The bridge to possible

Large Scale SP Interconnection & Merger

Field Experience and Lessons Learnt

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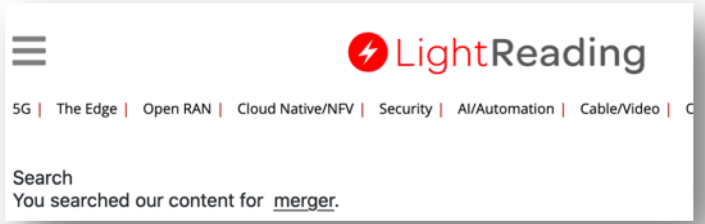
26/02/2021

Introduction and Project Context



- Market consolidation in SP landscape
  - *O2 and Virgin Media to merge in £31.4B deal*
  - *Proximus to buy Mobile Vikings for €130M*
  - *T-Mobile/Sprint Merger Gets DoJ Approval Thanks to Dish's $5B Deal*
  - *etc.*
- Not many public OSPF to ISIS migration references/success stories
  - AOL, OSPF to ISIS, NANOG29

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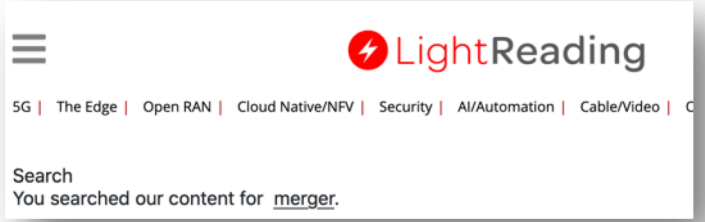

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  - *etc.*
- Not many public OSPF to ISIS migration references/success stories
  - AOL, OSPF to ISIS, NANOG29
- Unclassified project: migration performed few years ago
  - However customers privacy required: let's call them SP1 and SP2
  - Consider this experience as semi-public :-) (big enough to care)
- Good first NOG talk, back to fundamentals: MPLS/routing

Agenda

- Environment and project history
- Study phase
- Phase 1: interconnection
- Phase 2: OSPF to ISIS migration
- Phase 3: merge
- Work in progress
- Additional network merger topics

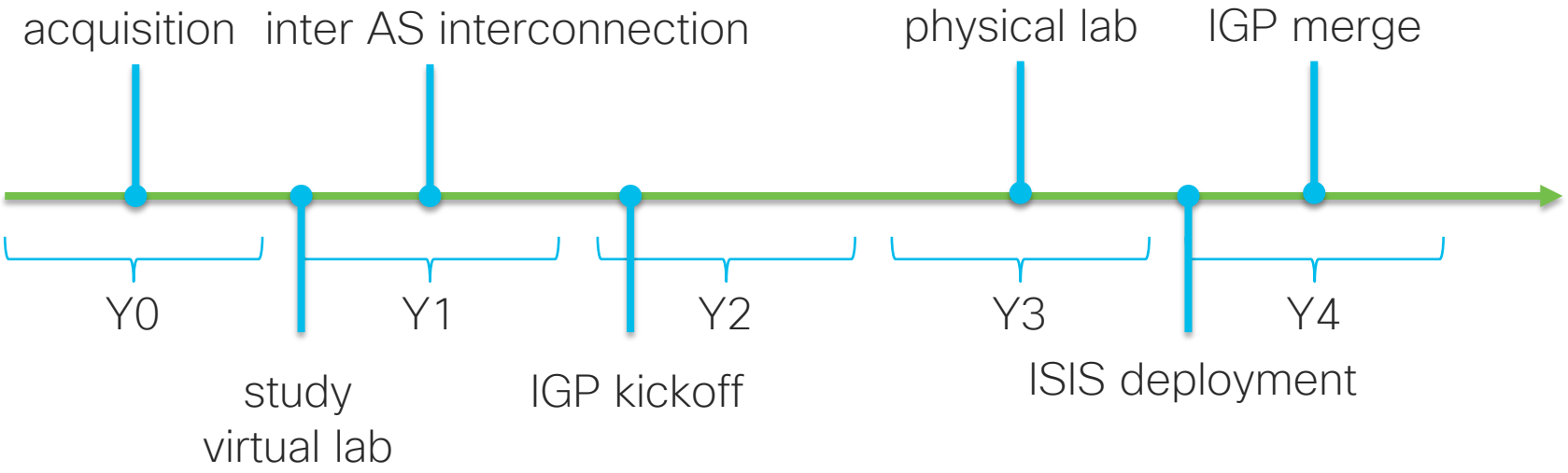
Environment and History

- SP1 and SP2 are major B2B SP actors
- SP1 has been acquired by SP2 (despite SP1>SP2)
- Network(s) consolidation plan: focus on B2B in this presentation

	SP1	SP2
IGP	ISIS	OSPF
Vendors	Multi (Cisco, Nokia, Redback)	Multi (Cisco, Redback, Juniper)
Legacy	Yes	Yes
Scale	500 nodes	500 nodes
Services	Dedicated B2B backbone Partially converged core for mobile Dedicated B2C backbone	Dedicated B2B PE for L2VPN and L3VPN services Dedicated B2C PE Converged core

Project Timeline

- It's been a long journey
  - But it can be done faster: no technical roadblock identified/hit



Study Phase

- Which inter-AS option?
  - Option C
- Which common IGP protocol?
  - ISIS (see annex)
- Target scale (IGP, BGP)?
  - Will it fit?

