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Advanced IPTV Networks:

Multicast Optimized Networks, Looking at Options

Peter Arberg
Director, Standards & Architecture
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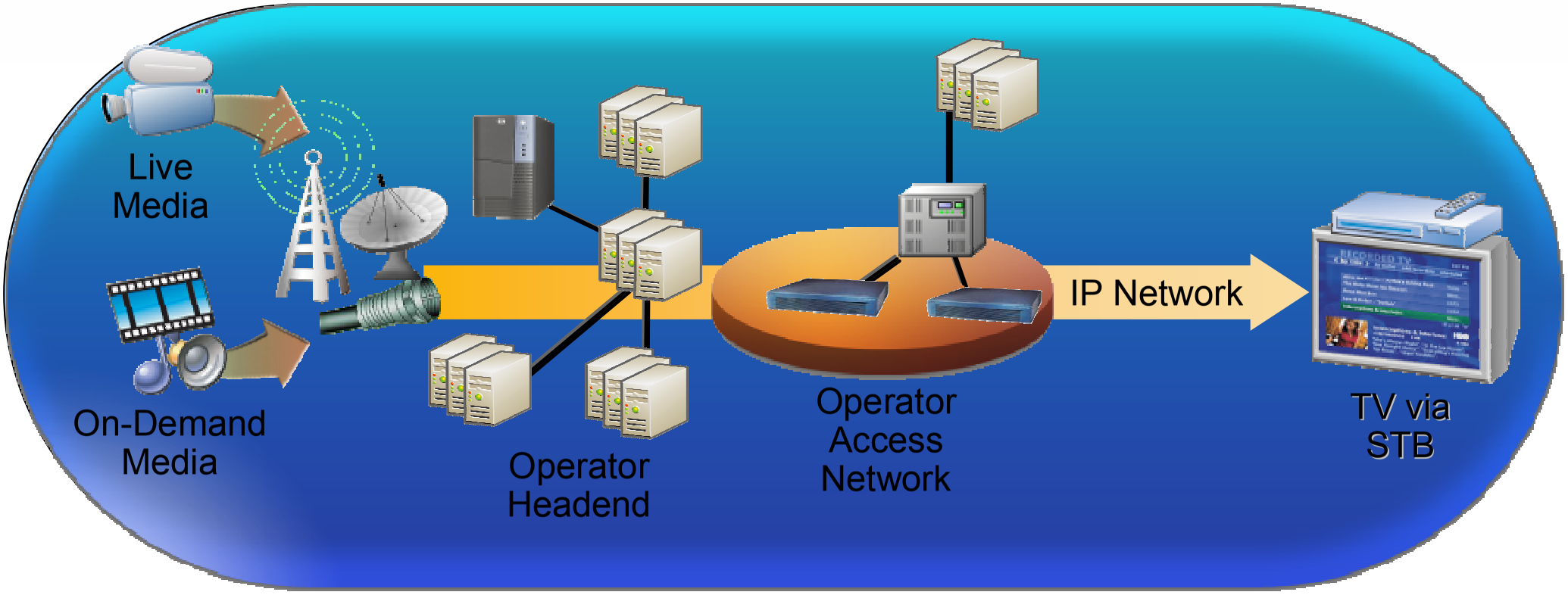
Agenda

Multicast Services

- A look at the IPTV Components
- The TR-101 View on Broadband IPTV Connections
- The IPTV Multicast Distribution, Core and Edge Network
- Multicast High Availability and Fast Convergence

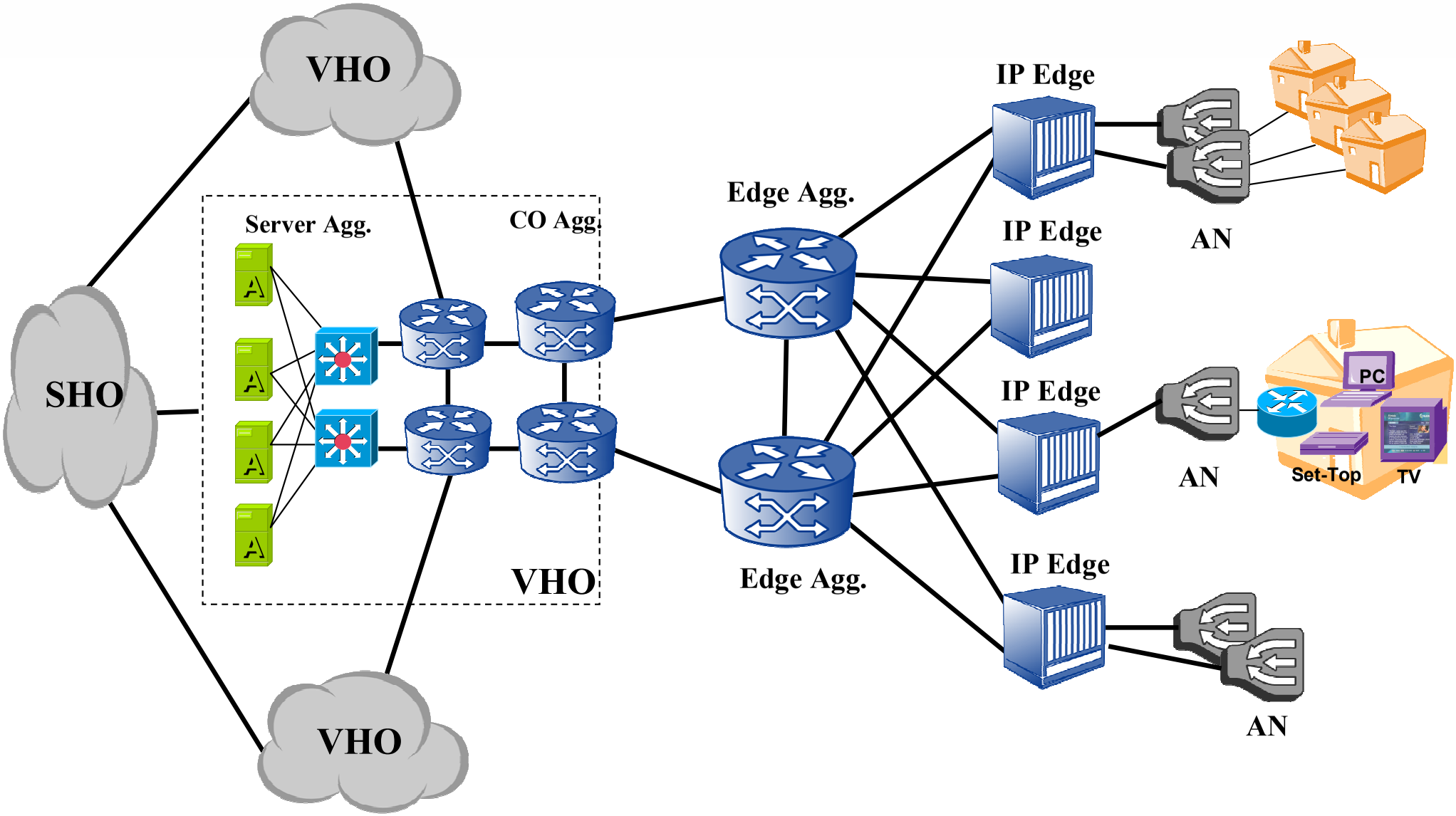
What's in this IPTV beast



- IP Video Encoders/Digital Headend equipment
- IPTV Video Servers, Servers and more Servers…
- IP set top boxes
- Core Routers, Edge Routers and more Routers...

