

EPON vs. BPON
Real-World Deployment Differences & Practical Considerations

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Overview

- PON Basics
- EPON and BPON Comparison
  - How GPON fits in
- Implications for deploying
  - IP Video
    - Clear up the basics (and not so basic) on how it works
    - Why you need IGMP awareness everywhere
    - Consider your future bandwidth needs
  - VoIP
    - Migration Strategies – TDM to VoIP
    - Features/functions
  - Multiple Services
    - QoS / Prioritization
    - Managing Services and Subscribers



PON Basics



Basic PON Architecture

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OLT

- Interconnect to network services
- Aggregation of subscriber services
- Fiber interface to OSP

Outside Plant Network

- Completely passive
  - No electronics
- Single-fiber concept
- Low cost
- Low maintenance
  - 80% < copper
- Simple

ONT

- Fiber-to-copper transition
- Interconnect to customer devices
- Dedicated or shared among users



EPON and BPON

- **PON is More Than FTTH/Residential Service**
  - Single Family Residential
  - Multi-Dwelling/Multi-Tenant
  - Government/Municipalities
  - Business
  - Backhaul
  - Security
- **BPON**
  - Defined by ITU-T G.983 Standard
  - Based on ATM Protocols
  - Constructed for Simple Ethernet Transport
    - Uses GEM Framing for Ethernet Encapsulation
- **GPON**
  - Virtually all "GPON" deployments today are actually fast BPON
  - Chipsets are lacking
  - Defined by ITU-T G.984
- **EPON**
  - Defined by IEEE 802.3ah Standard
  - Based on Ethernet Protocol
  - Clear Migration Path from 1Gbps to 10Gbps symmetrical bandwidth



IP Video
Unicast vs. Multicast



IP Video Traffic

- **Video streams transformed into IP packets**
  - Encoded, received, and streamed
  - Become MPEG2/MPEG4 encoded IP packets
- **Two types of IP Video traffic**
  - **Unicast (VoD)**
    - Single Sender and Receiver (Unicast IP Address)
    - Point to point connection
  - **Multicast (Broadcast TV)**
    - Group of interested Receivers (Class D IP Addresses)
    - The sender transmits a single IP datagram (from the sender's unicast address) to the multicast address, and the Host routers take care of making copies and sending them to all receivers that have registered their interest in receiving data from that sender.
    - IGMP Protocol is used to register and deregister receivers from a Multicast Group
    - Point to multipoint connection



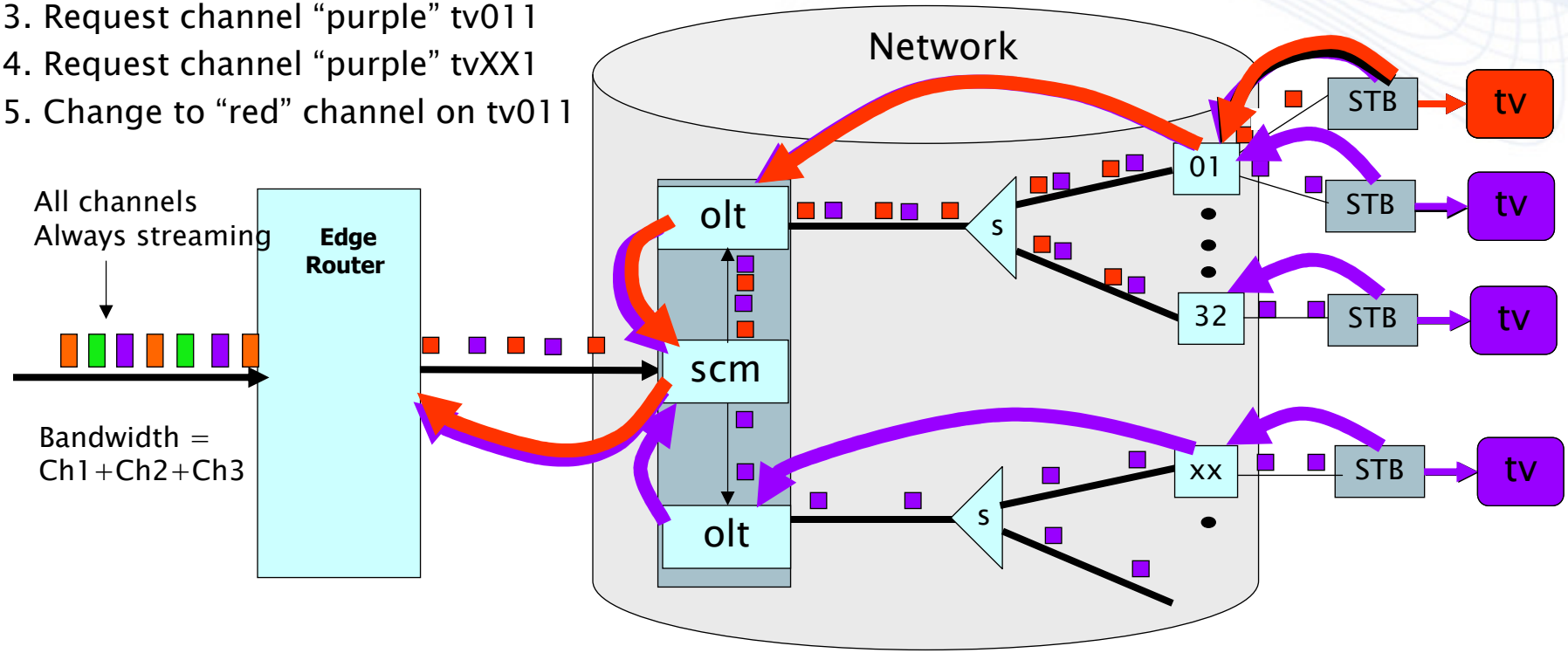
IGMP Features

- IGMP
  - Communications protocol used to manage the membership of IP multicast groups. Used by IP hosts and adjacent multicast routers to establish multicast group memberships
- IGMP Proxy
  - Enables a device to issue IGMP messages on behalf of hosts. The device acts as a proxy for its attached hosts to reduce bandwidth between the Proxy and Host devices, improve performance and reliability
- IGMP Snooping
  - Enables a device to "listen in" on the IGMP conversation between hosts and STBs. When a IGMP Snooping-enabled device hears an IGMP report for a given multicast group, the device adds that STB to the IGMP list for that group. And, when the device hears an IGMP leave, it removes the STB from the IGMP list. The device updates its table entries accordingly so that only STBs interested in receiving multicast traffic for the group are listed.
- Fast Leave
  - A technique used to improve leave latency. Used to achieve fast channel change times and eliminate “dead” channels from occupying bandwidth waiting for them to expire.



