Optimized Edge Routing

Pritam Shah (pritam@cisco.com)

"You're not allowed to use the sprinkler system to keep your audience awake."

Agenda

- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Performance
- Conclusion
- Q & A

Application Performance

- **Network availability**
  - **Redundant devices—HSRP**
  - **Redundant interfaces—NSF, SSO, EOT, EEM**
  - **Redundant paths—equal cost routing, MPLS**
- **Network performance**
  - **Shortest hop/hot potato routing (BGP, RIP, …)**
  - **Least cost routing (OSPF, EIGRP, …)**
  - **MPLS TE, MTR, queuing, …**
- **Necessary…but not sufficient**
- **Are the applications reachable and performing?**

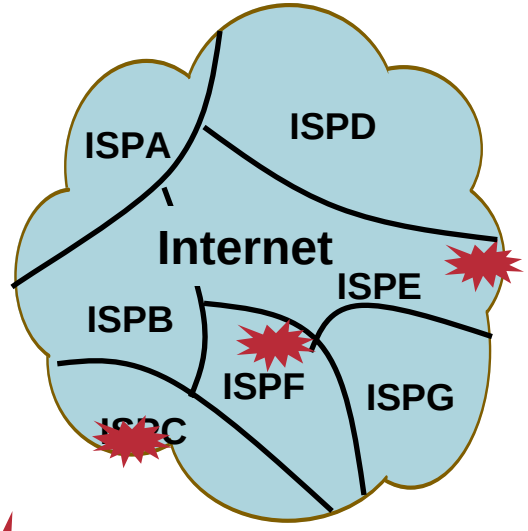
Things go wrong

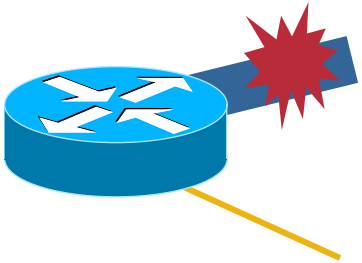
- **Soft failures and sub optimal routing can cause downtime, lost revenue…….more**

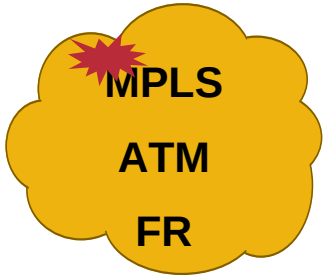
WAN Performance Challenge

"The network is up but are applications working?"

- **WAN availability**
  - **Routing indicates reachability, but:**
    - **Blackouts**
    - **Brownouts**
    - **Congestion**
- **WAN performance**
  - **Best path not performance based**
- **Load distribution**
  - **Over/under utilized links**
- **$ Cost management**
  - **Need to control/limit transport $cost**

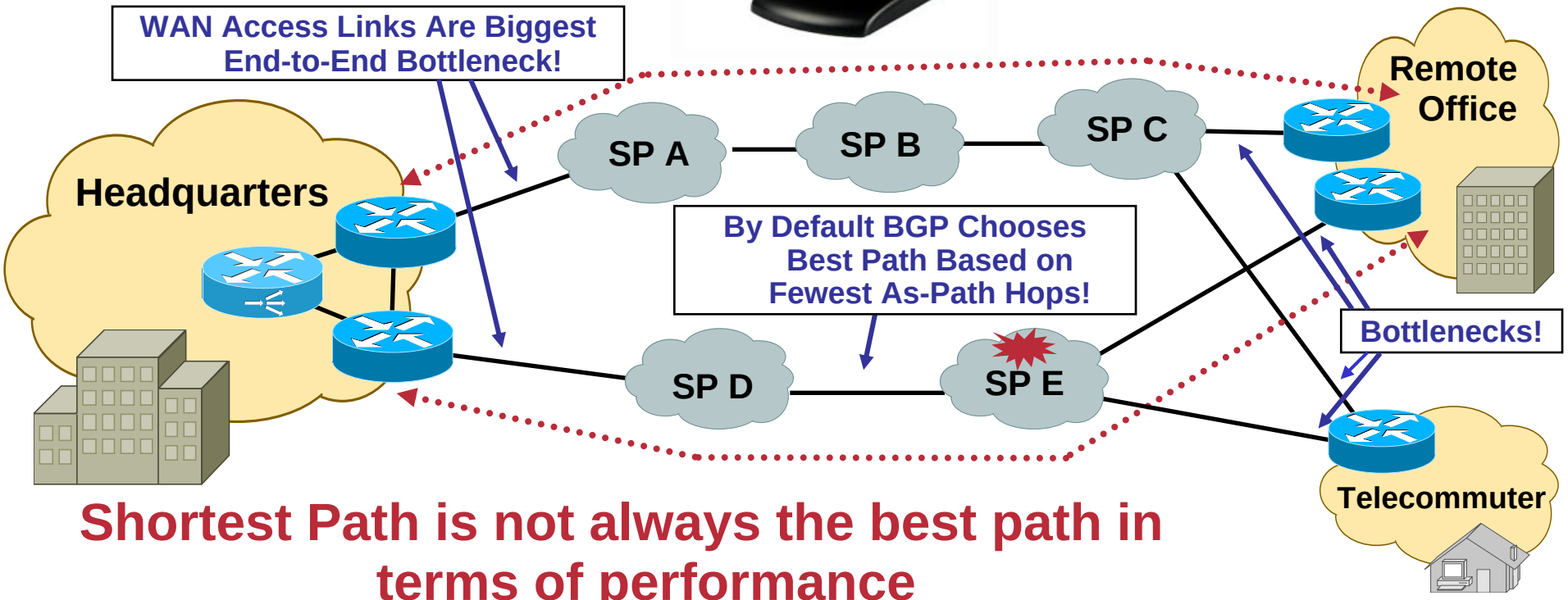






$$$$$$$

Best path selection per prefix, 2 or more Paths



Shortest Path is not always the best path in terms of performance

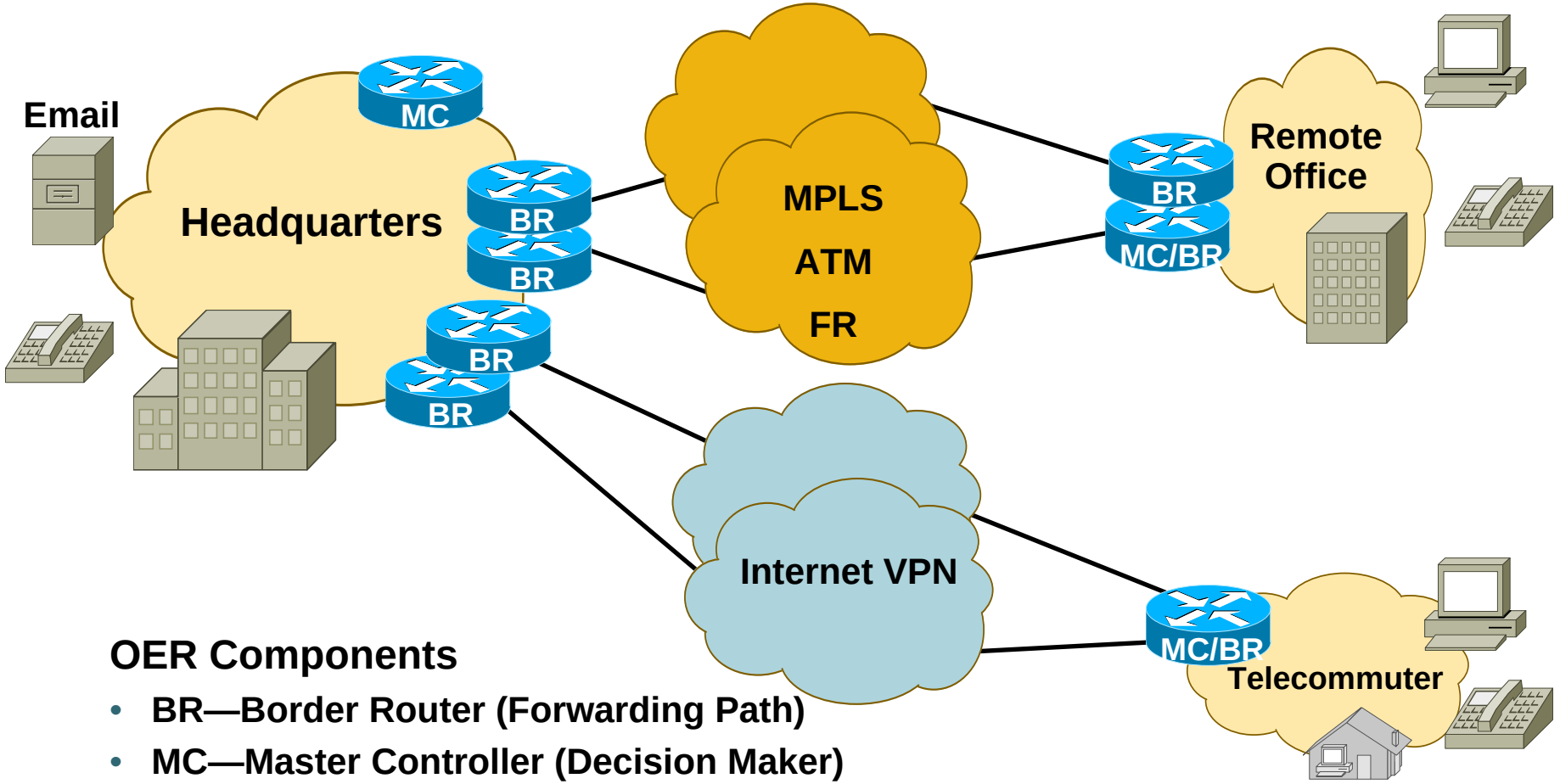
Agenda

- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Performance
- Conclusion
- Q & A

Optimized Edge Routing (OER)
Performance Based Routing for Enterprise WAN Edge

Exit Selection Criteria

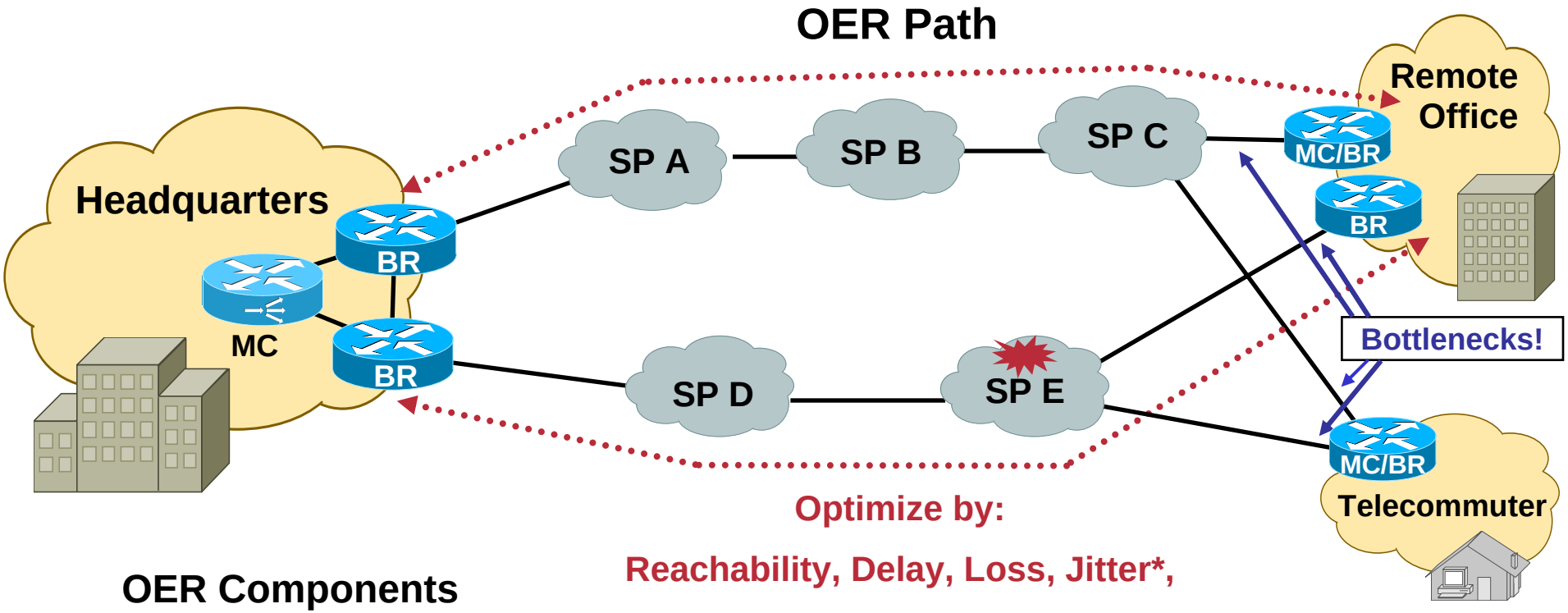
Reachability, Delay, Loss, Jitter, MOS, Load, $Cost



OER Components

- BR—Border Router (Forwarding Path)
- MC—Master Controller (Decision Maker)

Optimized Edge Routing



Optimize by:

Reachability, Delay, Loss, Jitter*,

MOS*, Throughput, Load and/or $Cost

OER Components

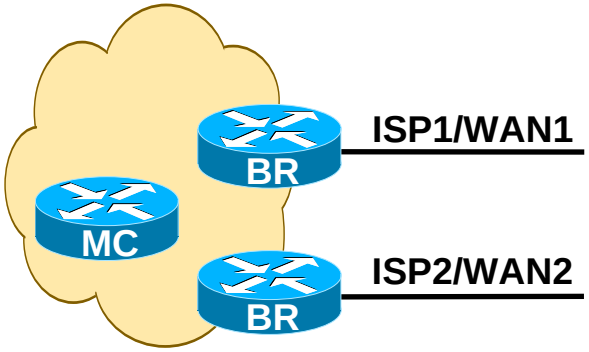
- **BR—Border Router**
- **MC—Master Controller (decision maker)**

Agenda

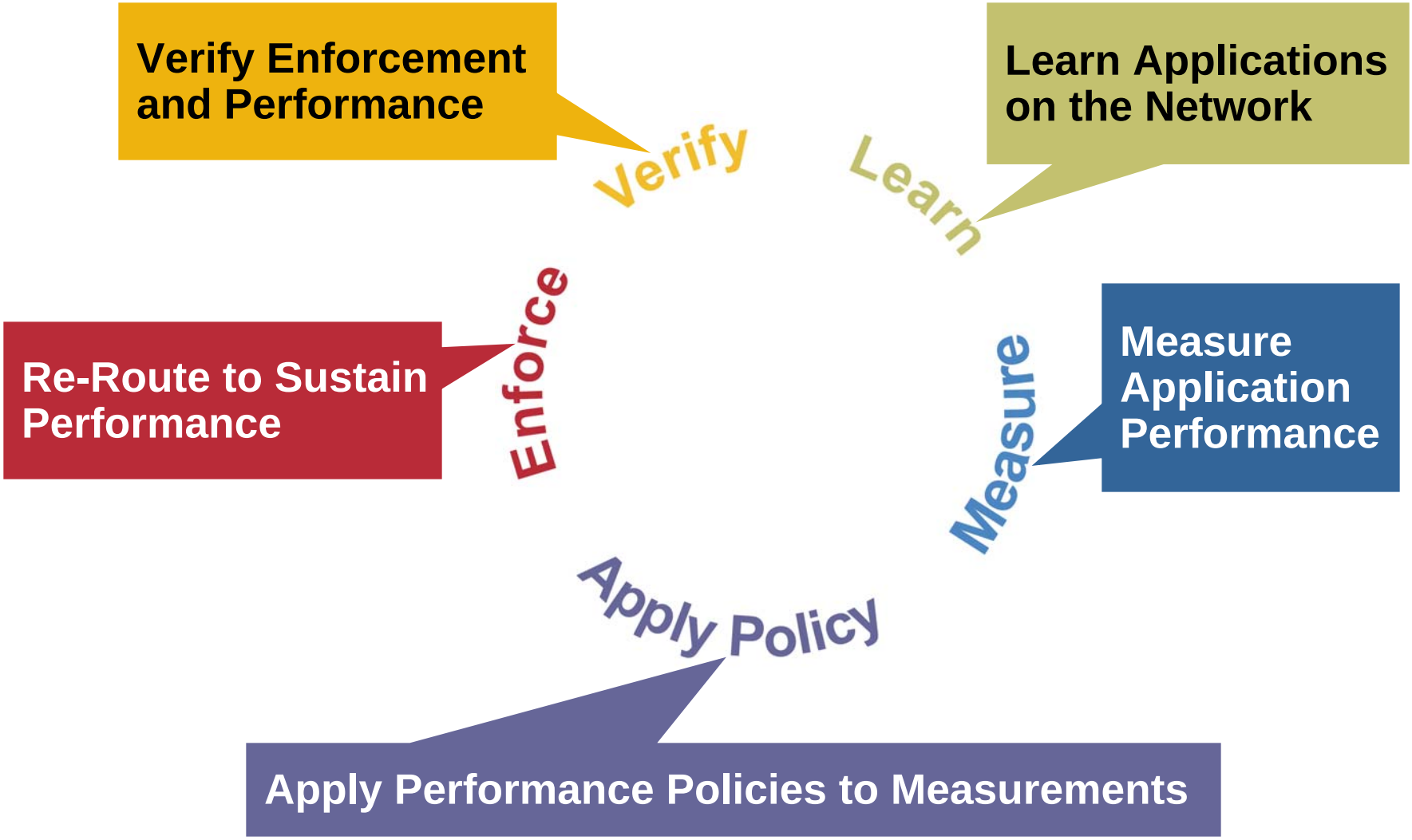
- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Performance
- Conclusion
- Q & A

Component Description

- **Master Controller (MC)**
  - **Cisco IOS® software feature**
  - **Apply Policy, Verification, Reporting**
  - **Standalone or collocated with BR**
  - **No routing protocol required**
  - **No packet forwarding/inspection required**
- **Border Router (BR)**
  - **Cisco IOS software feature in forwarding router**
  - **Learn, Measure, Enforcement**
  - **Netflow Collector**
  - **Probe Source (IP SLA Client)**



Performance Based Routing Control Loop



Which Applications to Manage?

