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Trends in Switching and Routing: Operator's Perspective

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IEEE HPSR 2012

IP Network Background and Strategy

Milestones

- Started as a Internet backbone/IGW
- Expansion with MAN networks
- Tripleplay and multimedia, VPN services
- Mobile backhaul, cloud and datacenters

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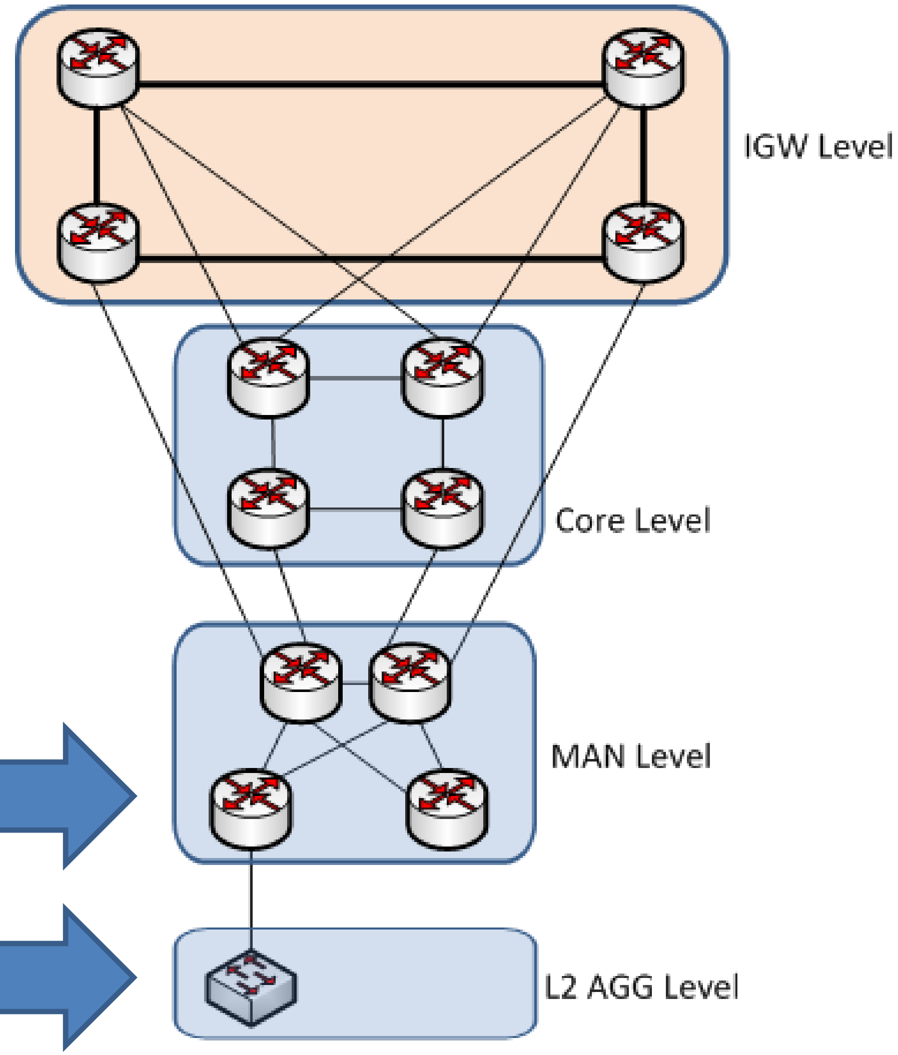
Internet Upstream and Downstream Operators

Basic Architecture/Topology



Access Network (xDSL, Optics, GPON, RBSs) – End Users

Telekom Srbija’s services

- ❑ Internet peering
- ❑ Retail and wholesale Internet
- ❑ Multimedia (IPTV, video distribution from Headend)
- ❑ IMS services
- ❑ MPLS L2 and L3 VPN based services
- ❑ Mobile services (CS and PS)

Telekom Srbija’s Strategy

- ❑ One IP network for all services
- ❑ “Any service any where”
- ❑ One IP network handling any access technology – fixed and mobile
- ❑ Mobile backhaul
- ❑ Datacenters and cloud solutions

Demands

- Robust and stable network providing redundancy
- Scalable and flexible for upgrade and operations
- Handling different types of traffic
- Network expansion and upgrading in a cost-effective manner

Setting the routing protocol structure

- Moved from OSPF to ISIS (level 2) as IGP
- BGP-free core
- IGW routers distribute a default route to all edge routers. Edge routers receive only “internal” and downstream prefixes. All other destinations reachable via default route from IGW
- Use of RRs for I-BGP and MP-BGP
- LDP for label distribution
- RSVP based link protection in core
- MP-BGP for L3 VPN, Targeted LDP for pseudowires
- L2 aggregation switch uses a point-to-point L2 ethernet uplink towards nearest edge (PE) router

Network Trends

- Doubling of Internet traffic every 12 months
- Providing QoS
- Connecting the mobile core
- Handling mobile CS and PS traffic
- Providing FRR features for mobile traffic. Handling SCTP.