IGMP Example

1. Request channel “purple” tv012
2. Request channel “purple” tv321
3. Request channel “purple” tv011
4. Request channel “purple” tvXX1
5. Change to “red” channel on tv011





Why All PON Systems are NOT created equally

- **PON access networks support either Layer 2 multicast or unicast**
  - In addition to participating in Layer 3 IP Multicast through IGMP Proxy and Snooping support
- **EPON systems support Layer 2 multicast traffic through a feature referred to as Single Copy Broadcast (SCB)**
  - Multicast IP video is delivered to multiple ONTs per PON
  - Only ONE copy of any IP multicast video stream is ever carried on the PON
    - e.g. 10 subscribers watching 1 program = 1 video stream
- **BPON systems carry all traffic as unicast**
  - An incoming IP video stream can only go to a single unique ONT address on the PON
  - Thus a unique copy of each IP multicast Video stream is carried for every ONT with STBs registered to that IP Multicast Group
    - e.g. 10 subscribers watching 1 program = 10 video stream



EPON vs. BPON
Multicast vs. Unicast

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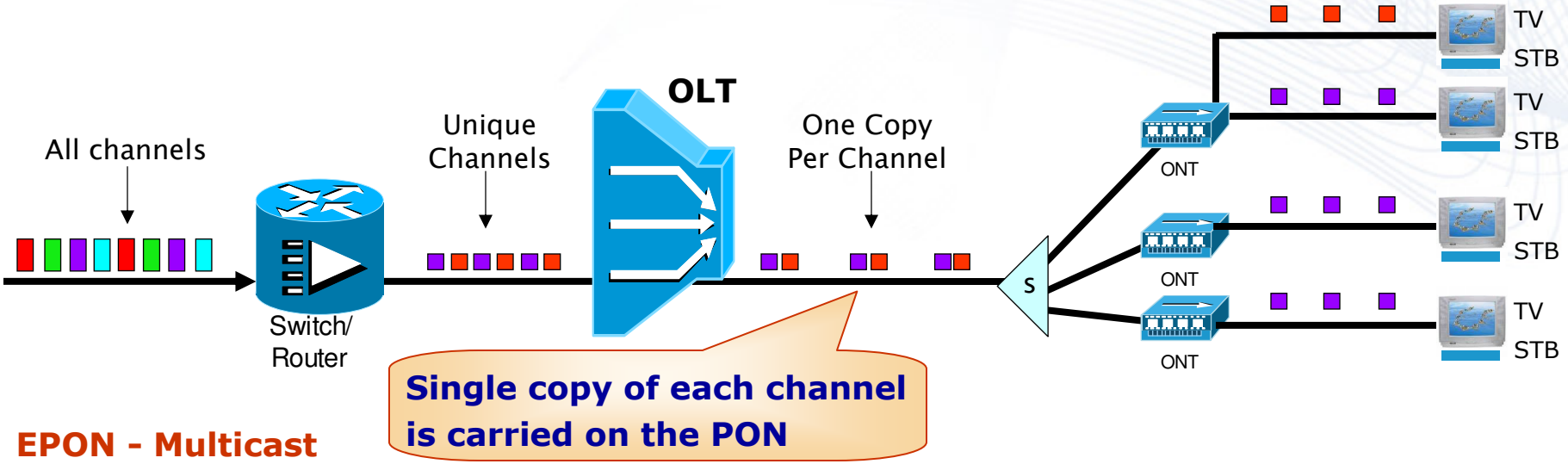
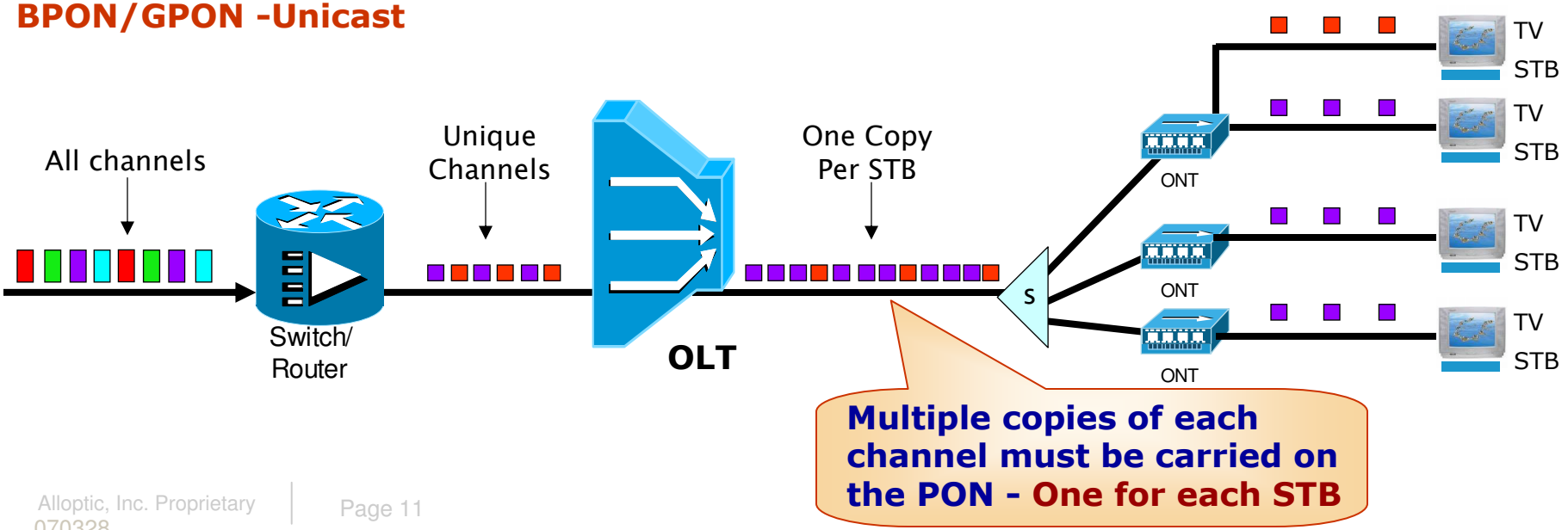


