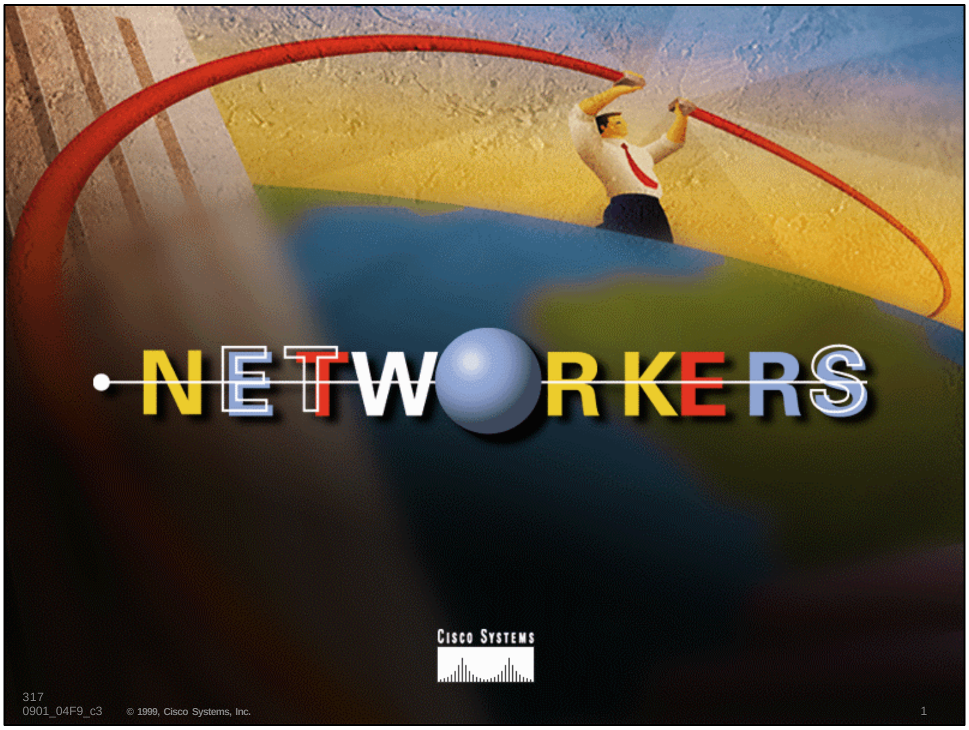

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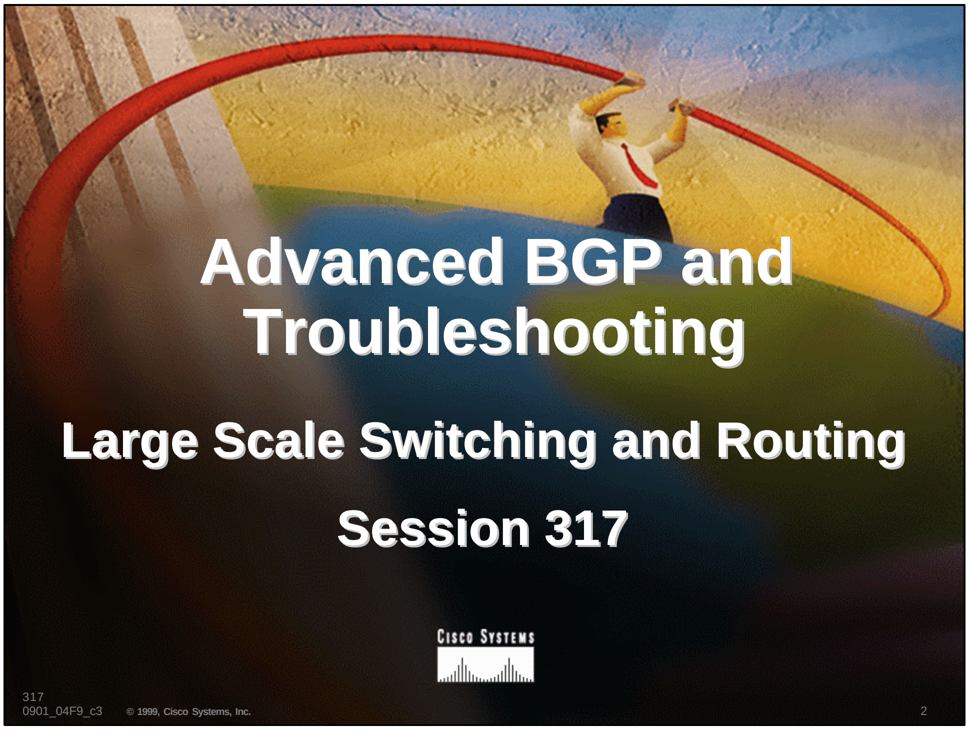

Advanced BGP and Troubleshooting

Large Scale Switching and Routing

Session 317

Cisco Systems

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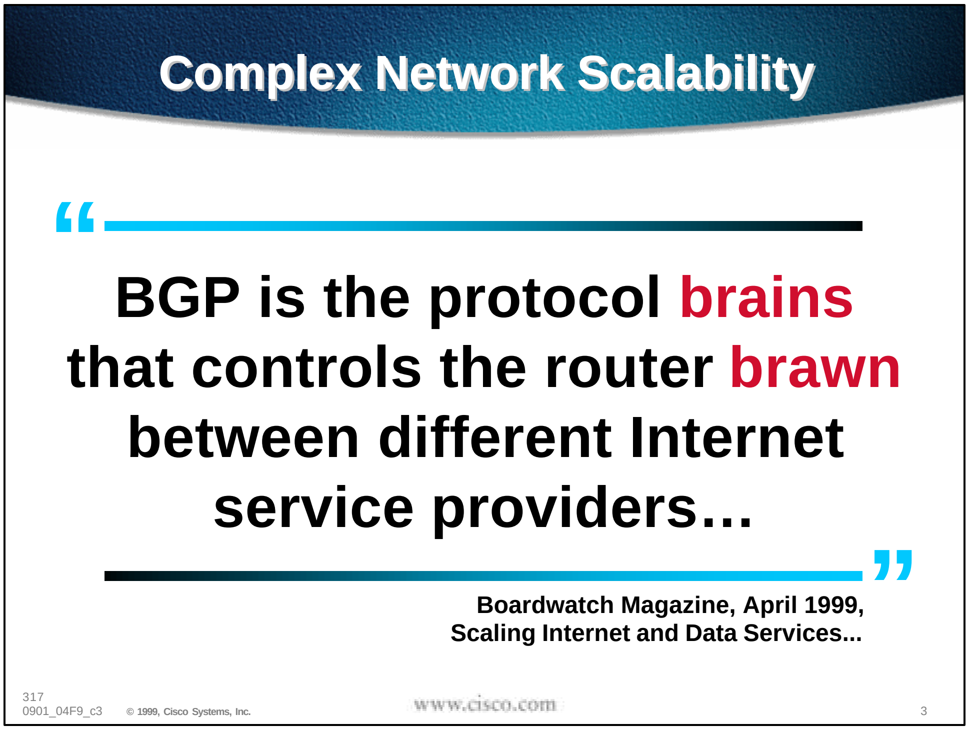
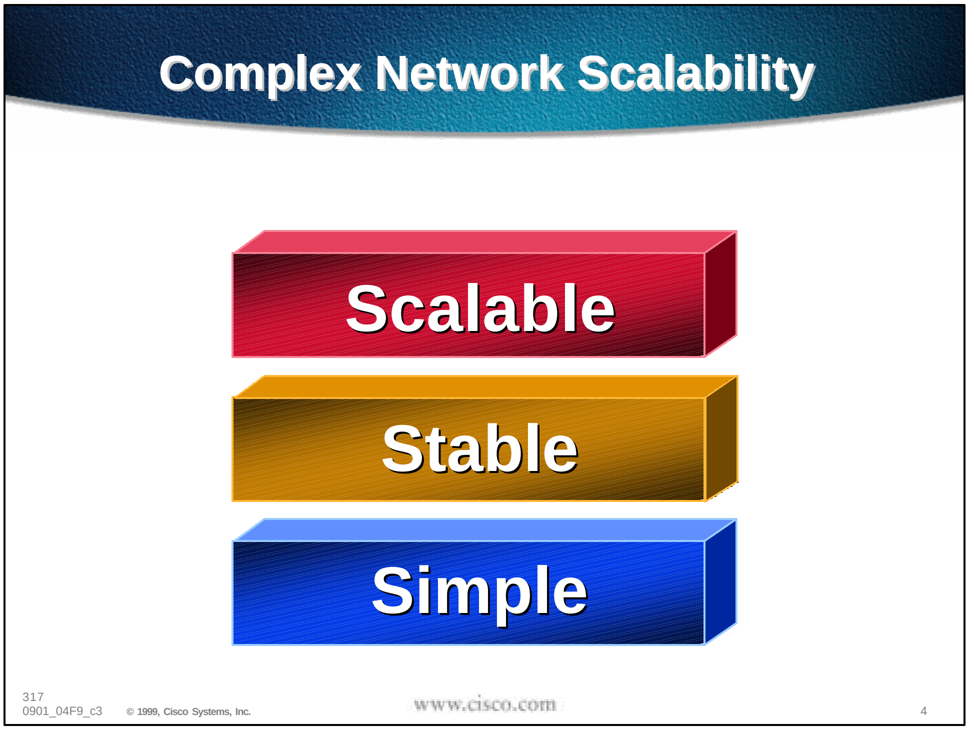


Complex Network Scalability

> “BGP is the protocol **brains** that controls the router **brawn** between different Internet service providers…”

Boardwatch Magazine, April 1999,
Scaling Internet and Data Services...



Complex Network Scalability

Scalable

Stable

Simple

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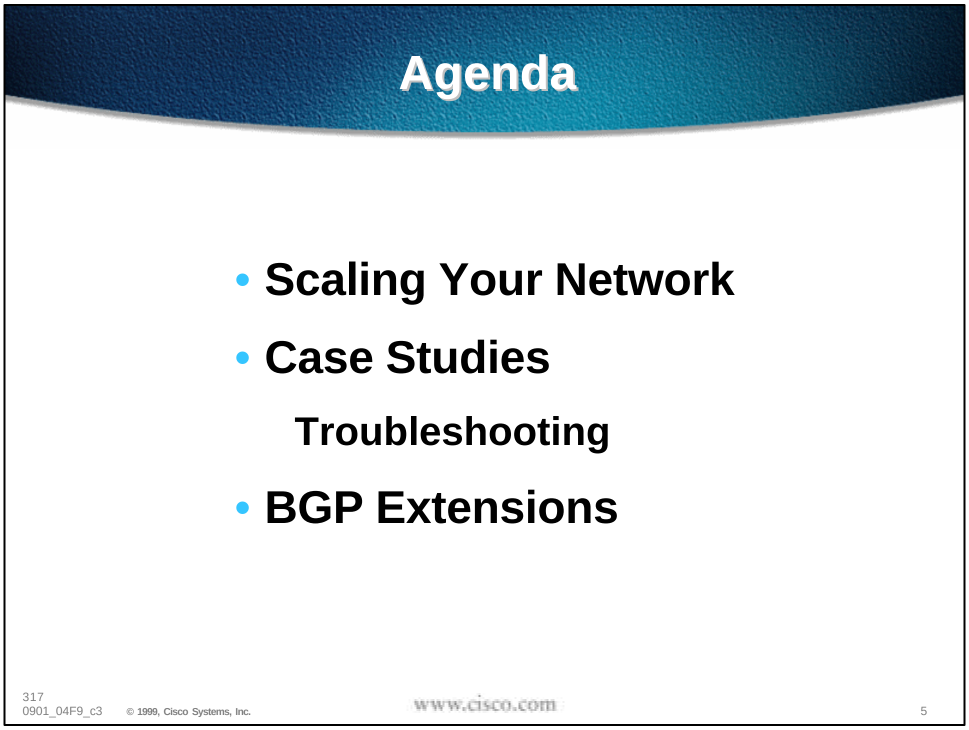

Agenda

- Scaling Your Network
- Case Studies

  Troubleshooting
- BGP Extensions

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Scaling Your Network

Doing More with Less!

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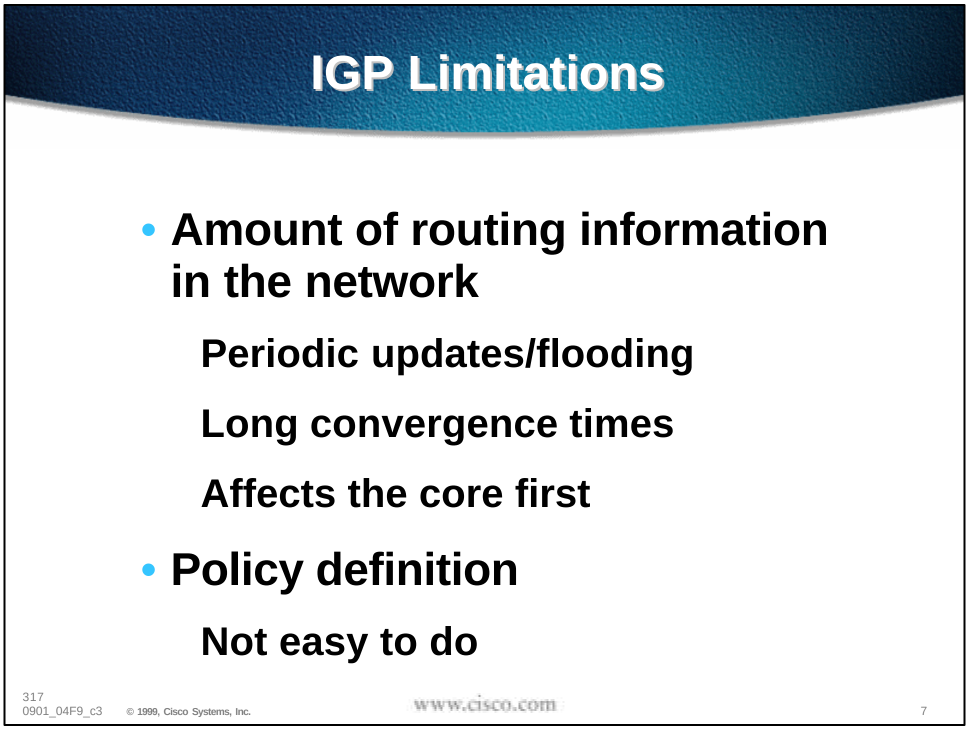

IGP Limitations

- Amount of routing information in the network

  Periodic updates/flooding

  Long convergence times

  Affects the core first

- Policy definition

  Not easy to do

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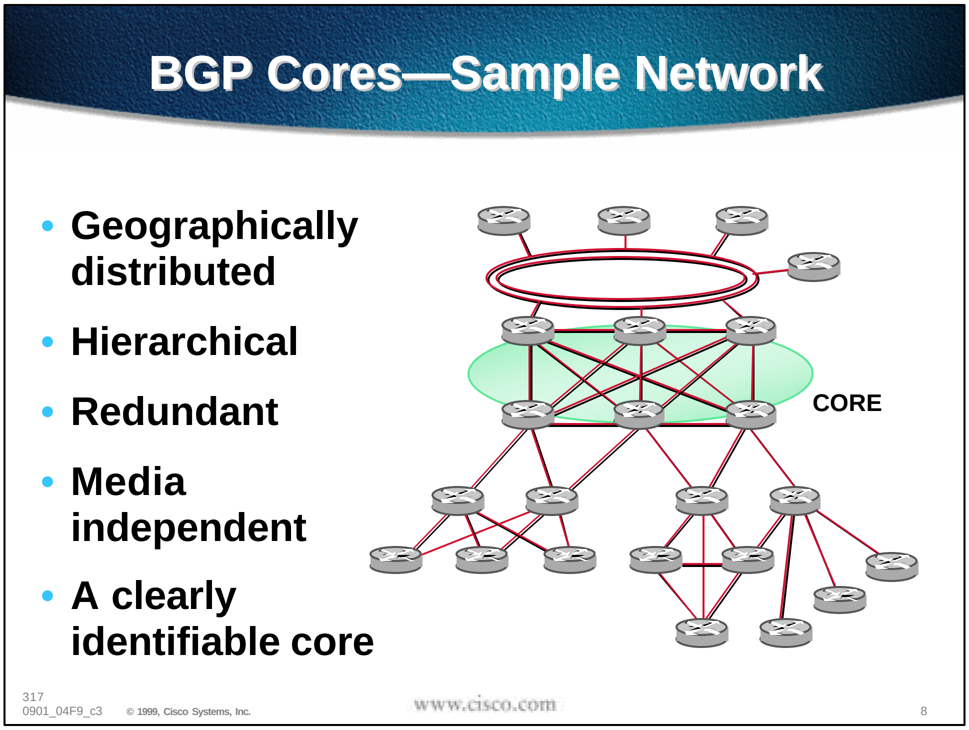

BGP Cores—Sample Network

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

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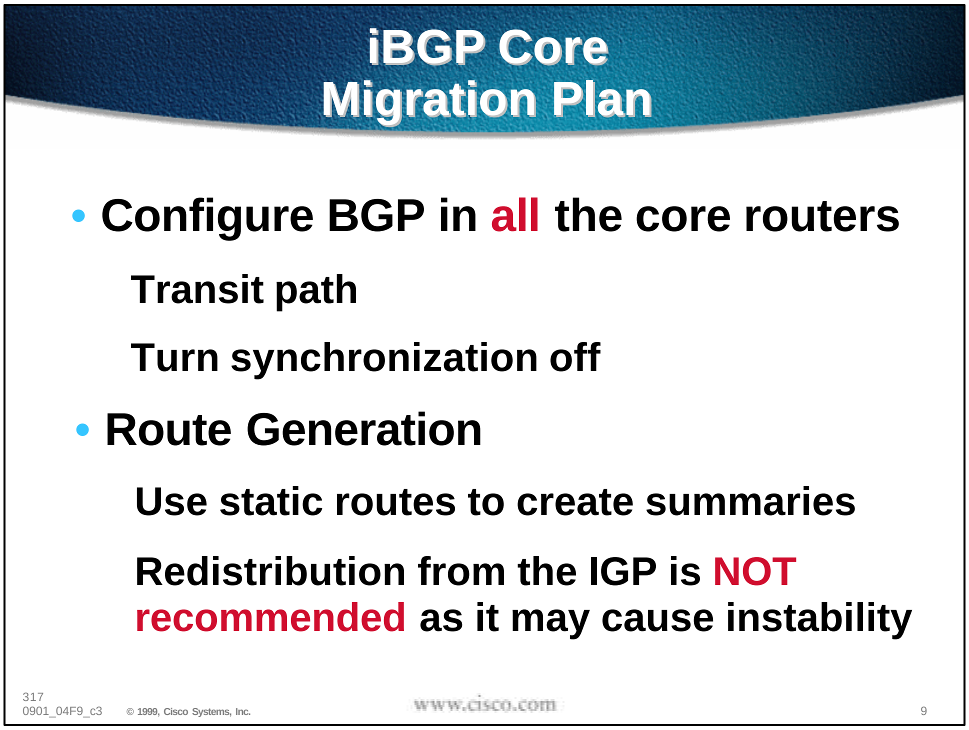

iBGP Core Migration Plan

- Configure BGP in all the core routers

  Transit path

  Turn synchronization off

- Route Generation

  Use static routes to create summaries

  Redistribution from the IGP is NOT recommended as it may cause instability

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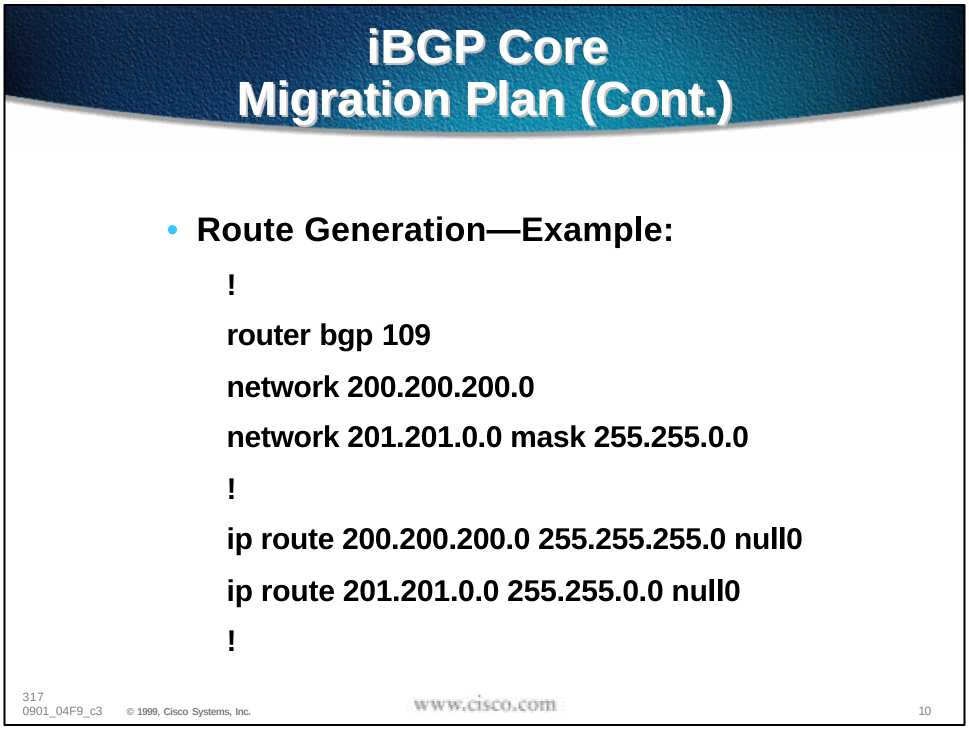

iBGP Core Migration Plan (Cont.)