Locations:
Super Headend Office
Video Headend Office
Video Serving Office
Operator Core & Access Network
Home Sweet Home

IPTV from a Network Perspective



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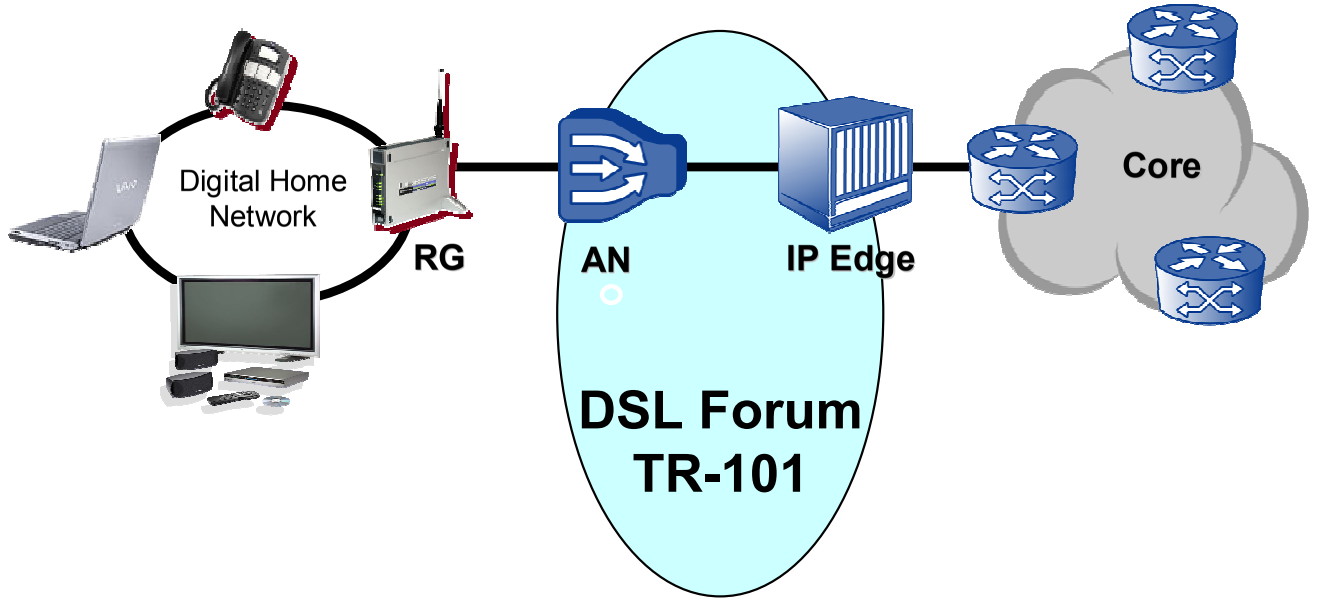
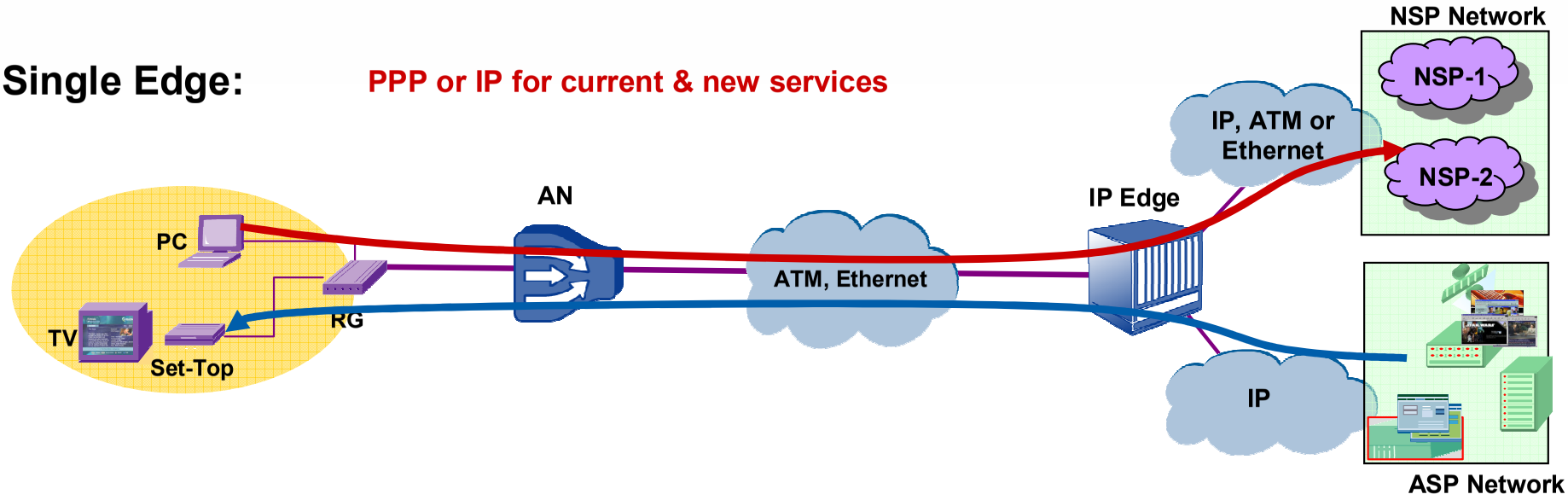
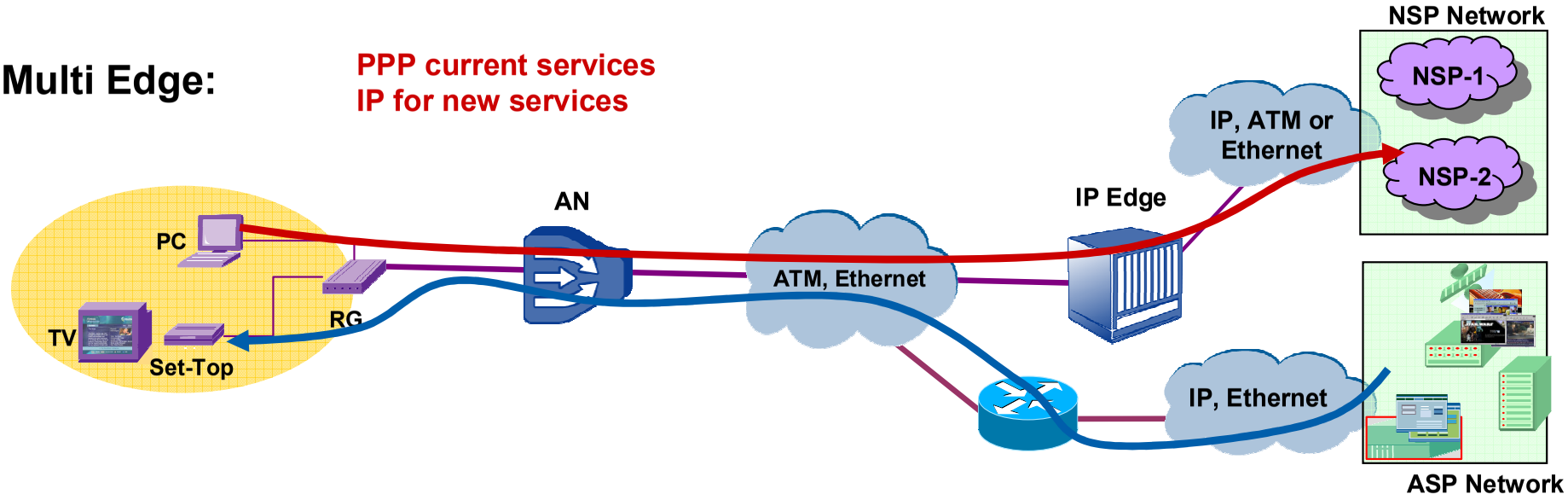


