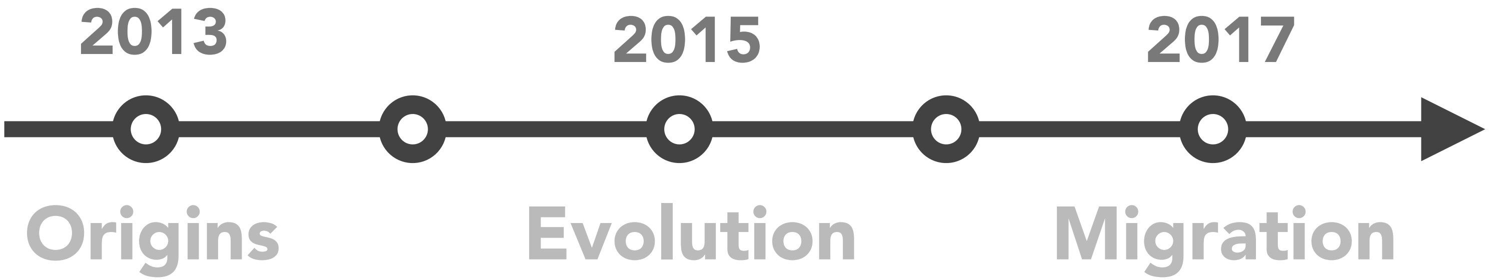
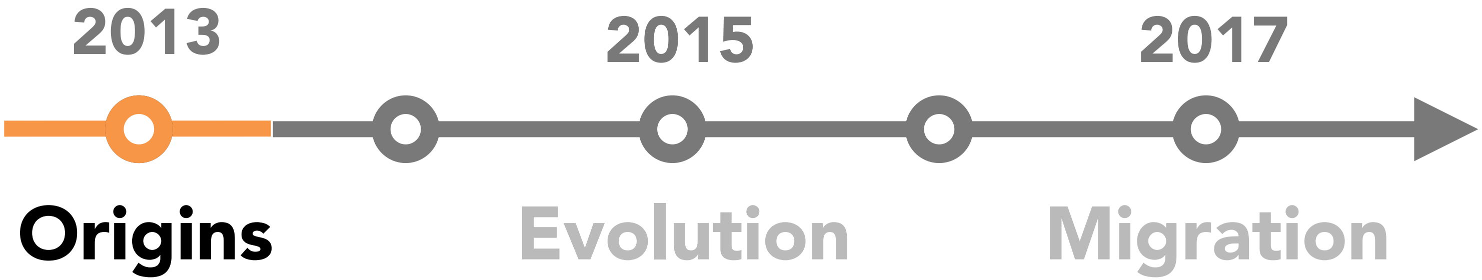
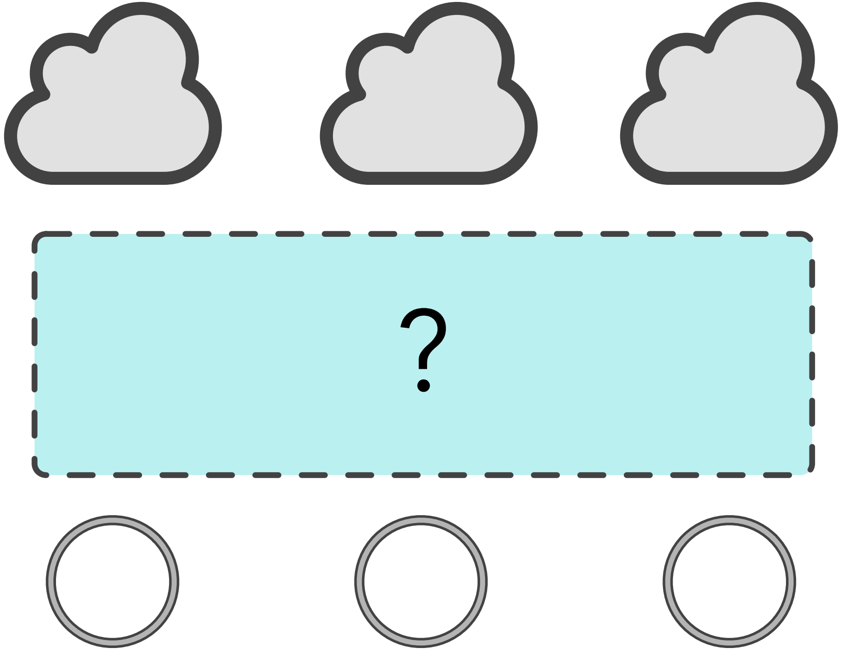
DEVELOPING AND EVOLVING YOUR OWN CONTROL PLANE

David Barroso

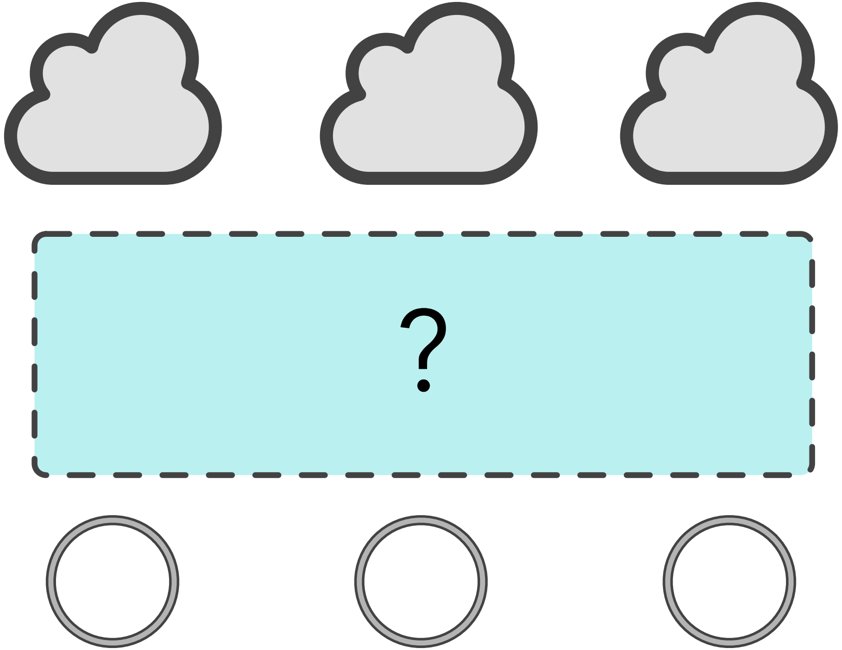

2013
2015
2017
Origins
Evolution
Migration


2013
2015
2017
Origins
Evolution
Migration

Requirements



Requirements

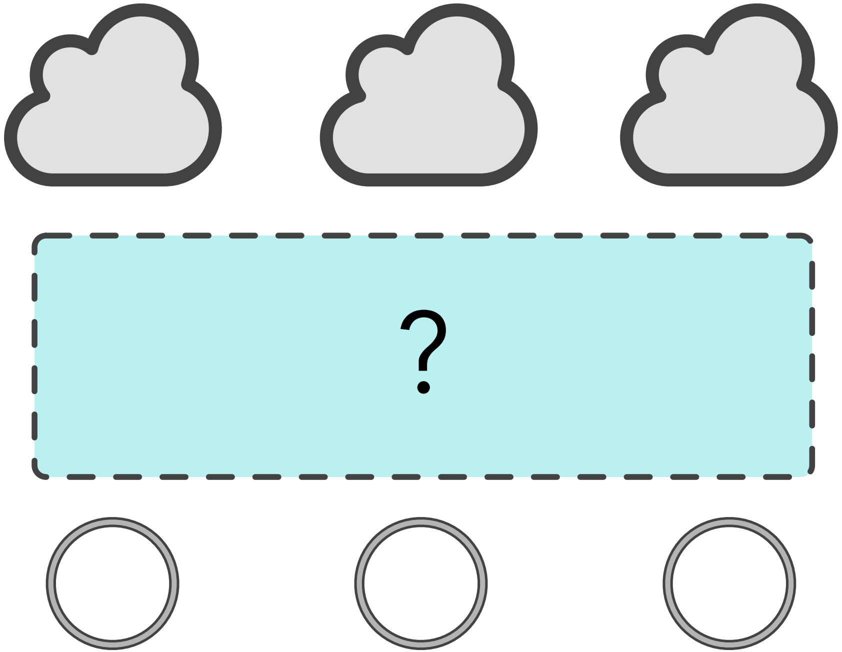


Multiple transits

each with different full routing tables

required for redundancy, performance

Requirements



Multiple transits

each with different full routing tables

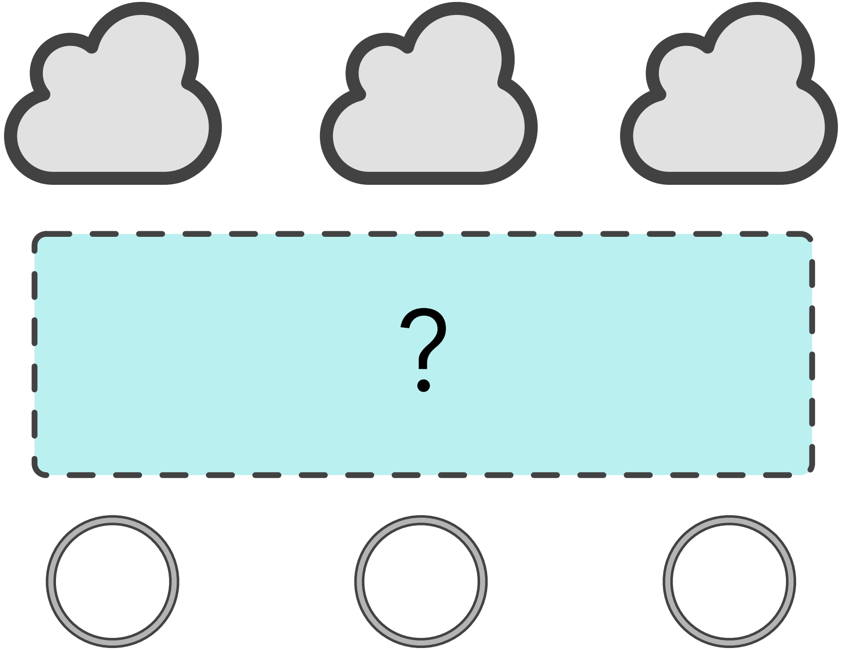
required for redundancy, performance

Multiple hosts

provide horizontal scalability

heavily optimized for application

Requirements



Multiple transits

each with different full routing tables

required for redundancy, performance

???

