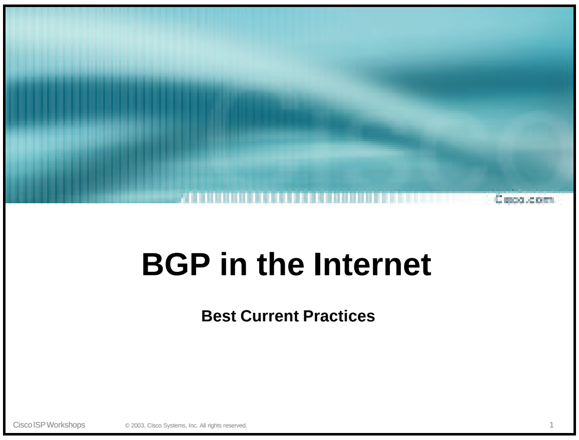
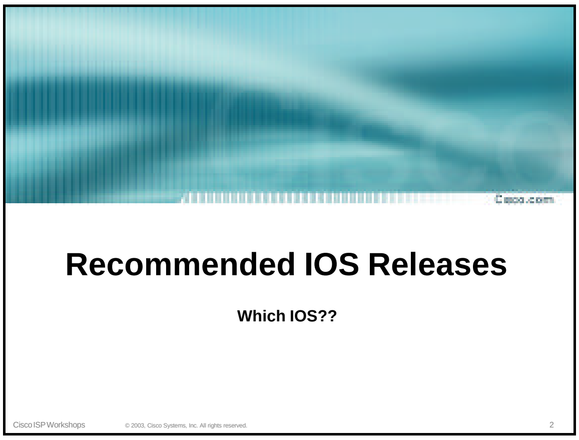


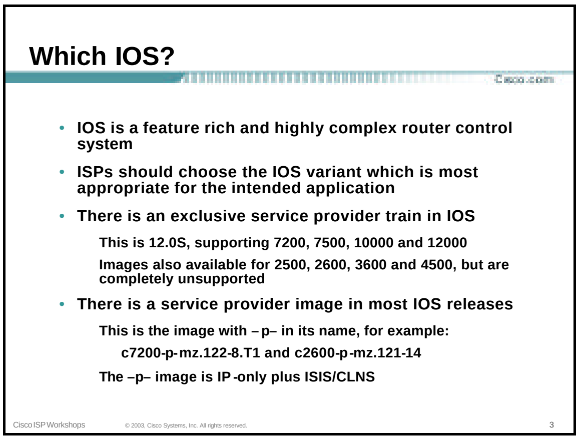
BGP in the Internet

Best Current Practices



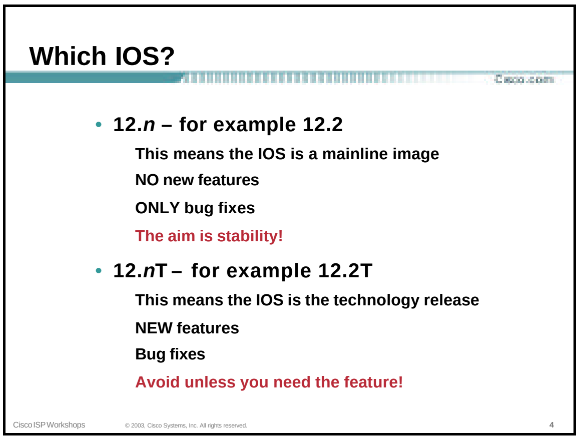
Recommended IOS Releases

Which IOS??



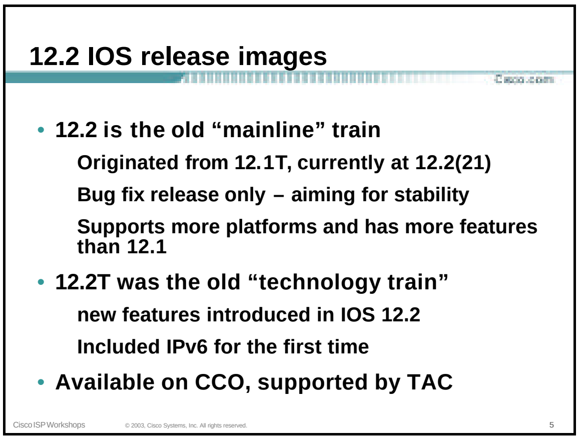
Which IOS?

- IOS is a feature rich and highly complex router control system
- ISPs should choose the IOS variant which is most appropriate for the intended application
- There is an exclusive service provider train in IOS
  - This is 12.0S, supporting 7200, 7500, 10000 and 12000
  - Images also available for 2500, 2600, 3600 and 4500, but are completely unsupported
- There is a service provider image in most IOS releases
  - This is the image with –p– in its name, for example:
    - c7200-p-mz.122-8.T1 and c2600-p-mz.121-14
  - The –p– image is IP-only plus ISIS/CLNS



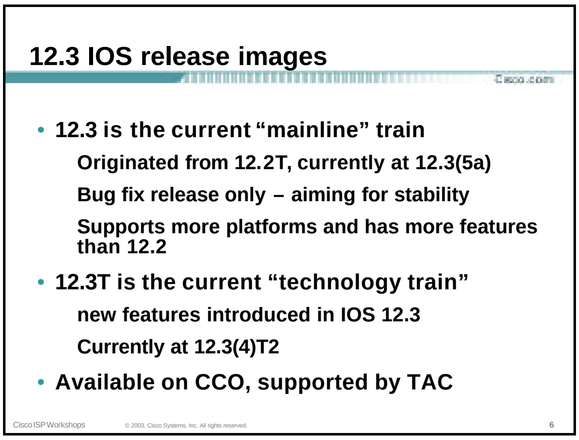
Which IOS?

- 12.*n* – for example 12.2
  - This means the IOS is a mainline image
  - NO new features
  - ONLY bug fixes
  - The aim is stability!
- 12.*n*T – for example 12.2T
  - This means the IOS is the technology release
  - NEW features
  - Bug fixes
  - Avoid unless you need the feature!



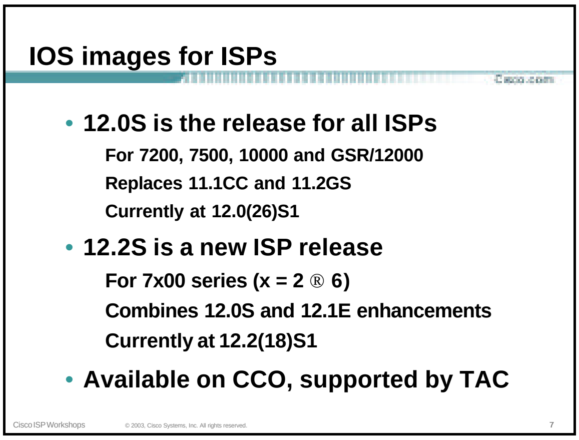
12.2 IOS release images

- 12.2 is the old “mainline” train
  - Originated from 12.1T, currently at 12.2(21)
  - Bug fix release only – aiming for stability
  - Supports more platforms and has more features than 12.1
- 12.2T was the old “technology train”
  - new features introduced in IOS 12.2
  - Included IPv6 for the first time
- Available on CCO, supported by TAC