Multicast Video Network design

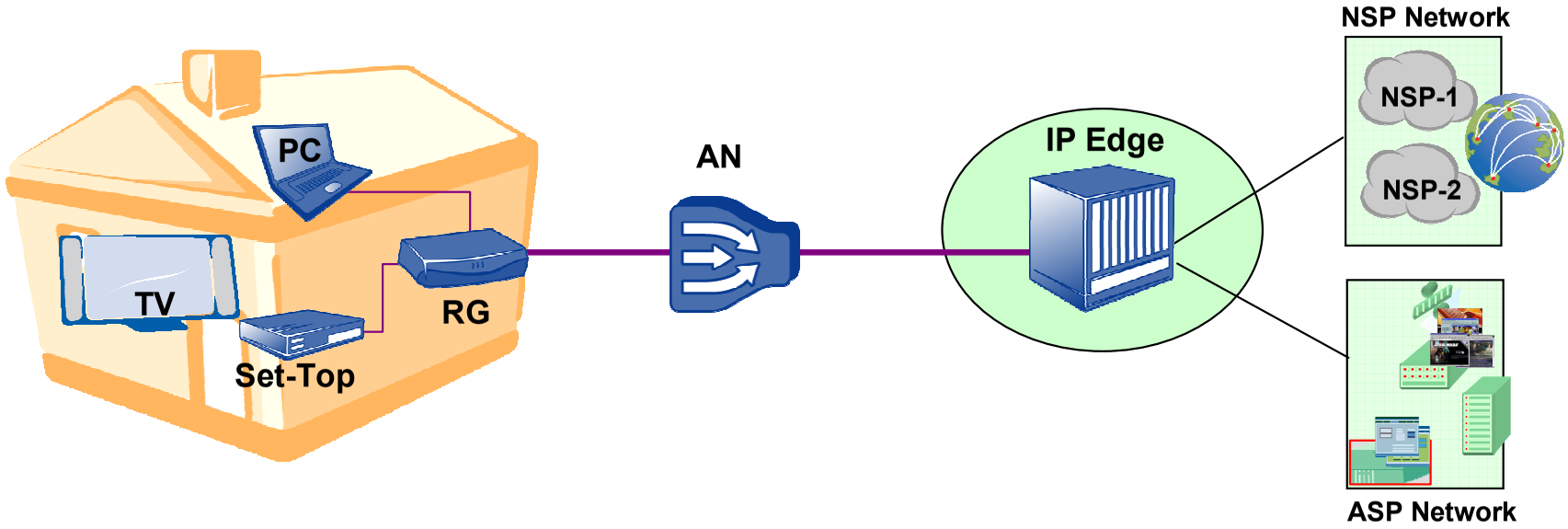
Single Edge: PPP or IP for current & new services



Multi Edge: PPP current services
IP for new services

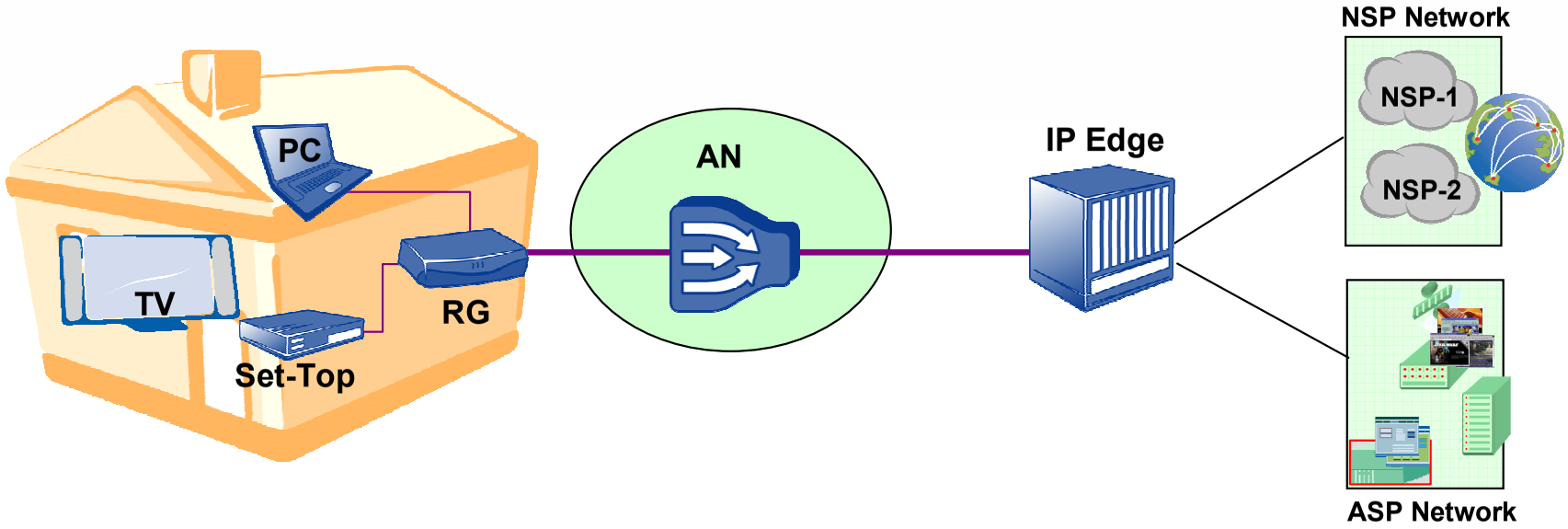


Multicast at Broadband Network Gateway



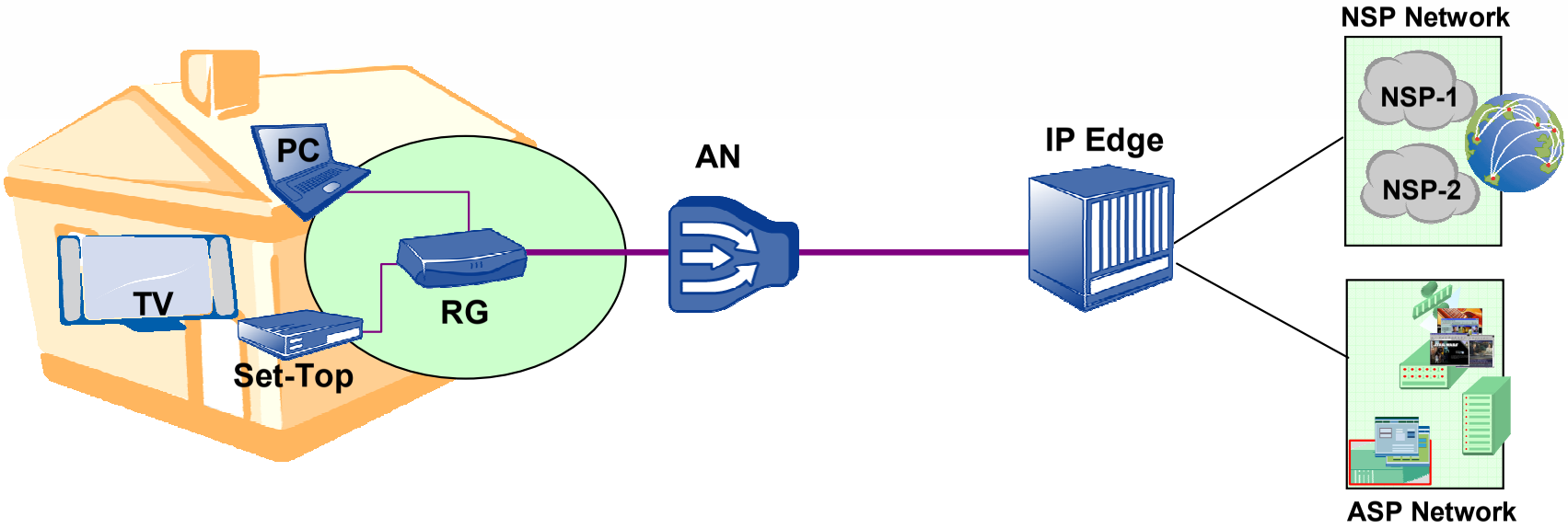
- IP Edge is Responsible for per Access Node Multicast Replication
- Different ”Circuit/Interface” for IGMP Control Traffic and Multicast Output
- Support multiple Multicast Service VLANs
- Support a Flexible Mapping of Subscribers to Multicast Service VLANs
- Support ”immidiate leave” functionality
- Dynamic adjust subscriber QoS Shaper according to MC-groups joined
- Set Multicast packets 802.1p priority bits
- Deliver per subscriber Multicast statistic and show information

