Taking the Edge off with Espresso

Scale, Reliability and Programmability for Global Internet Peering

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Problem Statement

Egress Terabits/sec of traffic to our Internet peers

- High-def video, cloud traffic, etc.

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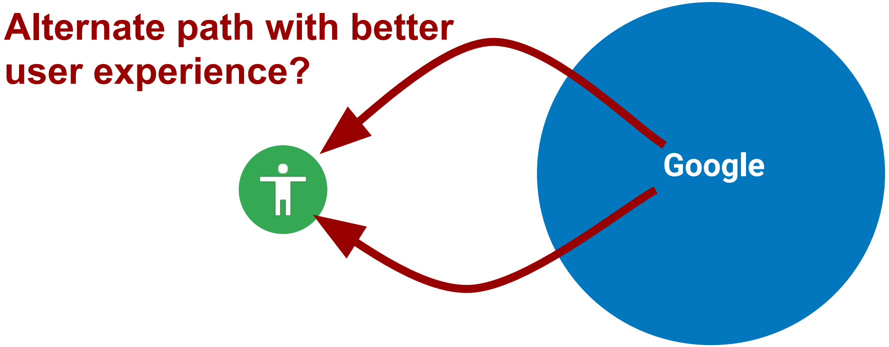
1. Optimize traffic per-customer and per-application

- e.g., optimal video quality, or differentiated service for cloud
- Problem: Constrained by BGP shortest path and lack of application awareness



Problem Statement

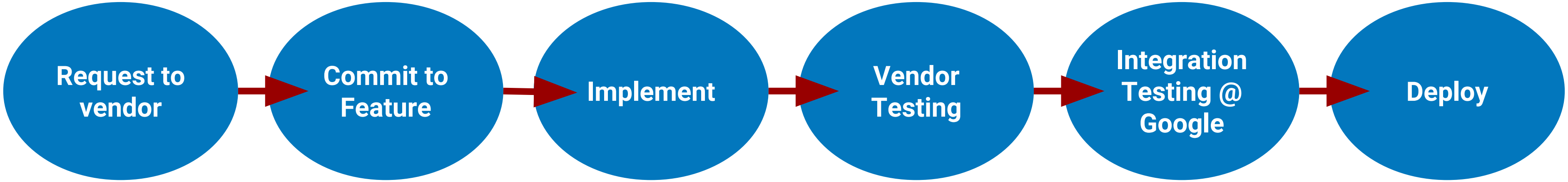
Egress Terabits/sec of traffic to our Internet peers

- High-def video, cloud traffic, etc.

2. Deliver new features quickly

- Problem: router-vendor feature cycles and qualification take many years

Novel L2 VPN?



Espresso: Google's SDN Peering Edge

Our previous experience with SDN

- B4 [SIGCOMM 2013] and Jupiter [SIGCOMM 2015]
- Enable flexible traffic engineering
- Increase feature velocity

SDN is only suited for walled gardens?

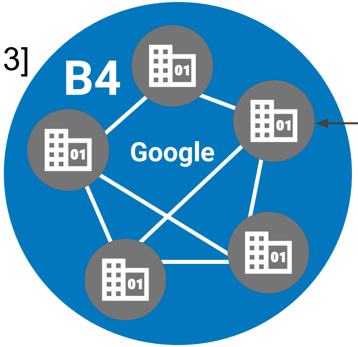
Peering edge requires interoperability with heterogeneous peers.

Agenda

- Problem Statement
- Espresso in Context
- Design Principles
- Architecture Overview
- Results
- Conclusion

Espresso in Context

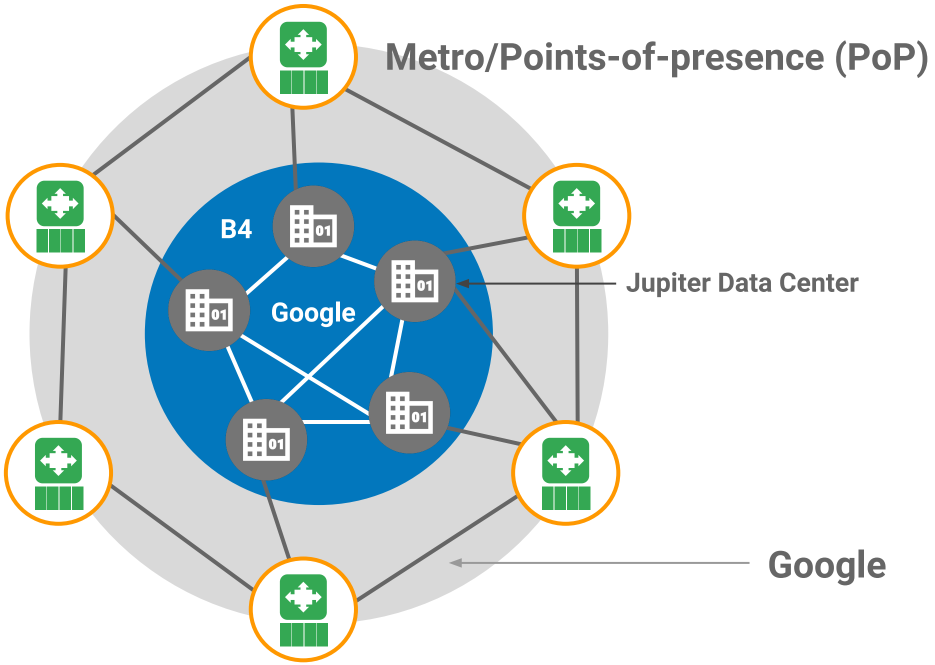
[SIGCOMM 2013]