- **Traffic class contains two objects**

Destination Prefix (Required)

12.4(5)

- **w.x.y.z/n**
- **Default—0.0.0.0/0**
- **Host—w.x.y.z/32**

Application Identifier (Optional)

12.4T

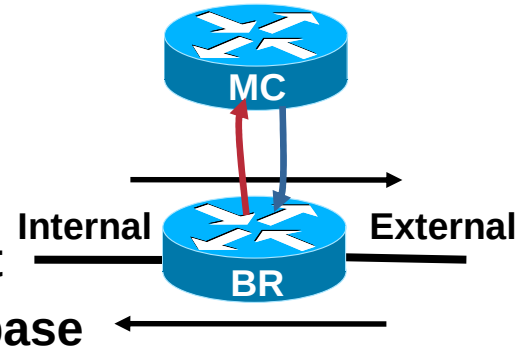
- **Source Prefix**
- **Src Port Range**
- **Dst Port Range**
- **DSCP**
- **Protocol**

Entering Traffic Classes in the MC
Traffic Class Learning

- MC commands BRs to learn traffic classes
- BRs inspect all flows
- BRs ignore non-interesting flows
- BRs aggregate flows to prefix boundaries

BRs Know Traffic Classes

- BRs measure traffic class performance
- BRs sort traffic classes
- BRs send sorted traffic class lists to MC
  - BRs send host addresses used for probe targets
- MC combines and sorts to a single traffic class list
- MC enters top throughput and top delay into database



MC Knows Traffic Classes

Entering Traffic Classes in the MC
Configured Traffic Class

Optimize	Match using	Example
Destination Prefix	Prefix-list	10.1.1.0/24
Application Flow	ACL	10.1.1.0/24 DSCP AF12
* Destination Prefix OR Application Flow	Traffic-class	Both of the above and more

*** Q1FY07**

Measuring Traffic Class Performance

- **Active**
  - OER enables IP SLA feature
  - Probes sourced from BRs
  - icmp probes learned or configured
  - tcp, udp, jitter need `ip sla responder`

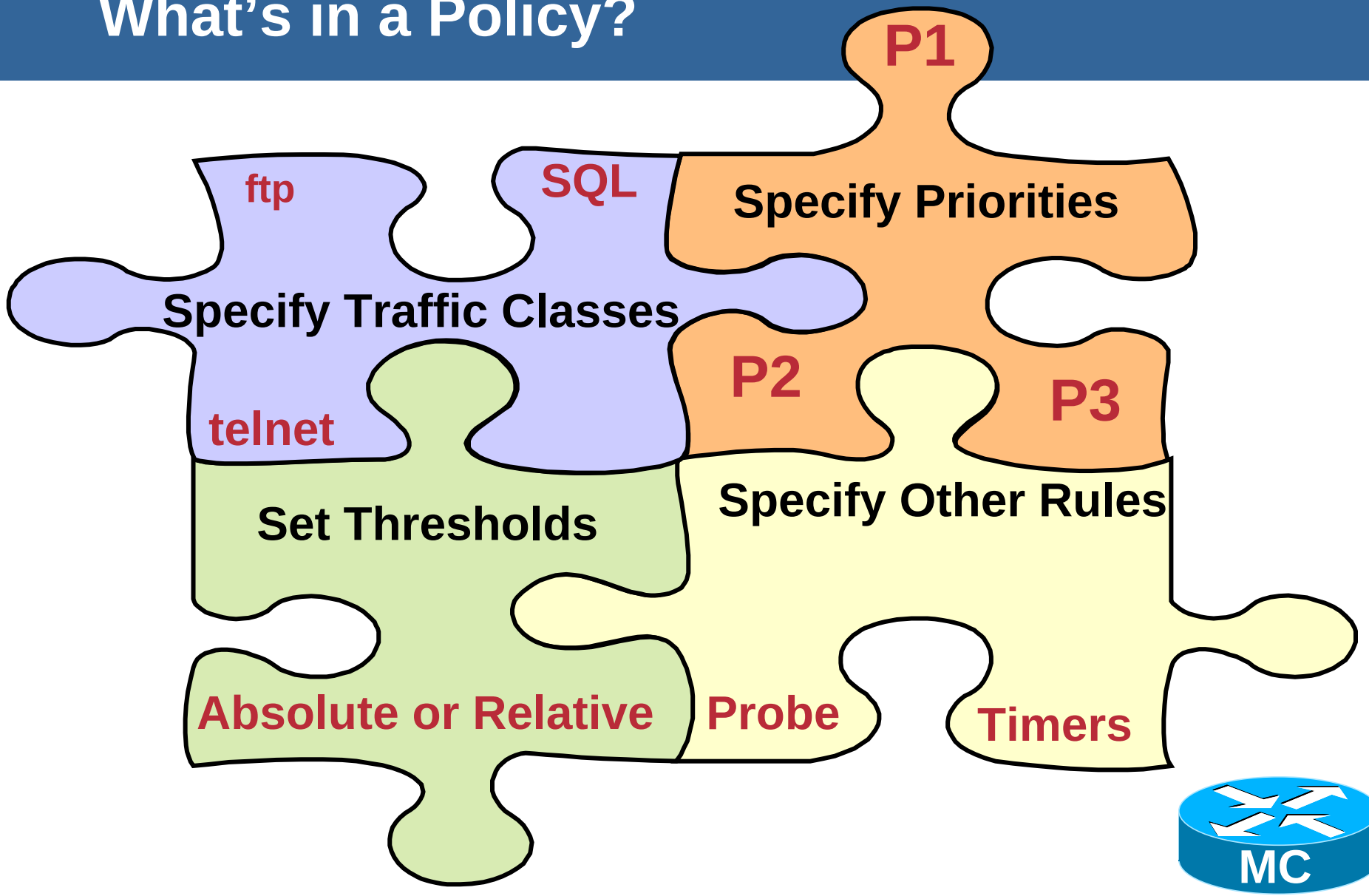
- Delay
- Reachability
- Jitter 12.4(6)T
- MOS 12.4(6)T

- **Passive**
  - OER Netflow monitoring of traffic classes

- **Both Mode**

- Delay
- Loss
- Reachability
- Egress BW
- Ingress BW

What's in a Policy?



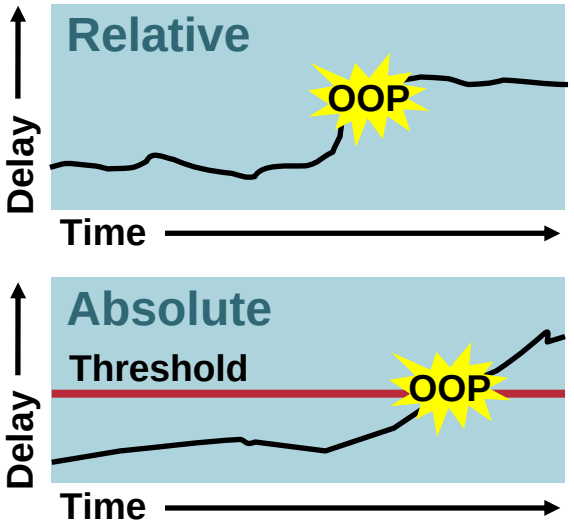
Traffic Class Policy

Performance	Security
• Delay • Loss • Reachability • MOS • Jitter	• Sinkhole • Blackhole

Scope	Global or Per Policy

Applying Policy
Traffic Classes and Link

- **Unreachable always applied**
- **Default policy**
  - **Traffic class relative delay**
    - **If delay increases, re-route traffic class**
  - **External link utilization**
    - **If utilization >75%, re-route traffic classes**
- **Policy type**
  - **Relative (default)**
    - **If metric rises sharply, then OOP**
  - **Absolute**
    - **If metric exceeds threshold, then OOP**



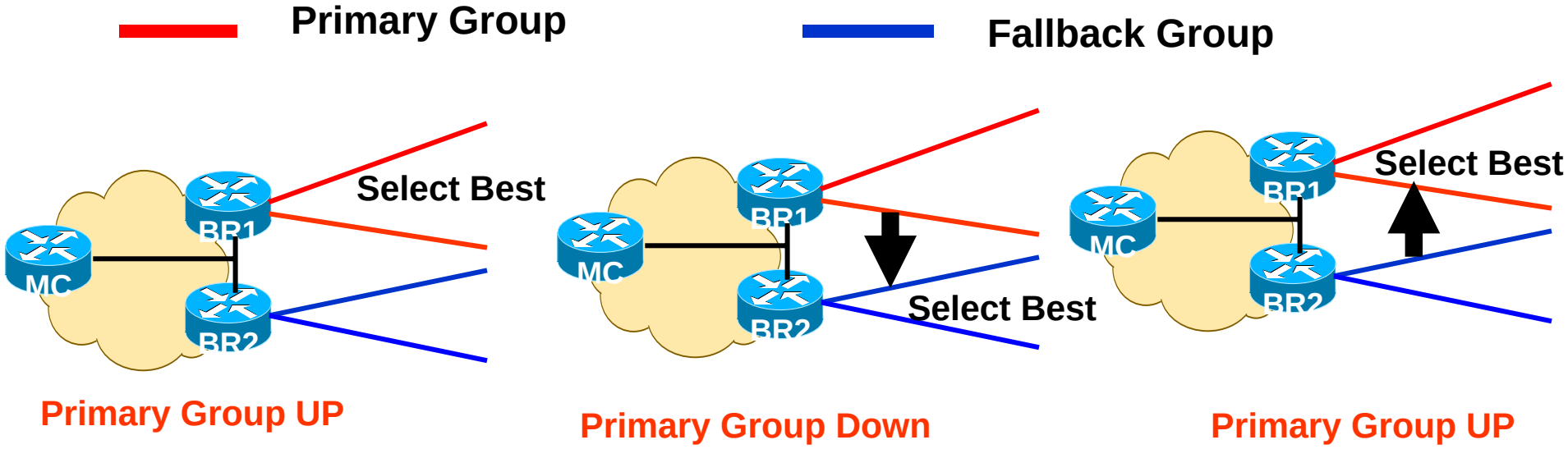
Link Policy

Performance	Administrative
• Load Balancing • Max Utilization	• Link Grouping

Scope	Global or Per Link

Primary & Fallback Links

How does it work?



Rules

- A link can be in more than one group
- A policy can have one primary and one fallback link group

Selecting “BEST” Traffic Class Exit

Selecting “Best” Traffic Class Exit

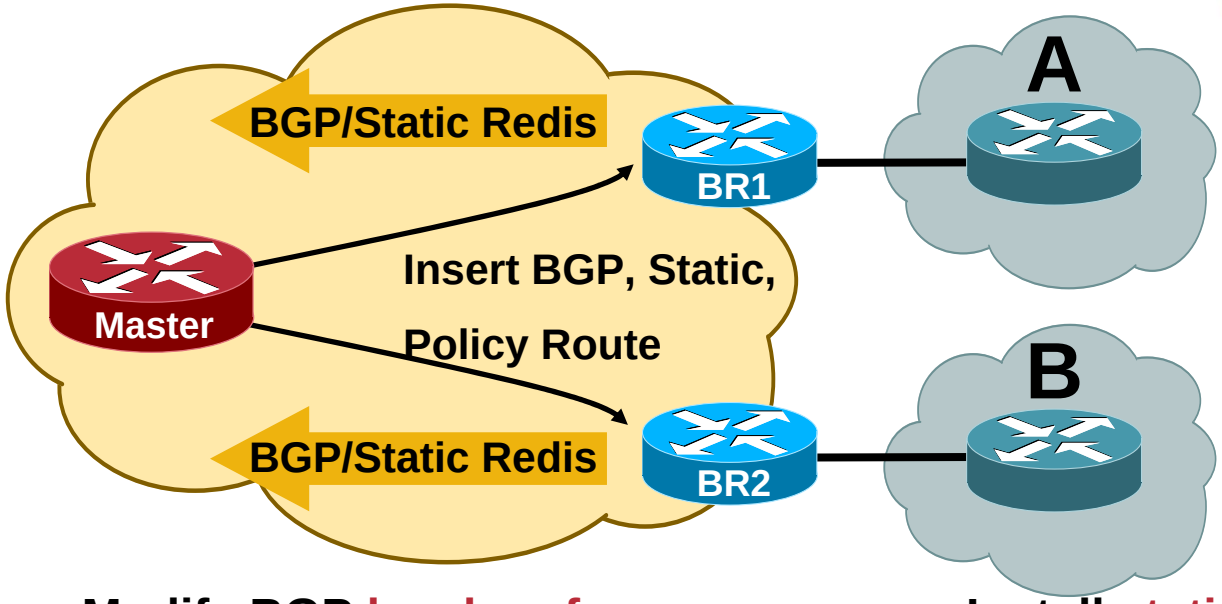
Link	Utilization	Delay (ms) Priority 1	Jitter (ms) Priority 2
Serial1	89%	100	30
Serial2	50%	113	30
Serial3	60%	119	32

Enforcing Traffic Class Exit

- MC tells BR to insert prefix in BGP or static table
- MC tells BR to insert Traffic Class in policy route

Enable enforcement

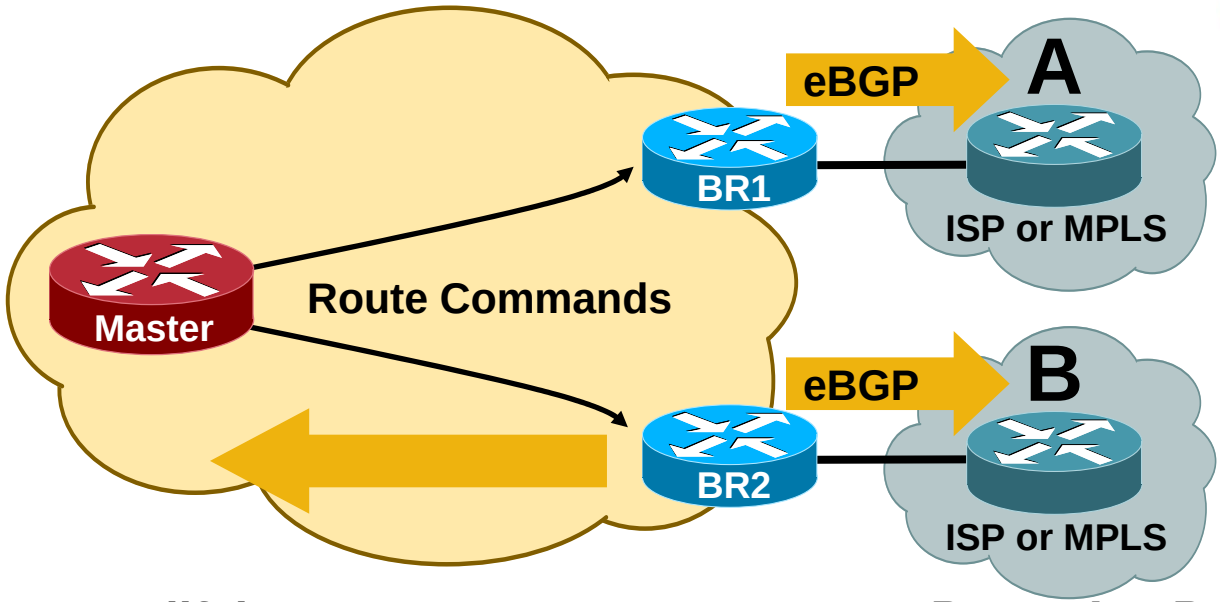
```
oer master
 mode route control
```



- Modify BGP local preference
  - Local preference must be highest
- Install static route at the exit
  - Redistribute static should be configured
- Report any route changes

