID, program pauses. Consumer controls voice call w/ remote.

Blended Web and TV

While watching TV, consumer experiences personalized, interactive communications:

Browse Web, Vote, Shop, Phone access, IM or Email.



iLocator for Family Finder™ Applications

Consumers locate family and friends from their TV, via loved ones cell phone.

Mobile Multimedia

TV service is forwarded to any location, on any device, with same look and feel as at home.

Source: Lucent Technologies

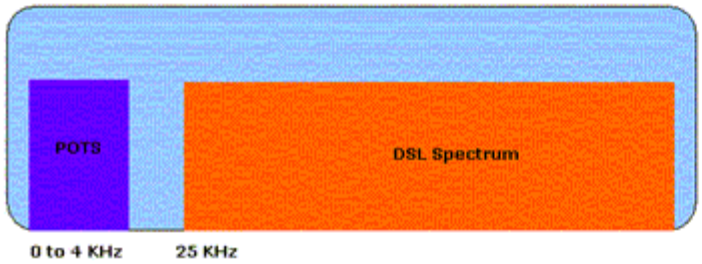
Technology Enablers

Digital Subscriber Line (DSL) Standard

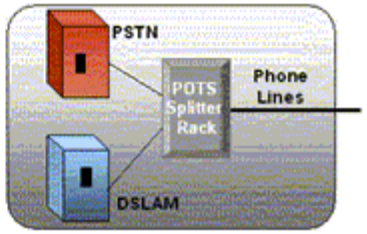
Enables bi-directional communication on the copper pair

- Existing copper plant can be leveraged without spending billions in fiber
- Designed to co-exist with the *plain old telephone service* (POTS)

Family of standards (*ADSL, ADSL2, ADSL2+, VDSL* etc.) with various rate and reach characteristics



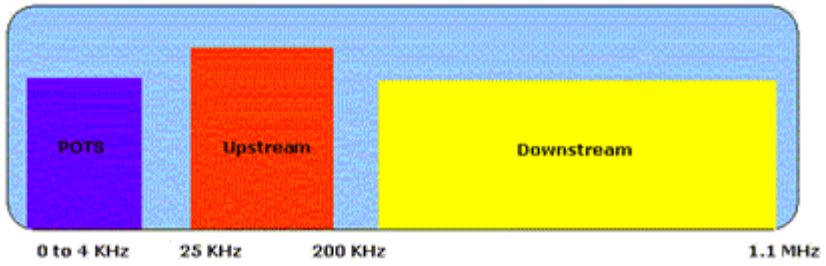
DSL Spectrum Space



Asymmetric DSL

First version of the standard

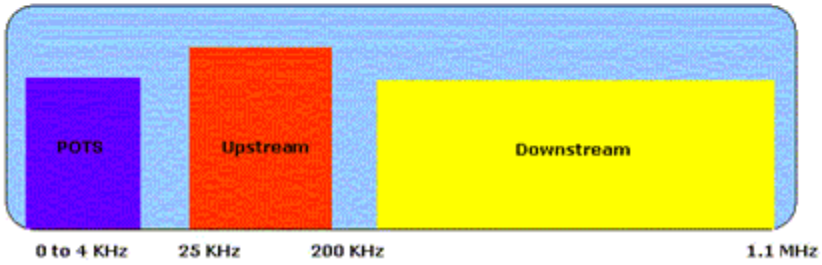
- DMT based modulation. Divides spectrum into small 4KHz (32 QAM) channels
- Peak data rate *10Mbps* downstream, *640Kbps* upstream
- Reach upto *18K* feet



ADSL2

Improves the rate and reach of ADSL on longer lines

- Improves rate by *50Kbps* downstream and reach by *600+ft*.
- Achieves higher coding gains, reduced frame-overhead (*programmable*), advance signal processing algorithms
- Rate adaptive. Power management support. Interoperable.
- *Deployment friendly!* Diagnostic capability built-in to support troubleshooting and in-service performance monitoring



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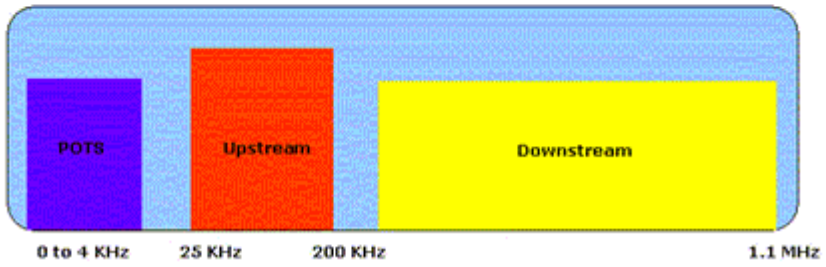

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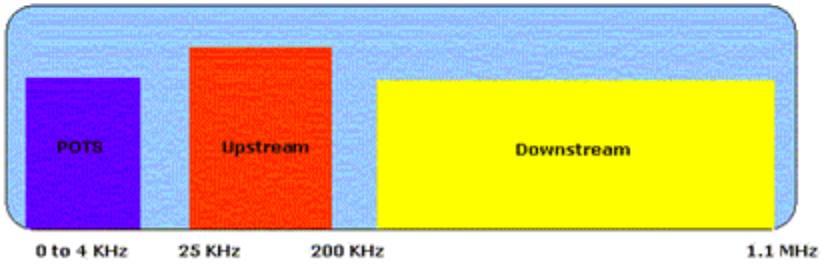
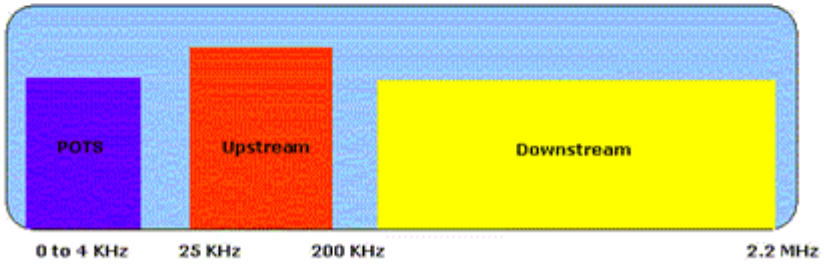


ADSL2+

Doubles the Downstream bandwidth for loops *< 9Kft*

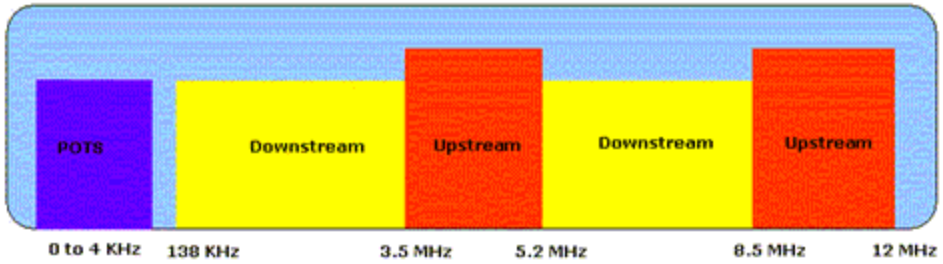
- Peak data rate *25+Mbps* downstream
- Supports masking of frequencies below *1.1MHz* to reduce crosstalk between CO and Remote Terminal *(RT)* based ADSL services



VDSL

Standard Finalized in late 2004

- Supports both DMT and QAM modulation schemes
- Peak data rate *52Mbps* downstream, *3Mbps* upstream for distances upto *2Kft*
- Supports symmetric mode