reduce cost of traffic between hosts

must be cost-effective in order to scale

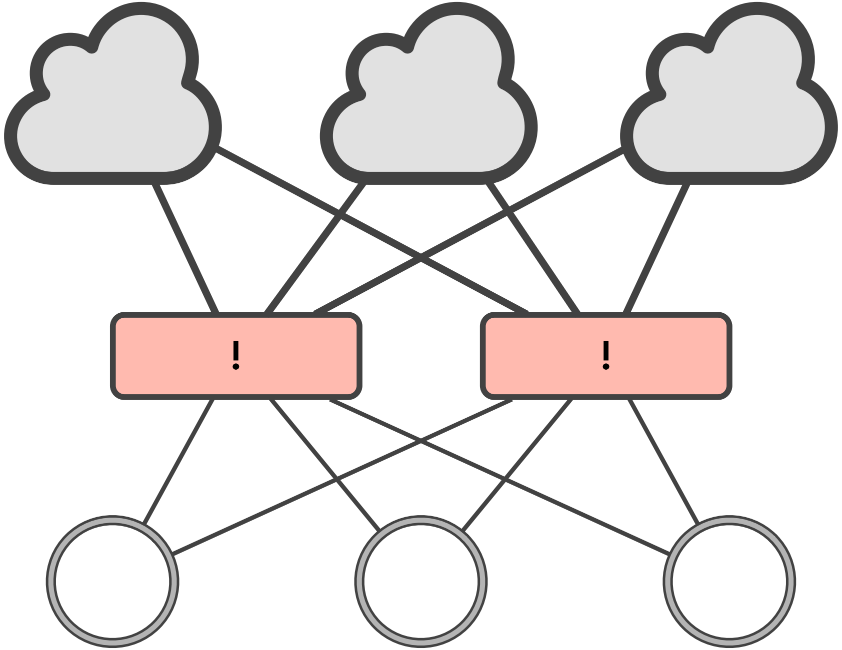
number of POPs

Multiple hosts

provide horizontal scalability

heavily optimized for application

Requirements



Multiple transits

- each with different full routing tables
- required for redundancy, performance

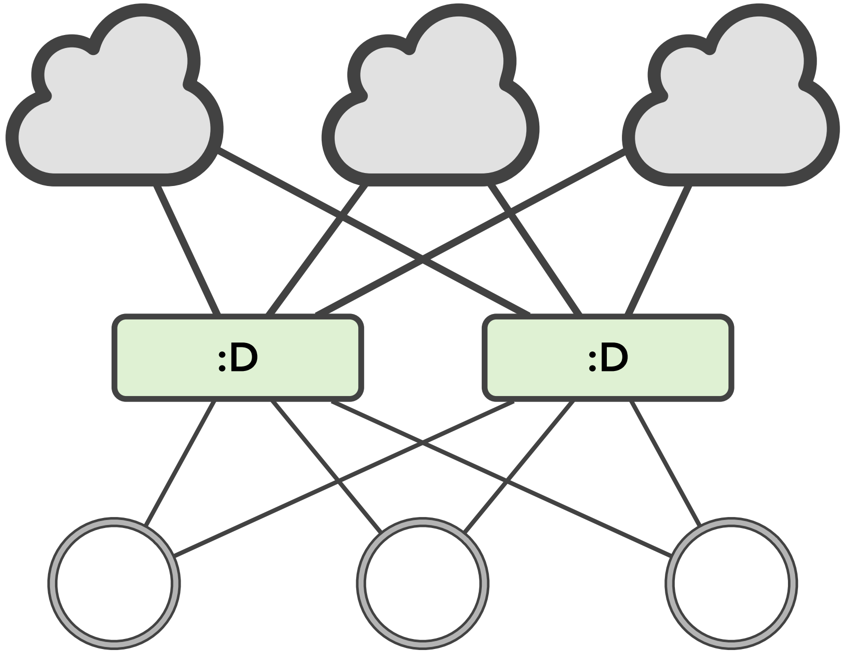
Routers

- lots of bells and whistles
- limited to “best-path” forwarding or PBR
- port density not very good
- power hungry
- expensive

Multiple hosts

- provide horizontal scalability
- heavily optimized for application

Requirements



Multiple transits

each with different full routing tables

required for redundancy, performance

Switches

limited FIB

only care about IP and ethernet

linux and programmable!

great port density

cheap

Multiple hosts

provide horizontal scalability

heavily optimized for application

The Team

~ 2 network engineers

responsible for entire infrastructure

too busy on-call to care about dealing with vendors

~ 2 software engineers

one was CEO, so doesn’t count

open source background, hate network appliances

determined to push control to application

The Epiphany

Routers are expensive

and don’t quite do what we want anyway

port density is terrible in terms of size, $$$ and power consumption

Switches are cheap

port density is great in terms of size, $$$ and power consumption

don’t do what we want and have plenty of hardware limitations

Programmable switches running linux!

and we have software engineers in the team

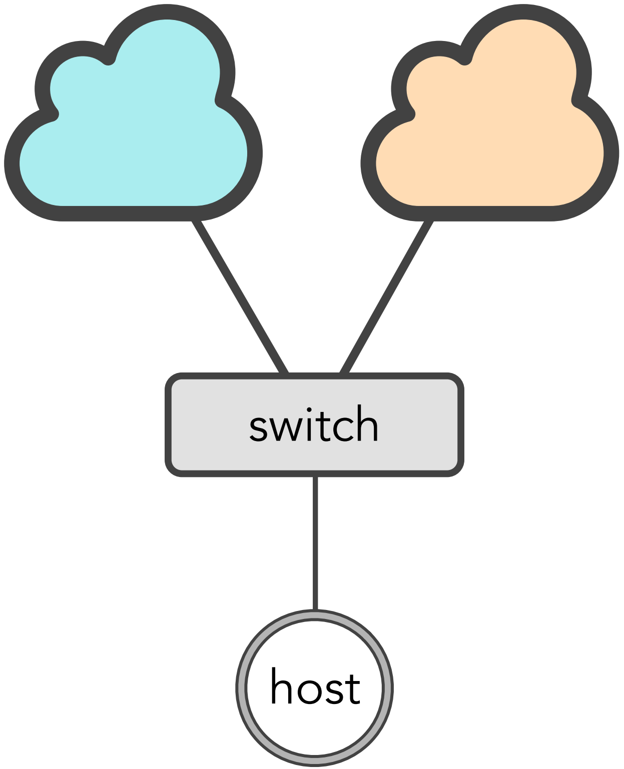
Silverton

LET'S BUILD OUR OWN CONTROL PLANE

(how hard can it be[1]?)

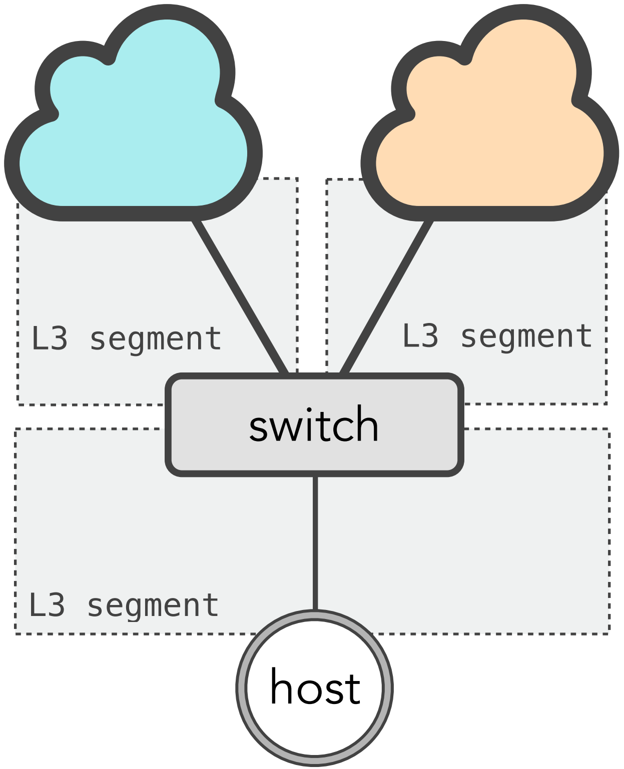
[1] https://www.fastly.com/blog/building-and-scaling-fastly-network-part-1-fighting-fib

Architecture



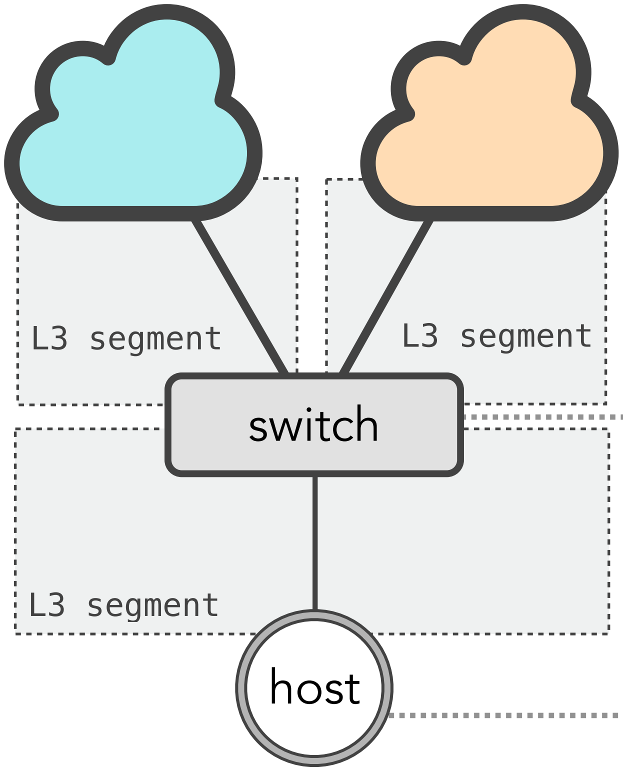
* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

Architecture



* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

Architecture



FIB

```
connected 192.168.1.0/24
connected 10.0.0.0/31
connected 10.0.1.0/31
```

ARP

```
192.168.1.2 AA:BB:CC:DD:EE:33
10.0.0.1    AA:BB:CC:DD:EE:00
10.0.1.0    AA:BB:CC:DD:EE:11
```

FIB

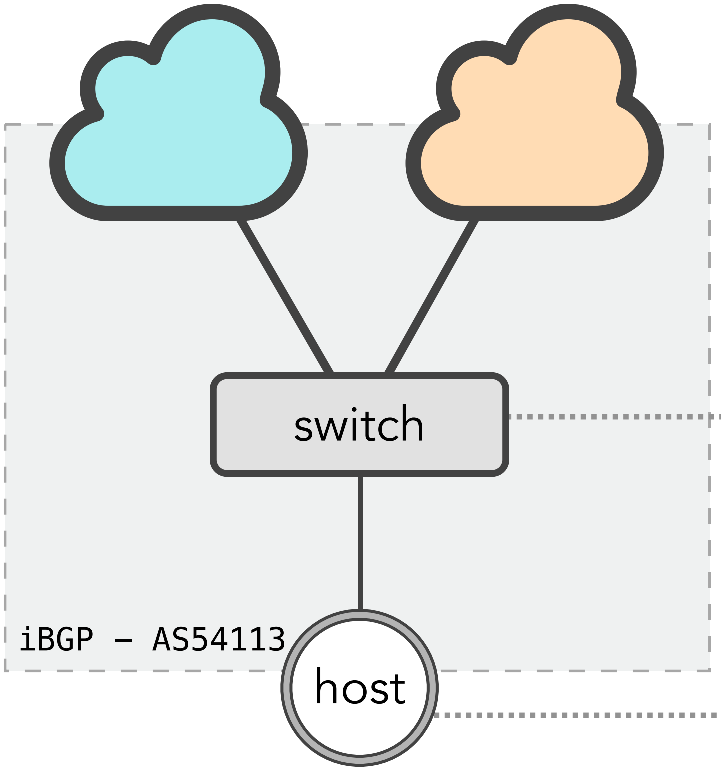
```
connected 192.168.1.0/24
```

ARP

```
192.168.1.1  AA:BB:CC:DD:EE:44
```

* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

Architecture



FIB

```
connected 192.168.1.0/24
connected 10.0.0.0/31
connected 10.0.1.0/31
```

ARP

```
192.168.1.2 AA:BB:CC:DD:EE:33
10.0.0.1    AA:BB:CC:DD:EE:00
10.0.1.0    AA:BB:CC:DD:EE:11
```

FIB

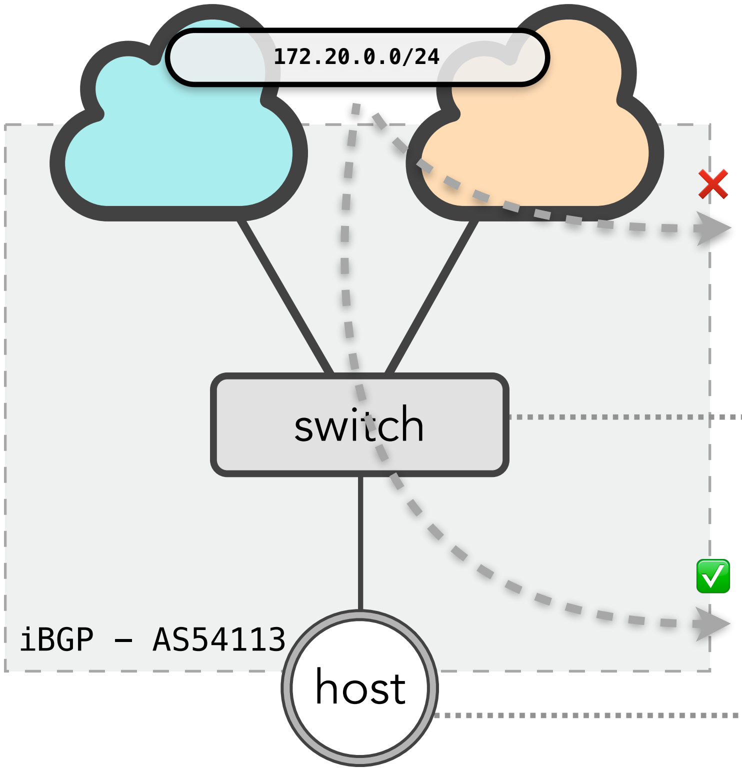
```
connected 192.168.1.0/24
```

ARP

```
192.168.1.1  AA:BB:CC:DD:EE:44
```

* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

Architecture



FIB

```
connected 192.168.1.0/24
connected 10.0.0.0/31
connected 10.0.1.0/31
```