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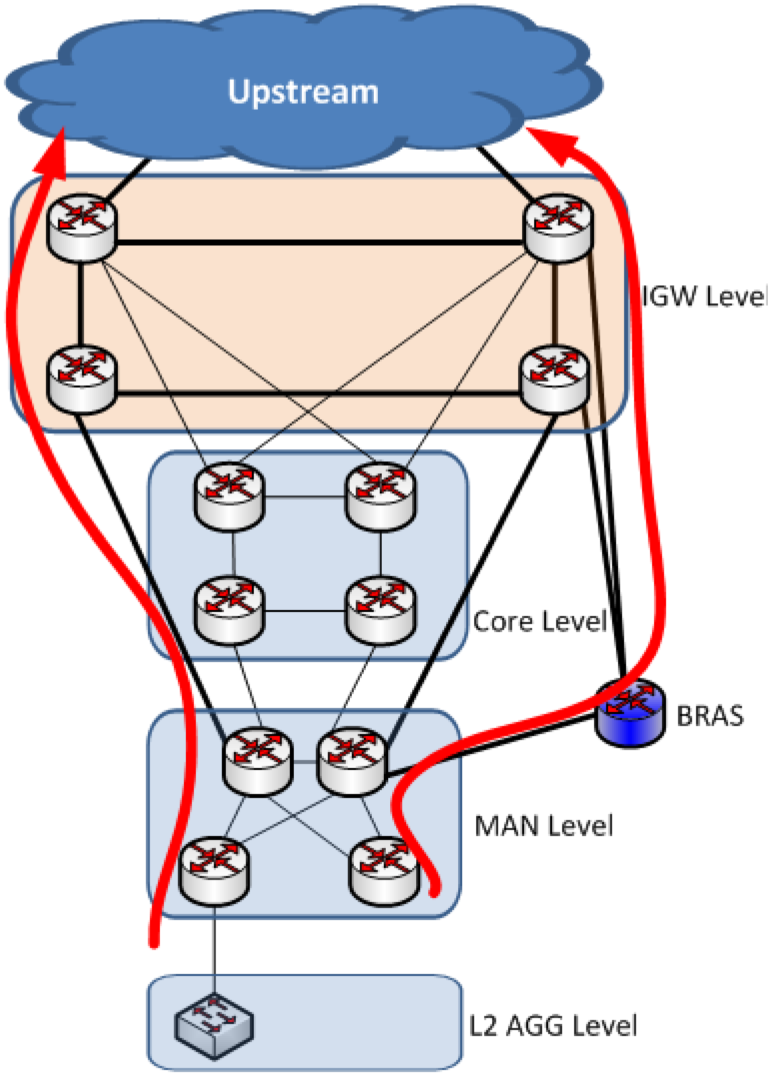
Handling the Internet traffic

- Core routers are more expensive due to more redundant switch fabric and route processor architecture, more performance, more throughput. Requires extensive upgrading of core with Internet traffic growth.
- Introduced a “IGW” network level (matrix) – mostly with standard PE routers that offloads Internet traffic from core via direct physical links to MAN networks
- IGW matrix built from regional, MAN-associated, IGW sub-levels
- IGW connects both upstream and downstream operators
- IGW with ISIS and MPLS – an logical and physical extension of the network
- IGW matrix distributes a default route for edge routers

Handling Internet traffic

IGW Matrix Effect

- ❑ Core "preserved" for multimedia and voice traffic – both fixed and mobile
- ❑ Core to be the mobile backhaul core
- ❑ IGW matrix turned to be a natural place for Telekom Srbija's regional datacenters providing web/cloud services (and cloud-bases network services e.g firewall, NAT etc)



Handling Internet traffic

Residential Internet

- IGW matrix directly handles BRAS traffic
- (Semi)-Centralized BRAS model proved to be scalable and manageable
- Having the IGW, the residential Internet would take the same path even with the distributed BRAS model