VDSL2

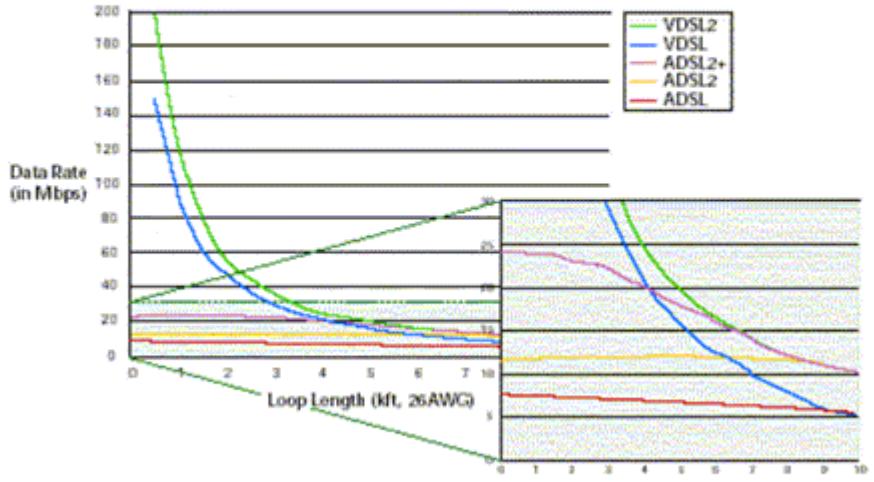
Still in the standards but chipsets in the market

- Extends the spectrum usage to *30MHz.* Supports single DMT based linecode
- Interoperable with VDSL
- Supports symmetric data rate *100Mbps*
- Works for very short distances. Useful for the FTTC deployments

DSL Rate Reach Comparison

DSL Performance Matrix

Source: Texas Instruments, Aware Inc. and the Yankee Group, 2004



Video Compression Technologies

High compression of video content is an important element in IPTV environment

- Last mile DSL bandwidth is limited
- Lowers bandwidth requirement in transport network
- Better compression means lower storage requirements for VoD servers and Personal Video Recording (PVR) devices

MPEG-2 is the most popular standard

- Developed in 1995. Can achieve compression ratio of 50:1
- Widely used in the Set-top boxes, DVDs
- Most of the content today is encoded in MPEG-2

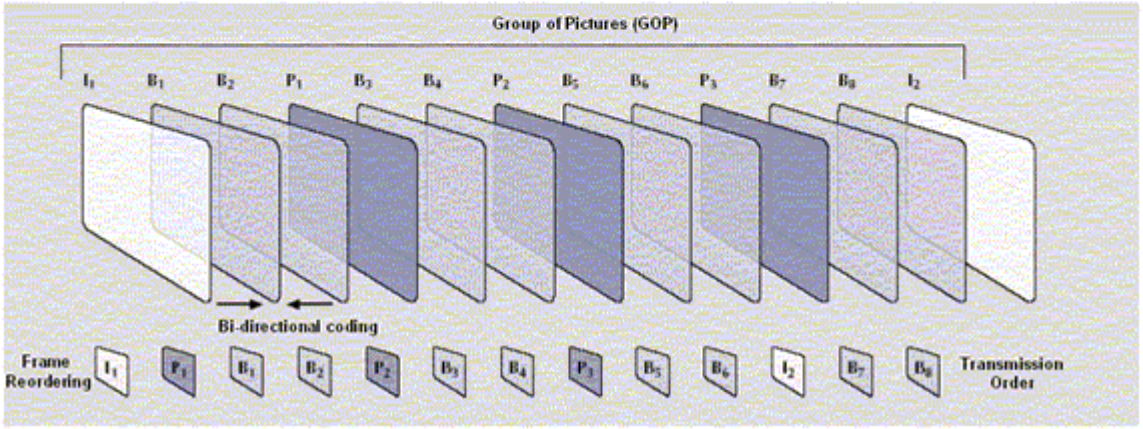
Advances in video compression significant in last decade

- Advances in algorithms
- Moore's law

MPEG Frames – Generation, Transmission, Reordering

All MPEG standards use identical I(Intra-coded), P(Forward predicted), B(Bi-directional predicted) frame structure

- Transmission order of frames different from display order



MPEG2 Compression

DTV Standard	Pixel Resolution	Data Rate
Standard Definition (SDTV or DVD Quality	640 x 480	4 Mbps
EDTV	704 x 480	7 Mbps
HDTV	1280 x 720	7 Mbps
HDTV	1920 x 1080	15 Mbps

HDTV sales in US low but expected to grow

- FCC forcing broadcasters to migrate to digital television

MPEG4-H.264

Recently standardized by ITU-T

- Also known as *MPEG-4 Part 10* or *MPEG4-AVC*

Most advanced codec in MPEG-4 standard.

- Substantially improves over MPEG-2 performance

DTV Standard	Data Rate
SDTV	< 2 Mbps
HDTV	6-8 Mbps

Utilizes object level structures to achieve better compression

Can achieve even better compression ratio for VoD content

- Ability to make multiple passes over data improves the performance

MPEG-4 standard "future-proofs" itself by providing a mechanism for incorporating new codecs as technology improves.

Windows Media 9 Series

Microsoft proprietary compression format

- Compression performance comparable to MPEG4-H.264 *(Microsoft claim!)*

End to end digital media solution

- Media server, player, codecs, encoder, Digital Rights Management, SDK

Offering better licensing terms (encoder/decoder) than MPEG-4

- Allowing developers to create software running on non-windows systems

Video Head End

Content acquisition from various satellite, over the air broadcast and terrestrial sources

- Demultiplex the Multi Program Transport Stream (MPTS)

Advertisement insertion

- Commercials inserted into video stream using various Digital Program Insertion (DPI) techniques

Grooms the signals for the downstream network

- Encoding/transcoding / Rate Shaping / Encapsulation
  - The three functions may be done by one device
  - Encapsulator packetizes the video stream into UDP/IP packets and maps to Multicast addresses

Feeds the transport network, house VoD servers, Middleware Servers, EPG servers, etc.

Middleware

Heart and soul of the end user experience

- Defines electronic program guide (EPG)
- Content management. Defines available VoD title etc.
- Service management platform allows operators to define, configure, and maintain services
- Defines channel packaging and pricing

Packaging

- Subscriber management
- Conditional access controls allow unique services to be defined to unique subscribers
- Transaction and billing management for PPV and VoD
- Digital rights Management, program rating and parental control
- Automated provisioning and remote management of STBs

Interfaces with other network elements and Service Provider's OSS infrastructure

Sample Program Guide

Source: www.sbc.com/lightspeed

IPTV CPE

DSL modem to terminate DSL signal

Set Top Box (STB)

- Not optional (unlike cable TV).
- Can run a middleware client software to render the EPG data or, a browser to obtain program guide data from server (thick vs. thin client)
- Support for MPEG2, MPEG4 decoding, DRM
- High-end box can run an operating system (Win CE) and off-loads some middleware tasks from Middleware Server
- DSL Modem may be integrated in STB. Obviates the need of an additional box
- Support for 802.11 becoming popular. Simplifying the home networking

Video Encoders

Performs various tasks like encoding of analog and digital baseband signals, transcoding, transrating

Satellite content typically delivered as Variable bit rate

- VBR peaks pose a challenge. May occur in one or more frames where bandwidth is abnormally high
- May overrun the STB buffer
- Cause congestion in the transport network or, exceed the bandwidth of the DSL pipe

Bit rate management is key to deliver superior quality video

- Primary goal *bit-rate reduction* (rate-shaping or, transrating)
- Convert VBR content to constant bit rate (CBR)
- Must preserve the quality of the incoming video
- Make optimum use of the access network resources
  - Scheme should be aware of available DSL bandwidth

Bit Rate Management Schemes

Decode and re-encode: Decode the incoming VBR signal and re-encode at desired CBR rate

