Video Delivery in Broadband Networks

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Agenda

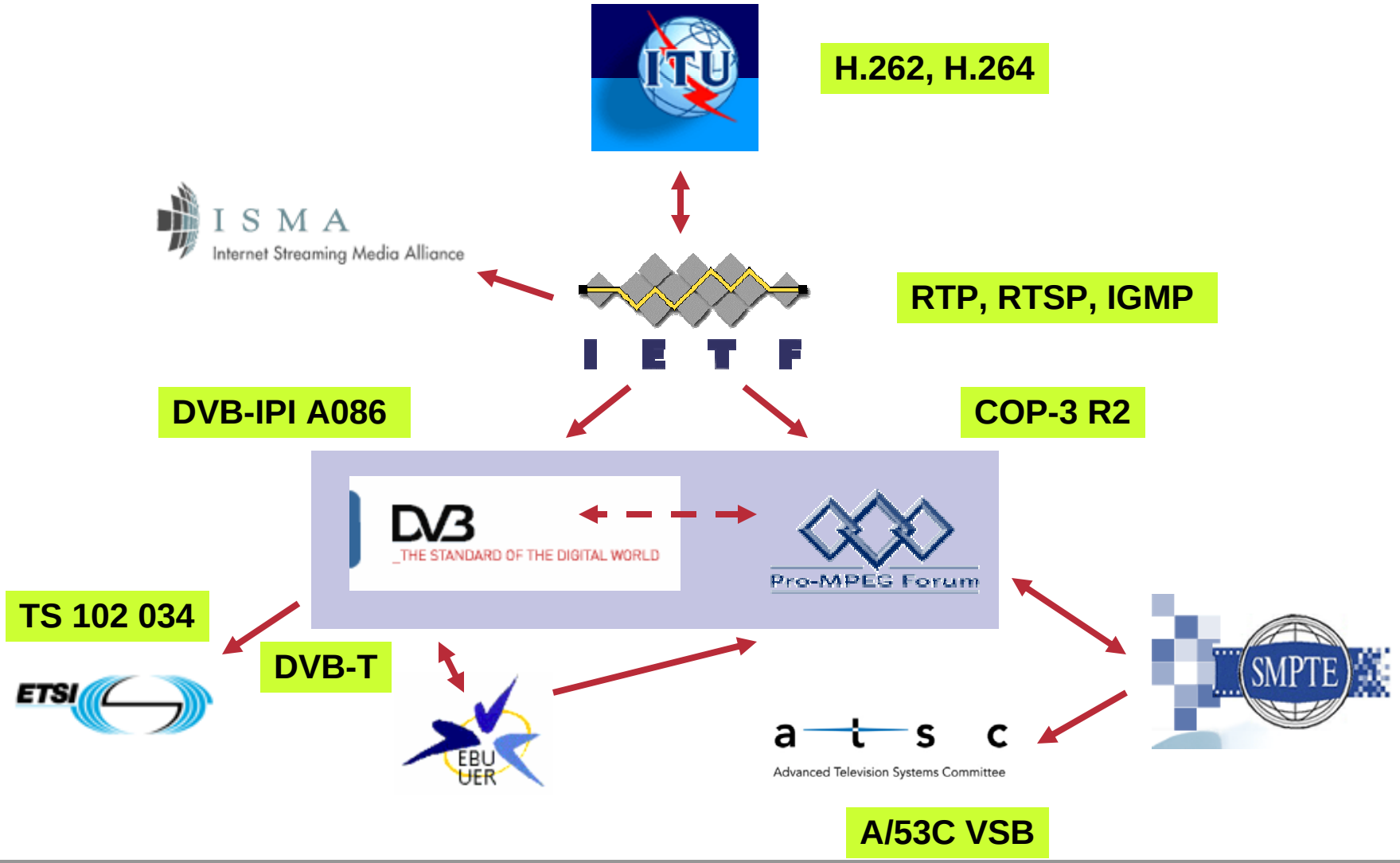
- **Introduction**
- **IPTV and Standards**
- **IPTV Building blocks**
- **IP Enablers**
- **Video over Broadband Architecture**
- **Q & A**

Introduction

- **IPTV is happening: 4 million subscribers by 2005 end**
  - **Enhanced customer experience driven by IP**
- **IPTV is an innovative technology that borrows many things from years of DVB/ATSC experience**
  - **MPEG digital video compression and transport for compatibility**
  - **IP for service flexibility**
- **IPTV services made possible by Broadband access leveraging on Carrier Ethernet architecture**
  - **Foundation for 3play services**
  - **Uses NGN architecture for service scalability**

IPTV and Standards

IPTV Standardization



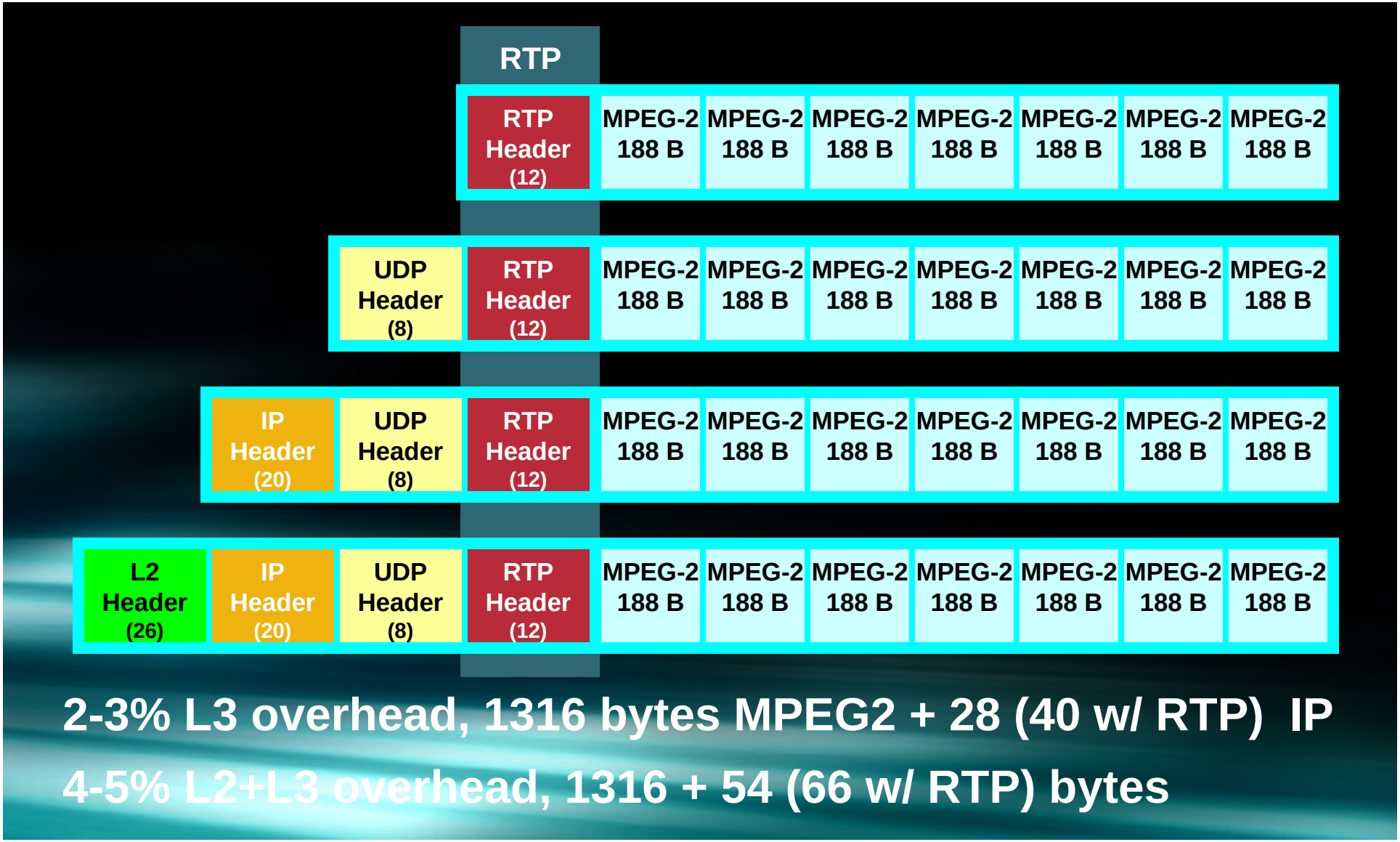
IETF (signaling)

- **Multicast-based services**
  - **RFC-3376 IGMPv3**
- **On-demand services**
  - **RFC-2326 RTSP**
- **Other IETF standards relevant: DHCP, DNS, …**
- **However, IGMPv2 is by far the most common signaling protocol used today**

IETF (transport)

- **Transport Service provided jointly by**
  - **UDP: checksum and multiplexing**
  - **RTP: sequencing and timestamping**
- **Defined in RFC-2250 "RTP Payload for MPEG-1/2 streams"**
  - **Section 2. MPEG TS encapsulation (MP2T payload type)**
  - **Section 3. MPEG ES encapsulation (MPV)**
- **However, industry keeps on using the "de-facto" MPEG-TS/UDP encapsulation**

Encapsulation of MPEG-2 TS on IP



2-3% L3 overhead, 1316 bytes MPEG2 + 28 (40 w/ RTP) IP

4-5% L2+L3 overhead, 1316 + 54 (66 w/ RTP) bytes

DVB-IPI An architecture for the delivery of DVB services over IP networks

- DVB-IPI Bluebook A086 – ETSI Draft TS 102 034 1.1.1
- Service delivery
  - MPEG-2 TS encapsulation
  - Use of RTP and RTSP for VoD
- Service discovery
  - Using DVB PSI/SI information and DNS
- Service selection
  - Using IGMP and RTSP
- STB authorization (DHCP)

http://www.dvb.org/documents/modules/a086.Draft%20TS%20102%20034%20v1.1.1.pdf

DVB-IPI Transport and Network requirements

- **MPEG-2 TS Encapsulation**
- **RTP is mandatory**
- **Each stream carries DVB SI tables (PAT/PMT)**

- **Total jitter < +/- 20 msec**
- **Packet loss < 1 noticeable artifact per hour (10^{-6})**
- **QoS settings recommendation**