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  - Will it fit?
- Check IP overlap for transport loopbacks
- Quick POC with virtual-lab
- Create design and MOP documents for phase 1

Phase 1: Interconnection

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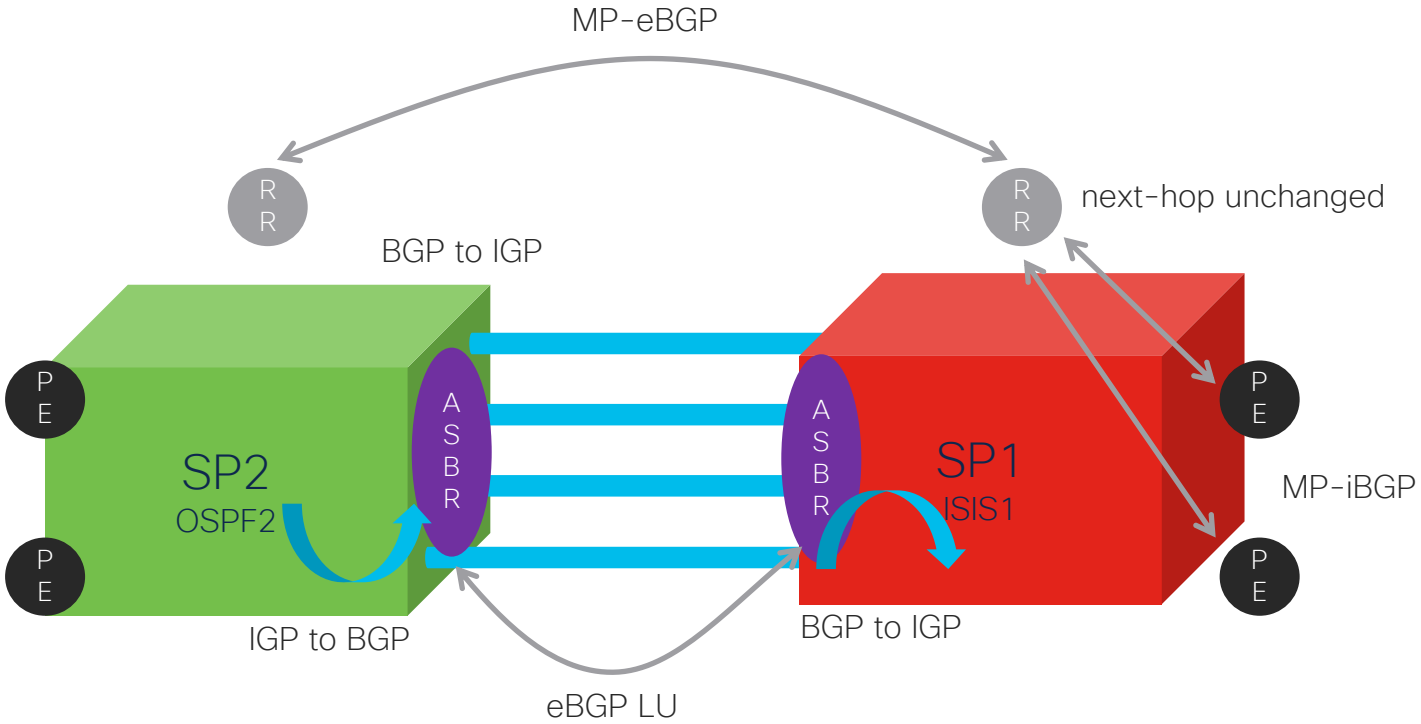
- 4 touchpoints, split geographically (north, south, east, west)



Phase 1: Interconnection

- Goal: provide services across the 2 networks asap
- Inter-AS option C, classic stuff
- Transport
  - eBGP LU (RFC 3107) between ASBR : BGP label allocation
  - Mutual redistribution in IGP: ISIS and OSPF tag assignment/filtering, LDP label allocation (host-routes or ACL). No support of iBGP LU for legacy
- Services
  - MP-eBGP multi-hop between VPN RR
  - BGP next–hop unchanged

Phase 1: Things to Know

- eBGP LU implementation on IOS-XR
  - Don't forget static /32 toward physical interface (equivalent of "mpls bgp forwarding" on Cisco IOS)
  - Control plane looks OK but forwarding plan fails

```
router bgp 65001 address-family ipv4 unicast allocate-label all
router bgp 65001 neighbor 10.1.0.6
router bgp 65001 neighbor 10.1.0.6 remote-as 65002
router bgp 65001 neighbor 10.1.0.6 address-family ipv4 labeled-unicast
router bgp 65001 neighbor 10.1.0.6 address-family ipv4 labeled-unicast send-community-ebgp
router bgp 65001 neighbor 10.1.0.6 address-family ipv4 labeled-unicast route-policy bgp_in in
router bgp 65001 neighbor 10.1.0.6 address-family ipv4 labeled-unicast route-policy bgp_out out

router static address-family ipv4 unicast 10.1.0.6/32 GigabitEthernet0/0/0/0 <<<
```

```
RP/0/0/CPU0:ASBR-SP2#sh mpls forwarding
Tue Feb 23 17:29:12.521 UTC
Local  Outgoing    Prefix            Outgoing     Next Hop        Bytes
Label  Label       or ID             Interface                    Switched
------ ----------- ----------------- ------------ --------------- ------------
24008  Pop         10.1.0.0/16                    10.1.0.6        0
24009  Pop         192.168.0.10/32                10.1.0.6        0
```

```
RP/0/0/CPU0:ASBR-SP2#sh mpls forwarding
Tue Feb 23 17:30:37.115 UTC
Local  Outgoing    Prefix            Outgoing     Next Hop        Bytes
Label  Label       or ID             Interface                    Switched
------ ----------- ----------------- ------------ --------------- ------------
24009  Pop         192.168.0.10/32   Gi0/0/0/0    10.1.0.6        0
24010  Pop         10.1.0.6/32       Gi0/0/0/0    10.1.0.6        0
```

Phase 1: Things to Know

- eBGP LU implementation on Nokia
  - Don’t forget export-tunnel-table policy, see doc
  - LSP was broken in 1 direction during 1st try, missed in virtual lab