- Step towards IPv6 in residential segment – NAT4-4-4
- IGW matrix will deliver CG-NAT functionality
- CG-NAT also for business users as a “cloud” network service

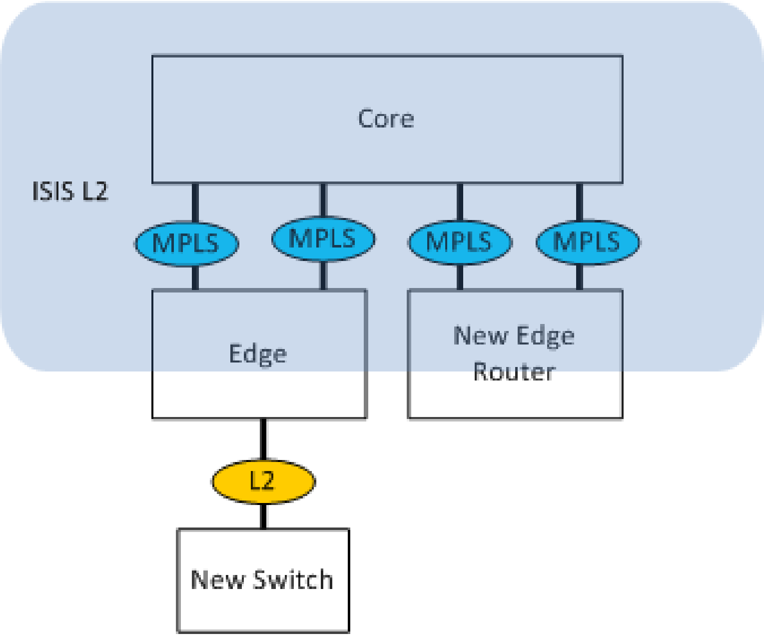
Handling Internet traffic

IPv6

- Introduced IPv6 peerings in IGW matrix
- User-facing dual-stack interfaces in IGW and EDGE
- full IPv6 routing table in IGW matrix
- IPv6 route distribution via MP-BGP: 6PE and 6VPE
- As with IPv4, the IGW matrix distributes only the IPv6 default route to edge routers

Expanding the Network

- Prior to mobile backhaul demands, the network was expanded with L3 edge routers and L2/L3 switches
- Switches with one L2 ethernet point-to-point uplink
- New edge router part of the ISIS level 2



Expanding the Network – integrating switches

Trends

- Shortening the local loop and building more optics bring more access nodes – therefore, more IP/ethernet aggregation nodes
- 3G and HSPA traffic on IP
- All-IP RAN – Iub control and user plane both on IP
- For a cost-effective solution we must use both L3 routers (smaller boxes) and L2/L3 switches and still ensure scalability, stability and redundancy requirements with fast convergence
- Scaling the L3 edge routers resources - new L3 routers handle a portion of MAC addresses, DHCP and multicast functions, VRF routes etc.

Case

- L3 routers can follow a similar expansion pattern as earlier. Now we have to provide a primary and backup uplink for a switch to make it more redundant with faster convergence of routing in case of link failure – all-IP Iub traffic demand.
- Ring topology for switches is efficient and cost-effective

Expanding the Network - integrating switches

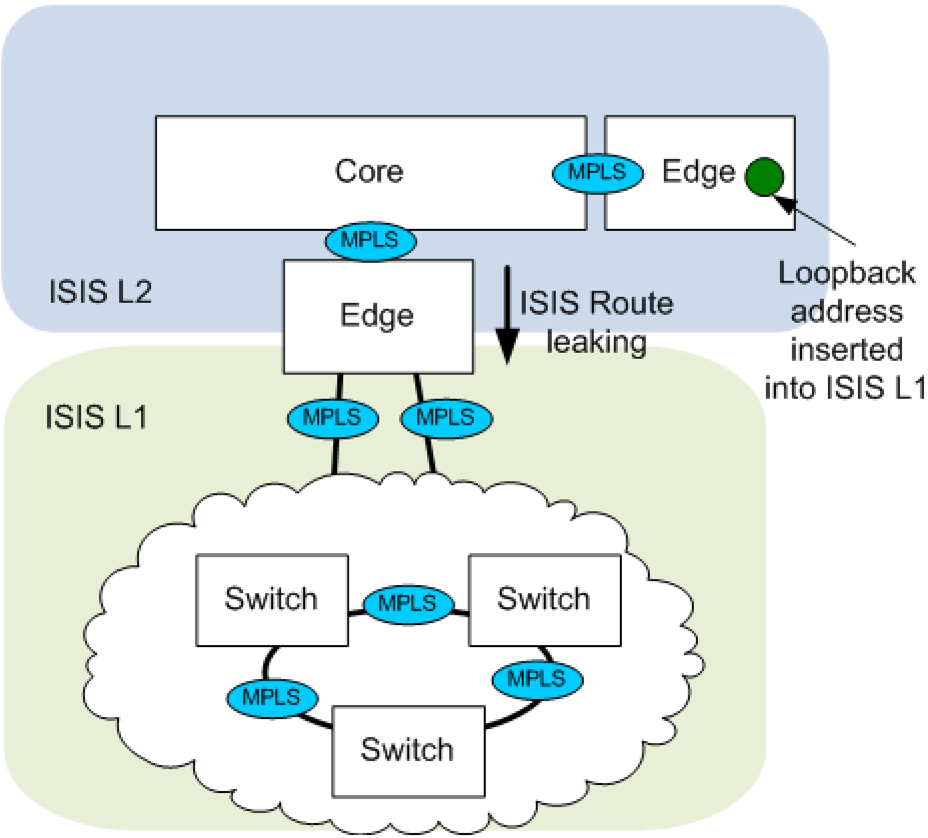
Options for switches?

