



BGP and the Internet

Transit and Internet Exchange Points

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Definitions

- **Transit** – carrying traffic across a network, usually for a fee

traffic and prefixes originating from one AS are carried across an intermediate AS to reach their destination AS

- **Exchange Points** – common interconnect location where several ASes exchange routing information and traffic

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ISP Transit Issues

- Only announce default to your BGP customers unless they need more prefixes
- Only accept the prefixes which your customer is entitled to originate
- If your customer hasn't told you he is providing transit, don't accept anything else

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ISP Transit Issues

Many mistakes are made on the Internet today due to incomplete understanding of how to configure BGP for transit

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ISP Transit Provider

Simple Example

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ISP Transit

- AS130 and AS100 are stub/customer ASes of AS120

they may have their own peerings with other ASes

minimal routing table desired

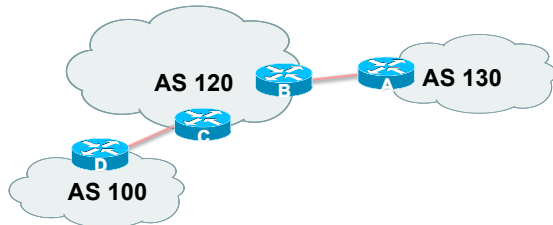
minimum complexity required

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ISP Transit



- AS120 is transit provider between AS130 and AS100

ISP Transit

• Router A Configuration

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.12.10.2 remote-as 120
 neighbor 122.12.10.2 prefix-list upstream out
 neighbor 122.12.10.2 prefix-list default in
 !
 ip prefix-list default permit 0.0.0.0/0
 ip prefix-list upstream permit 121.10.0.0/19
 !
 ip route 121.10.0.0 255.255.224.0 null0
```

ISP Transit

• Router B Configuration

```
router bgp 120
 neighbor 122.12.10.1 remote-as 130
 neighbor 122.12.10.1 default-originate
 neighbor 122.12.10.1 prefix-list Customer130 in
 neighbor 122.12.10.1 prefix-list default out
 !
 ip prefix-list Customer130 permit 121.10.0.0/19
 ip prefix-list default permit 0.0.0.0/0
```

- Router B announces default to Router A, only accepts customer /19

ISP Transit

• Router C Configuration

```
router bgp 120
 neighbor 122.12.20.1 remote-as 100
 neighbor 122.12.20.1 default-originate
 neighbor 122.12.20.1 prefix-list Customer100 in
 neighbor 122.12.20.1 prefix-list default out
 !
 ip prefix-list Customer100 permit 109.0.0.0/19
 ip prefix-list default permit 0.0.0.0/0
```

- Router C announces default to Router D, only accepts customer /19

ISP Transit

• Router D Configuration

```
router bgp 100
 network 109.0.0.0 mask 255.255.224.0
 neighbor 122.12.20.2 remote-as 120
 neighbor 122.12.20.2 prefix-list upstream out
 neighbor 122.12.20.2 prefix-list default in
 !
 ip prefix-list default permit 0.0.0.0/0
 ip prefix-list upstream permit 109.0.0.0/19
 !
 ip route 109.0.0.0 255.255.224.0 null0
```

ISP Transit

• This is simple case:

if AS130 or AS100 get another address block, it requires AS120 and their own filters to be changed

some ISP transit provider are better skilled at doing this than others!

May not scale if they are frequently adding new prefixes

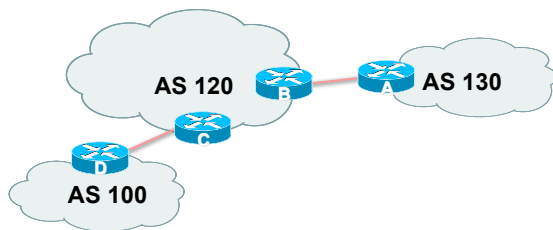
ISP Transit Provider

More complex Example 1

ISP Transit

- AS130 and AS100 are stub/customer ASes of AS120
 - AS120 provides transit between AS130 and AS100 only
 - AS120 does not provide Internet connectivity to AS130

ISP Transit



- AS120 is transit provider between AS130 and AS100

ISP Transit

- Router A Configuration