12.3 IOS release images

- 12.3 is the current “mainline” train
  - Originated from 12.2T, currently at 12.3(5a)
  - Bug fix release only – aiming for stability
  - Supports more platforms and has more features than 12.2
- 12.3T is the current “technology train”
  - new features introduced in IOS 12.3
  - Currently at 12.3(4)T2
- Available on CCO, supported by TAC

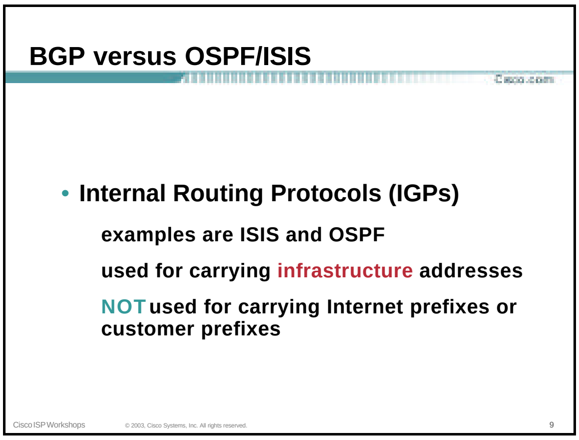


IOS images for ISPs

- 12.0S is the release for all ISPs
  - For 7200, 7500, 10000 and GSR/12000
  - Replaces 11.1CC and 11.2GS
  - Currently at 12.0(26)S1
- 12.2S is a new ISP release
  - For 7x00 series (x = 2 ® 6)
  - Combines 12.0S and 12.1E enhancements
  - Currently at 12.2(18)S1
- Available on CCO, supported by TAC

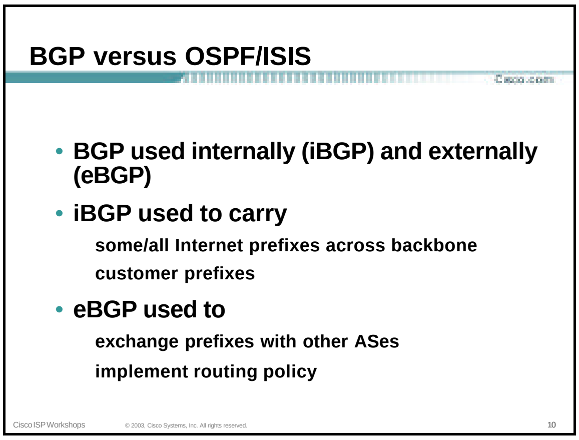
What is BGP for??

What is an IGP not for?



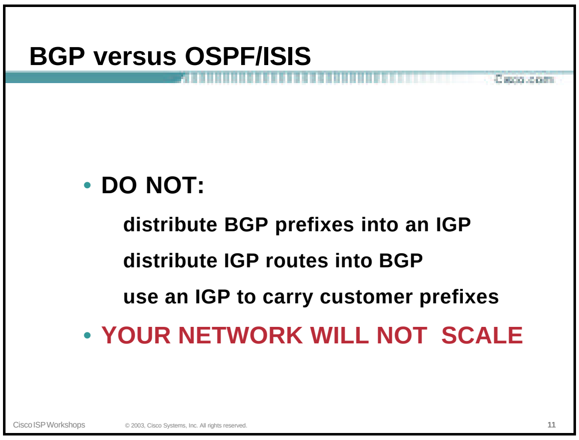
BGP versus OSPF/ISIS

- Internal Routing Protocols (IGPs)
  - examples are ISIS and OSPF
  - used for carrying infrastructure addresses
  - NOT used for carrying Internet prefixes or customer prefixes



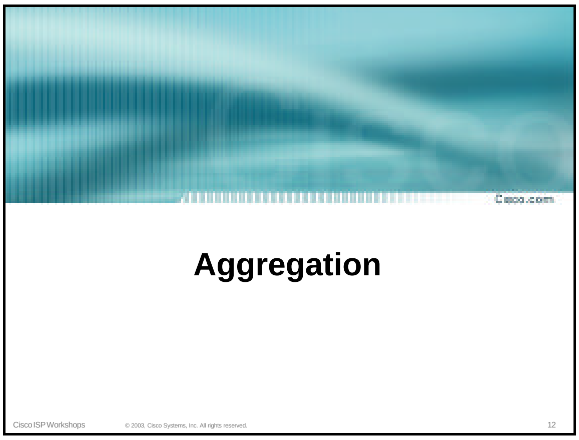
BGP versus OSPF/ISIS

- BGP used internally (iBGP) and externally (eBGP)
- iBGP used to carry
  - some/all Internet prefixes across backbone
  - customer prefixes
- eBGP used to
  - exchange prefixes with other ASes
  - implement routing policy



BGP versus OSPF/ISIS

- DO NOT:
  - distribute BGP prefixes into an IGP
  - distribute IGP routes into BGP
  - use an IGP to carry customer prefixes
- YOUR NETWORK WILL NOT SCALE



Aggregation

Aggregation

- Aggregation means announcing the address block received from the RIR to the other ASes connected to your network
- Subprefixes of this aggregate *may* be:
  - Used internally in the ISP network
  - Announced to other ASes to aid with multihoming
- Unfortunately too many people are still thinking about class Cs, resulting in a proliferation of /24s in the Internet routing table

Configuring Aggregation – Cisco IOS

- ISP has 221.10.0.0/19 address block
- To put into BGP as an aggregate:

```
router bgp 100
 network 221.10.0.0 mask 255.255.224.0
ip route 221.10.0.0 255.255.224.0 null0
```

- The static route is a “pull up” route
  - more specific prefixes within this address block ensure connectivity to ISP’s customers
  - “longest match lookup”

Aggregation

- Address block should be announced to the Internet as an aggregate
- Subprefixes of address block should NOT be announced to Internet unless special circumstances (more later)
- Aggregate should be generated internally
  - Not on the network borders!

Announcing Aggregate – Cisco IOS

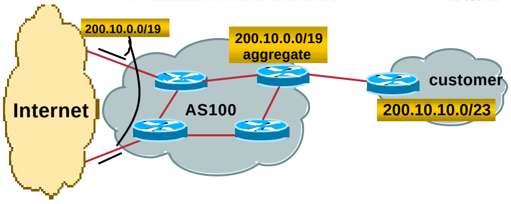
- Configuration Example

```
router bgp 100
 network 221.10.0.0 mask 255.255.224.0
 neighbor 222.222.10.1 remote-as 101
 neighbor 222.222.10.1 prefix-list out-filter out
!
ip route 221.10.0.0 255.255.224.0 null0
!
ip prefix-list out-filter permit 221.10.0.0/19
ip prefix-list out-filter deny 0.0.0.0/0 le 32
```

Announcing an Aggregate

- ISPs who don’t and won’t aggregate are held in poor regard by community
- Registries’ minimum allocation size is a /20
  - no real reason to see anything longer than a /21 prefix in the Internet
  - BUT there are currently >71000 /24s!

