BGP Routing for Large Scale Data Centers

Goal: Informational RFC

Agenda

Design Requirements

Network Design

Why BGP over IGP

Details and design choices

Feature Standartization?

Design Requirements

Online Service DC Specifics

Server Perspective

100's thousands of servers
10G NICs

Distributed Applications

Aware of the network
Explicit parallelism
Example: Web Index computation

"Network as a computer" concept

Online Services DC Specifics (cont.)

Two types of traffic flows

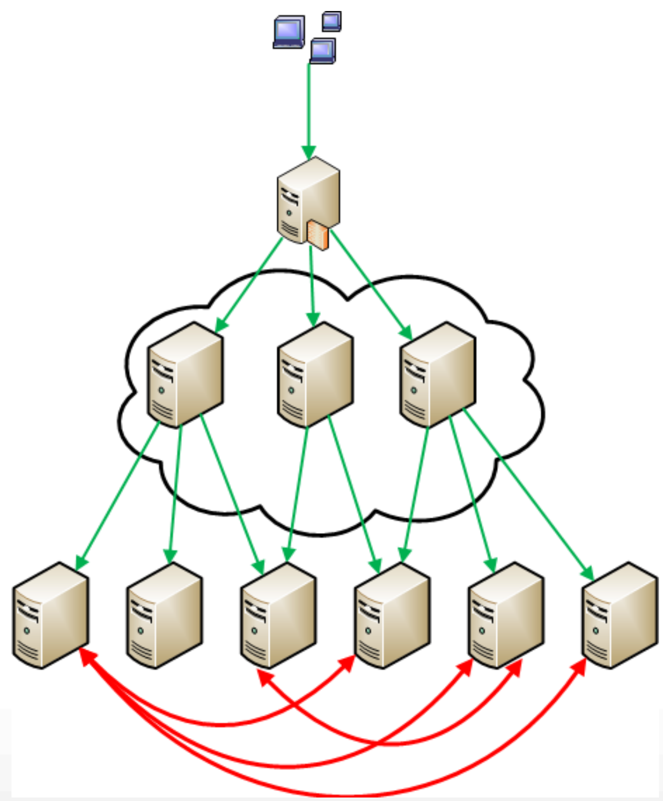
- Query
- Background

Query

- Latency Sensitive
- Partition/Aggregate

Background

- East/West
- Compute & Synchronize



Design Requirements

REQ1: Build upon a topology providing horizontal bandwidth scalability

REQ2: Minimize feature/protocol set

REQ3: Select simplest most common protocols

REQ4: Protocol must support “some” traffic engineering

Network Design

Topology choice: Clos

<u>Multiple definitions exist…</u>

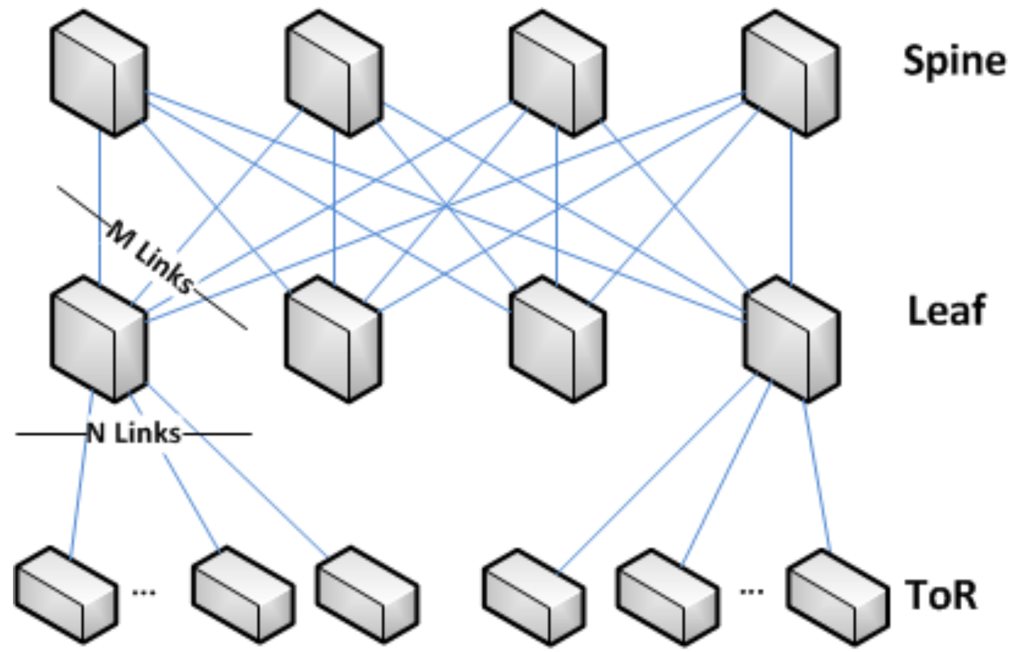
Has N stages (N=3,5,7..)