Influencing Prefix Entrance
12.4T

- **MC tells BR to modify eBGP advertisement**
  - **Learn which prefixes are advertised**



- **Modifying eBGP**
  - **Prepend AS Hop(s) (default)**
  - **Append BGP downgrade community aa:nn**

Report Any Route Changes

Verifying Enforcement

- **MC expects Netflow update from new interface**
- **MC ignores Netflow update from previous path**
- **If no Netflow update after ~ two minutes:**
  - **Uncontrol prefix**
  - **Syslog report**
- **MC expects bidirectional traffic**

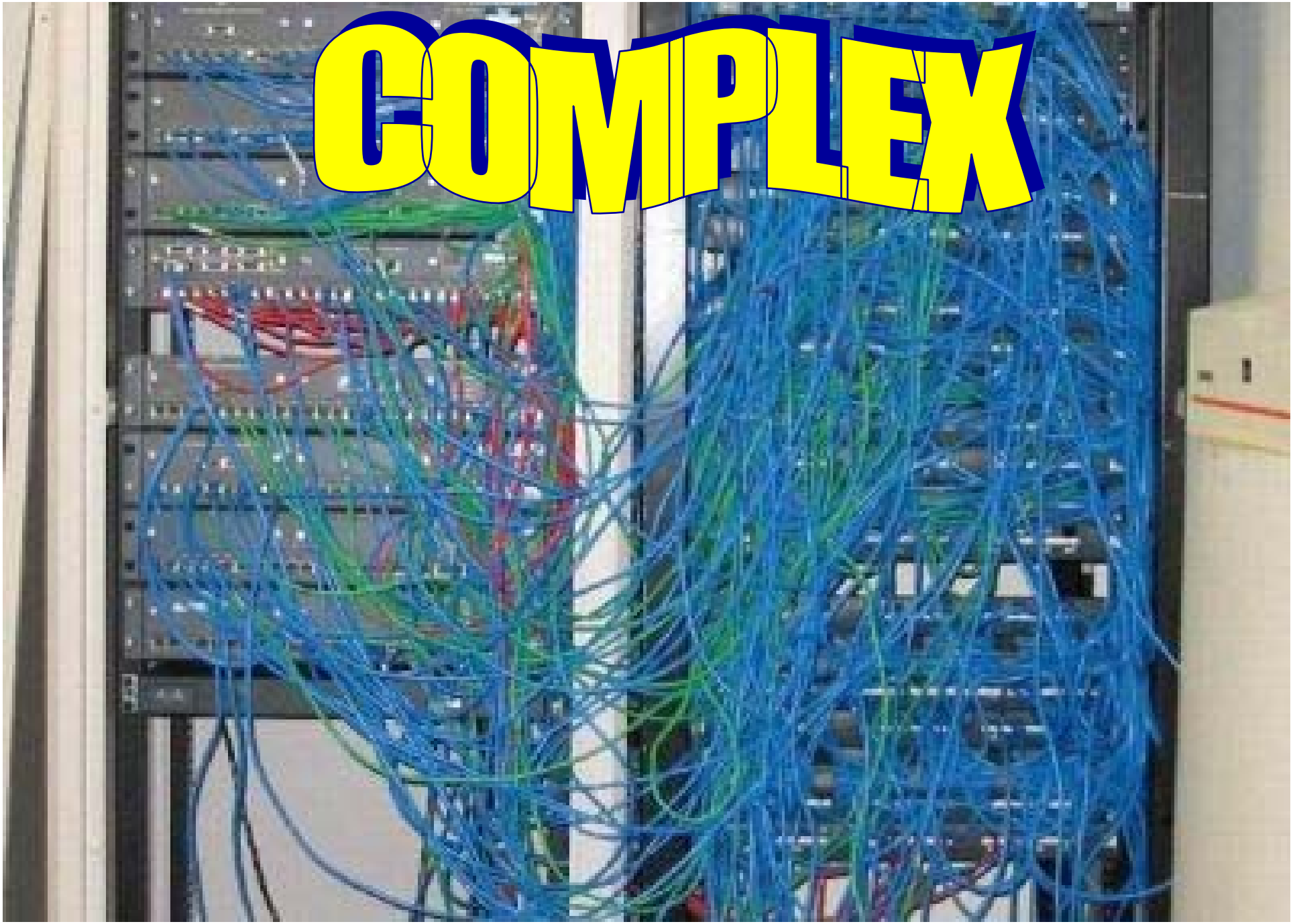
Reporting Results

- **Syslog**

```
sh log | i 100.1.1.0
*Apr 26 22:58:20.919: %OER_MC-5-NOTICE: Discovered Exit for prefix 100.1.1.0/24, BR
     10.10.10.1, i/f Et9/0
*Apr 26 23:03:14.987: %OER_MC-5-NOTICE: Route changed 100.1.1.0/24, BR 10.10.10.1, i/f
     Se12/0, Reason Delay, OOP Reason Timer Expired
*Apr 26 23:09:18.911: %OER_MC-5-NOTICE: Passive REL Loss OOP 100.1.1.0/24, loss 133, BR
     10.10.10.1, i/f Se12/0, relative loss 23, prev BR Unknown i/f Unknown
*Apr 26 23:10:51.123: %OER_MC-5-NOTICE: Route changed 100.1.1.0/24, BR 10.10.10.1, i/f Et9/0,
     Reason Delay, OOP Reason Loss
```

- **Show commands**

```
sh oer master prefix
Prefix          State    Time Curr BR     CurrI/F     Protocol
           PasSDly PasLDly  PasSUn  PasLUn PasSLos PasLLos
           ActSDly ActLDly  ActSUn  ActLUn   EBw   IBw
--------------------------------------------------------------------------------
100.1.1.0/24    HOLDDOWN  42 10.10.10.1   Et9/0       STATIC
                 16      16       0       0       0       0
                  U       U       0       0      55       2
```



GUI for Executive

- **Director of Network Operations**

Network Health

Critical issues

Show Stoppers?

GUI for Operator

- **Network Operator**

Policy Violations

Route Changes

Report Generation

Ticket Details

GUI for Troubleshooting Engineer

- **Troubleshooting Engineer**

Problem Details

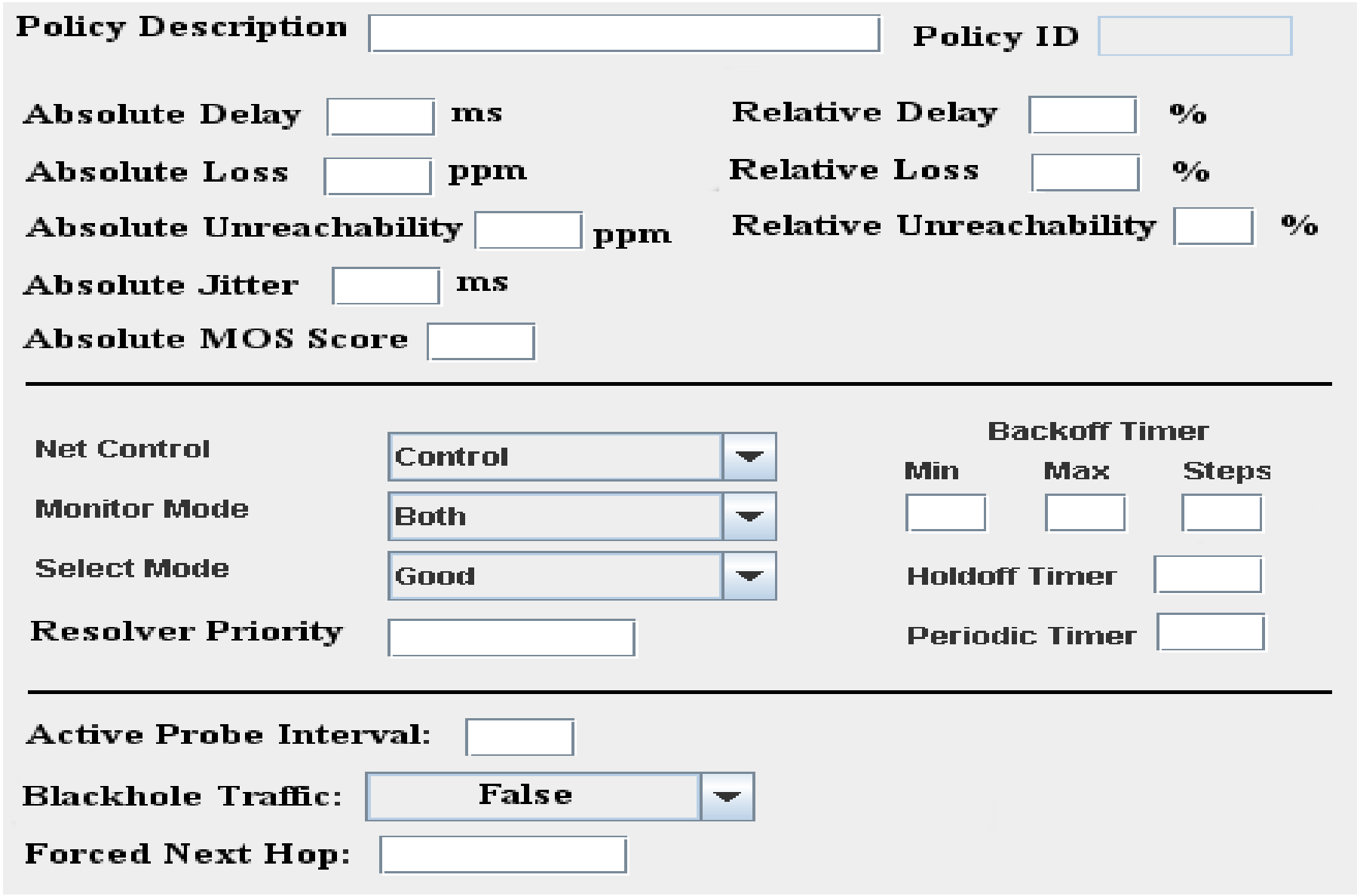
History

Correlate OER, NetFlow & IP SLA

Trend Analysis

Troubleshooting Tools

SAMPLE – Configure OER Policy

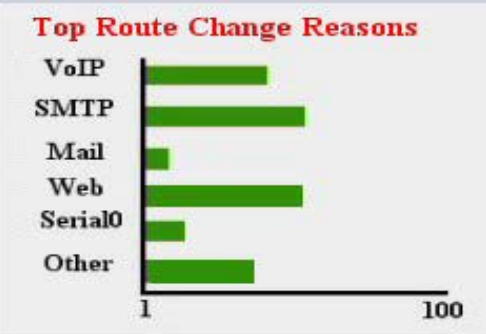


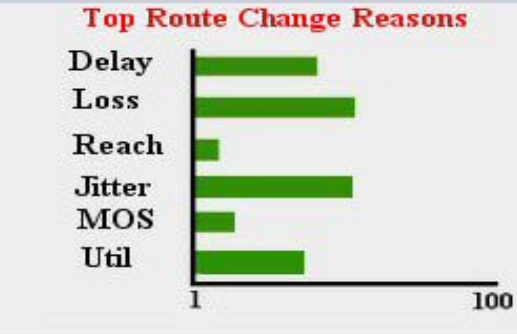
SAMPLE - OER Reporting –Executive Summary

