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The Access Tier ISP, considering upstream connectivity

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GameCORE / netLabs!UG

30 January 2018

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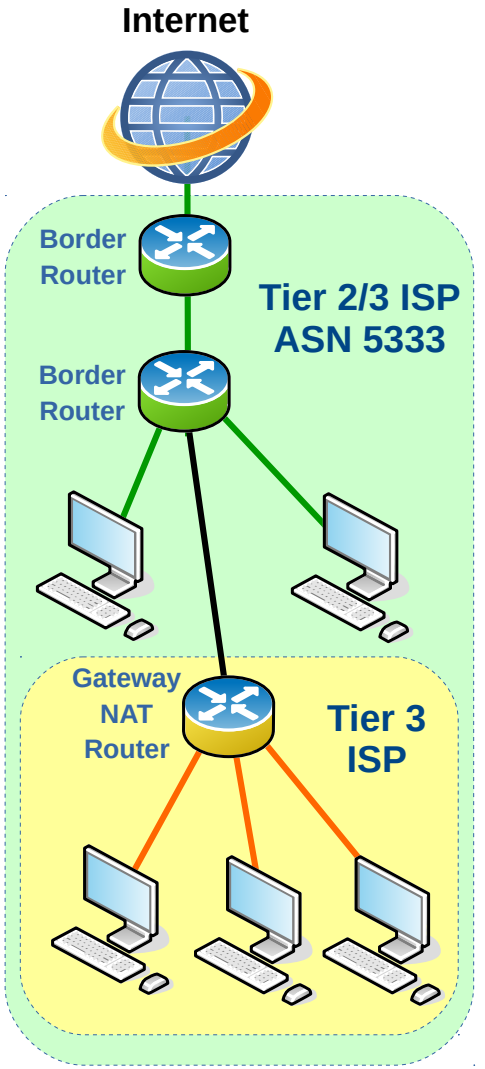
The Access ISP, connection to the Internet

- Access ISPs connectivity to the Internet falls into one of these general categories:
  - ISP with minimal L3 address from upstream provider
  - ISP with L3 address from upstream provider
  - Full ISP, with ASN, IPv4 and IPv6 blocks
  - Full ISP with IXP Connection
  - Virtualised ISP

ISP with minimal L3 address from upstream provider

- Access customers connected to upstream provider using Network Address Translation (NAT)
- Easy to setup but limits size of network
- Gateway NAT router high workload
- Dependence from upstream provider/ISP
  - Renumbering headaches
    - When scaling up
    - When changing providers
- No ability to multi-home
- Dependency on NAT limits services to customers



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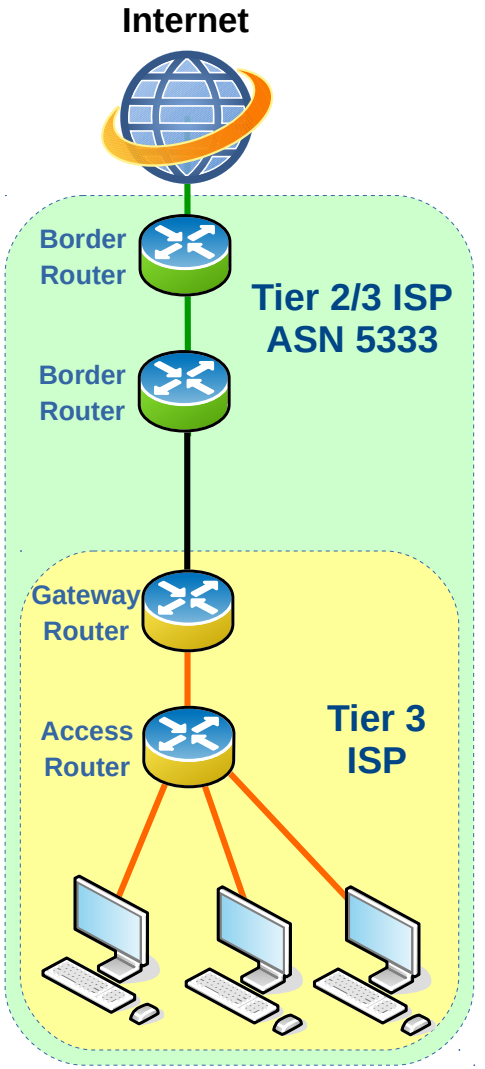
ISP with L3 address from upstream provider

- Dependence from upstream provider/ISP
  - Renumbering headaches if changing providers
  - Difficult to change providers
- Cannot multi-home between different upstream ISPs
- Services to end customers limited by services of upstream provider
- Routing policies dictated by upstream provider



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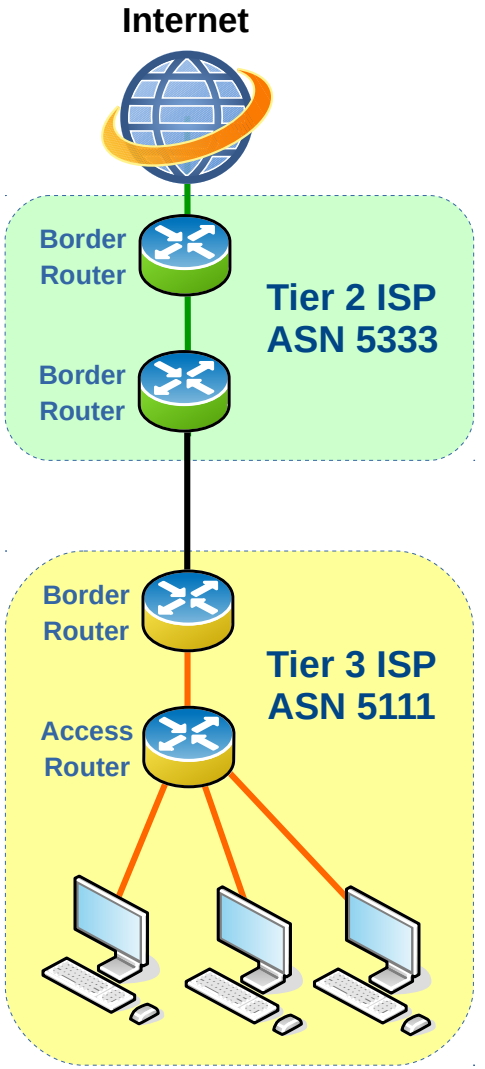
Full ISP, with ASN, IPv4 and IPv6 blocks

- Operational Advantage
- Independence from upstream provider/ISP
  - no renumbering headaches when changing providers
- Ability to multi-home
- No dependency on NAT, can offer enhanced services to end customers
- Simpler to implement routing policies that suit the company and services



REF: https://apps.afrinic.net/nmrp/

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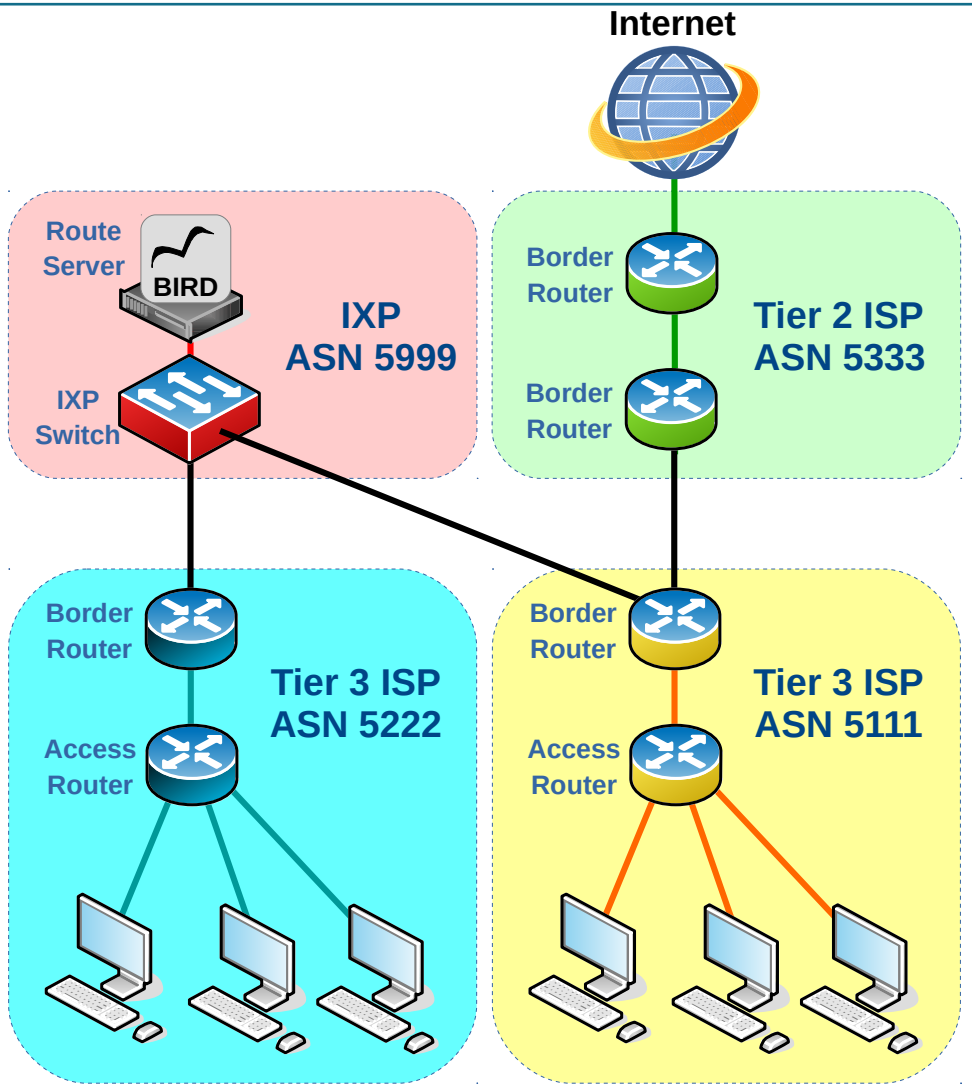
Full ISP with IXP Connection