Multicast at Access Node



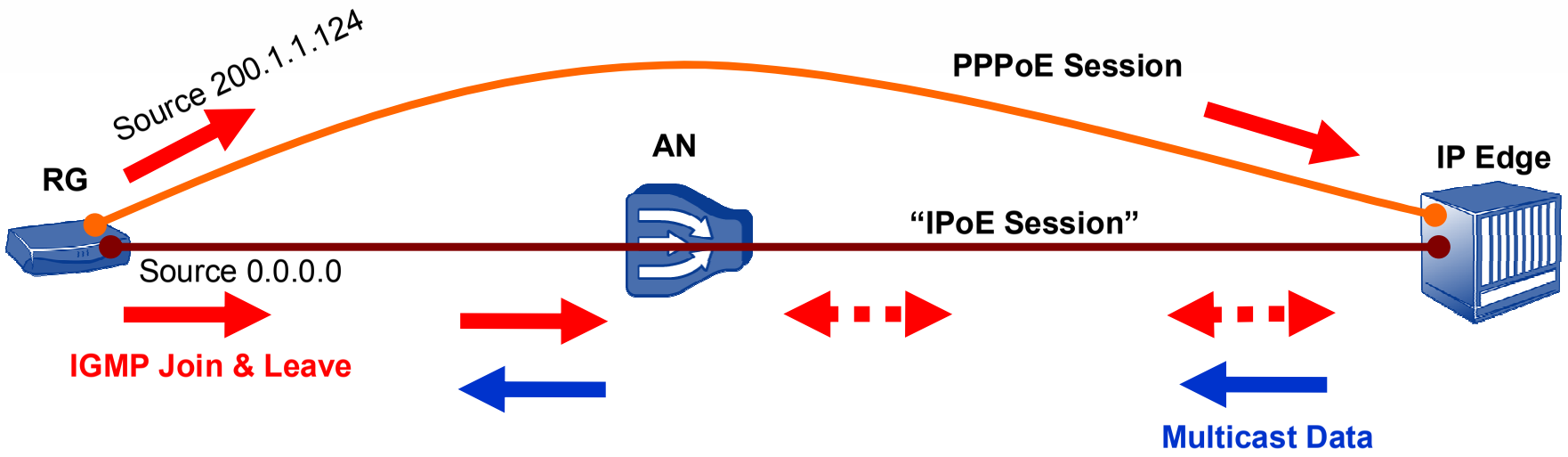
- AN is Responsible for per Residential Gateway Multicast Replication
- Support IGMP Transparent Snooping functionality
- Forward subscriber IGMP initiated packets to a multicast VLAN
- Support multiple Multicast Service VLANs
- Support a Flexible Mapping of Subscribers to Multicast Service VLANs
- Support ”immidiate leave” functionality
- Support droping all IGMP packets on a subscriber port
- Set IGMP packets 802.1p priority bits

Multicast at Residential Gateway



- RG is Responsible for per Home Multicast Replication
- Support IGMP Proxy functionality
- Must support IGMP communication on
  - PPPoE Session
  - IPoE Encapsulation
  - Both Simultaniously
- Must be able to source IGMP packets with IP-address 0.0.0.0

Multicast Option #1

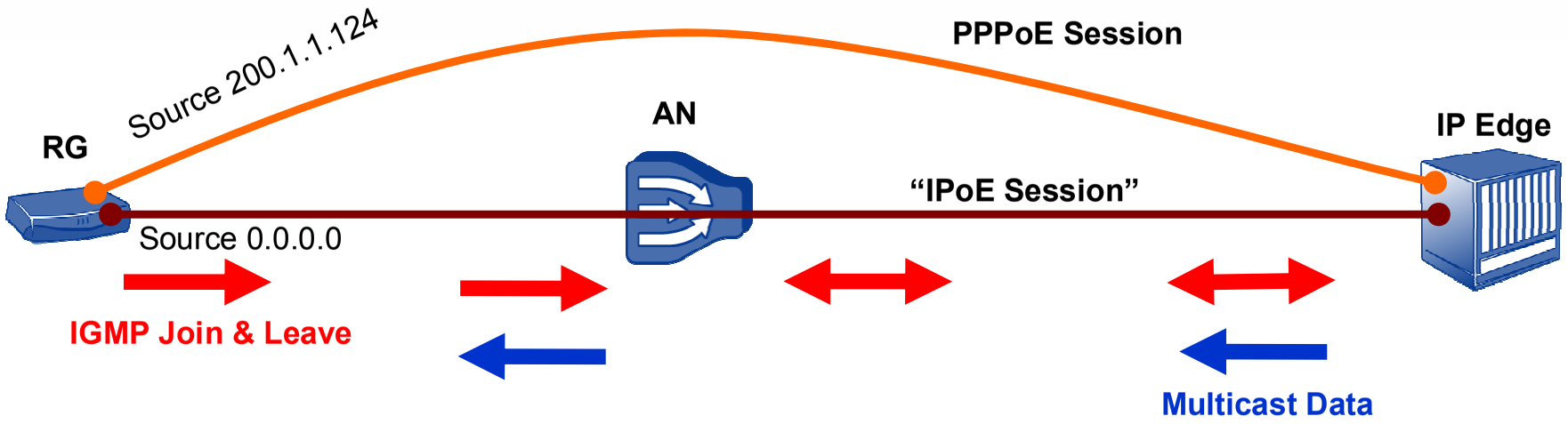


- PPPoE Session for Subscriber Internet Traffic
- IPoE Encapsulation for Multicast Traffic

- DHCP is not needed since Subscriber has IP-address from PPPoE IPCP

- IGMP Traffic on Both PPPoE and IPoE Encapsulation.