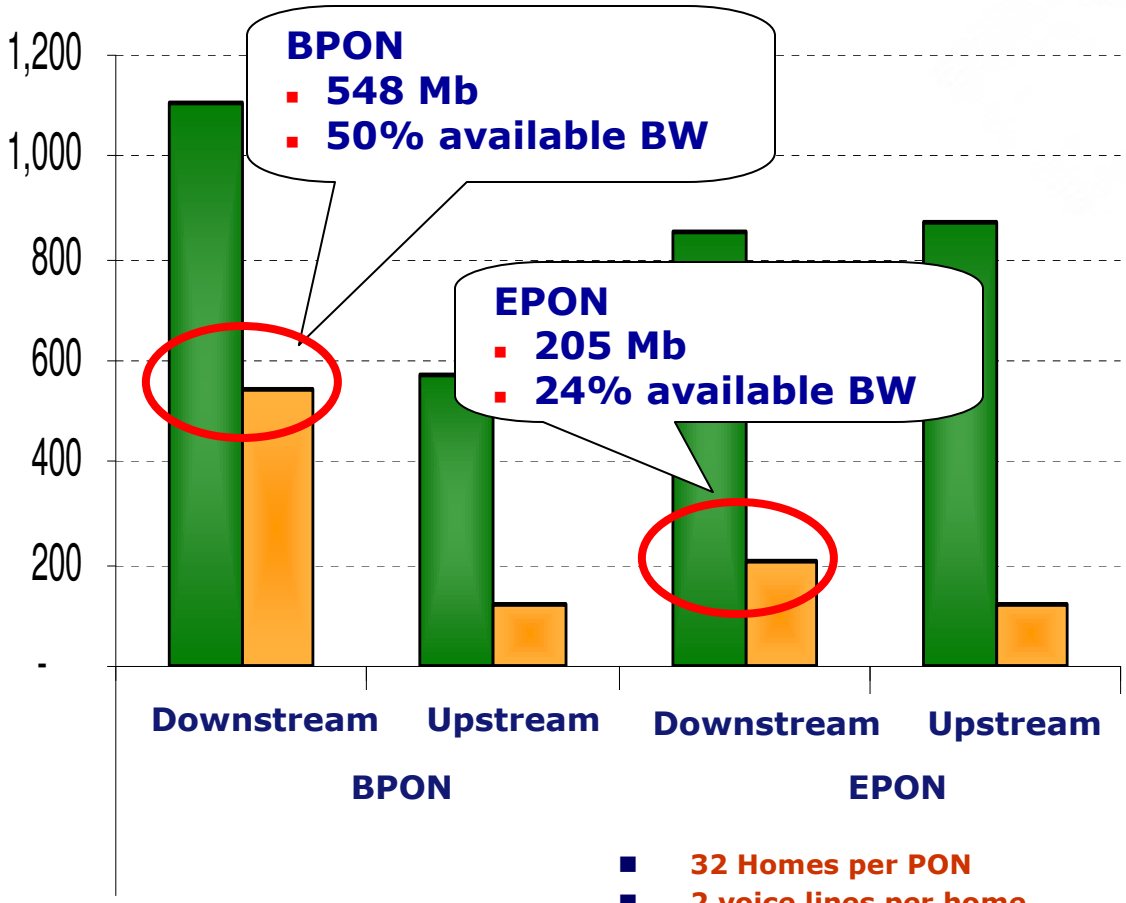
EPON - Multicast

BPON/GPON -Unicast





Bandwidth Efficiency - Payload



EPON Supports Multicast and Unicast

- One copy of each video stream on the PON
- Efficient payload utilization

BPON supports Unicast only

- Many copies of each video stream on the PON
- Inefficient use of payload bandwidth

- 32 Homes per PON
- 2 voice lines per home
- 3Mbps Internet service per home
- 2 STBs per home; 80% active
- 80% channels are HD
- 12 different active IP video channels



Why you need IGMP Awareness Everywhere

- Two types of Ethernet Switches
  - **Layer 2 Switch**
    - Distributes traffic using MAC addressing table
    - Broadcasts the Multicast traffic on all its ports (the sum of all the video traffic from all the STBs is sent to every STB)
      - STBs experience pixelization once the sum of the traffic exceeds their performance capability
    - Poor home network performance
  - **Layer 2 Switch with IGMP Snooping**
    - Distributes traffic to each destination using MAC addressing table
    - Controls Multicast traffic to prevent broadcast of the traffic to all ports.
- Best Solution: IGMP Snooping-aware ONT with enough ports for fanout
  - Otherwise you must use a Layer 2 Switch with IGMP Snooping for STB fanout



IP Video Summary

- **Two types of IPTV traffic**
  - BPON - Unicast for all IPTV
    - Multicast is not Supported by BPON Standards
    - Inefficient Payload Consumption
  - EPON – Both Multicast and Unicast (VoD) IPTV
    - Single Copy Broadcast (SCB) → Efficient Payload Use
- **Requirements for Successful IPTV Implementation**
  - Support IGMP Snooping on the ONT
  - Multiport home ONT
    - Avoids cost of external IGMP Snooping Ethernet switch
  - Support IGMP Proxy on the OLT
  - Support Layer 2 multicast on the PON / access network
    - SCB is important

Bandwidth for the Future

Be Sure You Have Enough



Market Drivers - Services

Consumers Insatiable Demand for Services/bandwidth

- Entertainment Services:
  - Time-shifted Television – Unicast Vs. Multicast
  - Interactive 3-D Gaming
  - Peer-to-peer Video Sharing
- Education
  - Distance Learning
  - Internet As an Educational Tool
- Home Automation
  - Utilities Telemetry, Management, Billing
  - Lighting, Appliance, Ventilation Systems Control

Businesses Demand More Services

- Telecommuting: Video Conferences, Data Access, File Transfers, Security
- Hosted Applications
- Remote Real-time Medical Imaging/diagnostics
- Remote CAD Design
- Data Storage and Backup
- Security Services
  - Real-time Video Monitoring
  - Response Systems
  - File Transfers to Off-site Storage/backup Facilities

Communities Demand Communications Services for Differentiation

- Attract Businesses
- Attract Residents



Future Residential Service

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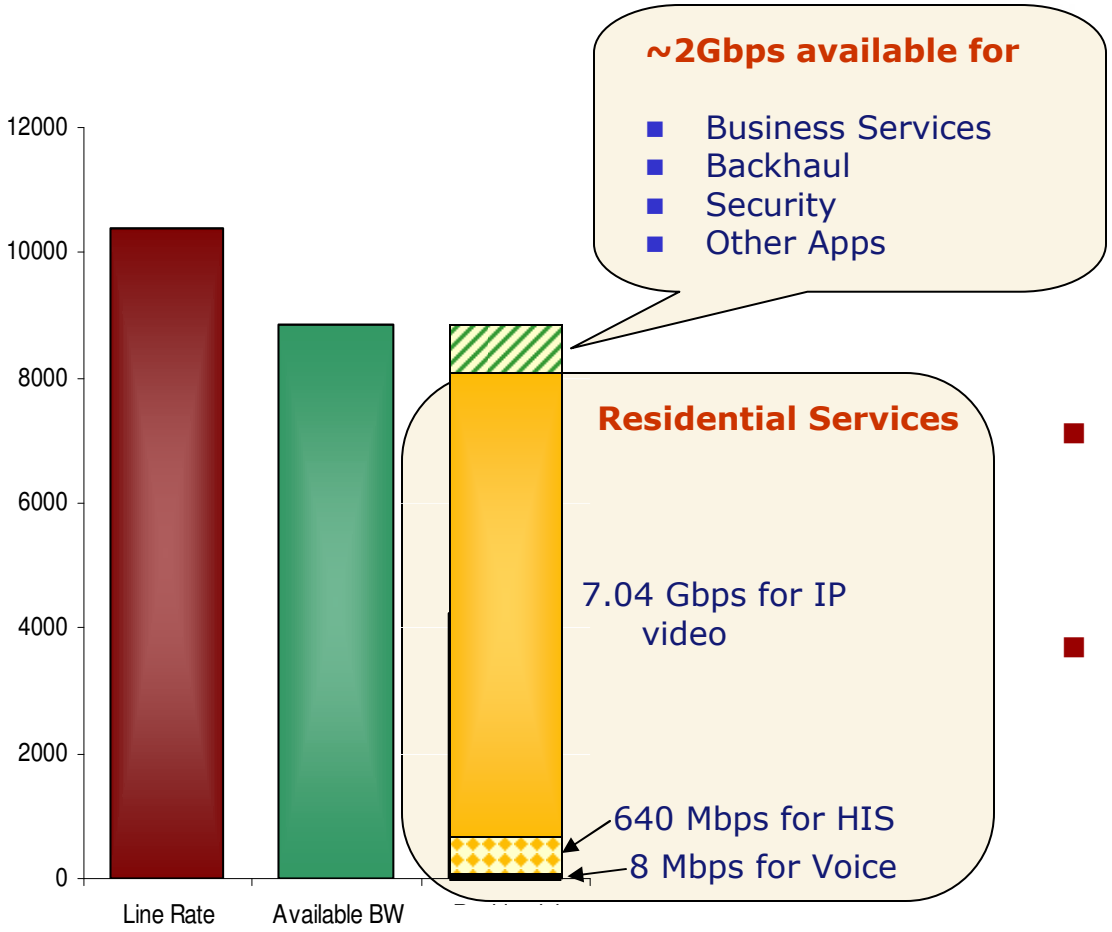
Residential Services Future	
64 Subscribers per PON	
200 Channel IPTV line-up	
MPEG4 compression	
SD, HD, HD/DVR, Time-Shifting, and Picture-In-Picture = 4 ch/STB	
100 HD channels	
100 SD channels	
2 phone lines per sub	
10 Mbps HIS per sub	
3 STB per home	
Downstream PON BW	
704 HD =	7040 Mbps
64 SD =	384 Mbps
64 HIS =	640 Mbps
128 phone lines =	8 Mbps
Total PON BW =	**8072 Mbps**