- 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
!
```

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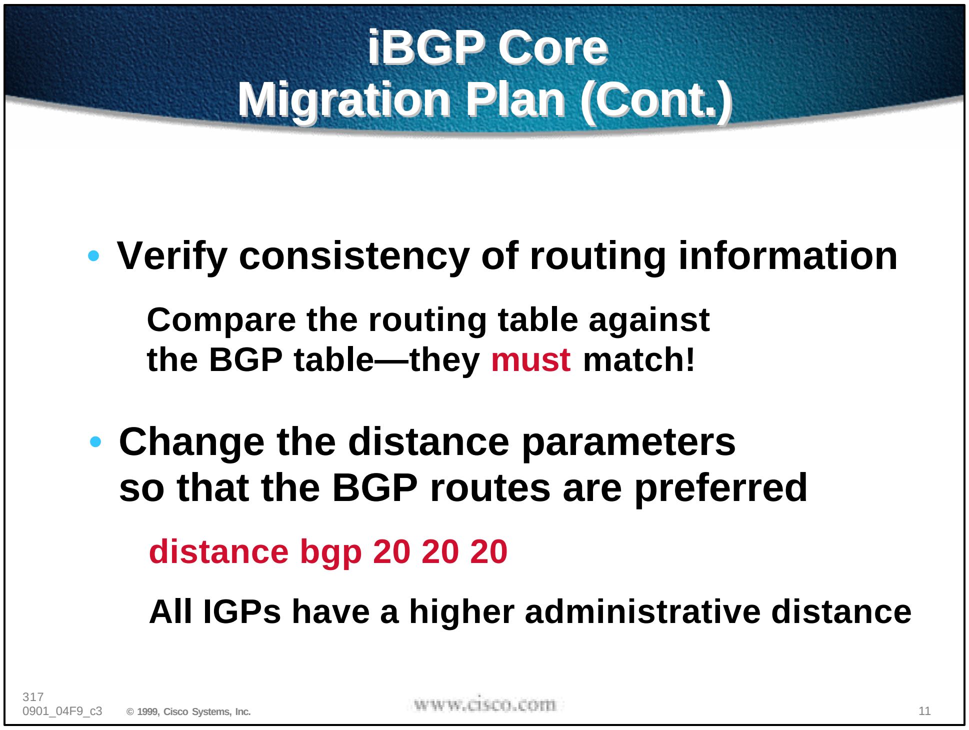


iBGP Core Migration Plan (Cont.)

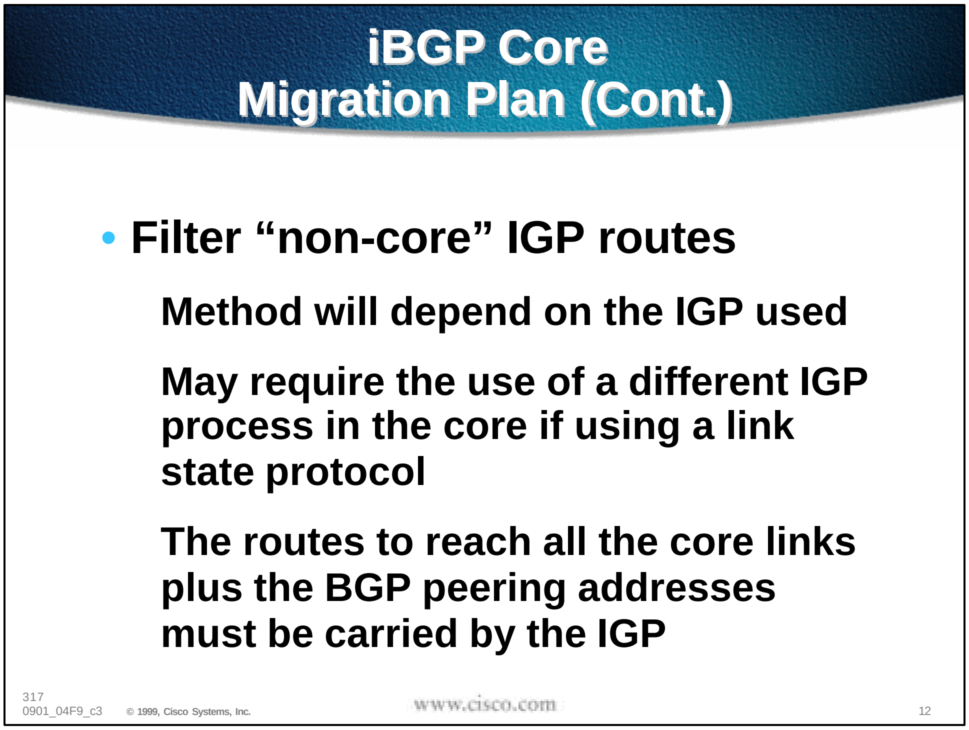
- Verify consistency of routing information

  Compare the 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

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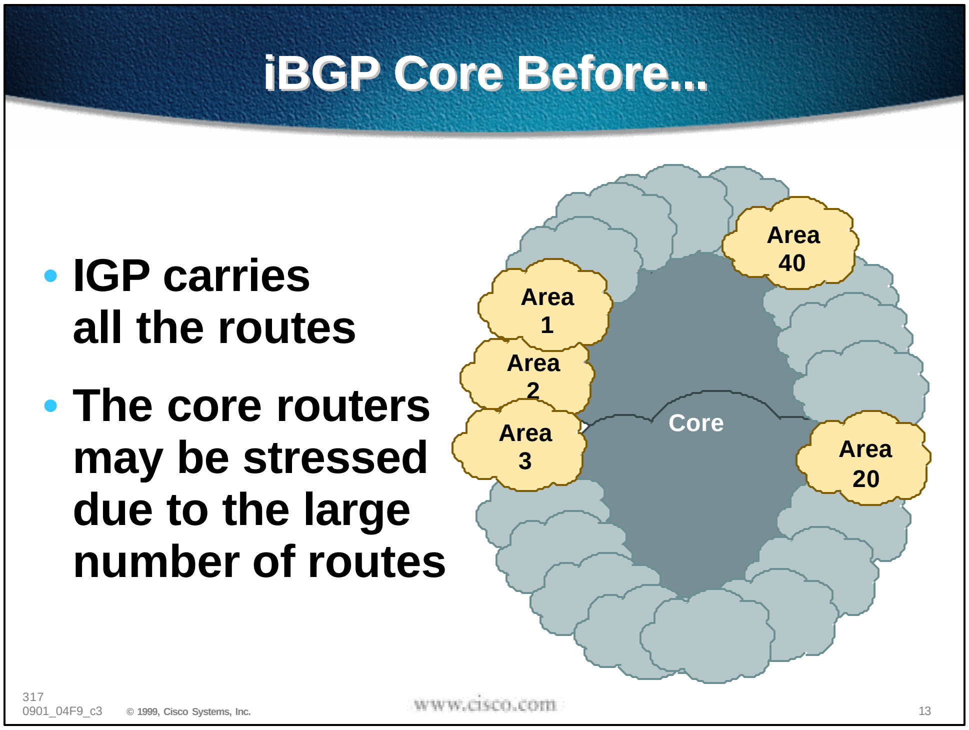

iBGP Core Before...

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

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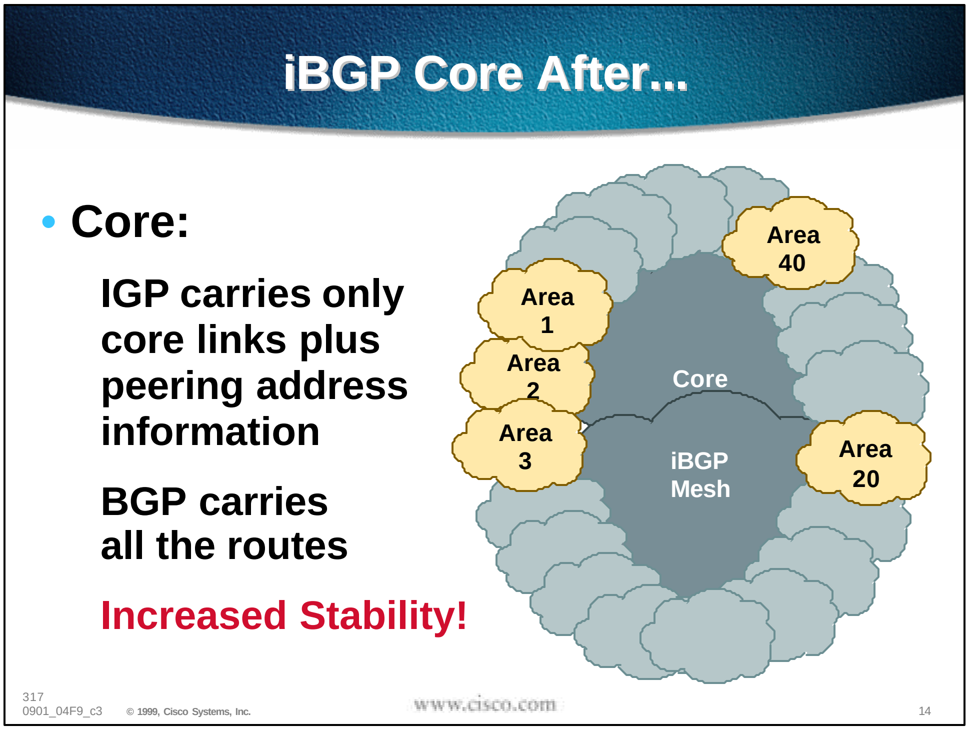

iBGP Core After...

- Core:

  IGP carries only core links plus peering address information

  BGP carries all the routes

  Increased Stability!

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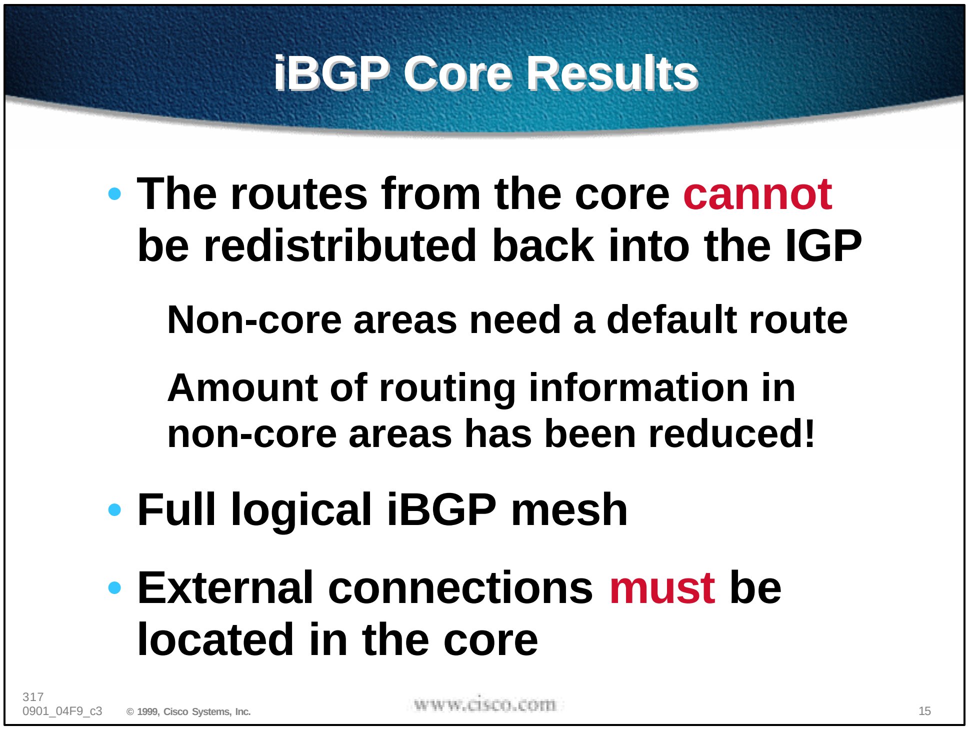

iBGP Core Results

- 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

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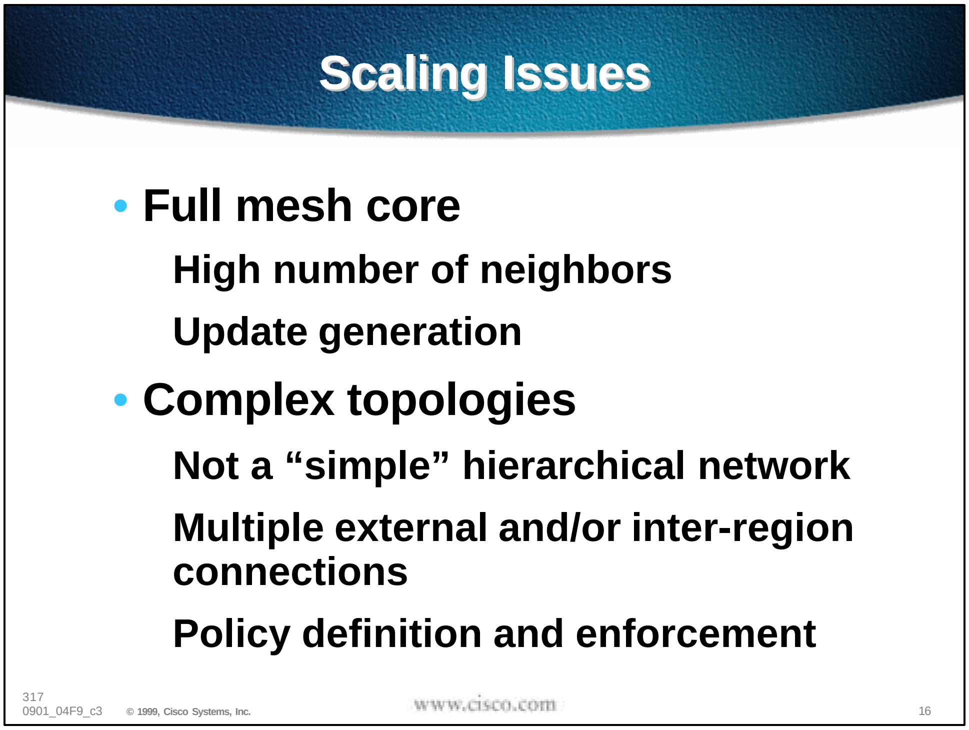

Scaling Issues

- 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

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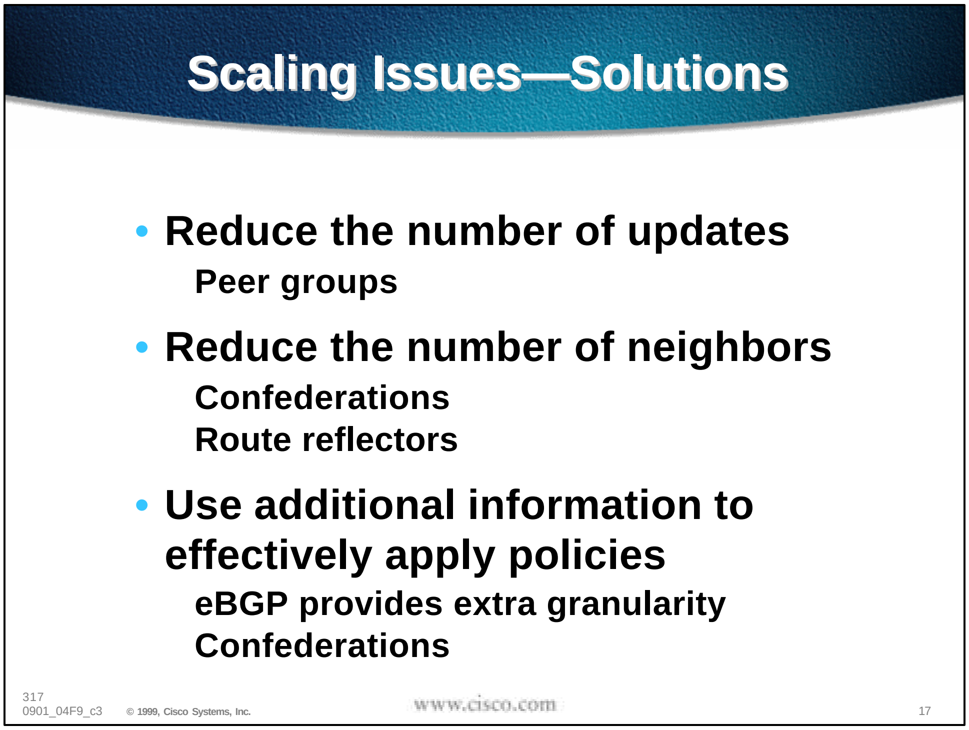
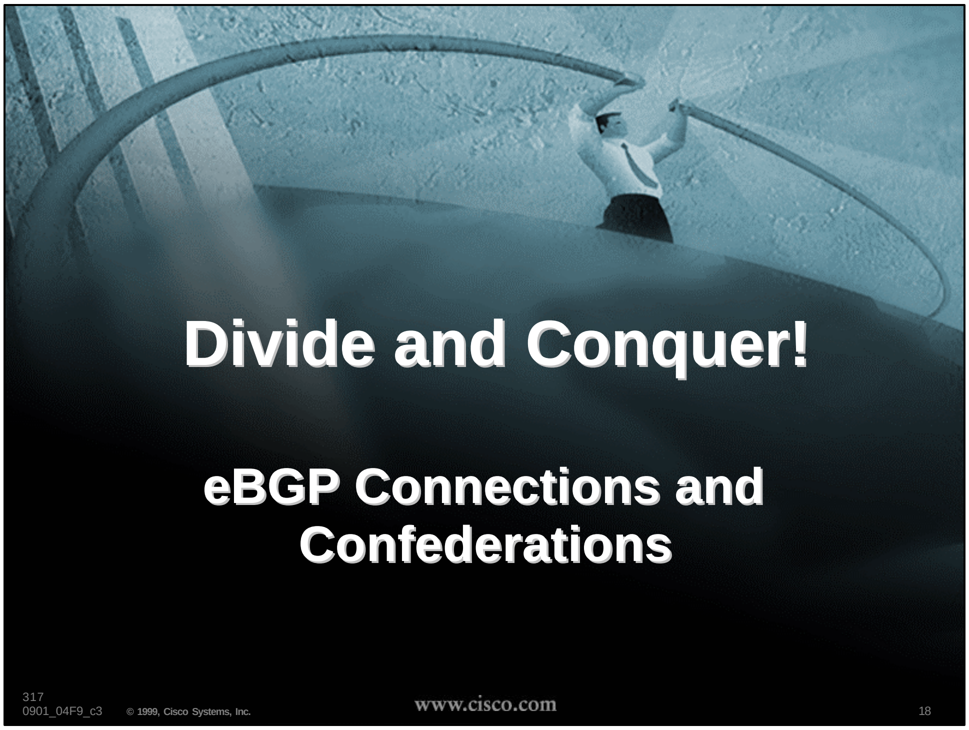


Scaling Issues—Solutions

- 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



Divide and Conquer!

eBGP Connections and Confederations

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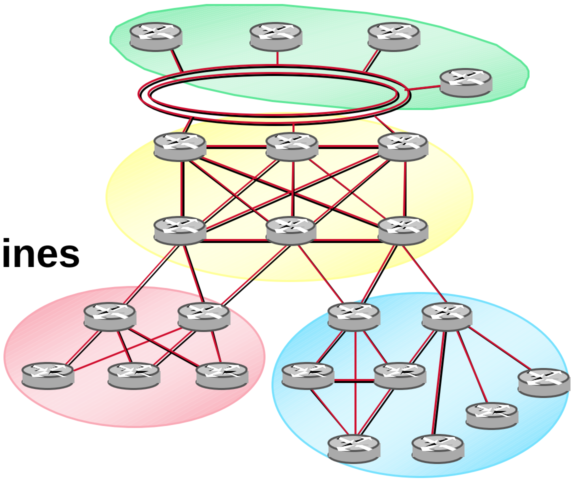
Implementation Strategy

- Divide the network into multiple regions/areas
- Connect each region using BGP
- Reconfigure the IGP in each region/area

Divide the Network into Pieces

- Where:
  - Geography
  - Department lines
  - Hierarchy
  - Etc.



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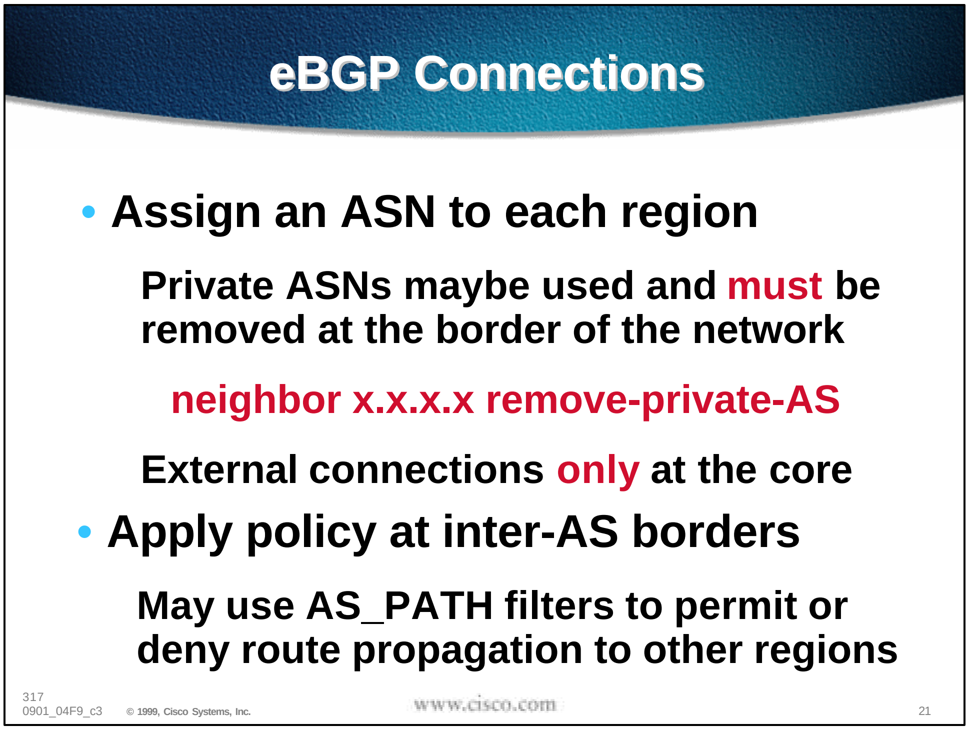


eBGP Connections

- Assign an ASN to each region

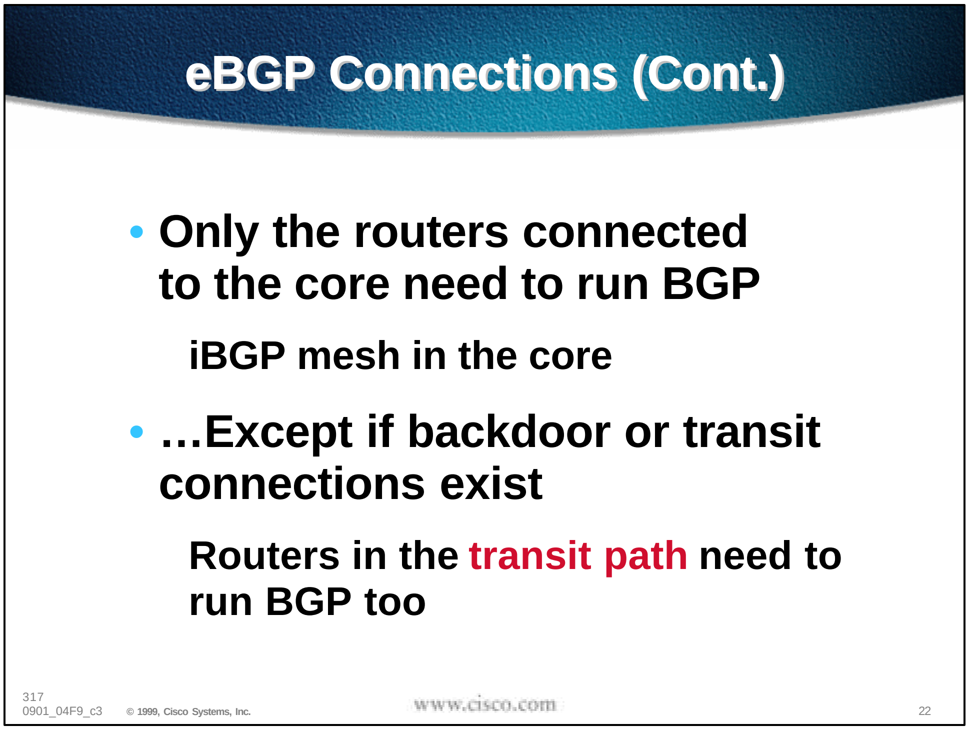
  Private ASNs maybe used and must be removed at the border of the network

  neighbor x.x.x.x remove-private-AS

  External connections only at the core

- Apply policy at inter-AS borders

  May use AS_PATH filters to permit or deny route propagation to other regions



eBGP Connections (Cont.)

- Only the routers connected to the core need to run BGP

  iBGP mesh in the core

- …Except if backdoor or transit connections exist

  Routers in the transit path need to run BGP too

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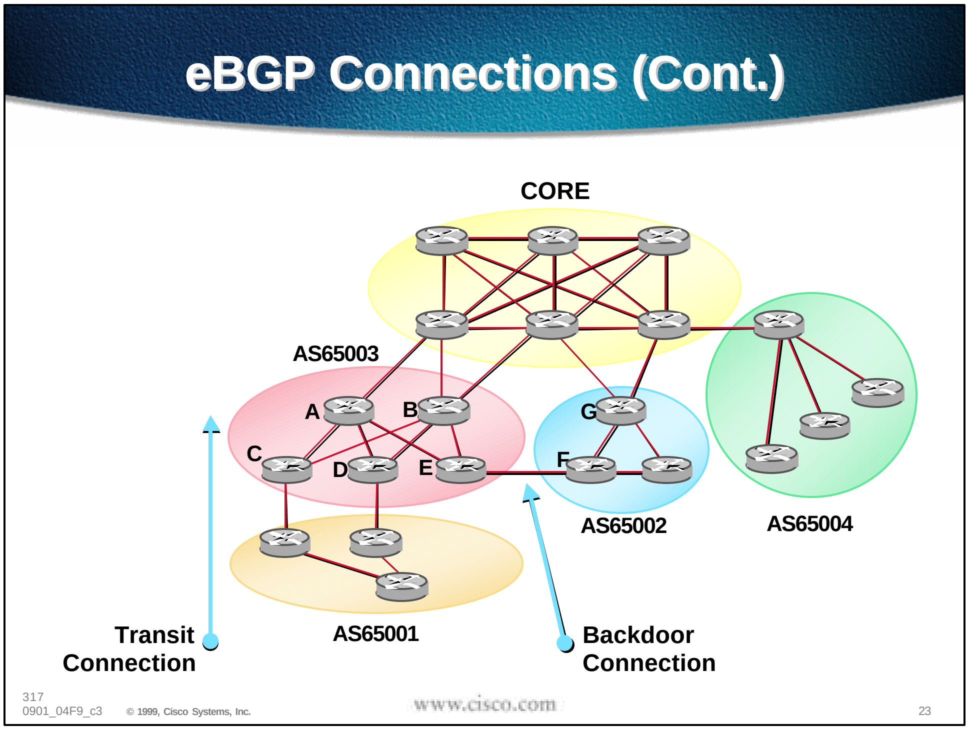
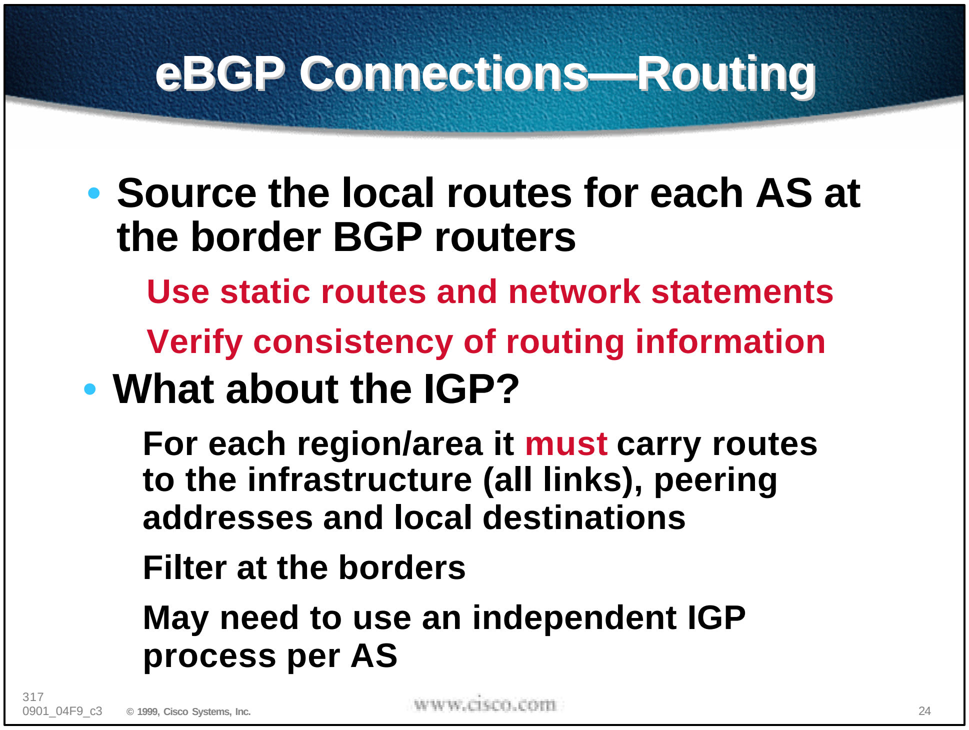


eBGP Connections (Cont.)



eBGP Connections—Routing

- Source the local routes for each AS at the border BGP routers

  Use static routes and network statements

  Verify consistency of routing information

- What about the IGP?

  For each region/area it must carry routes to the infrastructure (all links), peering addresses and local destinations

  Filter at the borders

  May need to use an independent IGP process per AS

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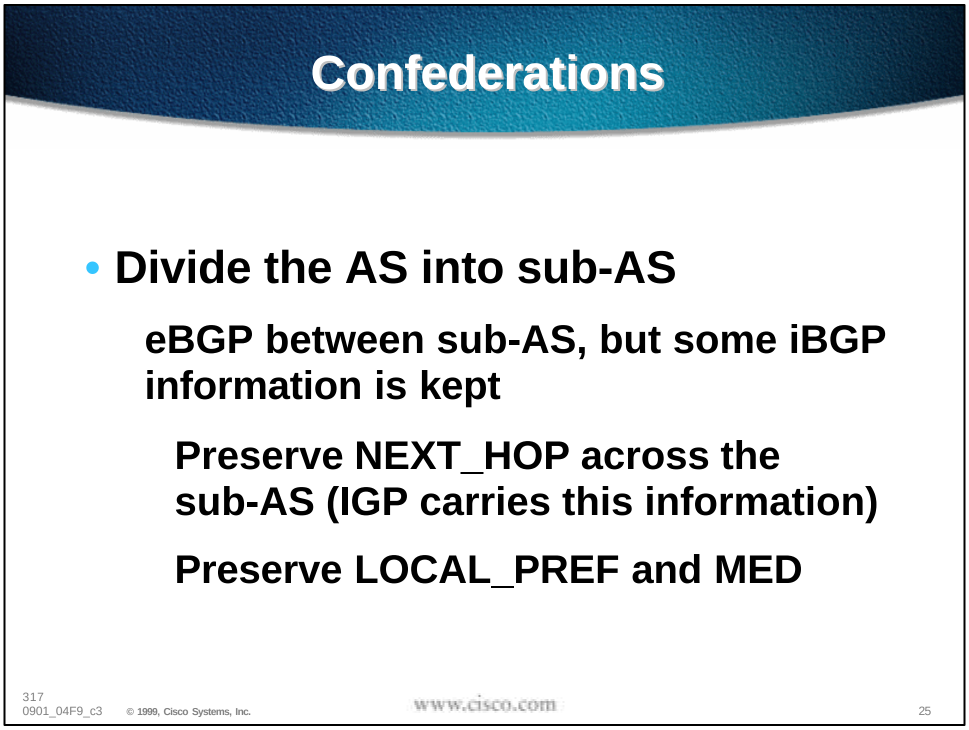

Confederations

- Divide the AS into sub-AS

  eBGP between sub-AS, but some iBGP information is kept

  Preserve NEXT_HOP across the sub-AS (IGP carries this information)

  Preserve LOCAL_PREF and MED

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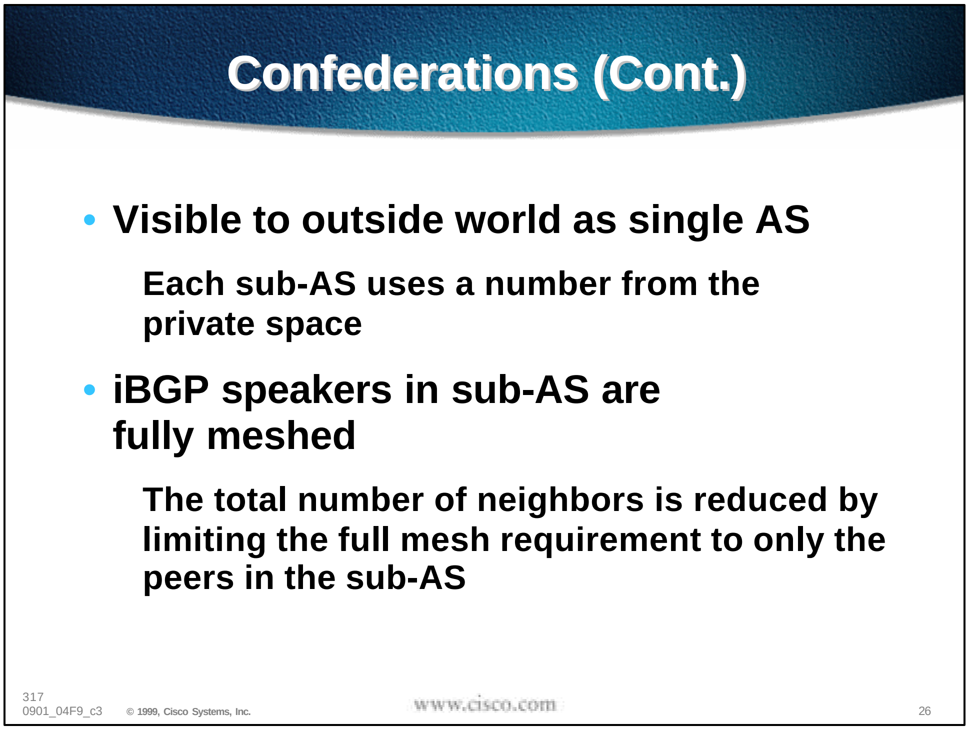

Confederations (Cont.)

- Visible to outside world as single AS

  Each sub-AS uses a number from the private space

- iBGP speakers in sub-AS are fully meshed

  The total number of neighbors is reduced by limiting the full mesh requirement to only the peers in the sub-AS

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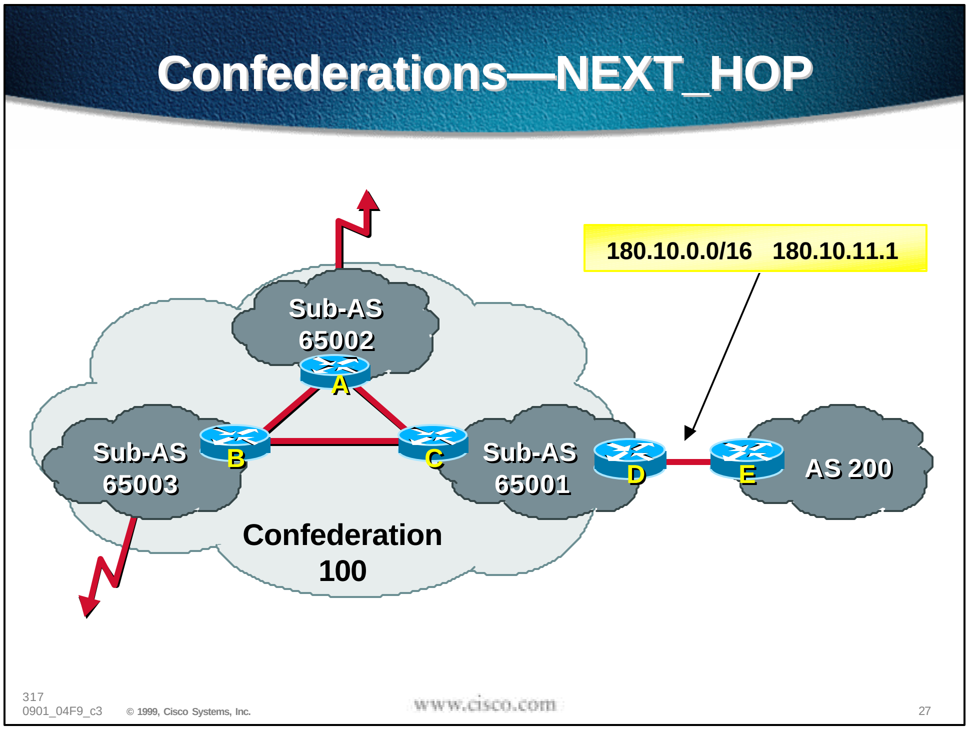
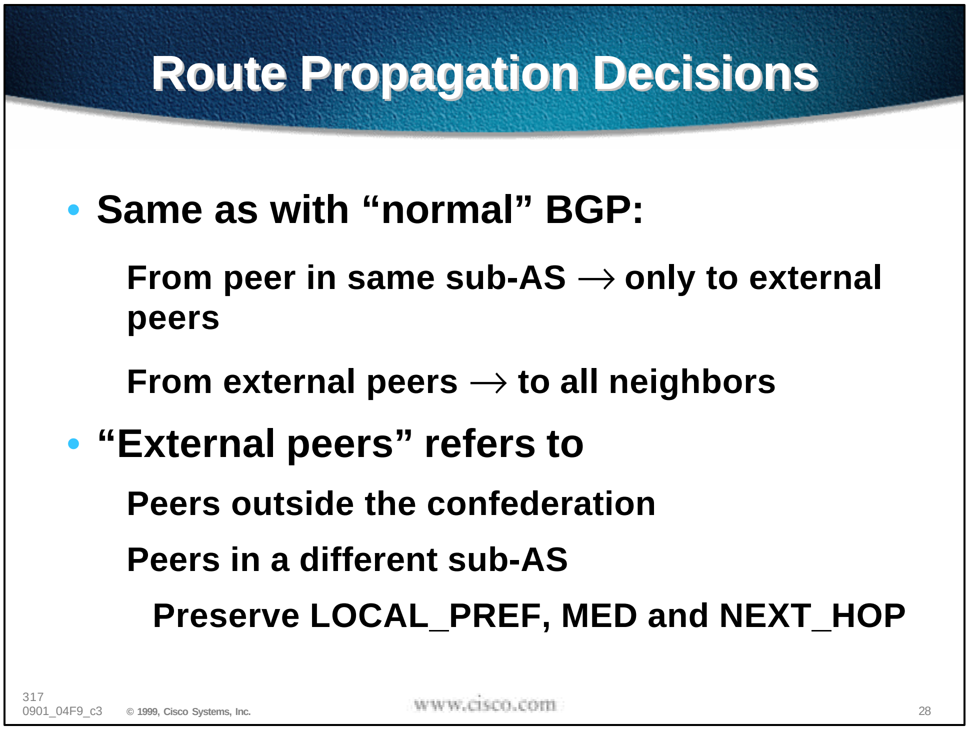


Confederations—NEXT_HOP



Route Propagation Decisions

- Same as with "normal" BGP:

  From peer in same sub-AS → only to external peers

  From external peers → to all neighbors

- "External peers" refers to

  Peers outside the confederation

  Peers in a different sub-AS

  Preserve LOCAL_PREF, MED and NEXT_HOP

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Confederations—AS_PATH

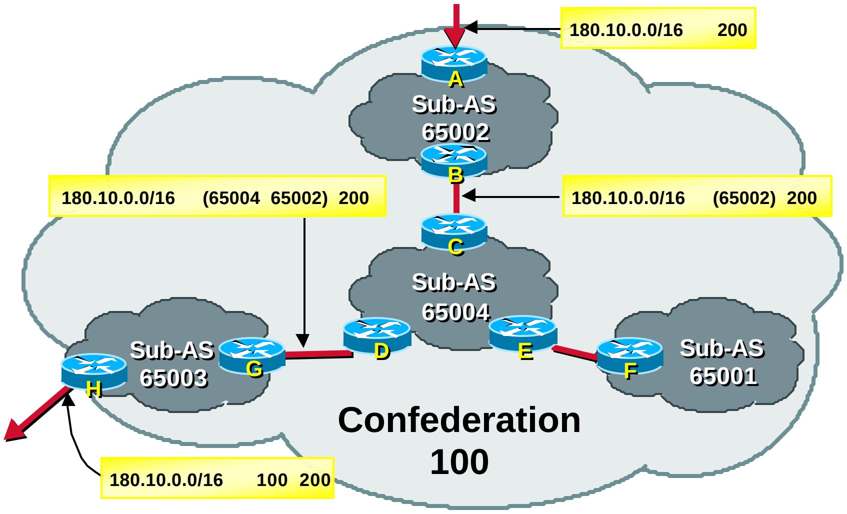
- Sub-AS traversed are carried as part of AS_PATH (AS_CONFED_SEQUENCE or AS_CONFED_SET) for loop avoidance

  Not counted as regular AS when comparing AS_PATH

  Paths with only confederation ASNs in the AS_PATH are skipped during MED comparison

  bgp bestpath med confed

Confederation—AS_PATH (Cont.)



180.10.0.0/16 200

A

Sub-AS 65002

B

180.10.0.0/16 (65004 65002) 200

180.10.0.0/16 (65002) 200

C

Sub-AS 65004

D

E

Sub-AS 65003

G

H

F

Sub-AS 65001

Confederation 100

180.10.0.0/16 100 200

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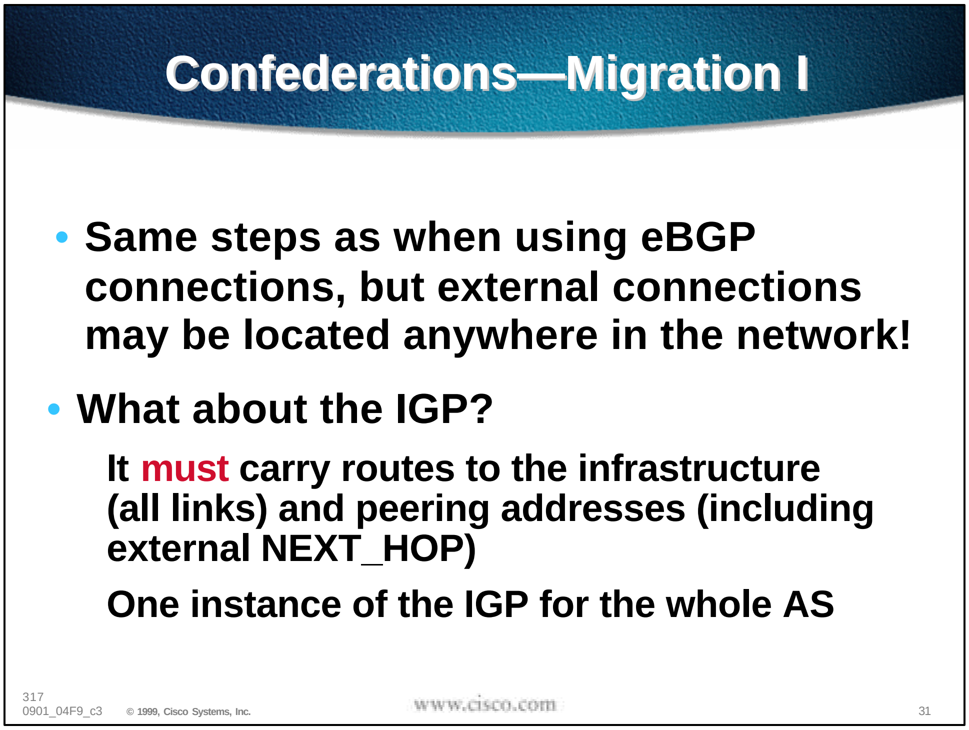
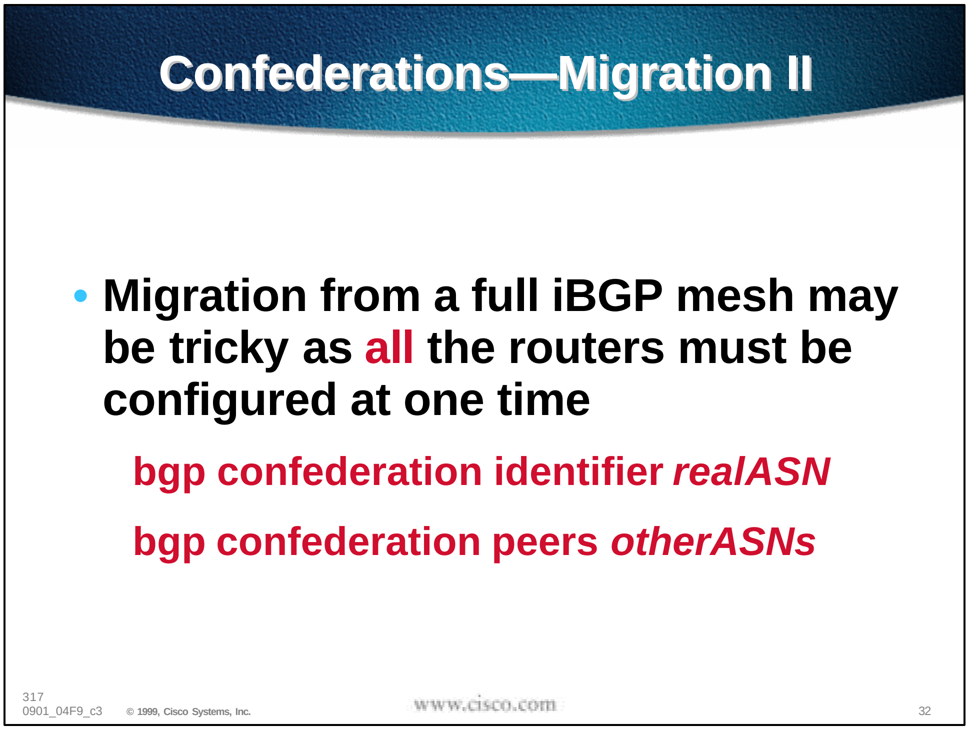


Confederations—Migration I

- Same steps as when using eBGP connections, but external connections may be located anywhere in the network!
- What about the IGP?

  It must carry routes to the infrastructure (all links) and peering addresses (including external NEXT_HOP)

  One instance of the IGP for the whole AS



Confederations—Migration II

- Migration from a full iBGP mesh may be tricky as all the routers must be configured at one time

  bgp confederation identifier *realASN*

  bgp confederation peers *otherASNs*

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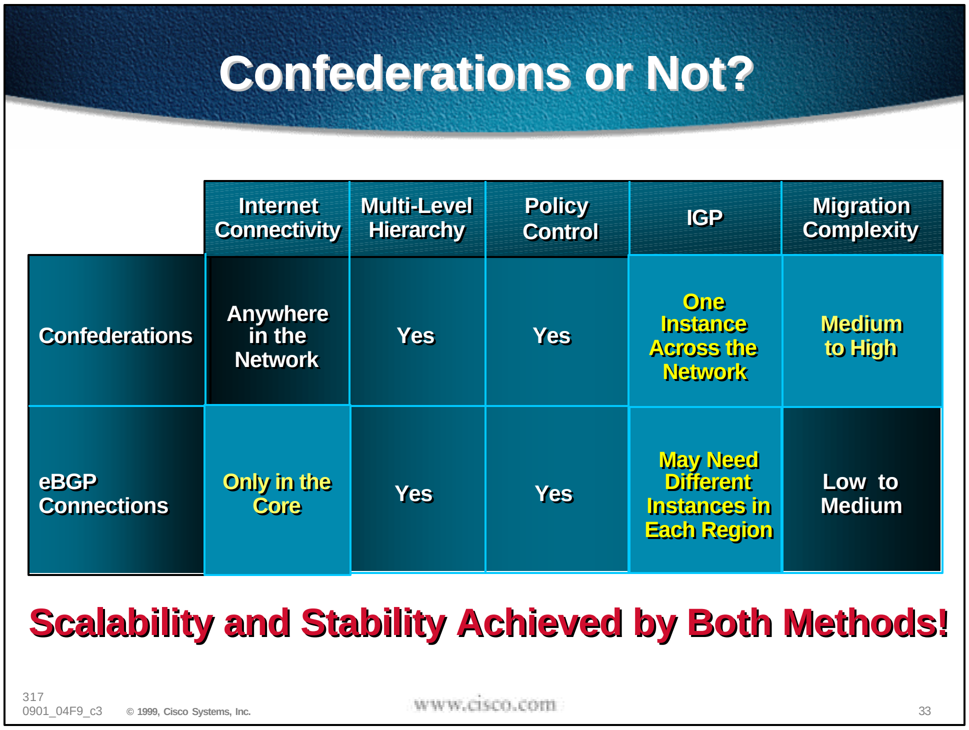

Confederations or Not?

	Internet Connectivity	Multi-Level Hierarchy	Policy Control	IGP	Migration Complexity
Confederations	Anywhere in the Network	Yes	Yes	One Instance Across the Network	Medium to High
eBGP Connections	Only in the Core	Yes	Yes	May Need Different Instances in Each Region	Low to Medium

Scalability and Stability Achieved by Both Methods!

Route Reflectors

Playing with Mirrors

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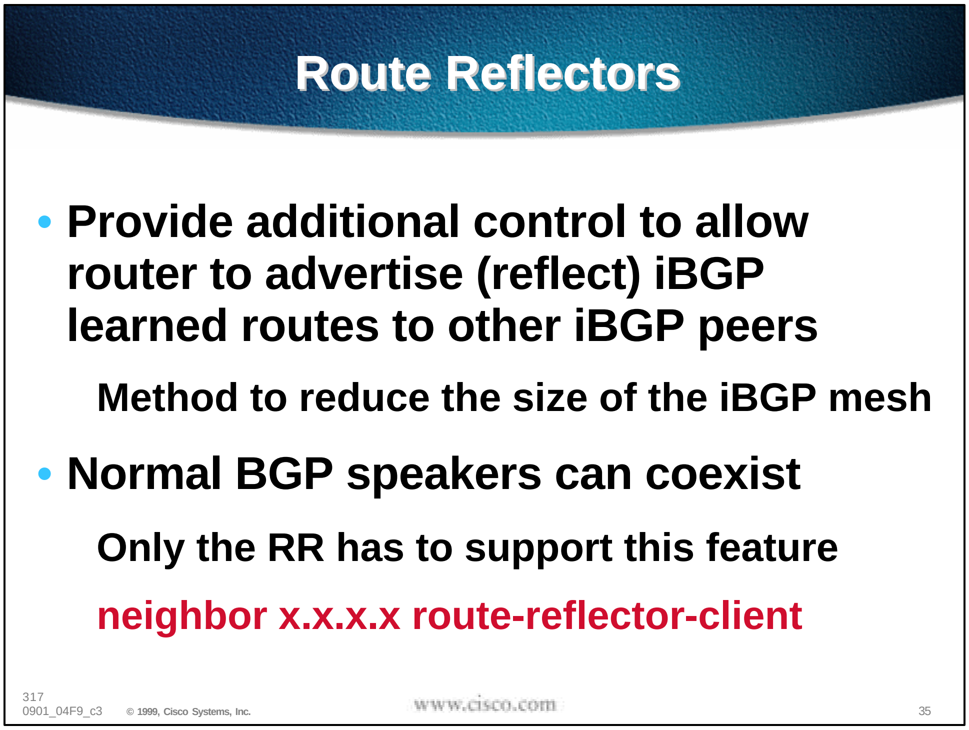

Route Reflectors

- Provide additional control to allow router to advertise (reflect) iBGP learned routes to other iBGP peers

  Method to reduce the size of the iBGP mesh

- Normal BGP speakers can coexist

  Only the RR has to support this feature

  neighbor x.x.x.x route-reflector-client

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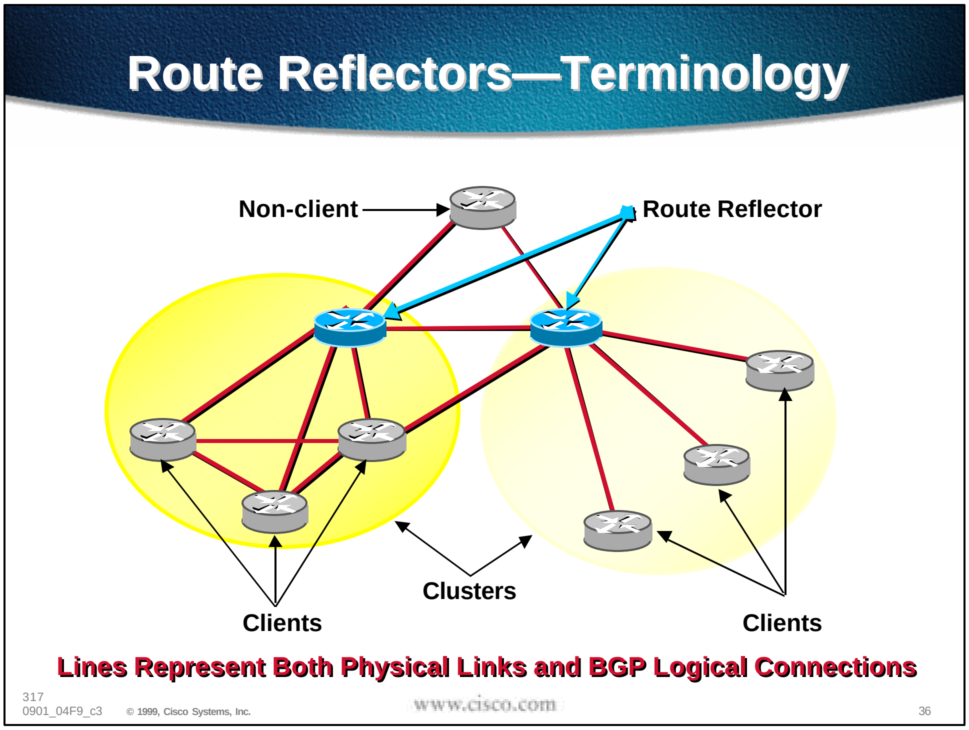

Route Reflectors—Terminology

Lines Represent Both Physical Links and BGP Logical Connections

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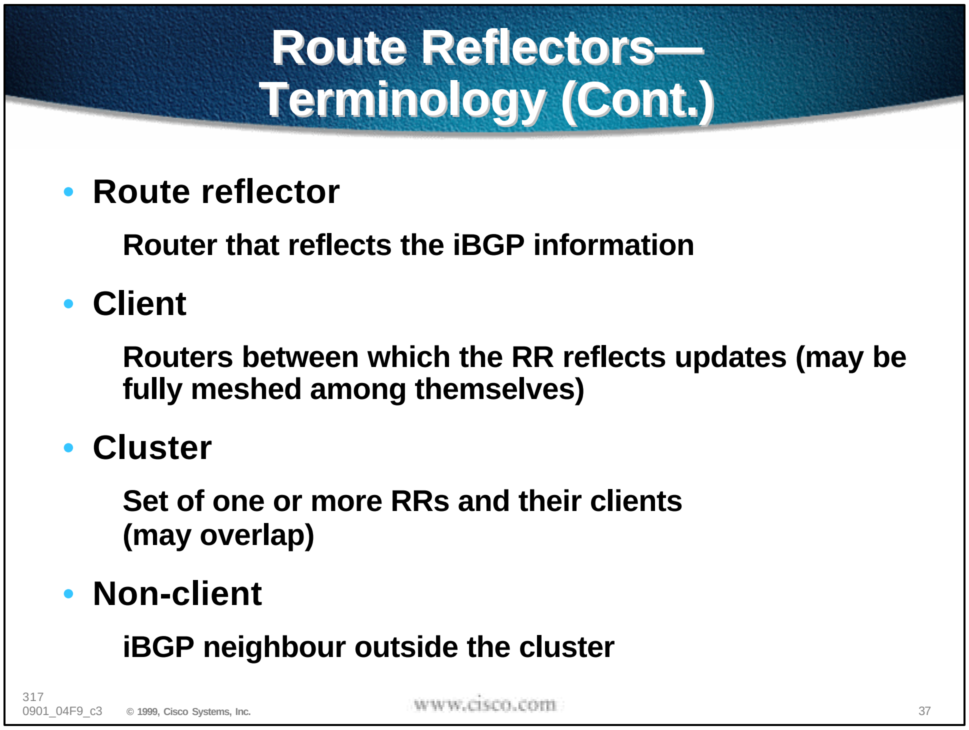


Route Reflectors— Terminology (Cont.)

- Route reflector

  Router that reflects the iBGP information

- Client

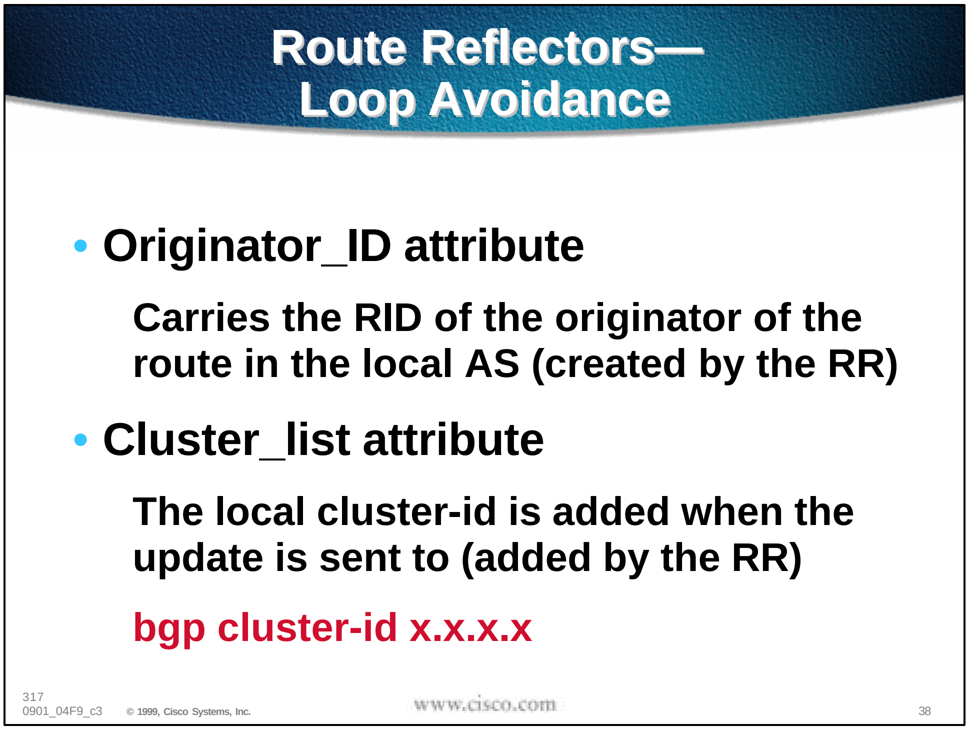
  Routers between which the RR reflects updates (may be fully meshed among themselves)

- Cluster

  Set of one or more RRs and their clients (may overlap)

- Non-client

  iBGP neighbour outside the cluster



Route Reflectors— Loop Avoidance

- Originator_ID attribute

  Carries the RID of the originator of the route in the local AS (created by the RR)

- Cluster_list attribute

  The local cluster-id is added when the update is sent to (added by the RR)

  bgp cluster-id x.x.x.x

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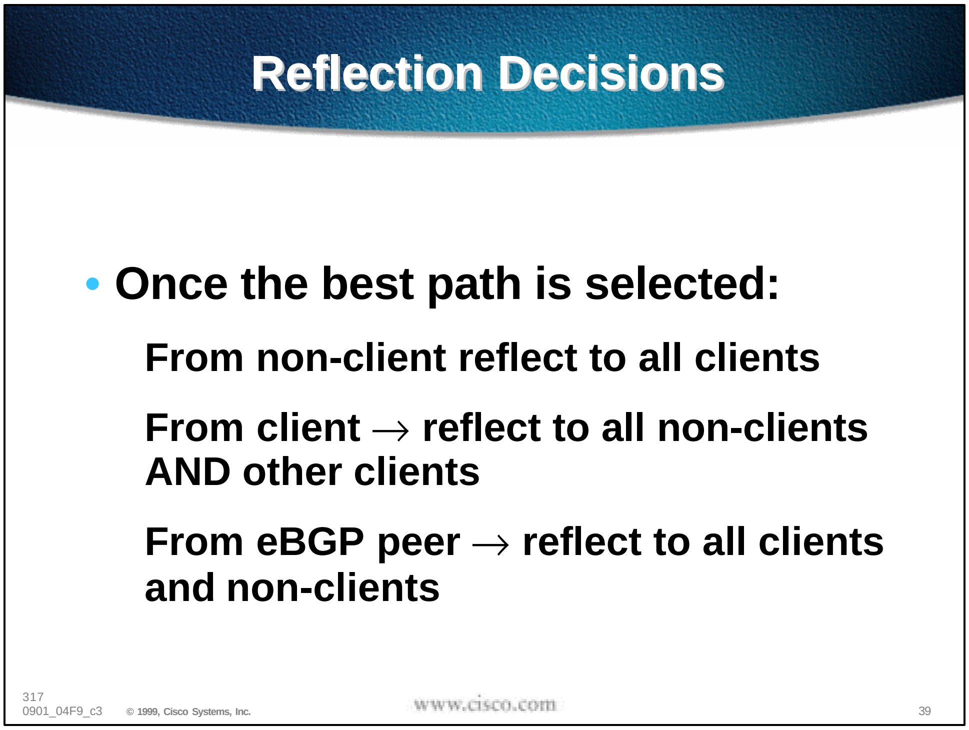


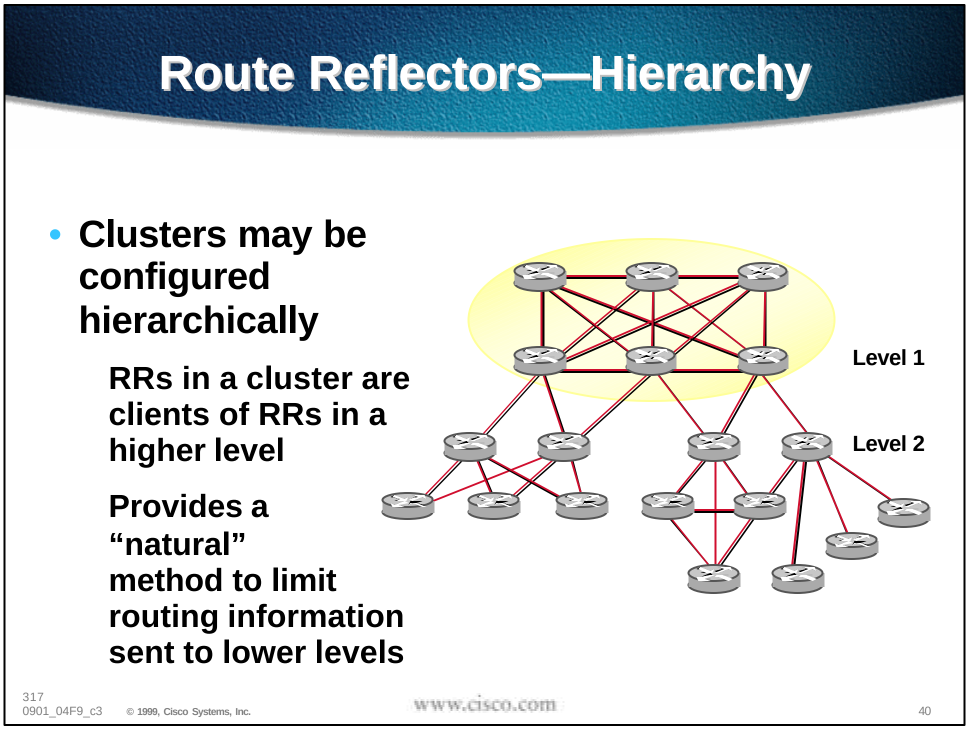
Reflection Decisions

- Once the best path is selected:

  From non-client reflect to all clients

  From client → reflect to all non-clients AND other clients

  From eBGP peer → reflect to all clients and non-clients



Route Reflectors—Hierarchy

- Clusters may be configured hierarchically

  RRs in a cluster are clients of RRs in a higher level

  Provides a “natural” method to limit routing information sent to lower levels

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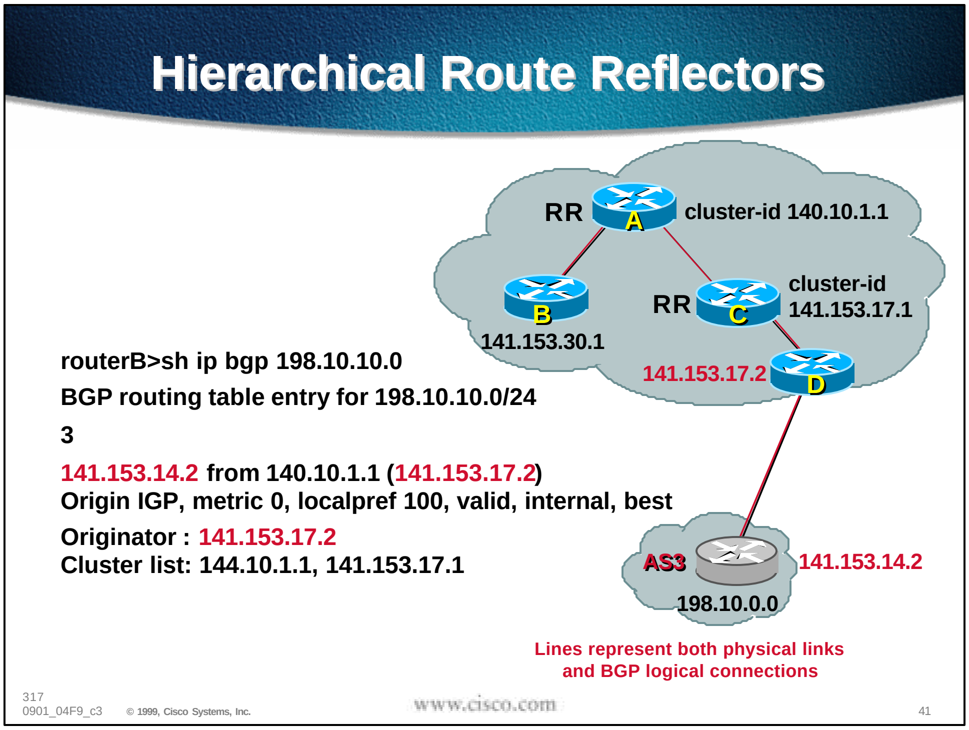

Hierarchical Route Reflectors