- All of the previous advantages
- Plus;
  - Local traffic kept local
  - Reduced transit costs
  - Reduced latency to local content and content caches
  - Improved service to customers



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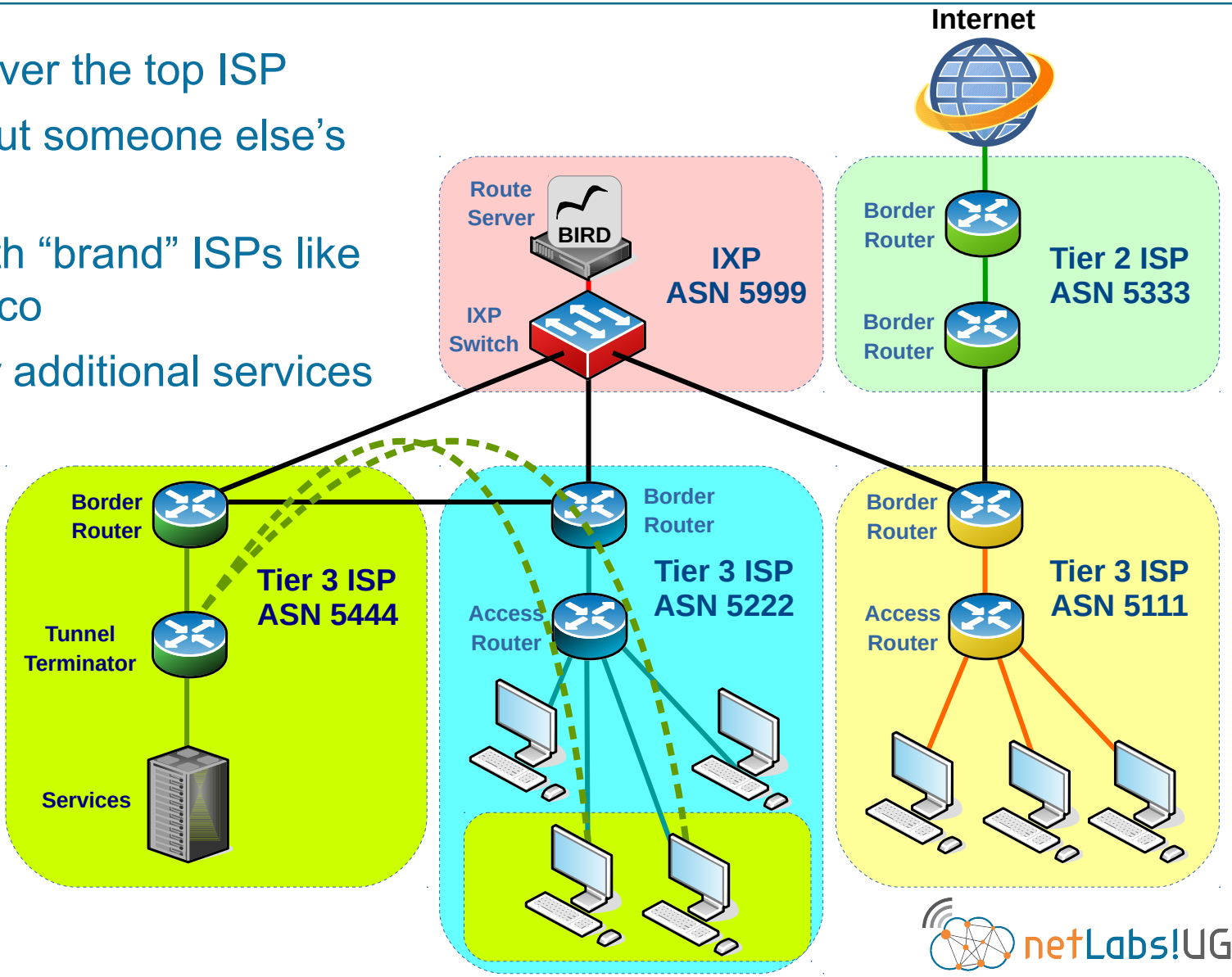
Virtualused ISP

- Virtualised over the top ISP
- Access rollout someone else's problem
- Common with "brand" ISPs like Sky and Tesco
- Usually offer additional services



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Inter Autonomous System routing

What exactly is an Autonomous System and how is routing carried out in one ?

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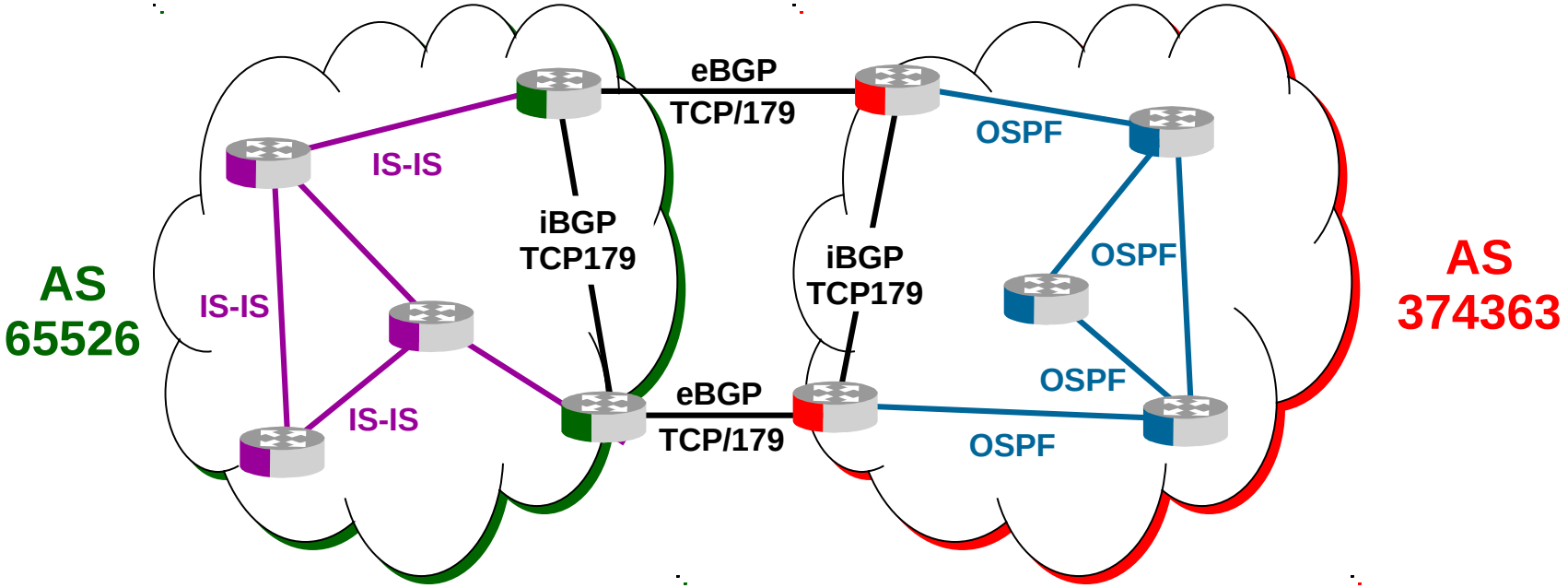
The Autonomous System & BGP