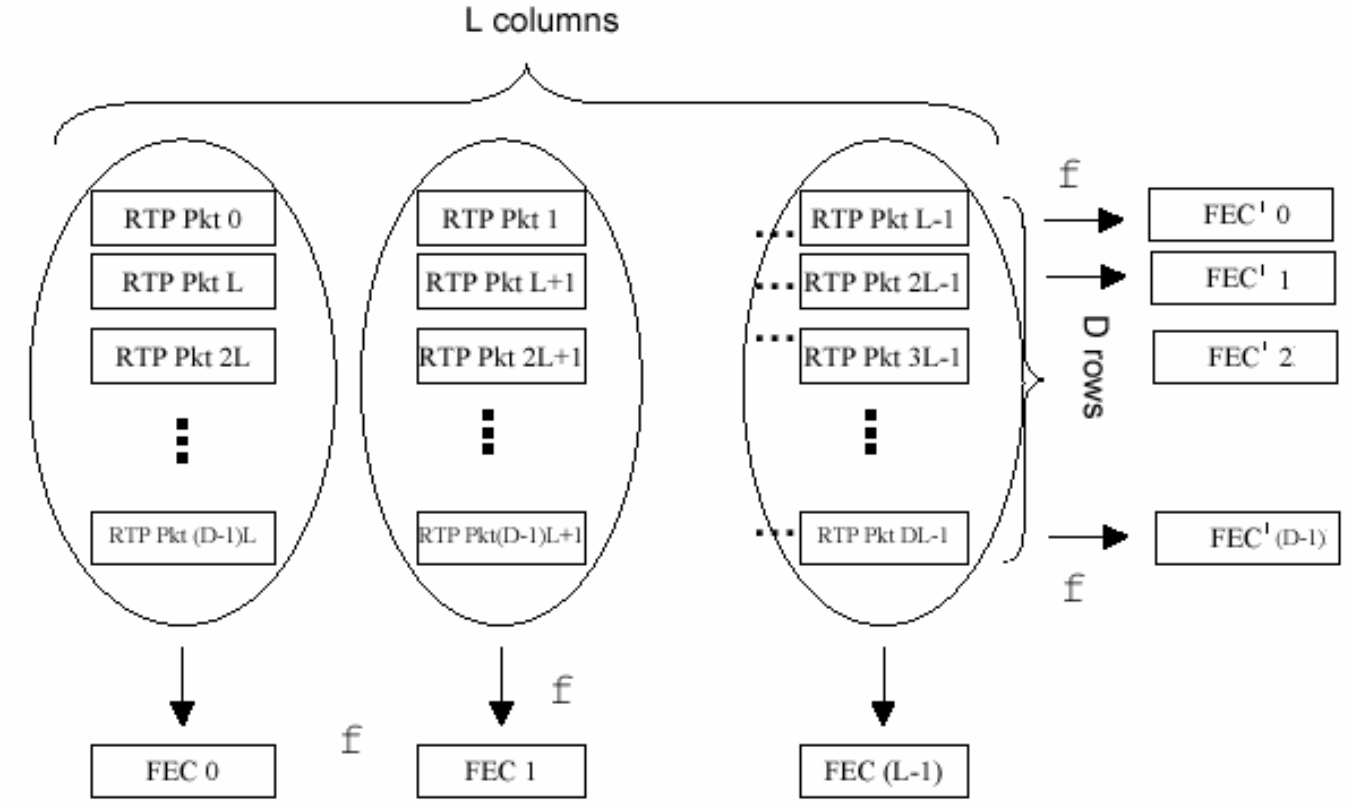
Pro-MPEG

- **Professional Video Transport focus**
- **Transport of MPEG-2 (COP-3) and uncompressed SMPTE 292M (HDTV) (COP-4)**
- **Use of RTP**
- **Generally more strict in packet loss, less in jitter**
- **Jitter < +/- 60 msec**
- **FEC scheme for error recovery**

http://www.pro-mpeg.org/publications/pdf/Vid-on-IP-CoP3-r2.pdf

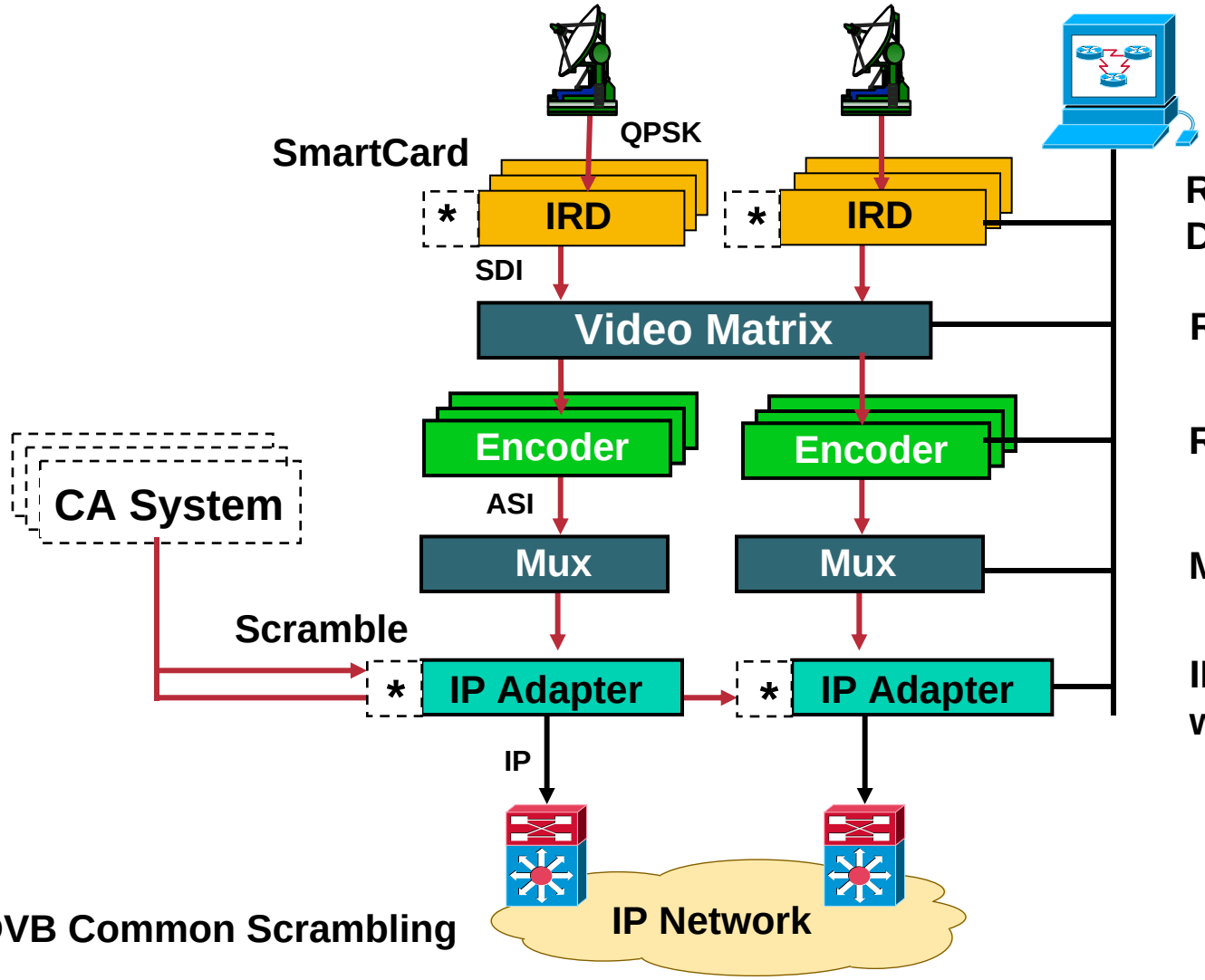
Pro-MPEG COP-3 2D-FEC scheme

- **Based on RFC2733, XOR FEC packets**
- **FEC streams sent on UDP ports RTP+2 (col), RTP+4 (row)**