```
routerB>sh ip bgp 198.10.10.0
BGP routing table entry for 198.10.10.0/24
3
141.153.14.2 from 140.10.1.1 (141.153.17.2)
Origin IGP, metric 0, localpref 100, valid, internal, best
Originator : 141.153.17.2
Cluster list: 144.10.1.1, 141.153.17.1
```

Lines represent both physical links and BGP logical connections

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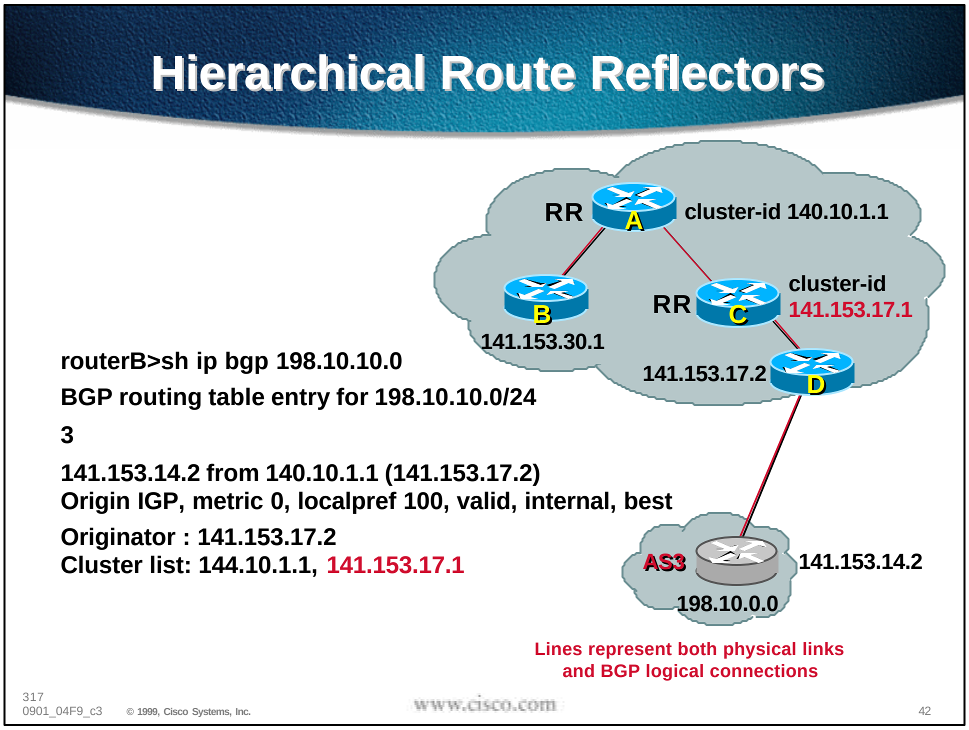

Hierarchical Route Reflectors