- Requires expensive hardware and may result in perceptible loss of quality if advance encoding methods are not used

Non-adaptive re-quantization: Drop data from frames which exhibit peak bandwidth

- Reduces the viewable video quality as peak frames are invariably associated with high on-screen motion

Sign-on rate manipulation: Simply pass through the VBR signal

- Attempt to reduce the number of simultaneous program channels at the DSL end

Video on Demand (VoD) servers

Consists of streaming engines (video pumps), switches, disks

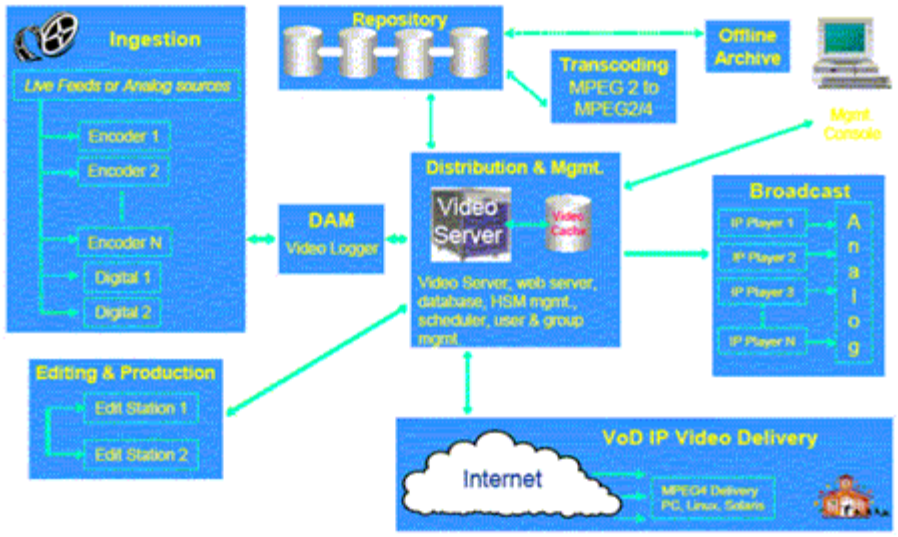
- Components may be packaged separately or integrated into single box
- Cost-effective scalability of the system to support increasing demand is key
  - Both centralized and distributed systems are available today

Storage requirements huge. Small content library not attractive to consumers

- Requirement to house 10000+ hrs of programming

VoD Servers are coupled with Asset Management Systems for automatic acquisition, storage, management of content

VoD end-to-end Architecture



Source: Callisto Media Systems

VoD Servers (Contd.)

- Supporting VoD places stringent requirement on the network transport infrastructure
  - Unlike broadcast content, each stream is unicast
  - Streaming engine Implements RTP, RTSP stack. Supports trick-play modes to enable pause, rewind, fast-forward features on stream
- GigE based transport on VoD server may not be sufficient in future
  - Can only deliver ~*200 (1000/5)* simultaneous streams
- Streaming requirements growing faster than the content storage requirement
  - Popular video titles may generate substantial traffic

Advertisement Insertion

Commercial insertion is important element of the overall operations

- National and local commercials inserted into video content

Ad insertion can happen in the local or regional headend

- Tradeoff of cost vs. advertisement relevance

Ad revenue is significant and can offset part of the programming costs

- Over 30% of 2003 Cable revenue is from Commercials

Nearly all video providers leverage commercial insertion opportunities

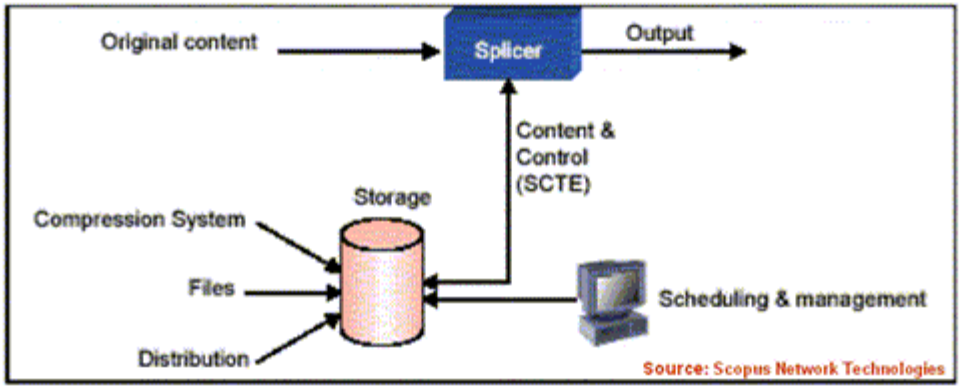
Advertisement Insertion

Three popular techniques – Differ in the mechanism used for insertion of the ad markers

Analog insertion: used in the uncompressed domain

Hybrid (Analog and Digital): used in the compressed digital domain, with analog tools

Digital insertion: used in the compressed digital domain



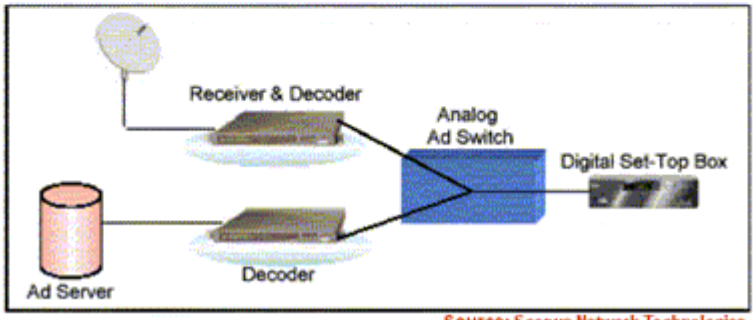
Generalized Architecture for Ad Insertion System

Analog Ad Insertion

Performed in uncompressed domain. Most widely used today

- Decodes the MPEG-2 program to baseband level, inserts commercial and re-encodes

Two encoding/decoding passes degrade the overall quality of video



Source: Scopus Network Technologies

Generalized Architecture for Ad Insertion System

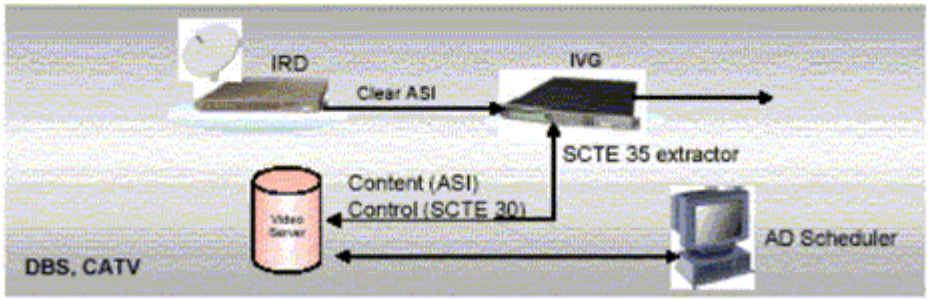
Digital Ad Insertion

Requires ad insertion markers in the transport stream, as *SI tables* (SCTE 35 standard)

Special encoders enable creation of the Ad insertion markers in the transport stream during the contribution process.

At headend, splicer detects the insertion markers and triggers video server to insert relevant ads.

- Communication between the Splicer and the video server is based on the SCTE 30 protocol.