IPTV Building Blocks

“Traditional” IPTV HE components



Receive & Decode & Descramble

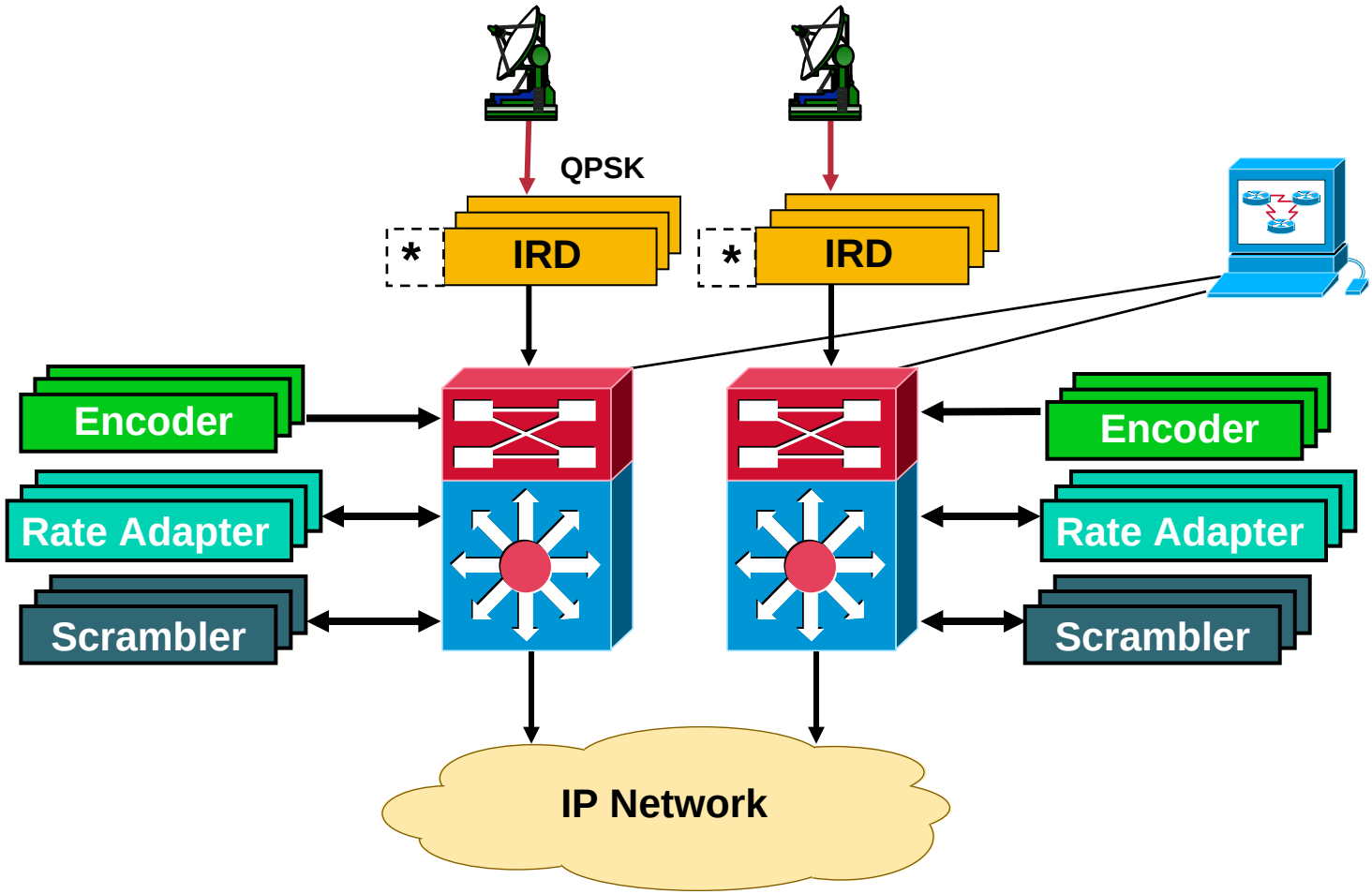
Route streams

Re-encode

Mux & Adapt rate

IP Encapsulation w/ optional scrambling

IP Centric HE



Content Protection: CAS and DRM

- **Conditional Access System (CAS) comes from Broadcasting world**
  - **Focus on protecting the service against theft**
  - **Protects content at the transport level**
  - **Moving from H/W based (SmartCard) to S/W based**
- **Digital Rights Management (DRM) comes from IT world**
  - **Focus on the contractual rights between the content owner and the consumer**
  - **When and how many times the content may be accessed and eventually recorded**
  - **Protects content at the application level**

Middleware

- **Service Discovery (EPG) and Selection**
- **Interface to Subscriber Management and Billing**
- **Abstraction layer that hides the access network to the STB**

- **Portal**
  - **Tandberg TV, Minerva**
- **Commercial**
  - **Orca, NDS, Envivio, Motorola**
- **Home made**
  - **Fastweb, Imagenio**
- **Vertically Integrated**
  - **Microsoft TV**

Set-Top-Box

- **Linux based (Amino, Kreatel)**
  - **Portal Middleware**
  - **Commercial (Orca, Myrio)**
  - **Home made (Telefonica, Fastweb)**
- **MSTV (Kiss)**
- **Recent trends to support**
  - **HD**
  - **AVC decoders**
- **Still no general support for**
  - **IGMPv3**

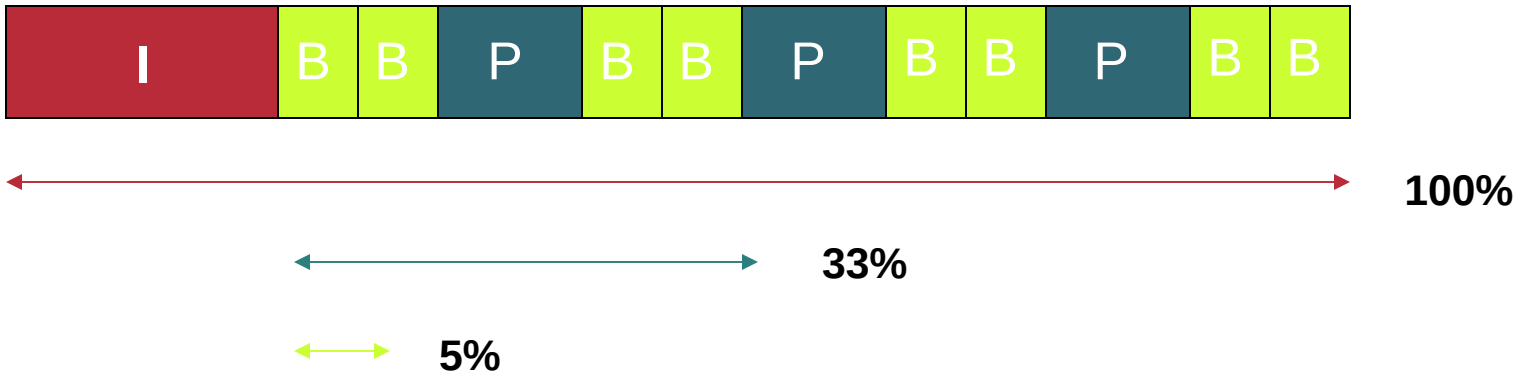
STB operation

TS → Look at the PCR

- **Transport buffer**
  - De-jitter and PCR synchronization (+/- 100 msec)
  - Look at the PID → TS payload
- **De-multiplex buffer**
  - Separate voice, video ES and other program components
  - Look at the DTS/PTS in the PES → PES
- **Decoding buffer**
  - Store reference frames
  - Reorder and decode frames
  - Display frames → TV

GOPs, network failures and channel change

- **Group Of Pictures (GOP) and frame relevance**



- **MPEG-2 GOP of size 12 => 480 msec (25 fps)**
  - **Hitting an I-frame (> 20% probability) affects the whole GOP**
  - **< 300 msec should cause a single-GOP loss, i.e. minor glitch**
  - **STB vendor dependencies**

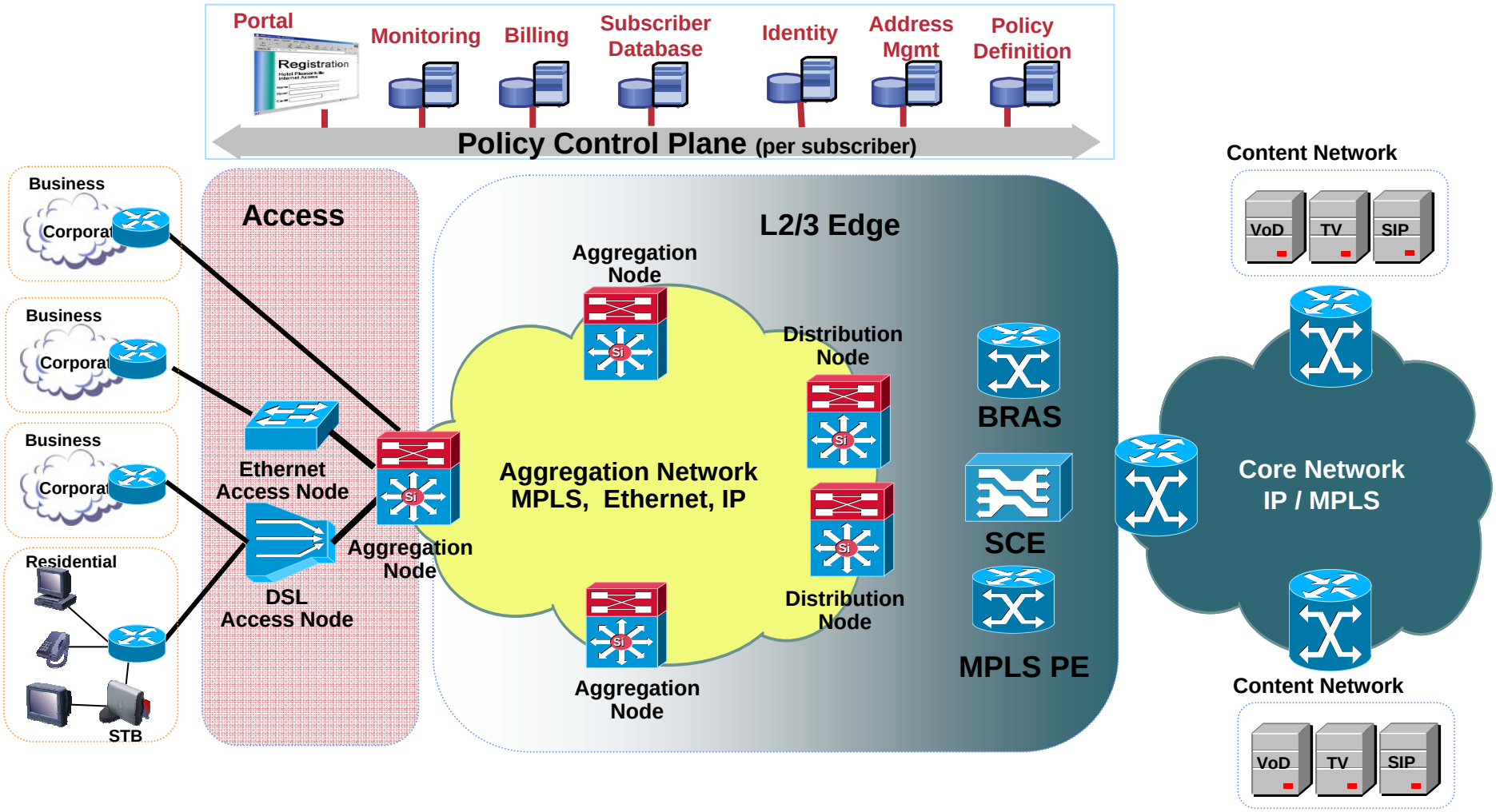
Publishing content

- **Asset = Content + Metadata describing the content**
- **Description uses XML language**
- **CableLabs specifications available**

- **Building and associating Metadata with content**
- **Linking Metadata with EPG**
- **Asset Management**
  - **Pushing titles (media + metadata) to the edge servers (CDN)**
  - **Making titles available/unavailable (publishing)**

Video over Broadband Architecture

Next Generation Broadband Architecture



Video over BB. Architecture highlights

- **Distributed injection point model**
  - **L2/L3 “Service Bus” concept**
  - **VoD and Broadcast separated from B-RAS**
- **QoS model in aggregation network**
  - **Mapping to .1p CoS on access**
  - **Packet queuing capabilities on DSLAM**
- **L3 preferred over L2 for Video on aggregation network**
- **PIM SSM for multicast**
- **CAC for unicast and multicast**
- **Service separation**
- **Asymmetric networking**

L2 vs. L3 on the Aggregation Network

- General scalability concerns of L2 domains
  - Scope of broadcast domain
  - Individual addresses vs. prefixes
- Default L2 forwarding is constrained flooding
  - By MAC learning (unicast)
  - By IGMP/PIM snooping (multicast)
- L3 forwarding is always optimal
- L2 reverts to flooding in the presence of
  - STP topology changes
  - MAC entries aging out
- L2 Multicast relies on the Designated Router and the Querier
  - Single injection point (DR)
  - Both must be re-elected in case of failure

Video is unidirectional!