- Future will require more bandwidth
  - More time-shifted video
  - More HD video
  - More video streams per home
  - Faster Internet connections
- EPON has a solution
  - **10Gbps EPON**



10G EPON Bandwidth



- 10G is ample bandwidth for residential AND business / other services
- 10G is the defined Ethernet progression
  - IEEE Standards-Based



Voice Services



Voice Services

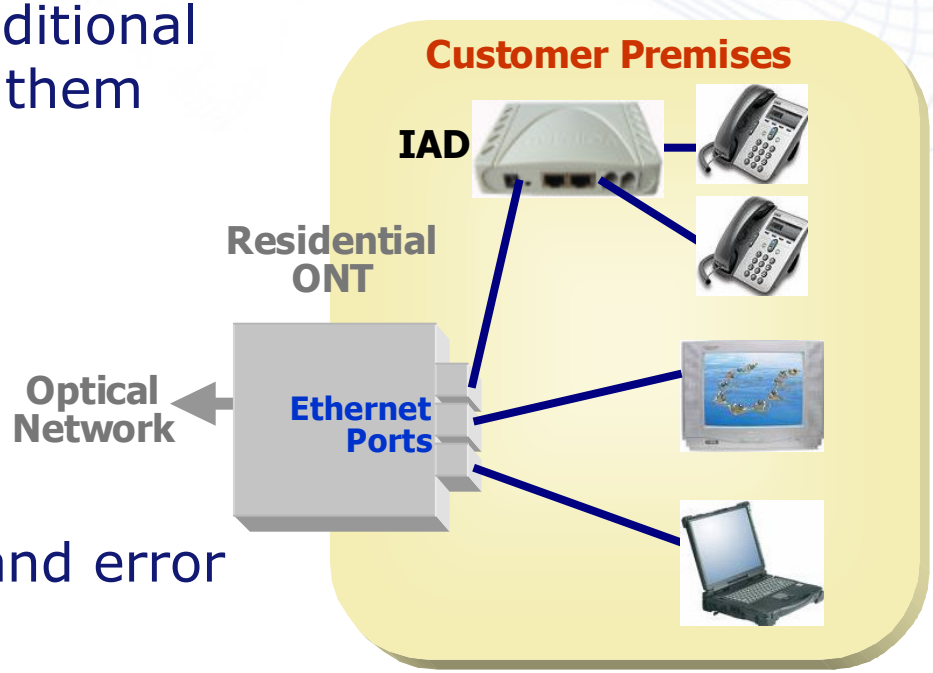
- **Current Status**
  - TDM / POTS voice services dominate today
  - Migrating to VoIP services underway
    - Operational cost savings
    - Network simplification
    - Subscriber perception
  - Transparent migration to VoIP is a MUST
    - Minimal subscriber impact
    - Least equipment changes
    - No change in service / features
    - Time of implementation control

- **BPON/GPON technology implementation is Ethernet transport**
  - Any TDM support is circuit emulation
    - Wander, jitter, and latency problems
  - Voice requires gateway device → extra $80-$150 costs
- **EPON supports TDM along with Ethernet**
  - Alloptic has patented TDM (T1/E1) support without wander, jitter and latency limitations
  - TDM POTS is supported by ONT
  - Seamless migration to VoIP via dual-technology ONTs



VoIP Deployment via Ethernet Ports on the ONT

- BPON/GPON Solution
  - Give the subscriber additional CPE (TA/IAD), and let them plug in phones

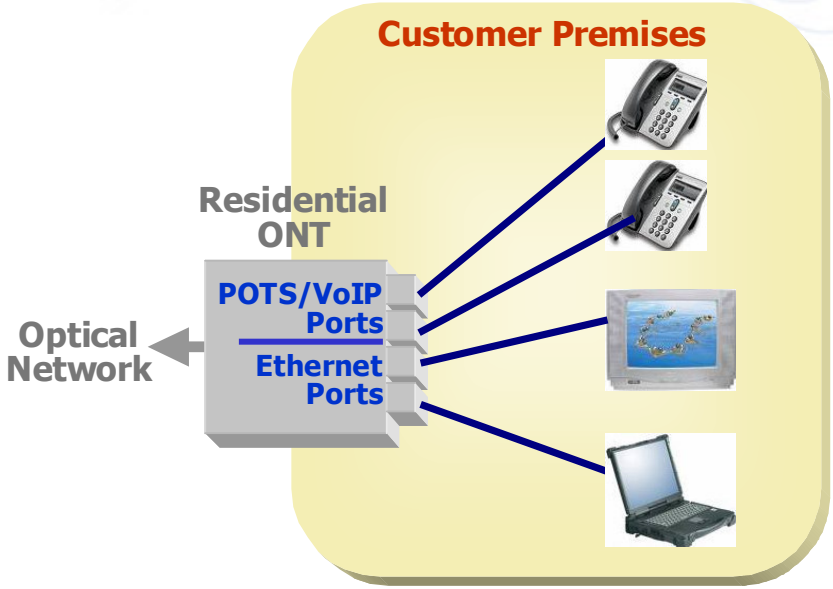


- Concerns
  - Subscriber confusion and error
  - Poor port utilization
  - Increased CapEx
    - Unrecoverable cost of TA/IAD (or charge subscriber)
  - No QoS control → Poor user experience; clips and clicks
  - Must coordinate service timing with customer install



VoIP Deployment via Phone Ports on the ONT

- EPON Solution – Phone ports on the ONT
  - Use ONT that supports both POTS and VoIP using the same RJ11 port