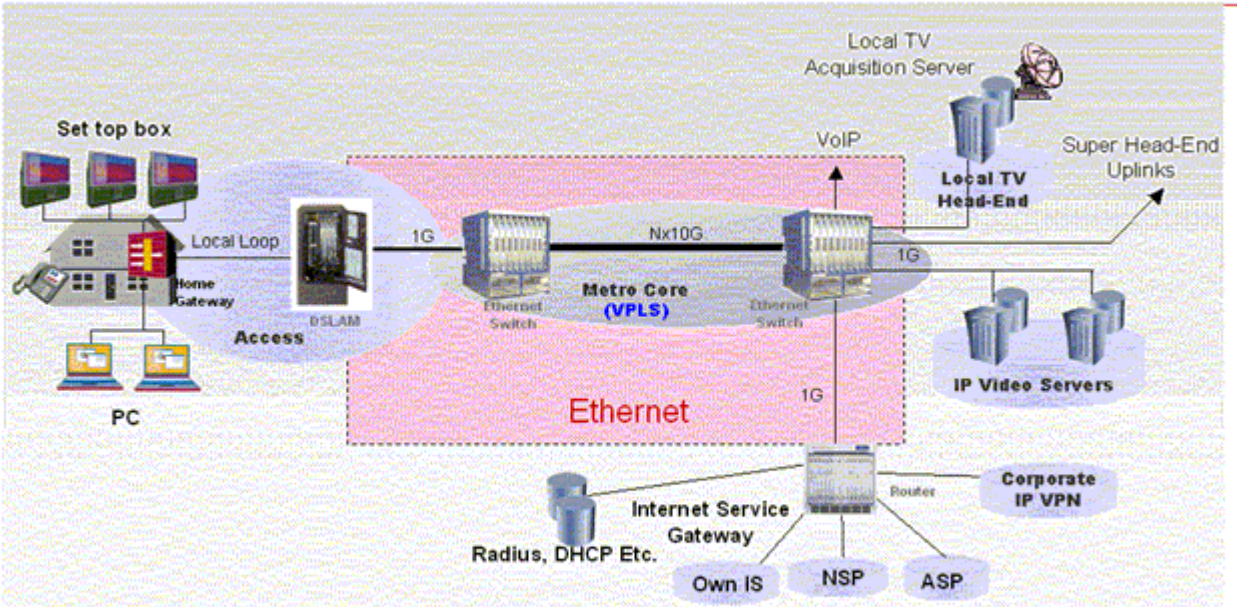
Source: Scopus Network Technologies

Personalizing TV Advertising

- "Addressable Advertising" holy grail for Ad world
  - Unique ads tailored to user groups (or, individual)
- Personalized Ads bring in more revenue
  - Avg cost per viewer for Superbowl 2005 ads: ~2c
    - Most expensive TV ad in the year
  - Avg cost per ad click on Google (2004): ~54c
- Cable companies starting to offer limited solutions
  - Comcast Spotlight: Adtag/Adcopy
    - Different commercials to different Zip codes
- How to leverage in-built addressability of IP to deliver personalized Ads via IPTV?

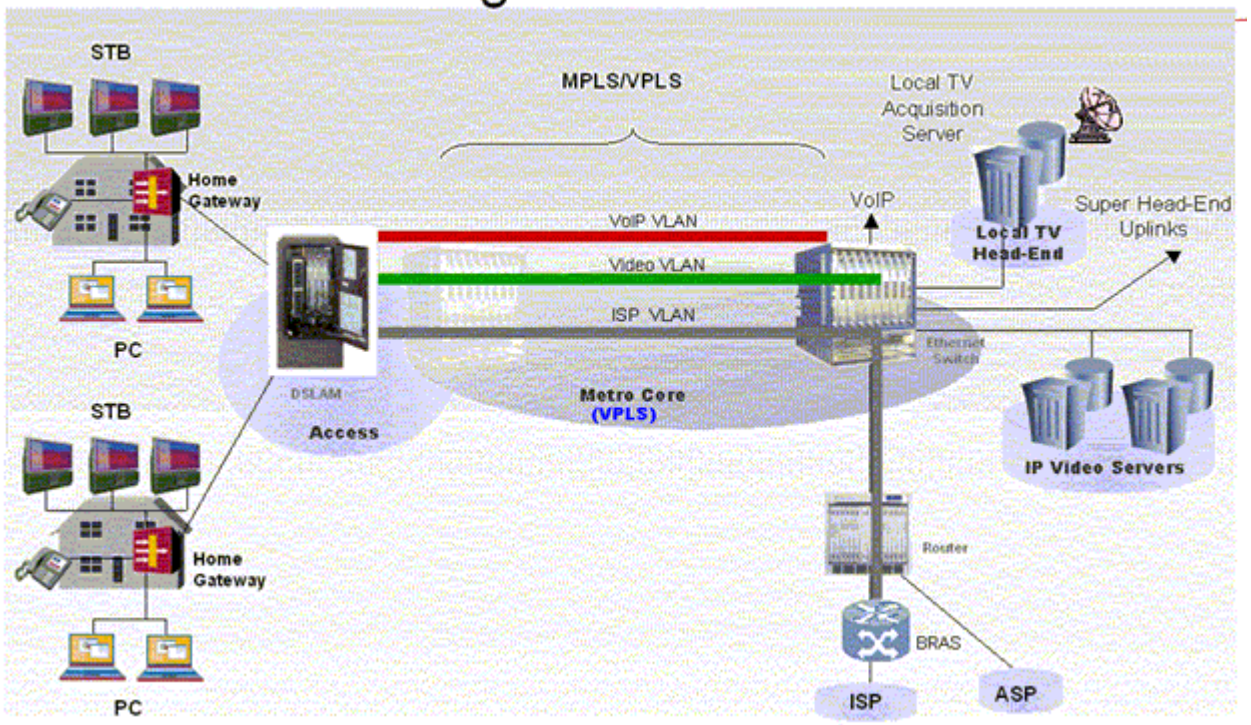
Network Transport Architectures

Ethernet Aggregation using VPLS

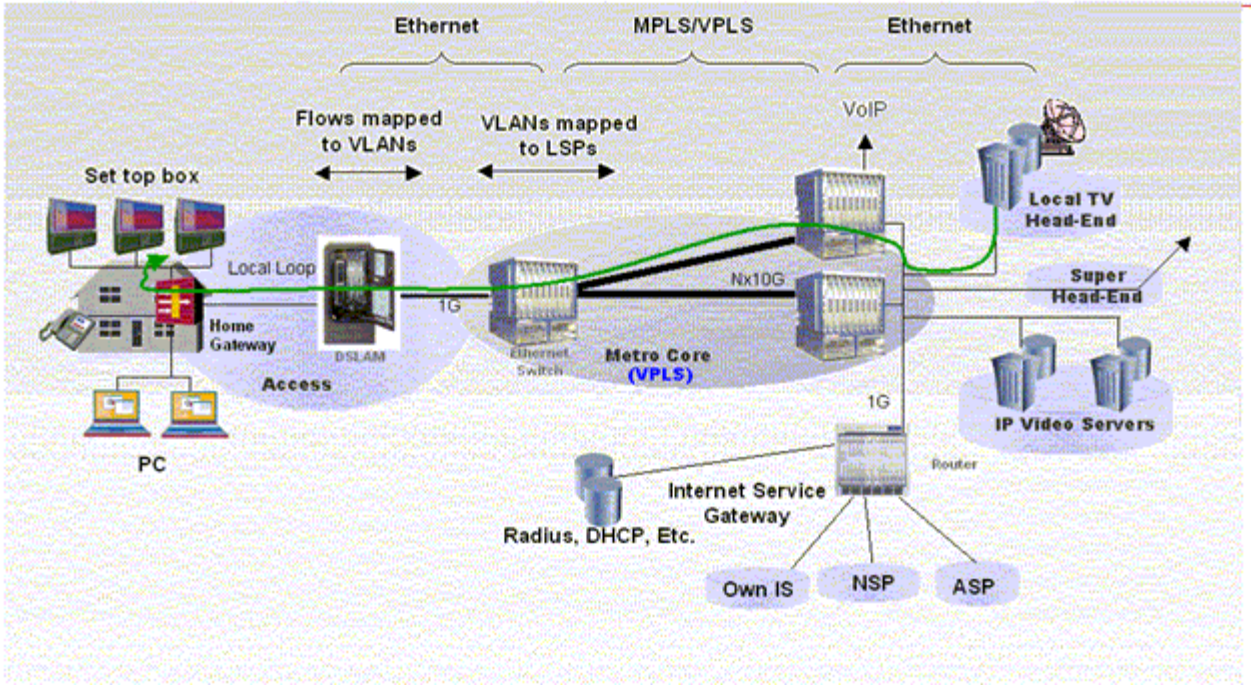


- Aggregates and transports voice, internet data and IP Video traffic
- QoS and traffic engineering to ensure reliable video & voice delivery
- Use Diff-Serv AF queuing, VLAN tagging, MPLS EXP bits, or 802.1p marking to ensure delivery of video and voice traffic