Multicast Option #2

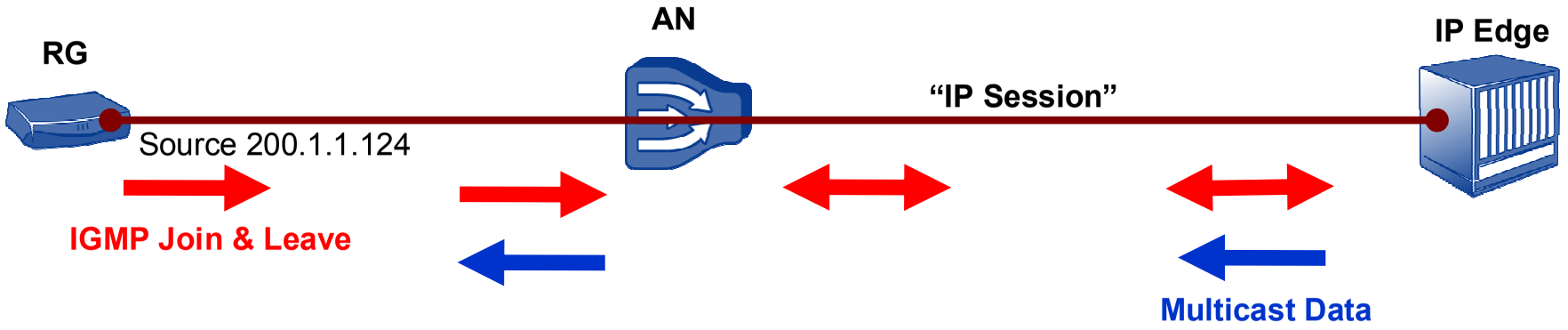


- PPPoE Session for Subscriber Internet Traffic
- IPoE Encapsulation for Multicast Traffic

- DHCP is not needed since Subscriber has IP-address from PPPoE IPCP

- IGMP Traffic ONLY on the IPoE Encapsulation

Multicast Option #3



- IP Session for Subscriber Internet Traffic
- IPoE Encapsulation for Multicast Traffic

- DHCP used for Subscriber IP-address allocation
- RADIUS can still be used for all Subscriber AAA functionality

- IGMP Traffic ONLY on the IPoE Encapsulation

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Multicast Services

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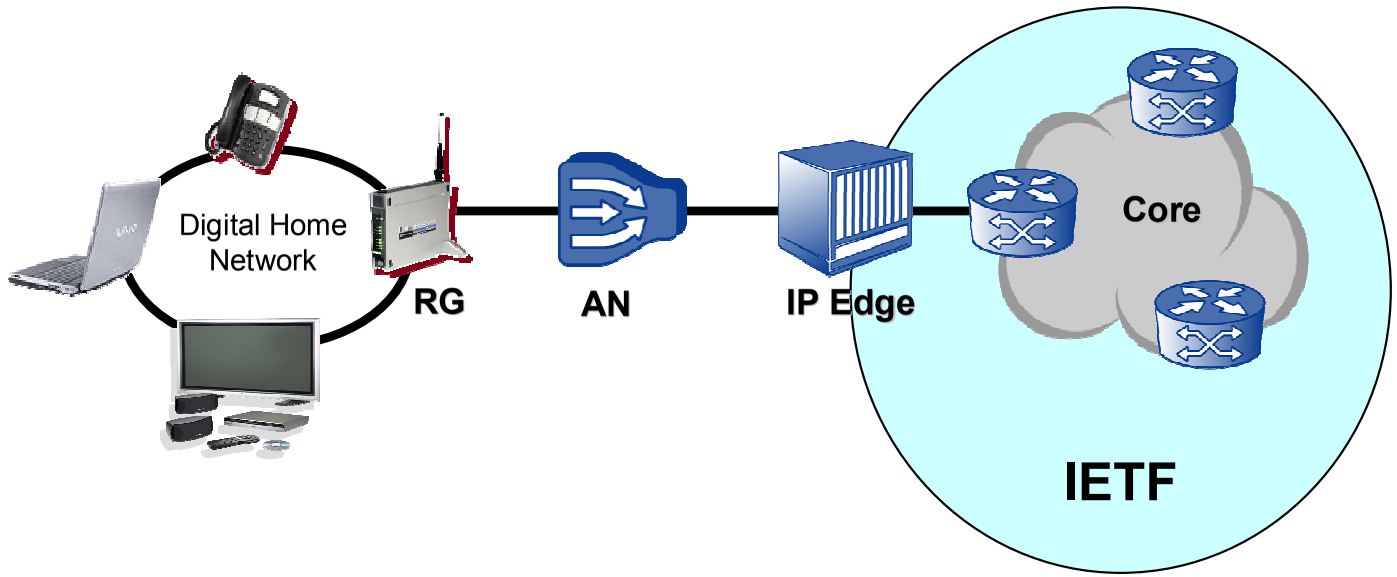
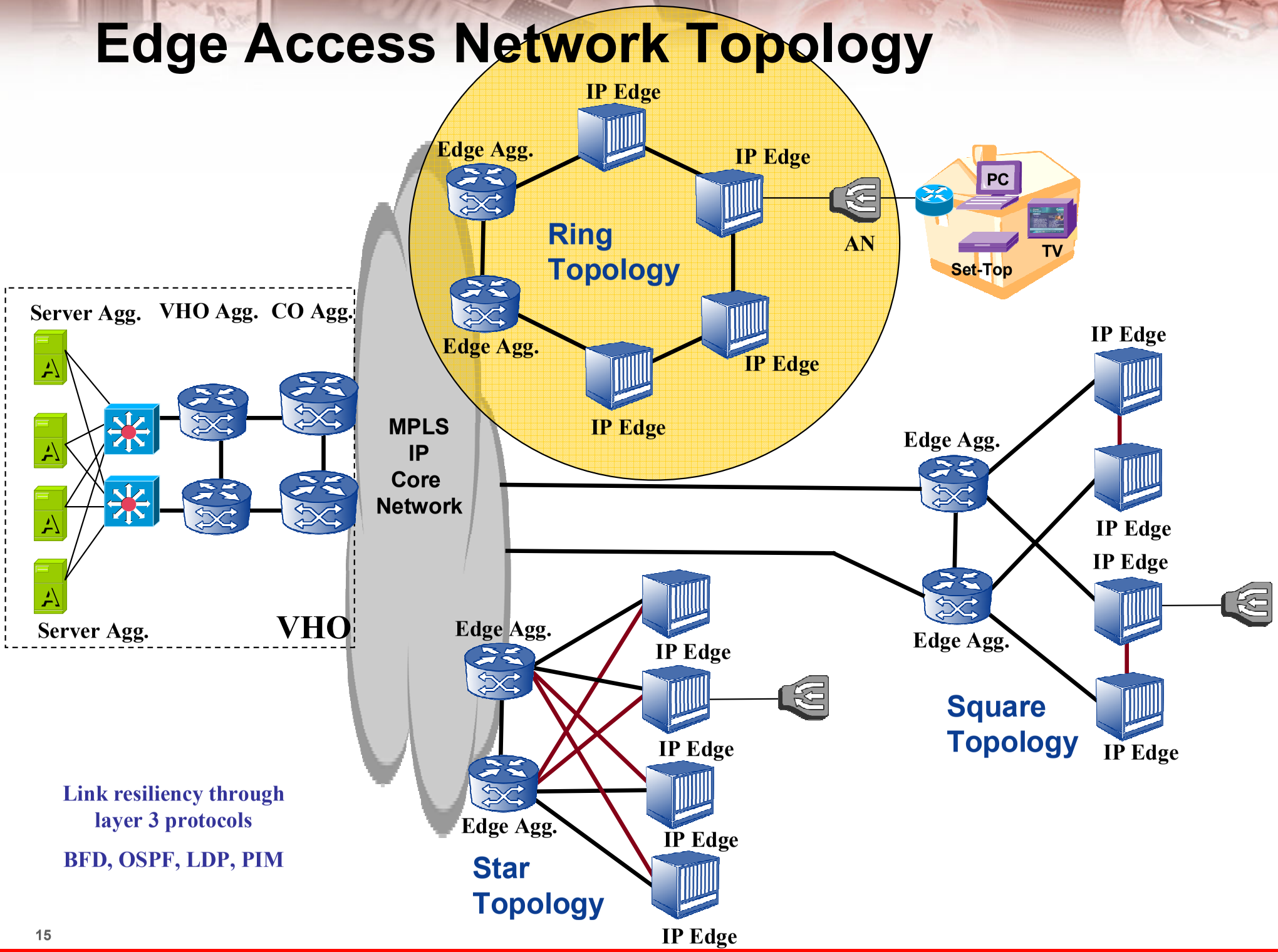
- Multicast High Availability and Fast Convergence