- **Folded on diagram**

Full bisection bandwidth if **M ≥N**

Natural link load-balancing

- **ECMP Based – implements Valiant Load Balancing**

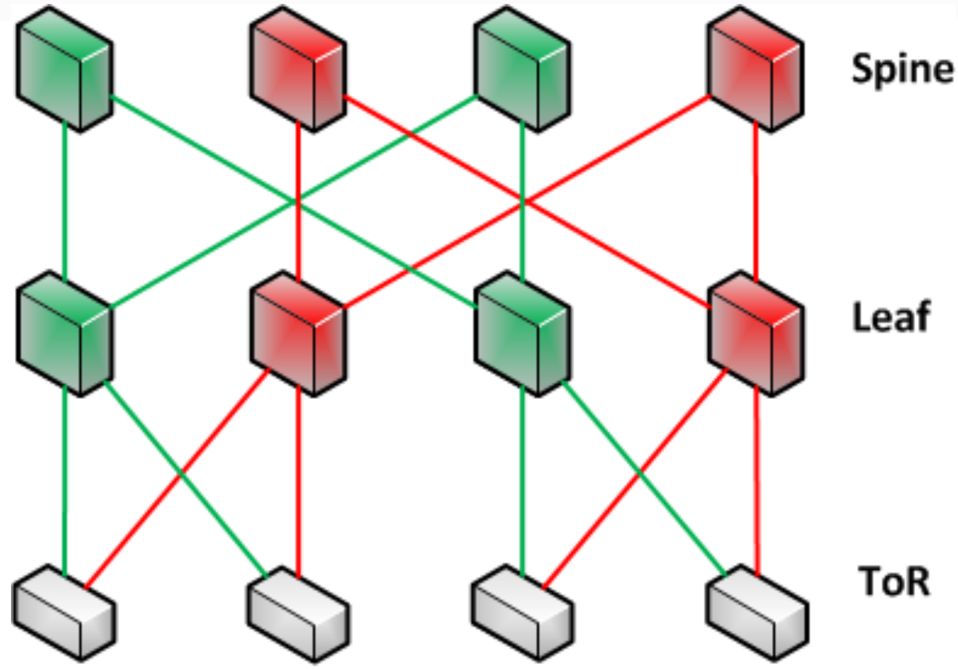


3-Stage Folded Clos Topology