Multicast trees

Applications Spectrum

One to Many

Many to Many

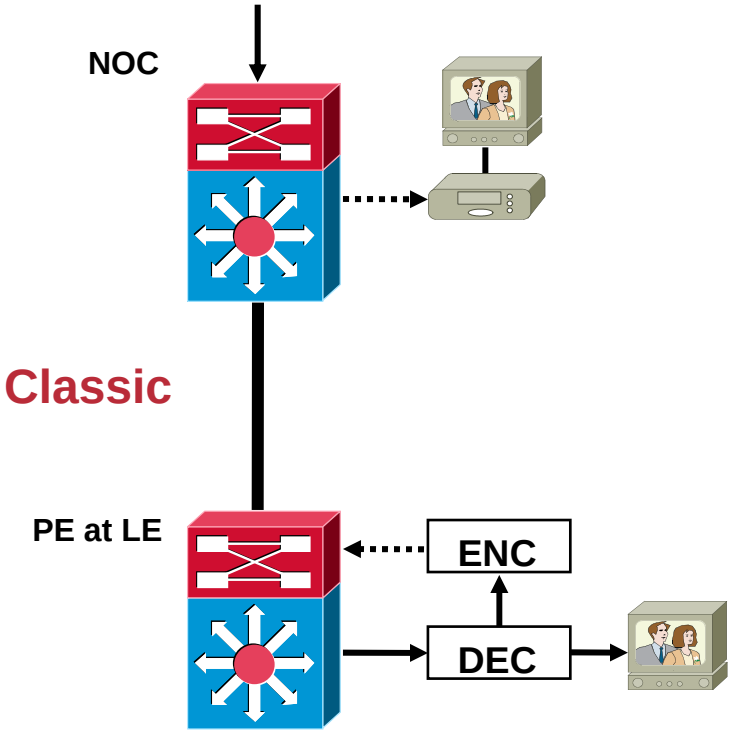
IPTV

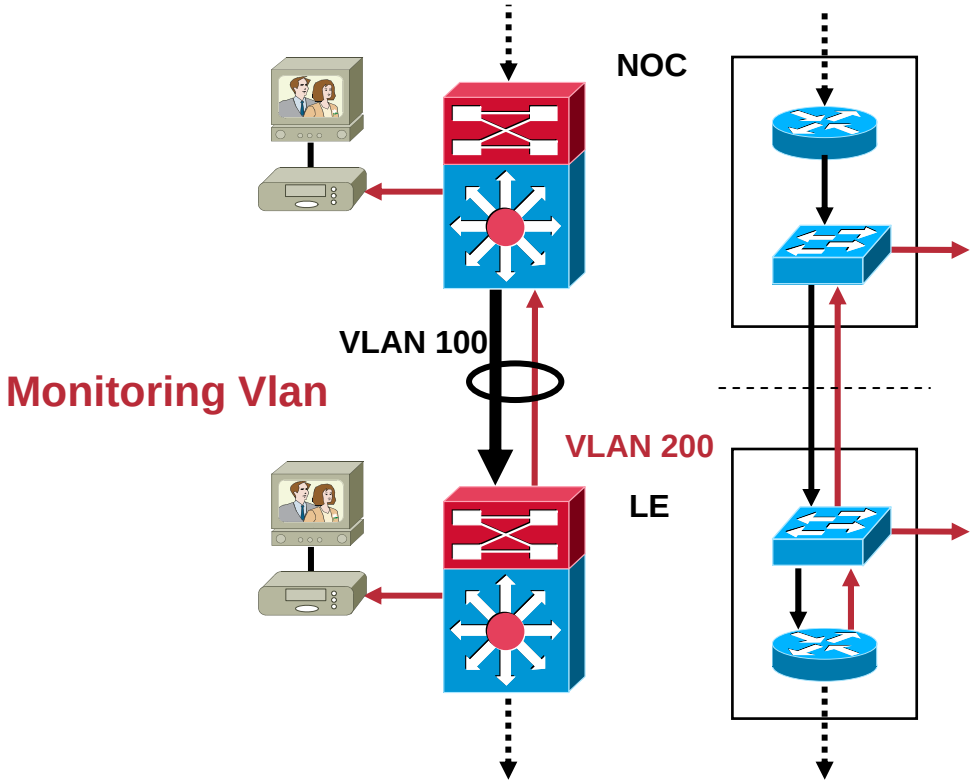
Video Conferencing

Advantages of SSM

- **Simpler**
  - **Sources are known in advance**
  - **No RP**
  - **Single (SPT) tree**
- **More secure**
  - **Only one source can send to SSM channel**
  - **Prevents DoS by malicious attacks or misconfigurations**
- **More scalable**
  - **Better use of address space**

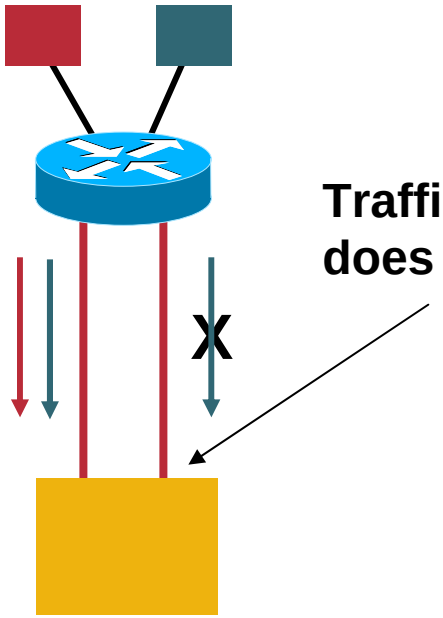
Monitoring



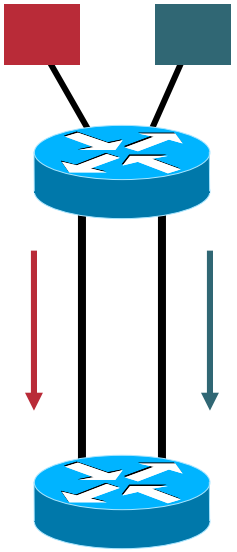


- One Monitoring VLAN per Remote Location
- Backhauled at L2 (e.g. EoMPLS) to NOC
- One channel per Monitoring VLAN. Reuses empty Aggregation network

Multicast Load Balancing



Traffic on this interface does not pass RPF check



`ip multicast multipath`

- **Layer 3 alternative to tunnels or link bundling (EtherChannel)**
- **Load balance IP multicast traffic on a per source/RP basis**

UDLR and Asymmetric Networking

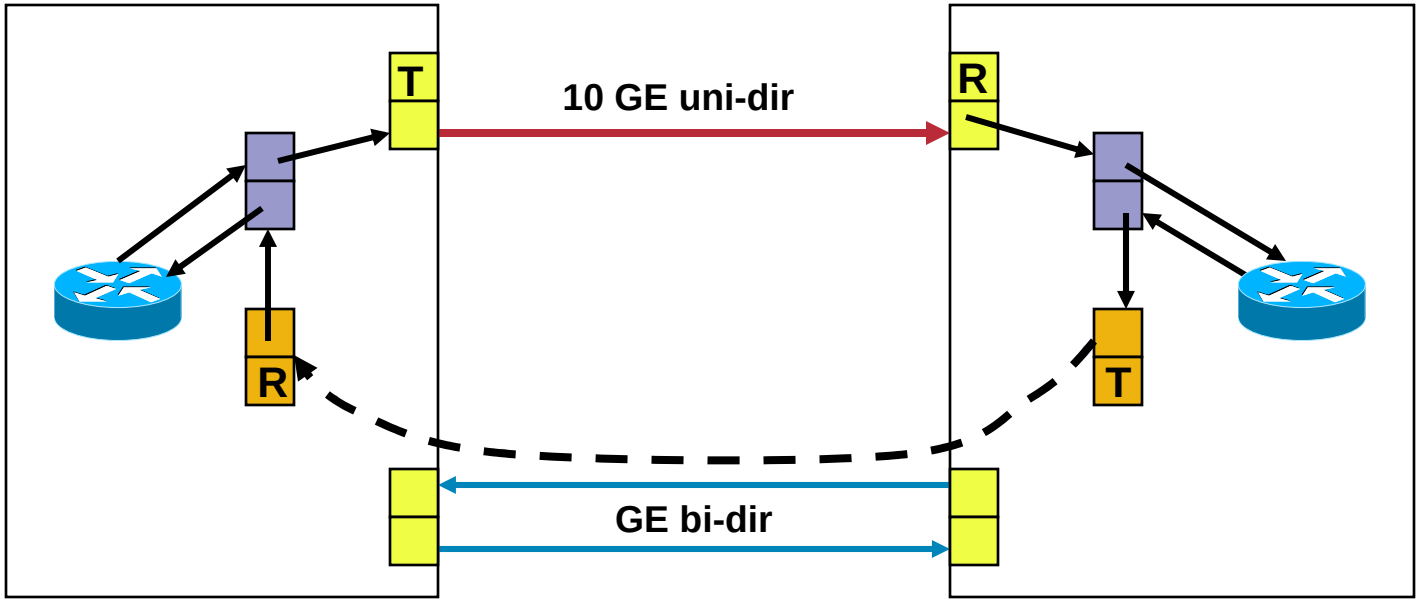
Physical Interface

Logical Interface (Vlan)