Out Of Policy Conditions

Help Text here

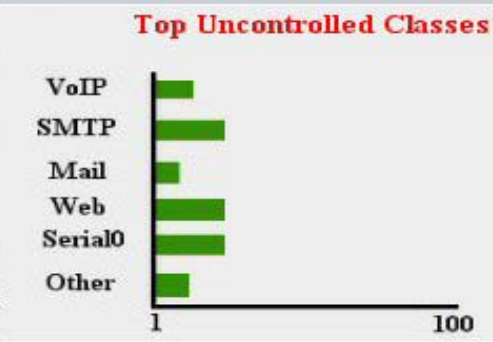
Route Change Conditions





Help Text here

Uncontrolled Conditions



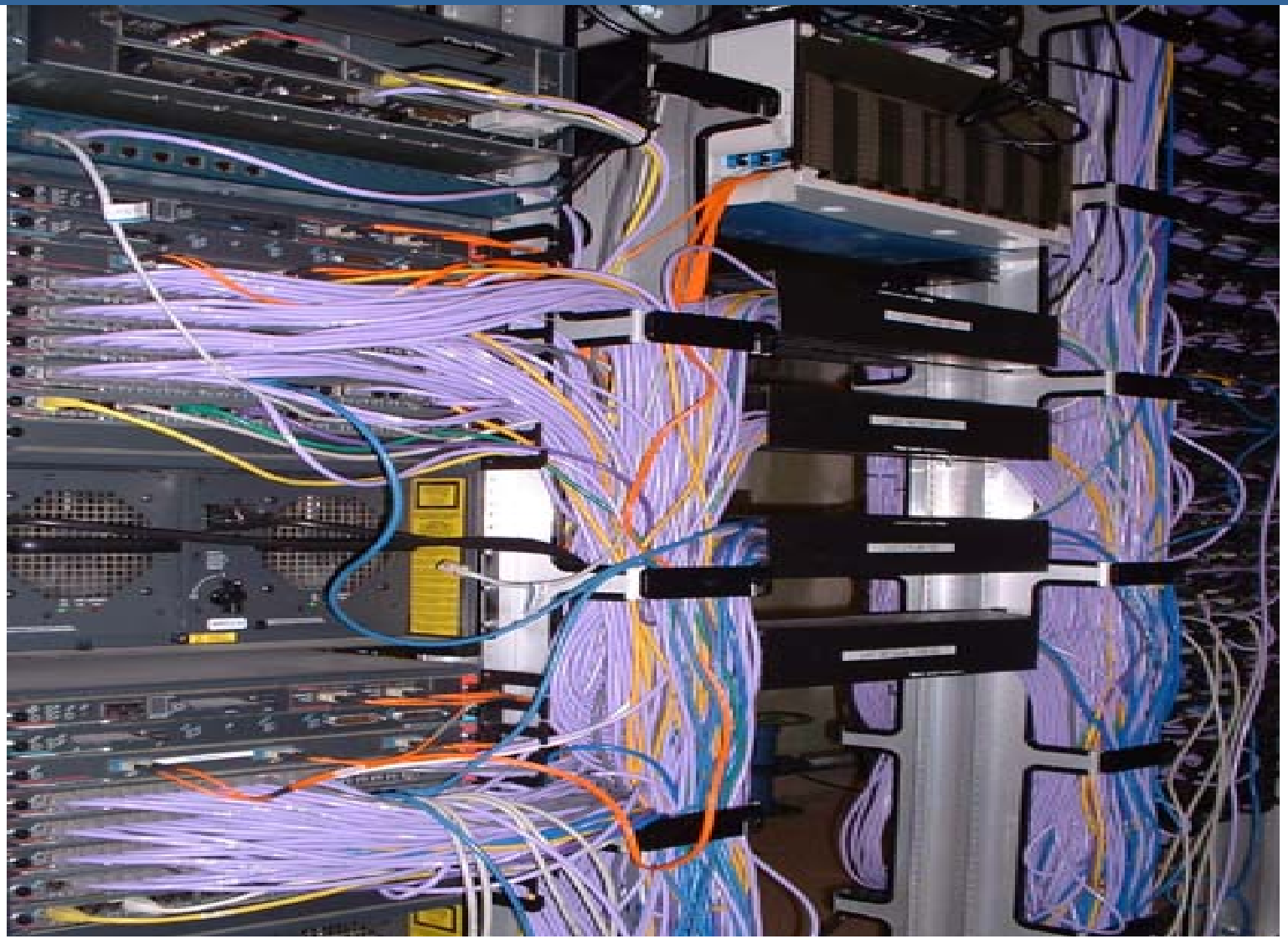
Help Text here

Key Features of OER UI

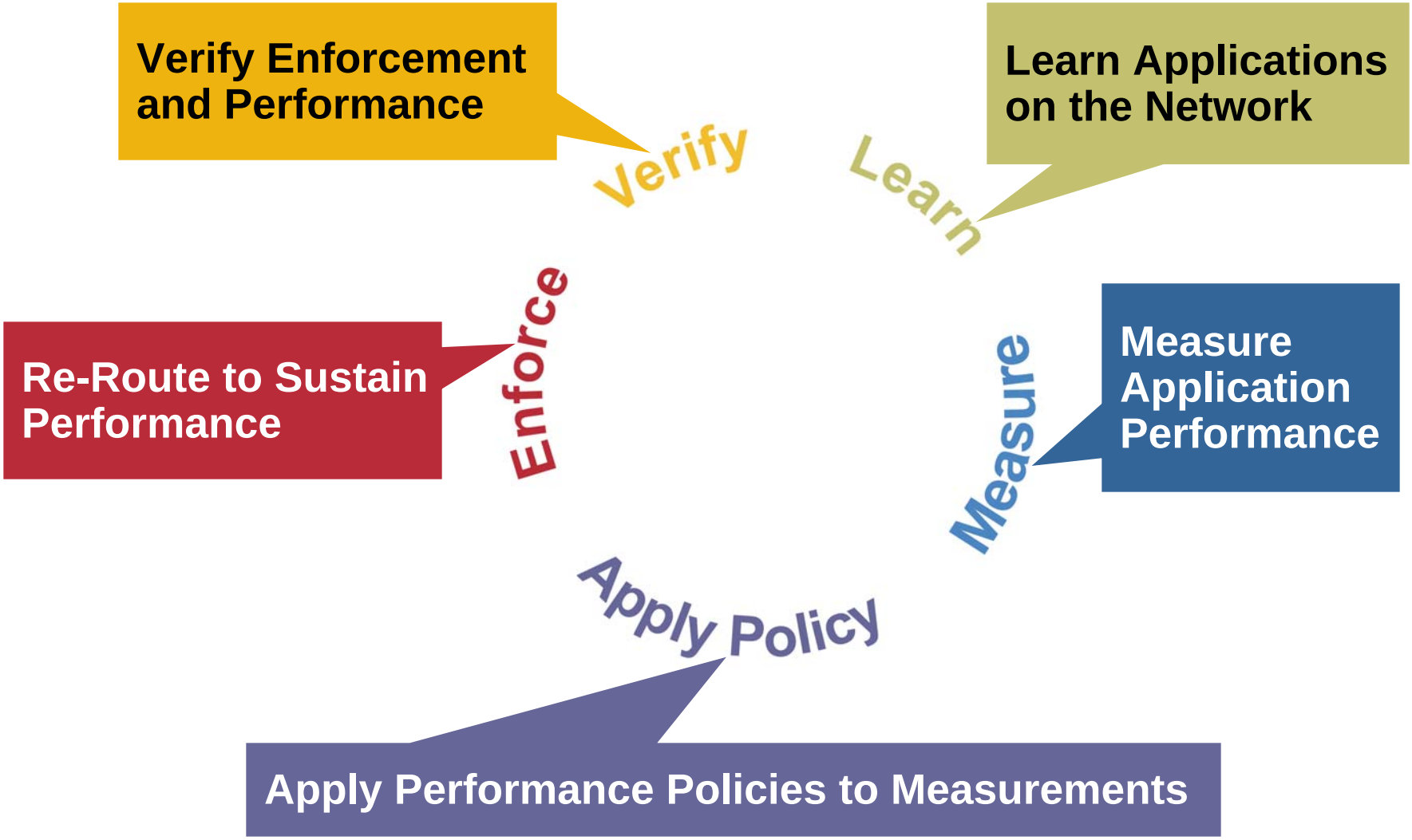
- **Executive Level Reporting.**
- **Network Health**
- **Fully Web Based**
- **Reports on Network Events**
- **Netflow and IPSLA based performance statistics presentation**
- **Historical and Trending Graphical reports**
- **Troubleshooting Analysis**
- **Easy Traffic Class and Policy Configuration.**

CRANNOGSOFTWARE

Easy to Manage and Easy to Understand



Performance Based Routing Control Loop

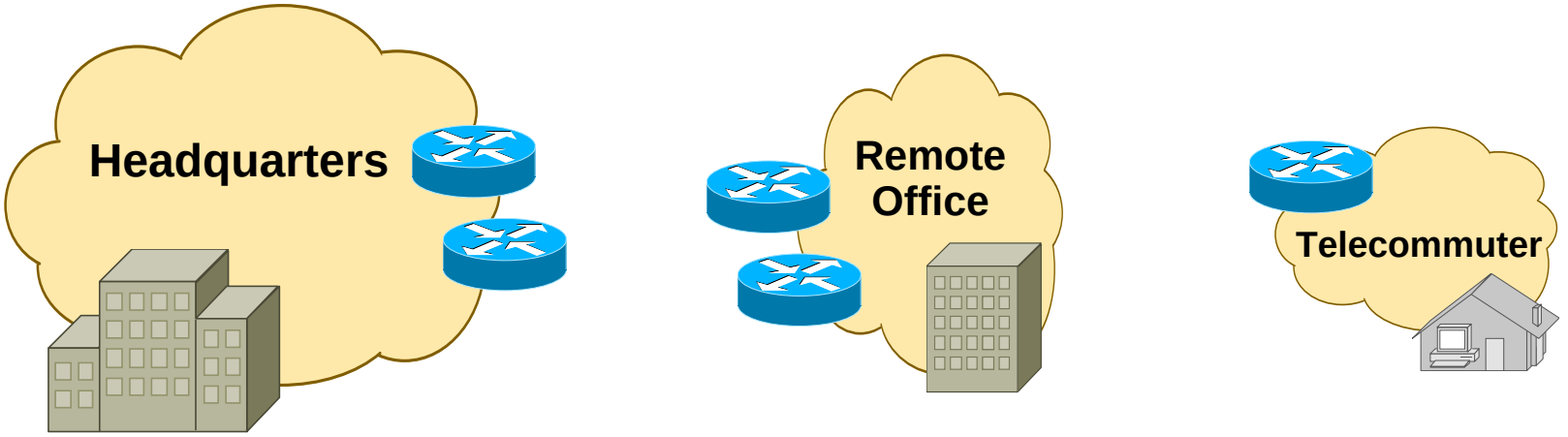


Agenda

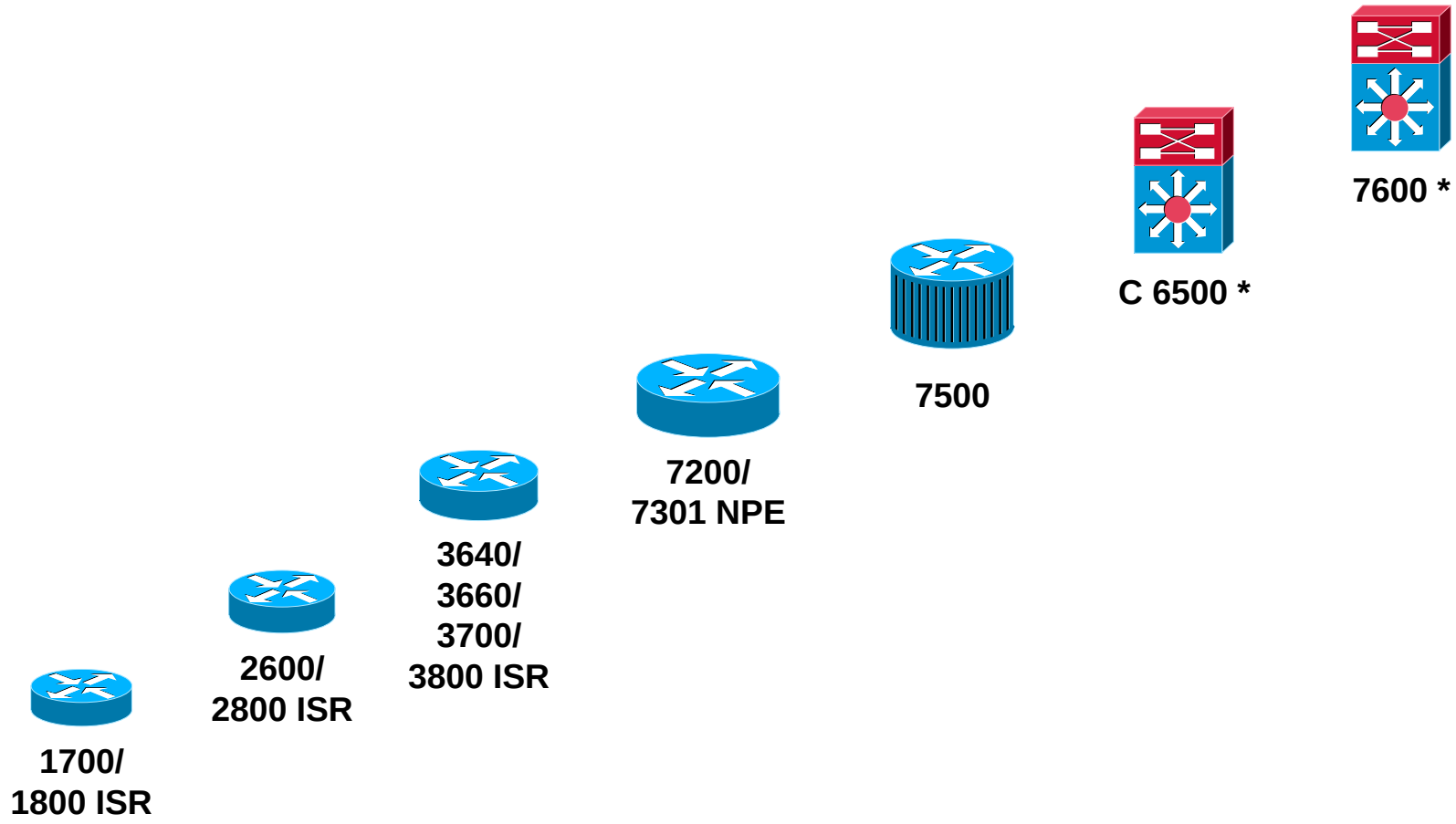
- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Performance
- Conclusion
- Q & A

OER Typical Customers

- Large, medium, and small enterprises with mission critical internet presence
- Enterprises with redundant WAN networks
- Enterprises with remote offices
- Home office with dual internet connections



OER Platform Support



*** C6500/7600 Supported in 12.2S 1Q07**

Agenda

- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Performance
- Conclusion
- Q & A

Design Questions

1. **Do I have redundant WAN connections ?**
   - **Internet, IPSEC/GRE, MPLS, ATM, Frame Relay**
   - **Configure as OER external interfaces**
2. **Which routers terminate the WAN ?**
   - **These are OER border routers**
3. **What routing protocols over WAN ?**
   - **BGP, Static covered by OER**
   - **All others, cfg static and filtering**
4. **Which router is OER master controller ?**
   - **Up to 5000 prefixes, dedicated 7200 or 3800 MC**
   - **For a few prefixes, configure MC on BR**

Design Questions

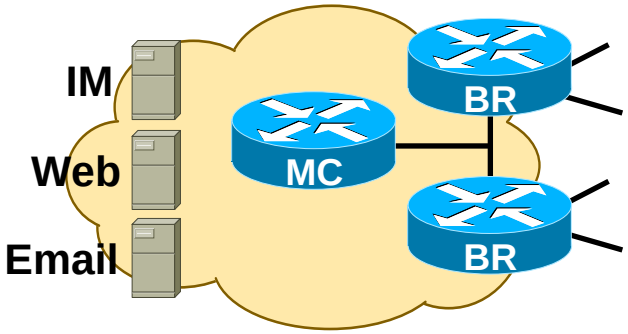
5. **What policy is important ?**
   - **Exit Performance**
     - **Delay, loss, reachability, throughput**
     - **Jitter, MOS**
   - **Entrance Performance - 12.4T**
     - **Delay, Loss, Reachability, Throughput**
   - **Load distribution**
   - **Cost minimization**
   - **Backup**
   - **Path discovery**
   - **Security 12.4T**
   - **Default priority is performance then load**

Design Questions

6. **Determine interesting traffic class by:**
   - **Configure Prefix**
   - **Configure Application**
   - **Configure Full ACL**
   - **Learn interesting prefixes**
   - **Learn interesting Traffic Classes**
   - **Learn eBGP advertised Prefixes**
   - **Learn Application**

Security Considerations

- Deploy MC behind Firewall
- Separate Private VLAN for MC and BR
- Private Addressing for MC and BR Communication
- No Routing on MC



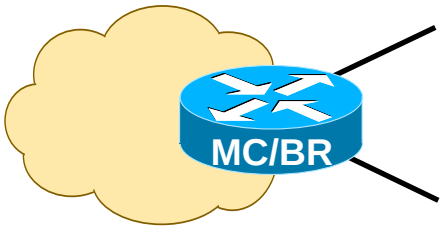

```
no ip routing
no router …
```

Routing not required on MC

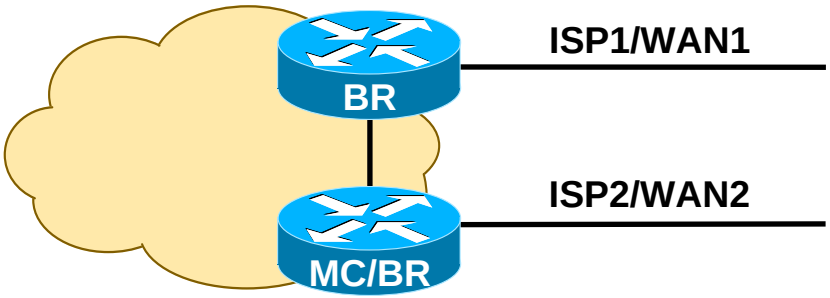
BR—Border Router, MC—Master Controller

Solution Topologies

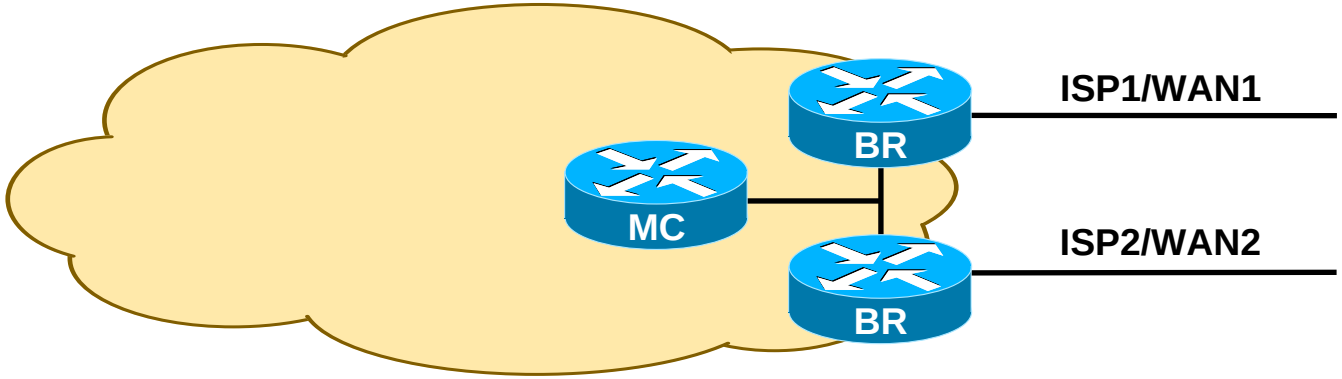
1) SOHO/Broadband



2) Remote Office



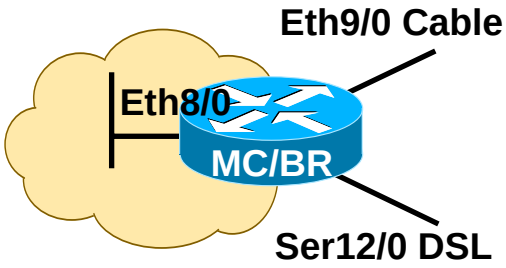
3) Headquarters/Content/Hosting/Data Centers



BR—Border Router, MC—Master Controller

SOHO/Broadband Deployment

1. **Cable and DSL WAN interfaces**
   - Eth8/0—OER Internal
   - Eth9/0—OER External
   - Ser12/0—OER External
2. **ISR router terminates WAN**
   - ISR is OER BR
3. **Static default routing**
4. **10 to 100 traffic-classes**
   - ISR is also MC
   - 12.4
5. **Performance is most important**
   - Use OER default policy
6. **Learn throughput and delay to get prefixes**



BR—Border Router, MC—Master Controller

SOHO/Broadband Configuration

```
key chain key1
 key 1
  key-string oer
oer master
 logging
 mode route control
 max prefix total 100
 backoff 90 3000 300
 border 10.10.10.1 key-chain key1
  interface Ethernet8/0 internal
  interface Ethernet9/0 external
    max-xmit-utilization absolute 1000
  interface Ser12/0 external
    max-xmit-utilization absolute 300
 learn
  throughput
  delay
  monitor-period 1
  periodic-interval 0
oer border
 logging
 local Ethernet8/0
 master 10.10.10.1 key-chain key1
interface Ethernet8/0
 ip address 10.10.10.1 255.255.255.0
interface Ethernet 9/0
 load-interval 30
interface Serial 12/0
 load-interval 30
```