RFC1105	1989	BGPv1		RFC1654	16-bit	2-Octet	AS65526
RFC1654	1994	BGPv4		RFC4893/6793	32-bit	4-Octet	AS374363



- **ORIGIN**: defines the origin of the path information
- **AS PATH**: sequence of AS path segments
- **NEXT HOP**: defines the IP address of the next hop router

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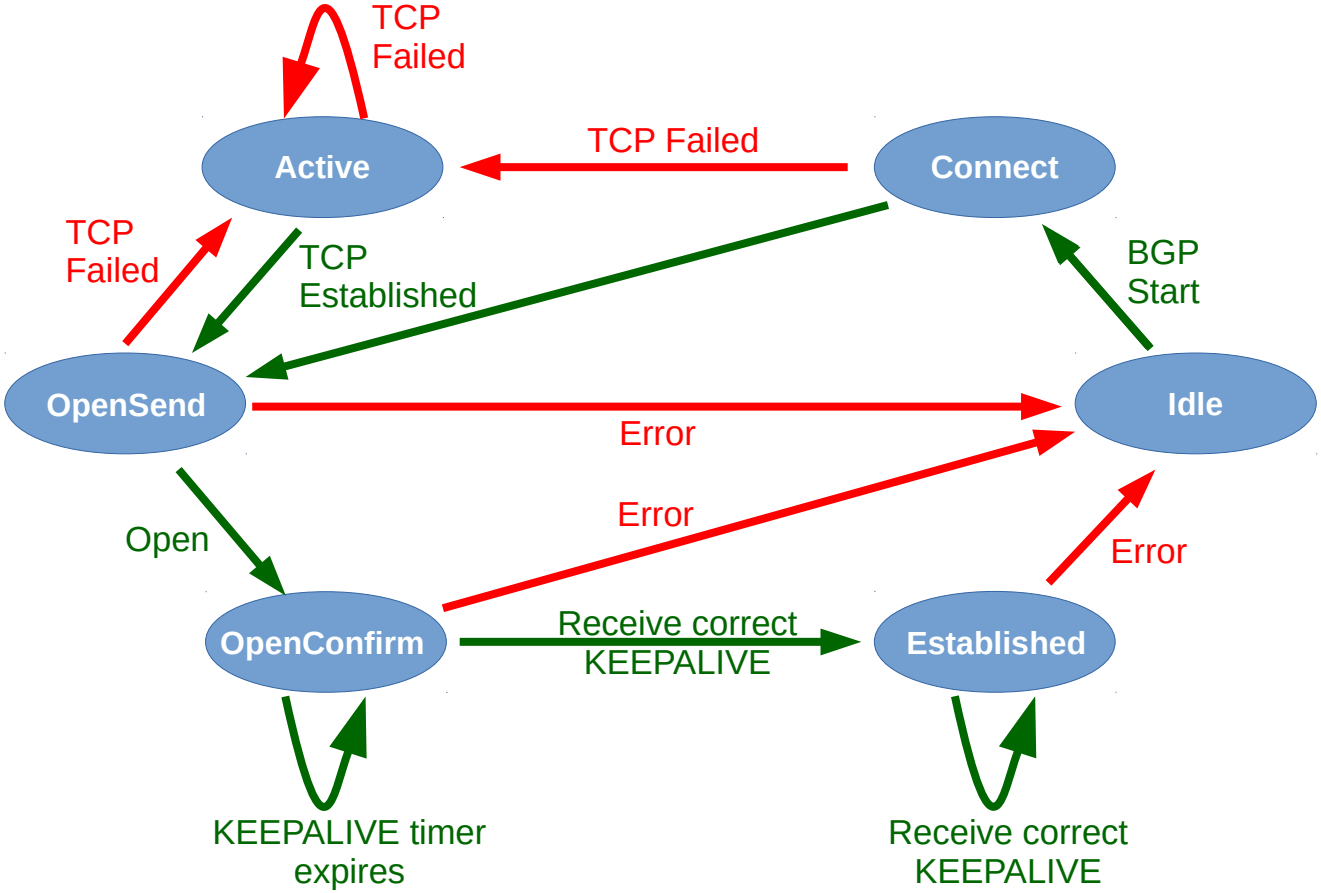
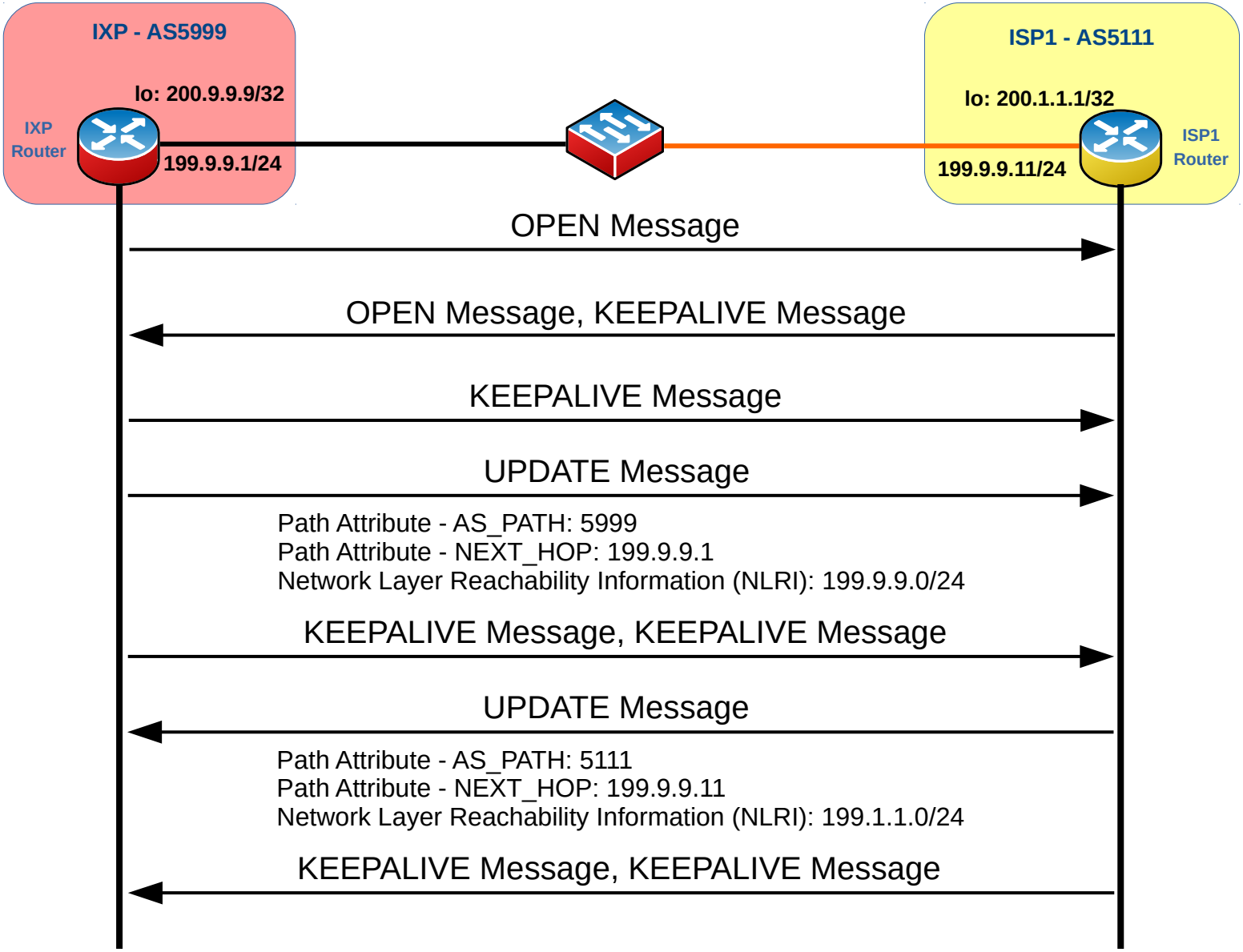
BGP Finite State Machine (FSM)