- Benefits
  - Subscriber unaffected
    - No equipment changes
    - No timing coordination
  - Cost controls
    - VoIP device is network equipment (not loose box)
  - QoS control → Excellent user experience



VoIP Migration Notes

- EPON Implementations Offer Ideal Migration from POTS to VoIP:
  - Subscribers experience no change in service level between POTS and VoIP
  - Subscriber often unaware that any change occurred
    - No additional CPE
    - Commands the same to invoke features
- VoIP services need to support Class 5 features
  - Subscribers are accustomed to Class 5 switch services and methods
    - e.g. #6 = call waiting enabled
  - FAX capability is important
- Not all VoIP services are equal
  - Feature support ranges from basic ring/dial/talk to full class 5 service options
  - FAX requires G.711 compliance
    - Auto-detect is critical to subscriber satisfaction

Multiple Data Services



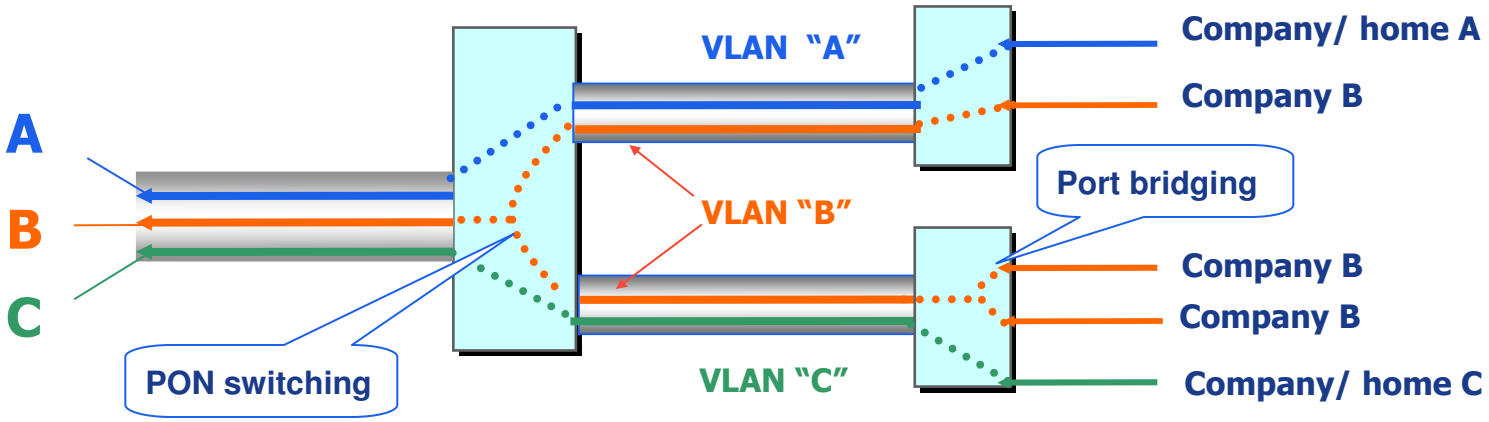
Rich Ethernet Services

- **Delivering Multiple Services requires end-to-end traffic control**
  - **Identification**
    - Separate ports, VLAN tags, mixed tagged and untagged on the same port
  - **Segregation**
    - Ensure you can segregate and path manage each service
      - VLAN, QinQ, T-Cont
      - By port, by service, by user
    - Easily map from Access to Core – Ethernet VLAN tags, Q-in-Q
  - **Traffic Management**
    - Bandwidth guarantees
    - Granularity
    - Bi-directional
    - Multiple classes / types of services
    - Policing and shaping when there is excess
- **BPON/GPON implemented as Ethernet transport only**
  - Lacks rich Ethernet features
- **EPON (Ethernet PON) carries full Ethernet features**
  - Supports all Traffic Identification, Segregation, and Traffic Management capabilities
  - Business services available for residential services



Managing Services and Subscribers

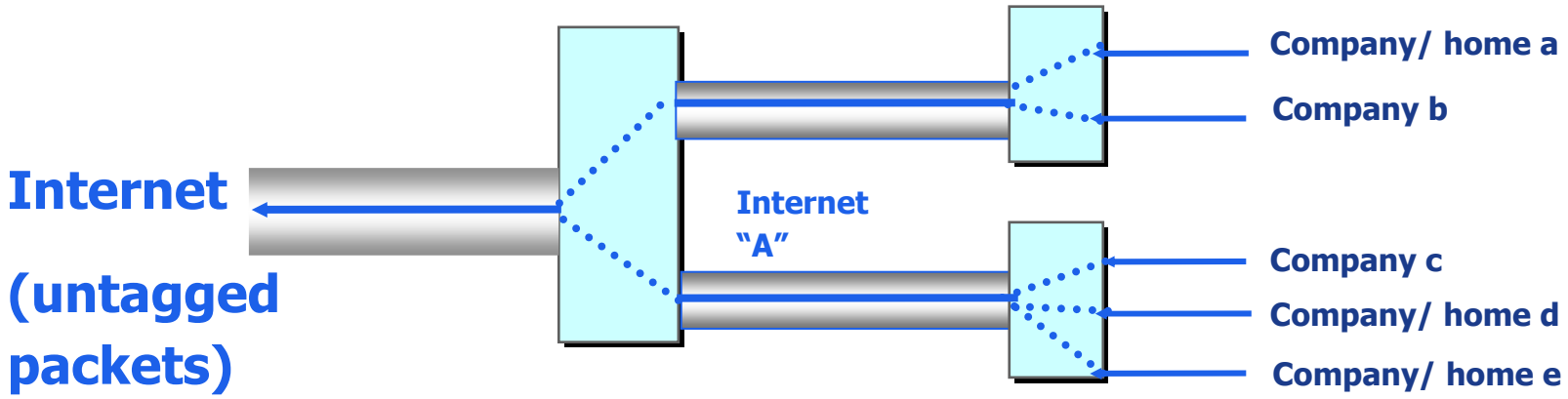
- BPON/GPON - Typical Implementation:
  VLAN per port or per user
  - VLANs provide traffic segregation and security
  - Ideal for business applications (E-Line and E-Lan Services), video, VoiP services
  - VLANs identify specific accounts for easy billing
  - Allows per user traffic management
  - Maps easily between Access and Core





Managing Services and Subscribers (Cont)

- EPON Implementation – ESAF
  - Very simple configuration, ideal for data services
  - Only 1 VLAN is required to support all data ports in the system
  - Allows for simple router/switching equipment in the head-end
  - Supports DHCP lease enforcement
  - Filters ARP and broadcast messages based on IP address
  - Supports Option 82 for subscriber billing
  - Allows IP restrictions and IP address limitations
  - Users on one port cannot gain access to other users on the system (uses an internal routing tag)
  - Support both VLAN tagged and ESAF traffic on the same port





Summary (1 of 2)

- **BPON/GPON and EPON are significantly different**
  - Technology is different
  - More importantly, implementations are different
  - Simply being able to deliver IP video and VoIP is not enough
  - Deployments can be difficult or easy and annoy or delight subscribers
- **IP Video**
  - BPON/GPON only supports unicast methods
  - Multicasting with widespread IGMP proxy and snooping support is critical
    - Most efficient bandwidth management
  - Consider future bandwidth
    - Best use of CapEx
  - EPON has a defined migration path to higher bandwidth (10Gbps) services