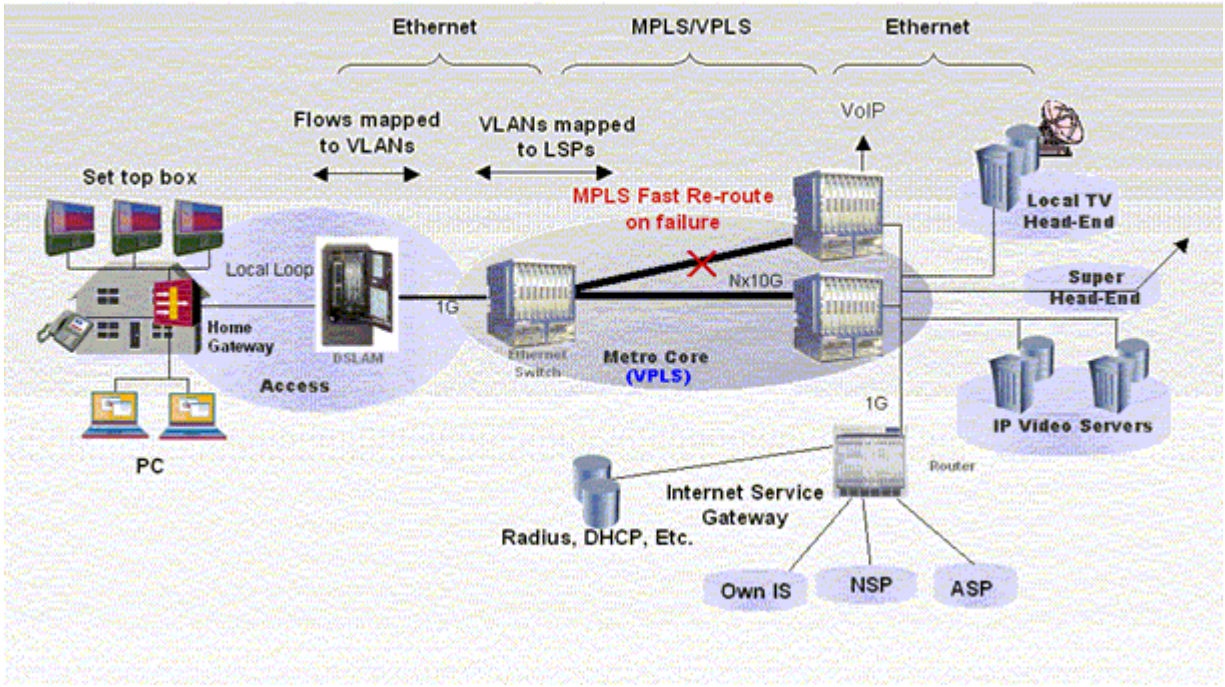
Data Flows – Logical View



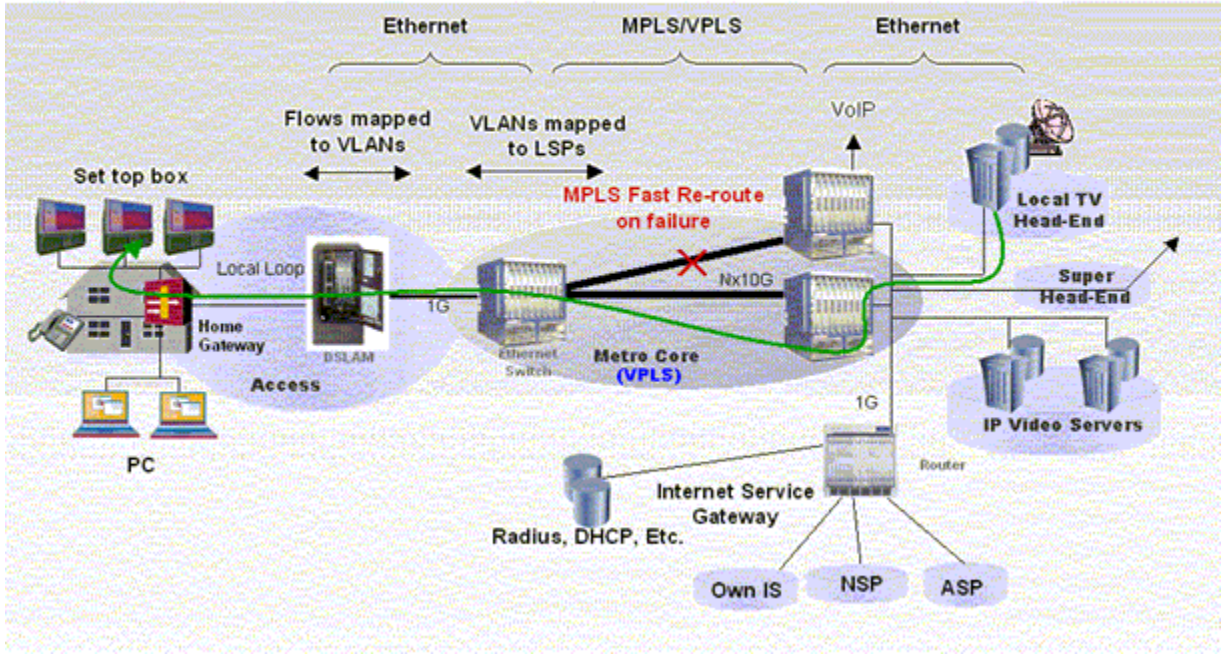
Redundancy using MPLS/VPLS overlay



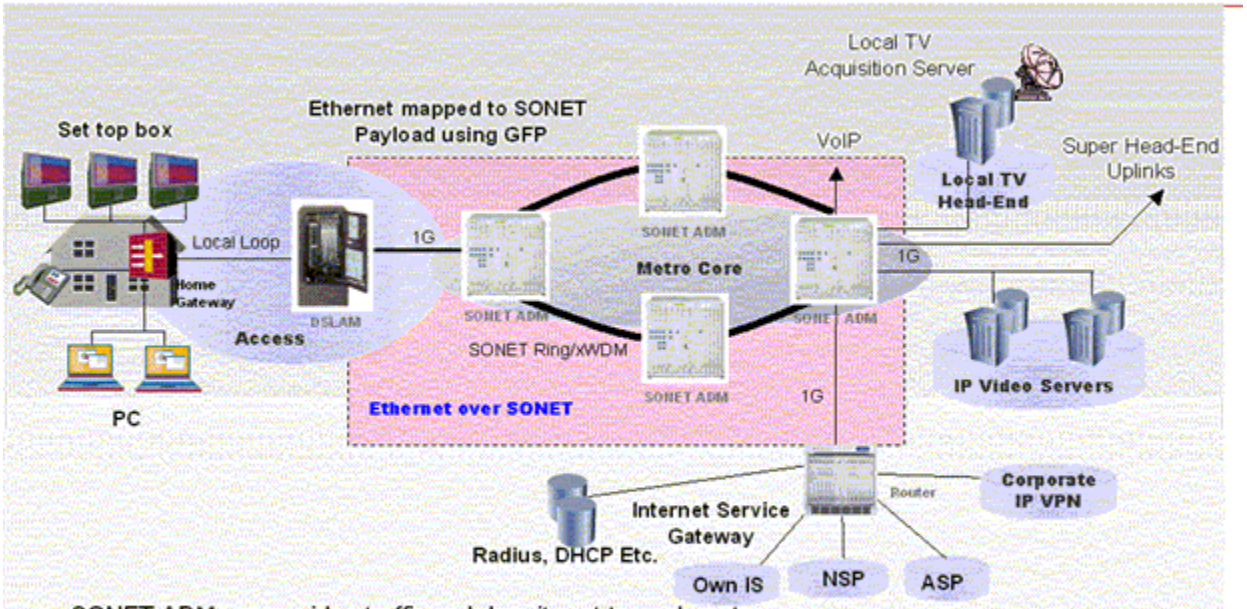
Redundancy using MPLS/VPLS overlay



Redundancy using MPLS/VPLS overlay



Ethernet over SONET Transport



- SONET ADMs carry video traffic and drop it next to each router
- Multiple SONET Rings can be stacked together using WDM for bigger channel lineup. Voice, internet data and IP Video traffic can be aggregated and transported in different VCGs
- Circuit switched nature of SONET ensures QoS, and traditional protection schemes such as BLSR or LCAS can be used for protection/restoration

Challenges

Content Acquisition

Content acquisition not a familiar territory for service providers

1. Acquiring rights
2. Transport of the content

Extensive channel lineup important for a competitive offering

Content Provider Type	Content	Transport
Direct	✓	X
Co-op (e.g. NCTC)	✓	X
Aggregator (AT&T HITS)	X	✓
Wholesaler	✓	✓

How much bandwidth is enough?

Number of TV sets per household *2-3 (Avg: 2.7, source: Yankee Group)*

HSIA, online gaming bandwidth requirements

Type of Service	Bandwidth Needed
3 HDTV channels	3 x 6Mbps = 18
HSIA (download, online gaming,VoIP, video telephony)	3-5Mbps
	21-23Mbps

Demonstrates the need for at least ***ADSL2+*** and ***MPEG4-AVC*** compression for a comprehensive offering

DSL Impairments

Noise sources:

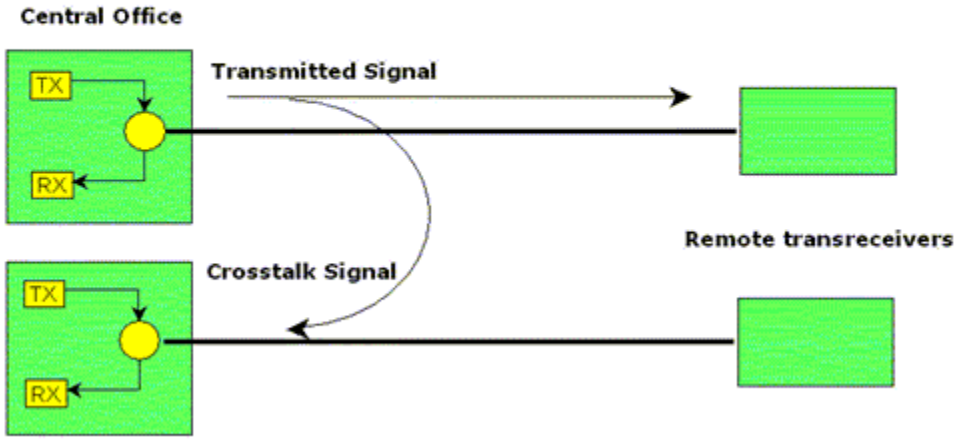
1. Capacity limiting e.g. *cross-talk*, thermal noise
   - Predictable and easy to account
2. Performance limiting e.g impulses, RFI