Scaling Clos Topology

Think multiple parallel Clos topologies
Lower port density on switches

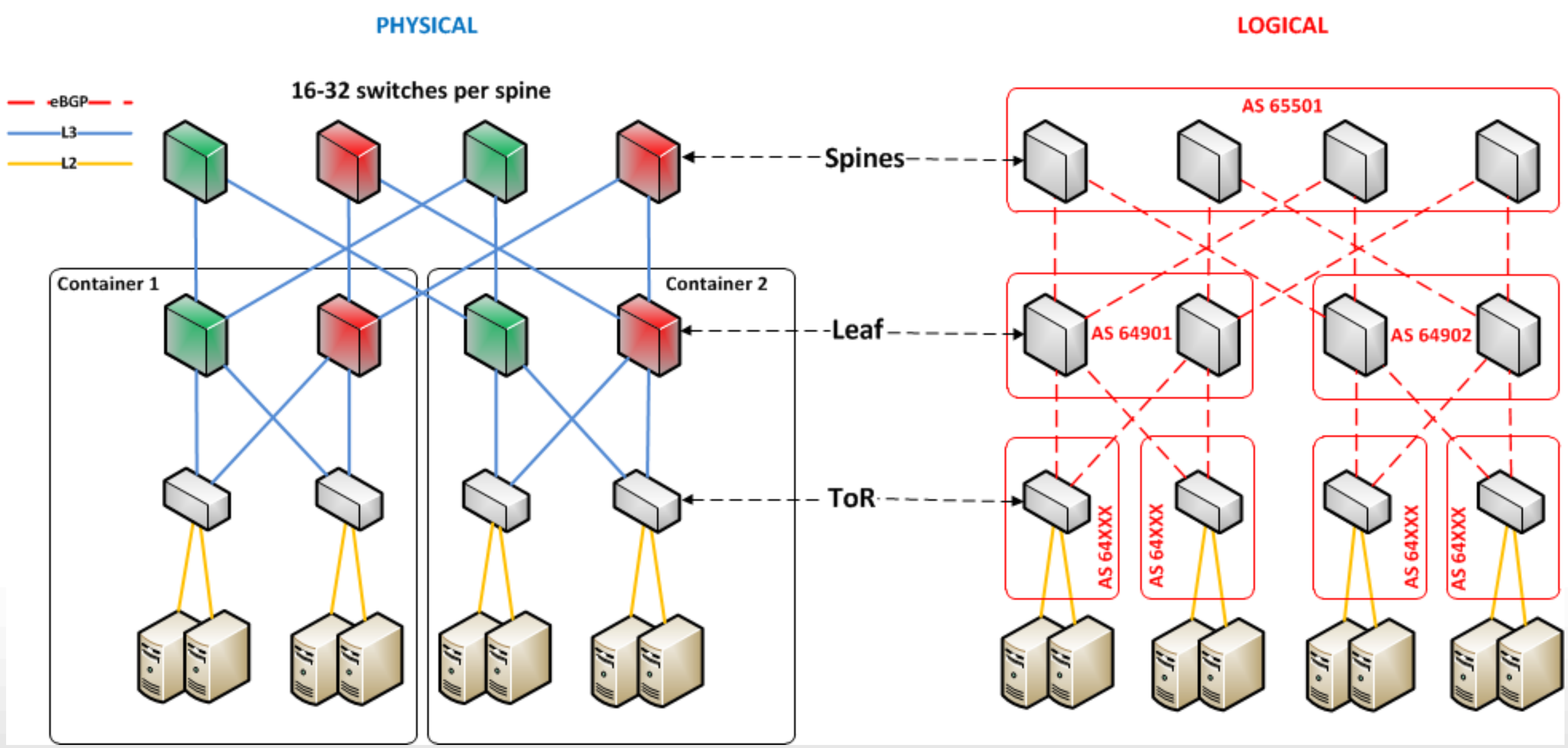
Horizontal capacity scaling at every layer above ToR