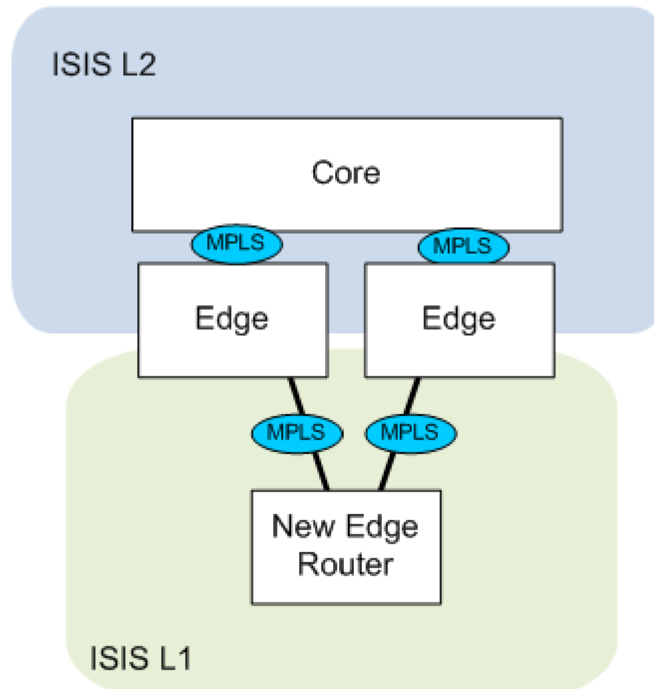
- ❖ MC-LAG towards two uplink edge routers? Slow convergence, replicated configurations, complexity
- ❖ Similar "plain" L2 solutions have slow convergence too

Design solution

- ✓ Must use MPLS. How?
- ✓ Must integrate switch into ISIS. Full ISIS integration into existing level 2 is heavy for the switch's ISIS SPF calculation.
- ✓ Have the switches inside a new ISIS level 1 and allow L2 routes leaking of remote node's loopbacks from nearest edge router – ensure end-to-end MPLS "visibility".
- ✓ This way, the switch "sees" only it's local level 1 ISIS for SPF
- ✓ For scalability, new smaller L3 routers can join this ISIS level 1

Expanding the Network





Expanding the Network – services on switches

Case

- ❖ Connectivity of end users and access nodes to L3 domain?
- ❖ “Visibility” of IP gateway interfaces, DHCP relay agents, VRFs, IGMP routers etc. ?