Jupiter Data Center

[SIGCOMM 2015]

Espresso in Context

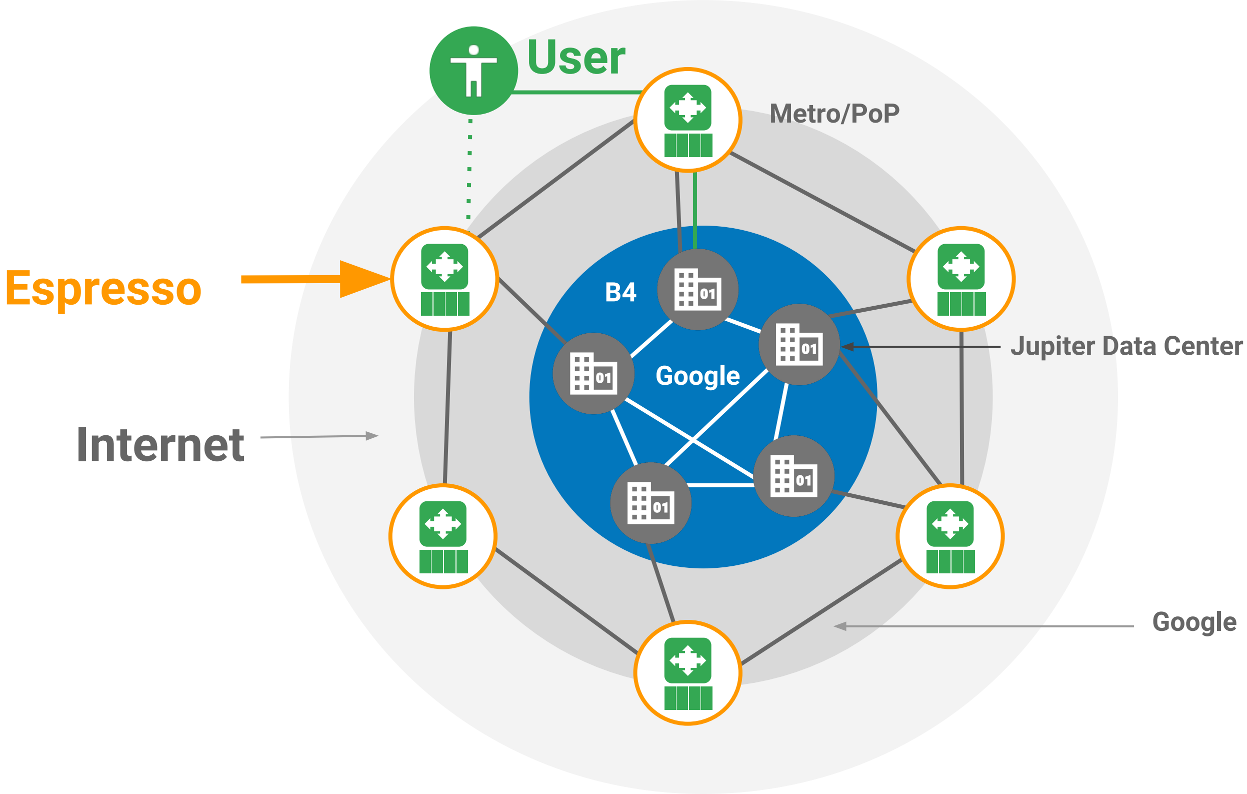


Metro/Points-of-presence (PoP)