Aggregation – Example



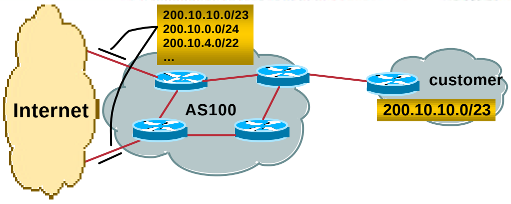
- Customer has /23 network assigned from AS100’s /19 address block
- AS100 announced /19 aggregate to the Internet

Aggregation – Good Example

- Customer link goes down
  - their /23 network becomes unreachable
  - /23 is withdrawn from AS100's iBGP
- /19 aggregate is still being announced
  - no BGP hold down problems
  - no BGP propagation delays
  - no damping by other ISPs

- Customer link returns
- Their /23 network is visible again
  - The /23 is re-injected into AS100's iBGP
- The whole Internet becomes visible immediately
- Customer has Quality of Service perception

Aggregation – Example



- Customer has /23 network assigned from AS100's /19 address block
- AS100 announces customers' individual networks to the Internet

Aggregation – Bad Example

- Customer link goes down
  - Their /23 network becomes unreachable
  - /23 is withdrawn from AS100's iBGP
- Their ISP doesn't aggregate its /19 network block
  - /23 network withdrawal announced to peers
  - starts rippling through the Internet
  - added load on all Internet backbone routers as network is removed from routing table

- Customer link returns
  - Their /23 network is now visible to their ISP
  - Their /23 network is re-advertised to peers
  - Starts rippling through Internet
  - Load on Internet backbone routers as network is reinserted into routing table
  - Some ISP's suppress the flaps
  - Internet may take 10-20 min or longer to be visible
  - Where is the Quality of Service???

Aggregation – Summary

- Good example is what everyone should do!
  - Adds to Internet stability
  - Reduces size of routing table
  - Reduces routing churn
  - Improves Internet QoS for everyone
- Bad example is what too many still do!
  - Why? Lack of knowledge?

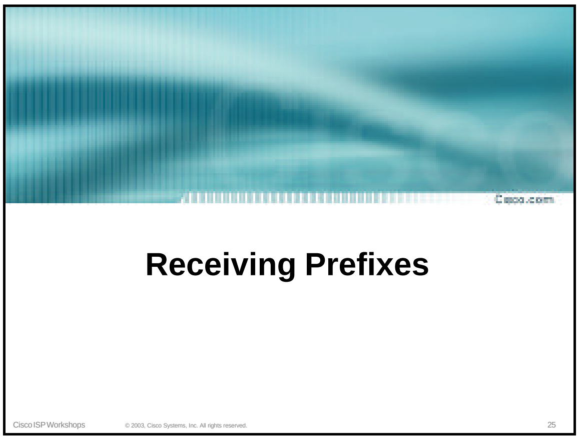
The Internet Today (January 2004)

- Current Internet Routing Table Statistics

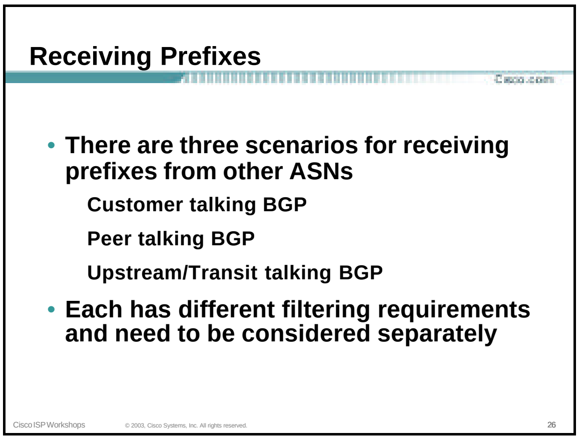
BGP Routing Table Entries	131486
Prefixes after maximum aggregation	80923
Unique prefixes in Internet	63391
Prefixes smaller than registry alloc	57949
/24s announced	71643
only 5521 /24s are from 192.0.0.0/8	
ASes in use	16426

Efforts to improve aggregation

- The CIDR Report
  - Initiated and operated for many years by Tony Bates
  - Now combined with Geoff Huston's routing analysis
    - www.cidr-report.org
  - Results e-mailed on a weekly basis to most operations lists around the world
  - Lists the top 30 service providers who could do better at aggregating

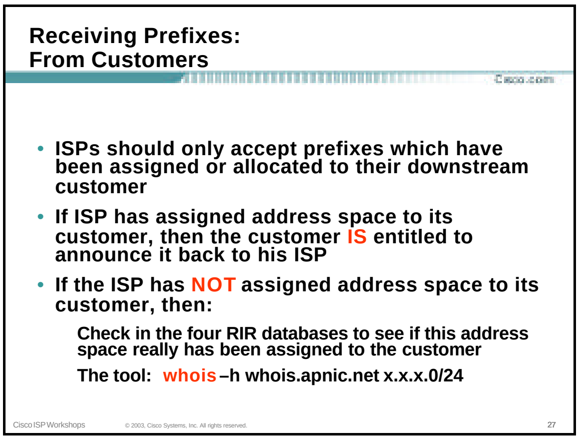


Receiving Prefixes



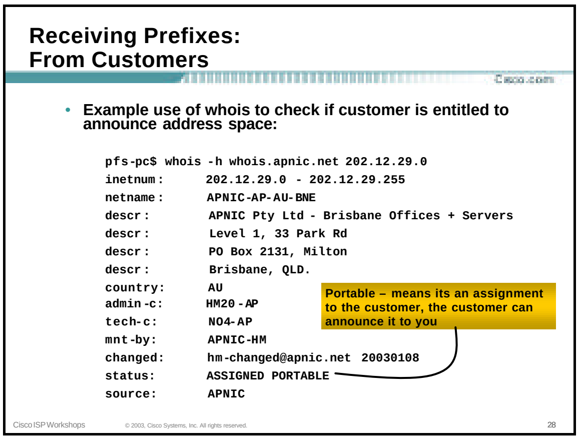
Receiving Prefixes

- There are three scenarios for receiving prefixes from other ASNs
  - Customer talking BGP
  - Peer talking BGP
  - Upstream/Transit talking BGP
- Each has different filtering requirements and need to be considered separately



Receiving Prefixes: From Customers

- ISPs should only accept prefixes which have been assigned or allocated to their downstream customer
- If ISP has assigned address space to its customer, then the customer IS entitled to announce it back to his ISP
- If the ISP has NOT assigned address space to its customer, then:
  - Check in the four RIR databases to see if this address space really has been assigned to the customer
  - The tool: whois –h whois.apnic.net x.x.x.0/24