ARP

```
192.168.1.2 AA:BB:CC:DD:EE:33
10.0.0.1    AA:BB:CC:DD:EE:00
10.0.1.0    AA:BB:CC:DD:EE:11
```

FIB

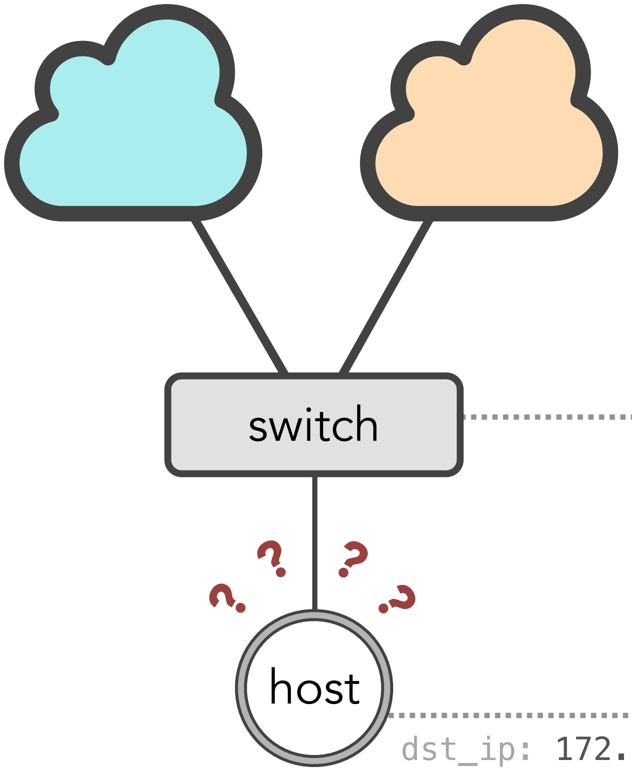
```
connected 192.168.1.0/24
BGP 172.20.0.0/24
          via 10.0.0.1
          via 10.0.1.1
```

ARP

```
192.168.1.1  AA:BB:CC:DD:EE:44
```

* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

Architecture



FIB

```
connected 192.168.1.0/24
connected 10.0.0.0/31
connected 10.0.1.0/31
```

ARP

```
192.168.1.2 AA:BB:CC:DD:EE:33
10.0.0.1    AA:BB:CC:DD:EE:00
10.0.1.0    AA:BB:CC:DD:EE:11
```

FIB

```
connected 192.168.1.0/24
BGP 172.20.0.0/24
          via 10.0.0.1
          via 10.0.1.1
```

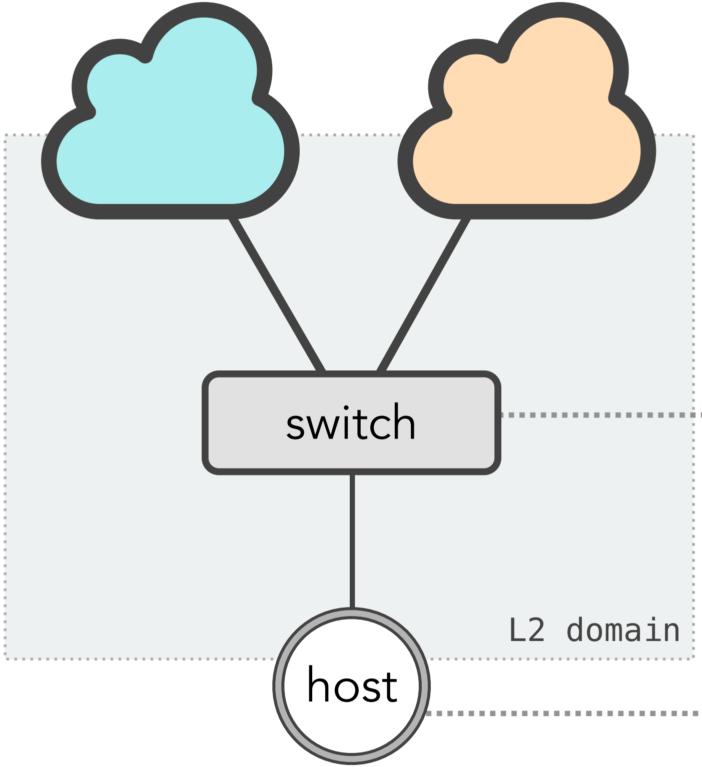
ARP

```
192.168.1.1  AA:BB:CC:DD:EE:44
```

```
dst_ip: 172.20.0.1
dst_mac: ??:??:??:??:??:??
```

* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

Architecture



FIB

```
connected 192.168.1.0/24
connected 10.0.0.0/31
connected 10.0.1.0/31
```

ARP

```
192.168.1.2 AA:BB:CC:DD:EE:33
10.0.0.1    AA:BB:CC:DD:EE:00
10.0.1.0    AA:BB:CC:DD:EE:11
```

FIB

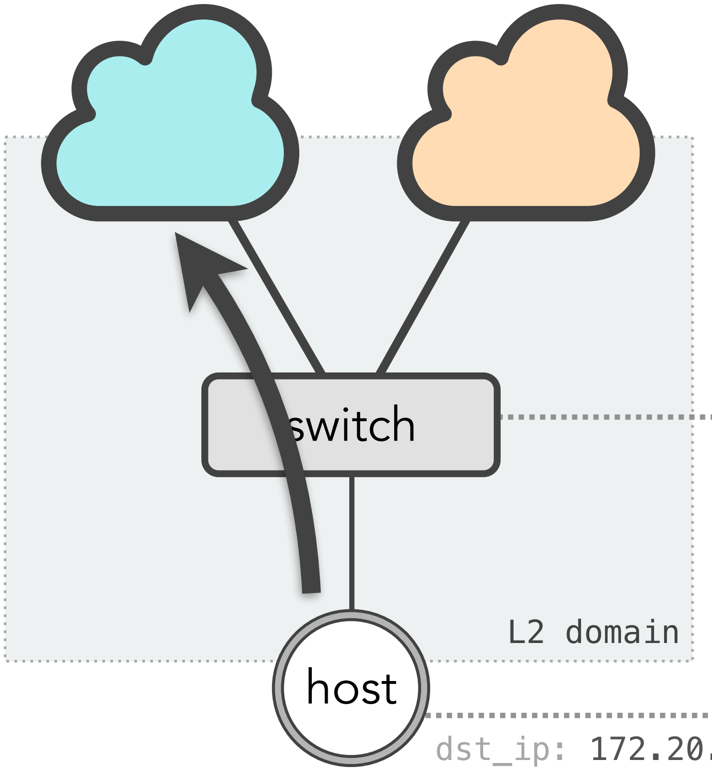
```
connected 192.168.1.0/24
BGP 172.20.0.0/24
          via 10.0.0.1
          via 10.0.1.1
```

ARP

```
192.168.1.1  AA:BB:CC:DD:EE:44
10.0.0.1     AA:BB:CC:DD:EE:00
10.0.1.0     AA:BB:CC:DD:EE:11
```

* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

Architecture



FIB

```
connected 192.168.1.0/24
connected 10.0.0.0/31
connected 10.0.1.0/31
```

ARP

```
192.168.1.2 AA:BB:CC:DD:EE:33
10.0.0.1    AA:BB:CC:DD:EE:00
10.0.1.0    AA:BB:CC:DD:EE:11
```

FIB

```
connected 192.168.1.0/24
BGP 172.20.0.0/24
          via 10.0.0.1
          via 10.0.1.1
```

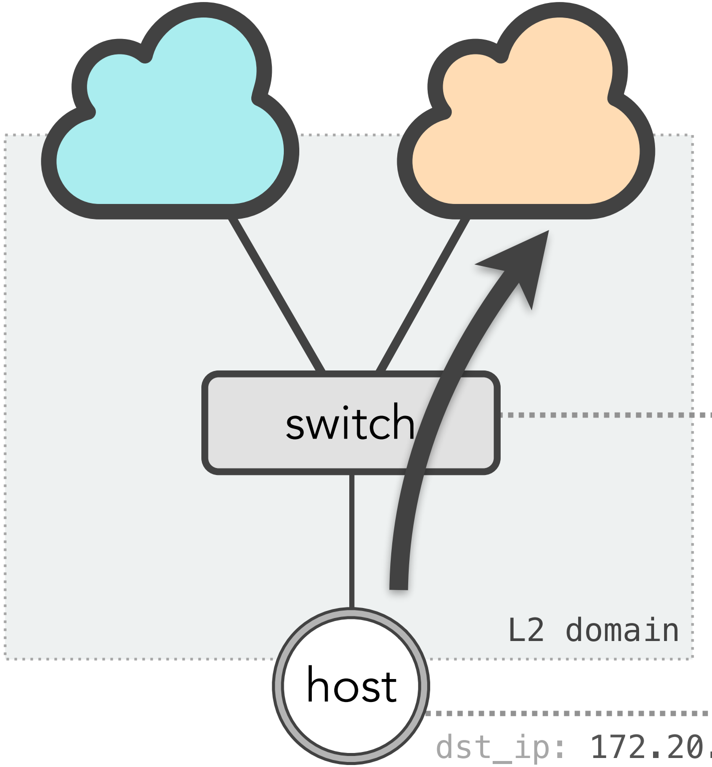
ARP

```
192.168.1.1  AA:BB:CC:DD:EE:44
10.0.0.1     AA:BB:CC:DD:EE:00
10.0.1.0     AA:BB:CC:DD:EE:11
```

```
dst_ip: 172.20.0.1
dst_mac: AA:BB:CC:DD:EE:00
```

* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

Architecture



dst_ip: 172.20.0.1
dst_mac: AA:BB:CC:DD:EE:01

FIB

```
connected 192.168.1.0/24
connected 10.0.0.0/31
connected 10.0.1.0/31
```

ARP

```
192.168.1.2 AA:BB:CC:DD:EE:33
10.0.0.1    AA:BB:CC:DD:EE:00
10.0.1.0    AA:BB:CC:DD:EE:11
```

FIB

```
connected 192.168.1.0/24
BGP 172.20.0.0/24
             via 10.0.0.1
             via 10.0.1.1
```

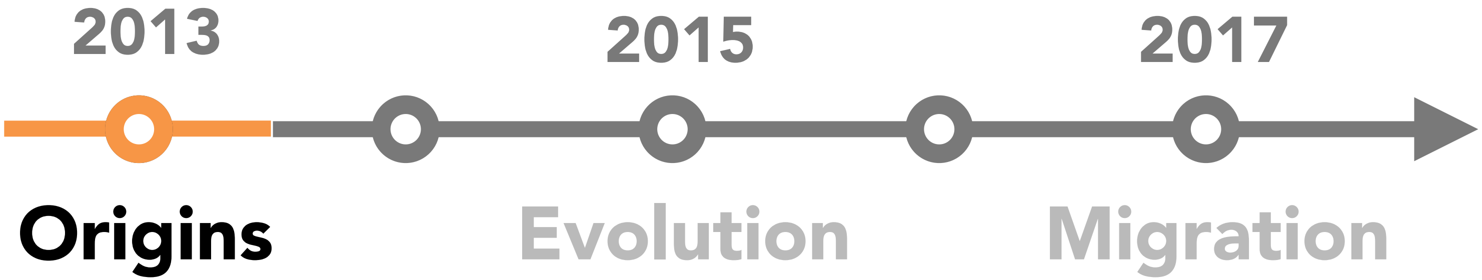
ARP

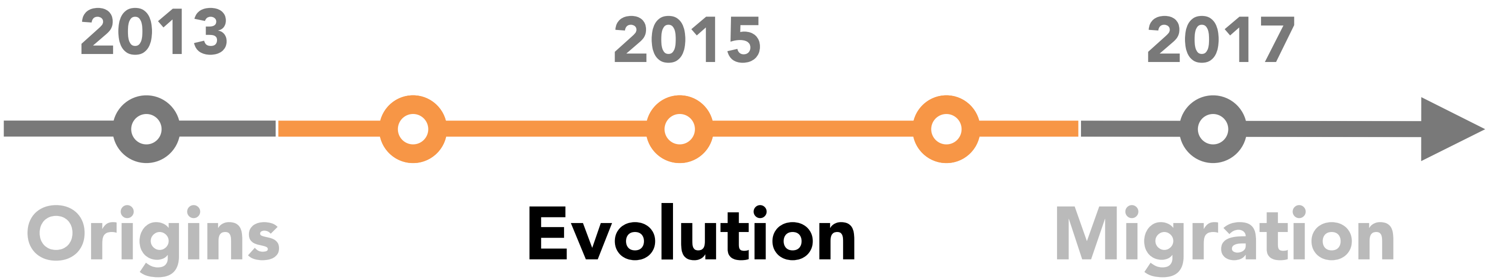
```
192.168.1.1   AA:BB:CC:DD:EE:44
10.0.0.1      AA:BB:CC:DD:EE:00
10.0.1.0      AA:BB:CC:DD:EE:11
```