Enable Logging

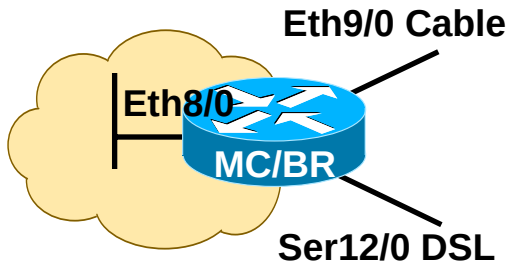
Enforce Routing Changes

Authentication Required

Limit Cable and DSL Throughput

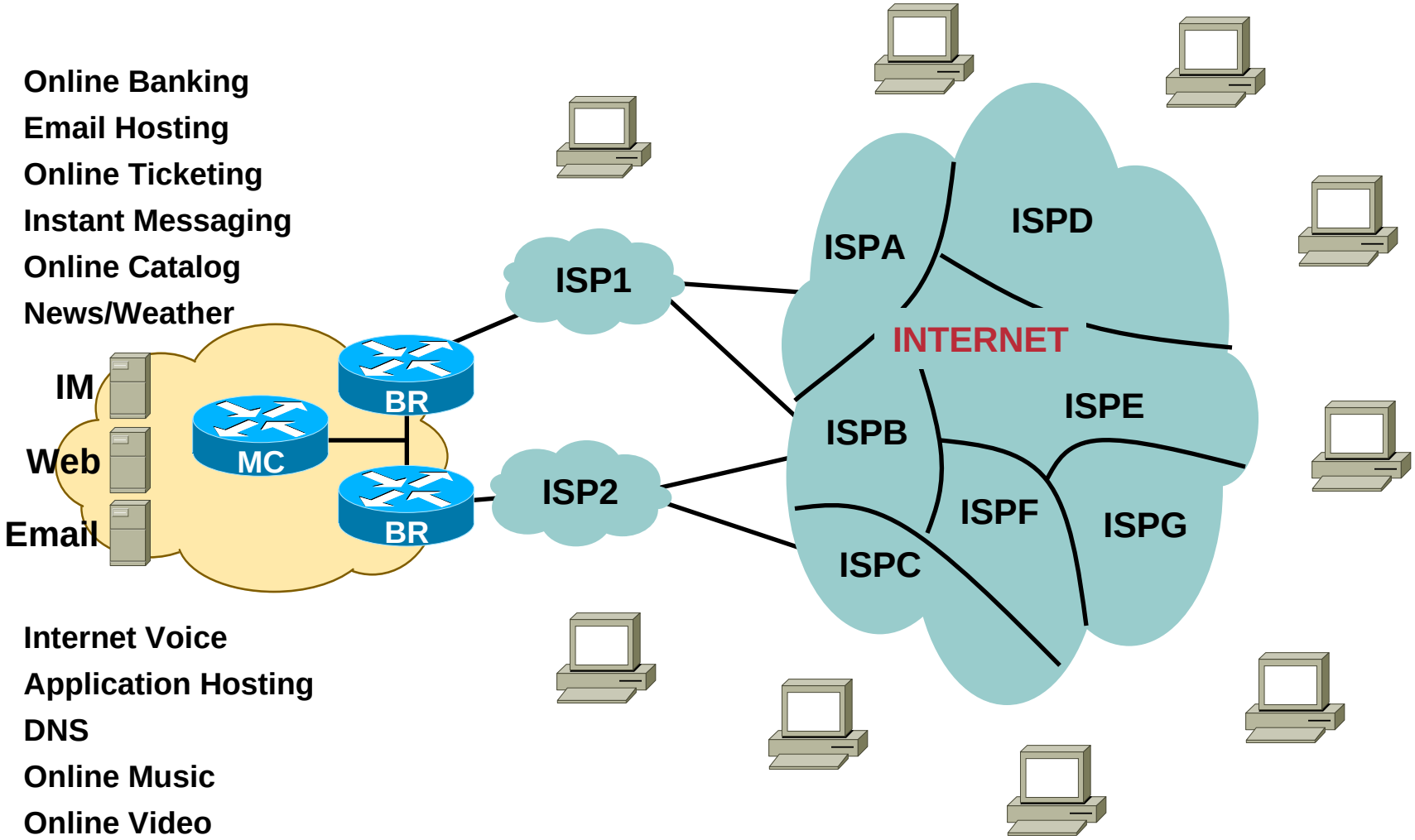
Learn Delay and Throughput Prefixes Every Minute

MC and BR on Same Router



Mission-Critical Internet Presence

- Online Banking
- Email Hosting
- Online Ticketing
- Instant Messaging
- Online Catalog
- News/Weather



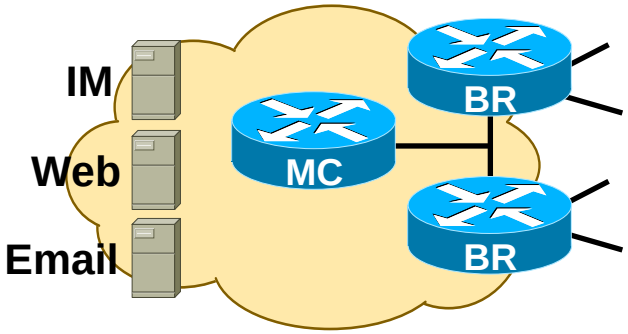
- Internet Voice
- Application Hosting
- DNS
- Online Music
- Online Video

BR—Border Router, MC—Master Controller

Internet Presence Deployment

1. **DS3 Interfaces**
   - **Ser12/0, Ser13/0, …**
2. **7500, 7200, 3800 terminates WAN**
3. **BGP Routing**
   - **BRs must be iBGP peers**
   - **Default Routing**
   - **Partial Routes**
   - **Full Routes**

   } **Same OER config for all**
4. **5000 Prefixes**
   - **12.4**
   - **Entrance Optimization***
5. **Customers differ on Policy priority**
6. **Learn prefixes by Throughput and Delay**



BR—Border Router, MC—Master Controller

Internet Presence Configuration
Default Policy: Performance then Load

MC 10.1.1.1

```
key chain key1
 key 1
  key-string oer
oer master
 logging
 mode route control
 mode select-exit best
 backoff 90 3000 300
 periodic 600
 border 10.1.1.2 key-chain key1
  interface Ethernet8/0 internal
  interface Serial12/0 external
  interface Serial13/0 external
 border 10.1.1.3 key-chain key1
  interface Ethernet 8/0 internal
  interface Serial12/0 external
  interface Serial13/0 external
 learn
  throughput
  delay
  monitor-period 1
  periodic-interval 0
  prefixes 500
  expire after time 240
```

Choose Best Exit Regardless of in or out of Policy

Revaluate Exit 10 Minutes

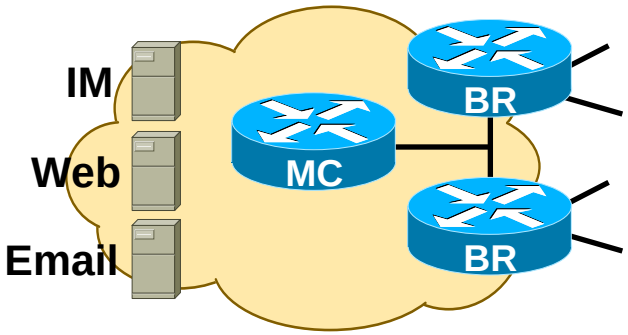
Learn 500 Prefixes

Delete Prefix if Not Re-Learned in 240 Minutes

BR 10.10.10.2

BR 10.10.10.3

```
key chain key1
 key 1
  key-string oer
oer border
 logging
 local loopback 1
 master 10.10.10.1 key-chain key1
interface ser12/0
 load-interval 30
interface ser13/0
 load-interval 30
```



Internet Presence Configuration
Load Balancing Only

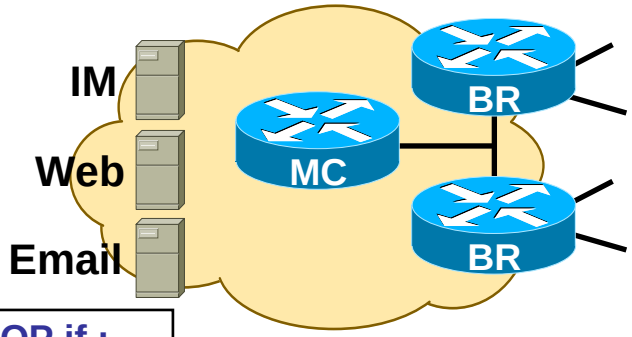
- **Add to Default Policy Configuration**

Disable Periodic Prefix Evaluation

MC 10.1.1.1

```
oer master
 no periodic
 resolve utilization priority 1 variance 5
 resolve range priority 2
 no resolve delay
 no resolve loss
 max-range-utilization percent 50
 border 10.1.1.2
  interface Serial12/0 external
   max-xmit-utilization percent 90
  interface Serial13/0 external
   max-xmit-utilization percent 90
 border 10.1.1.3
  interface Serial12/0 external
   max-xmit-utilization percent 90
  interface Serial13/0 external
   max-xmit-utilization percent 90
```

Link OOP if :
% util > lowest + 50
% util > 90

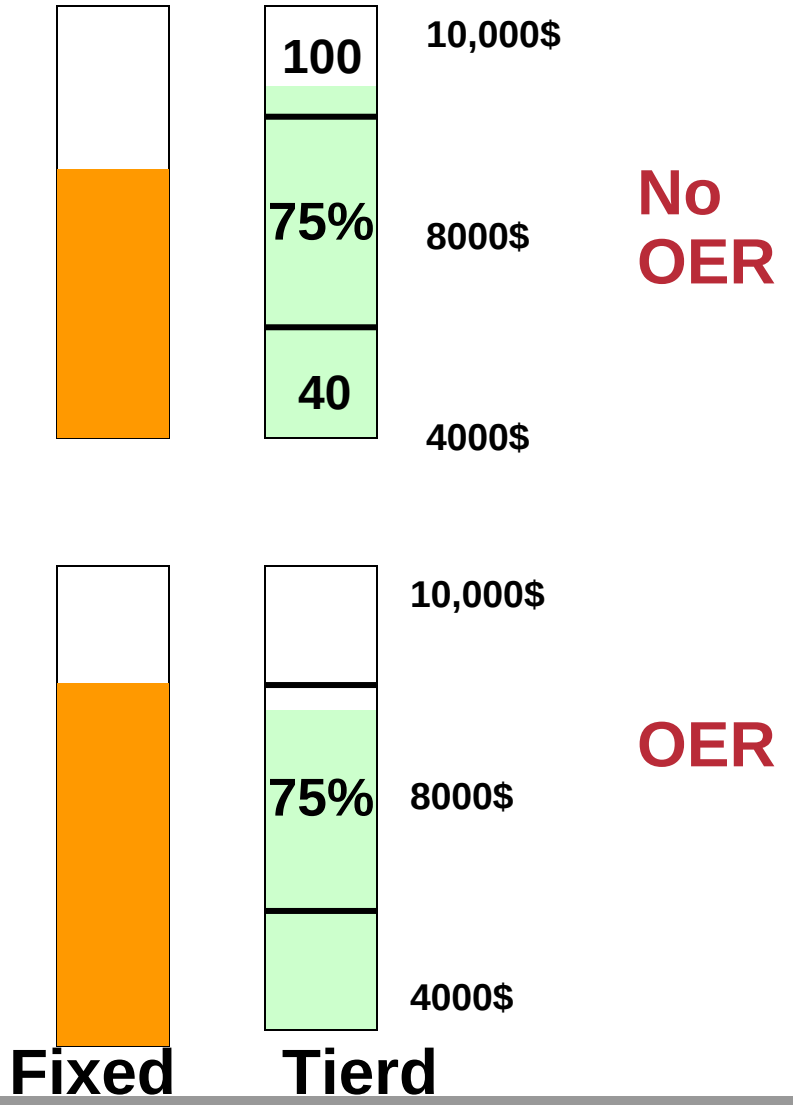


Internet Presence Configuration
$Cost Minimization Only

- **Add to Default Policy Configuration**

MC 10.1.1.1

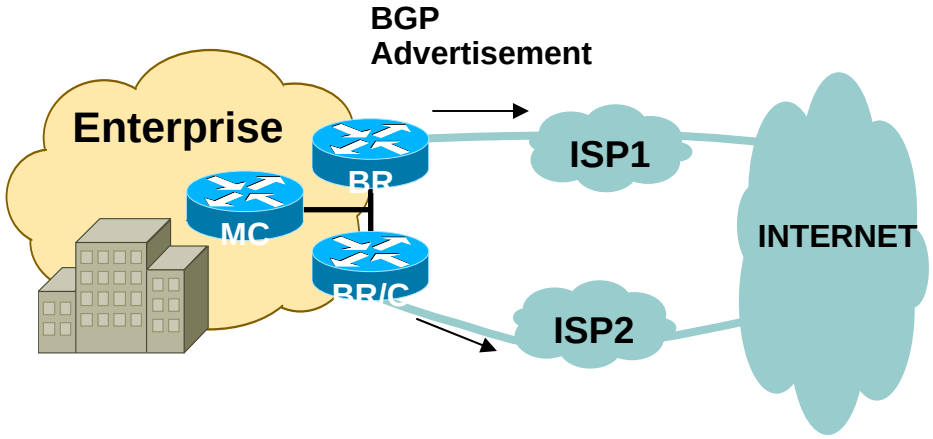
```
oer master
 no periodic
 resolve cost priority 1
 no resolve delay
 no resolve utilization
 border 10.1.1.2
  interface Serial12/0 external
   cost-minimization tier 100 fee      10000
   cost-minimization tier  75 fee       8000
   cost-minimization tier  40 fee       4000
   cost-minimization end day-of-month 31
  interface Serial13/0 external
   cost-minimization fixed fee 3000
 border 10.1.1.3
  interface Serial12/0 external
   cost-minimization fixed fee 3000
  interface Serial13/0 external
   cost-minimization fixed fee 3000
```



Internet Presence Configuration
OER Inbound

Learning inside prefix

```
oer master
  learn
    inside bgp
oer-map MAP 10
  match oer learn inside
```



Configuring inside prefix

```
ip prefix-list INSIDE permit 10.1.1.0/24
oer-map MAP 10
  ip address prefix-list INSIDE inside
```

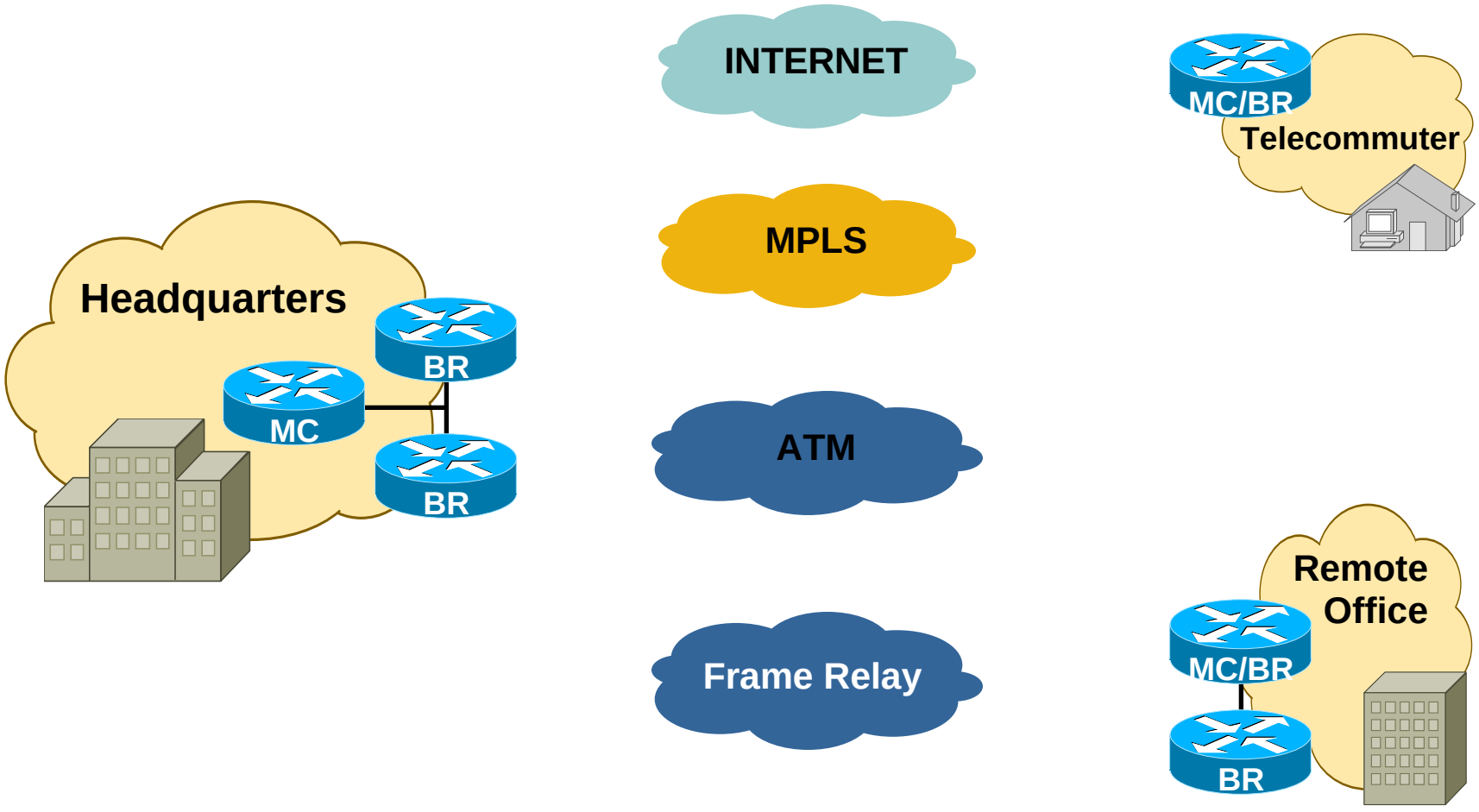
Choosing Downgrading Method

AS prepend – No Configuration required

BGP Community

```
Oer master
  border 10.1.1.1 key-chain oer
   interface ethernet1/0 external
    downgrade bgp community 3:2
```