Phase 2: OSPF to ISIS Migration

“It’s not dangerous, you just need to do the right things”

Paul Bonhomme, extreme steep skier

Phase 2: OSPF to ISIS Migration, Engineering

- IGP choice: ISIS was eventually chosen
  - IPv6 support
  - faster Segment-Routing features shipping
  - was present in SP1 B2C backbone (1 protocol used everywhere, easy ops)

Phase 2: OSPF to ISIS Migration, Engineering

- IGP choice: ISIS was eventually chosen
  - IPv6 support
  - faster Segment-Routing features shipping
  - was present in SP1 B2C backbone (1 protocol used everywhere, easy ops)
- IGP design:
  - Flat L2: physical topology did not allow hierarchical design. Faster to deploy
  - Backup design with L1 for legacy, just in case (did not use it)
- IGP scale:
  - SP2 had to support both OSPF and ISIS topologies, concern for legacy device (nodes, routes)

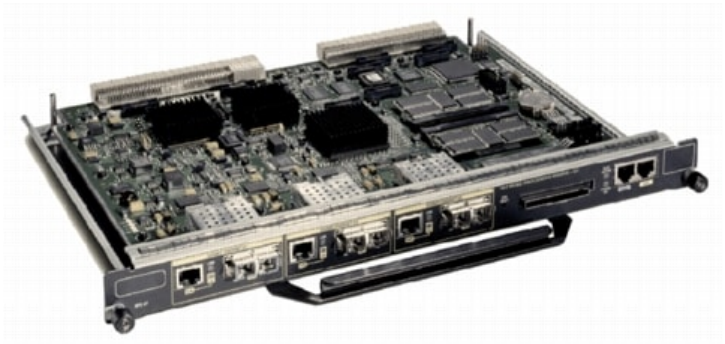
Phase 2: OSPF to ISIS Migration, Validation

- Extensive lab validation performed with real gear: interop, scale, migration scenario, high availability, convergence etc. 50 test cases

Test reference	Test name	Requirements	Topology	Comments	in DTP	Status
	IOS					Pass
Migration.3	OSPF deletion		Flat L2			Pass
Migration.4	ASBR migration (LDP+ISIS on interco, BGP removal)		Flat L2			Pass
Scale.1	Scale XR (RSP440 et CRS)		Flat L2			Pass
Scale.2	Scale XE (ASR1006 RP2)		Flat L2			Pass
Scale.3	Scale Ericsson (SE100/SE400)		Flat L2			Pass
Scale.4	Scale Nokia		Flat L2			Pass
Scale.5	Scale IOS 7300/7200		Flat L2			Pass

Phase 2: OSPF to ISIS Migration, Validation

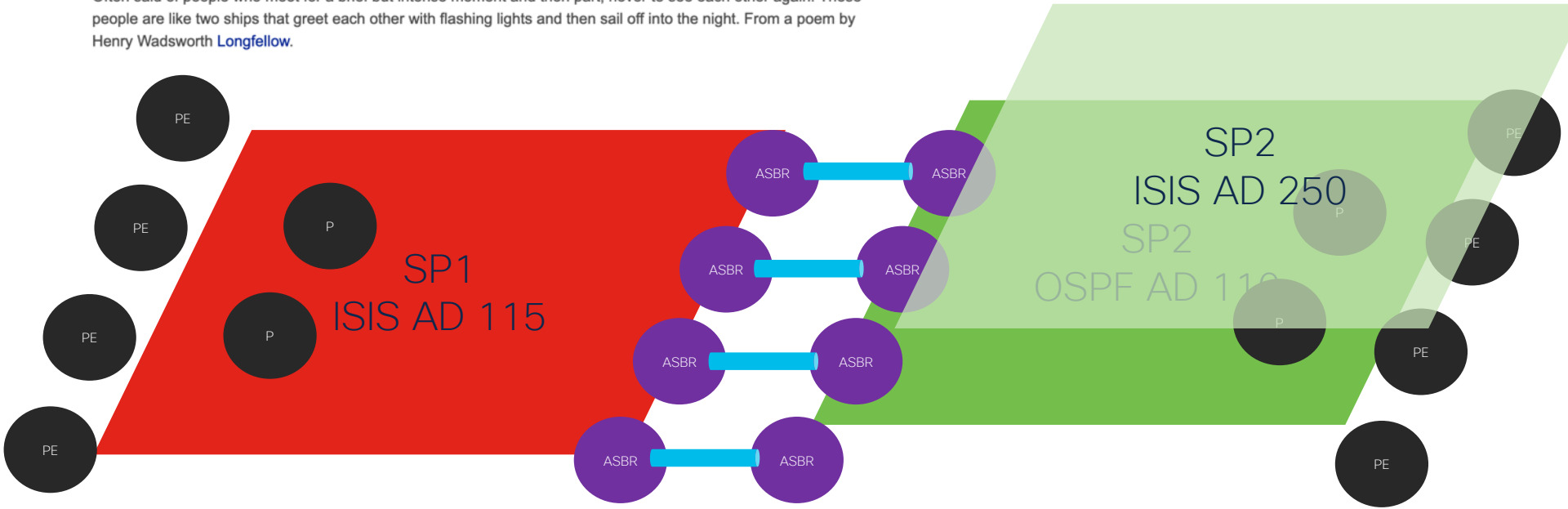
- Lessons learnt
  - ISIS LDP sync was not working on Redback
  - Cisco 7200 (NPEG1!)/7300 and Redback SE100 worked like a charm
    - Stress test performed with high scale (x2 production) (4000 OSPF + 5000 ISIS prefixes) + IGP churn over 24h
    - CPU and memory monitored: no leak, no crash