* Section of the network, full architecture usually consists of 4-way ECMP and may have more than one tier

st-ping

```
Pinging  <hostname>  via 14 upstreams.
  Upstream   intf          Nexthop  Sent   Loss      Min      Avg      Max      Dev
  cogent                              10   0.0%   13.017   13.051   13.164    0.044
  cogent                              10   0.0%   13.011   13.035   13.091    0.024
  cogent                              10   0.0%   13.008   13.021   13.046    0.052
  cogent                              10   0.0%   13.018   13.037   13.083    0.136
* l3                                  10   0.0%    10.52   10.546   10.621    0.133
* l3                                  10   0.0%   10.523   10.533   10.571    0.138
  ntt                                 10   0.0%   13.952   13.973   14.024    0.131
  ntt                                 10   0.0%   13.949   13.974   14.148    0.131
  ntt                                 10   0.0%    13.95   13.961   13.984    0.149
  ntt                                 10   0.0%   13.946   13.964     14.0    0.159
  telia                               10   0.0%   14.198   14.326   14.963    0.234
  telia                               10   0.0%   14.184   14.406   15.468    0.393
  telia                               10   0.0%   14.379   14.417   14.558    0.152
  telia                               10   0.0%   14.383   14.405   14.444    0.056
```


2013
2015
2017
Origins
Evolution
Migration


2013
2015
2017
Origins
Evolution
Migration

New Requirements

Address the shortcomings of the previous architecture

- L2 hacks don’t scale well
- Sharing L2 with transits means we had to filter broadcast traffic
- No clear separation between L2 and L3 tables confuses people

Support for IXPs

- sharing L2 with IXPs is a **strong NO**
- FIB limitations were starting to hurt

The State of Networking

Routers

lots of bells and whistles

~~limited to "best-path" forwarding or PBR~~

early days of Segment Routing/BGP-LU

expensive

Switches

cheap

limited FIB

~~only care about IP and ethernet~~

MPLS and other encapsulation protocols supported

The Team

~ 6 network engineers

responsible for entire infrastructure

too busy on-call to care about dealing with vendors

~ 6 software engineers

focused on many different products; load balancing, distributed health checking, routing architecture, automation, kernel development, etc…

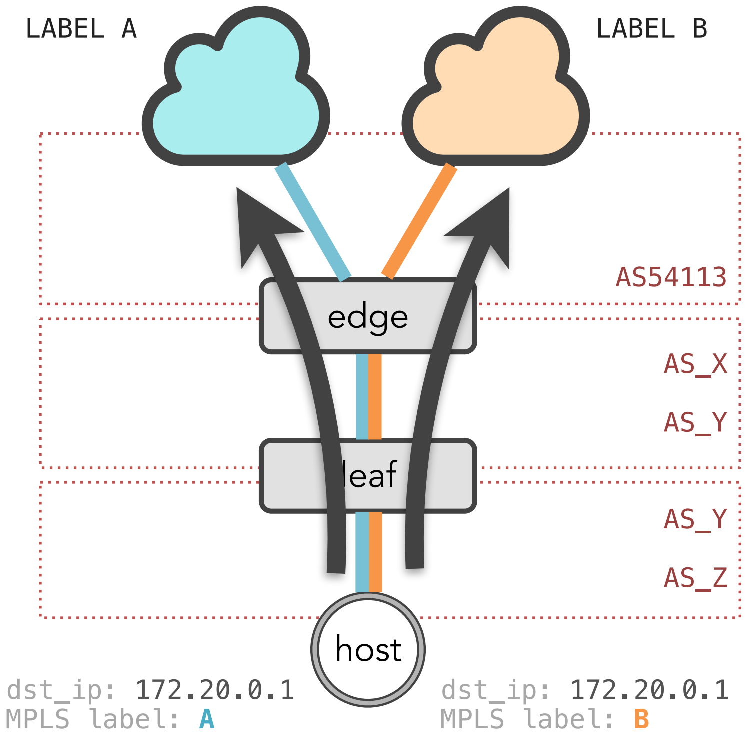
New Architecture

P-t-p links

eBGP

An MPLS label per exit
(transits, PNIs, peers…)

MPLS starts on the host
Host tags the packets with labels depending on the desired path



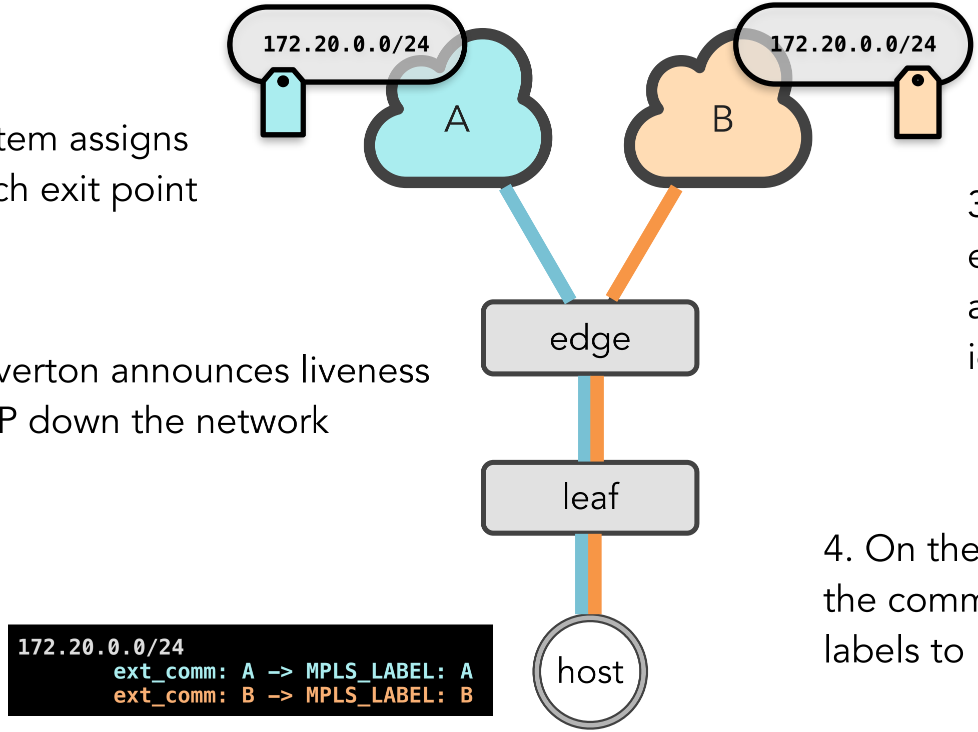
How does it work?

1. Provisioning system assigns unique label to each exit point

2. Silverton announces liveness of LSP down the network

3. Incoming prefixes from each transit are tagged with an extended community that identifies the LSP

4. On the host, BGP extracts the community and assigns labels to routes



The network couldn’t be simpler

```
switch-cmh8801#show mpls lfib route
Codes: S - Static MPLS Route, I A - ISIS-SR Adjacency Segment,
       I P - ISIS-SR Prefix Segment, L - LDP,
       I-L - ISIS-SR Segment to LDP, L-I - LDP to ISIS-SR Segment

In-Label Out-Label Metric Payload NextHop              Egress-Acl Source FEC
-------- --------- ------ ------- -------------------- ---------- ------ ---
1020     pop       50     ipv4    [illegible]          Apply      S
1021     pop       50     ipv6    [illegible]          Apply      S
1022     pop       50     ipv4    [illegible]          Apply      S
1023     pop       50     ipv6    [illegible]          Apply      S
```

Extended communities map to labels

```
dbarroso@cache-cmh8820:~$ sudo birdc show route 223.255.251.0/24 all
BIRD 1.6.3 ready.
223.255.251.0/24 via 172.18.128.1 (MPLS label 1020) [switch_cmh8801] * (100) [AS63199i]
     Type: BGP unicast univ
     BGP.as_path: 4210088000 174 3491 63199
     BGP.next_hop: 172.18.128.1
     BGP.med: 0
     BGP.local_pref: 50
     BGP.community: (174,21000) (174,22013)
     BGP.ext_community: (ro, 2, 3) (ro, 3, 1) (generic, 0x80860000, 1020)
                via 172.18.130.1 (MPLS label 1024) [switch_cmh8802] (100) [AS63199i]
     Type: BGP unicast univ
     BGP.as_path: 4210088000 174 3491 63199
     BGP.next_hop: 172.18.130.1
     BGP.med: 0
     BGP.local_pref: 50
     BGP.community: (174,21000) (174,22013)
     BGP.ext_community: (ro, 2, 3) (ro, 3, 1) (generic, 0x80860000, 1024)
```

Extended communities map to labels

```
dbarroso@cache-cmh8820:~$ sudo birdc show route 223.255.251.0/24 all
BIRD 1.6.3 ready.
223.255.251.0/24 via 172.18.128.1 (MPLS label 1020) [switch_cmh8801] * (100) [AS63199i]
     Type: BGP unicast univ
     BGP.as_path: 4210088000 174 3491 63199
     BGP.next_hop: 172.18.128.1
     BGP.med: 0
     BGP.local_pref: 50
     BGP.community: (174,21000) (174,22013)
     BGP.ext_community: (ro, 2, 3) (ro, 3, 1) (generic, 0x80860000, 1020)
                 via 172.18.130.1 (MPLS label 1024) [switch_cmh8802] (100) [AS63199i]
     Type: BGP unicast univ
     BGP.as_path: 4210088000 174 3491 63199
     BGP.next_hop: 172.18.130.1
     BGP.med: 0
     BGP.local_pref: 50
     BGP.community: (174,21000) (174,22013)
     BGP.ext_community: (ro, 2, 3) (ro, 3, 1) (generic, 0x80860000, 1024)
```

Extended communities map to labels

```
dbarroso@cache-cmh8820:~$ sudo birdc show route 223.255.251.0/24 all
BIRD 1.6.3 ready.
223.255.251.0/24 via 172.18.128.1 (MPLS label 1020) [switch_cmh8801] * (100) [AS63199i]
	Type: BGP unicast univ
	BGP.as_path: 4210088000 174 3491 63199
	BGP.next_hop: 172.18.128.1
	BGP.med: 0
	BGP.local_pref: 50
	BGP.community: (174,21000) (174,22013)
	BGP.ext_community: (ro, 2, 3) (ro, 3, 1) (generic, 0x80860000, 1020)
                 via 172.18.130.1 (MPLS label 1024) [switch_cmh8802] (100) [AS63199i]
	Type: BGP unicast univ
	BGP.as_path: 4210088000 174 3491 63199
	BGP.next_hop: 172.18.130.1
	BGP.med: 0
	BGP.local_pref: 50
	BGP.community: (174,21000) (174,22013)
	BGP.ext_community: (ro, 2, 3) (ro, 3, 1) (generic, 0x80860000, 1024)
```

Extended communities map to labels

```
dbarroso@cache-cmh8820:~$ sudo birdc show route 223.255.251.0/24 all
BIRD 1.6.3 ready.
223.255.251.0/24 via 172.18.128.1 (MPLS label 1020) [switch_cmh8801] * (100) [AS63199i]
     Type: BGP unicast univ
     BGP.as_path: 4210088000 174 3491 63199
     BGP.next_hop: 172.18.128.1
     BGP.med: 0
     BGP.local_pref: 50
     BGP.community: (174,21000) (174,22013)
     BGP.ext_community: (ro, 2, 3) (ro, 3, 1) (generic, 0x80860000, 1020)
                 via 172.18.130.1 (MPLS label 1024) [switch_cmh8802] (100) [AS63199i]
     Type: BGP unicast univ
     BGP.as_path: 4210088000 174 3491 63199
     BGP.next_hop: 172.18.130.1
     BGP.med: 0
     BGP.local_pref: 50
     BGP.community: (174,21000) (174,22013)
     BGP.ext_community: (ro, 2, 3) (ro, 3, 1) (generic, 0x80860000, 1024)
```

Routing decision is made on the host

```
dbarroso@cache-cmh8820:~$ ip rule
174:      from all fwmark 0xae lookup 174
1299:     from all fwmark 0x513 lookup 1299

dbarroso@cache-cmh8820:~$ ip route show table 174
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table 1299
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1022  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1026  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table main | head
1.0.4.0/24  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
1.0.4.0/22  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
```