Multicast Enabled Core and Edge Network

- **Many different ways to design IPTV Networks**
  - Do you go all IP ?
    - And as such created a multicast enabled network, end-2-end.
  - Do you go Layer-2 Network
    - And as such transport the multicast as a layer-2 packet
    - Where are IGMP and maybe PIM snooping enabled
- **The most obvious Core discussions are:**
  - PIM enabled core
  - MPLS P2MP Multicast transport, and no PIM
- **The most obvious Edge discussions are:**
  - IP enabled Edge
  - VPLS enabled Edge Network
- **The most obvious Access discussion are:**
  - Direct connected Access Nodes
  - L2 Ethernet Aggregation Network

Edge Access Network Topology



Link resiliency through layer 3 protocols

BFD, OSPF, LDP, PIM

Multicast Enabled Edge Network

- **"Reliable" Multicast delivery over an Ethernet or MPLS aggregation network is complex**
  - Carrier Ethernet based aggregation network
    - RSTP restores path fairly quickly after failure, but IGMP state is lost and hence multicast forwarding does not resume immediately (requires IGMP query sollicitation feature)
  - MPLS based aggregation network
    - Plain P2MP LSP are good for the core (where all channels are always distributed) but not for the aggregation
    - Standard VPLS suffers from ingress replication problems (painful in ring)
    - H-VPLS requires non-standard 'enhancements' to make it work over a ring architecture
    - Whatever you choose, it is always very complex
  - MPLS FRR problematic in ring architectures

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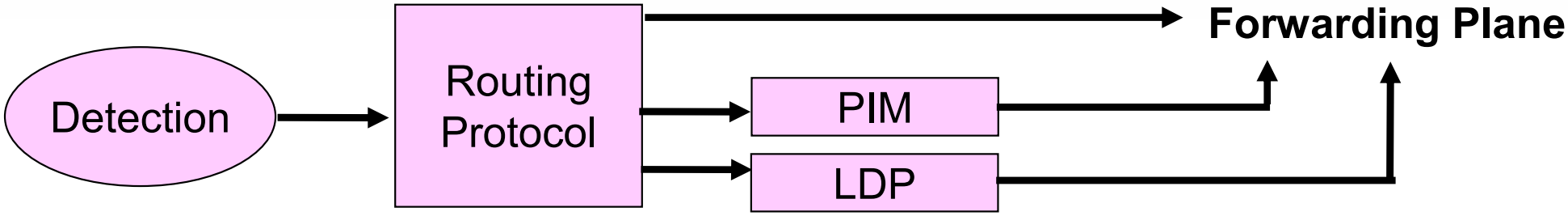
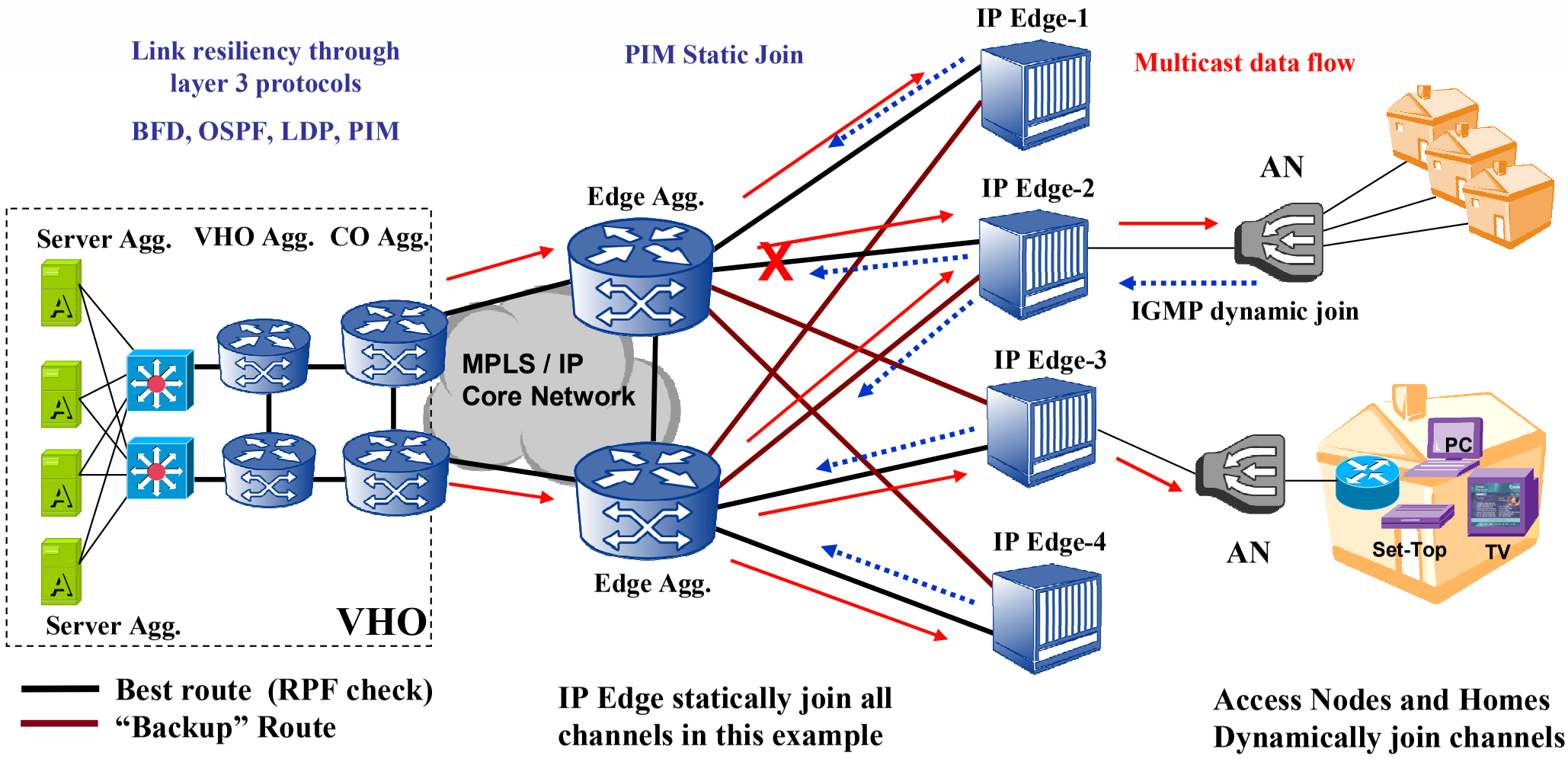
IGP Fast Convergence



- **IGP (OSPF & ISIS) is implemented in a ”event driven” mode to allow for immidiate SPF calculation**
- **IGP (OSPF & ISIS) is implemented with a ”fall back” to timer SPF calculation in case of network instability**
- **PIM is implemented in an enhanced mode to remember join & leave messages from unexpected interfaces in a ring topology**
- **LDP implementation enhanced to advertise all labels to everybody, and make it the responsibility of the receiver to discard labels.**