Phase 2: OSPF to ISIS Migration, Deployment

ships that pass in the night ☆

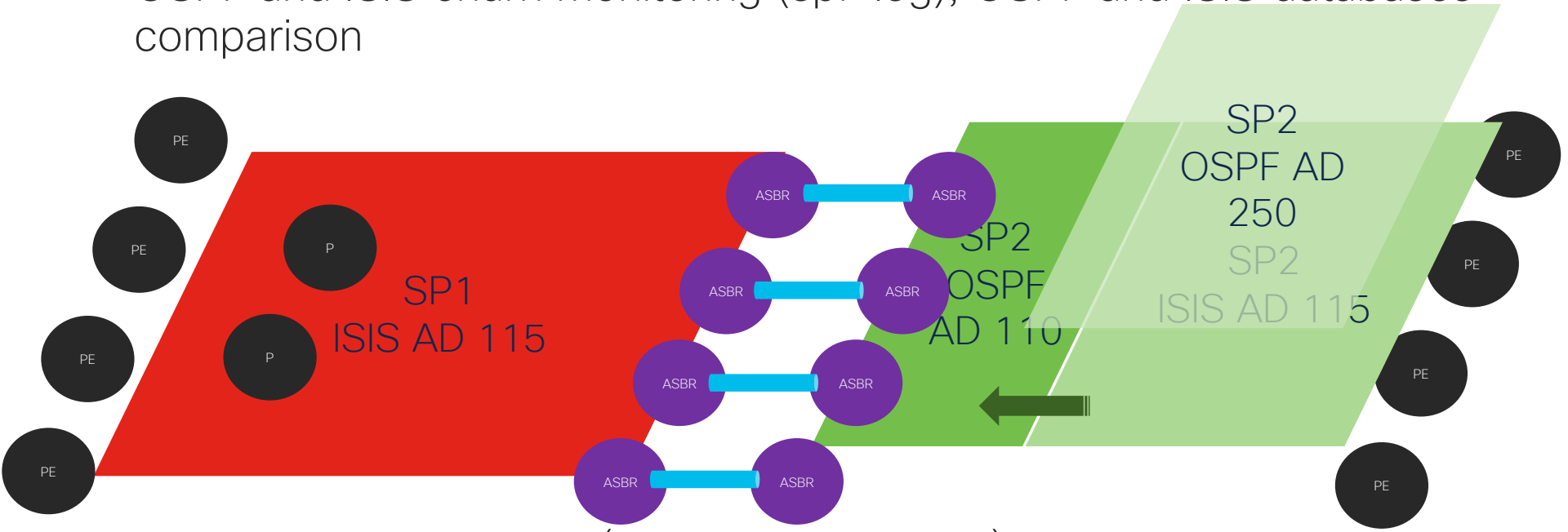
Often said of people who meet for a brief but intense moment and then part, never to see each other again. These people are like two ships that greet each other with flashing lights and then sail off into the night. From a poem by Henry Wadsworth Longfellow.



- data-plane not affected, OSPF still driving

Phase 2: OSPF to ISIS Migration, Deployment

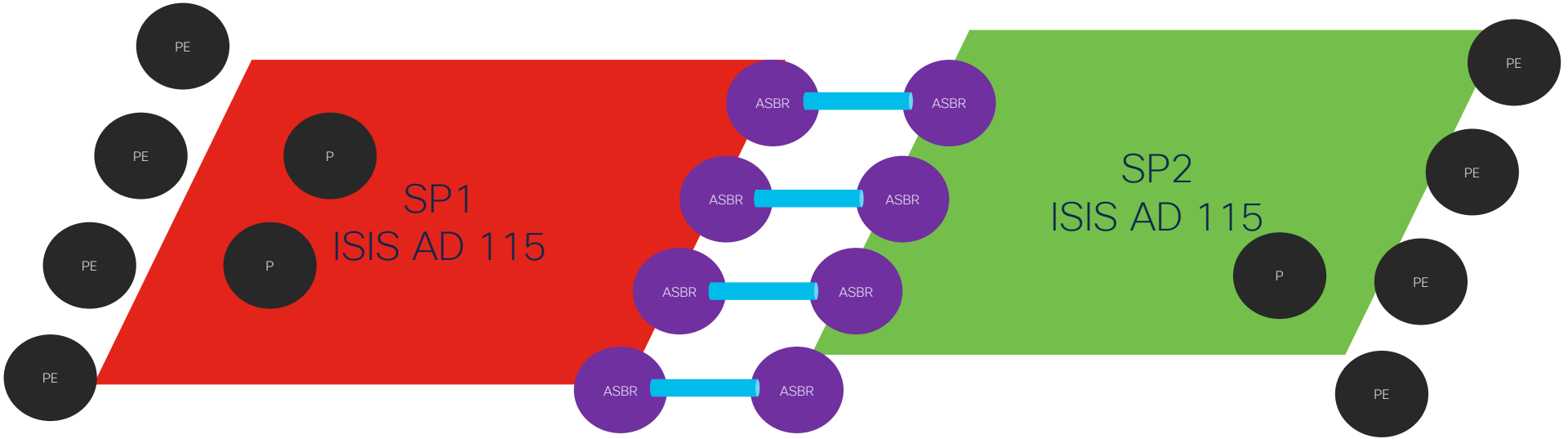
- OSPF and ISIS churn monitoring (spf-log), OSPF and ISIS databases comparison



- Gradual AD adjustment (from edges to core): OSPF to 250, ISIS to 115

Phase 2: OSPF to ISIS Migration

- BGP – ISIS instead of BGP – OSPF redistribution



- Et voilà!