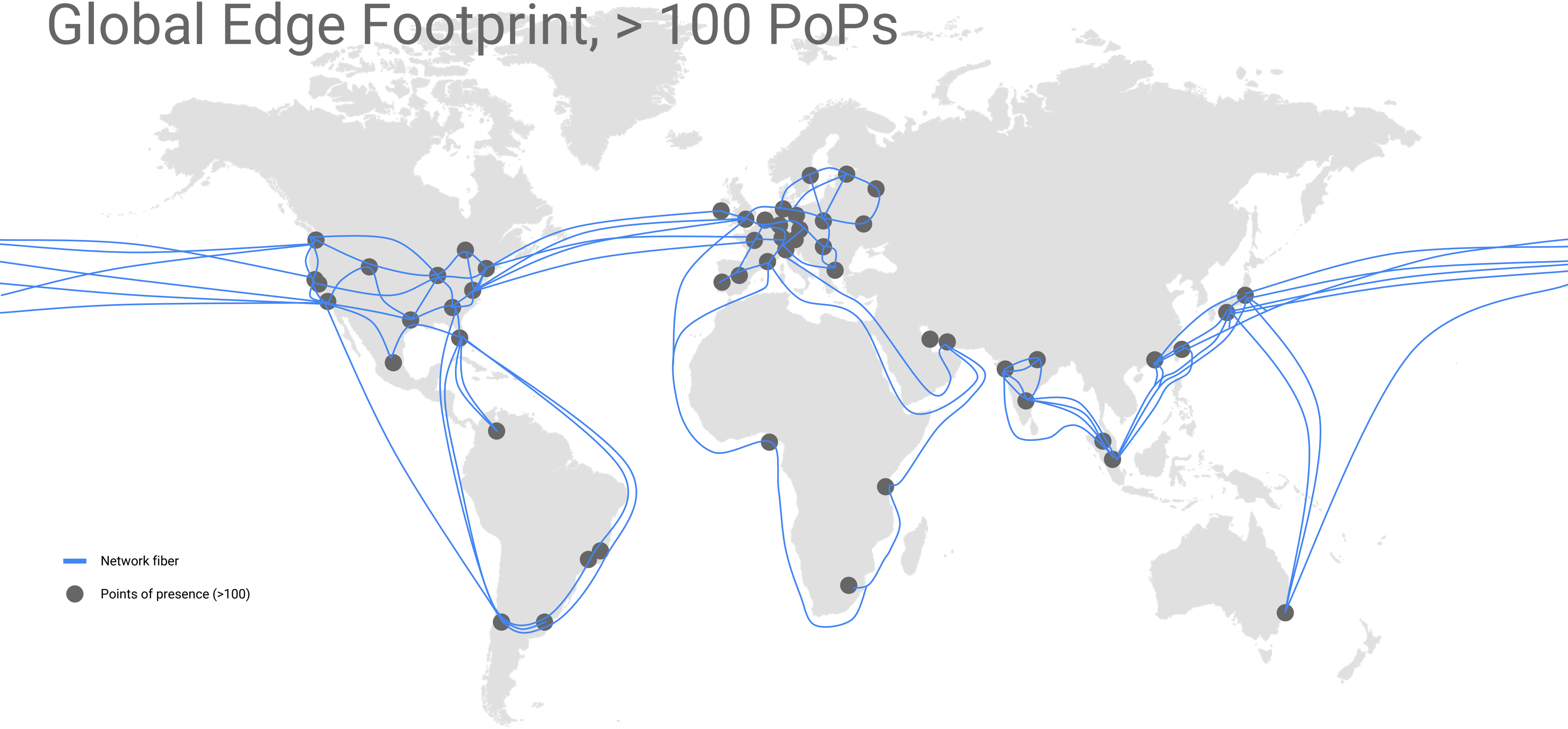
Jupiter Data Center

Google

Espresso in Context



Global Edge Footprint, > 100 PoPs



Google

Confidential + Proprietary

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Espresso’s Design Principles

1. Hierarchical control plane
   - Global optimization while local control plane provide fast reaction.
2. Fail static
   - Local control plane continues to function without global controller failure.
3. Software programmability
   - Externalize features into software to exploit commodity servers for scale.
4. Testability
5. Manageability

Espresso’s Design Principles

1. **Hierarchical control plane**
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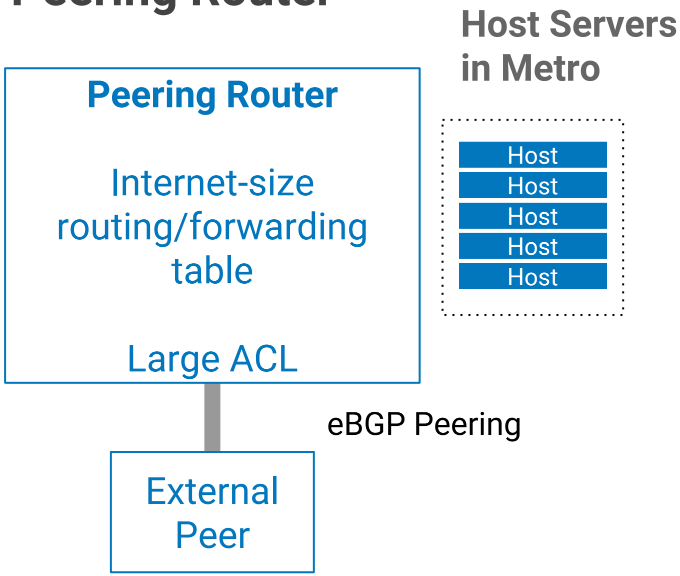
Hierarchical control plane
Fail static
Software programmability