Two parallel Clos topologies

Routing Design for Parallel Clos

BGP all the way down to the ToR (eBGP)
Separate BGP ASN per ToR

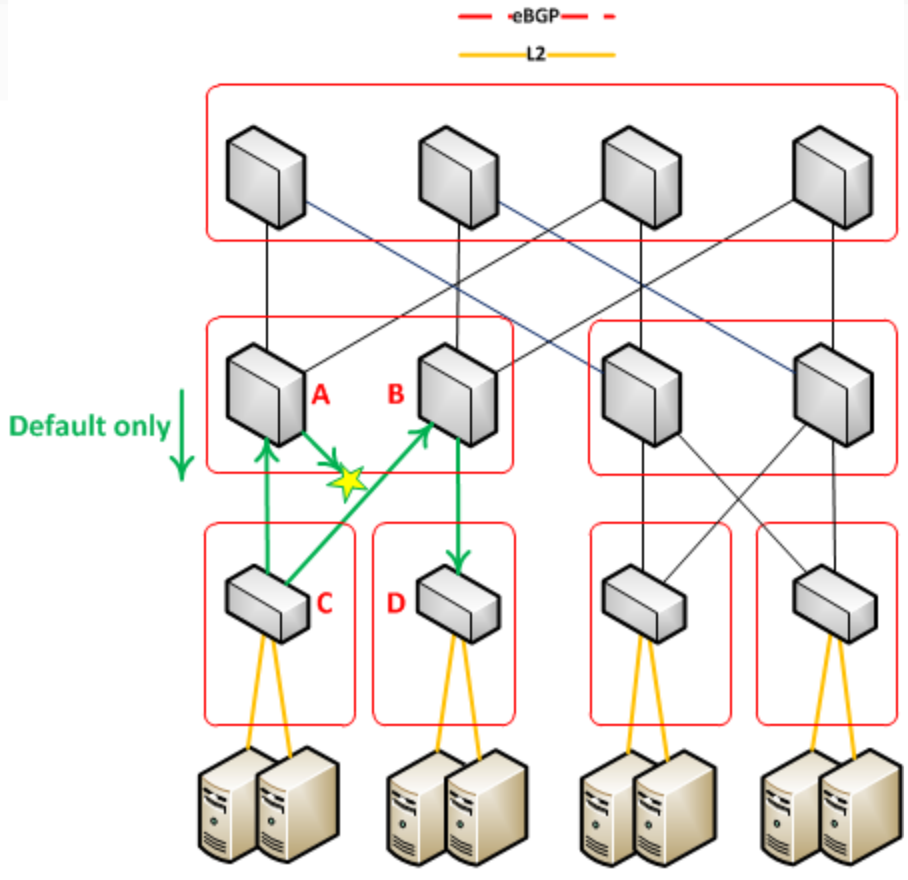


Design Specifics: Default Routing

Don’t use “default route only” model

Don’t hide specific prefixes

Otherwise: Route Black-Holing on link failure!



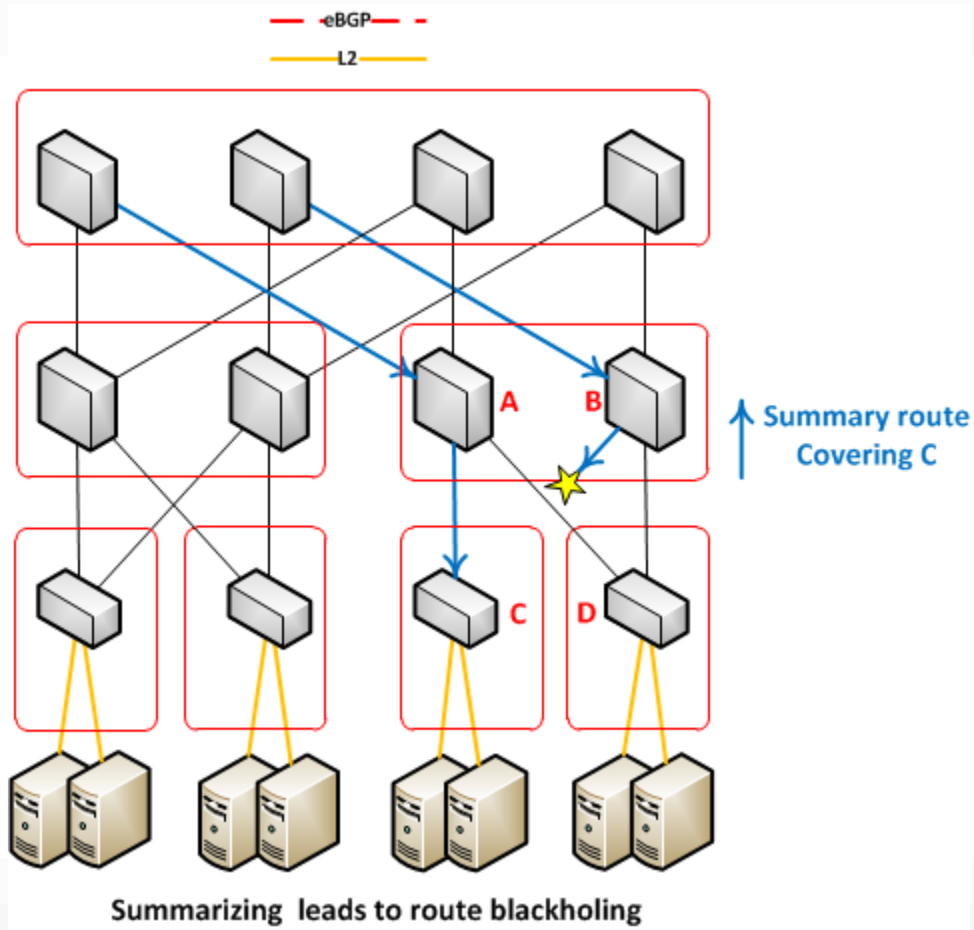
Using default route leads to blackholes

Design Specifics: Route Summarization

Don't summarize server subnets!