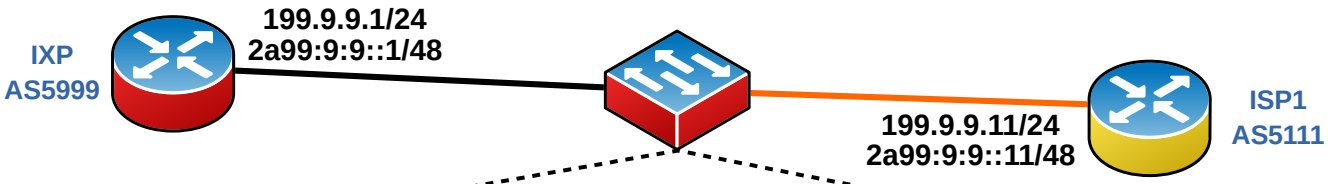



```
routing bgp peer print
  Flags: X - disabled, E - established
   #    INSTANCE          REMOTE-ADDRESS    REMOTE-AS
   0 E  ASN5111           199.5.5.33        5333
   1 E  ASN5111           2a99:5:5::33      5333
```


Basic BGP Message flow



BGP Update IPv4




```
IPv4, Src: 199.9.9.1, Dst: 199.9.9.11
TCP, Src Port: 40932, Dst Port: 179, Seq: 65, Ack: 65, Len: 52
BGP - UPDATE Message
    Marker: ffffffffffffffffffffffffffffffff
    Length: 52
    Type: UPDATE Message (2)
    Withdrawn Routes Length: 0
    Total Path Attribute Length: 25
    Path attributes
        Path Attribute - ORIGIN: IGP
        Path Attribute - AS_PATH: 5999
        Path Attribute - NEXT_HOP: 199.9.9.1
        Path Attribute - MULTI_EXIT_DISCRIMINATOR: 0
      Network Layer Reachability Information
        199.9.9.0/24
```

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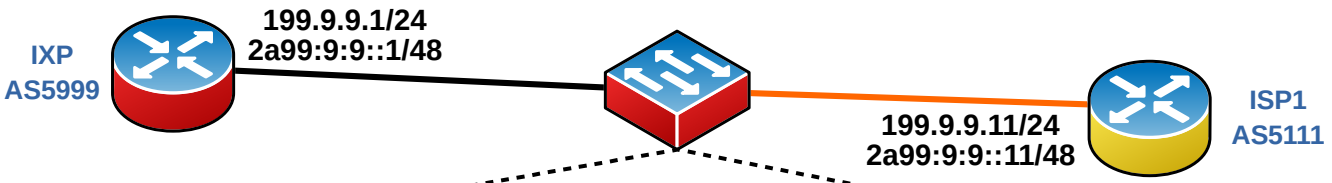
BGP Update IPv6




```
IPv6, Src: 2a99:9:9::1 , Dst: 2a99:9:9::11
TCP, Src Port: 40932, Dst Port: 179, Seq: 65, Ack: 65, Len: 52
BGP – UPDATE Message
    Marker: ffffffffffffffffffffffffffffffff
    Length: 90
    Type: UPDATE Message (2)
    Withdrawn Routes Length: 0
    Total Path Attribute Length: 67
    Path attributes
        Path Attribute – ORIGIN: IGP
        Path Attribute – AS_PATH: 5999
        Path Attribute – MULTI_EXIT_DISCRIMINATOR: 0
        Path Attribute – MP_REACH_NLRI
          Next hop network address (32 bytes)
            Next Hop: 2a99:9:9::1
            Next Hop: fe80::216:c7ff:fe9c:4860
          Network Layer Reachability Information
            2a99:9:9::/48
```

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Internet eXchange Points

How can an IXP help me ? Are they not just for the big boys ?

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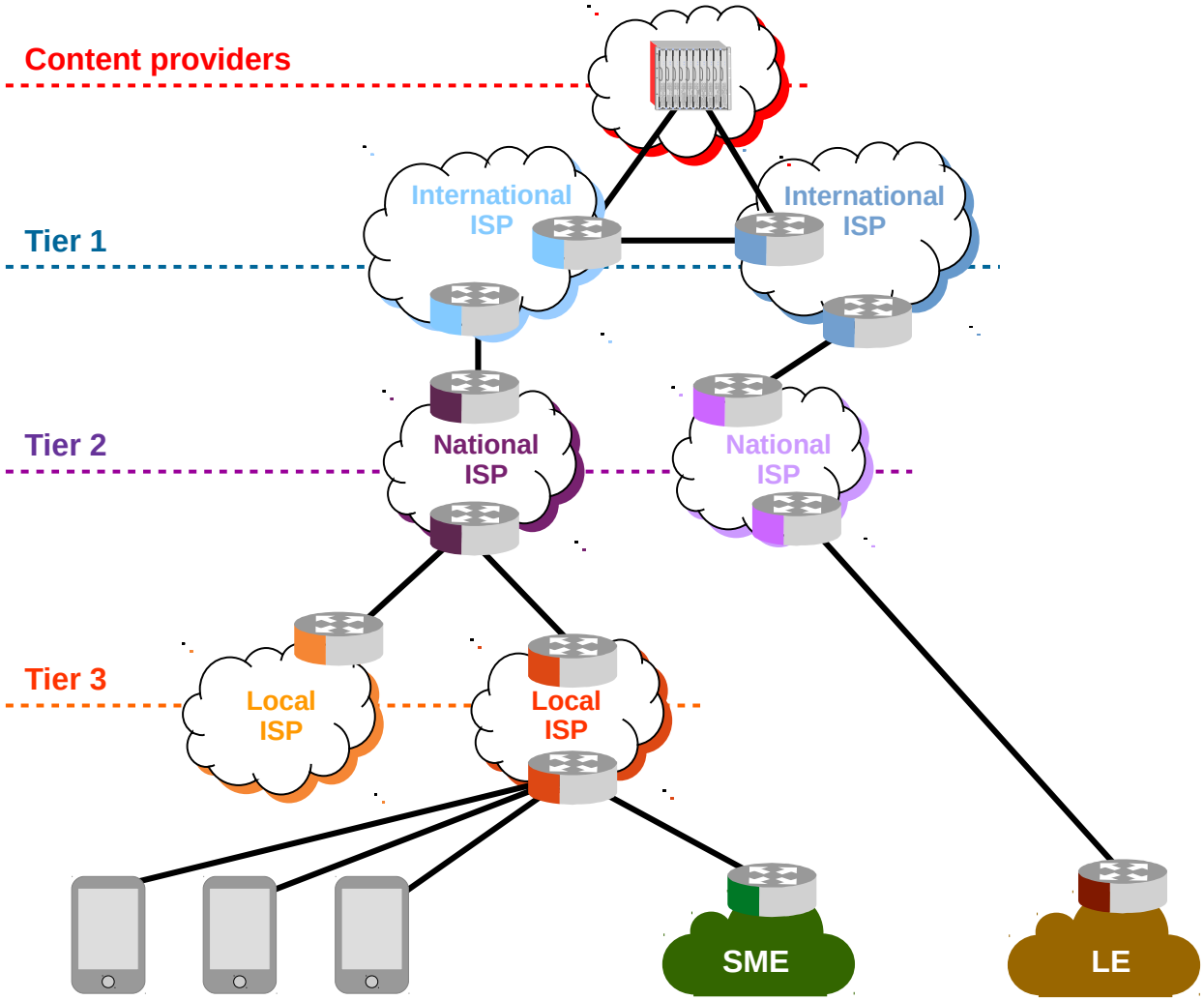
The make-up of the Internet