Enterprise VPN Deployment



BR—Border Router, MC—Master Controller

Enterprise VPN Deployment
OER EIGRP, …

1. **Configure Default to each external interface**

```
ip route 0.0.0.0 0.0.0.0 eth 9/0 50.50.50.2 tag 10
ip route 0.0.0.0 0.0.0.0 ser12/0 tag 10
ip route 0.0.0.0 0.0.0.0 tunnel0 tag 10
ip route 0.0.0.0 0.0.0.0 tunnel1 tag 10
```

OER External Interfaces

2. **Block redistribution of Default**

```
router eigrp 100
 redistribute static route-map block-def
route-map block-def deny 20
 match tag 10
route-map block-def permit 30
```

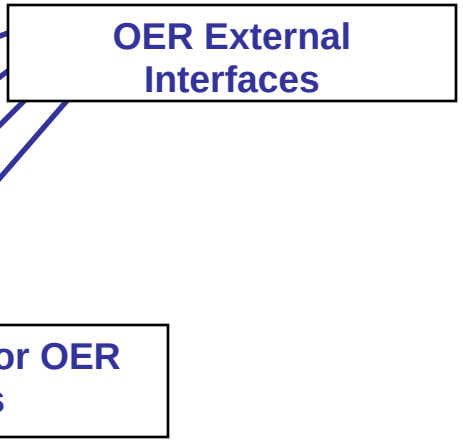
Enterprise VPN Deployment
OER with EIGRP, …

3. Configure OER Learn

```
oer master
 learn
  throughput
  delay
```

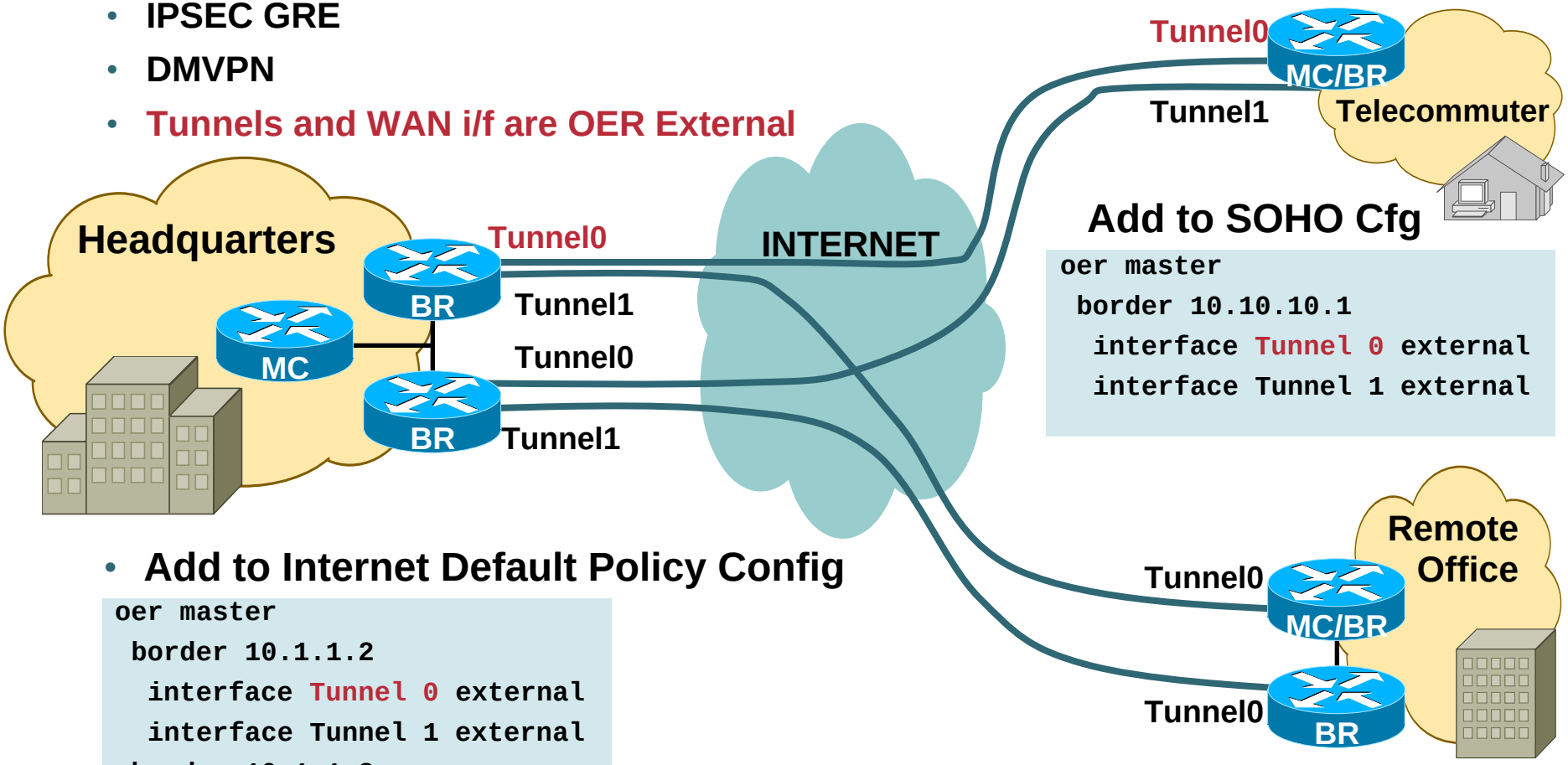
4. Block redistribution of OER statics over Externals

```
router eigrp 100
 distribute-list route-map block-oer out eth0/1
 distribute-list route-map block-oer out ser12/0
 distribute-list route-map block-oer out tunnel0
 distribute-list route-map block-oer out tunnel1
route-map block-oer deny 10
 match tag 5000
route-map block-oer permit 20
```



Enterprise VPN Deployment
Dual IPSEC/GRE Tunnels

- IPSEC GRE
- DMVPN
- Tunnels and WAN i/f are OER External



Add to SOHO Cfg

```
oer master
 border 10.10.10.1
  interface Tunnel 0 external
  interface Tunnel 1 external
```

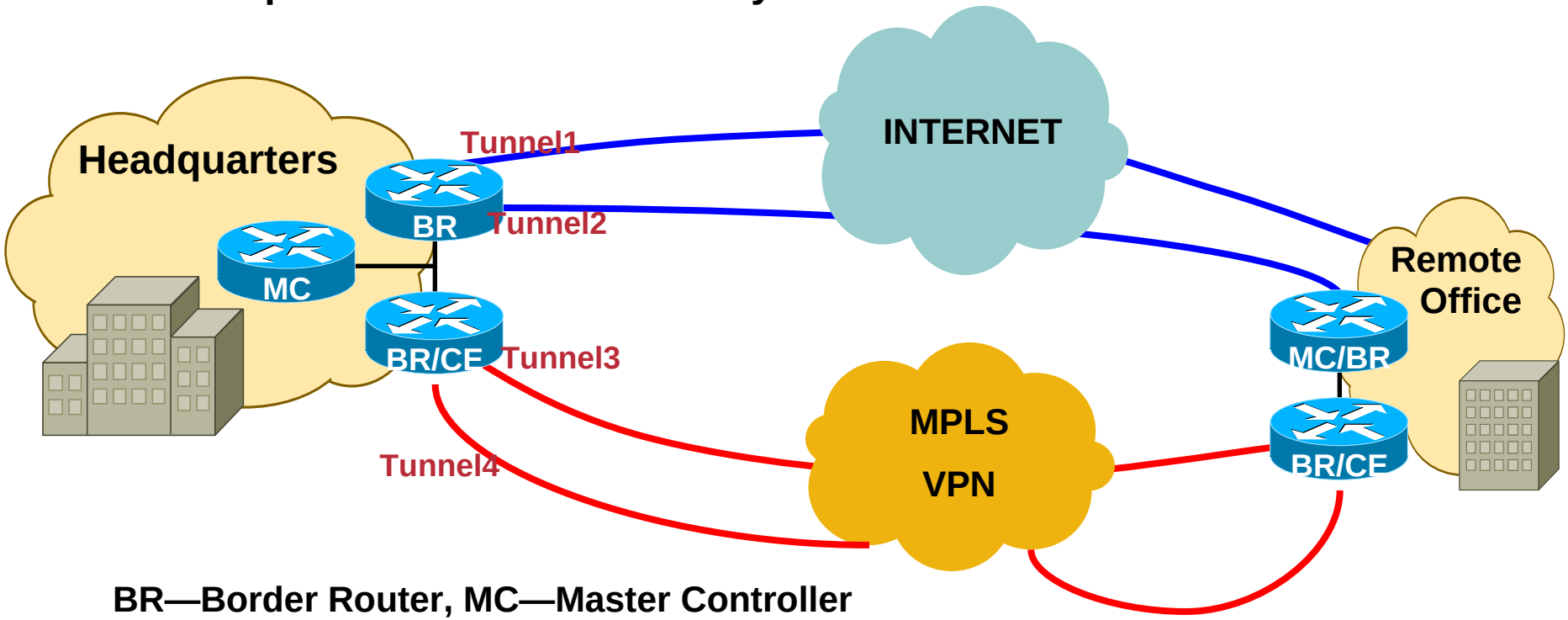
- Add to Internet Default Policy Config

```
oer master
 border 10.1.1.2
  interface Tunnel 0 external
  interface Tunnel 1 external
 border 10.1.1.3
  interface Tunnel 0 external
  interface Tunnel 1 external
```

BR—Border Router, MC—Master Controller

Enterprise VPN Deployment
MPLS and IPSEC/GRE

- BGP Routing
- Combines Internet and IPSEC/GRE
- Tunnel and MPLS I/F are OER External
- Backup then Performance Policy



BR—Border Router, MC—Master Controller

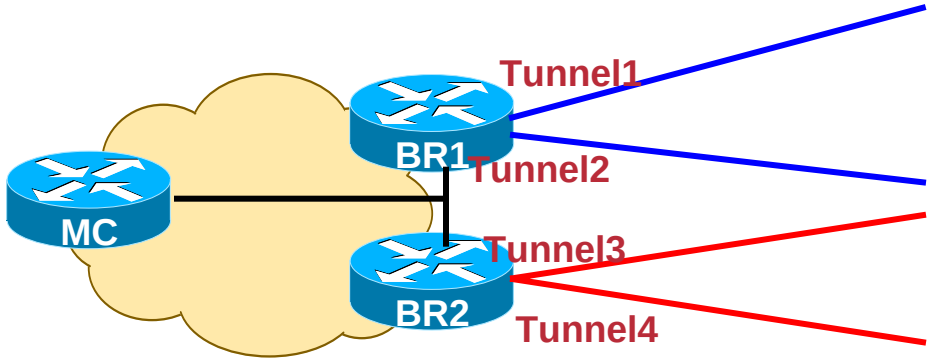
Enterprise VPN Deployment
Primary and Backup

Group Links

```
oer master
  border 1.1.1.1 key-chain key1
    interface Tu1/0 external
       link-group BLUE
    interface Tu2/0 external
       link-group BLUE
    interface eth1/1 internal

 border 1.1.1.2 key-chain key2
    interface Tu3/0 external
      link-group RED
    interface Tu4/0 external
      link-group RED
    interface et3/1 internal
```

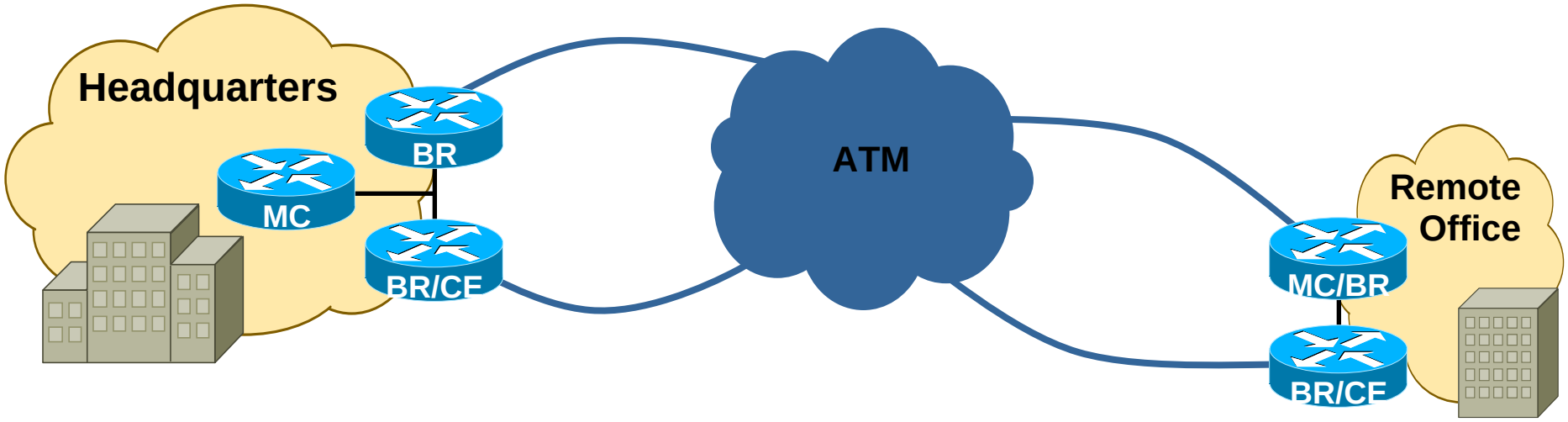
Specify Link Preference

```
oer-map MAP 10
match Appl1
set delay threshold 100
set link-group RED fallback BLUE


oer-map MAP 20
match Appl2
set link-group BLUE
```



Enterprise VPN Deployment
Dual ATM Links

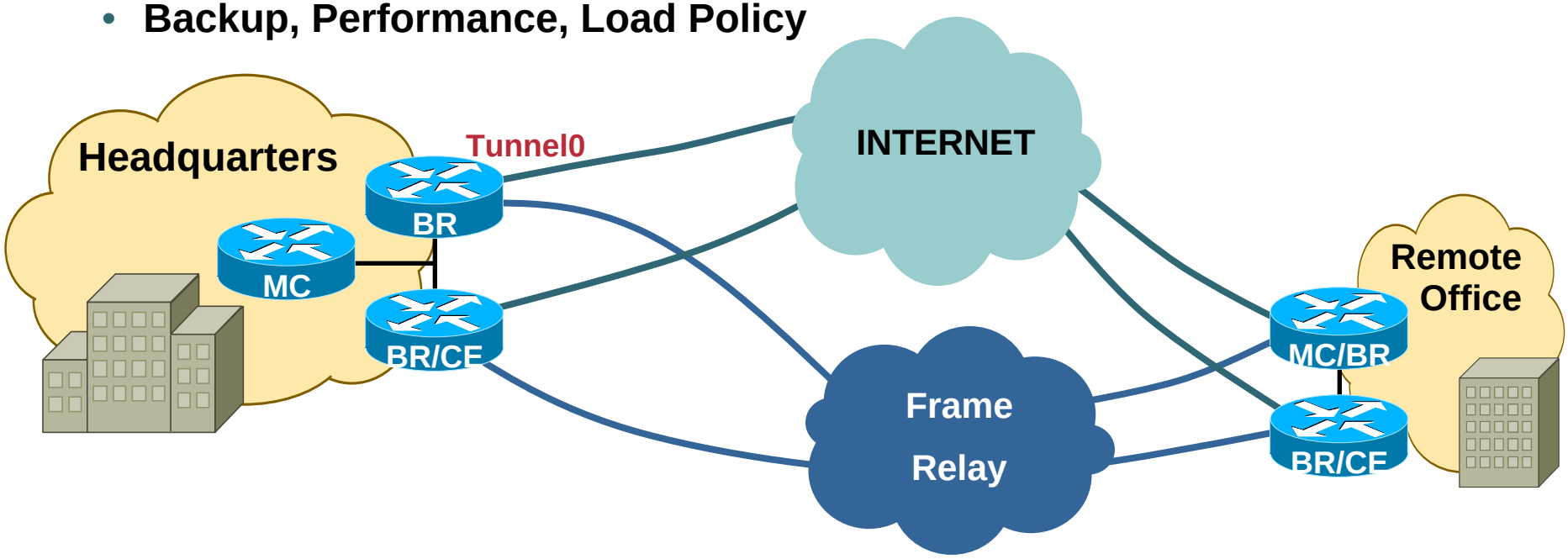
- EIGRP, OSPF
- Use OER Static w/ redistribute static
- Load Balancing is Primary Policy
- Use Load Balancing Only Config