Tunnel Interface

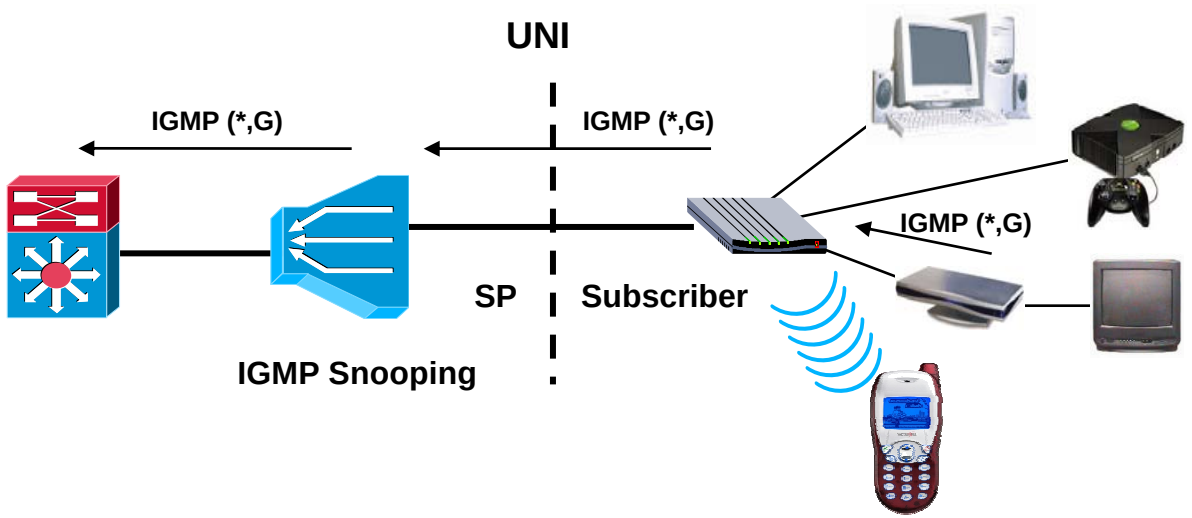
R Receive-only Interface

T Send-only Interface



L3 tools for securing the UNI

- **Data plane**
  - **Filter upstream multicast injection**
- **Control plane**
  - **PIM**
  - **IGMP**



Prevent	Using
PIM Adjacencies (hellos)	Administative Boundaries
PIM Registers	Mroute limits
PIM Assert election	Message Authorization
DR election	Access Control Lists
Unauthorized SA messages	Filtering
Unauthorized Access	Throttling
Flooding of control messages (DoS)	Rate limit

QoS Guidelines for Video

- **Network SLAs**
  - **Delay: not critical. Most applications unaffected**
  - **Jitter: not critical. STBs can buffer 200 msec**
  - **Packet-loss: critical. Packet loss rate < 10^{-6} (one noticeable artifact per hour of streaming)**
- **Packet loss due to queue drops by bursts at aggregation points from multiple sources (also number of hops, link occupation)**
- **Size the queue depth using probability analysis so packet loss rate (e.g. 10^{-6}) is below target**
- **If drop needed, drop VoD packets first (threshold)**

Service Oversubscription

1) What needs to be oversubscribed

	With Admission Control	Without Admission Control
Non oversubscribed		Broadcast Video
Oversubscribed	Voice VoD Switched Broadcast	Internet Access

2) Capacity planning

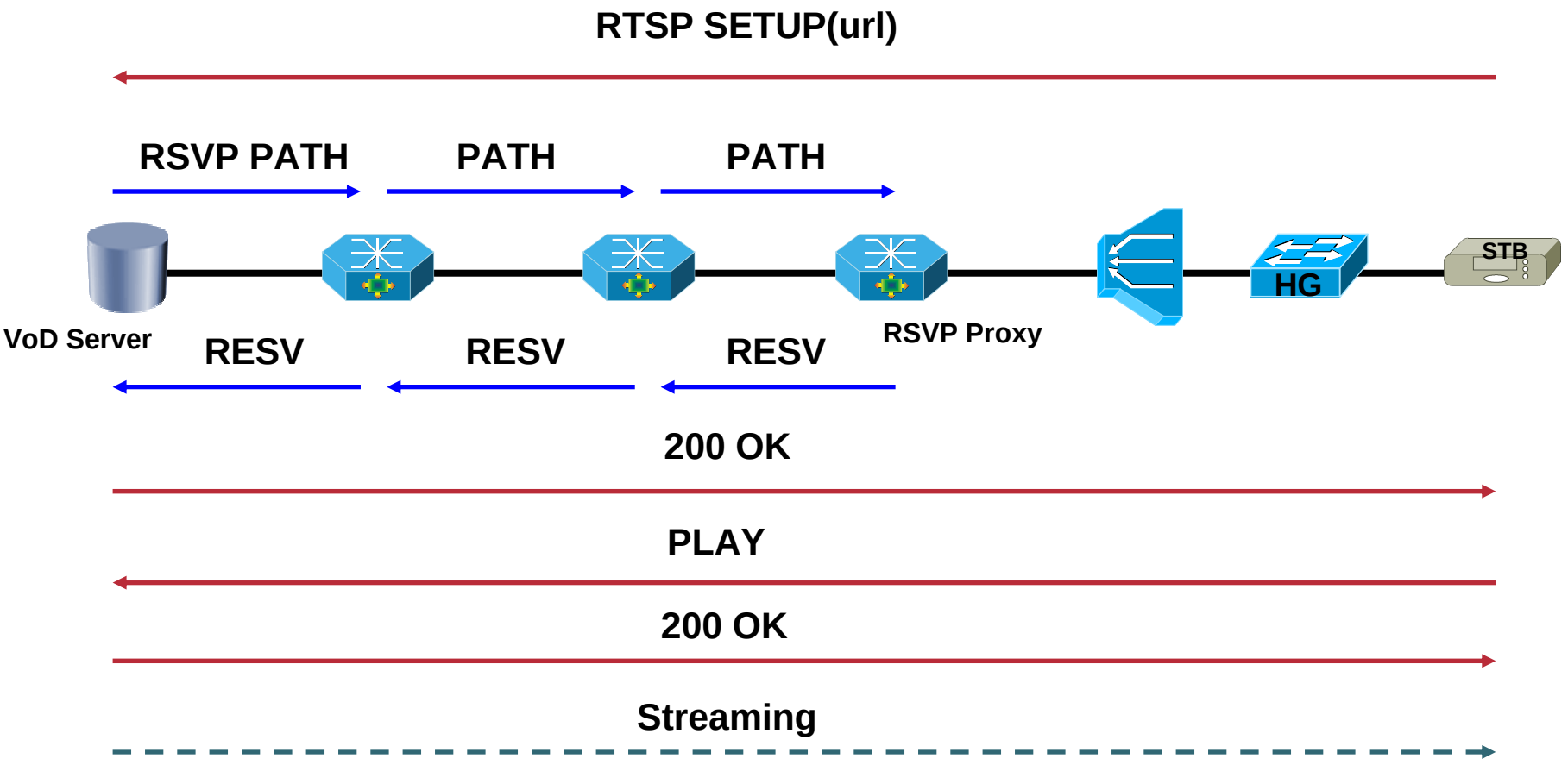
3) Define traffic classes and assign resources to them

4) Apply CAC (off-path geographical or on-path CAC)

Traffic classes and network behavior

	DiffServ DSCP	Prec	Behavior	Queuing	Other
Voice and voice signaling	EF	5	Low latency, High priority	Weighted queue	Police on exceeding weight
Video Broadcast	AF41	4	Assured forwarding, very low drop	Weighted queue	
Video on Demand	AF42	1	Assured forwarding, low drop		Drop on exceeding threshold
Video Signaling	CS3	3	Non oversubscribed class	Weighted queue	Police on exceeding weight
Internet Access	BE	0	Best effort	Weighted queue	WRED