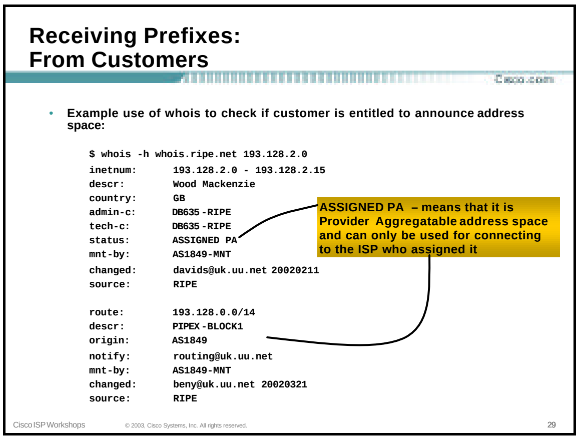


Receiving Prefixes: From Customers

- Example use of whois to check if customer is entitled to announce address space:

```
pfs-pc$ whois -h whois.apnic.net 202.12.29.0
inetnum:      202.12.29.0 - 202.12.29.255
netname:      APNIC-AP-AU-BNE
descr:        APNIC Pty Ltd - Brisbane Offices + Servers
descr:        Level 1, 33 Park Rd
descr:        PO Box 2131, Milton
descr:        Brisbane, QLD.
country:      AU
admin-c:      HM20-AP
tech-c:       NO4-AP
mnt-by:       APNIC-HM
changed:      hm-changed@apnic.net  20030108
status:       ASSIGNED PORTABLE
source:       APNIC
```

Portable – means its an assignment to the customer, the customer can announce it to you



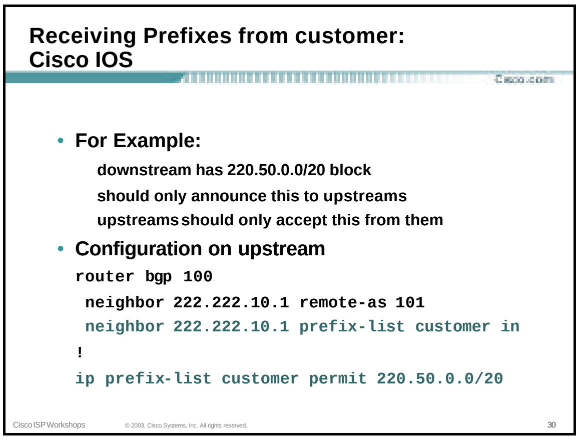
Receiving Prefixes: From Customers

- Example use of whois to check if customer is entitled to announce address space:

```
$ whois -h whois.ripe.net 193.128.2.0
inetnum:      193.128.2.0 - 193.128.2.15
descr:        Wood Mackenzie
country:      GB
admin-c:      DB635-RIPE
tech-c:       DB635-RIPE
status:       ASSIGNED PA
mnt-by:       AS1849-MNT
changed:      davids@uk.uu.net 20020211
source:       RIPE

route:        193.128.0.0/14
descr:        PIPEX-BLOCK1
origin:       AS1849
notify:       routing@uk.uu.net
mnt-by:       AS1849-MNT
changed:      beny@uk.uu.net 20020321
source:       RIPE
```

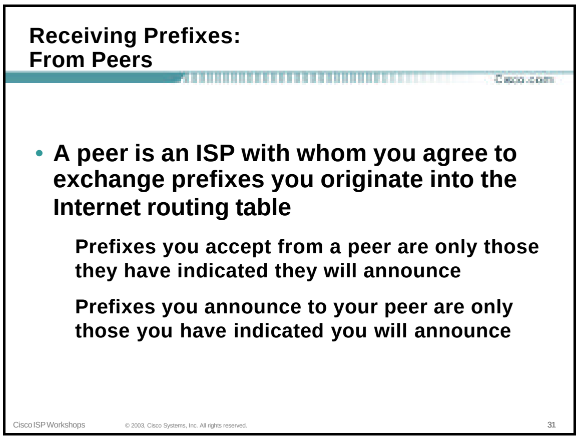
ASSIGNED PA – means that it is Provider Aggregatable address space and can only be used for connecting to the ISP who assigned it



Receiving Prefixes from customer: Cisco IOS

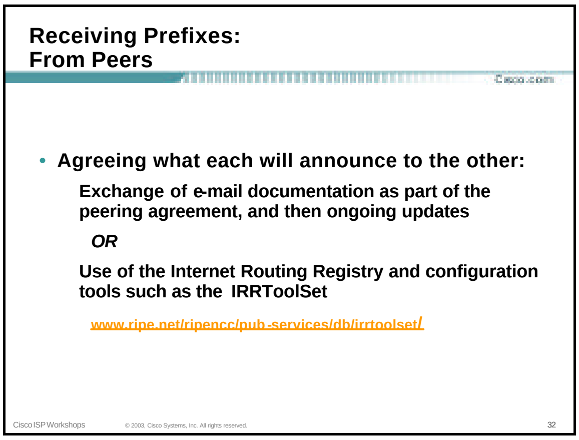
- For Example:
  - downstream has 220.50.0.0/20 block
  - should only announce this to upstreams
  - upstreams should only accept this from them
- Configuration on upstream

```
router bgp 100
 neighbor 222.222.10.1 remote-as 101
 neighbor 222.222.10.1 prefix-list customer in
!
ip prefix-list customer permit 220.50.0.0/20
```



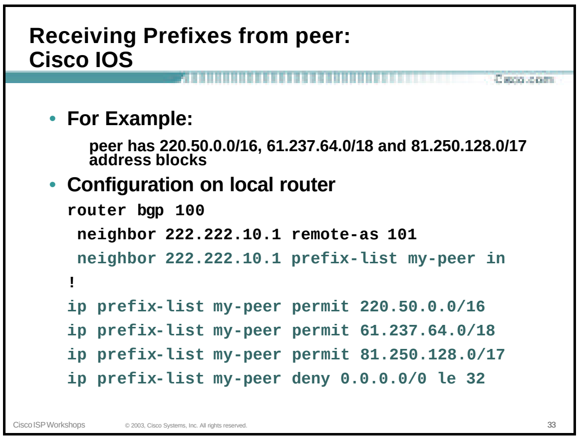
Receiving Prefixes: From Peers

- A peer is an ISP with whom you agree to exchange prefixes you originate into the Internet routing table
  - Prefixes you accept from a peer are only those they have indicated they will announce
  - Prefixes you announce to your peer are only those you have indicated you will announce



Receiving Prefixes: From Peers

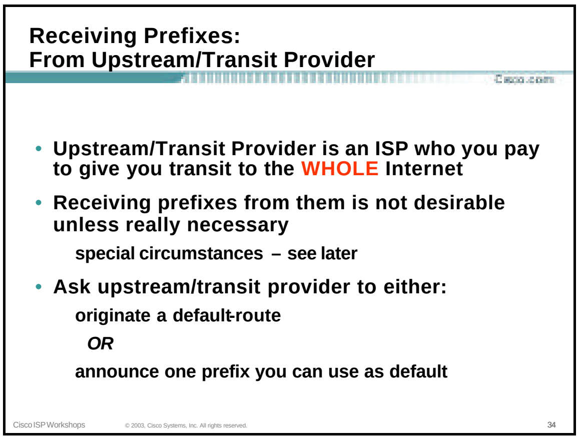
- Agreeing what each will announce to the other:
  - Exchange of e-mail documentation as part of the peering agreement, and then ongoing updates
  - *OR*
  - Use of the Internet Routing Registry and configuration tools such as the IRRToolSet
  - www.ripe.net/ripencc/pub-services/db/irrtoolset/