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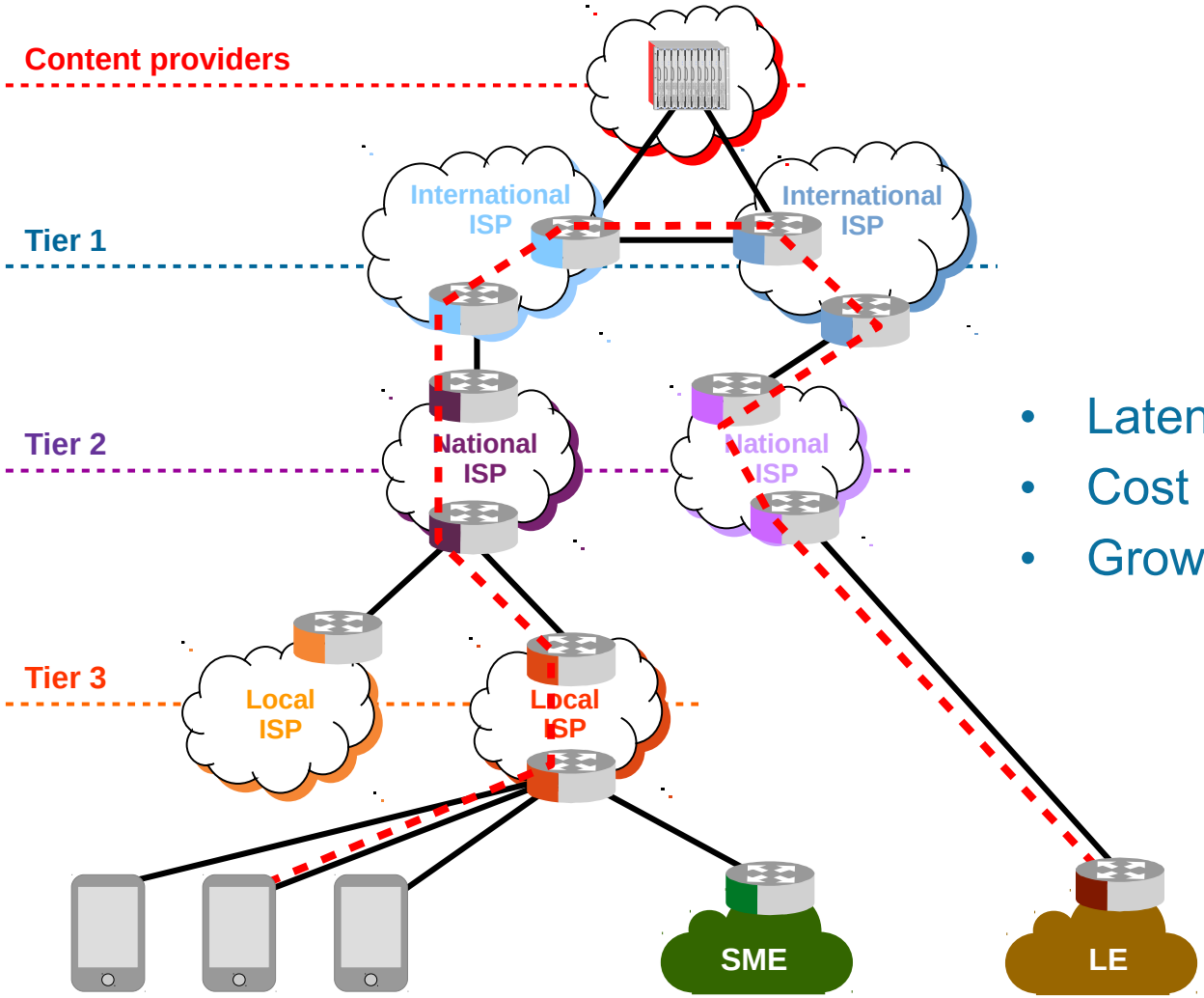
Tromboning



- Latency
- Cost
- Growth of ecosystem

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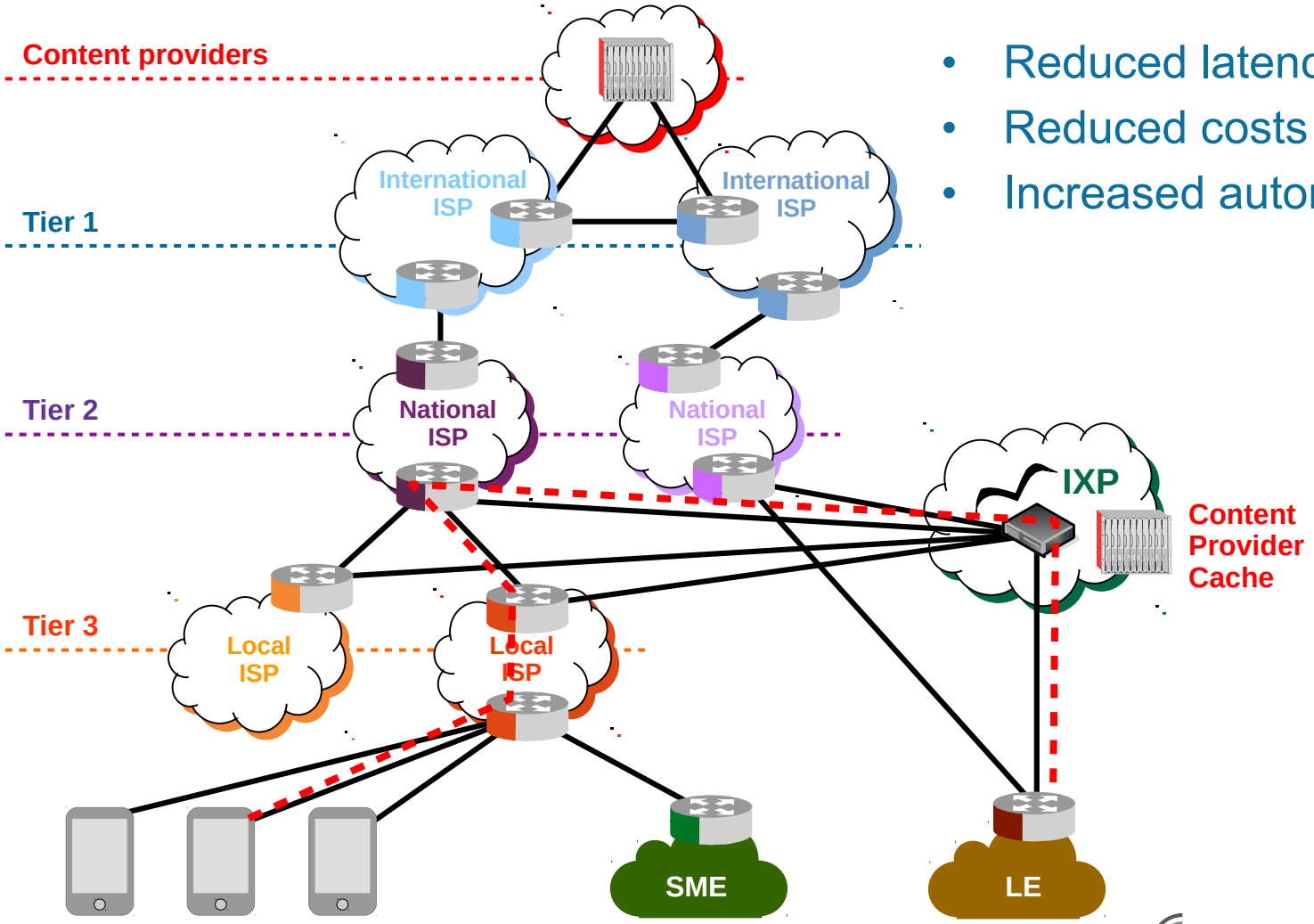
IXP – Keeping local traffic local



- Reduced latency
- Reduced costs
- Increased autonomy

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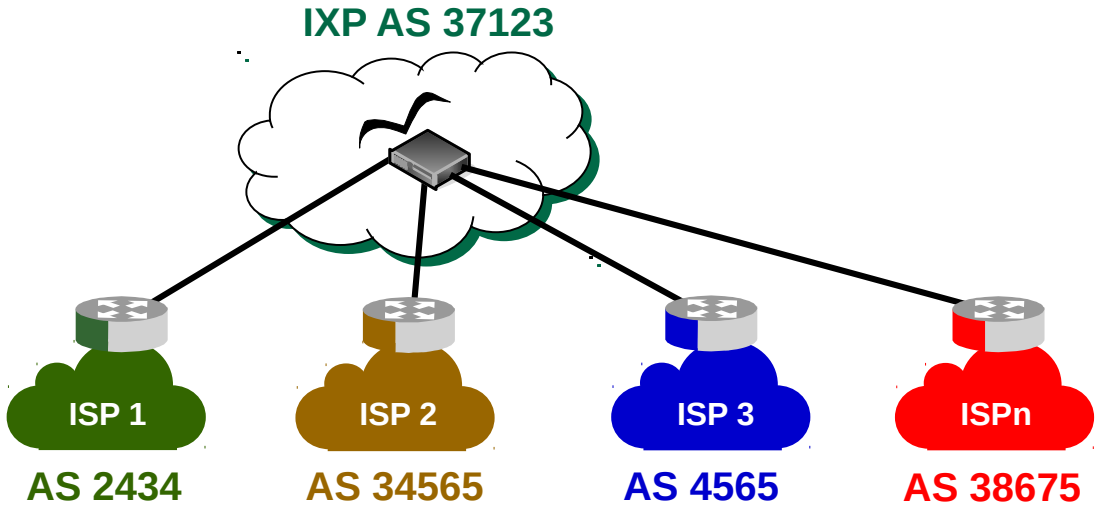
Route server – Route reflector




```
birdc> show route
165.253.0.0/23   via 197.243.54.38 on eth0 [ISP1 2017-05-15] * (100) [AS2434i]
105.179.200.0/22 via 197.243.54.51 on eth0 [ISP2 2017-05-15] * (100) [AS34565i]
198.51.100.0/24  via 197.243.54.46 on eth0 [ISP3 2017-05-15] * (100) [AS4565i]
41.221.89.0/24   via 197.243.54.33 on eth0 [ISP4 2017-05-15] * (100) [AS38675i]

birdc> show route export ISP4
41.221.89.0/24 via 196.243.54.33 on eth0 [ISP4 2017-05-15] * (100) [AS38675i]
    Type: BGP unicast univ
    BGP.origin: IGP
    BGP.as_path: 38675
    BGP.next_hop: 196.243.54.33
    BGP.med: 0
    BGP.local_pref: 100
```