Routing decision is made on the host

```
dbarroso@cache-cmh8820:~$ ip rule
174:      from all fwmark 0xae lookup 174
1299:     from all fwmark 0x513 lookup 1299

dbarroso@cache-cmh8820:~$ ip route show table 174
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table 1299
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1022  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1026  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table main | head
1.0.4.0/24  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
1.0.4.0/22  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
```

We have a routing table per transit/peer

Routing decision is made on the host

```
dbarroso@cache-cmh8820:~$ ip rule
174:      from all fwmark 0xae lookup 174
1299:     from all fwmark 0x513 lookup 1299

dbarroso@cache-cmh8820:~$ ip route show table 174
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table 1299
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1022  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1026  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table main | head
1.0.4.0/24  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
1.0.4.0/22  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
```

Per peer/ transit routing tables only contain a default route indicating the MPLS label required to use

Routing decision is made on the host

```
dbarroso@cache-cmh8820:~$ ip rule
174:      from all fwmark 0xae lookup 174
1299:     from all fwmark 0x513 lookup 1299

dbarroso@cache-cmh8820:~$ ip route show table 174
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table 1299
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1022  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1026  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table main | head
1.0.4.0/24  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
1.0.4.0/22  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
```

Rules allow the application to force traffic into specific routing tables

Routing decision is made on the host

```
dbarroso@cache-cmh8820:~$ ip rule
174:      from all fwmark 0xae lookup 174
1299:     from all fwmark 0x513 lookup 1299

dbarroso@cache-cmh8820:~$ ip route show table 174
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table 1299
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1022  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1026  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table main | head
1.0.4.0/24  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
1.0.4.0/22  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
```

If application sets the fwmark "ae" traffic is forced into the table 174

Routing decision is made on the host

```
dbarroso@cache-cmh8820:~$ ip rule
174:      from all fwmark 0xae lookup 174
1299:     from all fwmark 0x513 lookup 1299

dbarroso@cache-cmh8820:~$ ip route show table 174
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table 1299
default  proto static  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1022  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1026  via 172.18.130.1  dev vlan200 weight 1

dbarroso@cache-cmh8820:~$ ip route show table main | head
1.0.4.0/24  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
1.0.4.0/22  proto bird  src 199.27.79.20  mtu 1500 advmss 1460
     nexthop encap mpls  1020  via 172.18.128.1  dev vlan100 weight 1
     nexthop encap mpls  1024  via 172.18.130.1  dev vlan200 weight 1
```

main (default) routing table delegates decision to tradition best-path selection algorithm

Retrospective

Same nice features as the previous iteration

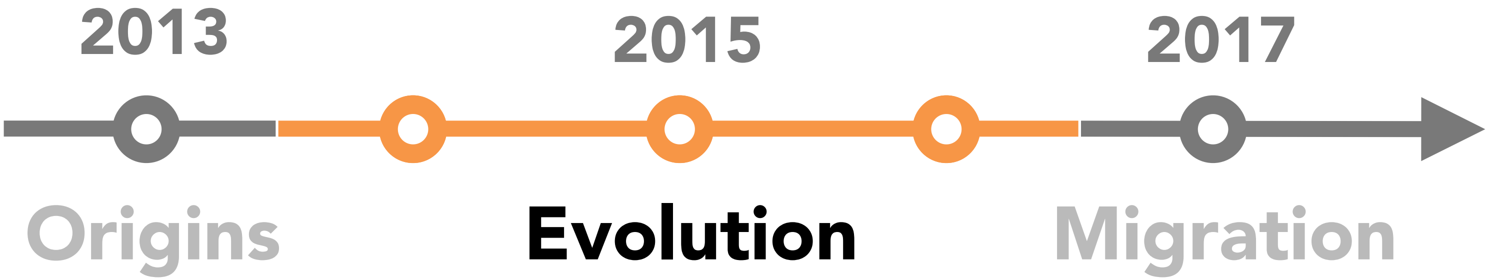
per flow routing

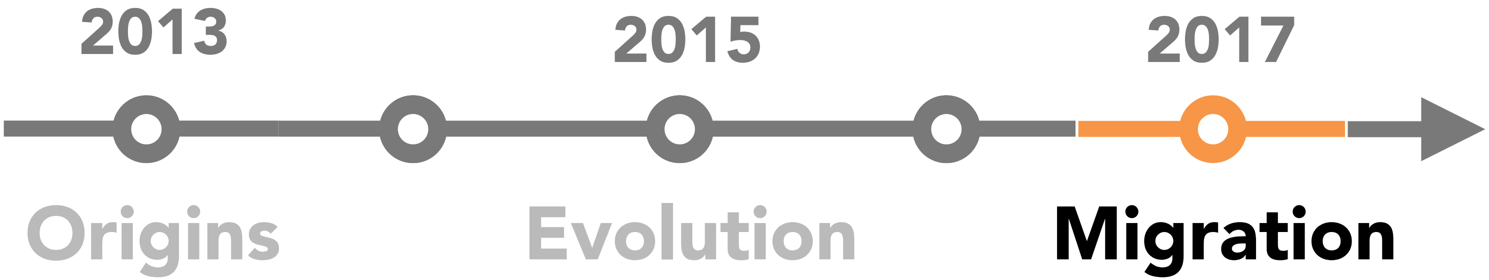
Shortcomings were addressed

no more broken assumptions on how networks work or are operated

no more L2 hacks

New architectural changes worked as expected


2013
2015
2017
Origins
Evolution
Migration


2013
2015
2017
Origins
Evolution
Migration

Objectives

Change of protocol

Old architecture used iBGP while new used eBGP

Must minimize concurrent architectures

twice the code

twice the tooling

twice the knowledge

twice the things that can go wrong

Must minimize migration period

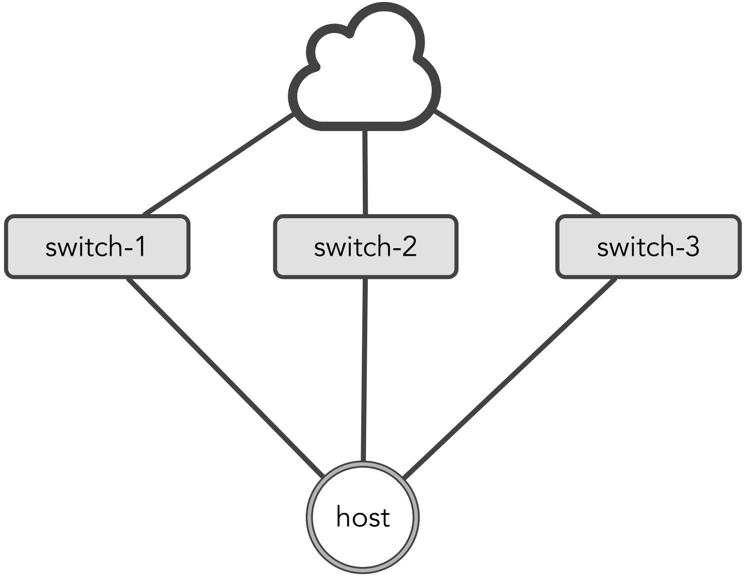
traditional migrations can take years for large infrastructure

scheduling, customer notification, executing the work must be reduced to bare minimum

iBGP to eBGP challenges

1. Changing of ASN requires synch'ing changes in multiple devices

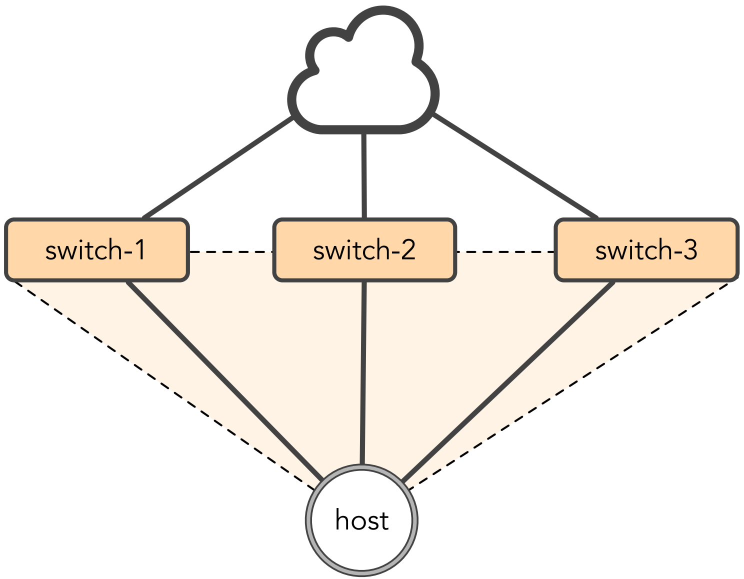
which comes with some automation challenges



iBGP to eBGP challenges

2. ECMP

While we have the same protocol everywhere all paths are eligible.



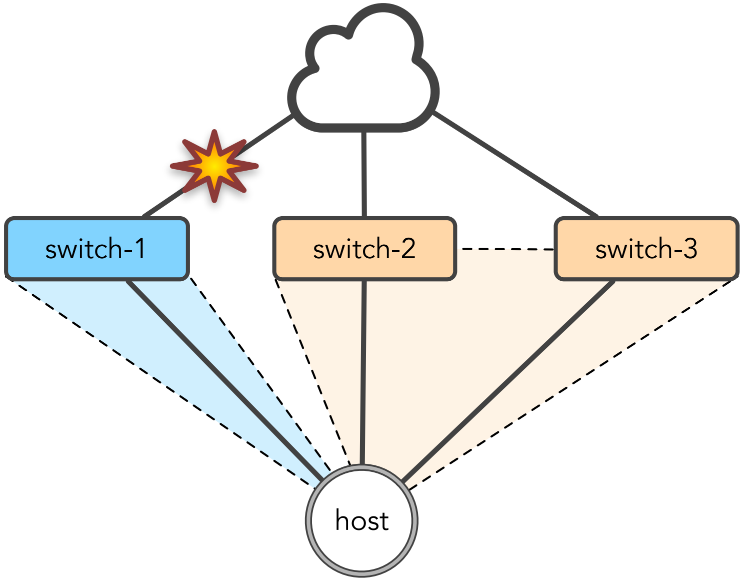
iBGP to eBGP challenges

2. ECMP

While we have the same protocol everywhere all paths are eligible.

eBGP wins over iBGP

now all traffic is going via a single link potentially congesting the links



How do we solve those problems?

"That's impossible and I could cite 5 RFCs and reference 20 $vendor white-papers explaining why"

Jimmy, Network Architect, CCIE, JNCIE, Naysayer

"I have no respect for my elders"

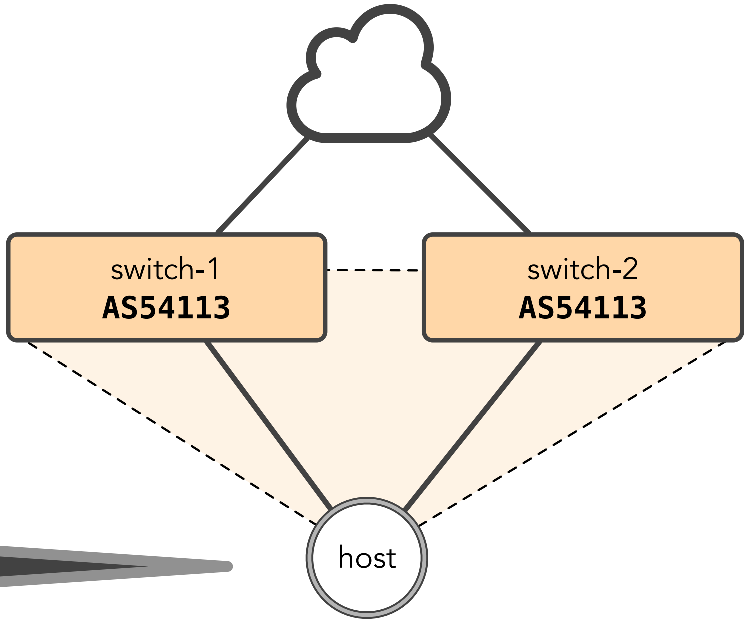
Lisa, Software Developer, Nihilist, Hacker

ASN migration

```
protocol bgp host-1 {
  local as 54113;
  neighbor host_ip as 54113;
}
```

```
protocol bgp switch-1 {
  local as 54113;
  neighbor switch1_ip as 54113;
}
```