```

router bgp 130
network 121.10.0.0 mask 255.255.224.0
neighbor 122.12.10.2 remote-as 120
neighbor 122.12.10.2 prefix-list upstream out
neighbor 122.12.10.2 prefix-list bogons in
!
ip prefix-list upstream permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.224.0 null0
            
```

ISP Transit

- Router B Configuration


```

router bgp 120
neighbor 122.12.10.1 remote-as 130
neighbor 122.12.10.1 prefix-list Customer130 in
neighbor 122.12.10.1 prefix-list bogons out
neighbor 122.12.10.1 filter-list 15 out
!
ip as-path access-list 15 permit ^$
ip as-path access-list 15 permit ^100$
ip prefix-list Customer130 permit 121.10.0.0/19
            
```
- Router B announces AS120 and AS100 prefixes to Router A, only accepts customer /19

ISP Transit

- Router C Configuration


```

router bgp 120
neighbor 122.12.20.1 remote-as 100
neighbor 122.12.20.1 default-originate
neighbor 122.12.20.1 prefix-list Customer100 in
neighbor 122.12.20.1 prefix-list default out
!
ip prefix-list Customer100 permit 109.0.0.0/19
ip prefix-list default permit 0.0.0.0/0
            
```
- Router C announces default to Router D, only accepts customer /19

ISP Transit

- Router D Configuration

```
router bgp 100
  network 109.0.0.0 mask 255.255.224.0
  neighbor 122.12.20.2 remote-as 120
  neighbor 122.12.20.2 prefix-list upstream out
  neighbor 122.12.20.2 prefix-list default in
  !
ip prefix-list default permit 0.0.0.0/0
ip prefix-list upstream permit 109.0.0.0/19
!
ip route 109.0.0.0 255.255.224.0 null0
```

ISP Transit

- AS130 only hears AS120 and AS100 prefixes

inbound AS path filter on Router A is optional, but good practice (never trust a peer)

inbound Martian prefix-list filters are mandatory on all Internet peerings



ISP Transit Provider

More complex Example 2

ISP Transit

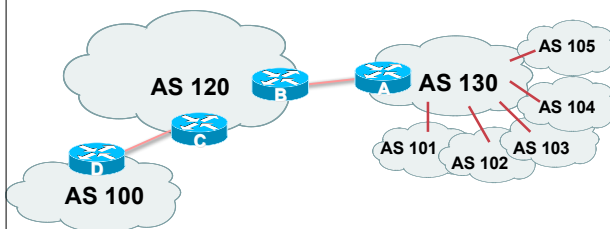
- AS130 and AS100 are stub/customer ASes of AS120

AS130 has many customers with their own ASes

AS105 doesn't get announced to AS120

AS120 provides transit between AS130 and AS100

ISP Transit



- AS130 has several customer ASes connecting to its backbone

ISP Transit

- Router A Configuration

```
router bgp 130
  network 121.10.0.0 mask 255.255.224.0
  neighbor 122.12.10.2 remote-as 120
  neighbor 122.12.10.2 prefix-list upstream-out out
  neighbor 122.12.10.2 filter-list 5 out
  neighbor 122.12.10.2 prefix-list upstream-in in
  !
ip route 121.10.0.0 255.255.224.0 null0 250
!
..next slide
```

ISP Transit

```
!  
! As-path filters..  
ip as-path access-list 5 permit ^$  
ip as-path access-list 5 permit ^(101_)+$  
ip as-path access-list 5 permit ^102$  
ip as-path access-list 5 permit ^103$  
ip as-path access-list 5 permit ^104$  
ip as-path access-list 5 deny ^105_  
!  
..next slide
```

ISP Transit

```
! Outbound Martian prefixes to be blocked to eBGP peers  
ip prefix-list upstream-out deny 0.0.0.0/8 le 32  
ip prefix-list upstream-out deny 10.0.0.0/8 le 32  
ip prefix-list upstream-out deny 127.0.0.0/8 le 32  
ip prefix-list upstream-out deny 169.254.0.0/16 le 32  
ip prefix-list upstream-out deny 172.16.0.0/12 le 32  
ip prefix-list upstream-out deny 192.0.2.0/24 le 32  
ip prefix-list upstream-out deny 192.168.0.0/16 le 32  
ip prefix-list upstream-out deny 224.0.0.0/3 le 32  
ip prefix-list upstream-out deny 0.0.0.0/0 ge 25  
! Extra prefixes  
ip prefix-list upstream-out deny 121.10.0.0/19 ge 20  
ip prefix-list upstream-out permit 0.0.0.0/0 le 32  
..next slide
```

ISP Transit