   - Unpredictable and geographically variable

ADSL avoided most of the crosstalk by transmitting upstream and downstream signals in different frequency band (FDD)

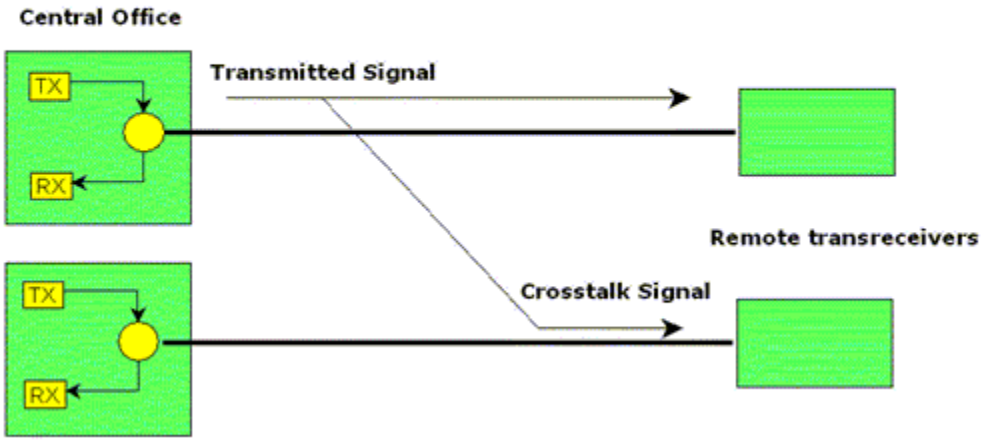
Cross-talk among different flavors (*spectrally incompatible*) of DSL becoming significant

- Higher take rates are producing more interference
- Unbundling of local loops to CLECs complicates the problem

Near End Crosstalk (NEXT)



Far End Crosstalk (FEXT)



Remedies

DSL spectrum management: Process of ensuring spectral compatibility while optimizing the loop plant

- Requires knowledge of all DSL systems in the network and how their crosstalk effects other systems

DSL Bonding effectively addresses the problem of declining speeds at longer distances

- Uses inverse multiplexing to split data on multiple DSL lines

Push fiber closer to the home (FTTN, FTTC)

Dynamic spectrum management

- Increases capacity utilization by adapting the transmit spectra of DSL lines to the actual time-variable crosstalk interference.

Headend/Transport Network Design

Headend design

- National vs. Regional vs. Local
  - Tradeoff between transport and equipment costs
- Encoding vs. Rate Shaping

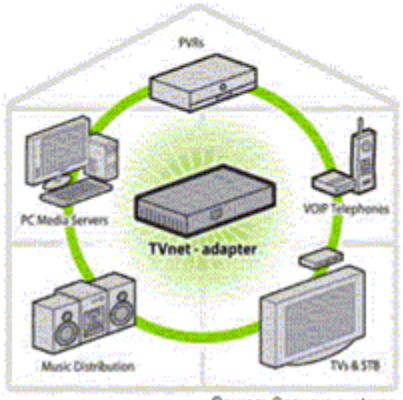
Transport network design

- ***Multicasting:*** Single Stage vs. Multi-Stage
- Number of Broadcast Channels, Bandwidth per video channel
  - MPEG-2: – 3.5 Mbps SDTV; 16-19 Mbps HDTV
  - MPEG-4/WM 9 : 1.5 – 2 Mbps SDTV; 6 - 8 Mbps HDTV
- Take rate, Over-subscription rate
- DSLAM uplink capacity

Home Networking

DSL terminates at the master STB

- How to deliver content to multiple TVs?