Starting config

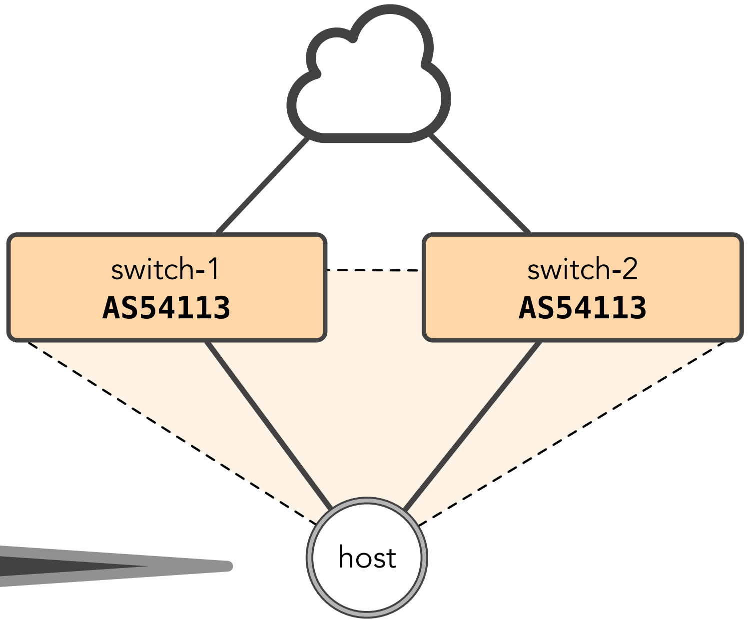


ASN migration

```
protocol bgp host-1 {
  local as 54113;
  neighbor host_ip as 54113 as 65100;
}
```

```
protocol bgp switch-1 {
  local as 54113;
  neighbor switch1_ip as 54113 as 65000;
}
```

We allow peers to connect with either ASN

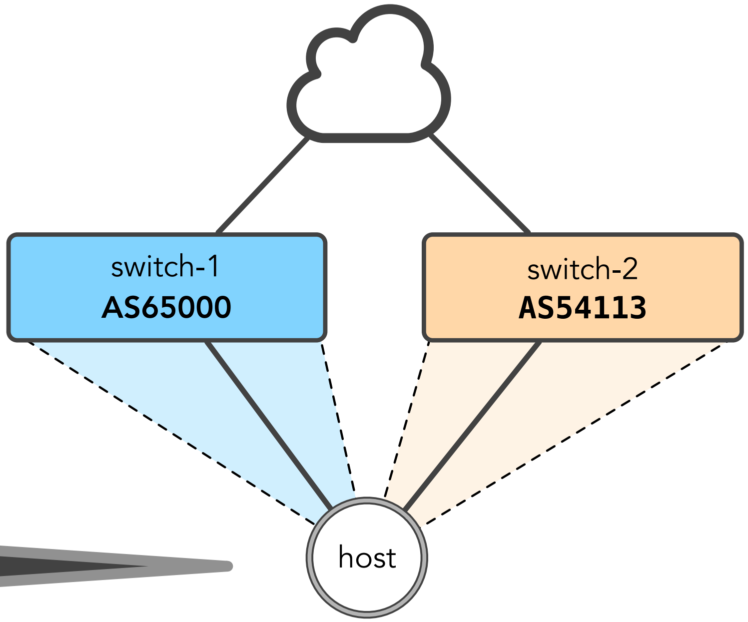


ASN migration

```
protocol bgp host-1 {
  local as 65000;
  neighbor host_ip as 54113 as 65100;
}
```

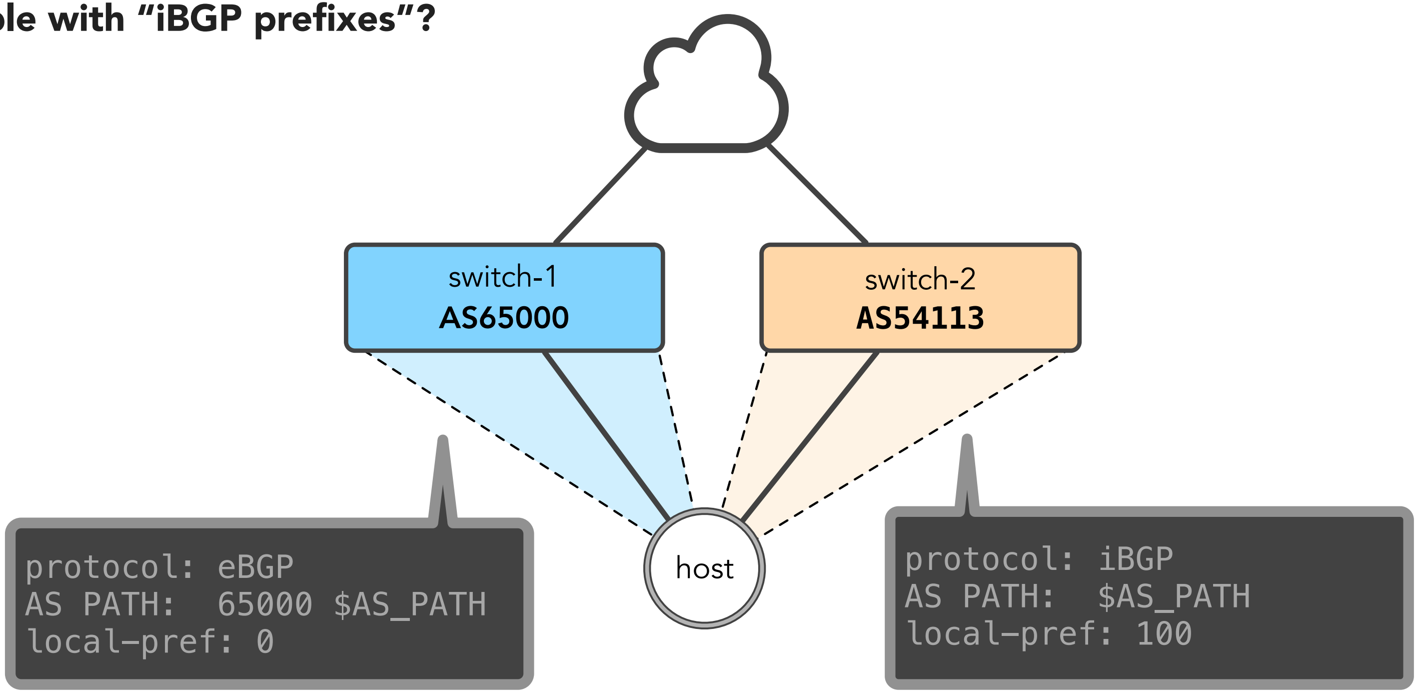
```
protocol bgp switch-1 {
  local as 54113;
  neighbor switch1_ip as 54113 as 65000;
}
```

Now we can change the local ASN independently on each device



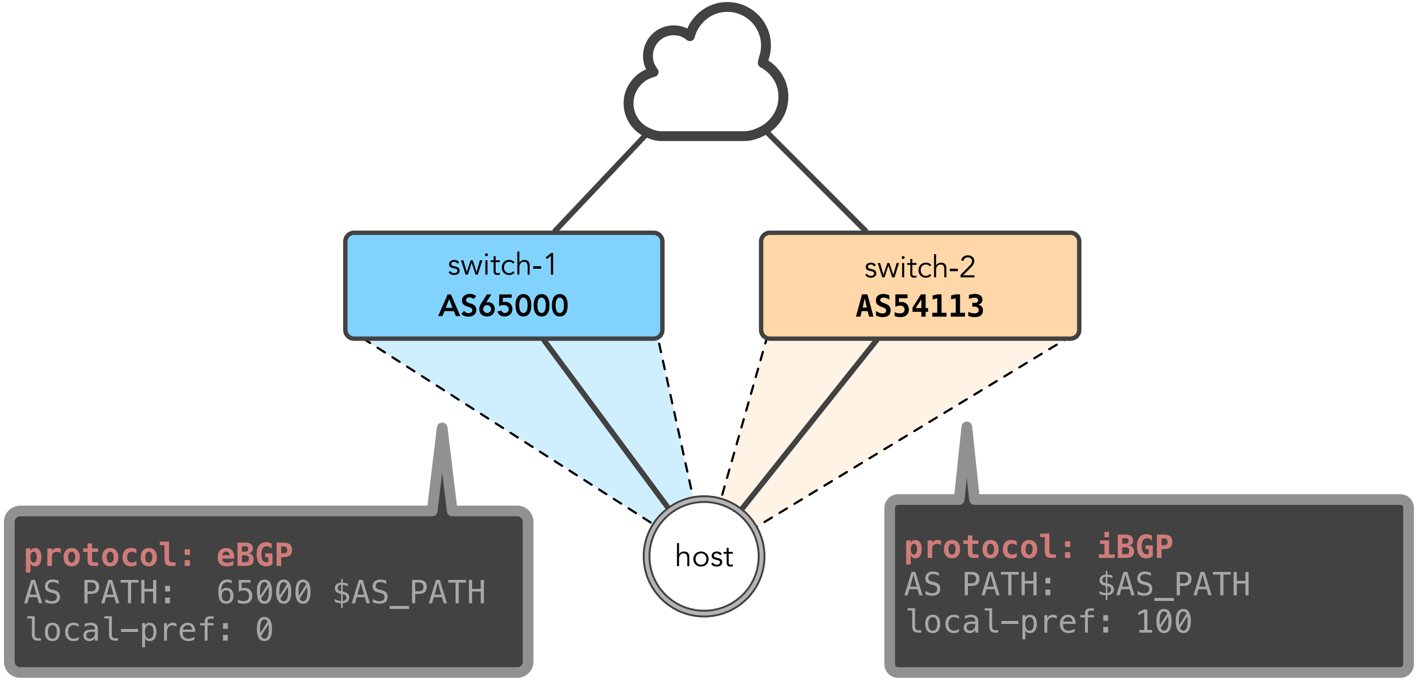
iBGP/eBGP prefix compatibility

How to make "eBGP prefixes" compatible with "iBGP prefixes"?