Summary (2 of 2)

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- **Voice Services**
  - Most of the network is TDM – it must be supported
  - EPON implementations handle TDM POTS and T1/E1 without circuit emulation and its jittery/wander/latency issues
  - Migration to VoIP is simpler and costs less with EPON
  - EPON implementations define features and services aligned with subscriber expectations – Class 5 and FAX

- **Multiple Data Services**
  - Requires end-to-end traffic controls
  - BPON/GPON implementations are simple Ethernet transport lacking rich Ethernet features
  - EPON, based on Ethernet, supports full range of SLA-quality Ethernet features for ALL customers



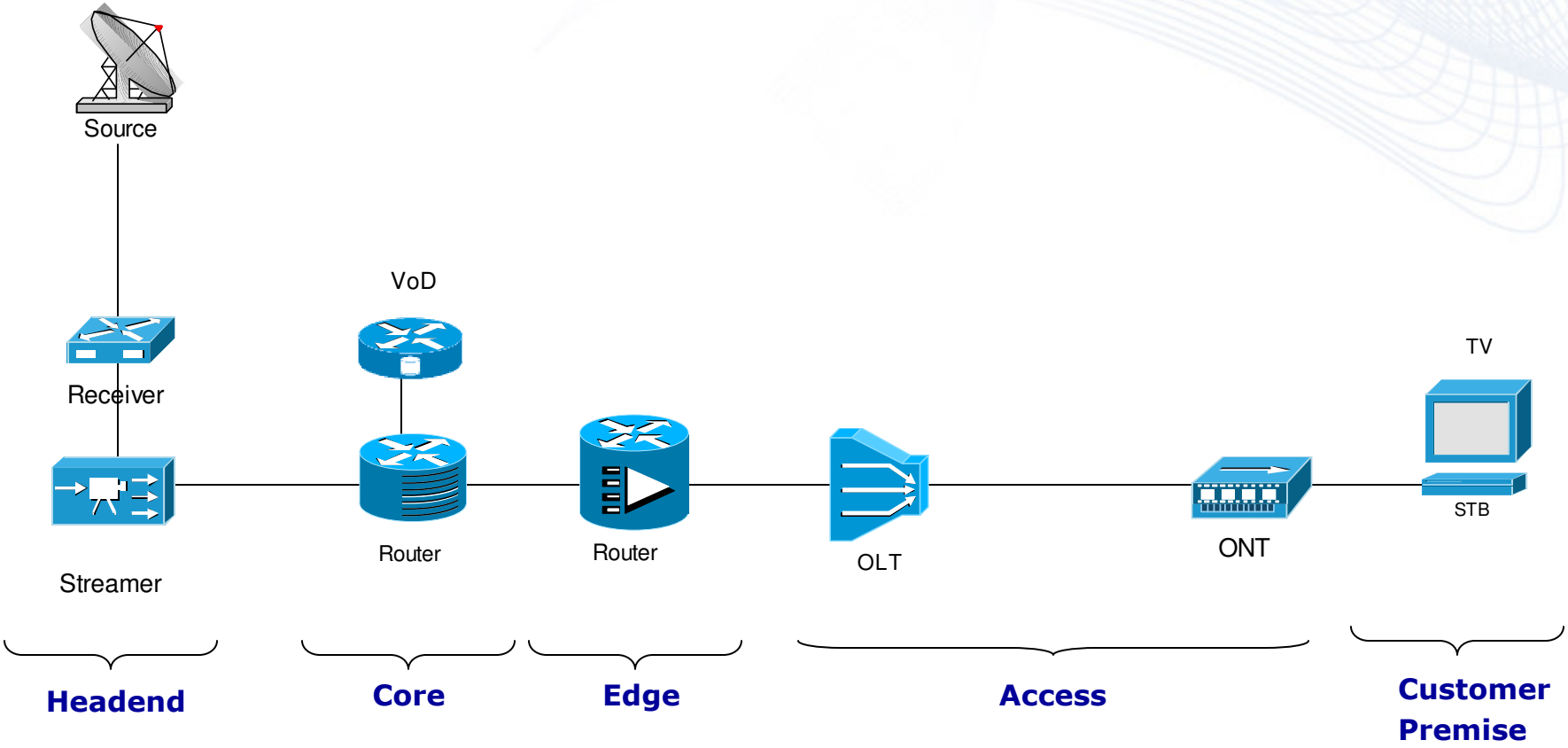
Imagine the Possibilities…



Bone Pile

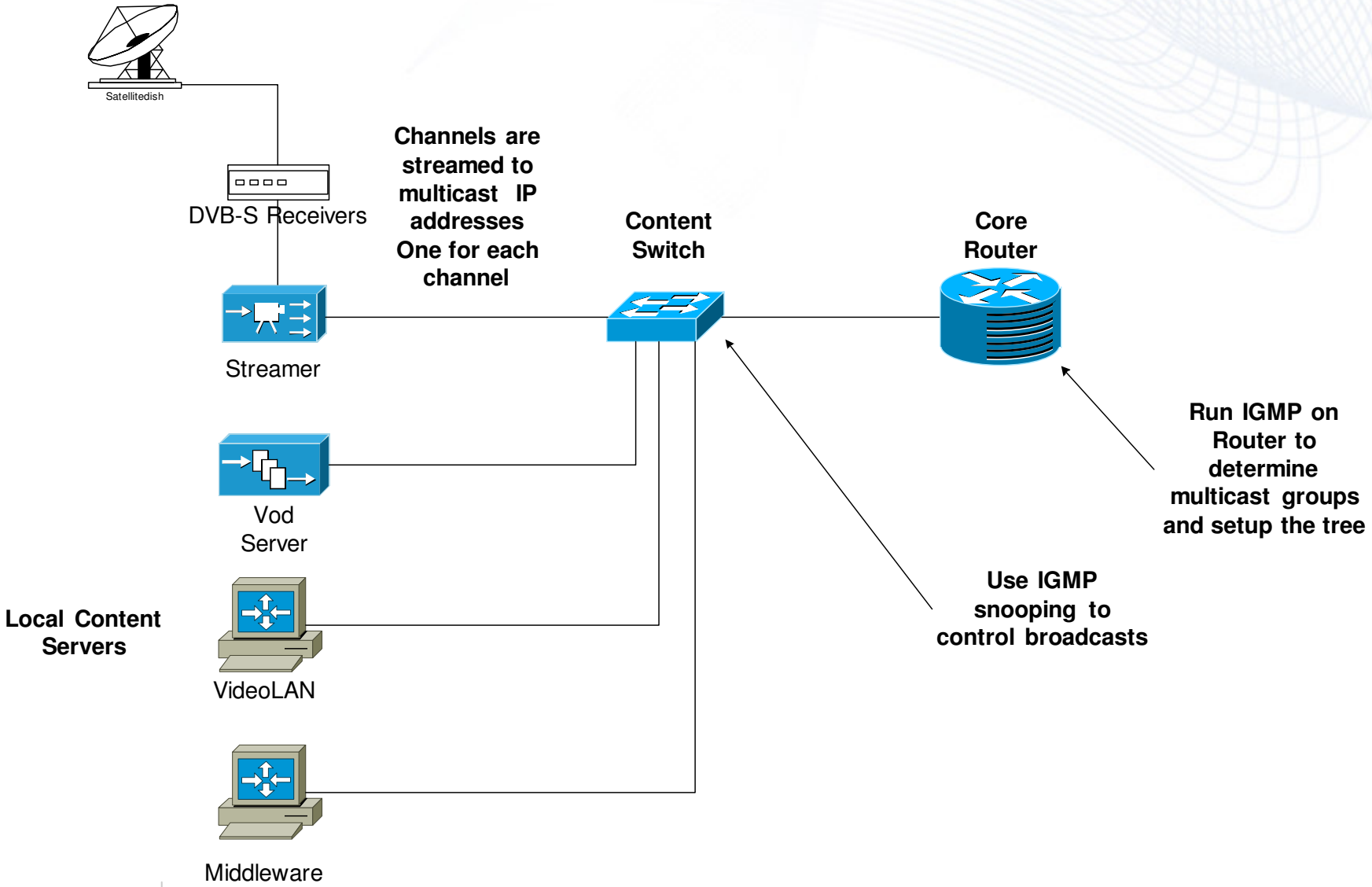


IP Video Architecture





Headend