BR—Border Router, MC—Master Controller

Enterprise VPN Deployment
IPSEC/GRE and Frame Relay

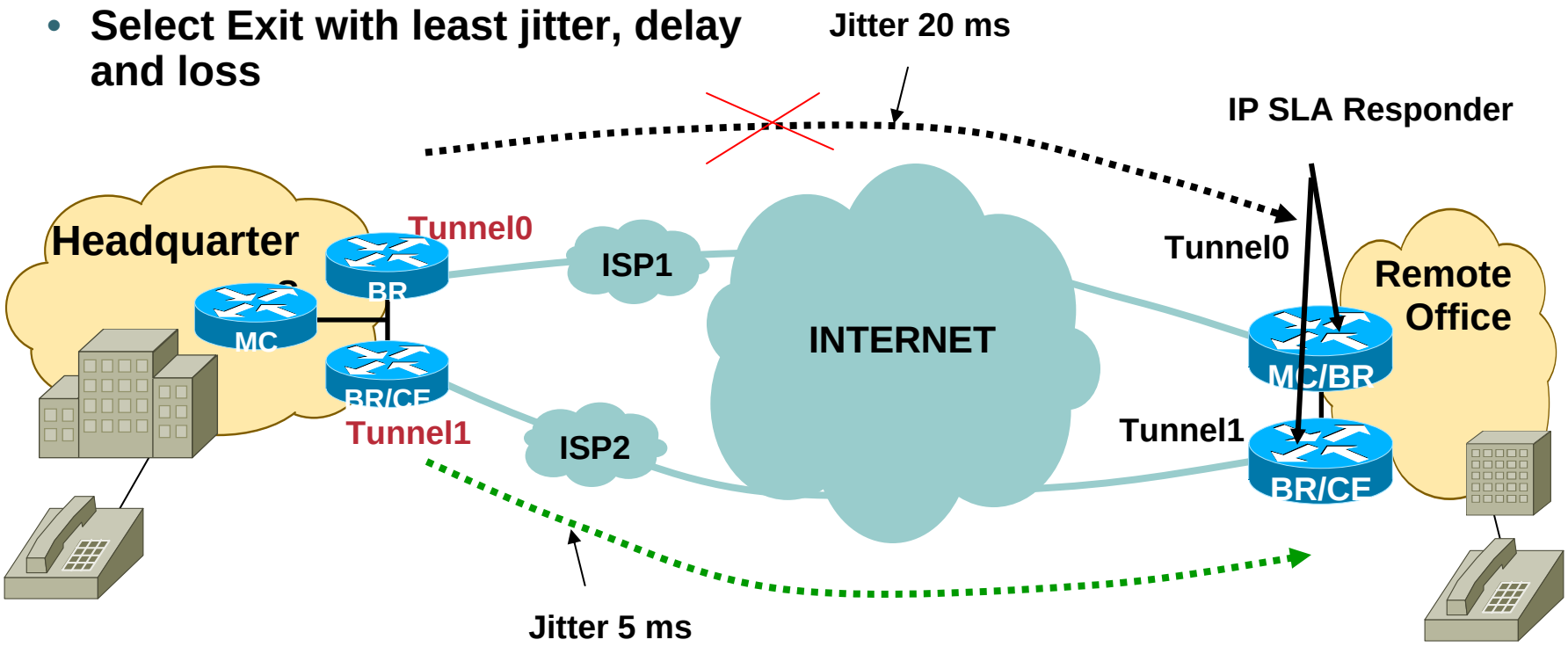
- Quadruple Redundancy
- EIGRP or OSPF
- Tunnel and FR I/F are OER External
- Backup, Performance, Load Policy



BR—Border Router, MC—Master Controller

Enterprise VPN Deployment
Optimize Voice Traffic between two sites

- **Select Exit with least jitter, delay and loss**



- **Select Exit with highest percentage of Estimated MOS above threshold**

Tunnel1 – 5 out of 100 sample had MOS < 4.00 ←Better

Tunnel0 – 20 out of 100 sample had MOS < 4.00

BR—Border Router, MC—Master Controller

Enterprise VPN Deployment
Optimize Voice Traffic

Identify voice traffic

- Packets marked with DSCP bits

```
ip access-list extended VOICE-LIST
 permit ip any 10.1.1.0 0.0.0.255 dscp ef
```

OR

- UDP port range

```
ip access-list extended VOICE-LIST
 permit udp any 10.1.1.0 0.0.0.255 range x y
```

Configure voice policy

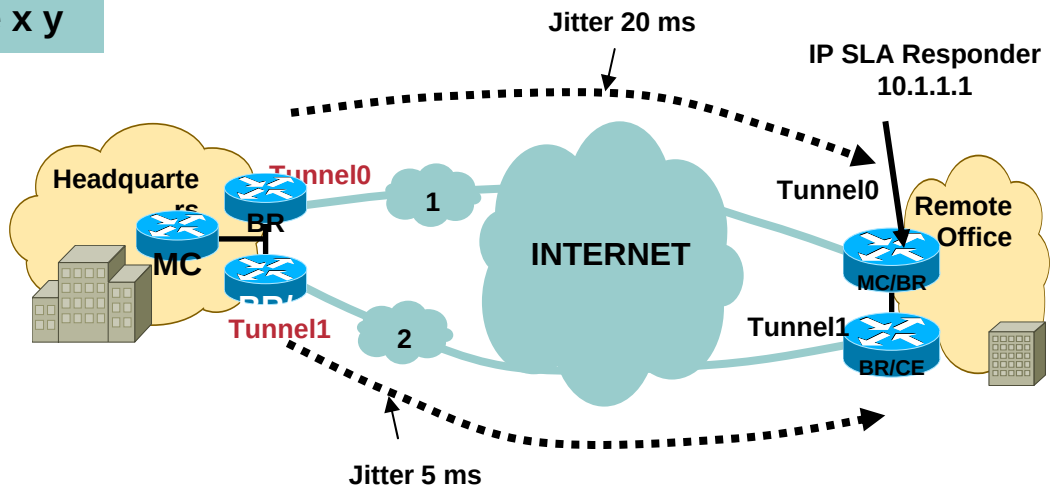
```
oer-map MAP 20
  match ip address access-list VOICE-LIST
  set Jitter threshold 15
  set mos percent 20 threshold 4.00
  set resolve mos priority 1
  set resolve jitter priority 2
```

Configure Jitter Probe

```
oer-map MAP 20
  set active-probe jitter 10.1.1.1
                target-port 2000 codec g729a
  set probe frequency 10
```

Configure Responder on remote router

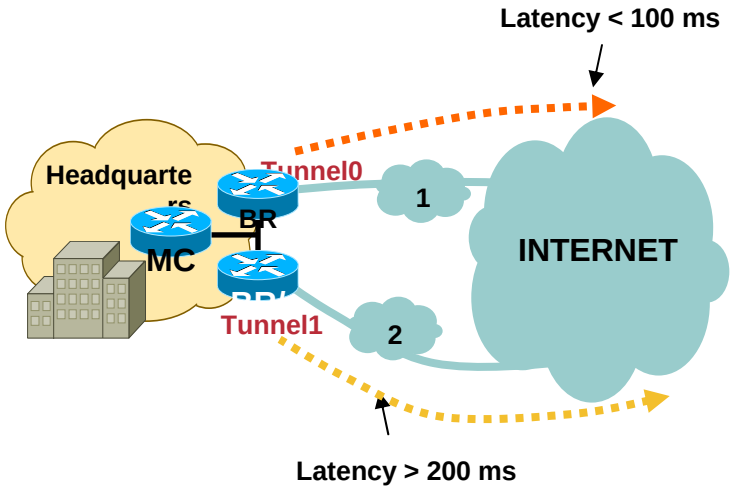
```
Ip sla responder
```



Enterprise VPN Deployment
Optimize Traffic Class

Destination Prefix 10.1.1.0/24

- **Latency sensitive - DSCP af12**
- **Latency tolerant – other**

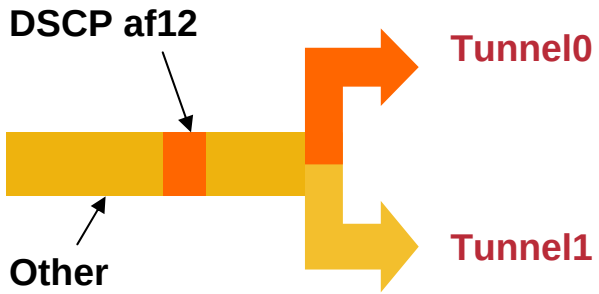


Configure Traffic class

```
ip access-list RMT-OFC-DELAY
  permit ip any 10.1.1.0 0.0.0.255 dscp af12

Ip prefix-list RMT-OFC-OTHER permit 10.1.1.0/24
```

Configure Policy

```
oer-map MAP 10
  match ip address access-list RMT-OFC-DELAY
  set delay threshold 100
  set resolve delay priority 1 variance 5
  set mode monitor active

oer-map MAP 20
 match ip address prefix-list RMT-OFC-OTHER
 set delay threshold 400
 set resolve utilization priority 1 variance 5
```



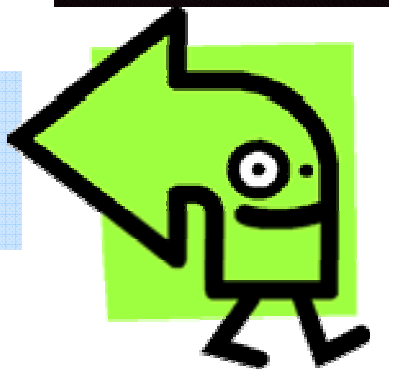
Security Policy – Ignore Performance

Identify Blackhole Traffic Class

```
ip prefix-list BLACKHOLE permit 100.1.1.0/24
ip access-list extended BLACKHOLE
permit tcp 10.10.10.0 0.0.0.255 any eq www
```

Identify Sinkhole Traffic Class

```
ip prefix-list SINKHOLE permit 9.1.1.1/32
ip access-list extended SINKHOLE
 permit udp 10.10.10.0 0.0.0.255 any eq domain
permit ip any any dscp cs4
```

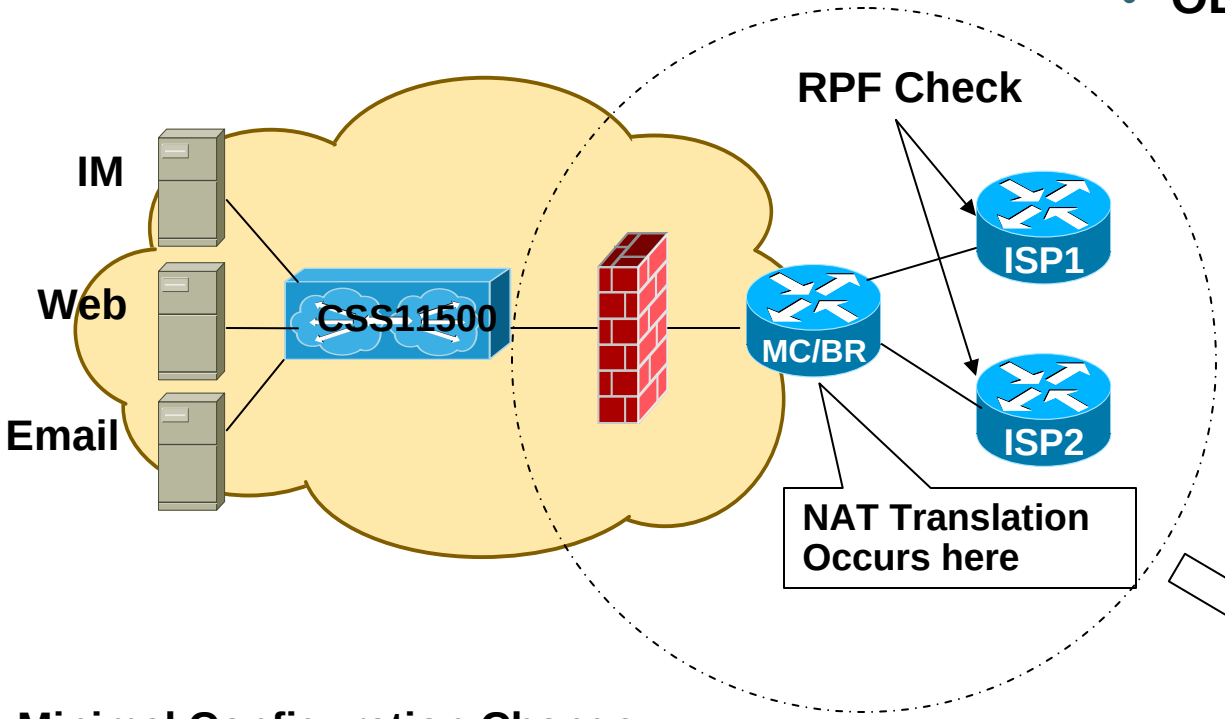


Apply Policy

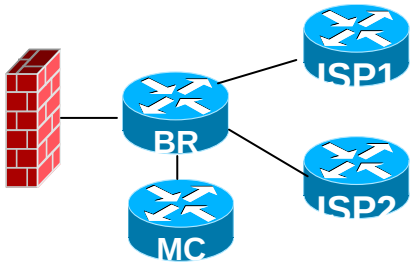
```
oer master
 policy-rules SECURITY
oer-map SECURITY 10
 match ip address prefix-list BLACKHOLE
 set interface Null0
oer-map SECURITY 40
 match ip address access-list SINKHOLE
 set next-hop 10.10.10.4
```

OER with NAT

MC/BR Router Combined



- **OER and NAT**
  - **Existing flow continues on same Exit. No sessions are dropped.**
  - **New flow goes out via new Exit.**



With Separate MC and BR

Minimal Configuration Change

```
interface virtual-template 1
ip nat inside source <x> interface Virtual-Template 1 overload oer
```

OER with NAT – Configuration Example

Identify traffic to be NAT translated

```
access-list 1 permit 10.1.0.0 0.0.255.255
route-map isp-1 permit 10
  match ip address 1
  match interface Se1/0
route-map isp-2 permit 10
  match ip address 1
  match interface Se2/0
```

```
interface Eth3/0
  ip nat inside
interface Se1/0
  ip nat outside
interface Se2/0
  ip nat outside
```

OER Internal Interface

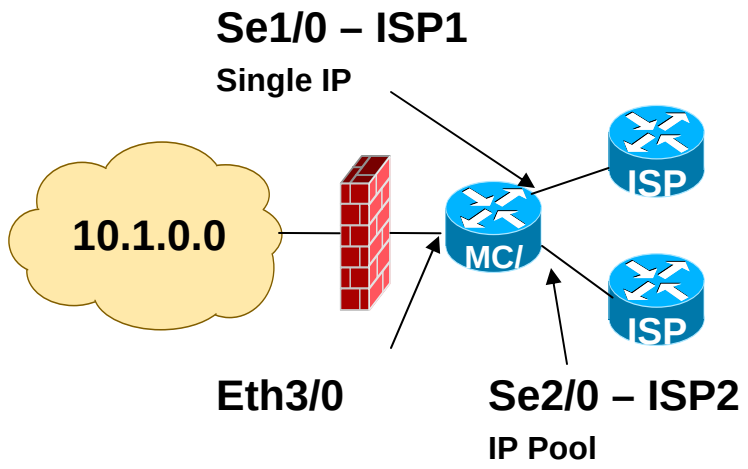
OER External Interface

Single IP

```
interface virtual-template 1
ip nat inside source route-map isp-1 interface
    Virtual-Template1 overload oer
```

IP Pool

```
ip nat pool ISP-2 <min-ip-addr> <max-ip-addr>
    prefix-length <len>
ip nat inside source route-map isp-2 pool ISP-2 oer
```



OER MC Redundancy

- **What if MC goes down?**

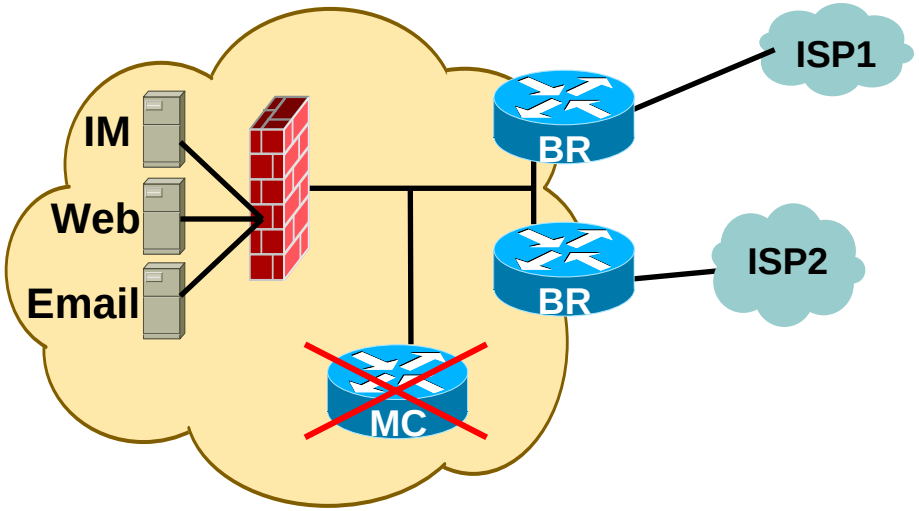
  Routing defaults to normal as if OER was not configured

- **Still need MC Redundancy?**
  - **Available:**

    Stateless redundancy without configuration synchronization available using HSRP.