Receiving Prefixes from peer: Cisco IOS

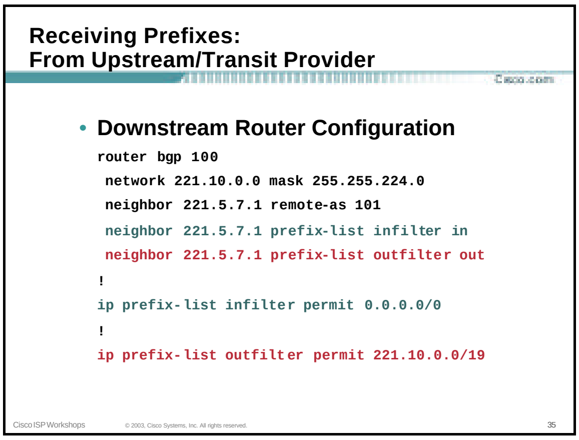
- For Example:
  - peer has 220.50.0.0/16, 61.237.64.0/18 and 81.250.128.0/17 address blocks
- Configuration on local router

```
router bgp 100
 neighbor 222.222.10.1 remote-as 101
 neighbor 222.222.10.1 prefix-list my-peer in
!
ip prefix-list my-peer permit 220.50.0.0/16
ip prefix-list my-peer permit 61.237.64.0/18
ip prefix-list my-peer permit 81.250.128.0/17
ip prefix-list my-peer deny 0.0.0.0/0 le 32
```



Receiving Prefixes: From Upstream/Transit Provider

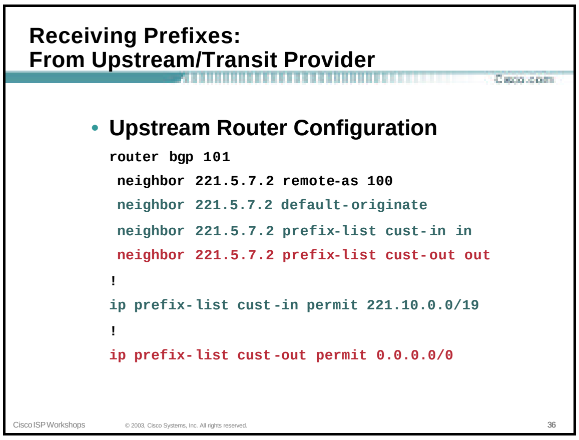
- Upstream/Transit Provider is an ISP who you pay to give you transit to the WHOLE Internet
- Receiving prefixes from them is not desirable unless really necessary
  - special circumstances – see later
- Ask upstream/transit provider to either:
  - originate a default-route
  - *OR*
  - announce one prefix you can use as default



Receiving Prefixes: From Upstream/Transit Provider

- Downstream Router Configuration

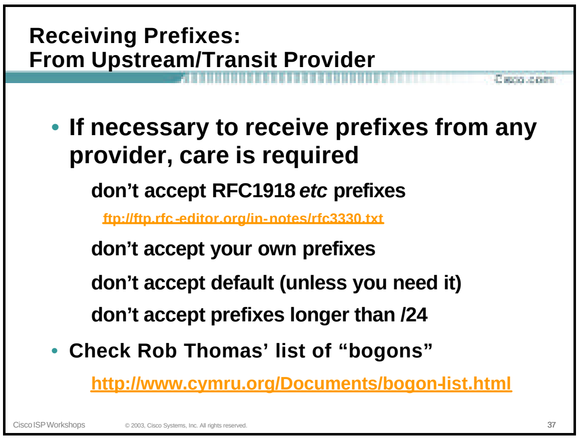
```
router bgp 100
 network 221.10.0.0 mask 255.255.224.0
 neighbor 221.5.7.1 remote-as 101
 neighbor 221.5.7.1 prefix-list infilter in
 neighbor 221.5.7.1 prefix-list outfilter out
!
ip prefix-list infilter permit 0.0.0.0/0
!
ip prefix-list outfilter permit 221.10.0.0/19
```



Receiving Prefixes: From Upstream/Transit Provider

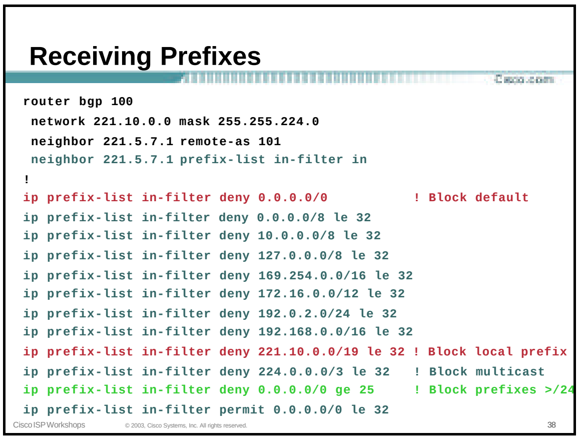
- Upstream Router Configuration

```
router bgp 101
 neighbor 221.5.7.2 remote-as 100
 neighbor 221.5.7.2 default-originate
 neighbor 221.5.7.2 prefix-list cust-in in
 neighbor 221.5.7.2 prefix-list cust-out out
!
ip prefix-list cust-in permit 221.10.0.0/19
!
ip prefix-list cust-out permit 0.0.0.0/0
```



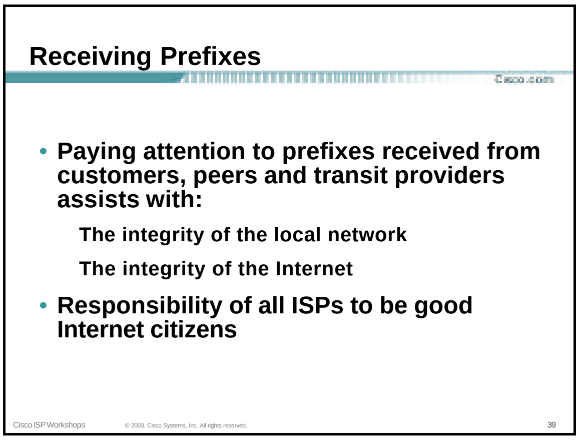
Receiving Prefixes: From Upstream/Transit Provider

- If necessary to receive prefixes from any provider, care is required
  - don’t accept RFC1918 *etc* prefixes
    - ftp://ftp.rfc-editor.org/in-notes/rfc3330.txt
  - don’t accept your own prefixes
  - don’t accept default (unless you need it)
  - don’t accept prefixes longer than /24
- Check Rob Thomas’ list of “bogons”
  - http://www.cymru.org/Documents/bogon-list.html