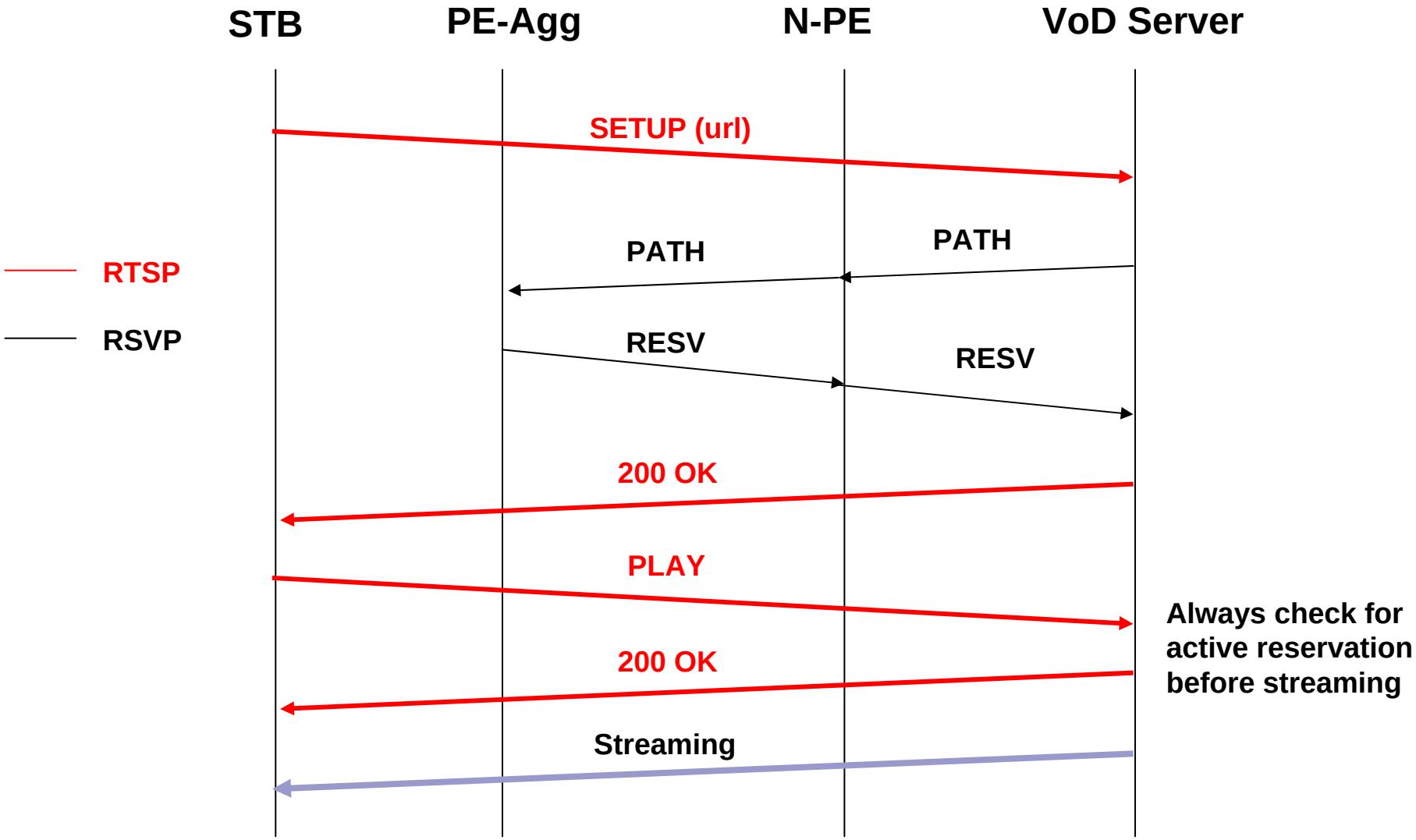
RSVP CAC for VoD



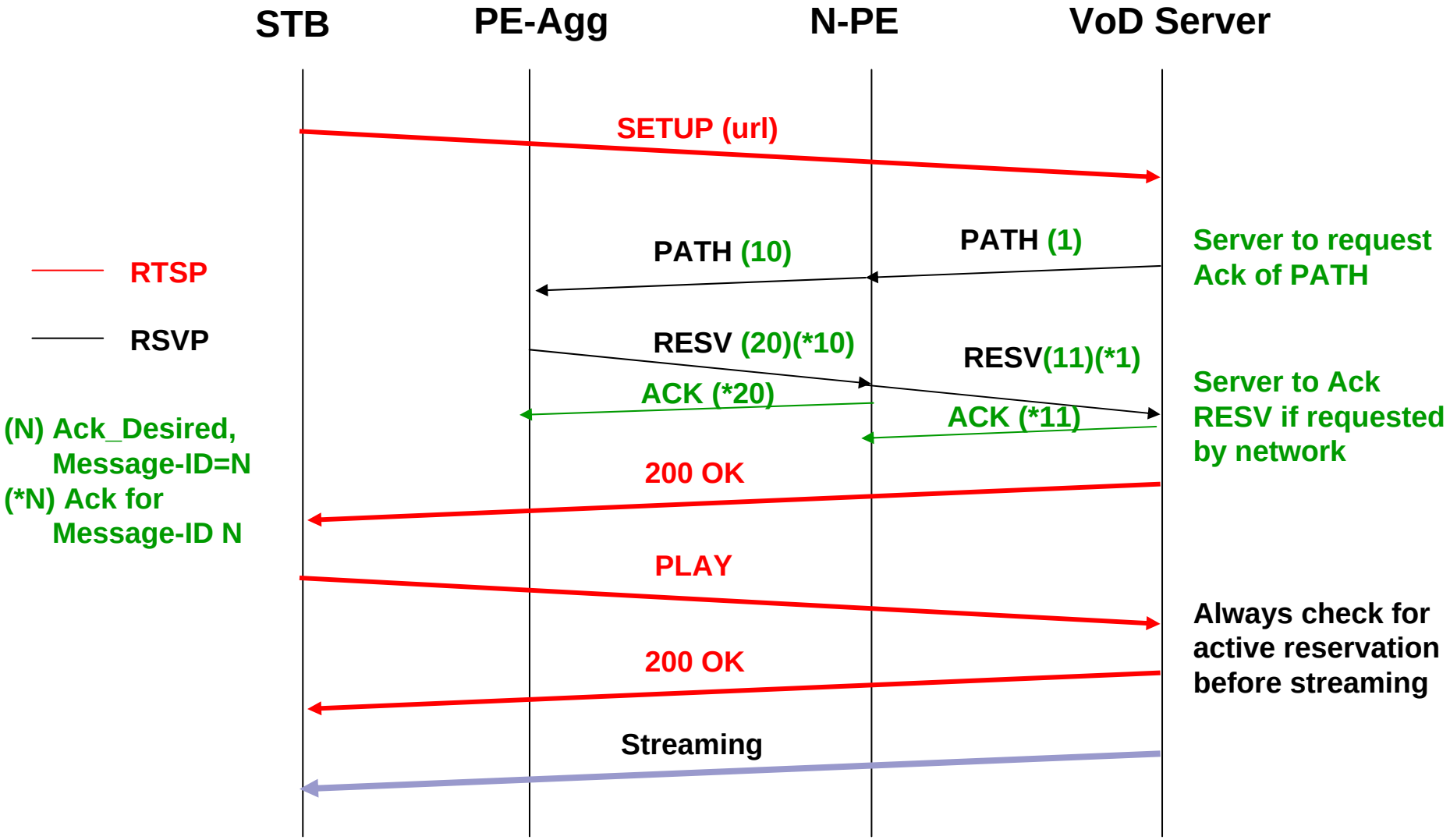
Key Scenarios

- **Those are the key Call Flows to achieve CAC for VoD:**
  - **Setup with successful Reservation**
  - **Session Termination by STB**
  - **Setup Failure due to Admission Control Rejection**