```
! Inbound Martian prefixes to be blocked from eBGP peers  
ip prefix-list upstream-in deny 0.0.0.0/8 le 32  
ip prefix-list upstream-in deny 10.0.0.0/8 le 32  
ip prefix-list upstream-in deny 127.0.0.0/8 le 32  
ip prefix-list upstream-in deny 169.254.0.0/16 le 32  
ip prefix-list upstream-in deny 172.16.0.0/12 le 32  
ip prefix-list upstream-in deny 192.0.2.0/24 le 32  
ip prefix-list upstream-in deny 192.168.0.0/16 le 32  
ip prefix-list upstream-in deny 224.0.0.0/3 le 32  
ip prefix-list upstream-in deny 0.0.0.0/0 ge 25  
! Extra prefixes  
ip prefix-list upstream-in deny 121.10.0.0/19 le 32  
ip prefix-list upstream-in permit 0.0.0.0/0 le 32  
!
```

ISP Transit

• Router B Configuration

```
router bgp 120  
neighbor 122.12.10.1 remote-as 130  
neighbor 122.12.10.1 prefix-list bogons in  
neighbor 122.12.10.1 prefix-list bogons out  
neighbor 122.12.10.1 filter-list 10 in  
neighbor 122.12.10.1 filter-list 15 out  
!  
ip as-path access-list 15 permit ^$  
ip as-path access-list 15 permit ^100$
```

Router B announces AS120 and AS100 prefixes to Router A, and accepts all AS130 customer ASes

ISP Transit

• Router C Configuration

```
router bgp 120  
neighbor 122.12.20.1 remote-as 100  
neighbor 122.12.20.1 default-originate  
neighbor 122.12.20.1 prefix-list Customer100 in  
neighbor 122.12.20.1 prefix-list default out  
!  
ip prefix-list Customer100 permit 109.0.0.0/19  
ip prefix-list default permit 0.0.0.0/0
```

• Router C announces default to Router D, only accepts customer /19

ISP Transit

• Router D Configuration

```
router bgp 100  
network 109.0.0.0 mask 255.255.224.0  
neighbor 122.12.20.2 remote-as 120  
neighbor 122.12.20.2 prefix-list upstream out  
neighbor 122.12.20.2 prefix-list default in  
!  
ip prefix-list default permit 0.0.0.0/0  
ip prefix-list upstream permit 109.0.0.0/19  
!  
ip route 109.0.0.0 255.255.224.0 null0
```

ISP Transit

- **AS130 only hears AS120 and AS100 prefixes**
inbound AS path filter on Router A is optional, but good practice (never trust a peer)
Special Use Address prefix-list filters are required on all Internet peerings



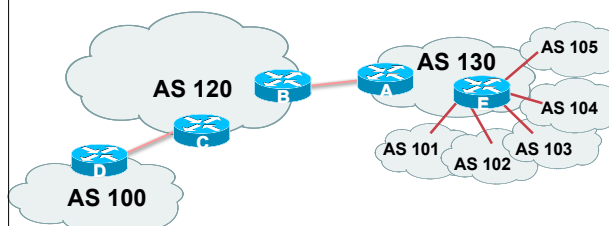
ISP Transit Provider

More complex Example 3

ISP Transit

- **AS130 and AS100 are stub/customer ASes of AS120**
AS130 has many customers with their own ASes
AS105 doesn't get announced to AS120
AS120 provides transit between AS130 and AS100
- Same example as previously but using communities

ISP Transit



- **AS130 has several customer ASes connecting to its backbone**

ISP Transit

- **Router A configuration is greatly simplified**
all prefixes to be announced to upstream are marked with community 130:5100
route-map on outbound peering implements community policy
Martian prefix-lists still required

ISP Transit

- **Router A Configuration**

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0 route-map setcomm
 neighbor 122.12.10.2 remote-as 120
 neighbor 122.12.10.2 prefix-list upstream-out out
 neighbor 122.12.10.2 route-map to-AS120 out
 neighbor 122.12.10.2 prefix-list upstream-in in
!
 ip route 121.10.0.0 255.255.224.0 null0 250
!
..next slide
```