```
routerB>sh ip bgp 198.10.10.0
BGP routing table entry for 198.10.10.0/24
3
141.153.14.2 from 140.10.1.1 (141.153.17.2)
Origin IGP, metric 0, localpref 100, valid, internal, best
Originator : 141.153.17.2
Cluster list: 144.10.1.1, 141.153.17.1
```

Lines represent both physical links and BGP logical connections

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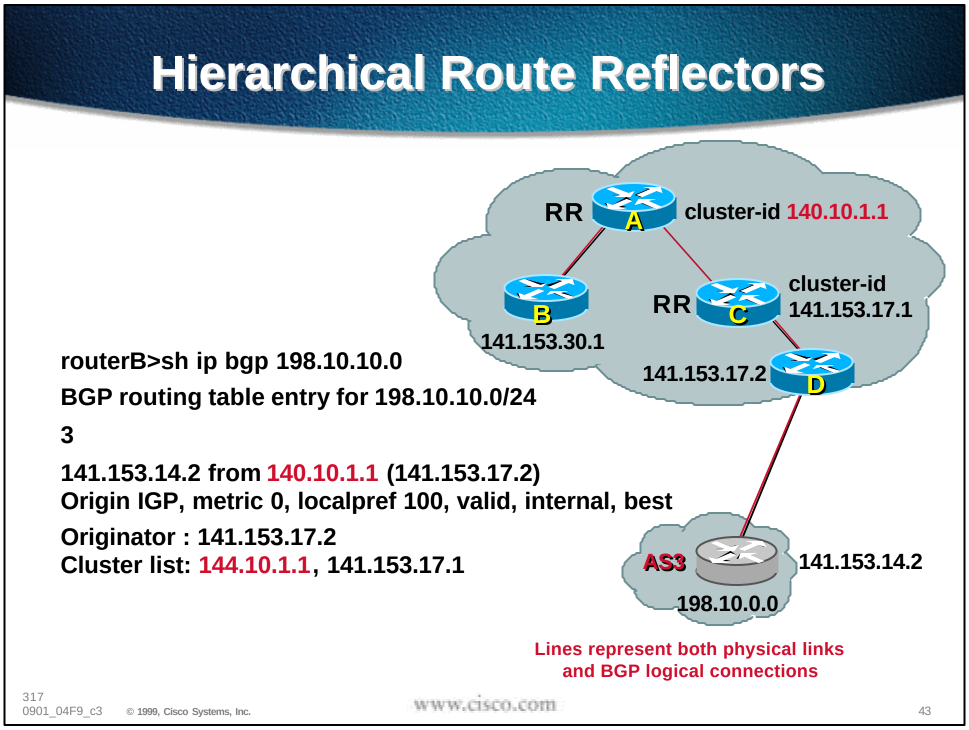
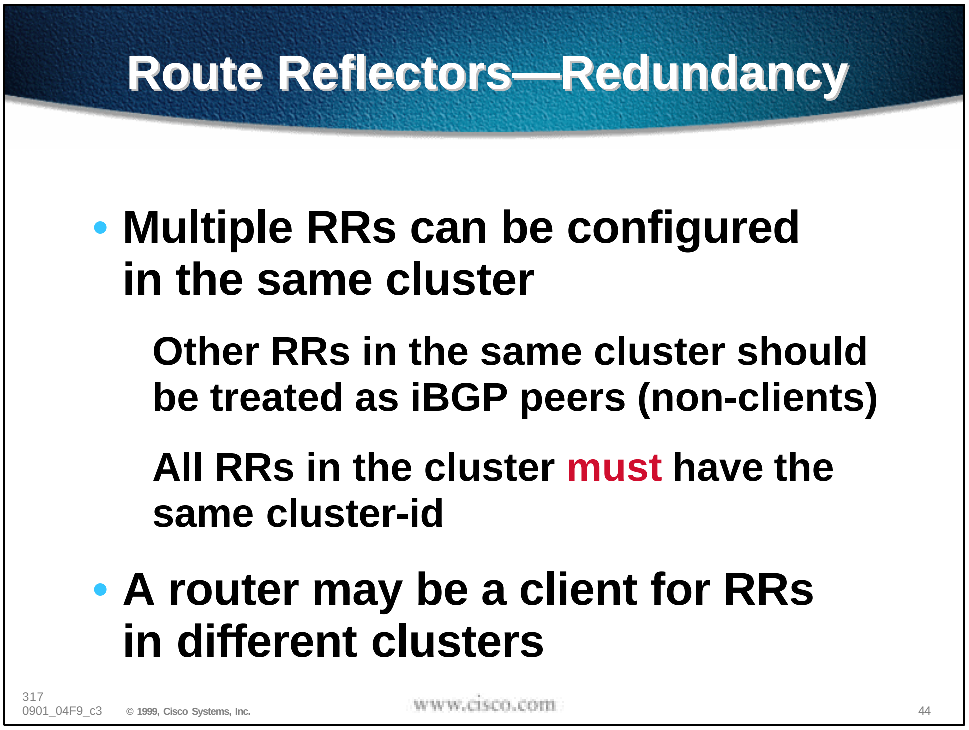


Hierarchical Route Reflectors