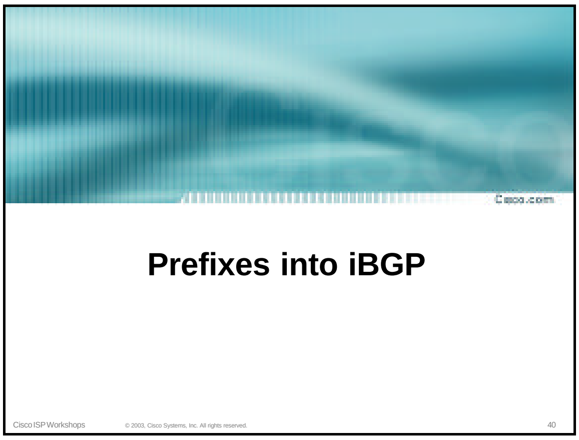
Receiving Prefixes

```
router bgp 100
 network 221.10.0.0 mask 255.255.224.0
 neighbor 221.5.7.1 remote-as 101
 neighbor 221.5.7.1 prefix-list in-filter in
!
ip prefix-list in-filter deny 0.0.0.0/0           ! Block default
ip prefix-list in-filter deny 0.0.0.0/8 le 32
ip prefix-list in-filter deny 10.0.0.0/8 le 32
ip prefix-list in-filter deny 127.0.0.0/8 le 32
ip prefix-list in-filter deny 169.254.0.0/16 le 32
ip prefix-list in-filter deny 172.16.0.0/12 le 32
ip prefix-list in-filter deny 192.0.2.0/24 le 32
ip prefix-list in-filter deny 192.168.0.0/16 le 32
ip prefix-list in-filter deny 221.10.0.0/19 le 32 ! Block local prefix
ip prefix-list in-filter deny 224.0.0.0/3 le 32   ! Block multicast
ip prefix-list in-filter deny 0.0.0.0/0 ge 25     ! Block prefixes >/24
ip prefix-list in-filter permit 0.0.0.0/0 le 32
```

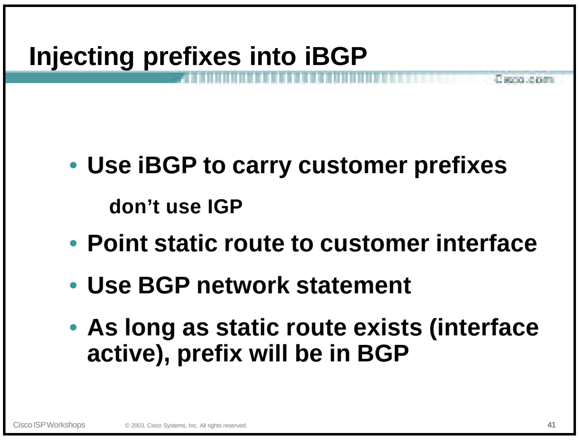


Receiving Prefixes

- Paying attention to prefixes received from customers, peers and transit providers assists with:
  - The integrity of the local network
  - The integrity of the Internet
- Responsibility of all ISPs to be good Internet citizens

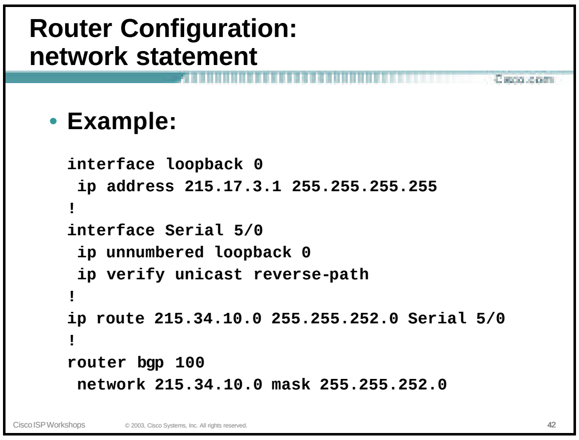


Prefixes into iBGP



Injecting prefixes into iBGP

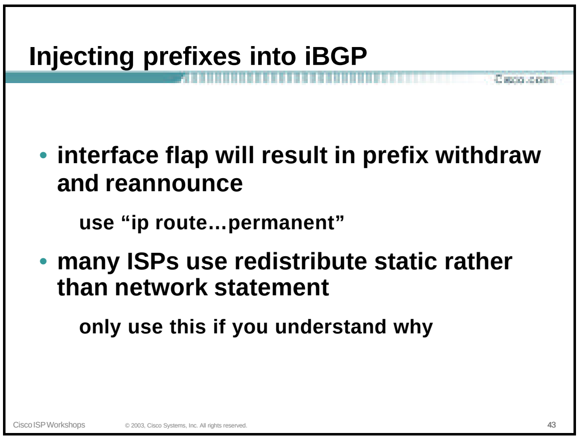
- Use iBGP to carry customer prefixes
  - don’t use IGP
- Point static route to customer interface
- Use BGP network statement
- As long as static route exists (interface active), prefix will be in BGP



Router Configuration: network statement

- Example:

```
interface loopback 0
 ip address 215.17.3.1 255.255.255.255
!
interface Serial 5/0
 ip unnumbered loopback 0
 ip verify unicast reverse-path
!
ip route 215.34.10.0 255.255.252.0 Serial 5/0
!
router bgp 100
 network 215.34.10.0 mask 255.255.252.0
```



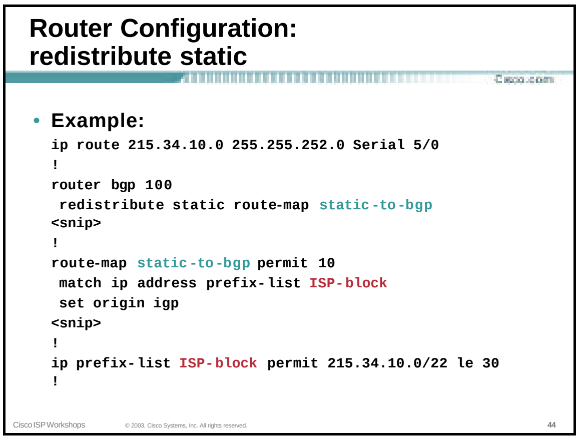
Injecting prefixes into iBGP

- interface flap will result in prefix withdraw and reannounce

  use “ip route…permanent”

- many ISPs use redistribute static rather than network statement

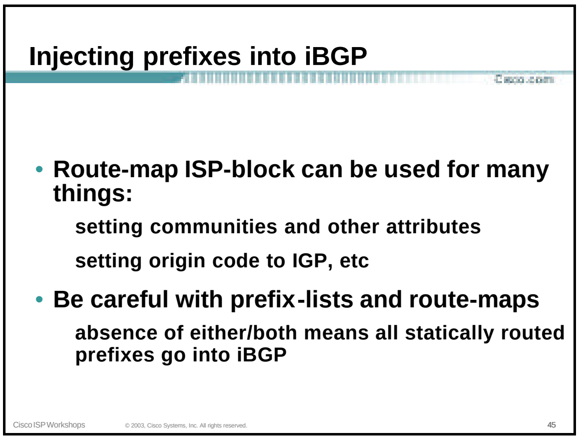
  only use this if you understand why



Router Configuration: redistribute static

- Example:

```
ip route 215.34.10.0 255.255.252.0 Serial 5/0
!
router bgp 100
 redistribute static route-map static-to-bgp
<snip>
!
route-map static-to-bgp permit 10
 match ip address prefix-list ISP-block
 set origin igp
<snip>
!
ip prefix-list ISP-block permit 215.34.10.0/22 le 30
!
```