ISP Transit

```
!  
ip community-list 5 permit 130:5100  
!  
! Set community on local prefixes  
route-map setcomm permit 10  
  set community 130:5100  
!  
route-map to-AS120 permit 10  
  match community 5  
!
```

- **upstream-in** and **upstream-out** prefix-lists are the same as in the previous example

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ISP Transit

- **Router E Configuration**

```
router bgp 130  
  neighbor x.x.x.x remote-as 101  
  neighbor x.x.x.x default-originate  
  neighbor x.x.x.x prefix-list customer101 in  
  neighbor x.x.x.x route-map bgp-cust-in in  
  neighbor x.x.x.x prefix-list default out  
  neighbor x.x.x.x remote-as 102  
  neighbor x.x.x.x default-originate  
  neighbor x.x.x.x prefix-list customer102 in  
  neighbor x.x.x.x route-map bgp-cust-in in  
  neighbor x.x.x.x prefix-list default out  
  ..next slide
```

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ISP Transit

```
neighbor s.s.s.s remote-as 105  
neighbor s.s.s.s default-originate  
neighbor s.s.s.s prefix-list customer105 in  
neighbor s.s.s.s route-map no-transit in  
neighbor s.s.s.s prefix-list default out  
!  
! Set community on eBGP customers announced to AS120  
route-map bgp-cust-in permit 10  
  set community 130:5100  
route-map no-transit permit 10  
  set community 130:5199
```

Notice that AS105 peering has no route-map to set the community policy

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ISP Transit

- **AS130 only announces the community 130:5100 to AS120**
- **Notice how Router E tags the prefixes to be announced to AS120 with community 130:5100**
- **More efficient to manage than using filter lists**

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Exchange Points

Simple Example

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Exchange Point Example

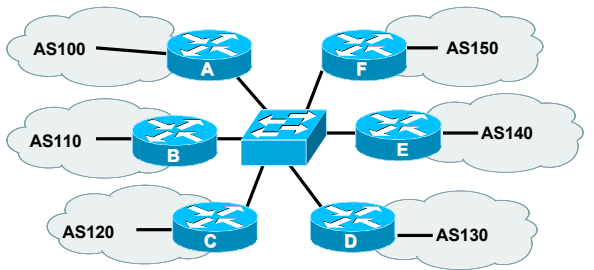
- **Exchange point with 6 ASes present**
Layer 2 – ethernet switch
- **Each ISP peers with the other**
NO transit across the IXP allowed

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Exchange Point



each of these represents a border router in a different autonomous system

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Exchange Point Router A configuration

```
interface fastethernet 0/0
  description Exchange Point LAN
  ip address 120.5.10.2 mask 255.255.255.224
  ip verify unicast reverse-path
  no ip directed-broadcast
  no ip proxy-arp
  no ip redirects
  !
router bgp 100
  neighbor ixp-peers peer-group
  neighbor ixp-peers send-community
  neighbor ixp-peers prefix-list myprefixes out
  neighbor ixp-peers route-map set-local-pref in
  ..next slide
```

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Exchange Point

```
neighbor 120.5.10.2 remote-as 110
neighbor 120.5.10.2 peer-group ixp-peers
neighbor 120.5.10.2 prefix-list peer110 in
neighbor 120.5.10.3 remote-as 120
neighbor 120.5.10.3 peer-group ixp-peers
neighbor 120.5.10.3 prefix-list peer120 in
neighbor 120.5.10.4 remote-as 130
neighbor 120.5.10.4 peer-group ixp-peers
neighbor 120.5.10.4 prefix-list peer130 in
neighbor 120.5.10.5 remote-as 140
neighbor 120.5.10.5 peer-group ixp-peers
neighbor 120.5.10.5 prefix-list peer140 in
neighbor 120.5.10.6 remote-as 150
neighbor 120.5.10.6 peer-group ixp-peers
neighbor 120.5.10.6 prefix-list peer150 in
```

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Exchange Point

```
ip route 121.10.0.0 255.255.224.0 null0
!
ip prefix-list myprefixes permit 121.10.0.0/19
ip prefix-list peer110 permit 122.0.0.0/19
ip prefix-list peer120 permit 122.30.0.0/19
ip prefix-list peer130 permit 122.12.0.0/19
ip prefix-list peer140 permit 122.18.128.0/19
ip prefix-list peer150 permit 122.1.32.0/19
!
route-map set-local-pref permit 10
  set local-preference 150
!
```