```
routerB>sh ip bgp 198.10.10.0
BGP routing table entry for 198.10.10.0/24
3
141.153.14.2 from 140.10.1.1 (141.153.17.2)
Origin IGP, metric 0, localpref 100, valid, internal, best
Originator : 141.153.17.2
Cluster list: 144.10.1.1, 141.153.17.1
```

Lines represent both physical links
and BGP logical connections



Route Reflectors—Redundancy

- Multiple RRs can be configured in the same cluster

  Other RRs in the same cluster should be treated as iBGP peers (non-clients)

  All RRs in the cluster **must** have the same cluster-id

- A router may be a client for RRs in different clusters

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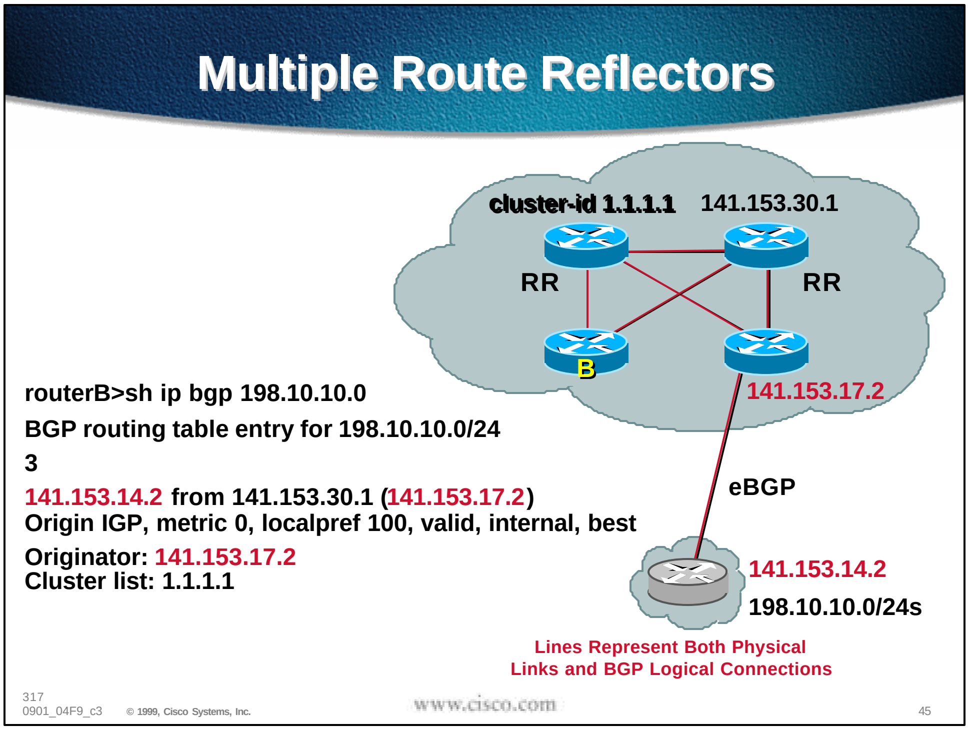

Multiple Route Reflectors

routerB>sh ip bgp 198.10.10.0

BGP routing table entry for 198.10.10.0/24

3

141.153.14.2 from 141.153.30.1 (141.153.17.2)
Origin IGP, metric 0, localpref 100, valid, internal, best

Originator: 141.153.17.2
Cluster list: 1.1.1.1

Lines Represent Both Physical
Links and BGP Logical Connections

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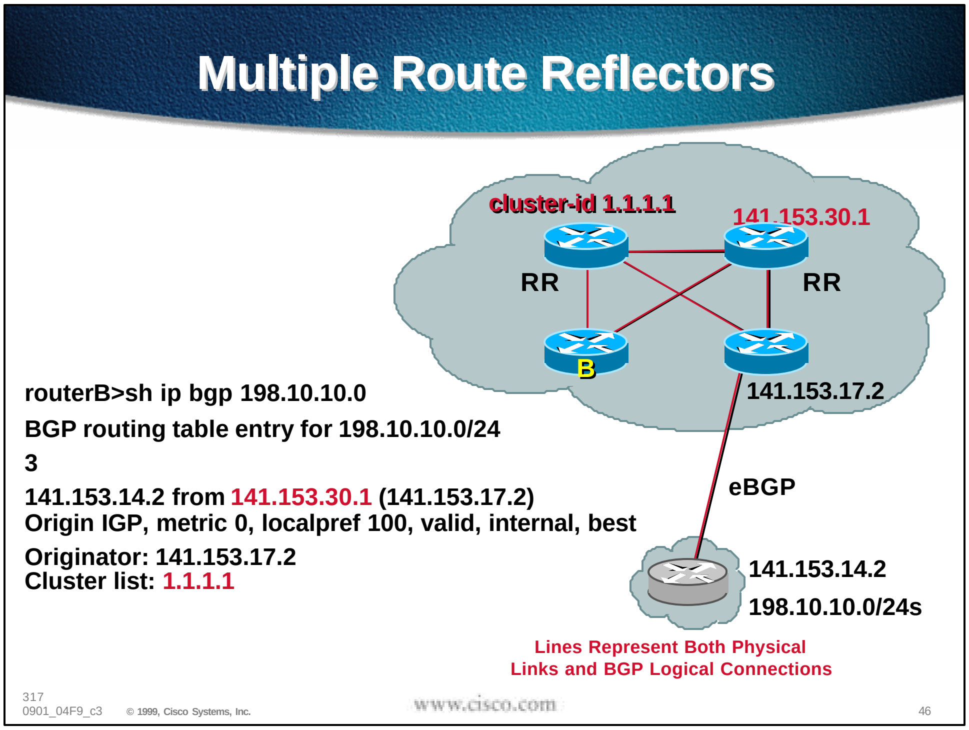

Multiple Route Reflectors

routerB>sh ip bgp 198.10.10.0

BGP routing table entry for 198.10.10.0/24

3

141.153.14.2 from 141.153.30.1 (141.153.17.2)
Origin IGP, metric 0, localpref 100, valid, internal, best

Originator: 141.153.17.2
Cluster list: 1.1.1.1

Lines Represent Both Physical
Links and BGP Logical Connections

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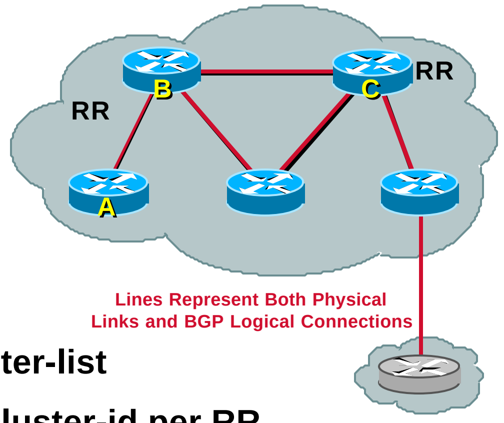
Multiple Route Reflectors

- The cluster-id **must** be different, otherwise B will not reflect any route to A if coming from C

  B will detect its own cluster-id in the cluster-list

  Tip: use a different cluster-id per RR



Lines Represent Both Physical Links and BGP Logical Connections

Route Reflectors—Migration

- Where to place the route reflectors?

  Follow the physical topology!

  This will guarantee that the packet forwarding won't be affected

- Configure one RR at a time

  Eliminate redundant iBGP sessions

  Place one RR per cluster

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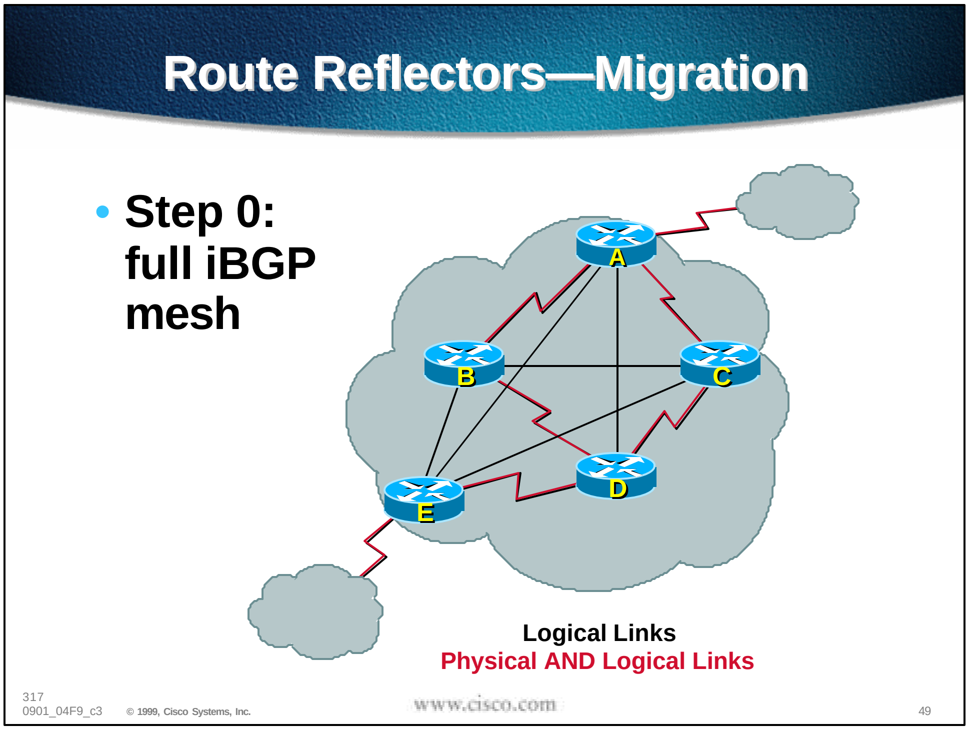
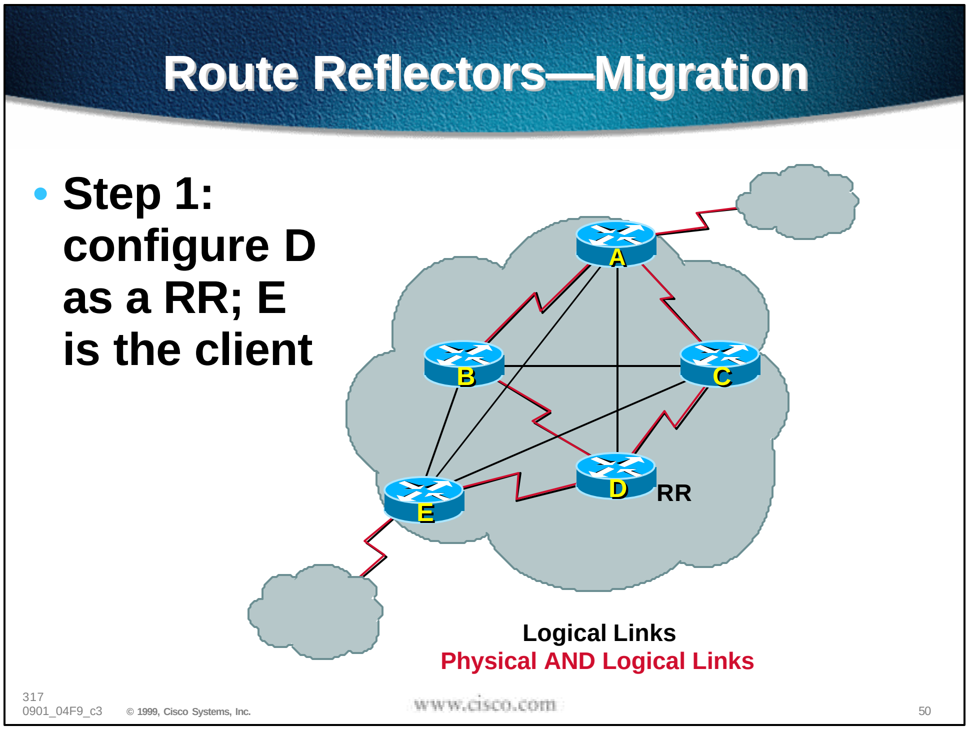


Route Reflectors—Migration

- Step 0: full iBGP mesh

Logical Links

Physical AND Logical Links



Route Reflectors—Migration

- Step 1: configure D as a RR; E is the client

Logical Links

Physical AND Logical Links

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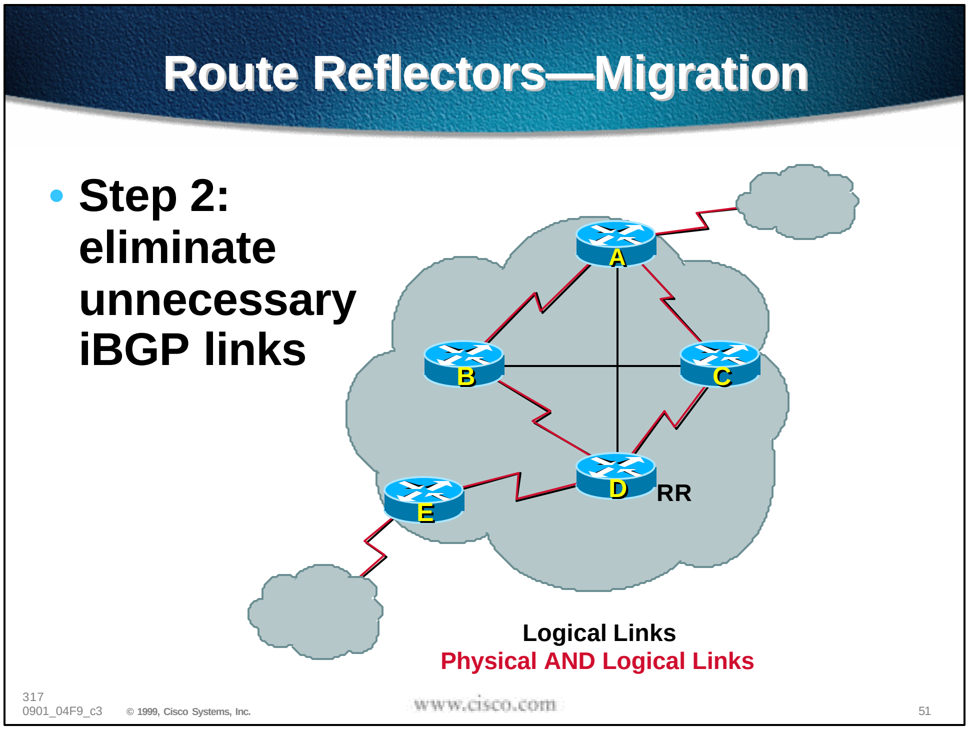

Route Reflectors—Migration

- **Step 2: eliminate unnecessary iBGP links**

Logical Links

Physical AND Logical Links

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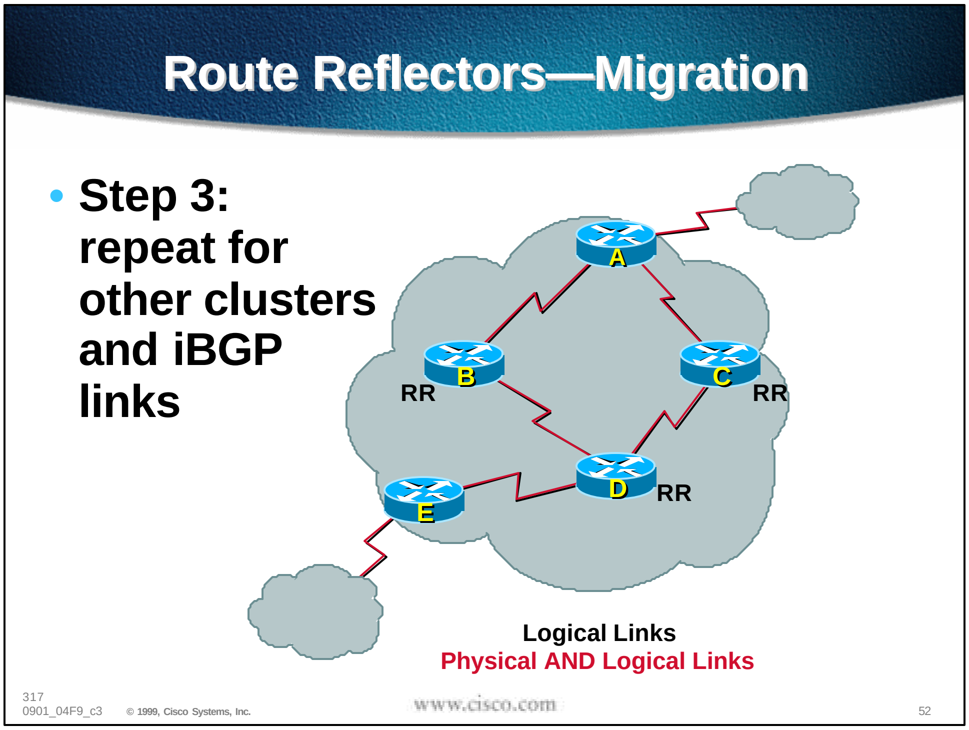

Route Reflectors—Migration

- **Step 3: repeat for other clusters and iBGP links**

Logical Links

Physical AND Logical Links

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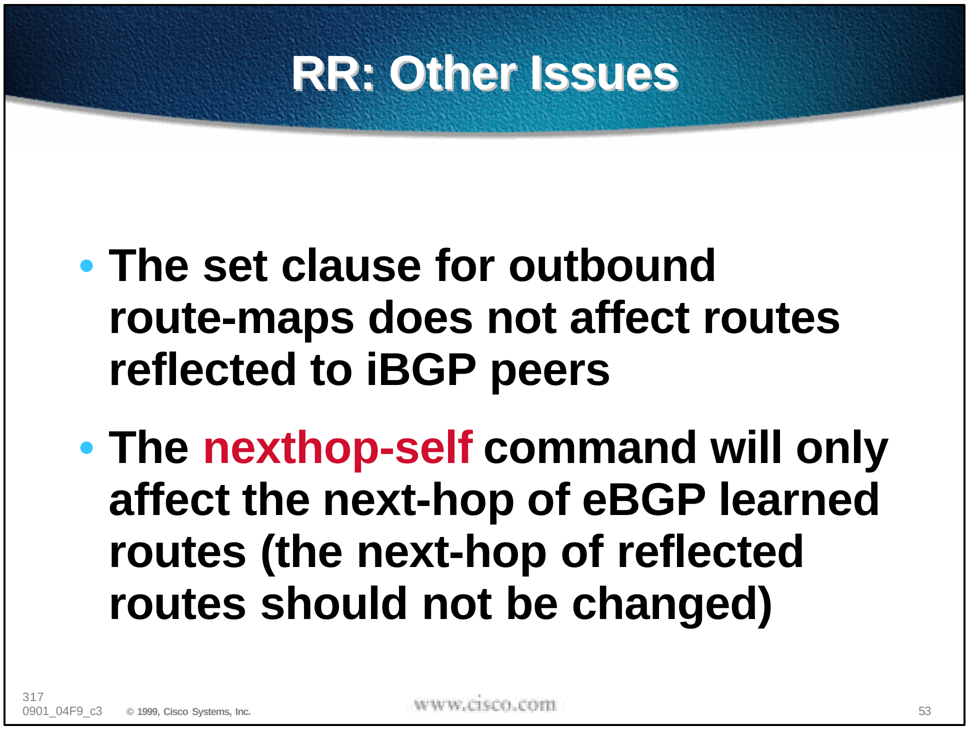
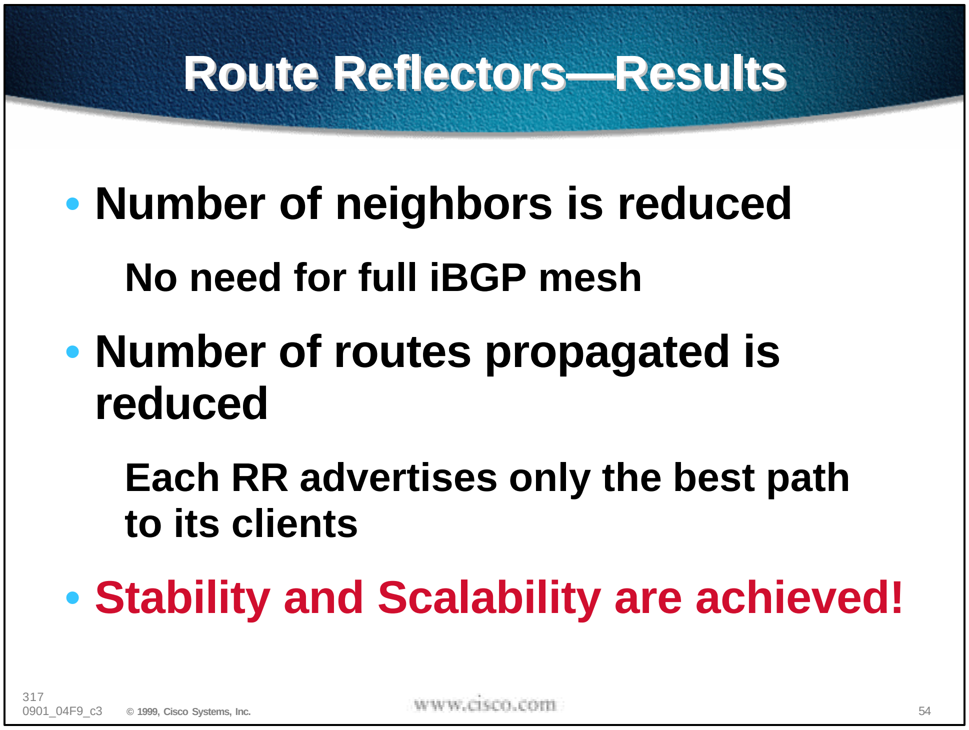


RR: Other Issues

- The set clause for outbound route-maps does not affect routes reflected to iBGP peers
- The nexthop-self command will only affect the next-hop of eBGP learned routes (the next-hop of reflected routes should not be changed)



Route Reflectors—Results

- Number of neighbors is reduced

  No need for full iBGP mesh

- Number of routes propagated is reduced

  Each RR advertises only the best path to its clients

- Stability and Scalability are achieved!

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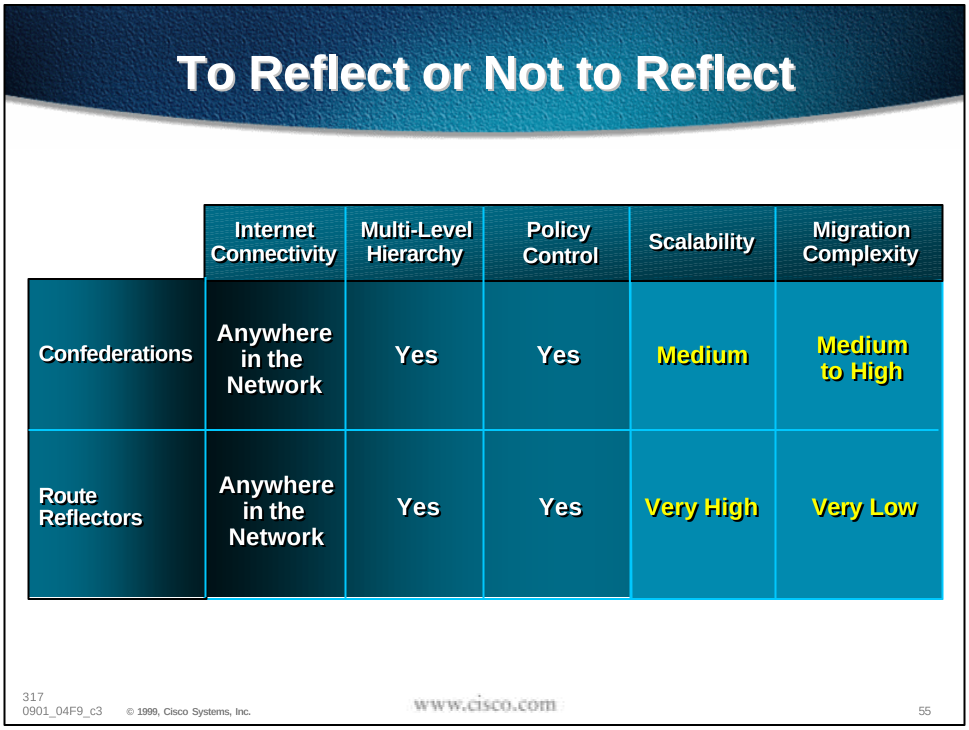

To Reflect or Not to Reflect

	Internet Connectivity	Multi-Level Hierarchy	Policy Control	Scalability	Migration Complexity
Confederations	Anywhere in the Network	Yes	Yes	Medium	Medium to High
Route Reflectors	Anywhere in the Network	Yes	Yes	Very High	Very Low

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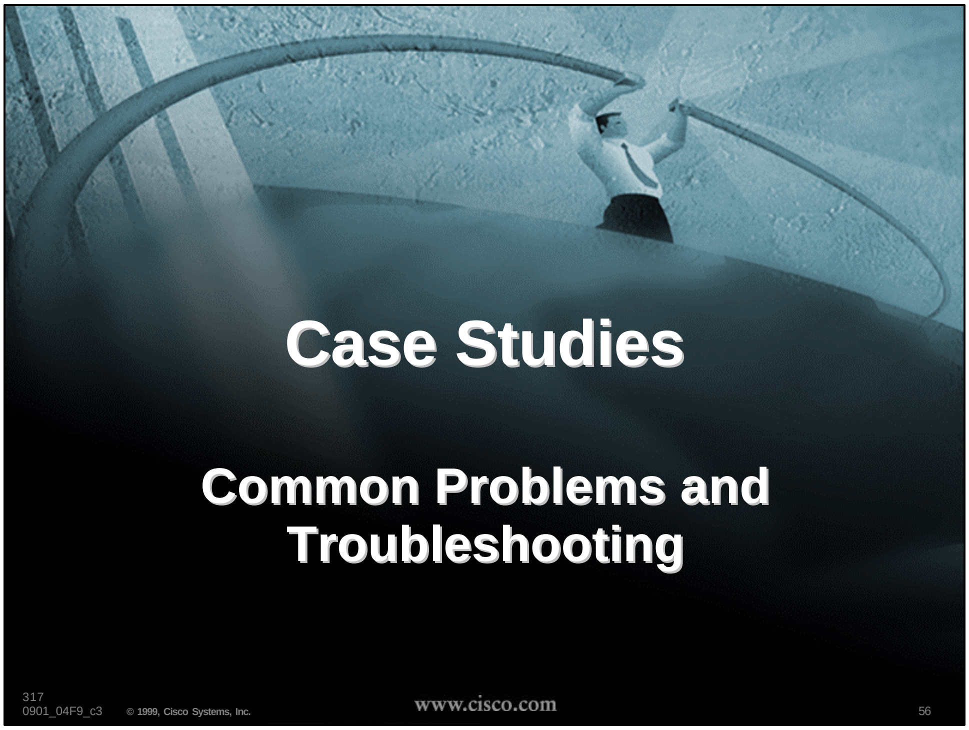

Case Studies

Common Problems and Troubleshooting

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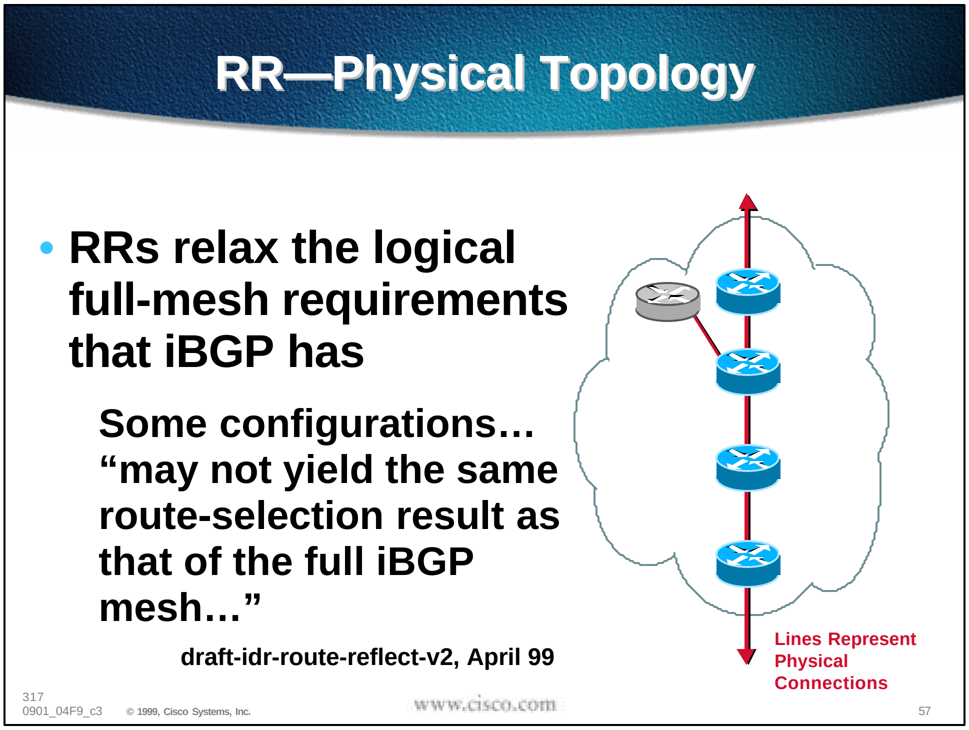
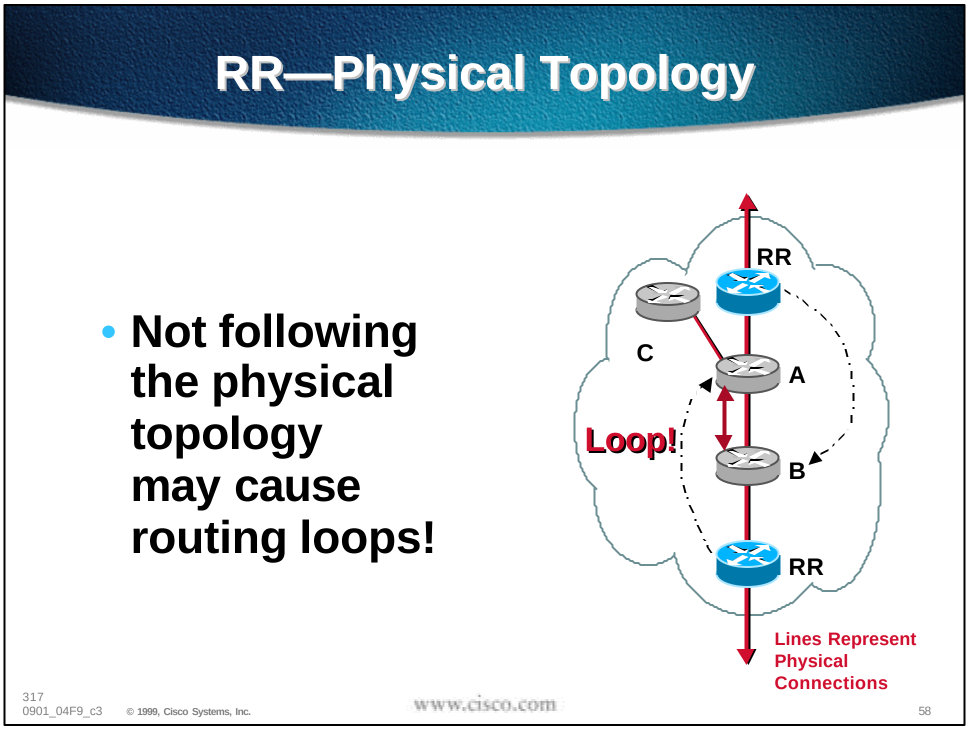


RR—Physical Topology

- RRs relax the logical full-mesh requirements that iBGP has

Some configurations… "may not yield the same route-selection result as that of the full iBGP mesh…"

draft-idr-route-reflect-v2, April 99



RR—Physical Topology

- Not following the physical topology may cause routing loops!

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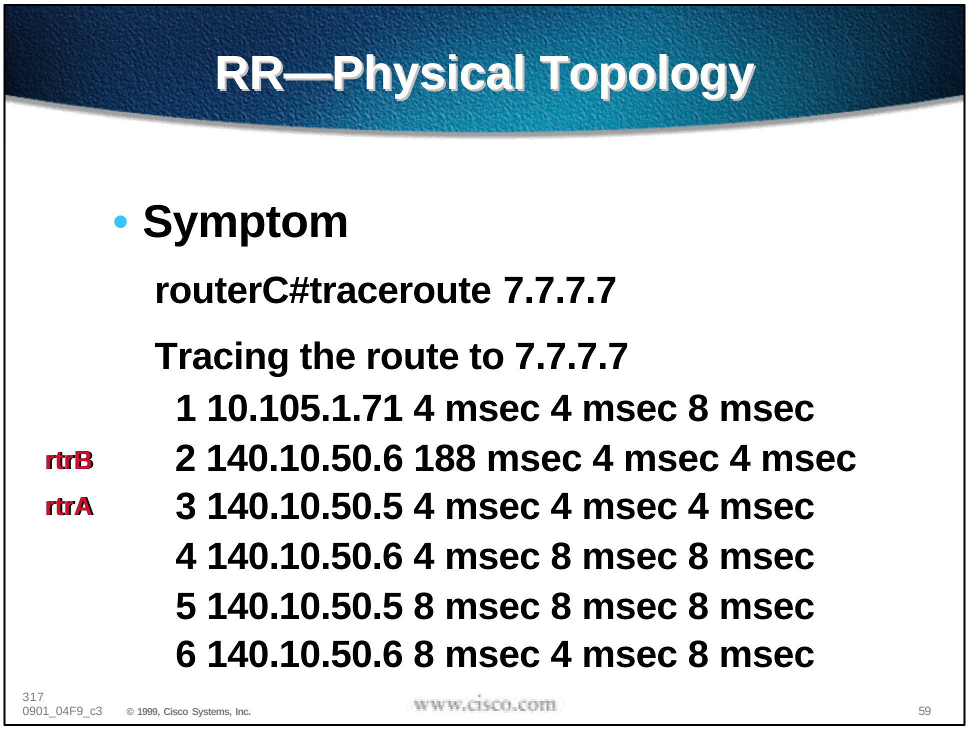

RR—Physical Topology

- **Symptom**