iBGP/eBGP prefix compatibility

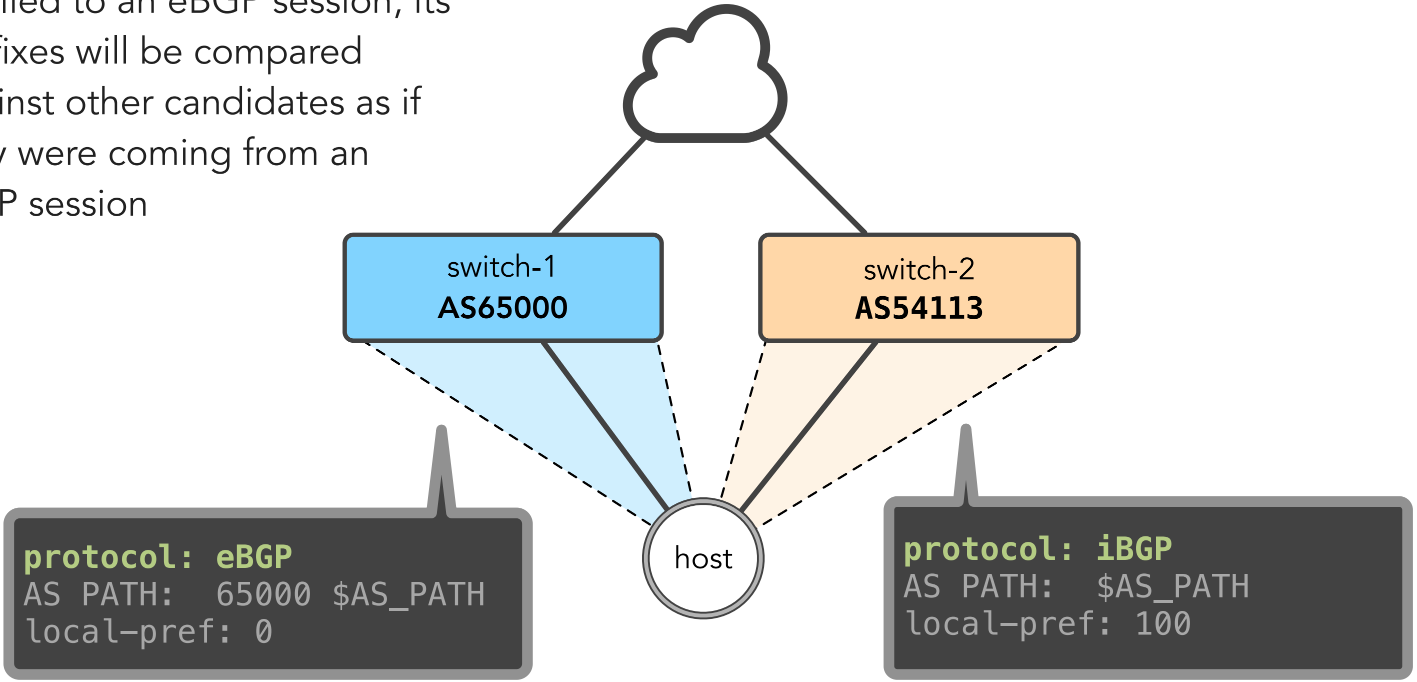
eBGP > iBGP



iBGP/eBGP prefix compatibility

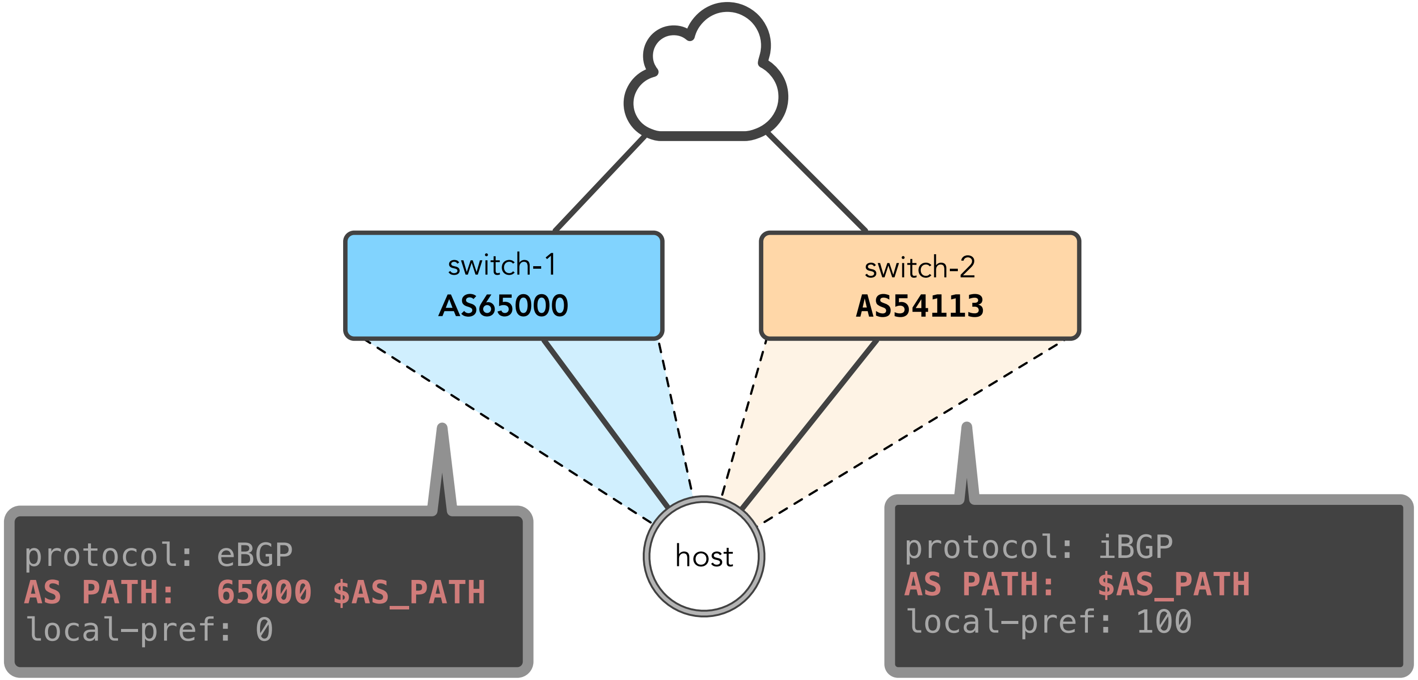
compare_as_ibgp

applied to an eBGP session, its prefixes will be compared against other candidates as if they were coming from an iBGP session



iBGP/eBGP prefix compatibility

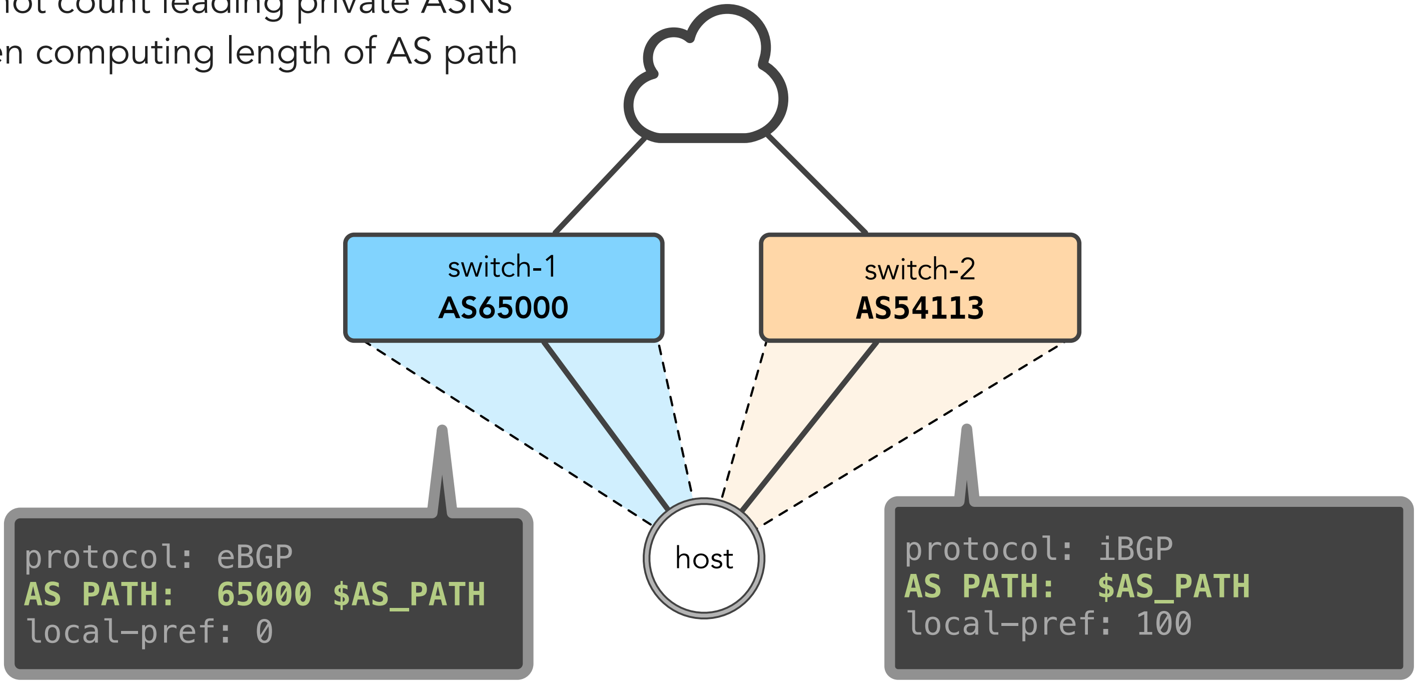
len(65000 $AS_PATH) > len($AS_PATH)



iBGP/eBGP prefix compatibility

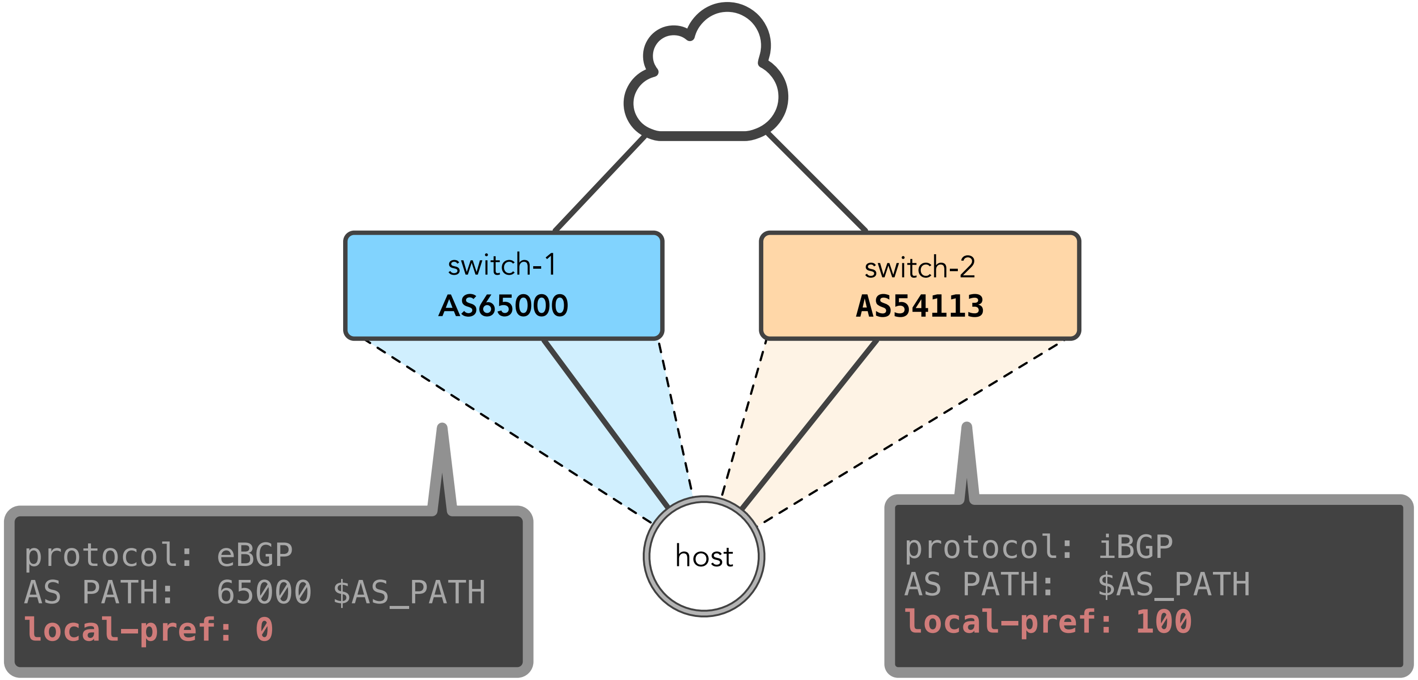
skip_private_as_path_prefix

do not count leading private ASNs
when computing length of AS path



iBGP/eBGP prefix compatibility

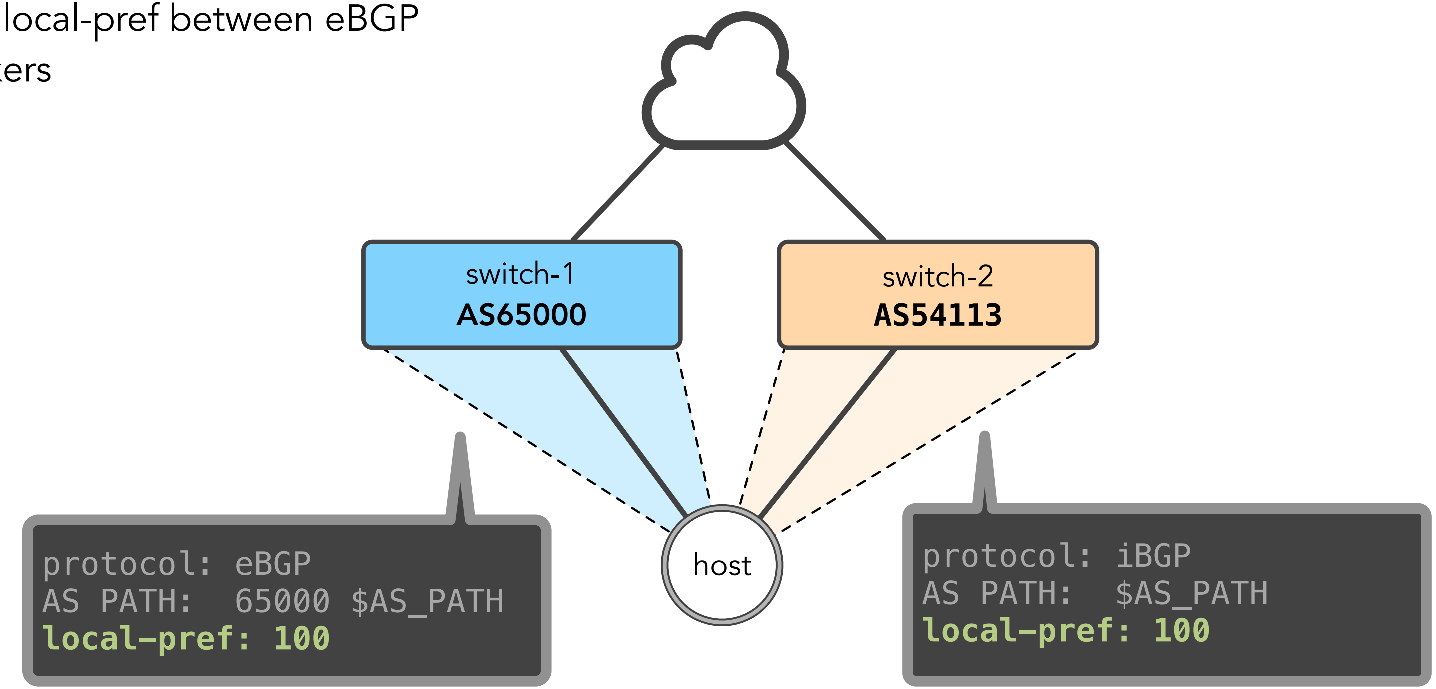
eBGP ~~local-pref~~



iBGP/eBGP prefix compatibility

allow bgp_local_pref

allow local-pref between eBGP speakers



Migration process (overview)