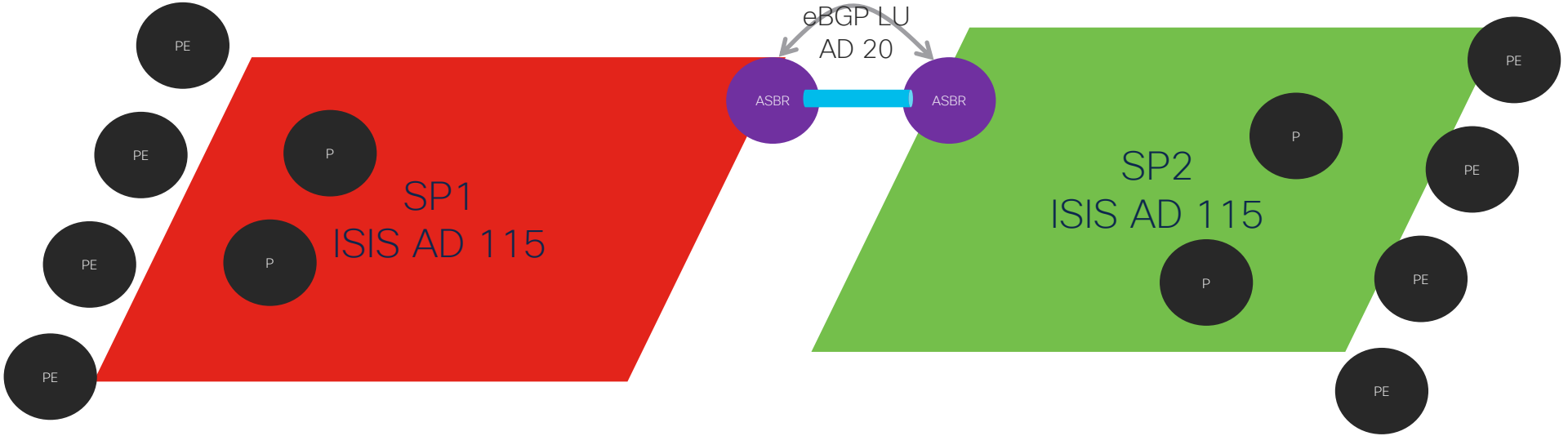
Phase 2: OSPF to ISIS Migration, Things to Know

- No out of band management in SP2
  - *YOLO-ops* compliancy
- Literally swapping an airplane engine in flight
- Surprisingly, no problem!

Phase 3: IGP Merge

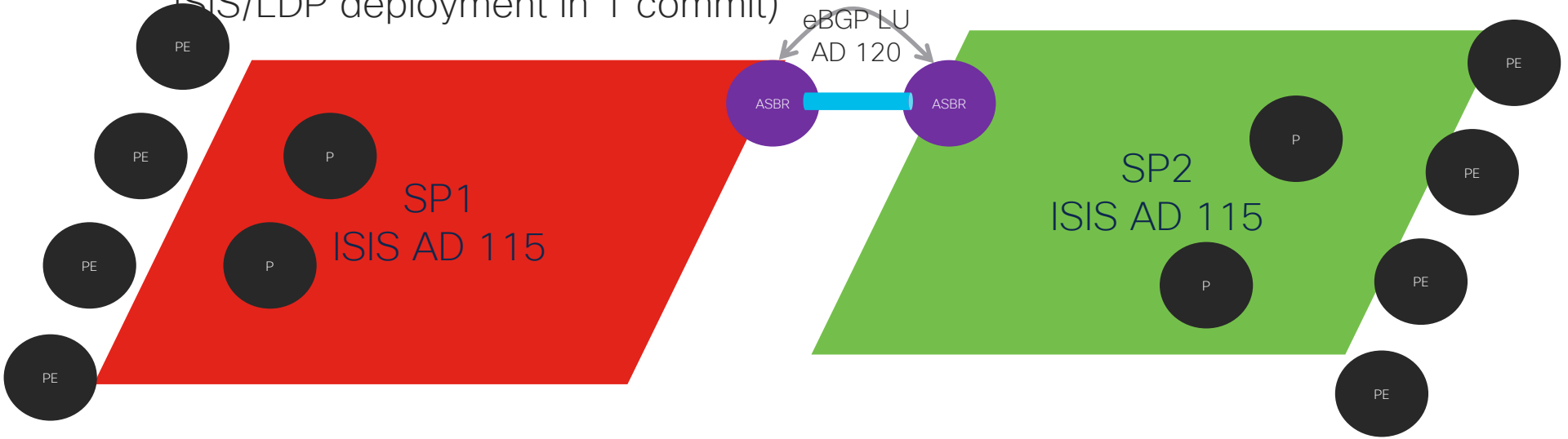
Phase 2: OSPF to ISIS Migration

- 3 out of 4 eBGP LU sessions were shutdown to control ISIS flooding between the 2 networks and monitor IGP stability