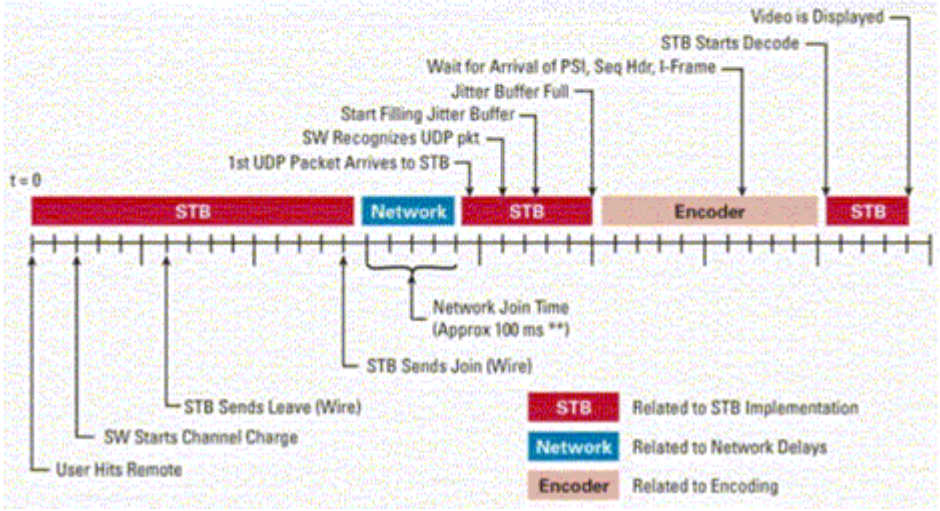
Source: Coaxsys systems

Technology	Pros	Cons
Home Phone Networking Alliance(HPNA V3)	100+Mbps	Must co-exist with DSL
100 Base-T Ethernet	100Mbps, in-expensive	Rare Ethernet wiring inside homes
HomePlug(AV) Power Alliance	250+Mbps	Still in development
Multimedia over Coax Alliance (MoCA)	High bandwidth, 250+Mbps, pervasive	Still in development

Channel Switching Issues

Small channel change latency key to user experience. Three main contributors to channel change timing

- MPEG coding structure (GOP size)
- IGMP join time (network dependent)
- Buffering delays



Network PVR (N-PVR)

Telcos considering mix approach of PVR and N-PVR

- Choice of PVR vs. N-PVR involves trade-offs

PVR: Requires a STB with disk and PVR software. A simple system from operations view.

Cable operators PVR systems offer ability to watch and record different channels using dual-tuner STBs

- Difficult to match the offering with disk based PVR. Limited DSL loop bandwidth may prevent simultaneous transmission of two channels

Disk based STB with PVR software also increases the cost per subscriber

N-PVR: Remote recording at a N-PVR system addresses the loop bandwidth issue for dual recording

Amortizes storage by keeping a single copy of programs recorded by multiple subscribers

Playing the recorded video is delivered as unicast stream (VoD)

- Large number of subscribers playing recorded video can seriously strain DSLAM Trunk capacity

Choice of PVR or N-PVR will be determined largely by network bottlenecks

Security – Content Theft vs. Service Theft

Content owners (Hollywood studios) require an end-to-end protection from source to STB. Do not want a *video napster*

- All digital content, VoD, PPV ➡ Higher Paranoia

Multicast in DSLAM exposes service theft, fraud

- Failure to reliably block secure channels (e.g. adult programming) => Lost service revenue and unhappy customers (e.g. parents).

Legacy CA system *(DVB's Simulcrypt)* designed for broadcast content

- Security provided only at the transport level. Does not address theft of content from Vod servers and PVR devices

Distributing content to multiple TVs can again expose the content (Ethernet/Coax)

- Integrated gateways, point-to-point DSL lines, port level protection lower the likelihood of service theft
- Frequent key exchanges between headend and STB makes it harder to penetrate

Service Monitoring

Service monitoring and troubleshooting capability key to business

- Unlike voice, customers have low tolerance for disruption in TV service
  - Cable operators have set the bar high for service downtime and quality
- Technologies and standards involved are complex and sometimes interpreted differently by hardware vendors
- Operator may need to comply with SLAs from content owners

Where to monitor?

- Errors in video can be introduced at several places:
  - Original video stream from broadcaster, Receivers in the head-end
  - Transcoders, Transraters IP streamers, Routers/switches/DSLAMs, Content protection systems, Set-top boxes
- End result of the error is always the same in form of *jerky playback, frozen picture.*

What to monitor?

- Monitoring all channels may be expensive in a big lineup
  - A *ratings based system* to monitor different channels at different times is more appropriate

Competitive Threat

Cable MSOs

Formidable competitor

- Huge customer base. Already offering digital TV, PPV, VoD, VoIP etc.

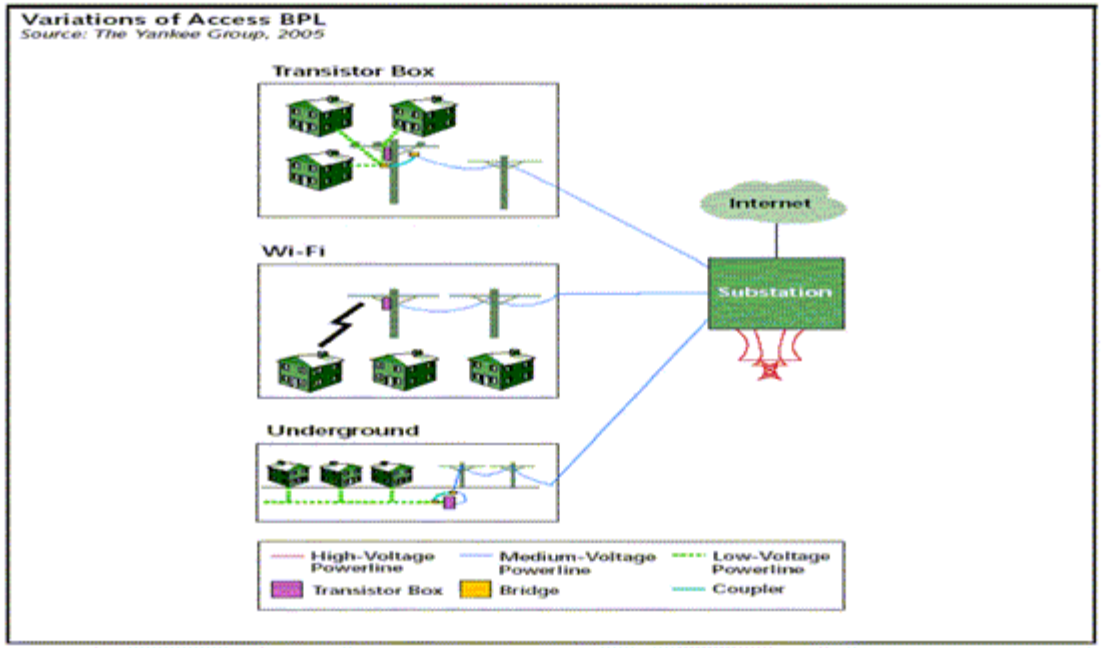
Business Challenge: Scalability issue for on-demand content. Analog TV channels consume precious 6MHz bandwidth

- Upstream channel is limited in b/w

Cable operators plan to move to all digital infrastructure to counter IPTV threat

- CableLabs Next Generation Network Architecture (NGNA) initiative underway
  - Significantly higher capacity will allow higher data download speeds (DOCSIS 3.0), True on-demand TV service
- Combining Cable Modem, STB functionality, Home networking (802.11x) , gaming into single Residential Gateway will offer economies of scale
  - Huge investment into the existing STBs ($3-4B). Newer STBs will enter the market with gradual pace

Broadband over Powerline (BPL)



BPL (Contd.)