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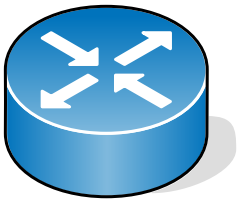

BGP v4

BGP Peering Configuration

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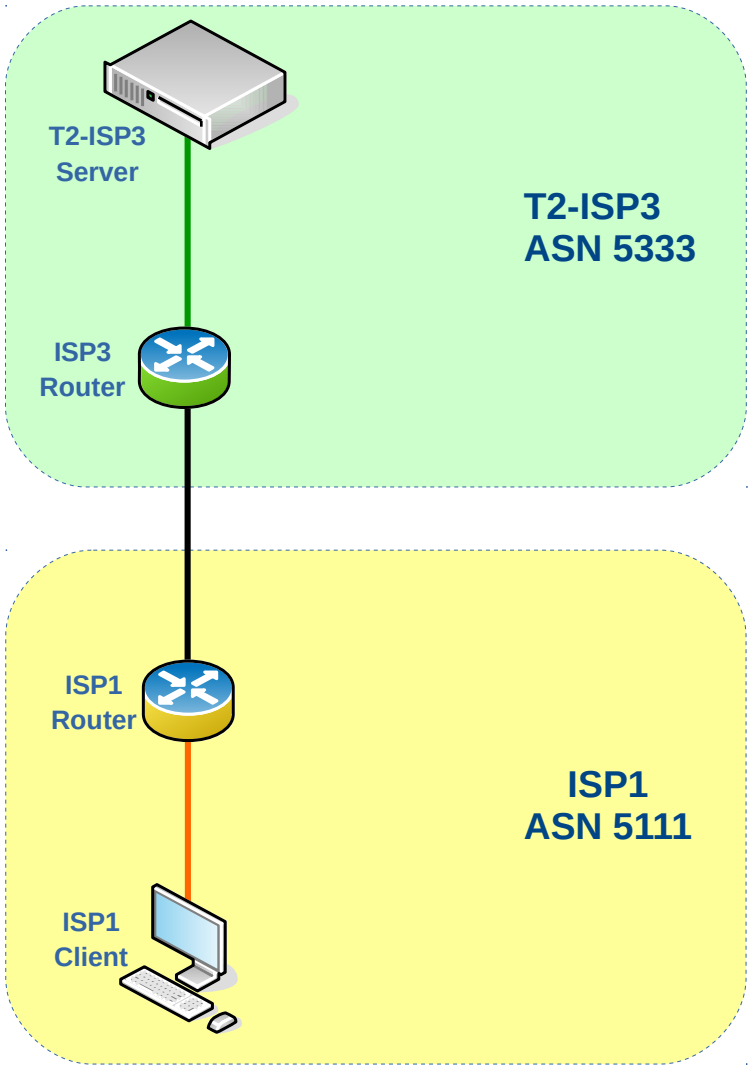
Demonstration testbed



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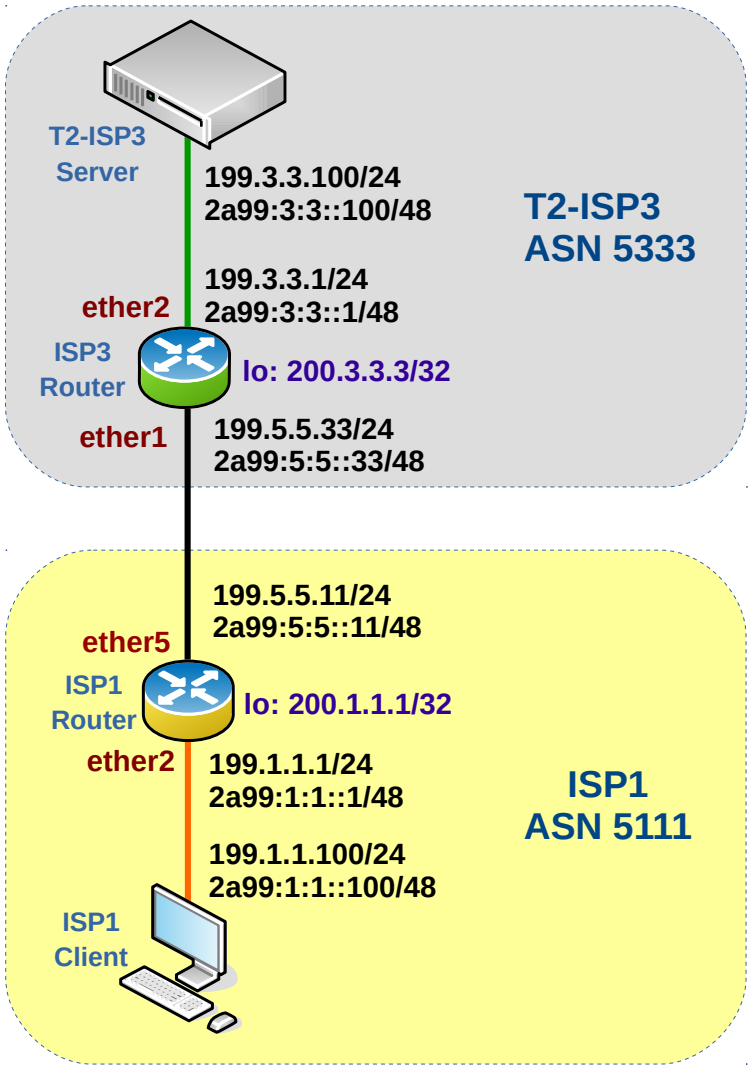
Demonstration testbed



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ISP1 – The preliminaries

- ## Enable IPv6

```
system package print
Flags: X - disabled
 #    NAME                                VERSION                 SCHEDULED
 0    routeros-mipsbe                     6.38.7
 1    system                              6.38.7
 2  X ipv6                                6.38.7
 3    wireless                            6.38.7
 4    hotspot                             6.38.7
 5    dhcp                                6.38.7
 6    mpls                                6.38.7
 7    routing                             6.38.7
 8    ppp                                 6.38.7
 9    security                            6.38.7
10    advanced-tools                      6.38.7
```

```
system package enable 2
```

- ## Reset configuration

```
system reset-configuration no-defaults=yes
```

- ## System identity

```
system identity set name=ISP1
```

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ISP1 – Initial IP addressing for transit

- Add IP Addresses to the interfaces

```
interface bridge add name=loopback0
ip address add address=200.1.1.1/32 interface=loopback0

ip address add address=199.1.1.1/24 interface=ether2
ipv6 address add address=2a99:1:1::1/48 interface=ether2

ip address add address=199.5.5.11/24 interface=ether5
ipv6 address add address=2a99:5:5::11/48 interface=ether5
```

```
ip address print
Flags: X - disabled, I - invalid, D - dynamic
 #   ADDRESS            NETWORK         INTERFACE
 0   200.1.1.1/32       200.1.1.1       loopback0
 1   199.9.9.11/24      199.9.9.0       ether1
 2   199.5.5.11/24      199.5.5.0       ether5

ipv6 address print
Flags: X - disabled, I - invalid, D - dynamic, G - global, L - link-local
 #    ADDRESS                                 FROM-POOL INTERFACE   ADVERTISE
 0 DL fe80::20c:42ff:fec2:117c/64                       ether2      no
 1 DL fe80::20c:42ff:fec2:117e/64                       ether4      no
 2 DL fe80::20c:42ff:fec2:117f/64                       ether5      no
 3 IG 2a99:9:9::11/48                                   ether1      yes
 4  G 2a99:5:5::11/48
```