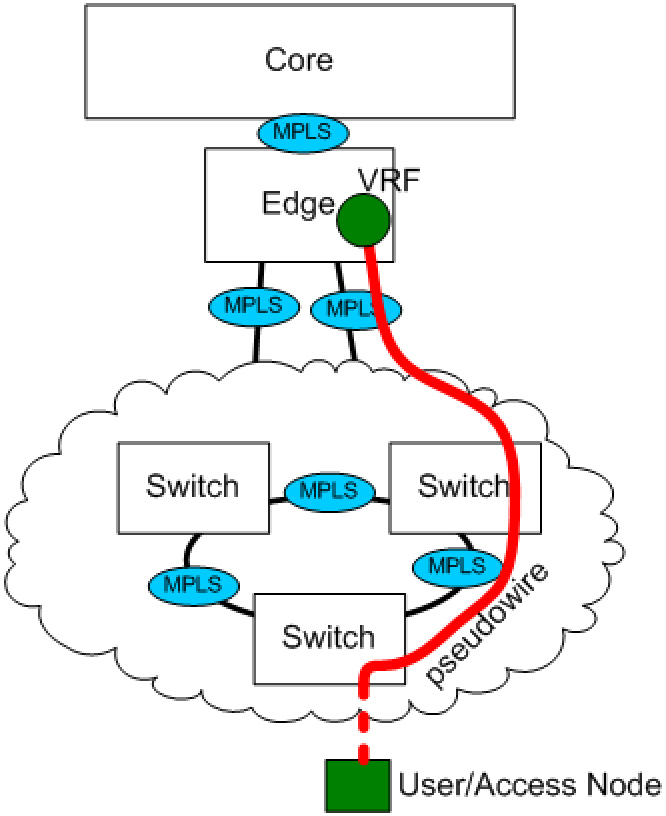
Options?

- ❖ Straightforward for L3 routers – bring up BGP, MP-BGP, VRFs, PIM etc.
- ❖ It would be desirable to bring up these “L3” functions on switches, but too heavy for switch’s CPU and memory

Design solution

- ✓ Use VPLS/pseudowires on switches
- ✓ Use routed VPLS on nearest “upstream” edge L3 router and existing L3 functionalities

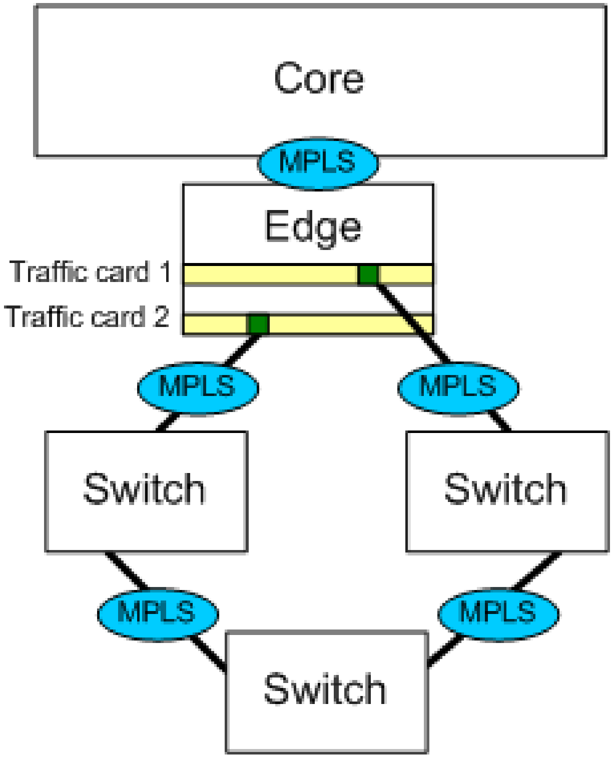
Expanding the Network – services on switches



Expanding the Network – integrating switches (back again)

- ❖ It would be desirable to have redundant uplinks for a switch or a group of switches (ring) towards two different L3 edge routers.
- ❖ This would require to terminate the pseudowires through a lot more hops to the "serving" L3 edge router – the backup path would have a greater delay which is not desirable for Iub voice and control plane traffic

- ✓ It is good enough to have the ring of switches to have two redundant uplinks towards the same edge L3 router
- ✓ All main aspects of redundancy are met - the edge router has redundant power, route processor cards, and the links can terminate on two different traffic cards



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Multicast Design

- PIM SSM chosen – complexity of MVPN,
- IGMPv2 messages to source mappings at L3 edge router
- Faster joining to a multicast group – streams are statically brought to L3 edge routers
- Multicast sources included in ISIS due to PIM SSM

- New VPLS/pseudowire aggregation level supports multicast on MPLS and inside a VPN – optimal and desirable multicast design

Faster Convergence

- ❑ RSVP FRR link protection in MPLS core
- ❑ Demand for sub-50ms convergence – particulary for voice and SIGTRAN traffic, Iub and Iu interfaces

- ❖ ISIS can solely achieve ~500ms
- ❖ Full-mash of RSVP link protections is not manageable and can be demanding for router processing

- ✓ ISIS LFA (Loop Free Alternate) is chosen
- ✓ Scalable and optimal with ISIS leveling in network
- ✓ Fits well into the switch aggregation part of the network – ISIS backup route provided with SPF calculation only for the local ISIS level 1 with a only a small number of ISIS nodes

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THANK YOU!