```
routerC#traceroute 7.7.7.7

Tracing the route to 7.7.7.7
       1 10.105.1.71 4 msec 4 msec 8 msec
rtrB   2 140.10.50.6 188 msec 4 msec 4 msec
rtrA   3 140.10.50.5 4 msec 4 msec 4 msec
       4 140.10.50.6 4 msec 8 msec 8 msec
       5 140.10.50.5 8 msec 8 msec 8 msec
       6 140.10.50.6 8 msec 4 msec 8 msec
```

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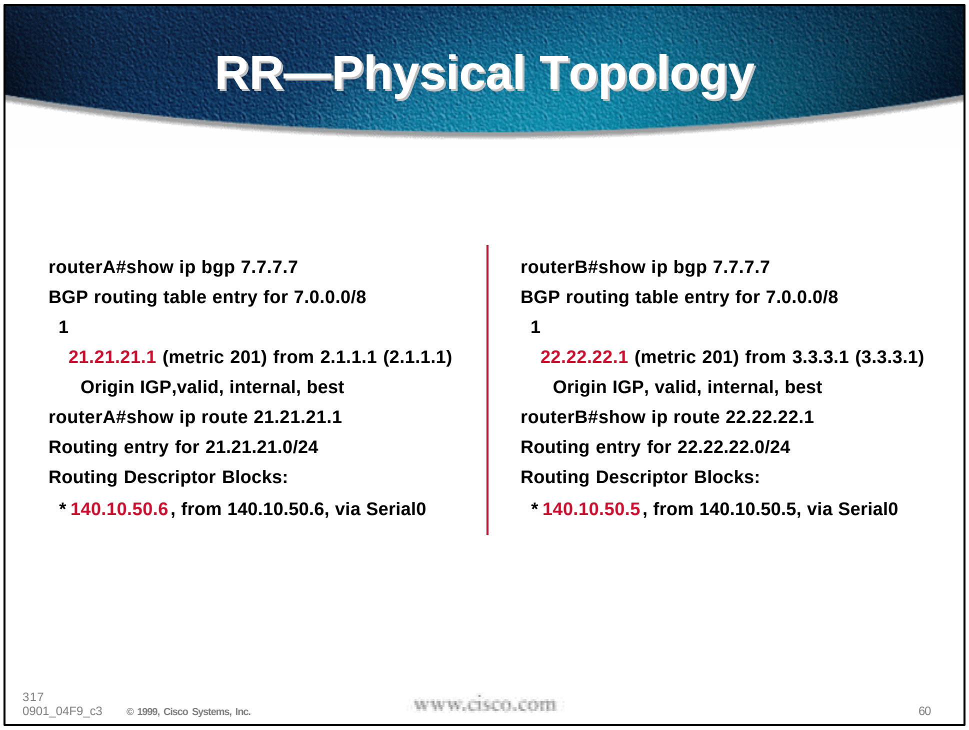

RR—Physical Topology

```
routerA#show ip bgp 7.7.7.7
BGP routing table entry for 7.0.0.0/8
 1
   21.21.21.1 (metric 201) from 2.1.1.1 (2.1.1.1)
     Origin IGP,valid, internal, best
routerA#show ip route 21.21.21.1
Routing entry for 21.21.21.0/24
Routing Descriptor Blocks:
 * 140.10.50.6, from 140.10.50.6, via Serial0
```

```
routerB#show ip bgp 7.7.7.7
BGP routing table entry for 7.0.0.0/8
 1
   22.22.22.1 (metric 201) from 3.3.3.1 (3.3.3.1)
     Origin IGP, valid, internal, best
routerB#show ip route 22.22.22.1
Routing entry for 22.22.22.0/24
Routing Descriptor Blocks:
 * 140.10.50.5, from 140.10.50.5, via Serial0
```

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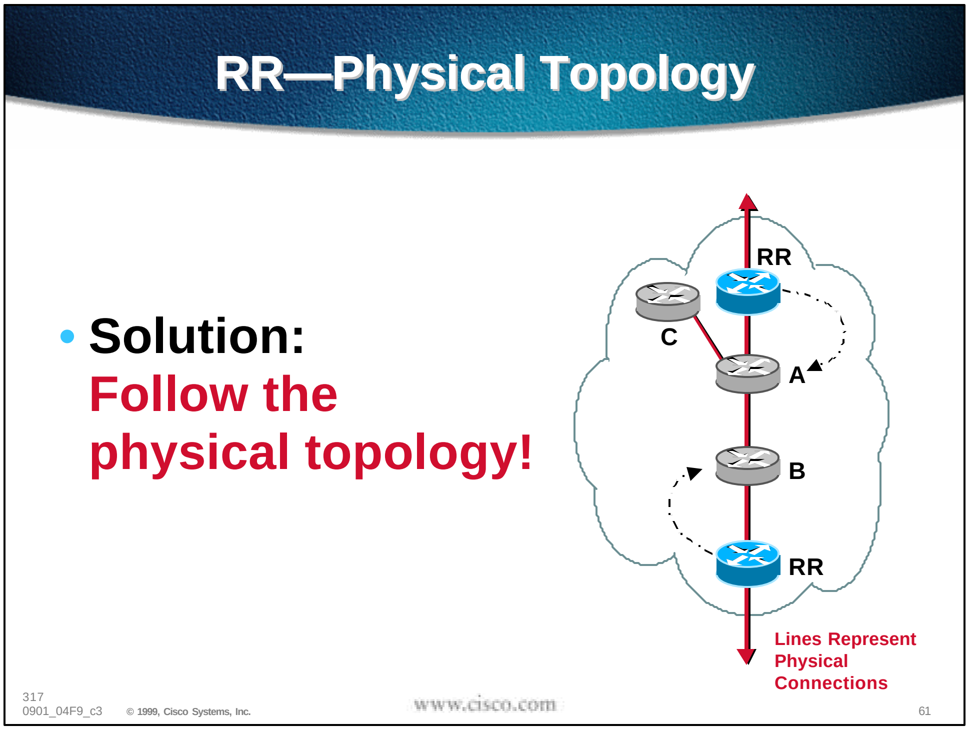
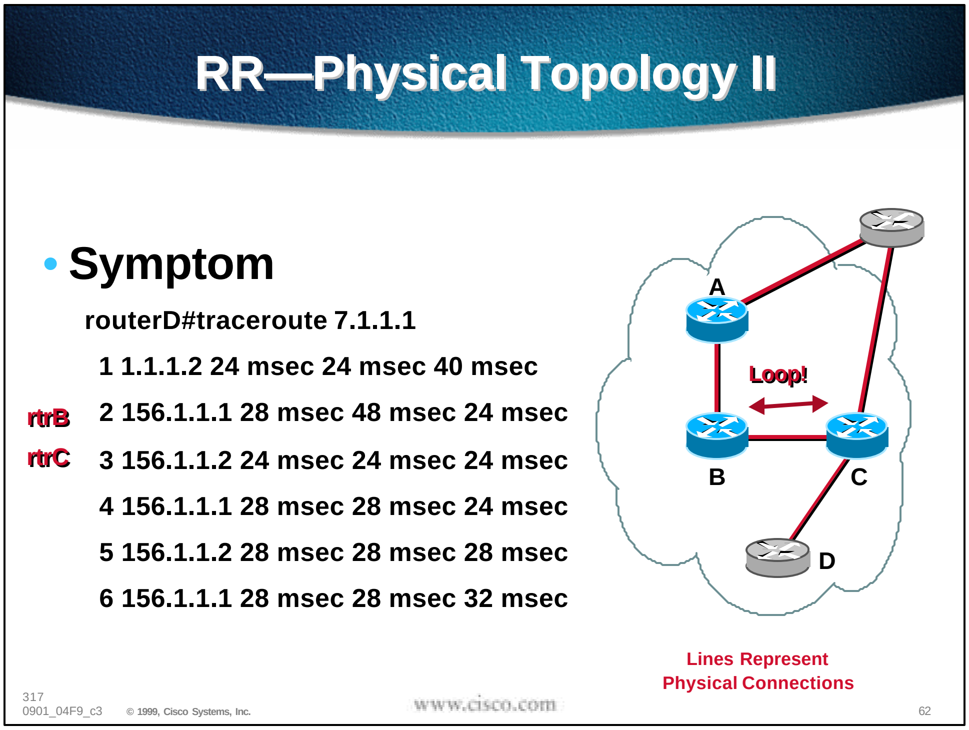


RR—Physical Topology

- **Solution:**
  Follow the physical topology!

Lines Represent Physical Connections



RR—Physical Topology II

- **Symptom**

```
     routerD#traceroute 7.1.1.1
       1 1.1.1.2 24 msec 24 msec 40 msec
rtrB   2 156.1.1.1 28 msec 48 msec 24 msec
rtrC   3 156.1.1.2 24 msec 24 msec 24 msec
       4 156.1.1.1 28 msec 28 msec 24 msec
       5 156.1.1.2 28 msec 28 msec 28 msec
       6 156.1.1.1 28 msec 28 msec 32 msec
```

Lines Represent Physical Connections

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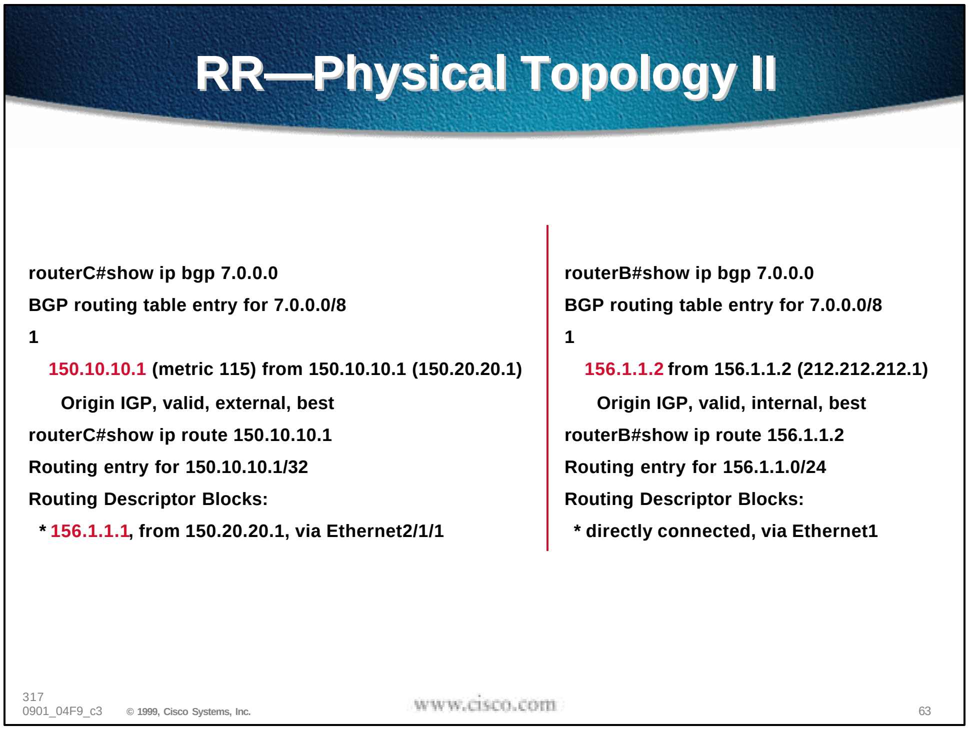
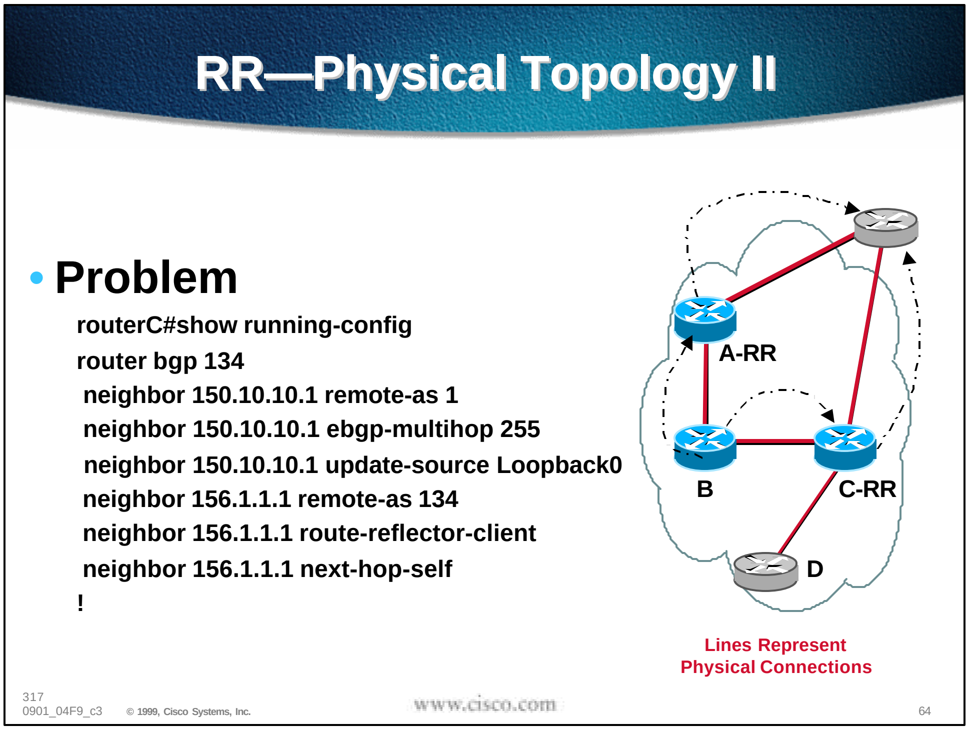


RR—Physical Topology II

```
routerC#show ip bgp 7.0.0.0
BGP routing table entry for 7.0.0.0/8
1
   150.10.10.1 (metric 115) from 150.10.10.1 (150.20.20.1)
     Origin IGP, valid, external, best
routerC#show ip route 150.10.10.1
Routing entry for 150.10.10.1/32
Routing Descriptor Blocks:
 * 156.1.1.1, from 150.20.20.1, via Ethernet2/1/1
```

```
routerB#show ip bgp 7.0.0.0
BGP routing table entry for 7.0.0.0/8
1
   156.1.1.2 from 156.1.1.2 (212.212.212.1)
     Origin IGP, valid, internal, best
routerB#show ip route 156.1.1.2
Routing entry for 156.1.1.0/24
Routing Descriptor Blocks:
 * directly connected, via Ethernet1
```



RR—Physical Topology II

- **Problem**

```
routerC#show running-config
router bgp 134
 neighbor 150.10.10.1 remote-as 1
 neighbor 150.10.10.1 ebgp-multihop 255
 neighbor 150.10.10.1 update-source Loopback0
 neighbor 156.1.1.1 remote-as 134
 neighbor 156.1.1.1 route-reflector-client
 neighbor 156.1.1.1 next-hop-self
!
```

Lines Represent Physical Connections

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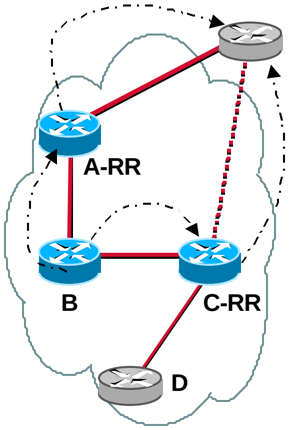
RR—Physical Topology II

- **Problem**

```
routerC#show running-config
router bgp 134
 neighbor 150.10.10.1 remote-as 1
 neighbor 150.10.10.1 ebgp-multihop 255
 neighbor 150.10.10.1 update-source Loopback0
 neighbor 156.1.1.1 remote-as 134
 neighbor 156.1.1.1 route-reflector-client
 neighbor 156.1.1.1 next-hop-self
!
ip route 150.10.10.1 255.255.255.255 s0 250
```



Lines Represent
Physical Connections

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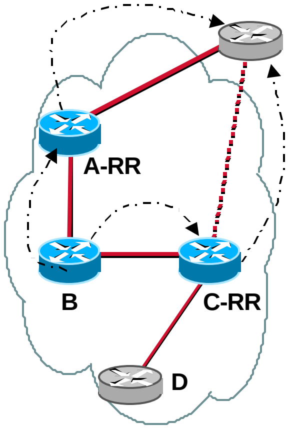
RR—Physical Topology II

- **Solution**

  Establish the eBGP peering permanently through the “backup” link

  Use LOCAL_PREF or MED to break any tie!



Lines Represent
Physical Connections

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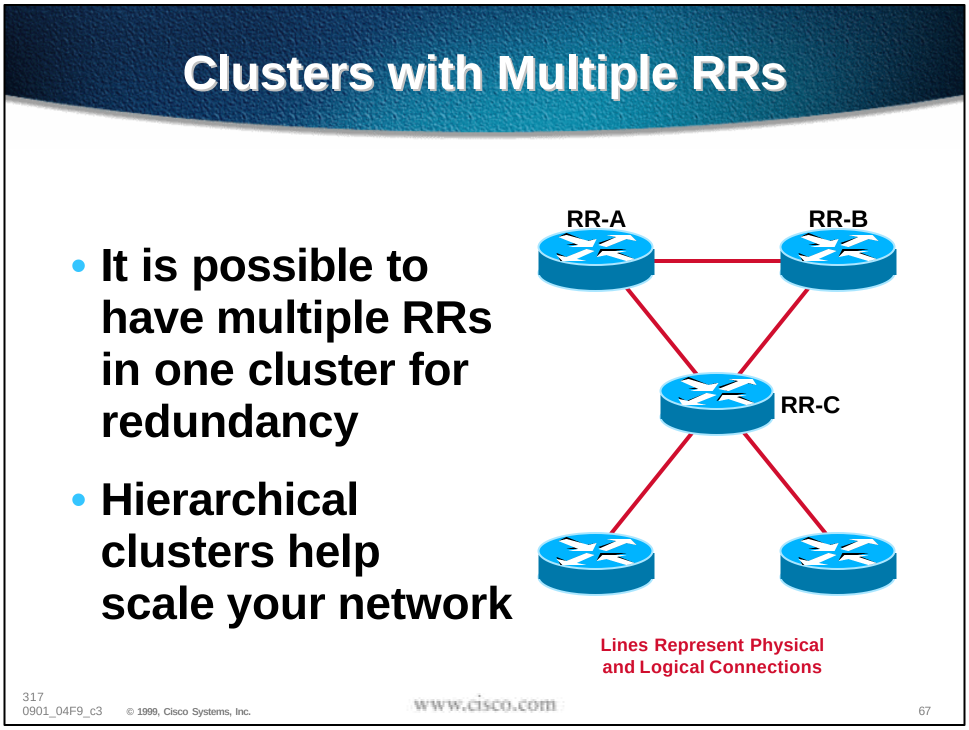

Clusters with Multiple RRs

- It is possible to have multiple RRs in one cluster for redundancy
- Hierarchical clusters help scale your network

RR-A

RR-B

RR-C

Lines Represent Physical and Logical Connections

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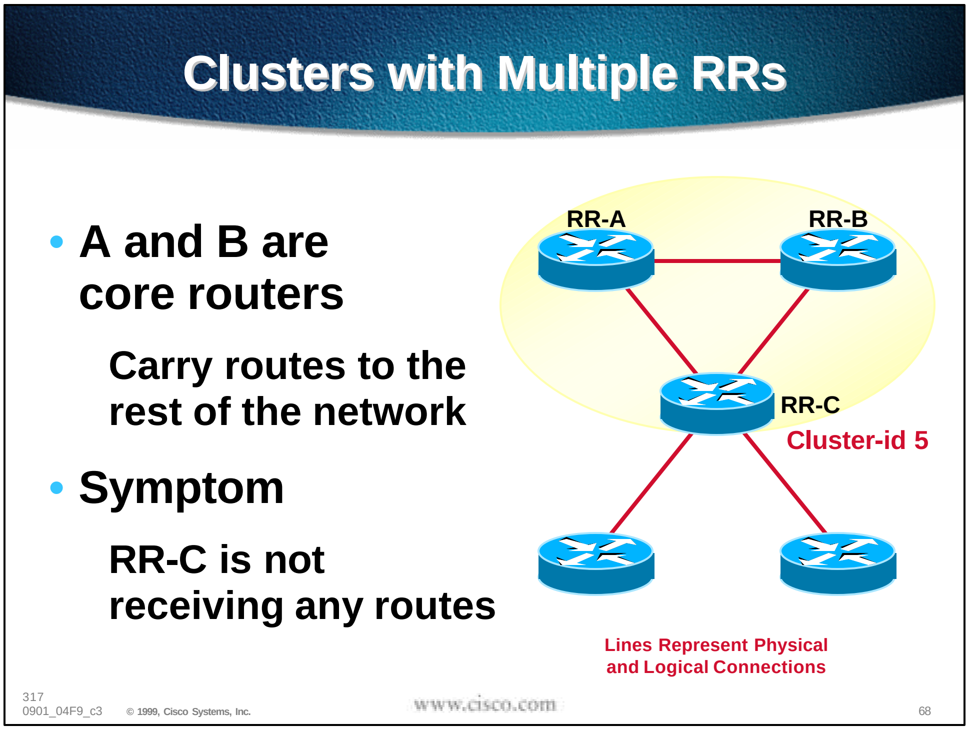

Clusters with Multiple RRs

- A and B are core routers

  Carry routes to the rest of the network

- Symptom

  RR-C is not receiving any routes

RR-A

RR-B

RR-C

Cluster-id 5

Lines Represent Physical and Logical Connections

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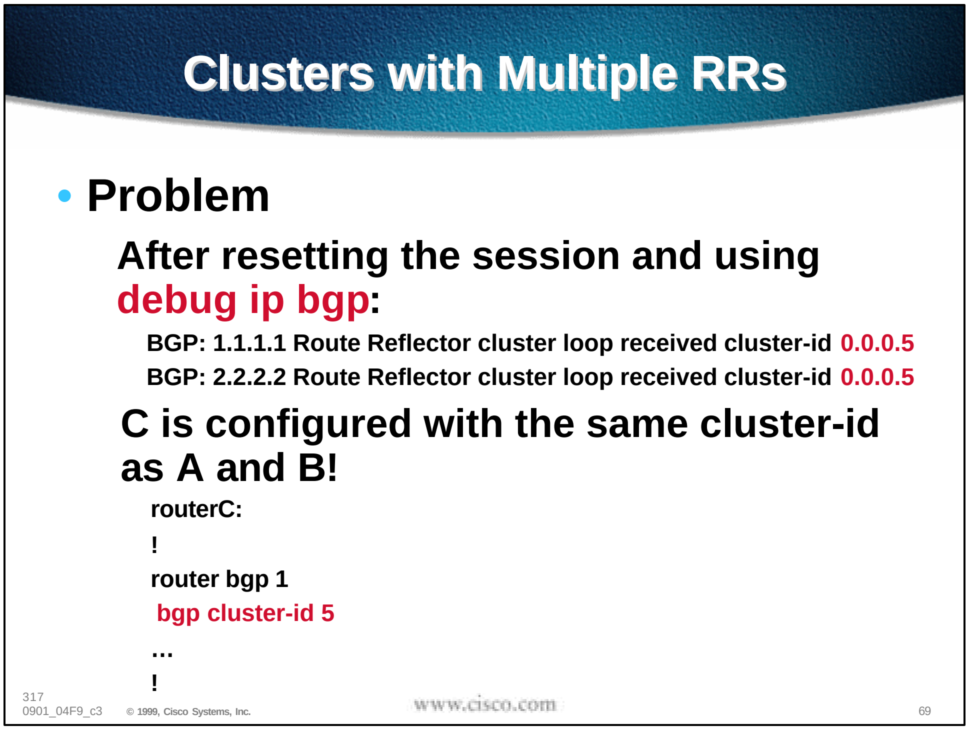


Clusters with Multiple RRs

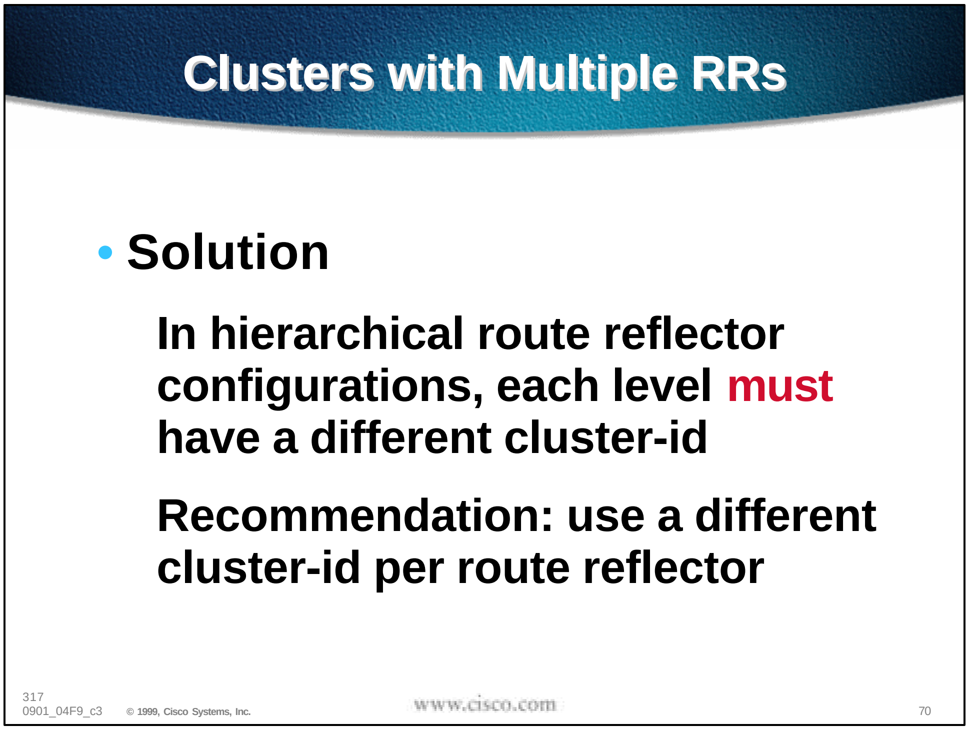
- Problem

After resetting the session and using **debug ip bgp**:

```
BGP: 1.1.1.1 Route Reflector cluster loop received cluster-id 0.0.0.5
BGP: 2.2.2.2 Route Reflector cluster loop received cluster-id 0.0.0.5
```

C is configured with the same cluster-id as A and B!