Satellitedish
DVB-S Receivers
Channels are streamed to multicast IP addresses One for each channel
Content Switch
Core Router
Streamer
Vod Server
Local Content Servers
VideoLAN
Middleware
Run IGMP on Router to determine multicast groups and setup the tree
Use IGMP snooping to control broadcasts

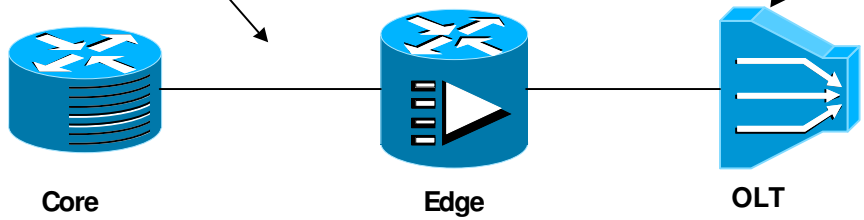


Core to Access

Run Multicast Routing between core and edge to control pruning of traffic

Prioritize IPTV traffic throughout the network. TV is actually MORE important than voice. Voice can handle some jitter. IPTV cannot

Proxy IGMP requests from access network to manage bandwidth back to the network, improve performance and reliabilty



Edge router should act as IGMP querier



Access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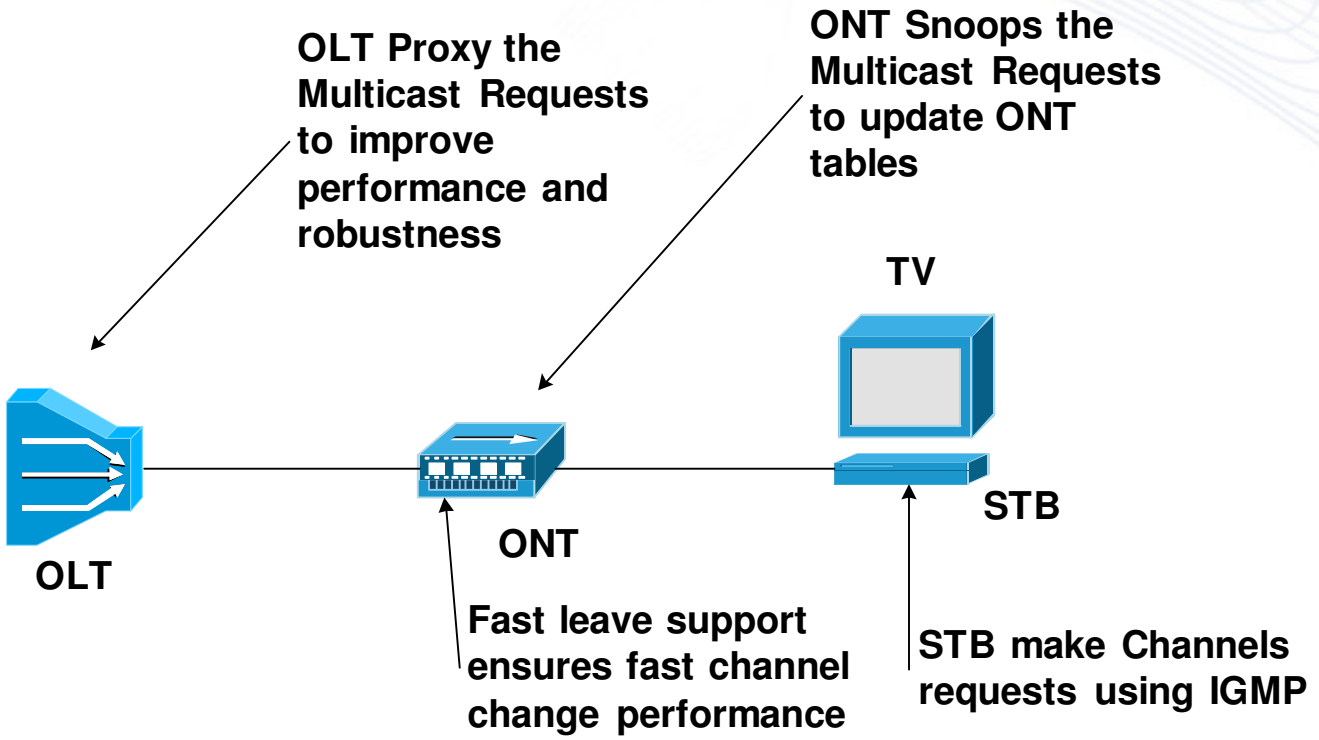
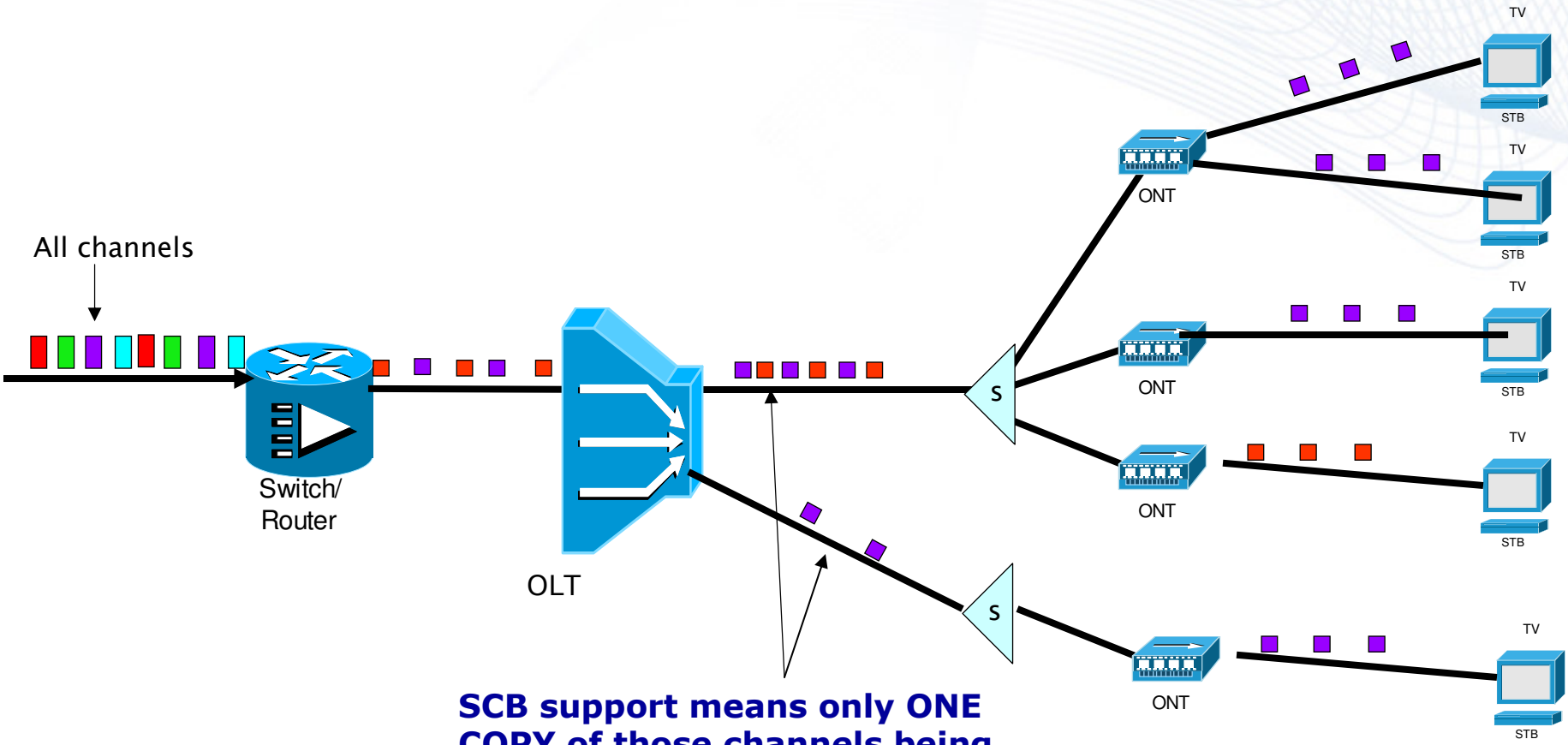