Architecture: Externalizing BGP

Traditional Peering Router



Host Servers in Metro

Peering Router

Internet-size routing/forwarding table

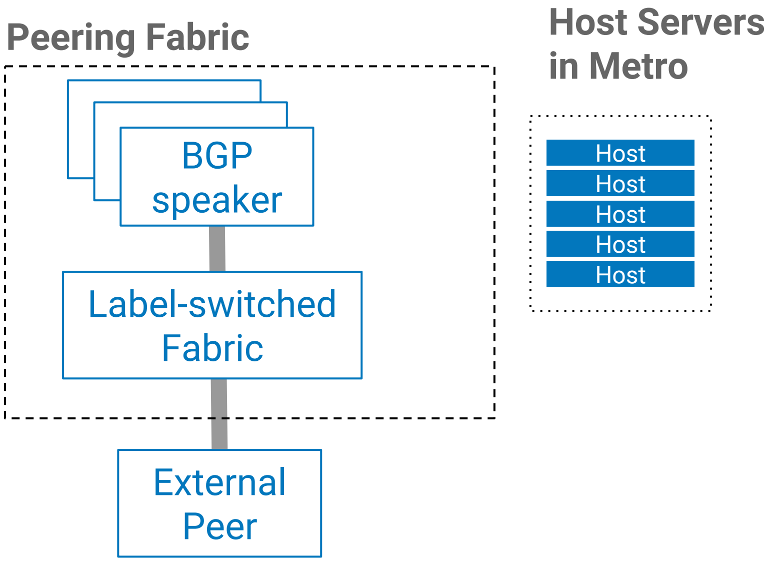
Large ACL

Host
Host
Host
Host
Host

eBGP Peering

External Peer

Espresso



Peering Fabric

Host Servers in Metro

BGP speaker

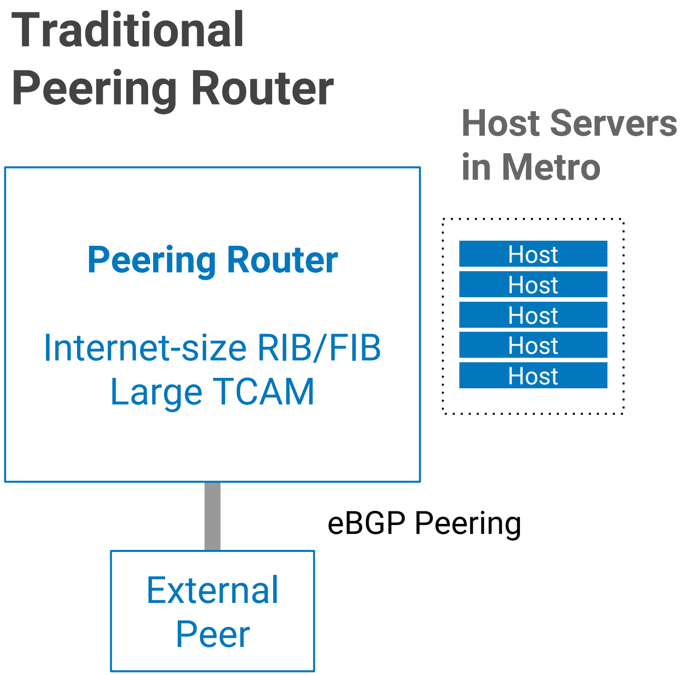
Label-switched Fabric

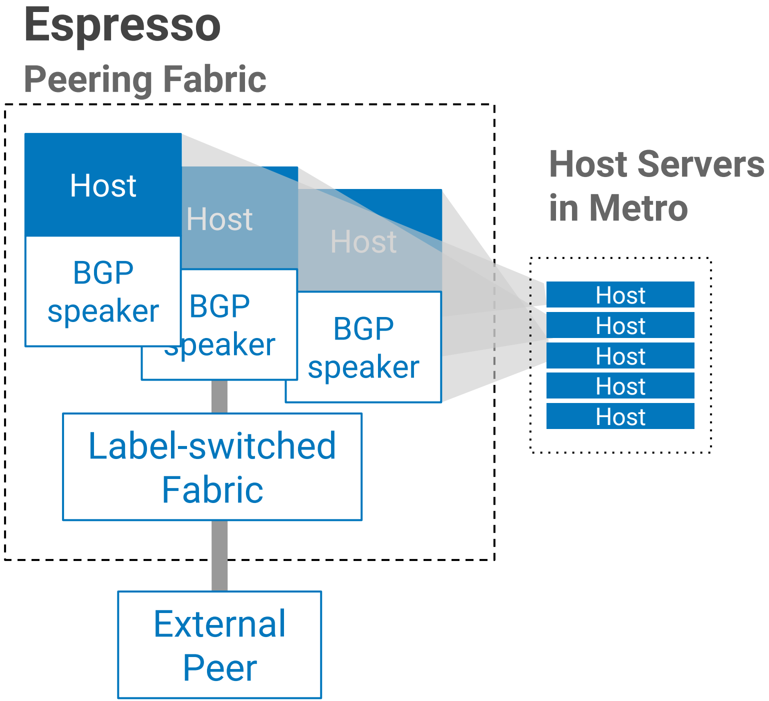
Host
Host
Host