Step 1. Enable new options.

```
protocol bgp cache-cmh8820 from tpl_bgp {
  local as 54113;
-  neighbor cache_cmh8820_ip as 54113;
+  neighbor cache_cmh8820_ip as 54113 as 4210088001;
+  compare_as_ibgp;
+  skip_private_as_path_prefix;
+  allow bgp_local_pref;
}
```

Impact: None

Step 2. Flip "local as":

```
protocol bgp cache-cmh8820 from tpl_bgp {
-  local as 54113;
+  local as 4210088000;
}
```

Impact: Only a BGP session flap thanks to the BGP "hacks". Progressive rollout is enough.

Example

```
bird> show route 2.2.2.2/32 all
2.2.2.2/32          via 10.0.0.2 on eth0 [switch_1] * (110) [AS123i]
    Type: BGP unicast univ
    BGP.origin: IGP
    BGP.as_path: 123
    BGP.next_hop: 10.0.0.2
    BGP.local_pref: 110
    BGP.originator_id: 10.0.0.51
    BGP.cluster_list: 10.0.0.101
                 via 10.0.0.1 on eth0 [switch_0] (110) [AS123i]
    Type: BGP unicast univ
    BGP.origin: IGP
    BGP.as_path: 65100 65000 65000 65000 65000 65000 123
    BGP.next_hop: 10.0.0.1
    BGP.local_pref: 110
bird> show route 2.2.2.2/32 export injector
2.2.2.2/32          multipath [switch_1 16:03:32 from 10.0.0.101] (100) [AS123i]
     via 10.0.0.1 on eth0 weight 1
     via 10.0.0.2 on eth0 weight 1
```

iBGP

eBGP

compare_as_ibgp

```
bird> show route 2.2.2.2/32 all
2.2.2.2/32          via 10.0.0.2 on eth0 [switch_1] * (110) [AS123i]
     Type: BGP unicast univ
     BGP.origin: IGP
     BGP.as_path: 123
     BGP.next_hop: 10.0.0.2
     BGP.local_pref: 110
     BGP.originator_id: 10.0.0.51
     BGP.cluster_list: 10.0.0.101
                   via 10.0.0.1 on eth0 [switch_0] (110) [AS123i]
     Type: BGP unicast univ
     BGP.origin: IGP
     BGP.as_path: 65100 65000 65000 65000 65000 123
     BGP.next_hop: 10.0.0.1
     BGP.local_pref: 110
bird> show route 2.2.2.2/32 export injector
2.2.2.2/32          multipath [switch_1 16:03:32 from 10.0.0.101] (100) [AS123i]
      via 10.0.0.1 on eth0 weight 1
      via 10.0.0.2 on eth0 weight 1
```

iBGP

eBGP

skip_private_as_path_prefix

```
bird> show route 2.2.2.2/32 all
2.2.2.2/32          via 10.0.0.2 on eth0 [switch_1] * (110) [AS123i]
          Type: BGP unicast univ
          BGP.origin: IGP
          BGP.as_path: 123
  iBGP    BGP.next_hop: 10.0.0.2
          BGP.local_pref: 110
          BGP.originator_id: 10.0.0.51
          BGP.cluster_list: 10.0.0.101
                       via 10.0.0.1 on eth0 [switch_0] (110) [AS123i]
          Type: BGP unicast univ
          BGP.origin: IGP
  eBGP    BGP.as_path: 65100 65000 65000 65000 65000 123
          BGP.next_hop: 10.0.0.1
          BGP.local_pref: 110
bird> show route 2.2.2.2/32 export injector
2.2.2.2/32          multipath [switch_1 16:03:32 from 10.0.0.101] (100) [AS123i]
        via 10.0.0.1 on eth0 weight 1
        via 10.0.0.2 on eth0 weight 1
```

allow bgp_local_pref

```
bird> show route 2.2.2.2/32 all
2.2.2.2/32          via 10.0.0.2 on eth0 [switch_1] * (110) [AS123i]
     Type: BGP unicast univ
     BGP.origin: IGP
     BGP.as_path: 123
     BGP.next_hop: 10.0.0.2
     BGP.local_pref: 110
     BGP.originator_id: 10.0.0.51
     BGP.cluster_list: 10.0.0.101
```

iBGP

```
                   via 10.0.0.1 on eth0 [switch_0] (110) [AS123i]
     Type: BGP unicast univ
     BGP.origin: IGP
     BGP.as_path: 65100 65000 65000 65000 65000 123
     BGP.next_hop: 10.0.0.1
     BGP.local_pref: 110
```

eBGP

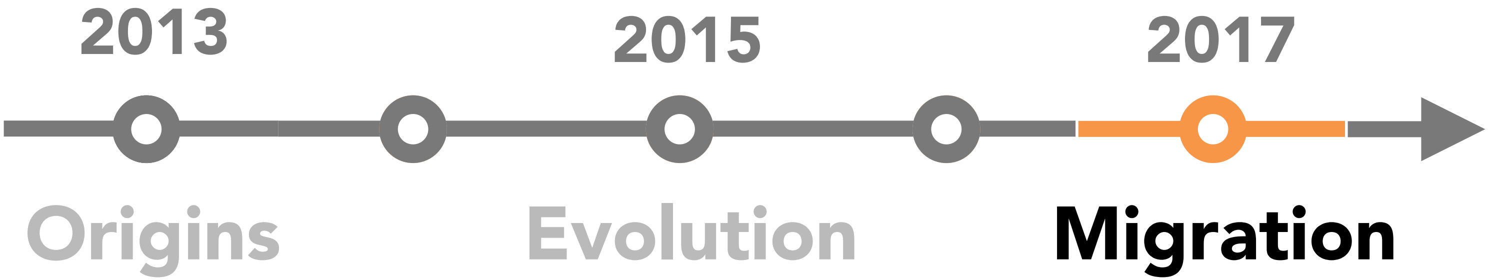
```
bird> show route 2.2.2.2/32 export injector
2.2.2.2/32          multipath [switch_1 16:03:32 from 10.0.0.101] (100) [AS123i]
      via 10.0.0.1 on eth0 weight 1
      via 10.0.0.2 on eth0 weight 1
```

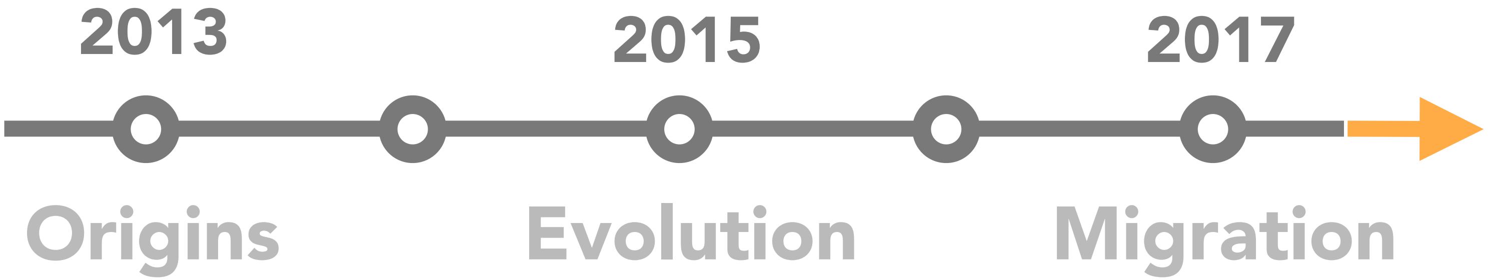
iBGP/eBGP "compatible" prefix

```
bird> show route 2.2.2.2/32 all
2.2.2.2/32          via 10.0.0.2 on eth0 [switch_1] * (110) [AS123i]
     Type: BGP unicast univ
     BGP.origin: IGP
     BGP.as_path: 123
     BGP.next_hop: 10.0.0.2
     BGP.local_pref: 110
     BGP.originator_id: 10.0.0.51
     BGP.cluster_list: 10.0.0.101
                   via 10.0.0.1 on eth0 [switch_0] (110) [AS123i]
     Type: BGP unicast univ
     BGP.origin: IGP
     BGP.as_path: 65100 65000 65000 65000 65000 123
     BGP.next_hop: 10.0.0.1
     BGP.local_pref: 110
bird> show route 2.2.2.2/32 export injector
2.2.2.2/32          multipath [switch_1 16:03:32 from 10.0.0.101] (100) [AS123i]
      via 10.0.0.1 on eth0 weight 1
      via 10.0.0.2 on eth0 weight 1
```

iBGP

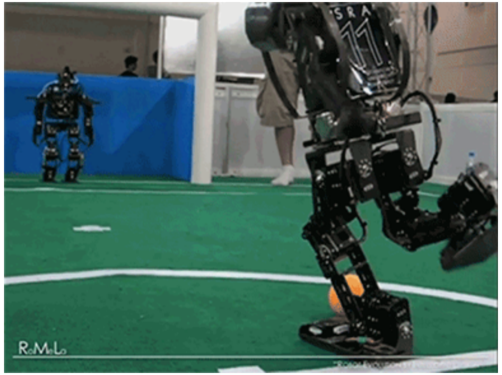
eBGP


2013
2015
2017
Origins
Evolution
Migration


2013
2015
2017
Origins
Evolution
Migration

Did you consider…

Did you consider… Openflow



No comments

No, seriously, no comments

Did you consider… Segment Routing

Core ideas are great

We borrowed some and we will probably borrow more

Complexity

Many protocols doing many things, complexity better in the host

Solves half the problem

How does it integrate with the application/host?

No open-source option

not even sure vendors support it yet

Did you consider… BGP-LU

Egress Peer Engineering using BGP-LU

draft-gredler-idr-bgplu-epe-09

similar idea but different implementation

Solves half the problem

How does it integrate with the application/host?

No OSS implementation

requires new AF

requires dealing with race conditions

Using BGP-LU is probably the right thing to do

to revisit in the future

Building your own control plane

No viable alternatives in 2013

existing solutions were expensive

didn't quite do what we wanted

hardware constraints limited our options

Custom control plane solution was critical

saved money and time

attracted talent

Revisited problem space

addressed issues in the previous architecture

less hardware constraints

hacked our way towards seamless migration

open source was critical

Questions?


€
$
GRRRRR
SECURITY!
LEVERAGE
SYNERGY
SERVICE
DEPLOY
CONTAINERS
DISRUPTION!
DEVOPS

Appendix

https://www.mail-archive.com/netdev@vger.kernel.org/msg123533.html
https://www.mail-archive.com/netdev@vger.kernel.org/msg176877.html
https://patchwork.kernel.org/patch/9552935/
http://bird.network.cz/pipermail/bird-users/2017-June/011352.html
http://bird.network.cz/pipermail/bird-users/2017-March/011028.html
http://bird.network.cz/pipermail/bird-users/2017-March/011084.html
http://bird.network.cz/pipermail/bird-users/2017-February/010911.html
http://bird.network.cz/pipermail/bird-users/2017-February/010925.html
http://bird.network.cz/pipermail/bird-users/2017-August/011467.html
http://bird.network.cz/pipermail/bird-users/2017-August/011468.html