```
routerC:
!
router bgp 1
 bgp cluster-id 5
...
!
```



Clusters with Multiple RRs

- Solution

In hierarchical route reflector configurations, each level **must** have a different cluster-id

Recommendation: use a different cluster-id per route reflector

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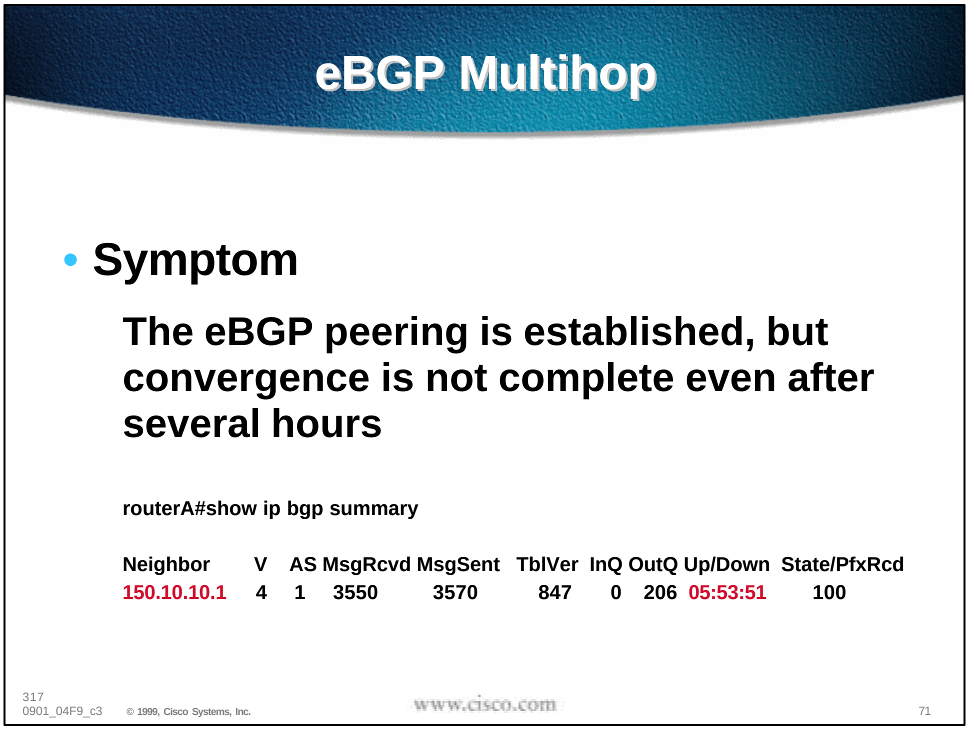


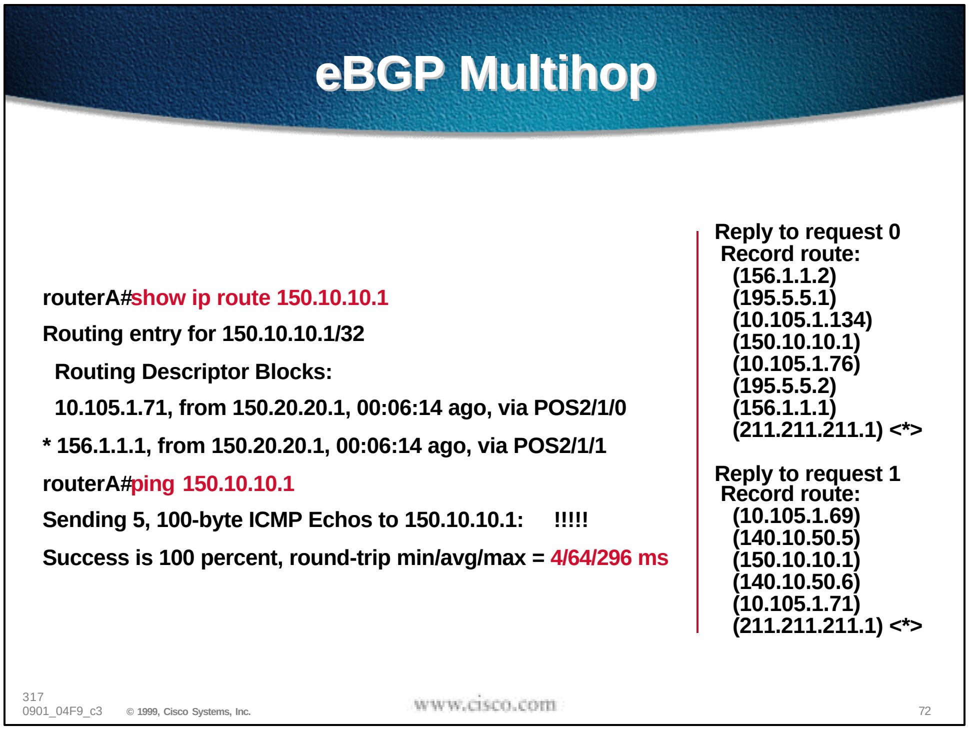
eBGP Multihop

- **Symptom**

  The eBGP peering is established, but convergence is not complete even after several hours

```
routerA#show ip bgp summary

Neighbor       V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
150.10.10.1    4    1     3550        3570       847     0    206  05:53:51       100
```



eBGP Multihop

```
routerA#show ip route 150.10.10.1
Routing entry for 150.10.10.1/32
  Routing Descriptor Blocks:
  10.105.1.71, from 150.20.20.1, 00:06:14 ago, via POS2/1/0
* 156.1.1.1, from 150.20.20.1, 00:06:14 ago, via POS2/1/1
routerA#ping 150.10.10.1
Sending 5, 100-byte ICMP Echos to 150.10.10.1:     !!!!!
Success is 100 percent, round-trip min/avg/max = 4/64/296 ms
```

```
Reply to request 0
 Record route:
   (156.1.1.2)
   (195.5.5.1)
   (10.105.1.134)
   (150.10.10.1)
   (10.105.1.76)
   (195.5.5.2)
   (156.1.1.1)
   (211.211.211.1) <*>