ISP1 – BGP configuration

- Create a BGP instance and add networks to be routed

```
routing bgp instance add name=ASN5111 as=5111 router-id=200.1.1.1

routing bgp network add network=199.1.1.0/24
routing bgp network add network=2a99:1:1::/48


routing bgp instance print from=ASN5111
Flags: * - default, X - disabled
0 name="ASN5111" as=5111 router-id=200.1.1.1 redistribute-connected=no
  redistribute-static=no redistribute-rip=no redistribute-ospf=no
  redistribute-other-bgp=no out-filter="" client-to-client-reflection=yes
  ignore-as-path-len=no routing-table=""


routing bgp network print
Flags: X - disabled
 #    NETWORK                SYNCHRONIZE
 0    199.1.1.0/24           yes
 1    2a99:1:1::/48          yes
```

BGP ingress Filters

- Ingress filters are used to filter advertisements into the network
- Best practice for ingress filters for all peers are:
  - Discard receiving ones own prefix
  - Discard receiving a default route as we are doing full routing
  - Discard special purpose address registry entries stated at RFC 6890
- RFC6890 - Special-Purpose IP Address Registries
  - IETF reserved blocks that should not be received in routing update messages

Create BGP ingress Filters for transit

- Create a BGP ingress filter for IPv4
  - Discard own network
  - Discard Default route
  - Jump the filter to the RFC-6890 IPv4 filter

```
routing filter add chain=IN-ISP3-IPv4 prefix=199.1.1.0/24 action=discard
routing filter add chain=IN-ISP3-IPv4 prefix=0.0.0.0/0 action=discard
routing filter add chain=IN-ISP3-IPv4 action=jump jump-target=IN-RFC-6890-IPv4

routing filter add chain=IN-RFC-6890-IPv4 prefix=0.0.0.0/8 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=10.0.0.0/8 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=100.64.0.0/10 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=127.0.0.0/8 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=169.254.0.0/16 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=172.16.0.0/12 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=192.0.2.0/24 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=192.88.99.0/24 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=192.168.0.0/16 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=198.18.0.0/15 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=198.51.100.0/24 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=203.0.113.0/24 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=240.0.0.0/4 action=discard
routing filter add chain=IN-RFC-6890-IPv4 prefix=255.255.255.255/32 action=discard
```

Create BGP ingress Filters for transit

- Create a BGP ingress filter for IPv6
  - Discard own network
  - Discard Default route
  - Jump the filter to the RFC-6890 IPv6 filter

```
routing filter add chain=IN-ISP3-IPv6 prefix=2a99:1:1::/48 action=discard
routing filter add chain=IN-ISP3-IPv6 prefix=::/0 action=discard
routing filter add chain=IN-ISP3-IPv6 action=jump jump-target=IN-RFC-6890-IPv6

routing filter add chain=IN-RFC-6890-IPv6 prefix=::1/128 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=::/128 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=64:ff9b::/96 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=::ffff:0:0/96 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=100::/64 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=2001::/23 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=2001::/32 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=2001:2::/48 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=2001:db8::/32 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=2001:10::/28 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=2002::/16 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=fc00::/7 action=discard
routing filter add chain=IN-RFC-6890-IPv6 prefix=fe80::/10 action=discard
```

Create BGP egress Filters for transit

- Egress filters are used to filter advertisements from the network, limiting it to only advertise the specific local networks
  - ***invert-match=yes*** statement, this instructs the filter to discard all but the prefix specified

```
routing filter add chain=OUT-IPv4 prefix=199.1.1.0/24 invert-match=yes
action=discard
```

```
routing filter add chain=OUT-IPv6 prefix=2a99:1:1::/48 invert-match=yes
action=discard
```

Add BGP Peers for transit

- Create the peer link to the other BGP peer at IXP3 for IPv4 and IPv6
  - Note that IPv4 family is the default and for IPv6 the family must be specified

```
routing bgp peer add name=isp3 instance=ASN5111 remote-as=5333
remote-address=199.5.5.33 in-filter=IN-ISP3-IPv4 out-filter=OUT-IPv4
```

```
routing bgp peer add name=isp3 instance=ASN5111 remote-as=5333
remote-address=2a99:5:5::33 address-families=ipv6
in-filter=IN-ISP3-IPv6 out-filter=OUT-IPv6
```

Confirm routing with transit ISP3

- Confirm that the routes have been learnt from ISP3

```
routing bgp peer print
Flags: X - disabled, E - established
 #    INSTANCE          REMOTE-ADDRESS                          REMOTE-AS
 0 E  ASN5111           199.5.5.33                              5333
 1 E  ASN5111           2a99:5:5::33                            5333

ip route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
 #      DST-ADDRESS         PREF-SRC        GATEWAY             DISTANCE
 0 ADC  199.1.1.0/24        199.1.1.1       ether2                     0
 1 ADb  199.3.3.0/24                        199.5.5.33                20
 2 ADC  199.5.5.0/24        199.5.5.11      ether5                     0
 3 ADC  200.1.1.1/32        200.1.1.1       loopback0                  0
```

BGP ingress Filters Team Cymru

- http://www.team-cymru.org/
- A bogon prefix should never appear in the Internet routing table.
  - bogon route-servers
    - 65333:888
  - fullbogon route-servers
    - 65332:888

http://www.team-cymru.org/bgp-examples.html#mikrotik-full

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Internet eXchange Point (IXP) Configuration

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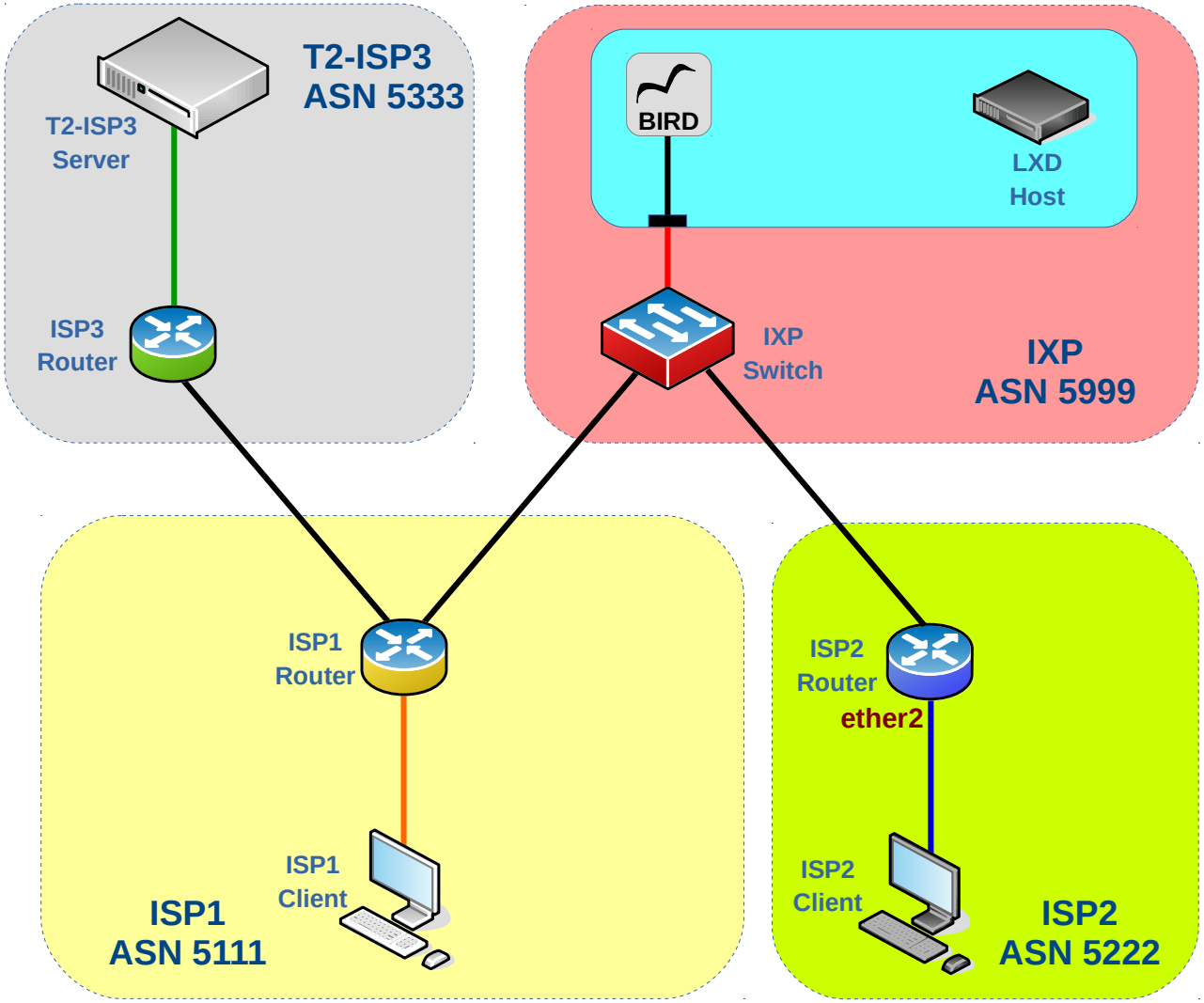
Demonstration testbed, IXP added