PIM Convergence, Rely on IGP Convergence



- Multicast Stream switch over is waiting for IGP convergence
- IP Edge will PIM join the stream to the new RPF route

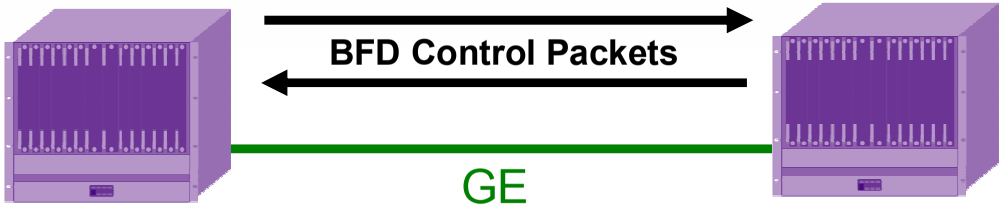
Multicast Fast Recovery

- Biggest Benefit of Multicast over MPLS P2MP delivery is High Availability with MPLS FRR
- To Compete with this Multicast delivery based on PIM need to be able to recover in less than 50msec.

PIM Dual Join

- Reuse lessons learned from multicast high-availability financial networks
- Receivers join the multicast stream from 2 different places
- Move this responsibility to the IP Edge, the last IP aware replication point before the multicast receiver.
- Keep IP Edge network as is from a routing & provisioning perspective, no need for MPLS just to transport multicast.

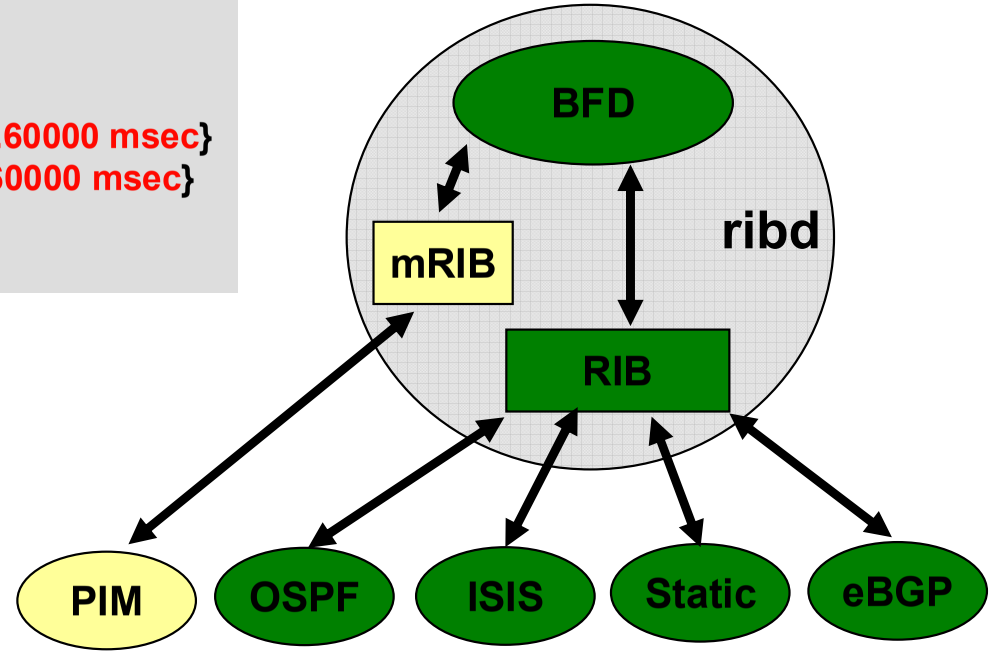
Use a Fast Failure Detection Notification to PIM



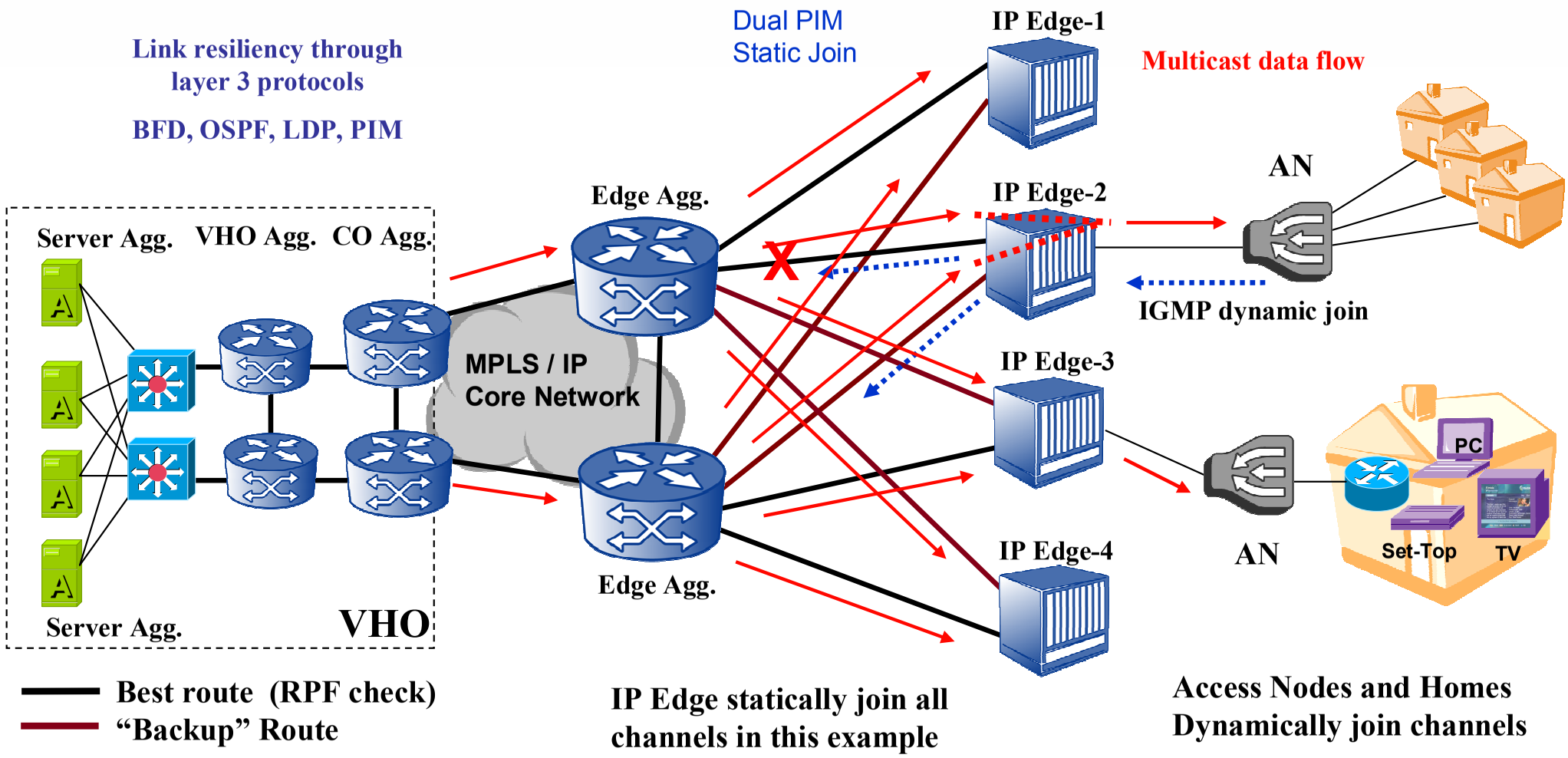
in Asynchronous Mode, the BFD control packets (IP – UDP) are sent in both directions, and are used to detect link failure when control packets stops being received.

```
[local]rbak(config)#cont bfd
[local]rbak(config-ctx)#router bfd
[local]rbak(config-bfd)#neighbor 10.1.1.1   (or interface xxx)
[local]rbak(config-bfd-nbr)#minimum transmit-interval { 10..60000 msec}
[local]rbak(config-bfd-nbr)#minimum receive-interval { 10..60000 msec}
[local]rbak(config-bfd-nbr)#detection-multiplier { 1..10 }
[local]rbak(config-bfd-nbr)#end
```

```
[local]rbak(config)#cont local
[local]rbak(config-ctx)#router ospf 1
[local]rbak(config-bfd)#bfd detection
[local]rbak(config-bfd-nbr)#end
```