Reply to request 1
 Record route:
   (10.105.1.69)
   (140.10.50.5)
   (150.10.10.1)
   (140.10.50.6)
   (10.105.1.71)
   (211.211.211.1) <*>
```

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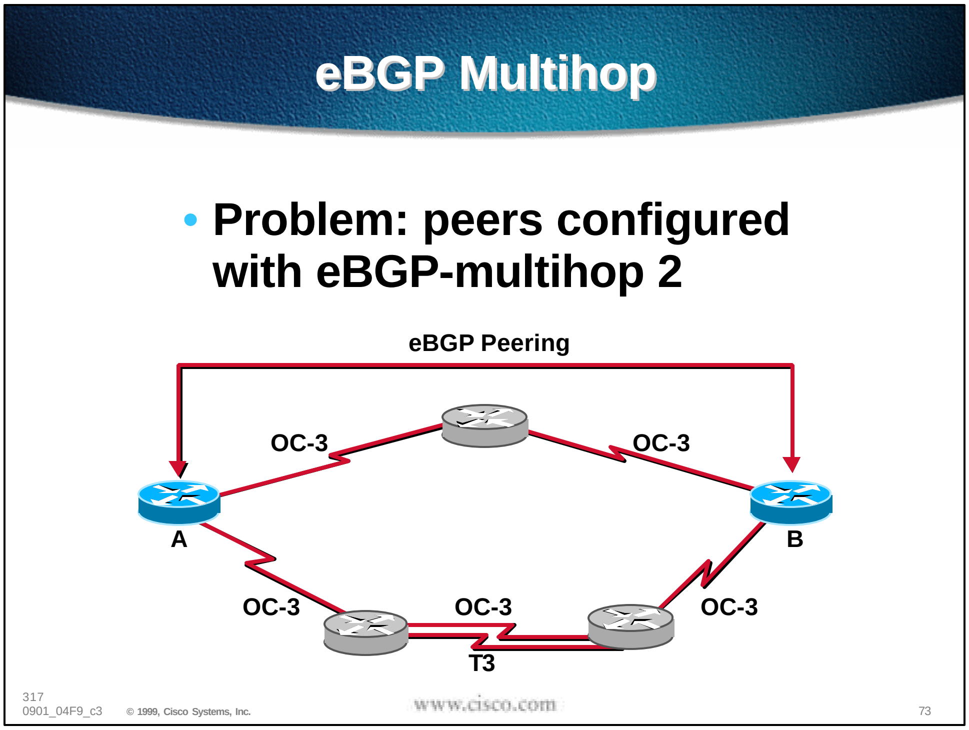

eBGP Multihop

- Problem: peers configured with eBGP-multihop 2

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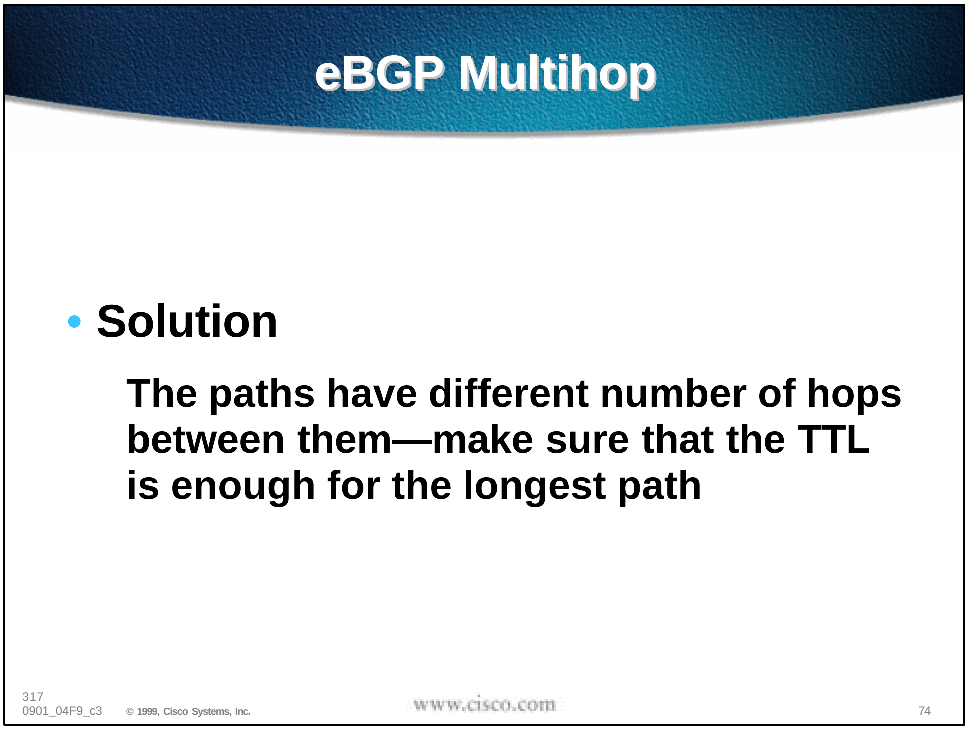

eBGP Multihop

- Solution

  The paths have different number of hops between them—make sure that the TTL is enough for the longest path

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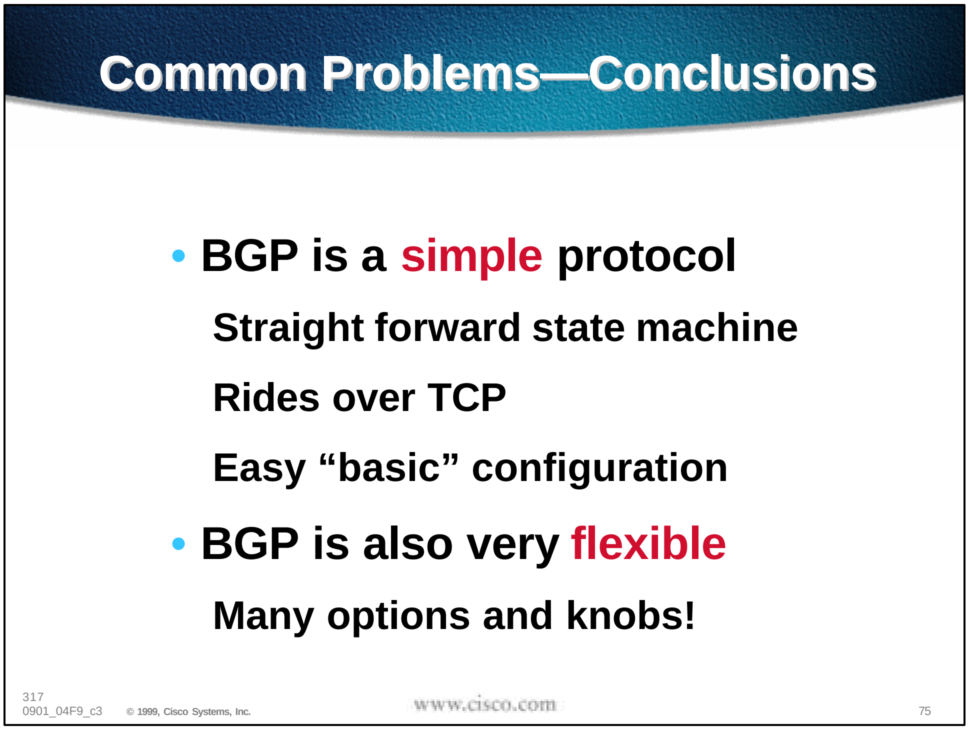

Common Problems—Conclusions

- BGP is a simple protocol

  Straight forward state machine

  Rides over TCP

  Easy “basic” configuration

- BGP is also very flexible

  Many options and knobs!

BGP Extensions

There’s More!

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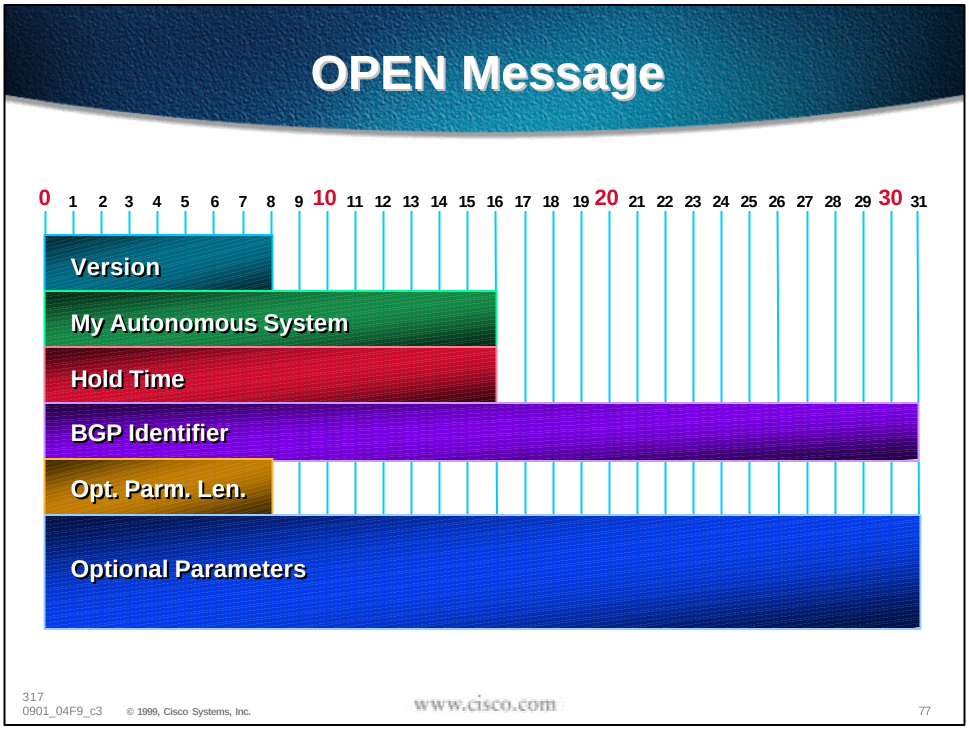


OPEN Message

Version

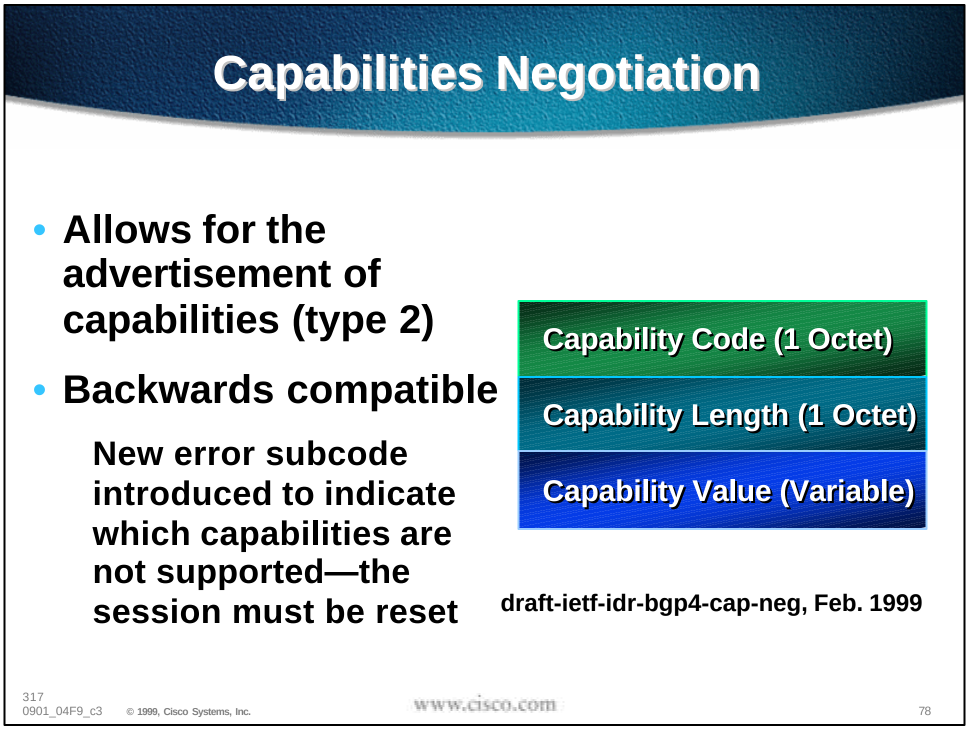
My Autonomous System

Hold Time

BGP Identifier

Opt. Parm. Len.

Optional Parameters



Capabilities Negotiation

- Allows for the advertisement of capabilities (type 2)
- Backwards compatible

  New error subcode introduced to indicate which capabilities are not supported—the session must be reset

Capability Code (1 Octet)

Capability Length (1 Octet)

Capability Value (Variable)

draft-ietf-idr-bgp4-cap-neg, Feb. 1999

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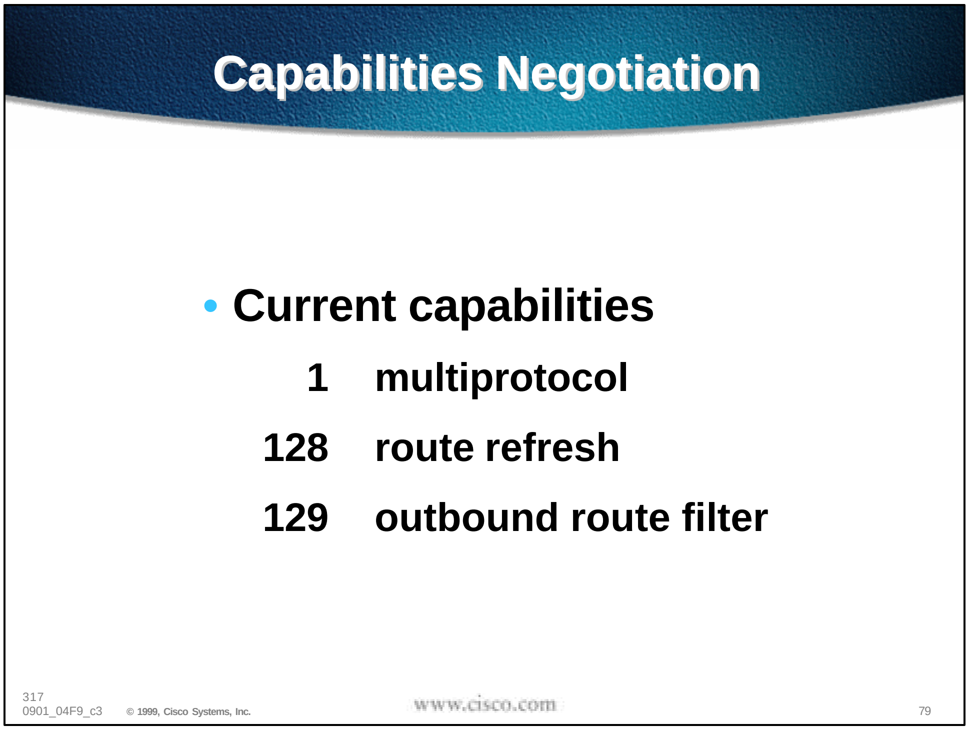
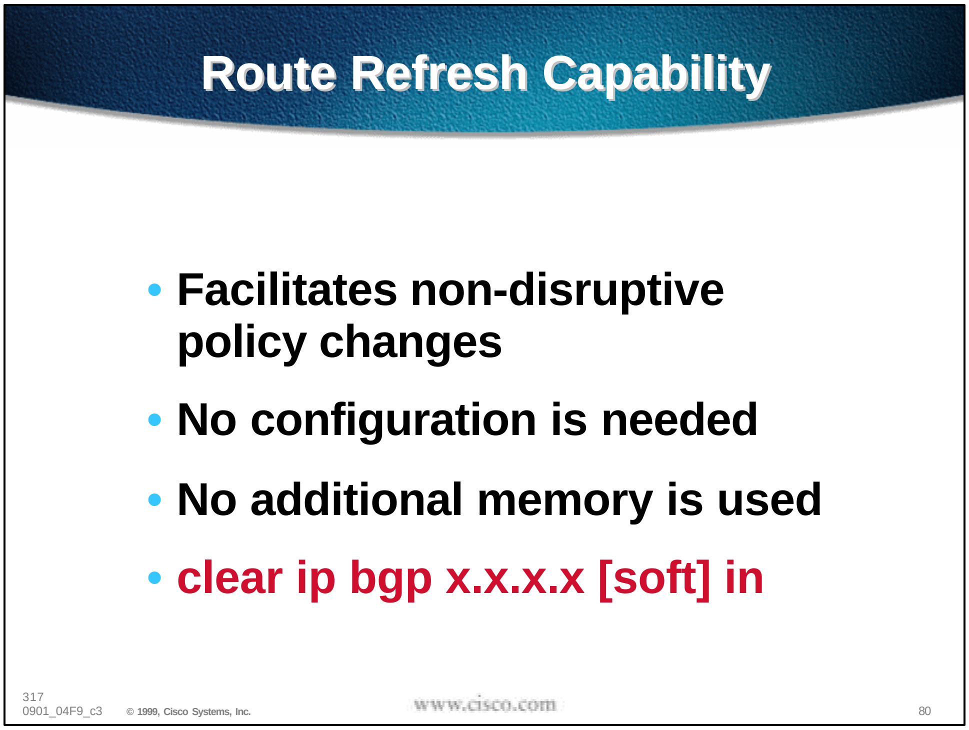


Capabilities Negotiation

- Current capabilities

1	multiprotocol
128	route refresh
129	outbound route filter



Route Refresh Capability

- Facilitates non-disruptive policy changes
- No configuration is needed
- No additional memory is used
- clear ip bgp x.x.x.x [soft] in

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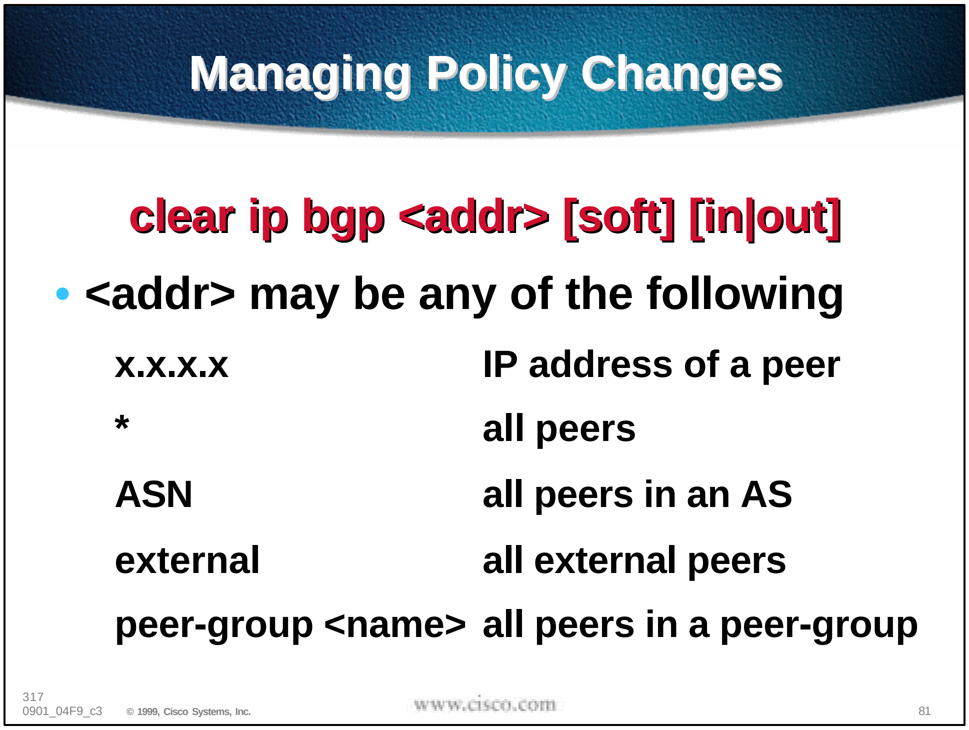
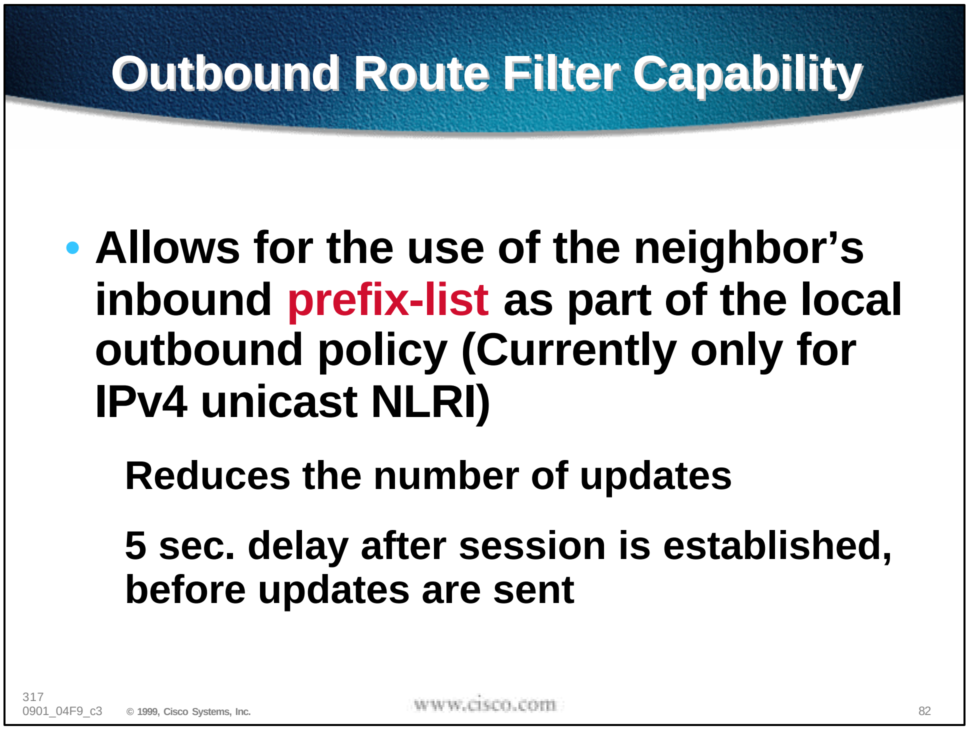


Managing Policy Changes

clear ip bgp <addr> [soft] [in|out]

- <addr> may be any of the following

x.x.x.x	IP address of a peer
*	all peers
ASN	all peers in an AS
external	all external peers
peer-group <name>	all peers in a peer-group



Outbound Route Filter Capability

- Allows for the use of the neighbor’s inbound prefix-list as part of the local outbound policy (Currently only for IPv4 unicast NLRI)

  Reduces the number of updates

  5 sec. delay after session is established, before updates are sent

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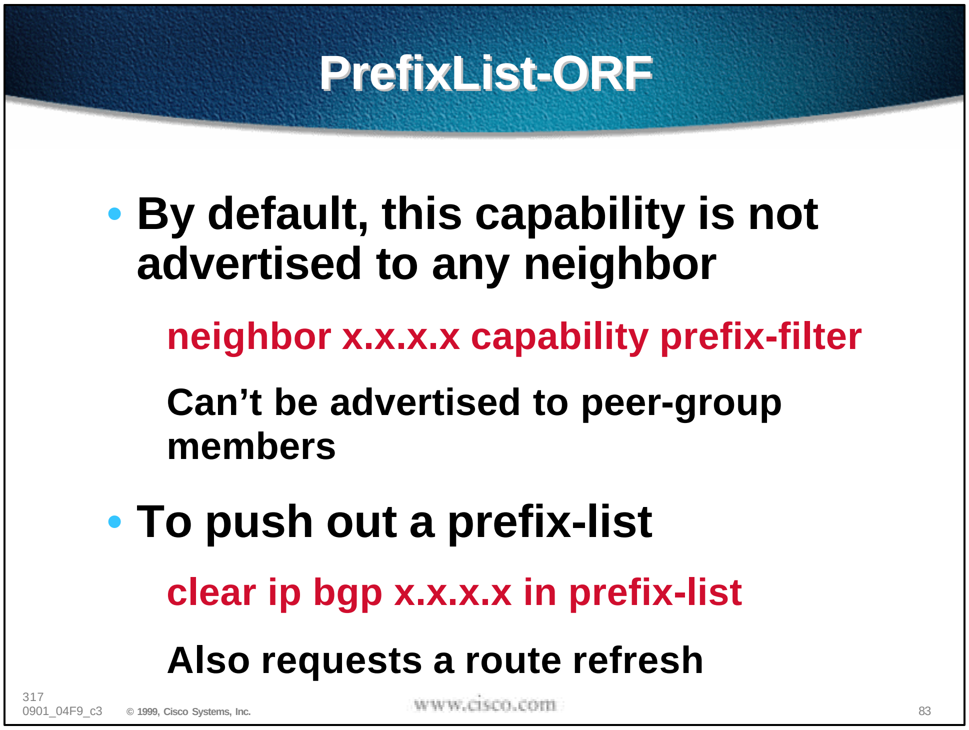


PrefixList-ORF

- **By default, this capability is not advertised to any neighbor**

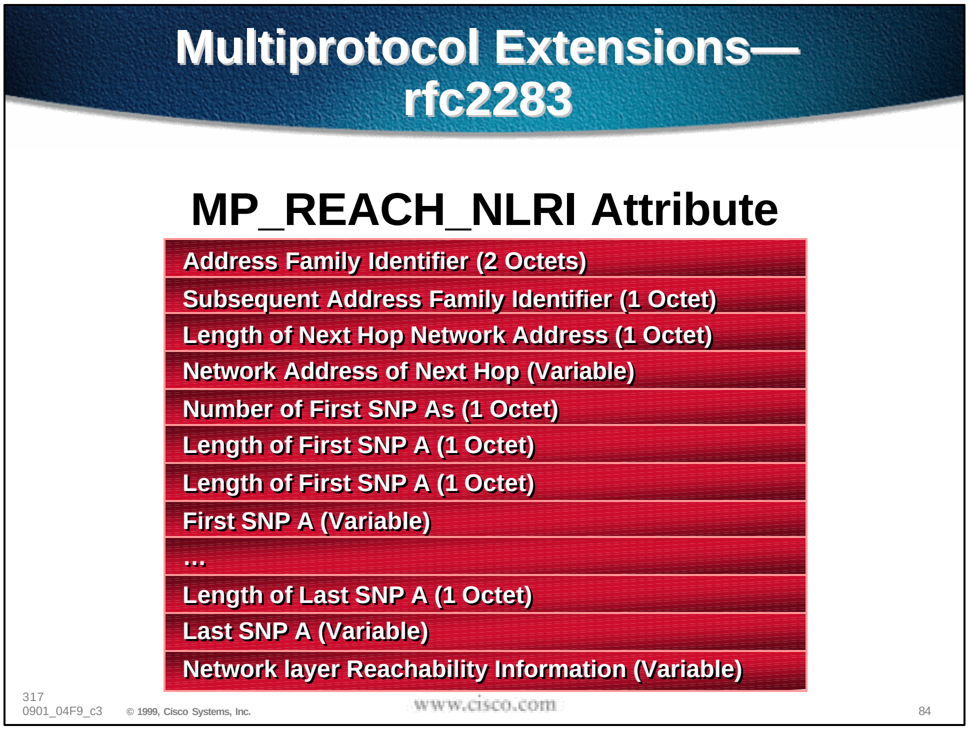
  neighbor x.x.x.x capability prefix-filter

  Can’t be advertised to peer-group members

- **To push out a prefix-list**

  clear ip bgp x.x.x.x in prefix-list

  Also requests a route refresh



Multiprotocol Extensions—rfc2283

MP_REACH_NLRI Attribute

Address Family Identifier (2 Octets)
Subsequent Address Family Identifier (1 Octet)
Length of Next Hop Network Address (1 Octet)
Network Address of Next Hop (Variable)
Number of First SNP As (1 Octet)
Length of First SNP A (1 Octet)
Length of First SNP A (1 Octet)
First SNP A (Variable)
…
Length of Last SNP A (1 Octet)
Last SNP A (Variable)
Network layer Reachability Information (Variable)

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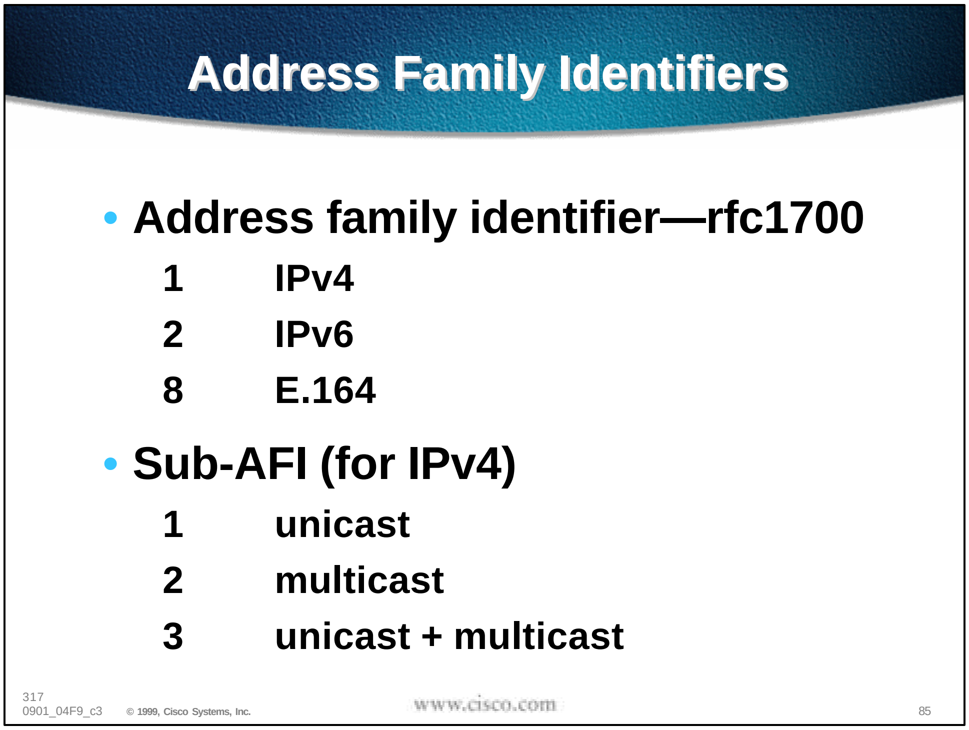

Address Family Identifiers

- Address family identifier—rfc1700

1	IPv4
2	IPv6
8	E.164

- Sub-AFI (for IPv4)

1	unicast
2	multicast
3	unicast + multicast

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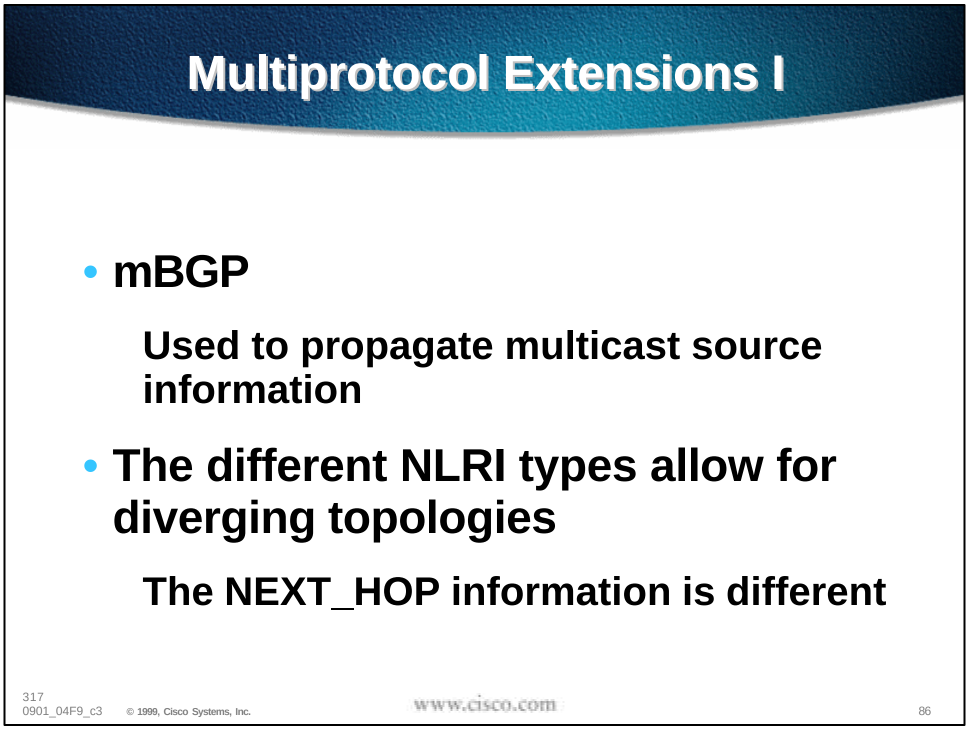

Multiprotocol Extensions I

- mBGP

  Used to propagate multicast source information

- The different NLRI types allow for diverging topologies

  The NEXT_HOP information is different

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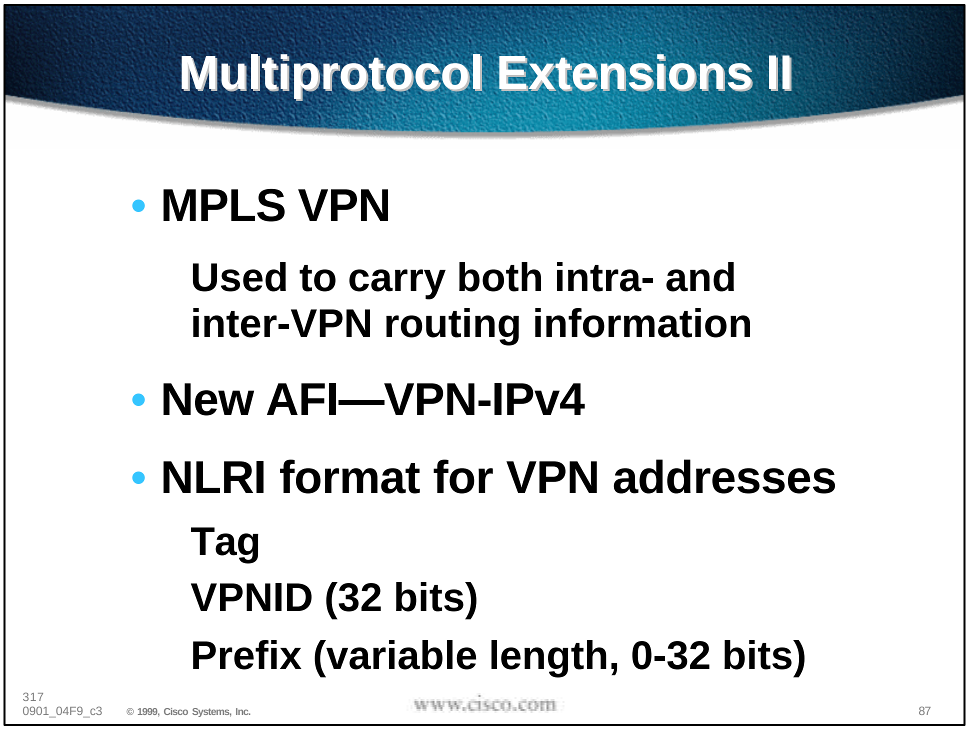

Multiprotocol Extensions II

- MPLS VPN

  Used to carry both intra- and inter-VPN routing information

- New AFI—VPN-IPv4

- NLRI format for VPN addresses

  Tag

  VPNID (32 bits)

  Prefix (variable length, 0-32 bits)

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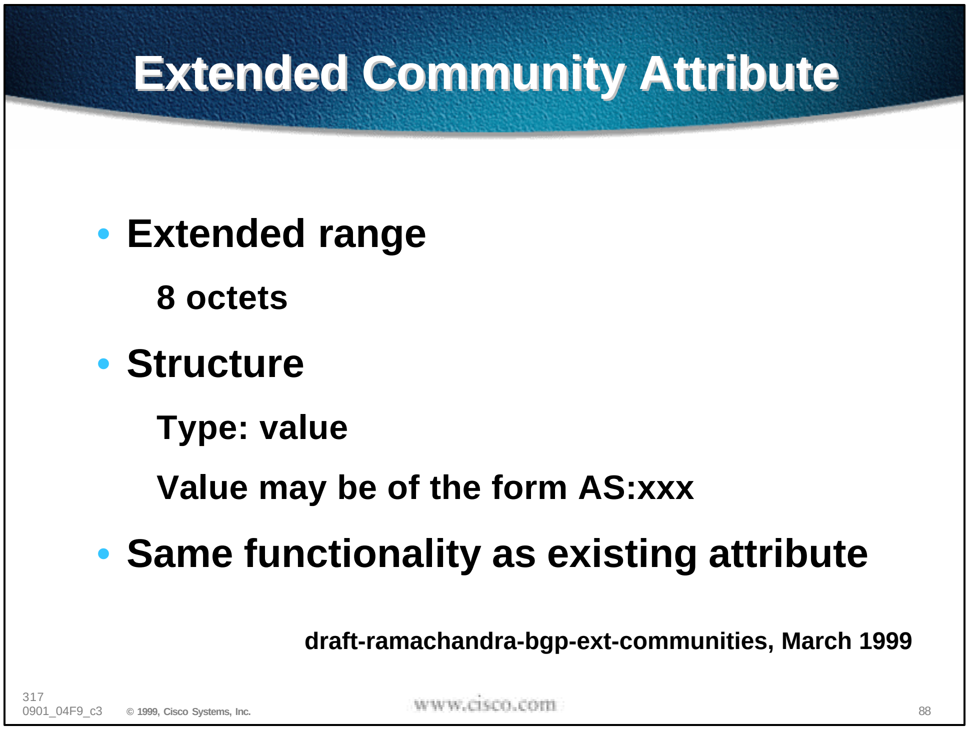

Extended Community Attribute

- Extended range

  8 octets

- Structure

  Type: value

  Value may be of the form AS:xxx

- Same functionality as existing attribute

draft-ramachandra-bgp-ext-communities, March 1999

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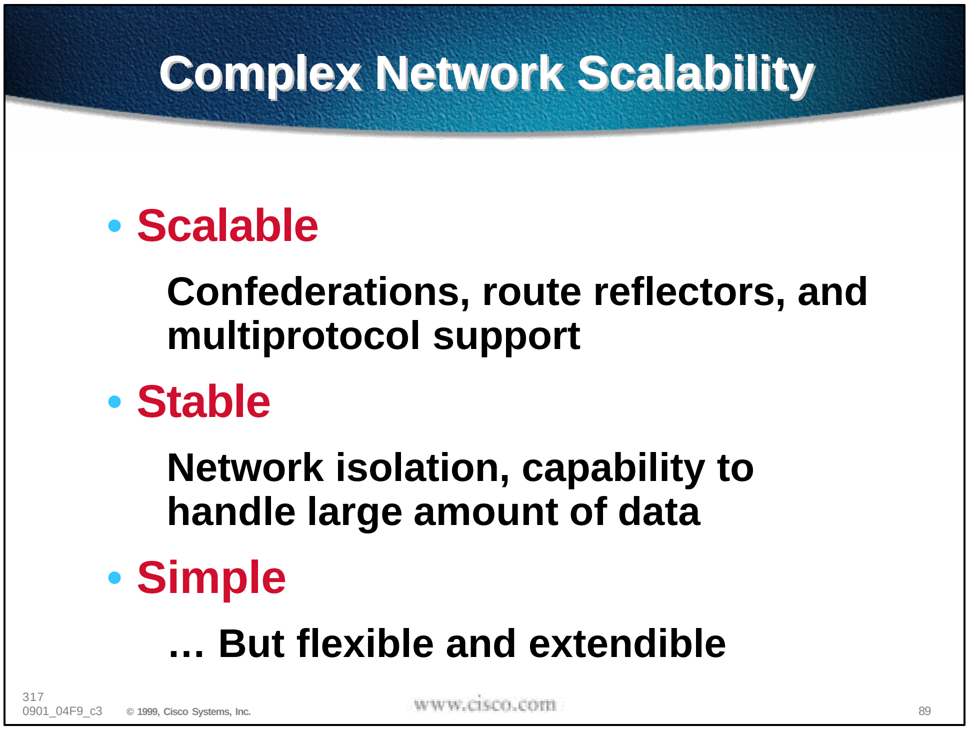

Complex Network Scalability

- **Scalable**

  Confederations, route reflectors, and multiprotocol support

- **Stable**

  Network isolation, capability to handle large amount of data

- **Simple**

  … But flexible and extendible

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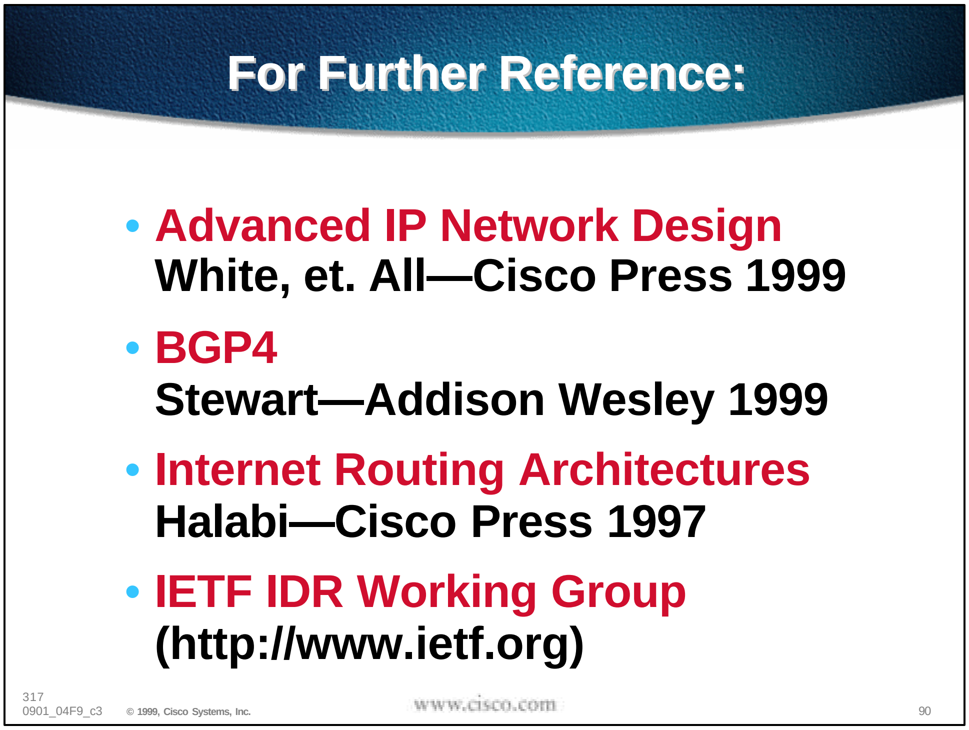

For Further Reference:

- **Advanced IP Network Design**
  White, et. All—Cisco Press 1999
- **BGP4**
  Stewart—Addison Wesley 1999
- **Internet Routing Architectures**
  Halabi—Cisco Press 1997
- **IETF IDR Working Group**
  (http://www.ietf.org)

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