Summarizing P2P links is OK

Otherwise: Route Black-Holing on link failure!



Why BGP over IGP

BGP Simplicity

Simpler protocol design concepts compared to IGPs

- **Better vendor interoperability**
- **Less state-machines, data-structures etc**

BGP allows for per-hop traffic engineering

- **This way we can inject prefixes at any layer**
- **Used for unequal-cost Anycast load-balancing solution**

BGP Simplicity

Troubleshooting BGP is simpler

- **BGP RIB structure is simpler compared to link-state LSDB**
- **Clear picture of what sent where (RIBIn, RIBOut)**

Event propagation is more constrained in BGP

- **E.g. link failures have limited propagation scope**
- **More stability due to reduced event “flooding” domains**
- **Hard to achieve the same using areas in IGPs**

Common arguments against BGP

What about configuration complexity – BGP neighbors, etc?

- **Not a problem with automated configuration generation**

What about convergence properties?

- **Is not our primary goal anyways, few seconds are OK**
- **Practical convergence in less than a second (Fast Fallover)**

Details and Design Choices

BGP Specific: Features

Requires "BGP AS_PATH Multipath Relax"

- **We rely on ECMP for routing**
- **Needed for Anycast prefixes**

We use *16-bit* Private BGP ASN's ONLY

- **Simplifies path hiding at WAN edge (remove private AS)**
- **Simplifies route-filtering at WAN edge (single regexp)**

But we only have 1022 Private ASN's…

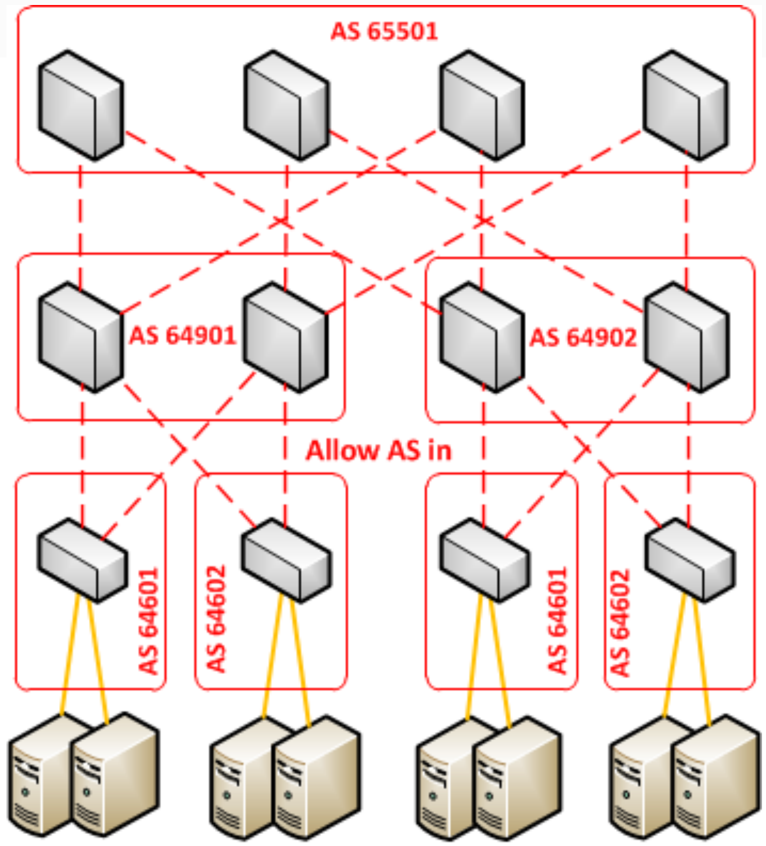
BGP Specifics: Allow AS In

Reuse Private ASNs on the ToRs

Use of *Allow AS in* on ToR eBGP peerings

Effectively, ToR numbering is local to the container

Requires vendor support…



AllowAS In configured on ToR eBGP sessions to the Leafs

Features that would benefit standardizing

There isn't that many requirements…

- **ECMP programming**
- **AS_PATH Multipath Relax**
- **Allow AS In**
- **Fast eBGP Fall-over**
- **Remove Private AS**
- **Unequal-cost load-balancing**
- **32-bit Private ASNs**

Questions?