FCC's endorsement is increasing the awareness of technology

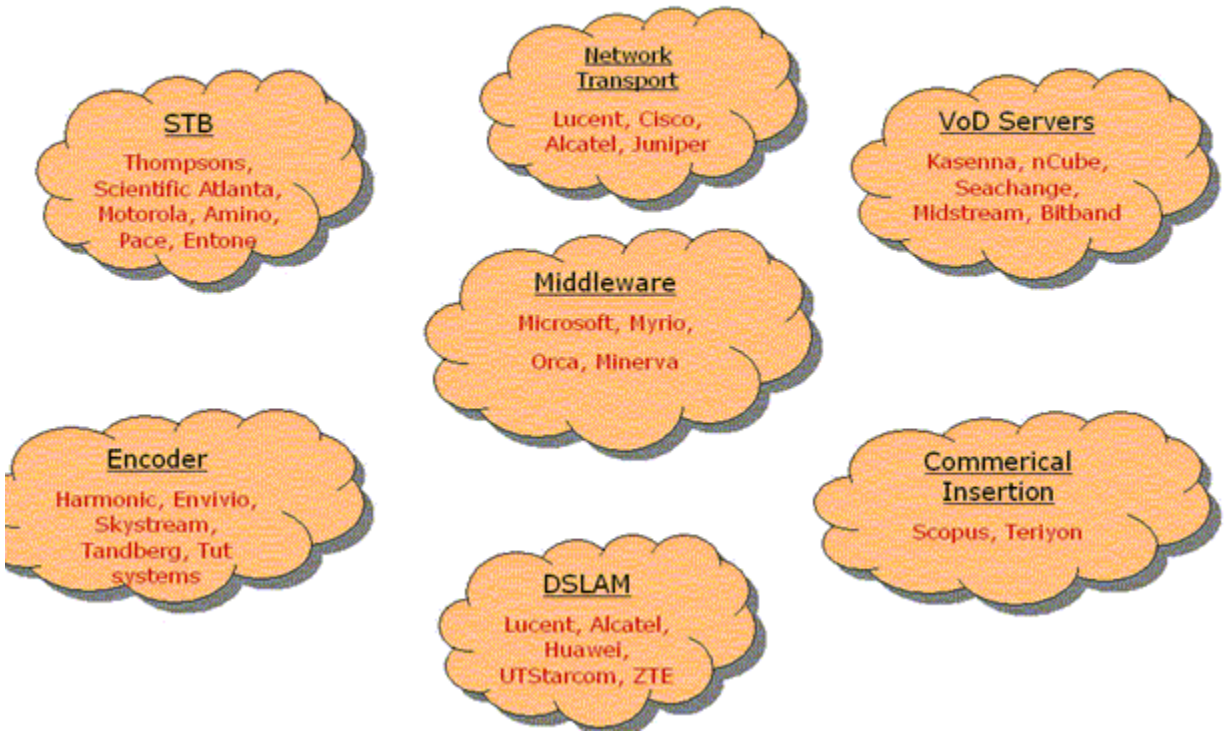
- ***Speed:*** Advertised speeds are up to 45 Mbps shared among multiple homes. Next generation technology capable of 200 Mbps.
- ***Shared bandwidth:*** Low-voltage line services approximately five to 10 houses in populated areas
- ***Distance-sensitive:*** Like DSL, BPL speeds lose momentum over distance. A signal can usually be carried between 0.5 mile and 1 mile. Problem in rural areas

Barrier:

- Interference
  - Most controversial element of the technology. Operation in 2-80Mhz spectrum interferes with ham radio operation
  - Vendors claim notching mitigates the problem
- Late to market
- Slow moving standard process

Major IPTV Vendors

IPTV Vendors



Service Provider Strategies

SBC

After FCC's announcement, laid out the *Project Lightspeed* milestones

- Aims to reach 18M households by 2007
- Plans to use Fiber to the curb (FTTC) system and use DSL in the last mile

Awarded contract to Alcatel ($1.7B) and Microsoft ($400M) for the complete IPTV system

Negotiated its own content distribution rights with content provider

Distribution network:

- Two national content aggregation centers (master headends), (LA, Midwest), 40 IP video hubs (regional headends), and 140 IP video serving offices (local distribution points).
- Will cover about 50% of SBC's territory.

Currently testing IPTV service in Austin area. Plans to other markets in *3rd Quarter, 2006*

Bell South

Plans to expand its FTTC network to pass *1.25M* customers in 2005

90% lines are in pairs and within *9K* ft.

- Plans to ADSL2+ based "bonding" to get higher speeds

Currently co-markets with *DirectTV* to provide bundle

- Goal to cover 80% of customer base by 2009

IPTV feature-rich video offer under limited trails

- Currently trialing Microsoft's middleware in lab

Verizon

- Most aggressive pursuers of FTTP deployment among bell companies
  - Deploying FTTP network in 12 states. Expects to pass *3M* homes by the end of 2005
- FiOS TV service under limited trials in Virginia, NY
- Recently obtained statewide franchise in Texas
- Taking a cautious approach to enter the video delivery business
  - Plans to offer RF-based video service
- Awarded contract to *Microsoft* for middleware and to *Motorola* for network infrastructure and CPE

PCCW Hong Kong

Hong Kong Incumbent telco operator

Largest IPTV deployment to date(Nov 2005)

- 500K subscribers (30% of worldwide IPTV subscribers)
- Offers a la carte programming instead of bundled package
- Revenue sharing model with content owners, no minimum subscriber guarantee

ADSL based service

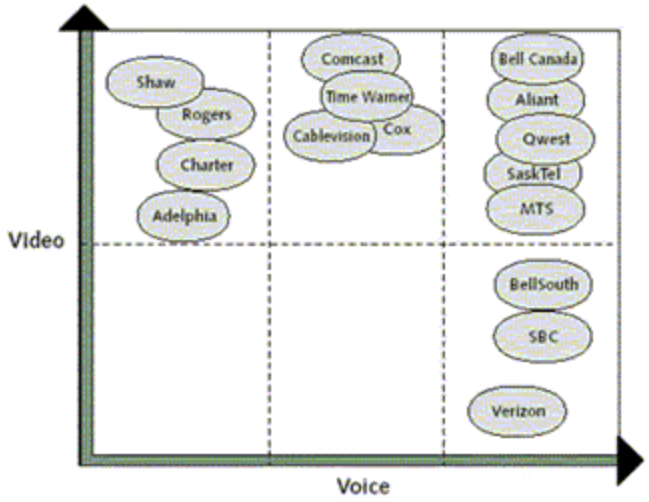
- Works well due to dense population, shorter copper loops
- Open system with software centric solution based on HP/IBM servers

Sharing its operational, technical expertise with other IPTV providers such as Telefonica, China Netcom

Triple Play Penetration

Broadband Providers Closest to the Voice, Video and Broadband Triple Play

Source: The Yankee Group, 2004



Conclusion

ADSL has provided the highly anticipated "*big pipe*" to consumers home

Advancements in video compression, reliability of IP transport enabling digital-quality video transmission

Transport cost $$/bit is constantly declining

Regulatory and franchisee issues working in favor of service providers

Telecom service providers have the know-how in operating large scale IP/MPLS networks

Conclusion (Contd.)

- Content acquisition, video head-end design, service assurance and monitoring key field deployment challenges
  - Negotiating content rights at low prices is important to successful business
- Overcoming home networking challenge is critical
- Service differentiation is must to compete with cable MSOs
  - EPG, PPV, VoD may not win cable subscribers
- Telcos need to offer unique *blended applications* leveraging their wireline/wireless presence
  - Offering wireless centric applications on to the TV sets can prove to be an unique advantage