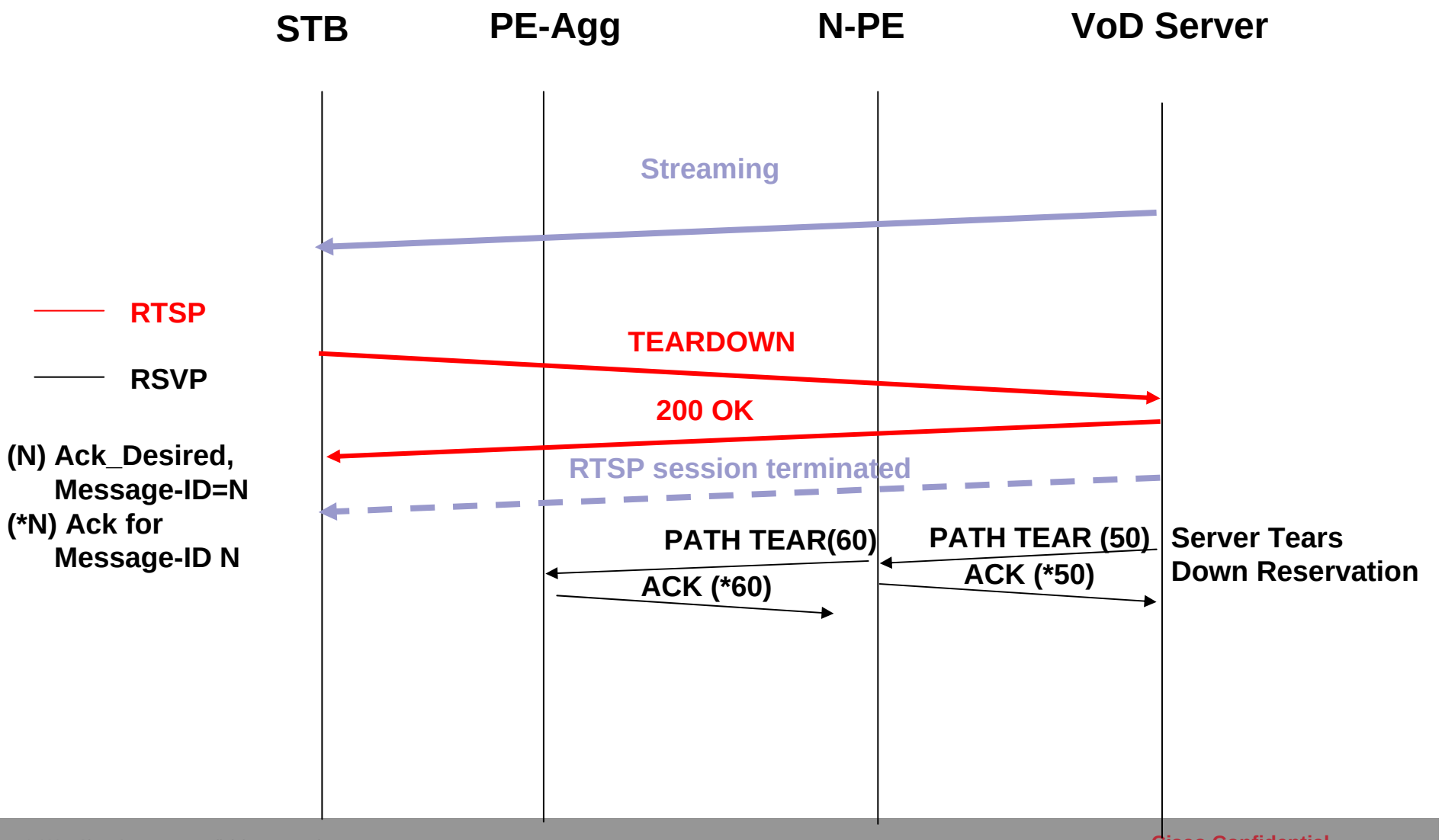
Setup with Successful Reservation



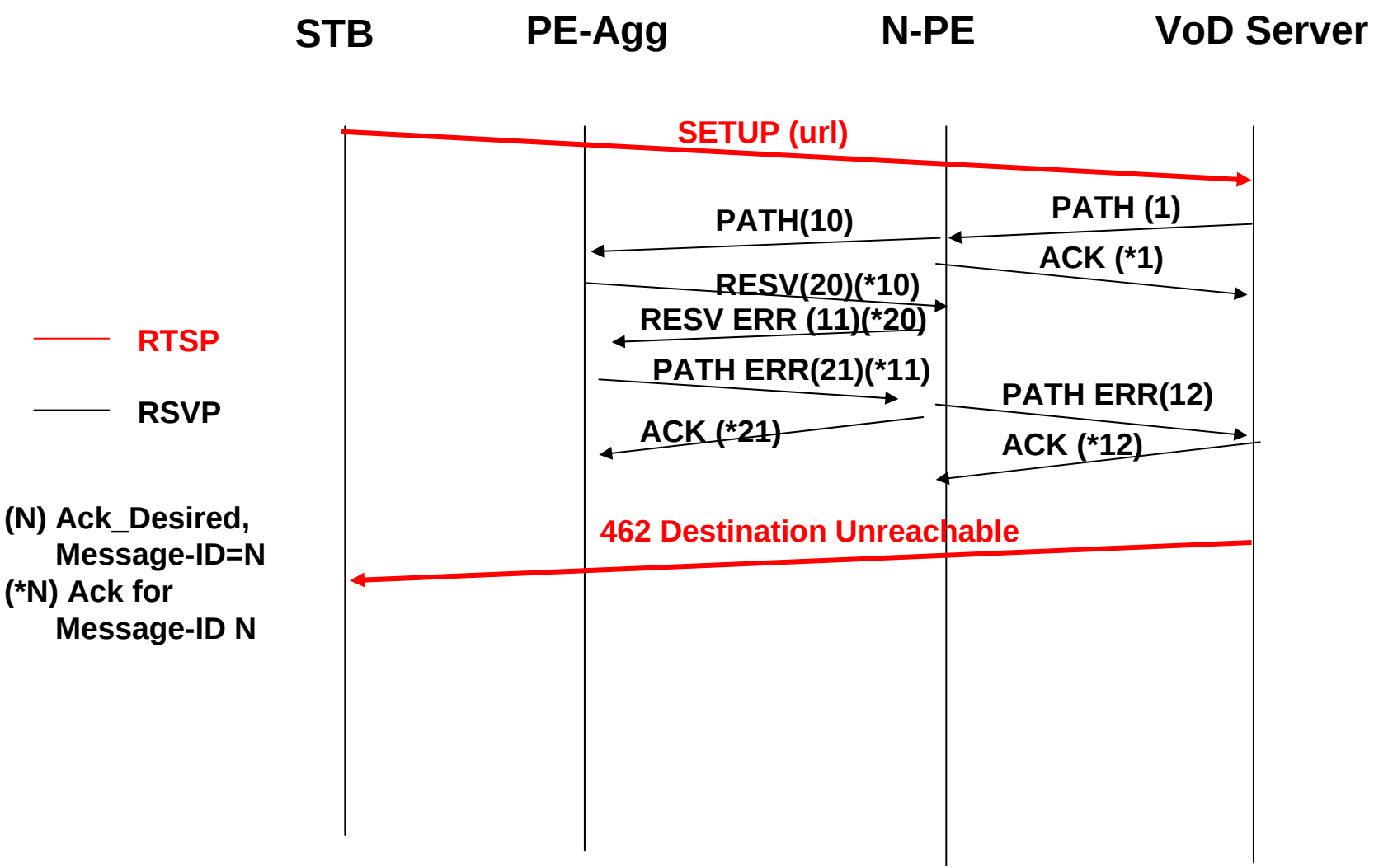
Setup with Successful Reservation (using RSVP Reliable Messaging)



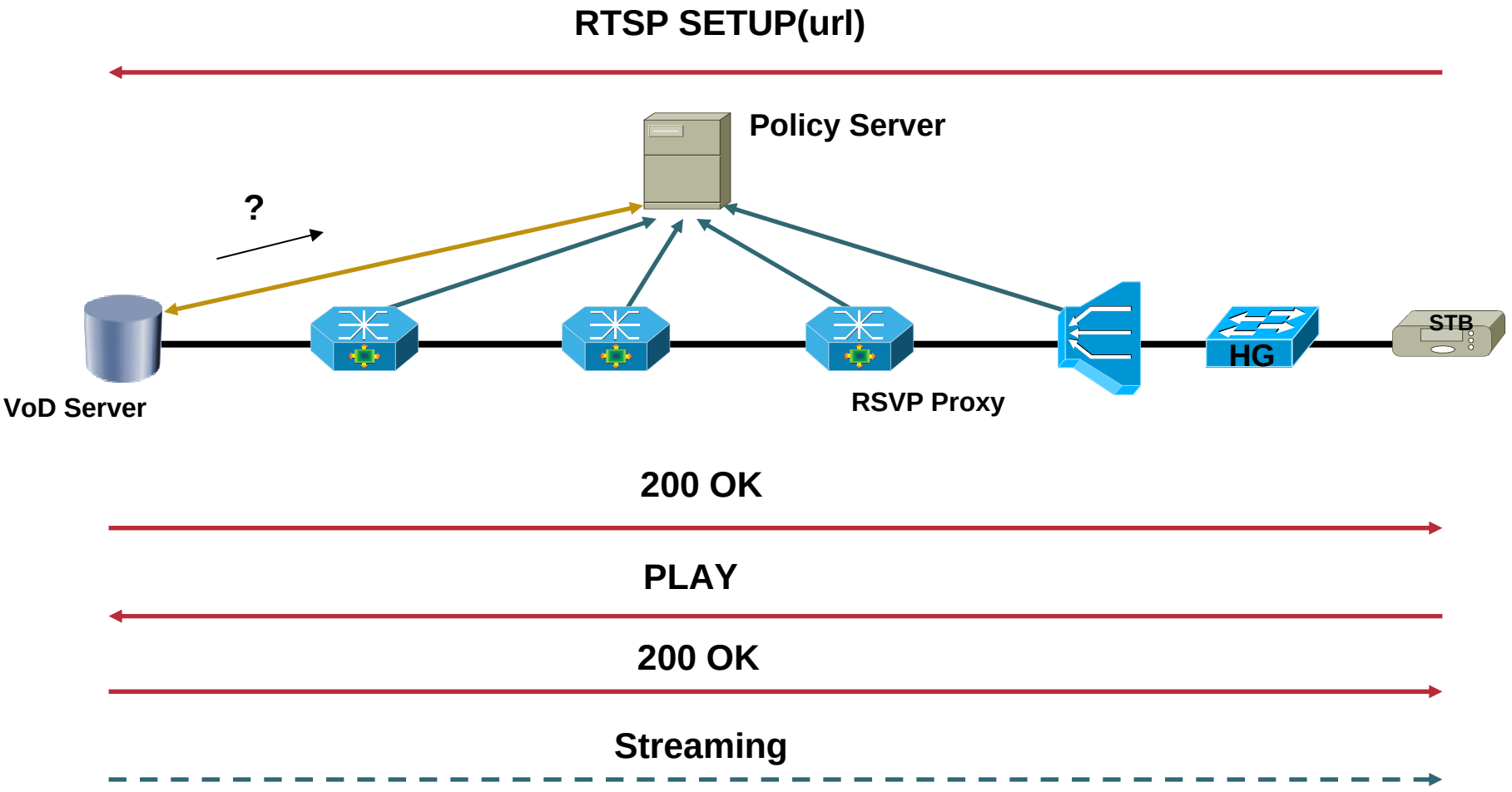
Session Termination by STB



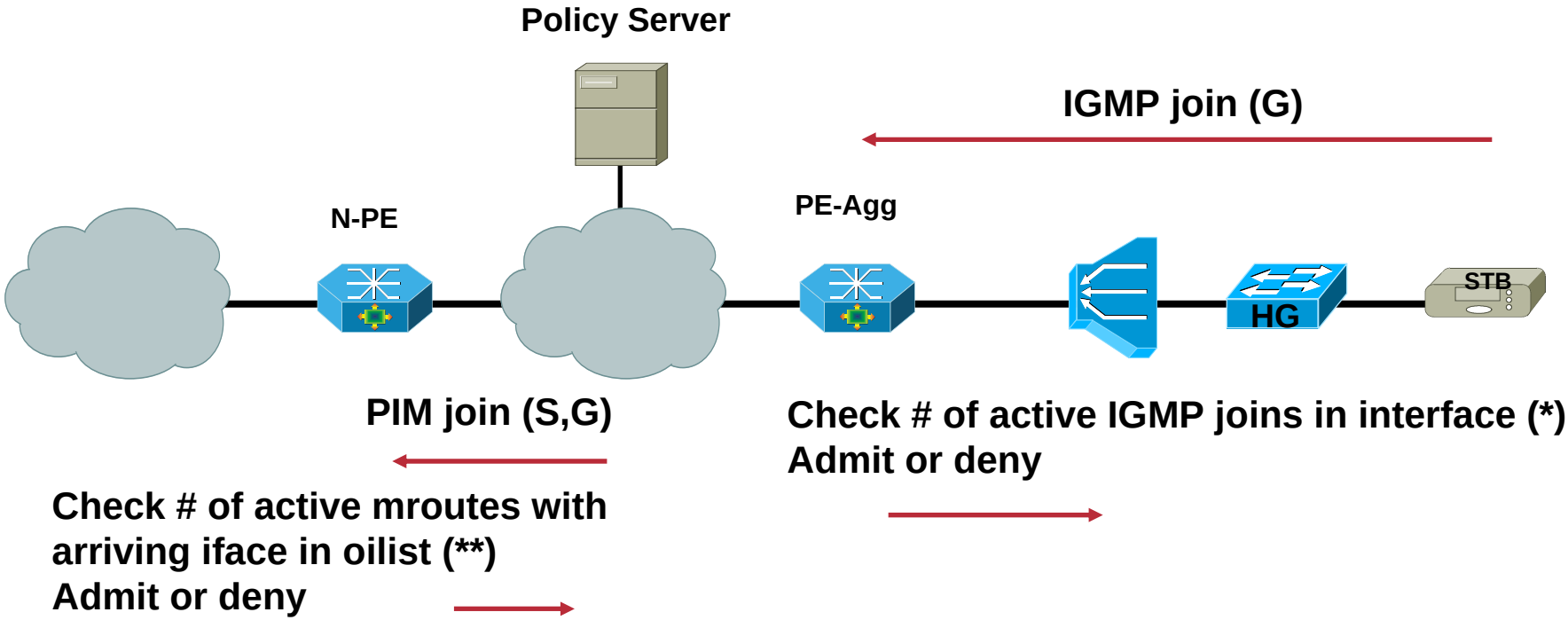
Setup Failure due to Admission Control Rejection



Policy Server CAC for VoD



CAC for Multicast (Switched Broadcast)