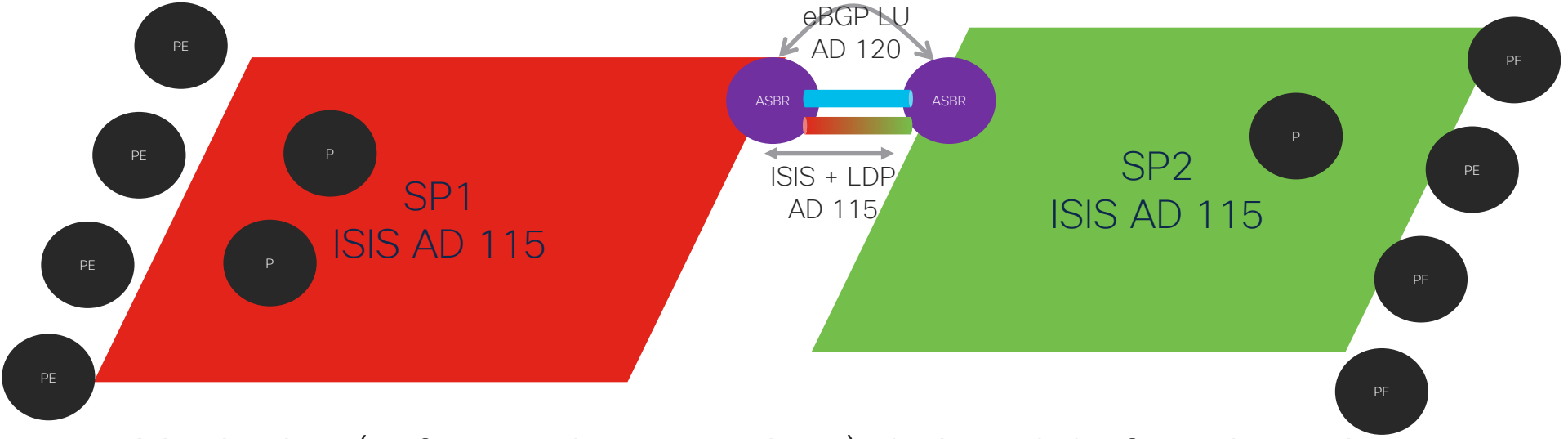
Phase 2: OSPF to ISIS Migration

- AD was raised from 20 (eBGP) to 120 (> ISIS 115). Routes had to be cleared to apply new AD. MPLS forwarding still using BGP LU
  - Easy rollback if needed
  - Turned out to have less impact on traffic (compared to BGP shutdown + ISIS/LDP deployment in 1 commit)



Phase 2: OSPF to ISIS Migration

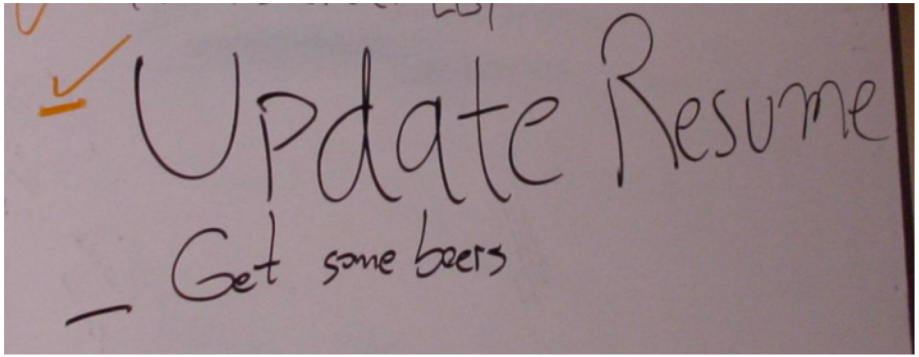
- ISIS + LDP configuration on interconnection: routes automatically switched to IGP (AD 115<120). MPLS forwarding moved to LDP



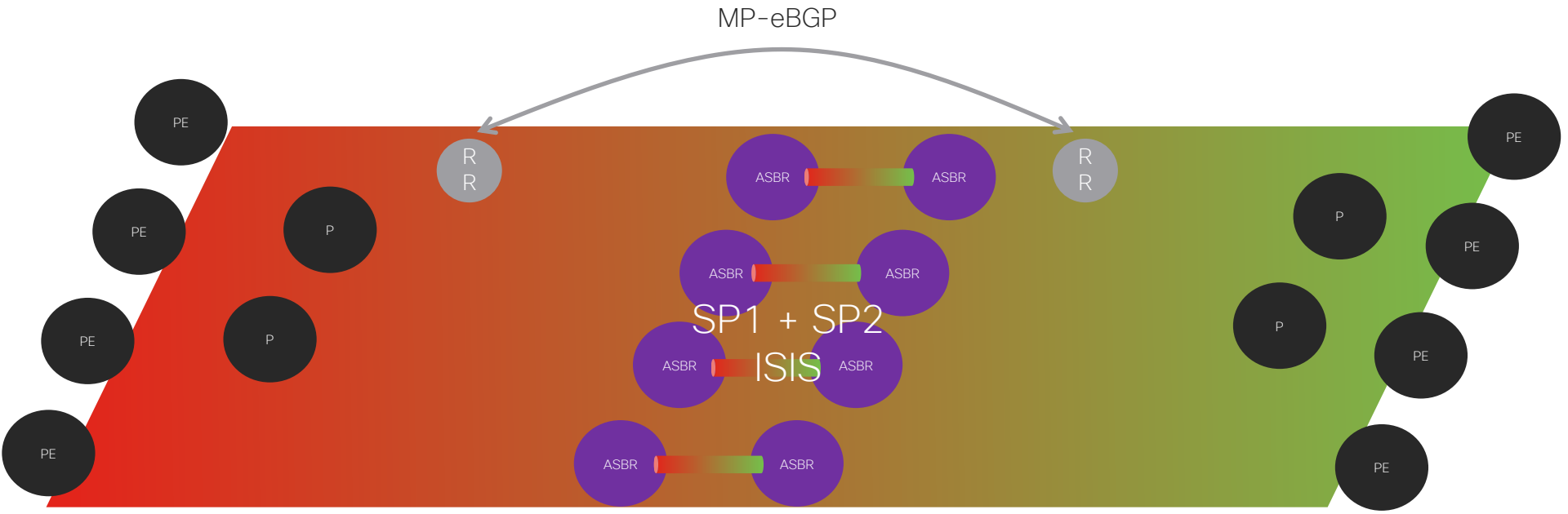
- Monitoring (spf logs, churn, services) during 1h before deploying ISIS + LDP on remaining ASBR

Phase 3: IGP Merge

- Application on the 3 remaining interconnections
- Full sanity check
- No network meltdown
  - Followed Vijay Gill & Jon Mitchell action plan till the end:



Phase 3: IGP Merge, Final Picture



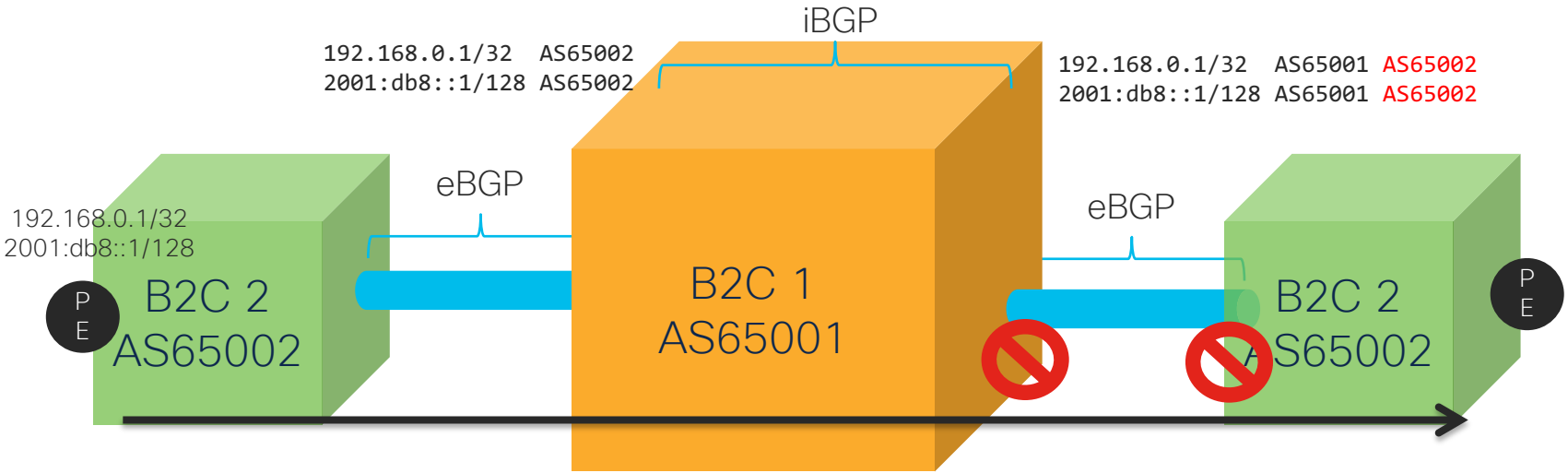
Phase 3: IGP Merge, Things to Know

- BGP session flap between RR and distant routers when merging IGP
  - Low bandwidth & high delay links, small MTU: triggered BGP slow-peer
  - Mitigation with BGP shutdown (temporary) and ISIS timers modification
- Except that, IGP merge done in 90min!
- BGP LU and OSPF configurations in SP2 remained few weeks before full removal

What about B2C Merger?

Other Tricks Used for B2C

- Out of this project scope, provided limited support. Use of full BGP toolbox to propagate loopbacks across single core
  - BGP loop avoidance removal on XR ASBR: as-path-loopcheck out disable + allow-as in: don't try this at home
  - Same hacks required later for CPE… (local-as, as-override, etc.)



Work in Progress

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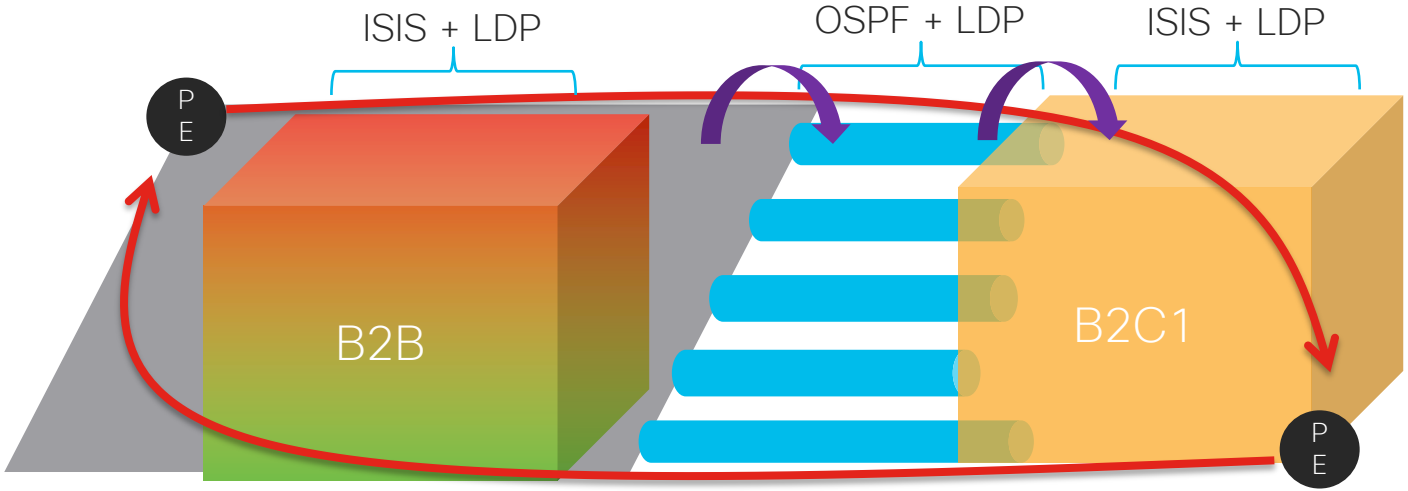
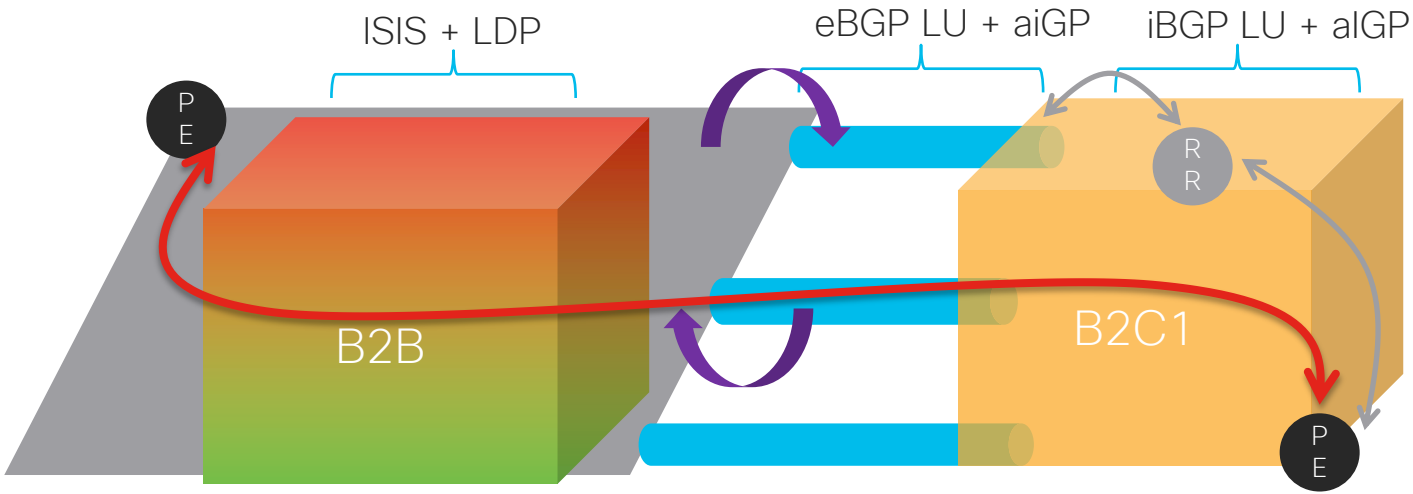
- BGP LU + alGP deployment
  - This converged B2B network is interconnected to several other ones, but without BGP LU, and on multiple locations (too many)
    - BGP LU deployment: better traffic engineering/scale/stability
    - alGP deployment: optimal routing between 2 routing domains