Host
Host

External Peer

Hierarchical control plane
Fail static
Software programmability

Architecture: Reliability and Scale of BGP

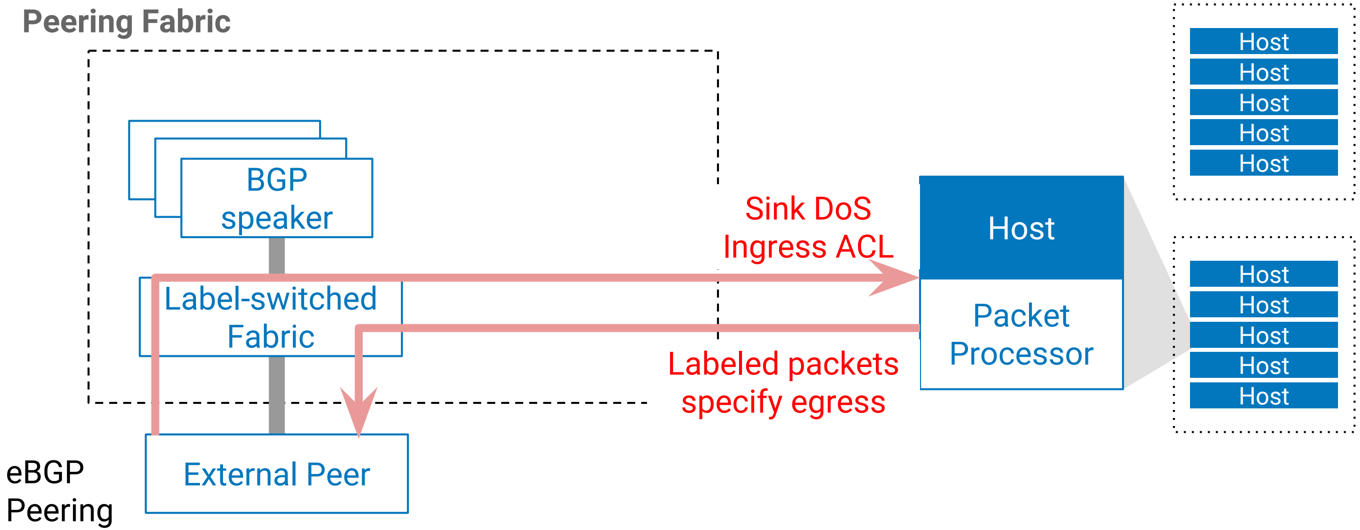




Hierarchical control plane
Fail static
Software programmability

Architecture: Externalize Packet Processing

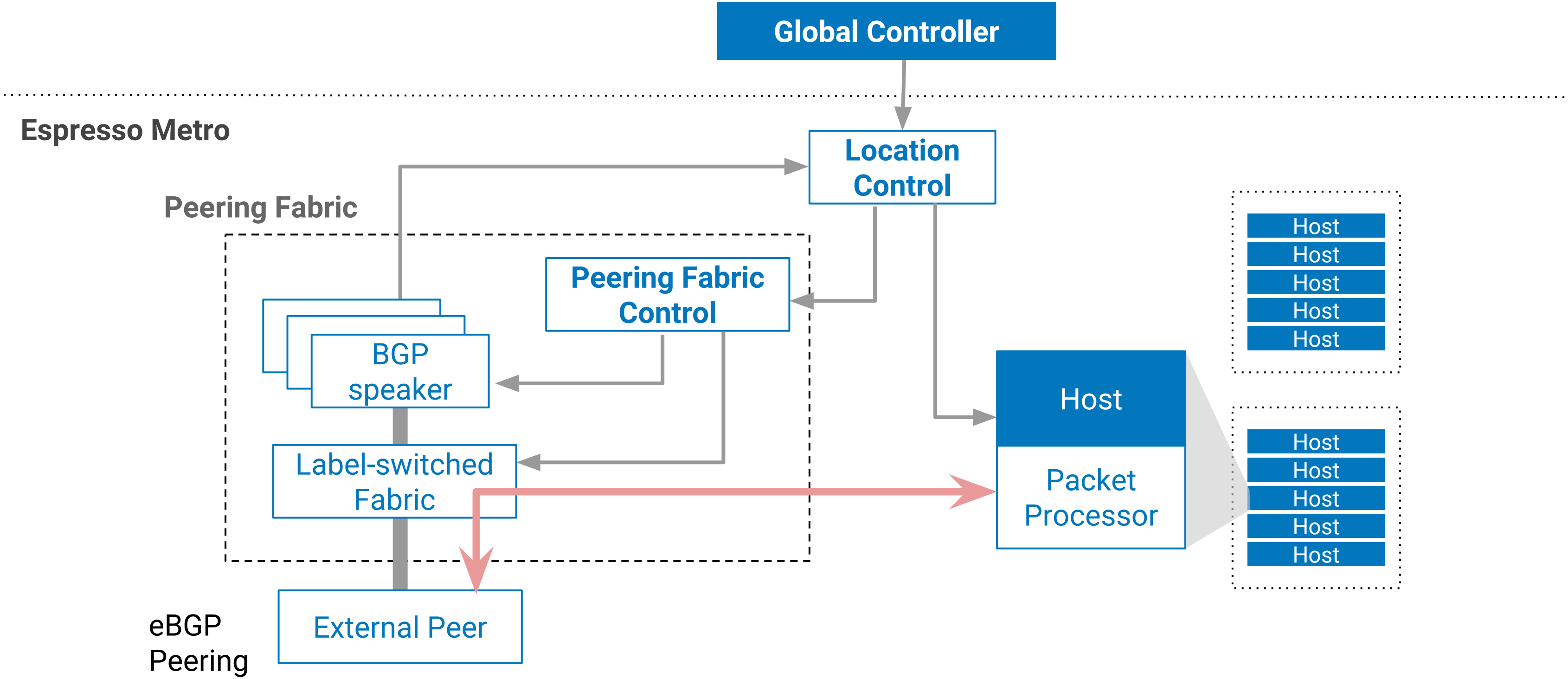
Host-based packet processor allows flexible packet processing, including ACL and handling of DoS.