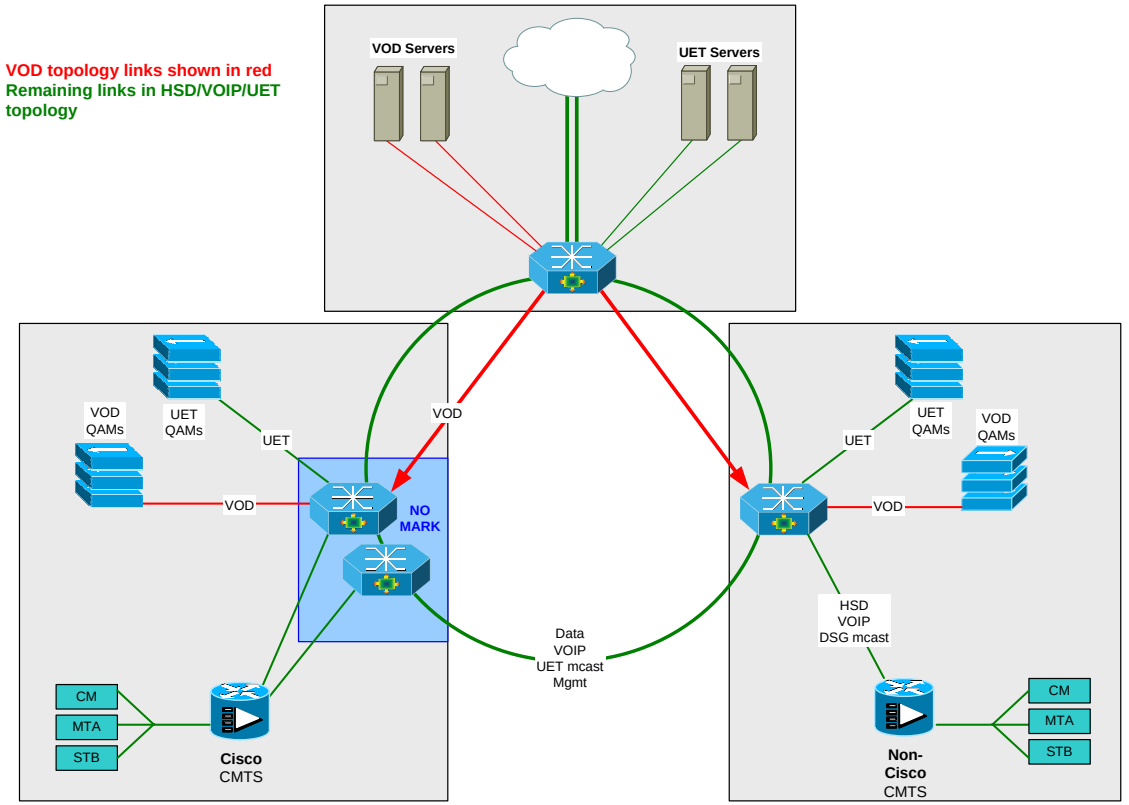



```
(*)  ip igmp limit <limit> [exclude <acl>]                    12.2(15)T
(**) ip multicast limit out|rpf|connected <acl> <limit> 12.3(14)T
```

May use Policy Server in the future through Multicast AAA interface

Service Specific Routing (Multi-VRF)

- **Multi-VRF allows for multiple routing topologies separated by interfaces**
- **Each interface (VLAN, subinterface) can belong to only *one* topology**
- **One IGP session *per topology***



Redundancy models

- **Dual streams (1+1 RTP sessions)**

  Let the receiver decide which one to take

- **Heartbeat**

  Active sends periodic hello to standby (muted) source

- **Receiver driven**

  Same group with two sources. STB decides which one to join using IGMPv3

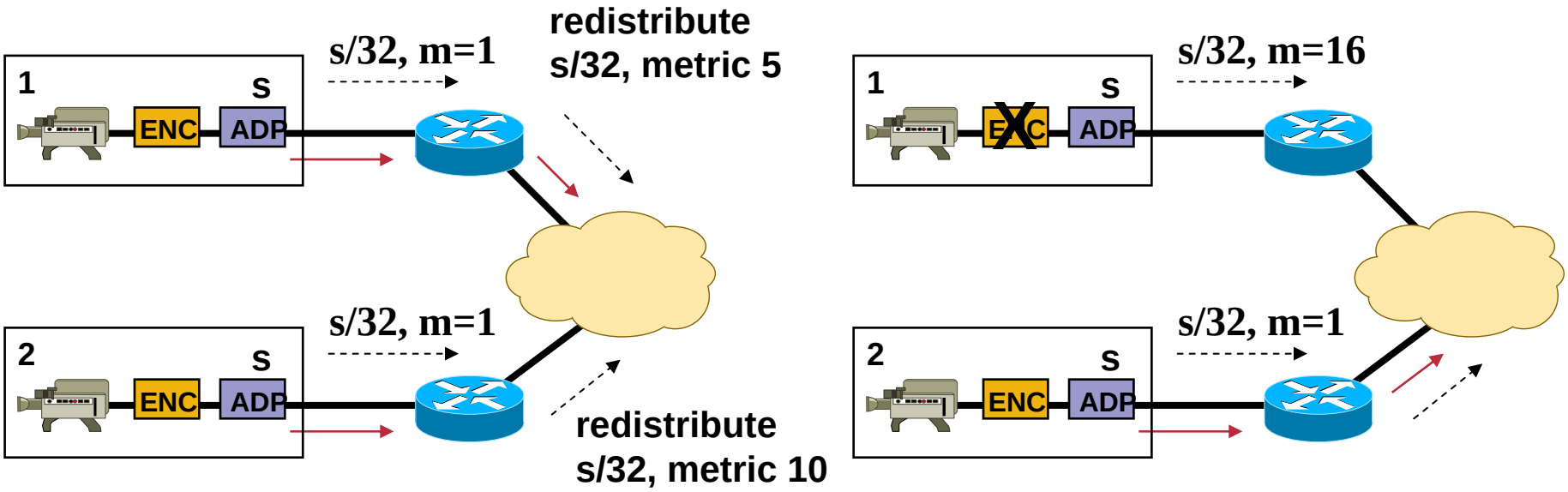
- **Anycast-Source**

  Two (or more) sources actively sending with same origin IP address

  Network decides which one to use using its metrics

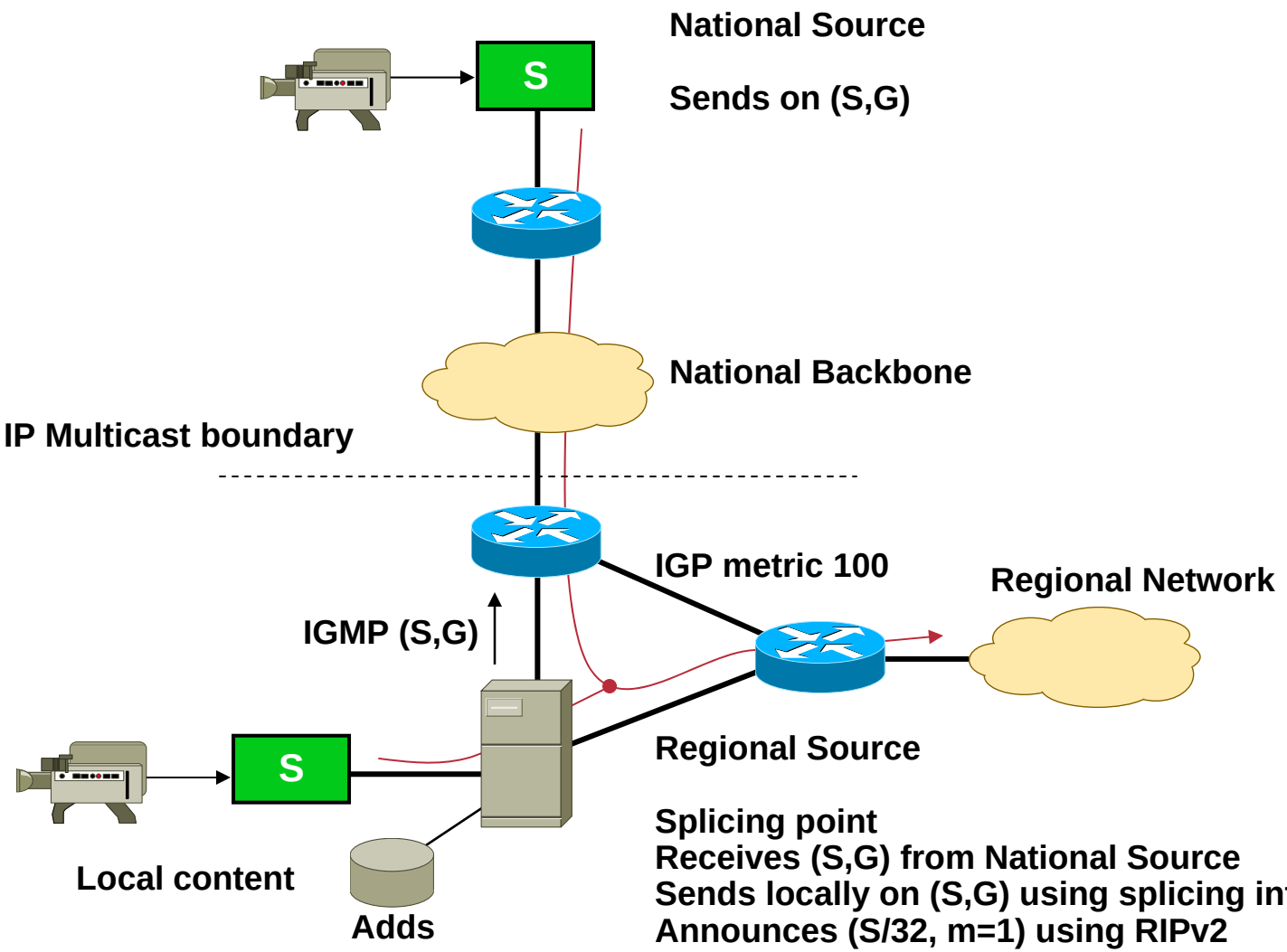
  Disaster-recovery and redundant headend applications

Anycast-Source with RIPv2 Poison Reverse



- The two sources are active and sending
- s/32 routes are generated by both source using RIPv2 updates
- Host routes for anycast source are redistributed into IGP with variable metrics (optional)
- Network selects source (PIM join messages) based on metric
- Upon video failure, sources withdraw s/32 routes using Poison Reverse (infinite metric) updates

Local content insertion with splicing



Q and A