Work in Progress

- BGP LU + aIGP deployment
  - Get rid of BGP to ISIS redistribution in B2C 1 (very high IGP scale)
  - iBGP LU RR selects best ASBR (can be combined with BGP add-path)
- Consolidate number of interconnexions



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- IPv6 deployment in the core
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  - ISIS is IPv6 aware, good opportunity to deploy it if not already. Single or multi topology
  - Use case: management in v6, private IP overlap management
- QoS coordination
  - Each SP has its own QoS strategy
  - QoS is end to end and must be aligned
- MTU harmonization
  - SP1 uses 4014 bytes
  - SP2 uses 9192 (Cisco) or 7814 (Redback) bytes

Additional Merger Topics

- Common administration plane
  - Centralized monitoring/AAA, updated SNMP communities etc
- Security: jumphost, ACL, DDoS mitigation
- Peering/transit consolidation

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- Security: jumphost, ACL, DDoS mitigation
- Peering/transit consolidation
- Misc
  - Hostnames, interfaces description, etc.
  - Software versions to be aligned, vendor strategy
- Legacy extinction (migration, or replaced by NFV platforms)

Additional Merger Topics

- BGP AS migration/consolidation
  - Transit-Peering is easy, few BGP peers consolidated on few nodes
  - Huge effort for subscribers: does it worth it for existing installed based (150k + 150k sub)?
    - For this customer, legacy extinction/migration will take care of it. AS1 takes over

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    - For this customer, legacy extinction/migration will take care of it. AS1 takes over
- Network is easy… people/organization more challenging
  - Who manages what?
  - With which process?
  - Single engineering, support teams, NOC etc.
  - Service provisioning, billing, OSS/BSS: this one is tough
  - 1+1 never = 2 in acquisitions/mergers

Things I Would Do Differently in 2021

- Telemetry: real time visibility
  - BGP with BMP
  - IGP with BGP-LS or RIB/ISIS telemetry (see my xrdocs.io post)
- TWAMP/IP SLA: test services and transport during migration

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  - BGP with BMP
  - IGP with BGP-LS or RIB/ISIS telemetry (see my xrdocs.io post)
- TWAMP/IP SLA: test services and transport during migration
- More automation:
  - IGP modeling for automatic and reliable ISIS deployment
    - 1 button ‘IGP deploy’, 1 button ‘IGP swap’
  - IGP db parsing
- Overall it was a:

The bridge to possible

Annex

OSPF vs ISIS

	ISIS	OSPF
Design	2-level hierarchy Originally: Only totally stub areas route leaking makes areas non-stub	2-level hierarchy Multiple types or areas
Encapsulation	Runs directly over layer 2	On top of IP (can be remotely attacked)
Flooding	Reliable on p2p links 1 LSP per router Fexibility via TLVs Unrecognized TLVs are flooded Requesting info and acks (PSNP) DIS	Reliable Many different types (11) of LSAs Fixed LSA formats Unrecognized LSA are not flooded Requesting info and acks (LS Request/Update) DR and BDR

OSPF vs ISIS

	ISIS	OSPF
Network types	P2P Broadcast	P2P Broadcast Non-broadcast Point-to-multipoint
Aging	Periodic flooding Aging: counts down Remaining lifetime is configurable Cannot disable aging	Periodic flooding Aging: counts up Maxage is not configurable DoNotAge (DNA) bit cancels aging out
MPLS TE	Yes	Yes
IPv6	Integrated	Seperate and new protocol: OSPFv3
Authentication	Yes	Yes

OSPF vs ISIS

	ISIS	OSPF
Operation	Less deployed so less known	Widely deployed and well known
Scale	High	High
Convergence	Fast	Fast
Segment Routing	Earlier features	Takes more time
How it works	Link-state, Dijkstra,	Link-state, Dijkstra,