Google

Hierarchical control plane
Fail static
Software programmability

Architecture: Hierarchical Control

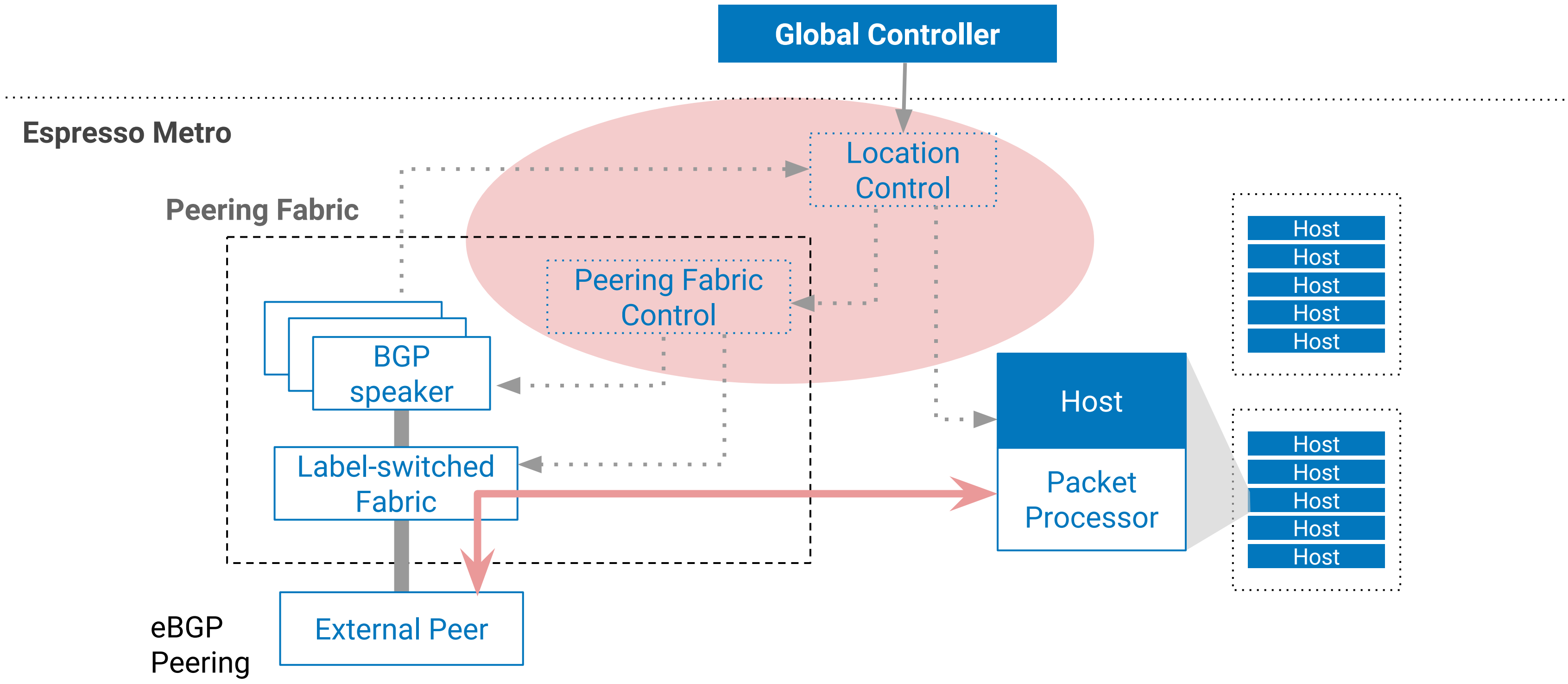


Hierarchical control plane

Fail static

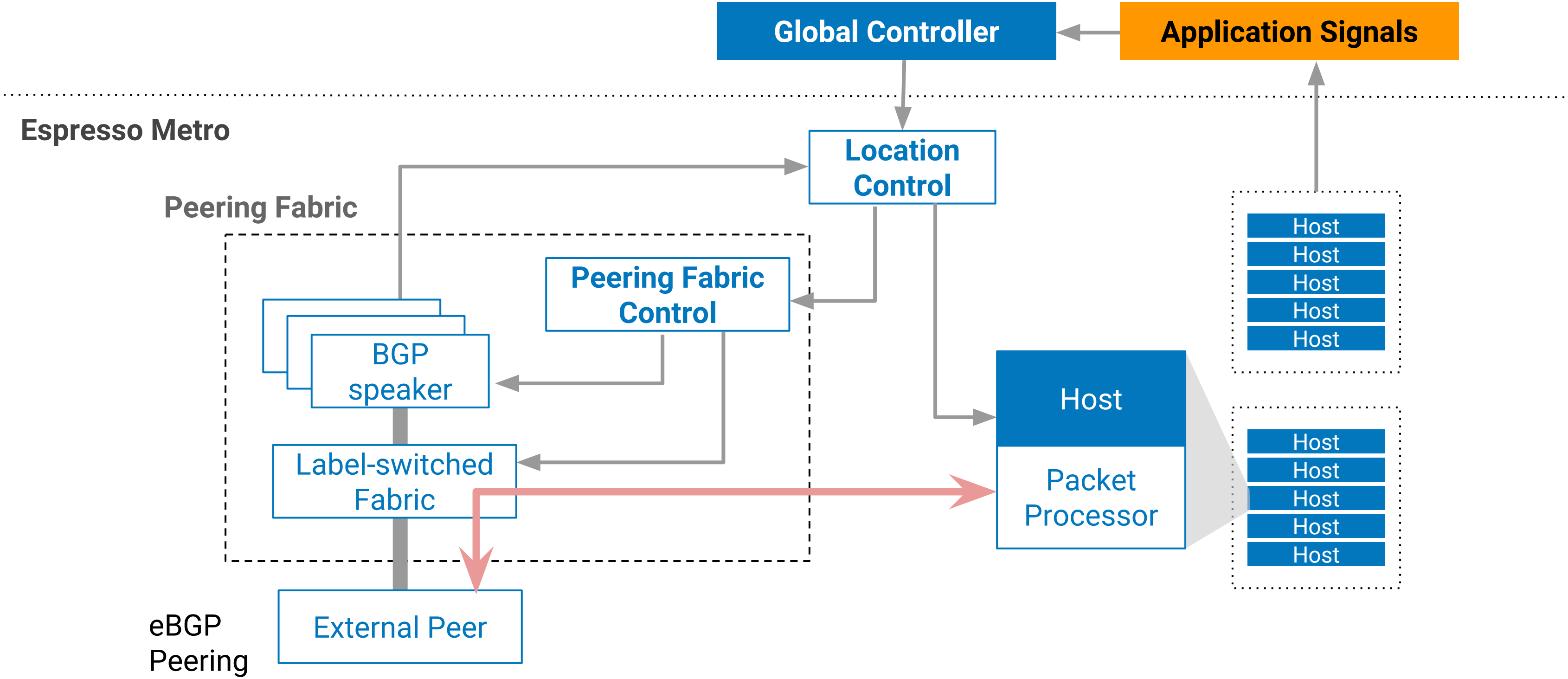
Software programmability

Architecture: Fail Static

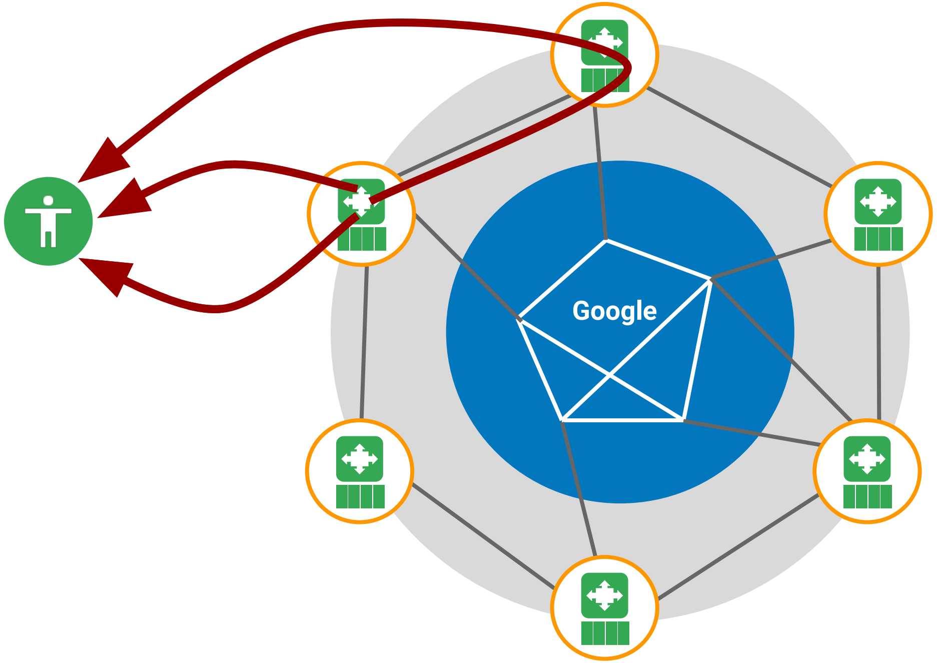


Hierarchical control plane
Fail static
Software programmability

Architecture: Application Aware Routing



Using User's Best Path, not BGP's



- Serve **13% more traffic** than BGP best path in application aware manner.