Injecting prefixes into iBGP

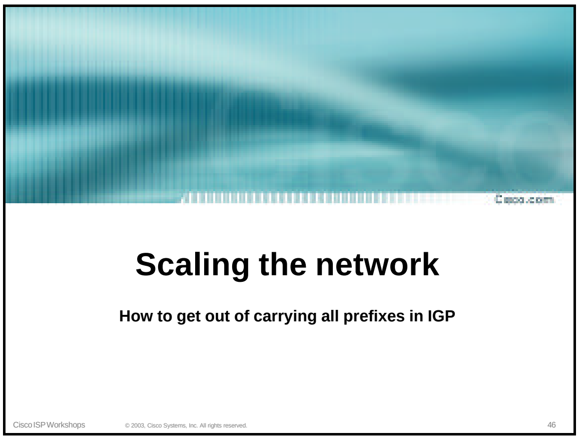
- Route-map ISP-block can be used for many things:

  setting communities and other attributes

  setting origin code to IGP, etc

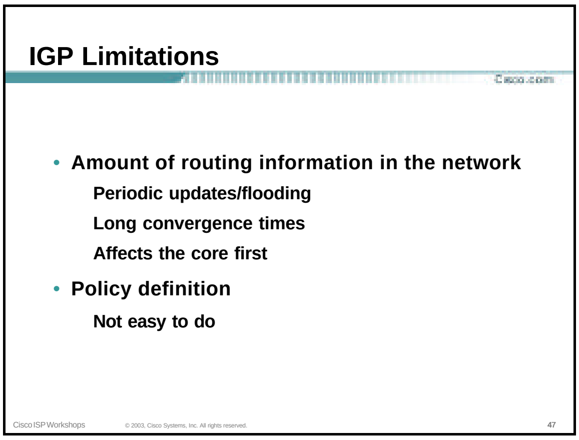
- Be careful with prefix-lists and route-maps

  absence of either/both means all statically routed prefixes go into iBGP



Scaling the network

How to get out of carrying all prefixes in IGP



IGP Limitations

- Amount of routing information in the network

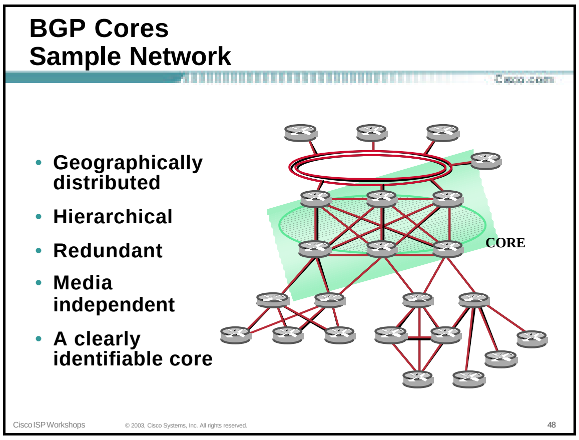
  Periodic updates/flooding

  Long convergence times

  Affects the core first

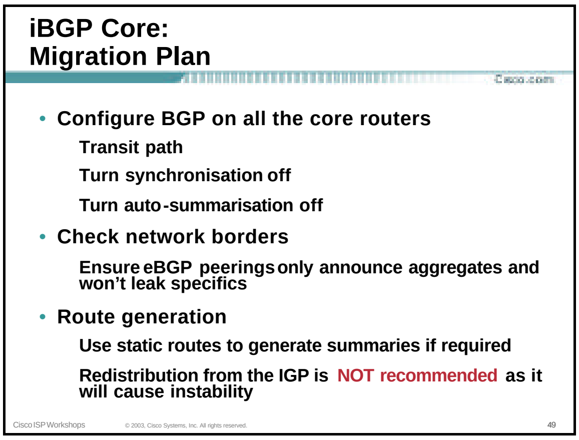
- Policy definition

  Not easy to do



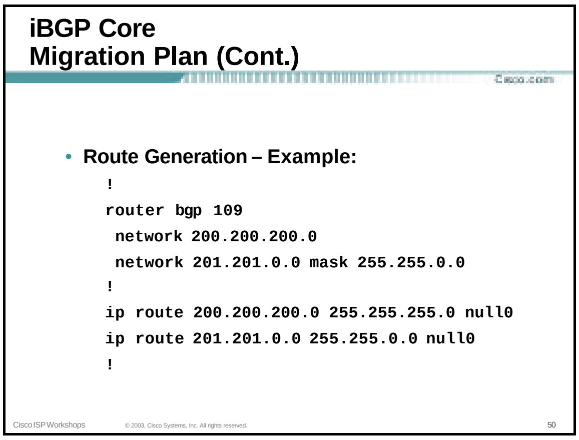
BGP Cores Sample Network

- Geographically distributed
- Hierarchical
- Redundant
- Media independent
- A clearly identifiable core



iBGP Core: Migration Plan

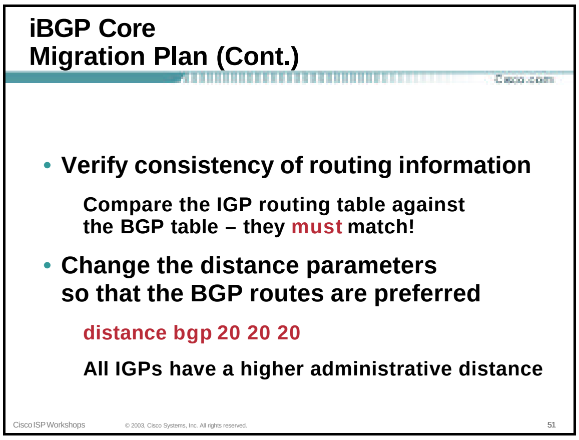
- Configure BGP on all the core routers
  - Transit path
  - Turn synchronisation off
  - Turn auto-summarisation off
- Check network borders
  - Ensure eBGP peerings only announce aggregates and won’t leak specifics
- Route generation
  - Use static routes to generate summaries if required
  - Redistribution from the IGP is NOT recommended as it will cause instability



iBGP Core Migration Plan (Cont.)

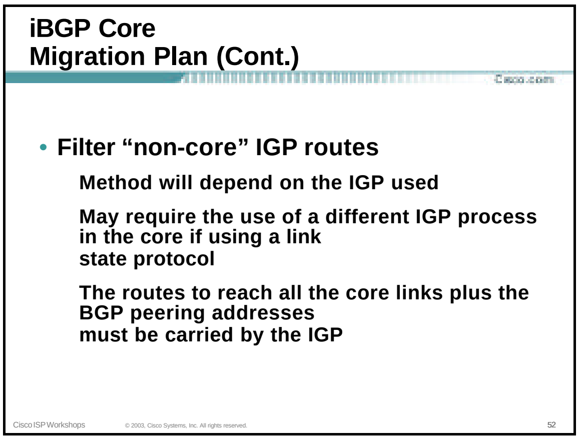
- Route Generation – Example:

```
!
router bgp 109
 network 200.200.200.0
 network 201.201.0.0 mask 255.255.0.0
!
ip route 200.200.200.0 255.255.255.0 null0
ip route 201.201.0.0 255.255.0.0 null0
!
```



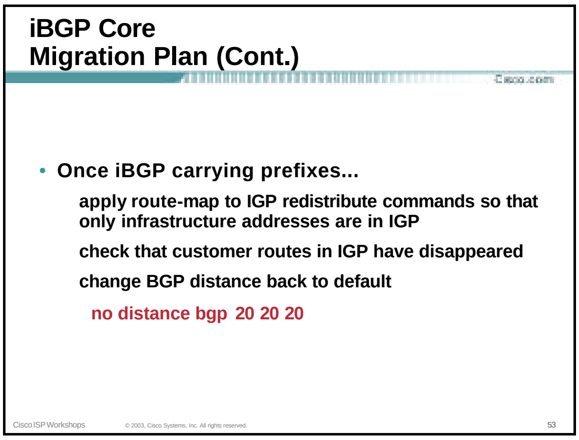
iBGP Core Migration Plan (Cont.)