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Exchange Point

- Configuration of the other routers in the AS is similar in concept
- Notice inbound and outbound prefix filters
 - outbound announces **myprefixes** only
 - inbound accepts **peer** prefixes only
- Notice inbound route-map
 - Set local preference higher than default ensures that local traffic crosses the exchange

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Exchange Point

- Ethernet port configuration
 - use *ip verify unicast reverse-path*
 - helps prevent “stealing of bandwidth”
- IXP border router must **NOT** carry prefixes with origin outside local AS and IXP participant ASes
 - helps prevent “stealing of bandwidth”

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Exchange Point

- **Issues:**
 - AS100 needs to know all the prefixes its peers are announcing
 - New prefixes requires the prefix-lists to be updated
- **Alternative solutions**
 - Use the Internet Routing Registry to build prefix list
 - Use AS Path filters (could be risky)



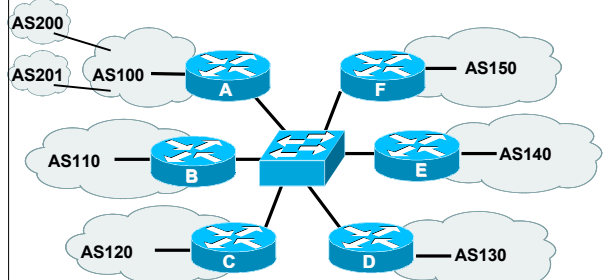
Exchange Points

More Complex Example

Exchange Point Example

- **Exchange point with 6 ASes present**
 - Layer 2 – ethernet switch
- **Each ISP peers with the other**
 - NO transit across the IXP allowed
 - ISPs at exchange points provide transit to their customers

Exchange Point



each of these represents a border router in a different autonomous system

Exchange Point Router A configuration

```
interface fastethernet 0/0
  description Exchange Point LAN
  ip address 120.5.10.2 mask 255.255.255.224
  ip verify unicast reverse-path
  no ip directed-broadcast
  no ip proxy-arp
  no ip redirects
  !
router bgp 100
  neighbor ixp-peers peer-group
  neighbor ixp-peers send-community
  neighbor ixp-peers prefix-list bogons out
  neighbor ixp-peers filter-list 10 out
  neighbor ixp-peers route-map set-local-pref in
  ..next slide
```

Exchange Point

```
neighbor 120.5.10.2 remote-as 110
neighbor 120.5.10.2 peer-group ixp-peers
neighbor 120.5.10.2 prefix-list peer110 in
neighbor 120.5.10.3 remote-as 120
neighbor 120.5.10.3 peer-group ixp-peers
neighbor 120.5.10.3 prefix-list peer120 in
neighbor 120.5.10.4 remote-as 130
neighbor 120.5.10.4 peer-group ixp-peers
neighbor 120.5.10.4 prefix-list peer130 in
neighbor 120.5.10.5 remote-as 140
neighbor 120.5.10.5 peer-group ixp-peers
neighbor 120.5.10.5 prefix-list peer140 in
neighbor 120.5.10.6 remote-as 150
neighbor 120.5.10.6 peer-group ixp-peers
neighbor 120.5.10.6 prefix-list peer150 in
```

Exchange Point

```
ip route 121.10.0.0 255.255.224.0 null0
!
ip as-path access-list 10 permit ^$
ip as-path access-list 10 permit ^200$
ip as-path access-list 10 permit ^201$
!
ip prefix-list myprefixes permit 121.10.0.0/19
ip prefix-list peer110 permit 122.0.0.0/19
ip prefix-list peer120 permit 122.30.0.0/19
ip prefix-list peer130 permit 122.12.0.0/19
ip prefix-list peer140 permit 122.18.128.0/19
ip prefix-list peer150 permit 122.1.32.0/19
!
route-map set-local-pref permit 10
  set local-preference 150
```

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Exchange Point

- Notice the change in router A's configuration
 - filter-list instead of prefix-list permits local and customer ASes out to exchange
 - prefix-list blocks Special Use Address prefixes – rest get out, could be risky
- Other issues as previously

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