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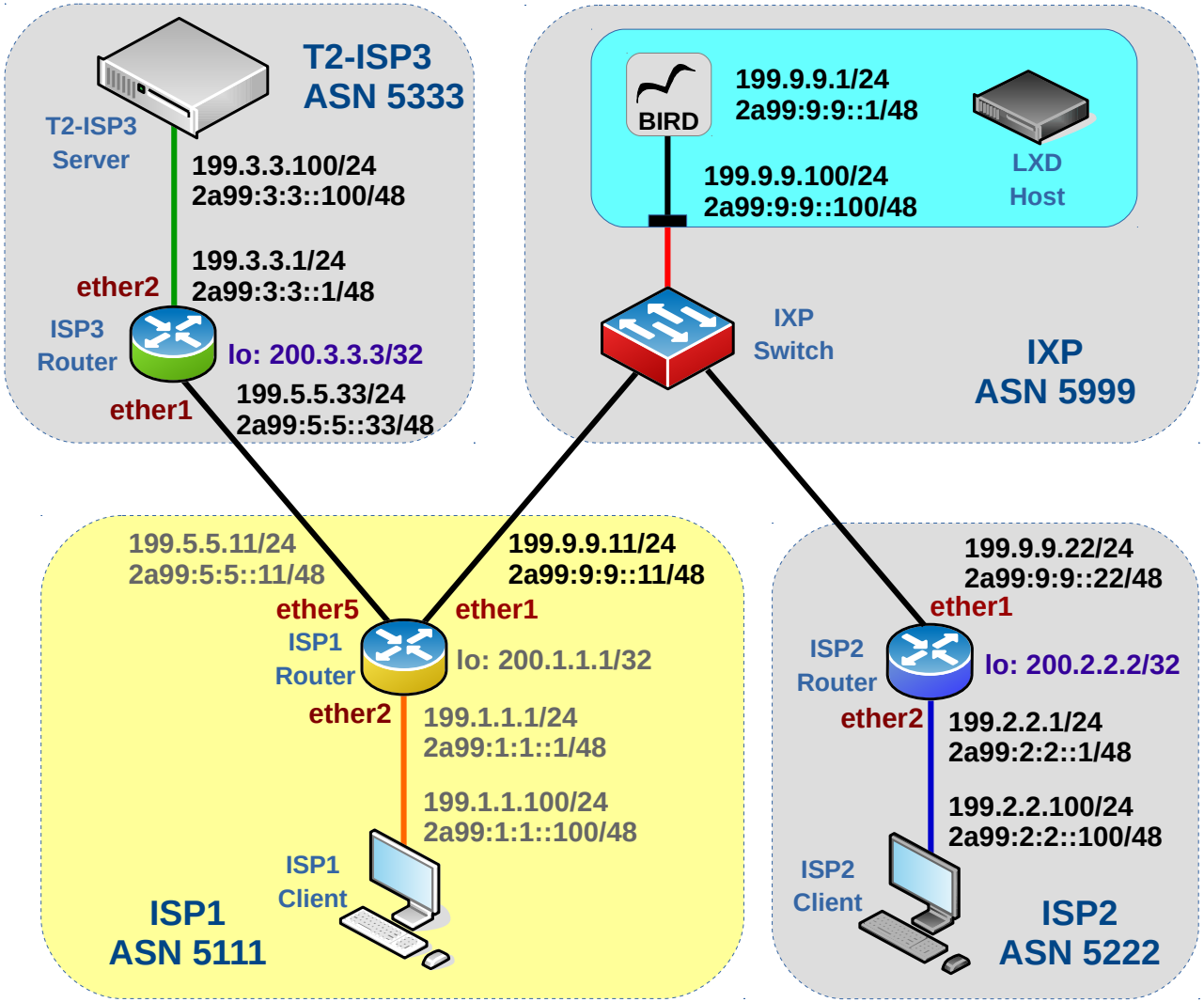
Demonstration testbed, IXP added



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ISP1 – IP Address on IXP interface

- Add IP Addresses to the interface facing the IXP

```
ip address add address=199.9.9.11/24 interface=ether1

ipv6 address add address=2a99:9:9::11/48 interface=ether1

ip address print
Flags: X - disabled, I - invalid, D - dynamic
 #   ADDRESS            NETWORK         INTERFACE
 0   200.1.1.1/32       200.1.1.1       loopback0
 1   199.5.5.11/24      199.5.5.0       ether5
 2   199.1.1.1/24       199.1.1.0       ether2
 3   199.9.9.11/24      199.9.9.0       ether1

ipv6 address print
Flags: X - disabled, I - invalid, D - dynamic, G - global, L - link-local
 #    ADDRESS                                FROM-POOL INTERFACE   ADVERTISE
 0 DL fe80::20c:42ff:fec2:117c/64                      ether2       no
 1 DL fe80::20c:42ff:fec2:117e/64                      ether4       no
 2 DL fe80::20c:42ff:fec2:117f/64                      ether5       no
 3  G 2a99:5:5::11/48                                  ether5       yes
 4 DL fe80::20c:42ff:fec2:117d/64                      ether3       no
 5  G 2a99:1:1::1/48                                   ether2       yes
 6 DL fe80::20c:42ff:fec2:117b/64                      ether1       no
 7  G 2a99:9:9::11/48                                  ether1       yes
```

ISP1 – Routing filters for IXP

- Chains IN-IXP-IPv4 and IN-IXP-IPv6 are input filters that discards receiving ones own prefix or a default route as full routing is taking place
  - IPv4

```
routing filter add chain=IN-IXP-IPv4 prefix=199.1.1.0/24 action=discard
routing filter add chain=IN-IXP-IPv4 prefix=0.0.0.0/0 action=discard
routing filter add chain=IN-IXP-IPv4 action=jump jump-target=IN-RFC-6890-IPv4
```

  - IPv6

```
routing filter add chain=IN-IXP-IPv6 prefix=2a99:1:1::/48 action=discard
routing filter add chain=IN-IXP-IPv6 prefix=::/0 action=discard
routing filter add chain=IN-IXP-IPv6 action=jump jump-target=IN-RFC-6890-IPv6
```

Add IXP Route Server as a BGP Peer

- Create the peer link to the IXP for IPv4 and IPv6
- Note that IPv4 family is the default and for IPv6 the family must be specified
  - IPv4

```
routing bgp peer add name=ixp instance=ASN5111 remote-as=5999
remote-address=199.9.9.1 in-filter=IN-IXP-IPv4 out-filter=OUT-IPv4
```

  - IPv6

```
routing bgp peer add name=ixp instance=ASN5111 remote-as=5999
remote-address=2a99:9:9::1 address-families=ipv6 in-filter=IN-IXP-IPv6
out-filter=OUT-IPv6
```

Confirm peering with IXP

- Confirm that the routes have been learnt from IXP

```
routing bgp peer print
Flags: X - disabled, E - established
 #    INSTANCE                    REMOTE-ADDRESS                  REMOTE-AS
 0 E  ASN5111                     199.5.5.33                      5333
 1 E  ASN5111                     2a99:5:5::33                    5333
 2 E  ASN5111                     199.9.9.1                       5999
 3 E  ASN5111                     2a99:9:9::1                     5999


ip route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
 #      DST-ADDRESS         PREF-SRC        GATEWAY             DISTANCE
 0 ADC  199.1.1.0/24        199.1.1.1       ether2                     0
 1 ADb  199.2.2.0/24                        199.9.9.22                20
 2 ADb  199.3.3.0/24                        199.5.5.33                20
 3 ADC  199.5.5.0/24        199.5.5.11      ether5                     0
 4 ADC  199.9.9.0/24        199.9.9.11      ether1                     0
 5 ADC  200.1.1.1/32        200.1.1.1       loopback0                  0
```

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Thank you for your attention

Complete configurations can be found at:

http://www.obriain.com/mikrotik

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