- Verify consistency of routing information
  - Compare the IGP routing table against the BGP table – they must match!
- Change the distance parameters so that the BGP routes are preferred
  - distance bgp 20 20 20
  - All IGPs have a higher administrative distance



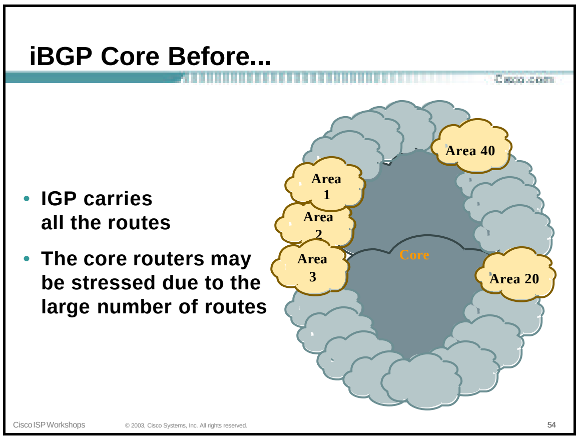
iBGP Core Migration Plan (Cont.)

- Filter “non-core” IGP routes
  - Method will depend on the IGP used
  - May require the use of a different IGP process in the core if using a link state protocol
  - The routes to reach all the core links plus the BGP peering addresses must be carried by the IGP



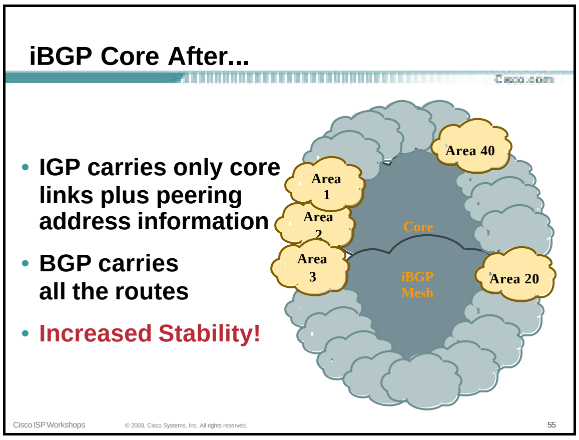
iBGP Core Migration Plan (Cont.)

- Once iBGP carrying prefixes...
  - apply route-map to IGP redistribute commands so that only infrastructure addresses are in IGP
  - check that customer routes in IGP have disappeared
  - change BGP distance back to default
  - no distance bgp 20 20 20



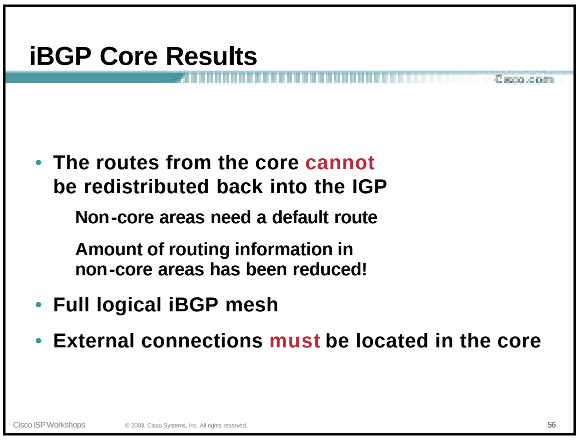
iBGP Core Before...

- IGP carries all the routes
- The core routers may be stressed due to the large number of routes



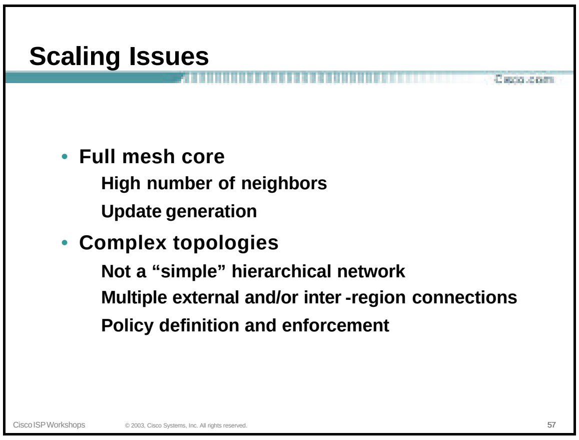
iBGP Core After...

- IGP carries only core links plus peering address information
- BGP carries all the routes
- Increased Stability!



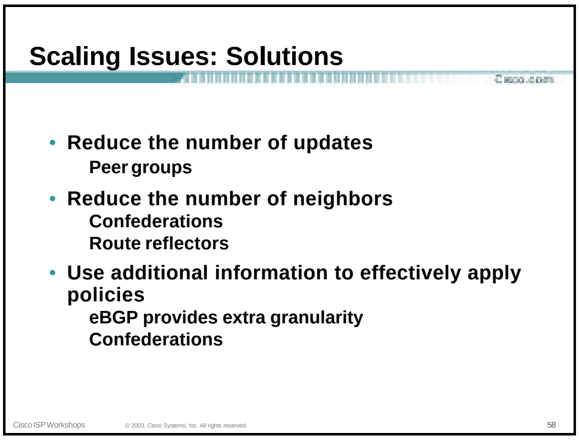
iBGP Core Results

- The routes from the core cannot be redistributed back into the IGP
  - Non-core areas need a default route
  - Amount of routing information in non-core areas has been reduced!
- Full logical iBGP mesh
- External connections must be located in the core



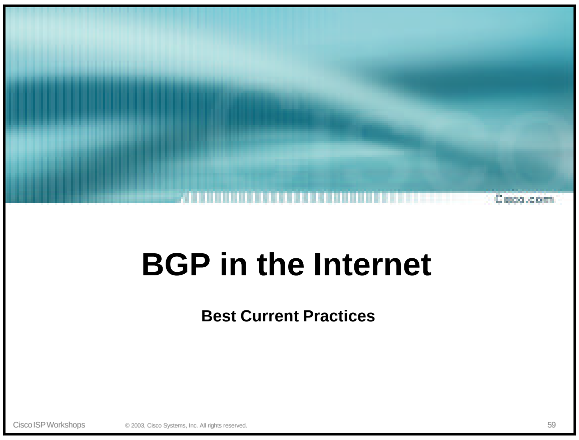
Scaling Issues

- Full mesh core
  - High number of neighbors
  - Update generation
- Complex topologies
  - Not a “simple” hierarchical network
  - Multiple external and/or inter-region connections
  - Policy definition and enforcement



Scaling Issues: Solutions

- Reduce the number of updates
  - Peer groups
- Reduce the number of neighbors
  - Confederations
  - Route reflectors
- Use additional information to effectively apply policies
  - eBGP provides extra granularity
  - Confederations



BGP in the Internet

Best Current Practices