- Helps capacity-constrained ISPs by overflowing demand to alternate paths within local metro and **also via remote metros.**

Improvements in End User Experience

Client ISP	Change in mean time between rebuffers (MTBR)	Change in Mean Goodput
A	10 → 20 min	2.25 → 4.5 Mbps
B	4.6 → 12.5 min	2.75 → 4.9 Mbps
C	14 → 19 min	3.2 → 4.2 Mbps

Provide significant improvements to end-user experience.

Release Velocity

Component	**Average Velocity (days)**
Local Controller	11.2
BGP speaker	12.6
Peering Fabric Controller	15.8

> 50× more frequently than with traditional peering routers.

Novel L2 VPN delivered 6× faster via incremental rollout.

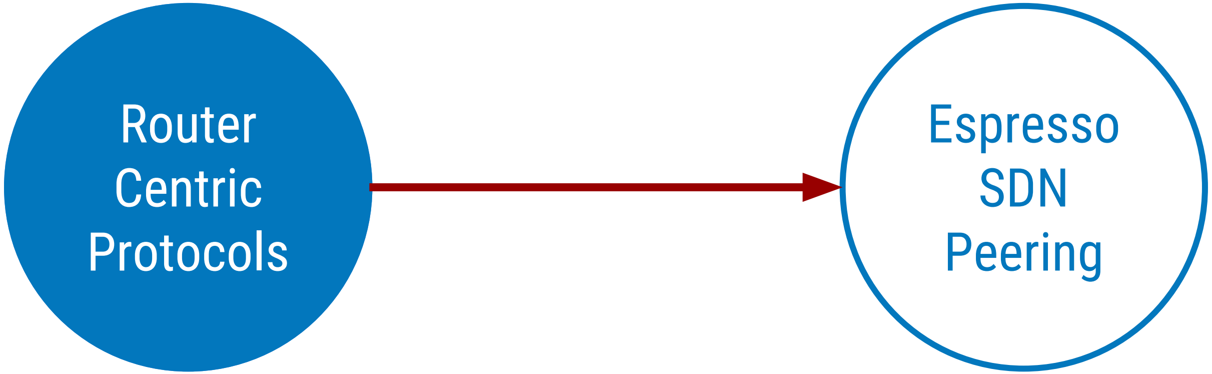
Conclusion

~~SDN is only suited for walled gardens.~~

Espresso demonstrates that

- traditional peering architecture can evolve to exploit SDN
- SDN’s value is in flexibility and feature velocity

Conclusion



Router Centric Protocols

Espresso SDN Peering

Local view
Connectivity based optimization
Slow evolution
Costly

Global view
Application signals-based optimization
Rapid deploy-and-iterate
75% Cheaper