PIM Fast Convergence w. Dual Joins



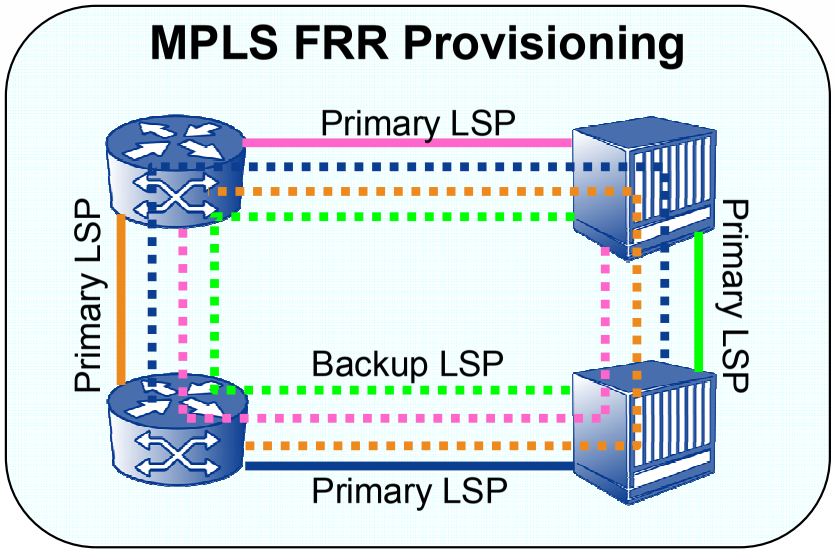
- Multicast Stream switch over is a local decision
- IP Edge have the "backup" stream, so no new PIM Join is needed

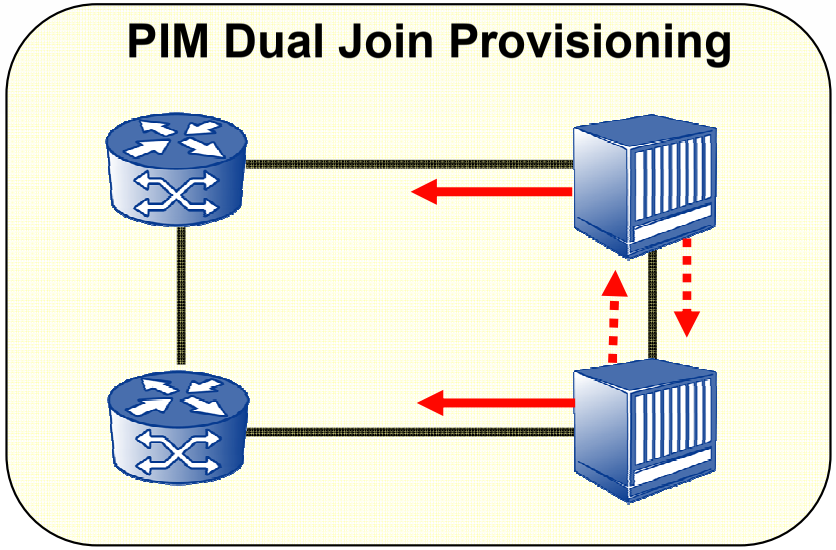
Lets do a Quick Comparison

	Dynamic Leaf Addition/Removal	Tree Optimization	Fast Reroute
PIM	Yes	Nope	Dual Join
P2MP	Nope	Yes (MCT)	MPLS FRR

- P2MP MPLS-TE: Current Lack of dynamicity
  - As IPTV services grow, most suitable for usage in the core
  - Possible traffic increase on backup link in case of failure
- PIM: No advanced TE for Tree Optimization
  - Network designed for redundancy, do you care if the BW is used all the time, or unused in no failure scenario ?
  - Dynamicity, only use BW for channel watched
  - And FRR capability with the Dual Join Functionality
- Relevant design: Combine P2MP MPLS-TE in the core and PIM Dual Join in the Edge

PIM Dual Join Summary

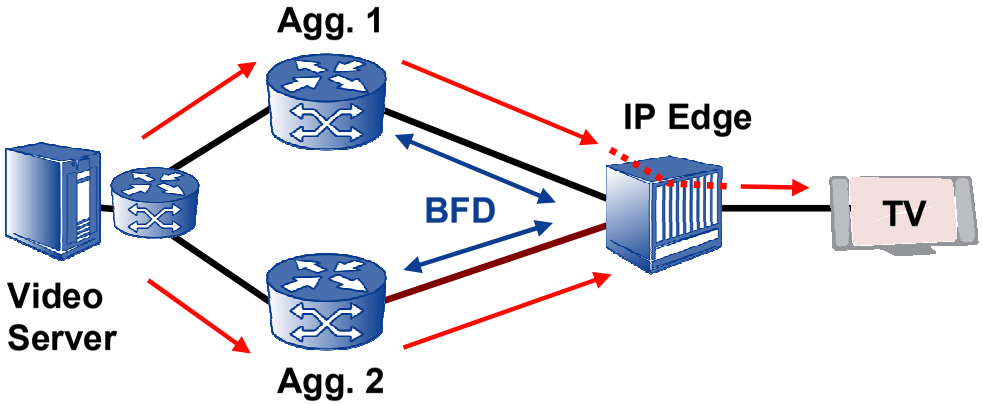




PIM Dual Join will support

- Static PIM Join for low latency channel join
- Dynamic ASM to SSM conversion
- Easy provisioning; the configuration is local to the IP edge
- Will NOT increase traffic on any links in case of failure
- Fast channel switchover in case of failure, due to local decision
- Will be 50msec. or better in both Link as well as Node failure.

PIM Dual Join – Test Results



Test Setup:
- Test done with “Static” PIM Join, IGMPv2 & IGMPv3
- IGMP ASM to PIM SSM translation
- BFD: multiplier = 3, Tx & Rx = 10msec
- Multicast traffic rate: 10,000 packets/sec
- IP Edge send “primary” (S,G) PIM join to Agg. 1
- IP Edge send “secondary” (S,G) PIM join to Agg. 2

Test Failure:
- Introduce link failure between IP Edge & Agg. 1
- Introduce Agg. 1 Node failure

Test Measurement:
- Monitor the Multicast traffic switchover when failure
- Monitor the Multicast traffic switchover when recovery

	Light-Out	BFD
Static Join	F: 11.6msec R: 0msec	F: 48.7msec R: 0msec
IGMPv.2	F: 8.0msec R: 0msec	F: 43.7msec R: 0msec
IGMPv.3	F: 12.2msec R: 0msec	F: 46.2msec R: 0msec

Thank You.

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