OLT Proxy the Multicast Requests to improve performance and robustness
ONT Snoops the Multicast Requests to update ONT tables
TV
STB
ONT
OLT
Fast leave support ensures fast channel change performance
STB make Channels requests using IGMP



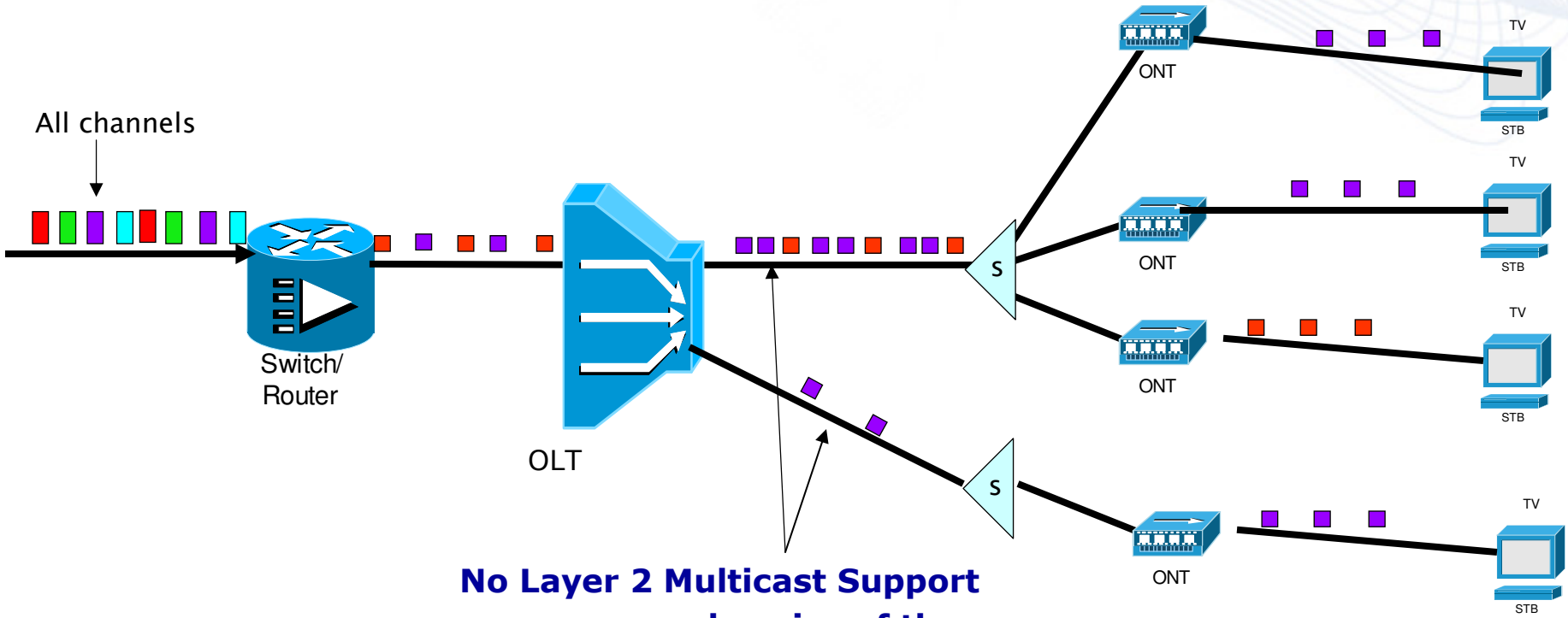
GE-PON



SCB support means only ONE COPY of those channels being used is ever carried on the PON



ITU Based GPON



No Layer 2 Multicast Support means several copies of the channel must be carried on the PON - One for each ONT



In the Home

- Option 1
  - ONT with 4 Ethernet Ports
  - 1 port for data (fanout to WAP, Switches, VPN Routers)
  - 3 ports for IPTV STBs
  - No IGMP Aware Ethernet Switch needed in the home
  - Guarantee Performance / QoS
  - Cost effective

- Option 2
  - ONT with 1 or 2 Ethernet Ports
  - Requires Ethernet Switch with IGMP Snooping for fanout
  - Adds to customer's cost ~ US$150 - $200 / switch
  - Difficult to Guarantee Performance (unmanaged device)



VoIP Interoperability

- Most problems with VoIP deployments are related to interoperability
  - Standards do not fully address how the elements work together
  - Softswitch integration is largest area of concern
- Choose a vendor that can help
  - A list of "interoperable partners" is a start but not sufficient
  - Every network is unique in features/services
  - No substitute for experience