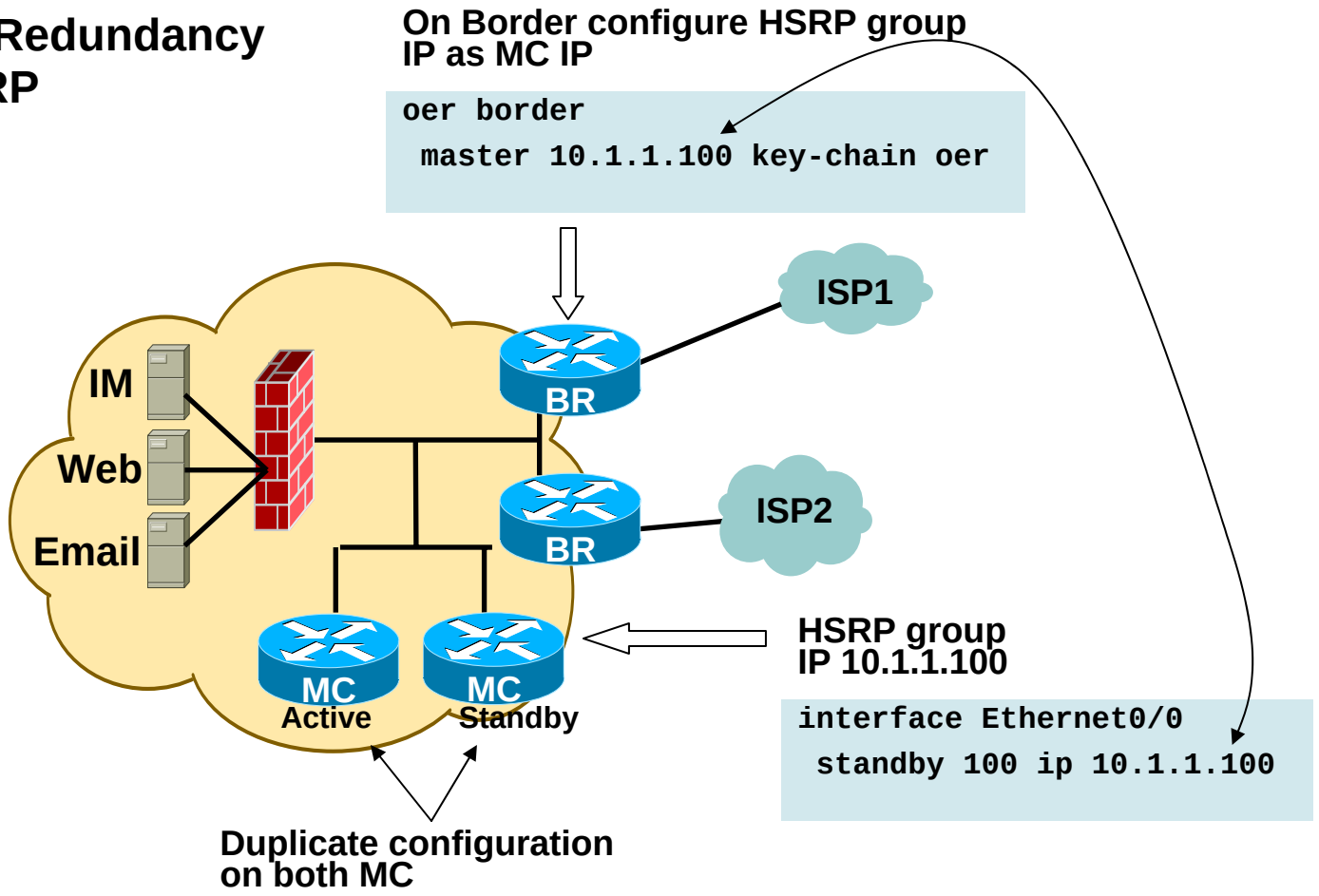
  - **On Roadmap**

    Stateless Redundancy with synchronized configuration and Stateful Redundancy.



OER MC Redundancy

- **Stateless Redundancy using HSRP**



How to Discover Current Path?

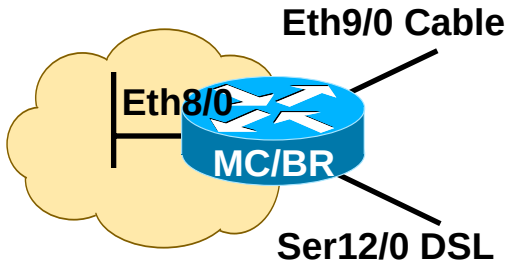
`show oer master prefix 100.1.1.0/24 traceroute current [now]`

- **Displays current path of prefix**
- **Uses responding target**
- **If now, generate new result**
- **Otherwise, display most recent result**

```
sh oer master prefix 100.1.1.0/24 traceroute current now
Path for Prefix: 100.1.1.0/24        Target: 100.1.1.1
Exit ID: 2, Border: 10.10.10.1       External Interface: Se12/0
Status: DONE, How Recent: 00:00:00 minutes old
Hop  Host            Time(ms) AS
1    30.30.30.2      24       0
2    60.60.60.4      12       0
3    100.0.0.2       20       0
```

DONE or INPROGRESS

AS Is Unknown
Likely Not Using BGP

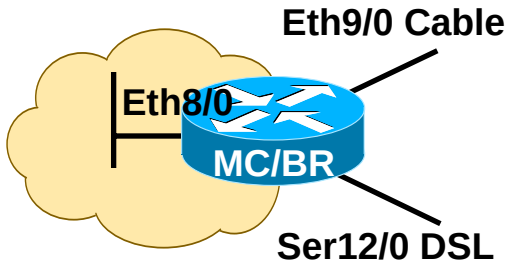


How to Discover All Paths?

`show oer master prefix 100.1.1.0/24 traceroute [now]`

- **Displays Path over Each External Interface**
- **Uses Responding Target**

```
------------------------------------------------------------------------------
Path for Prefix: 100.1.1.0/24        Target: 100.1.1.1
Exit ID: 1, Border: 10.10.10.1       External Interface: Et9/0
Status: DONE, How Recent: 00:01:04 minutes old
Hop  Host            Time(ms) AS
1    40.40.40.2      4        0
2    60.60.60.4      4        0
3    100.0.0.2       20       0
------------------------------------------------------------------------------
Path for Prefix: 100.1.1.0/24        Target: 100.1.1.1
Exit ID: 2, Border: 10.10.10.1       External Interface: Se12/0
Status: DONE, How Recent: 00:05:44 minutes old
Hop  Host            Time(ms) AS
1    30.30.30.2      12       0
2    60.60.60.4      16       0
3    100.0.0.2       32       0
```



How to Discover Path on OOP?

```
oer-map foo 10
 match oer learn throughput
 set traceroute reporting policy delay
 set traceroute reporting policy loss
 set traceroute reporting policy unreachable
```

Learned Top Throughput Prefixes,

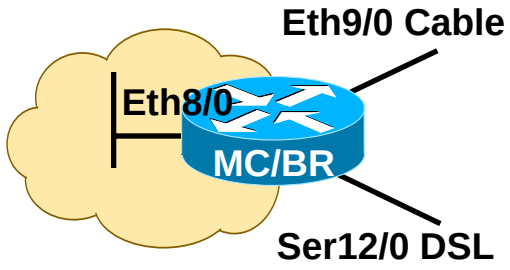
Discover Path on Delay OOP

Discover Path on Loss OOP

Discover Path on Unreachable OOP

- **To display traceroute result**

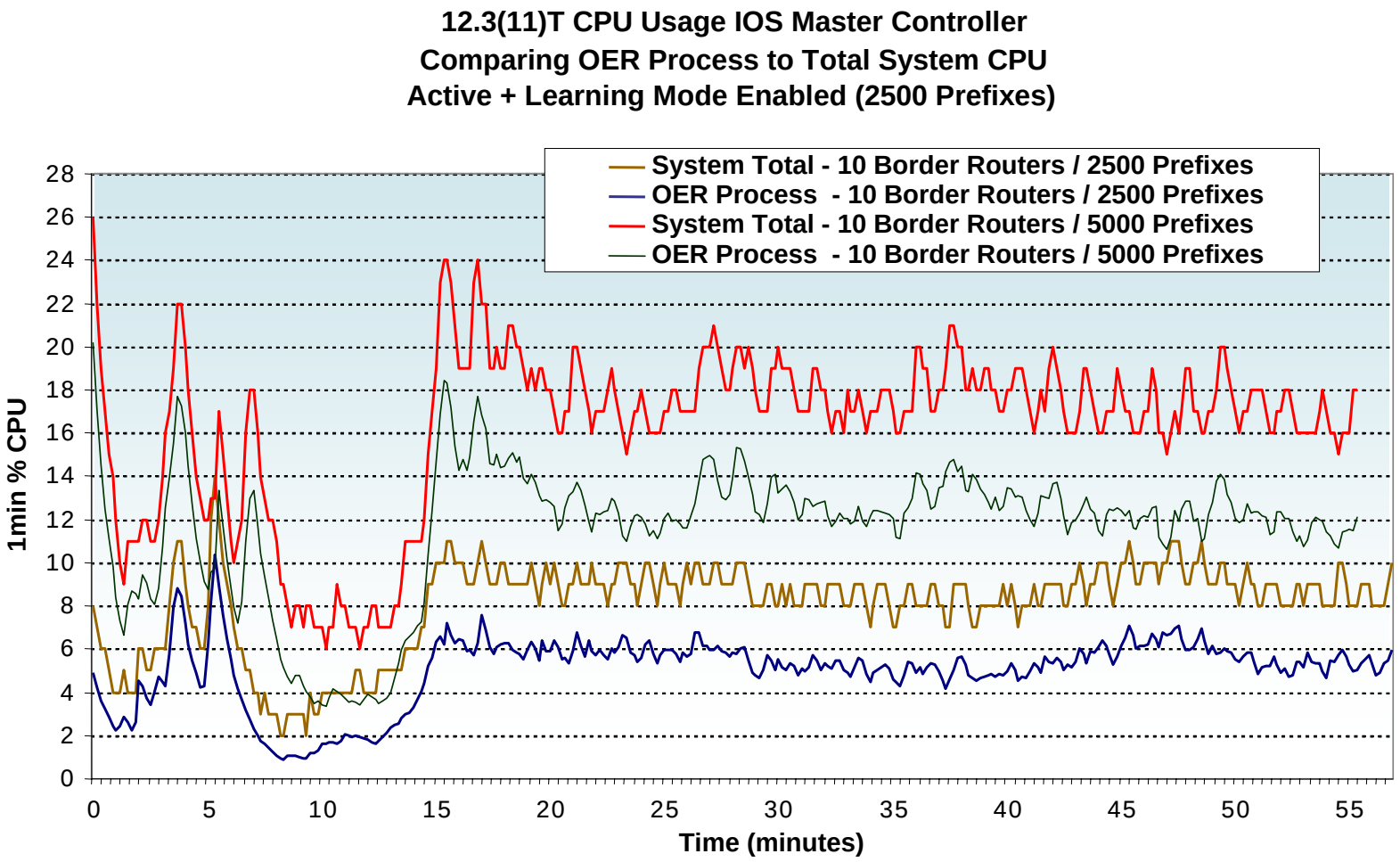
```
sh oer master prefix 100.1.1.0/24 traceroute current now
Path for Prefix: 100.1.1.0/24        Target: 100.1.1.1
Exit ID: 2, Border: 10.10.10.1       External Interface: Se12/0
Status: DONE, How Recent: 00:00:00 minutes old
Hop  Host            Time(ms) AS
1    30.30.30.2      24       0
2    60.60.60.4      12       0
3    100.0.0.2       20       0
```



Agenda

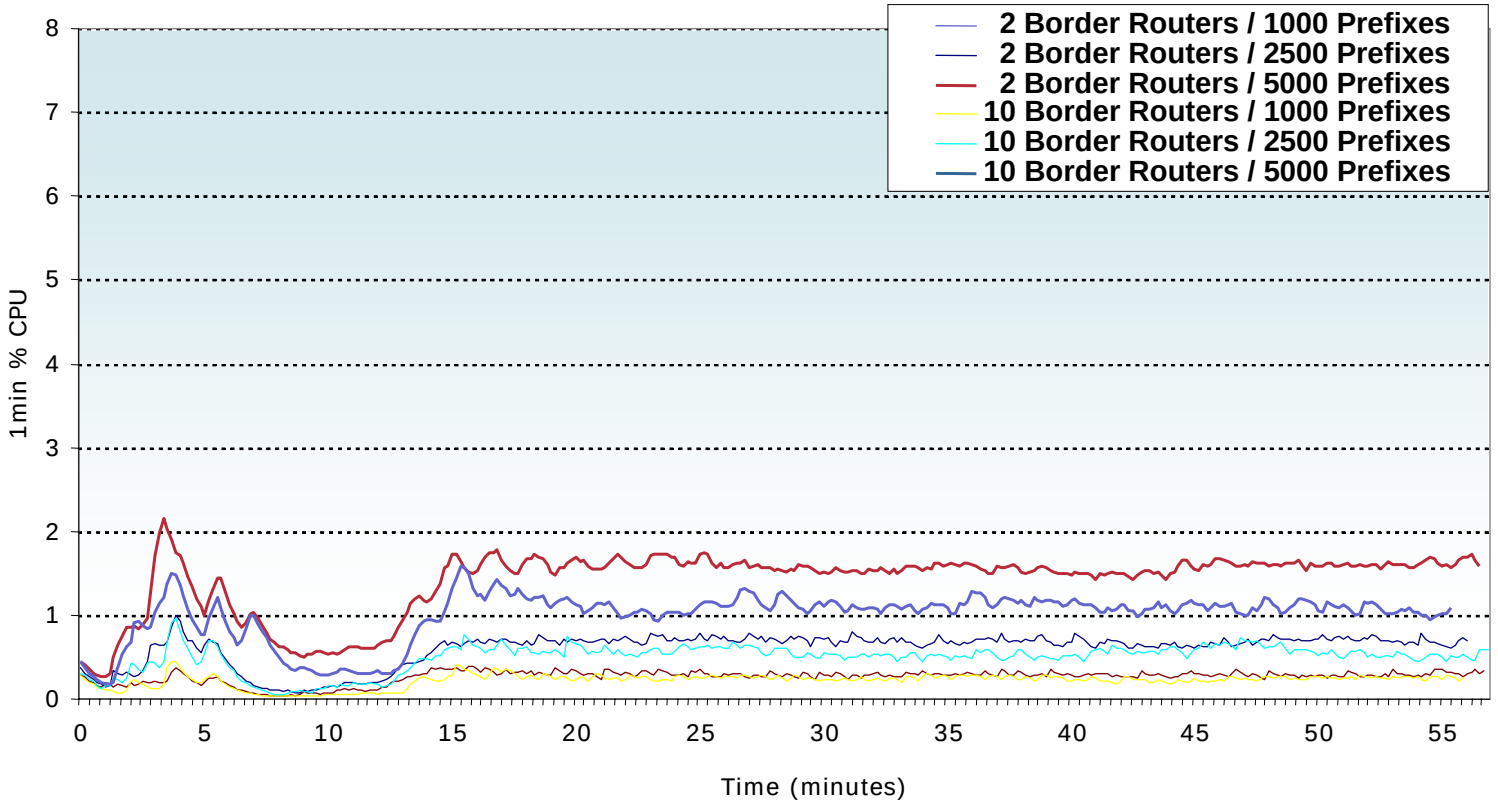
- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Performance
- Conclusion
- Q & A

OER MC Process vs. Total System CPU



OER BR Learning Enabled

12.3(11)T CPU Usage IOS Border Router
OER BR Process Only
Active + Learning Mode Enabled (2500 Prefixes)



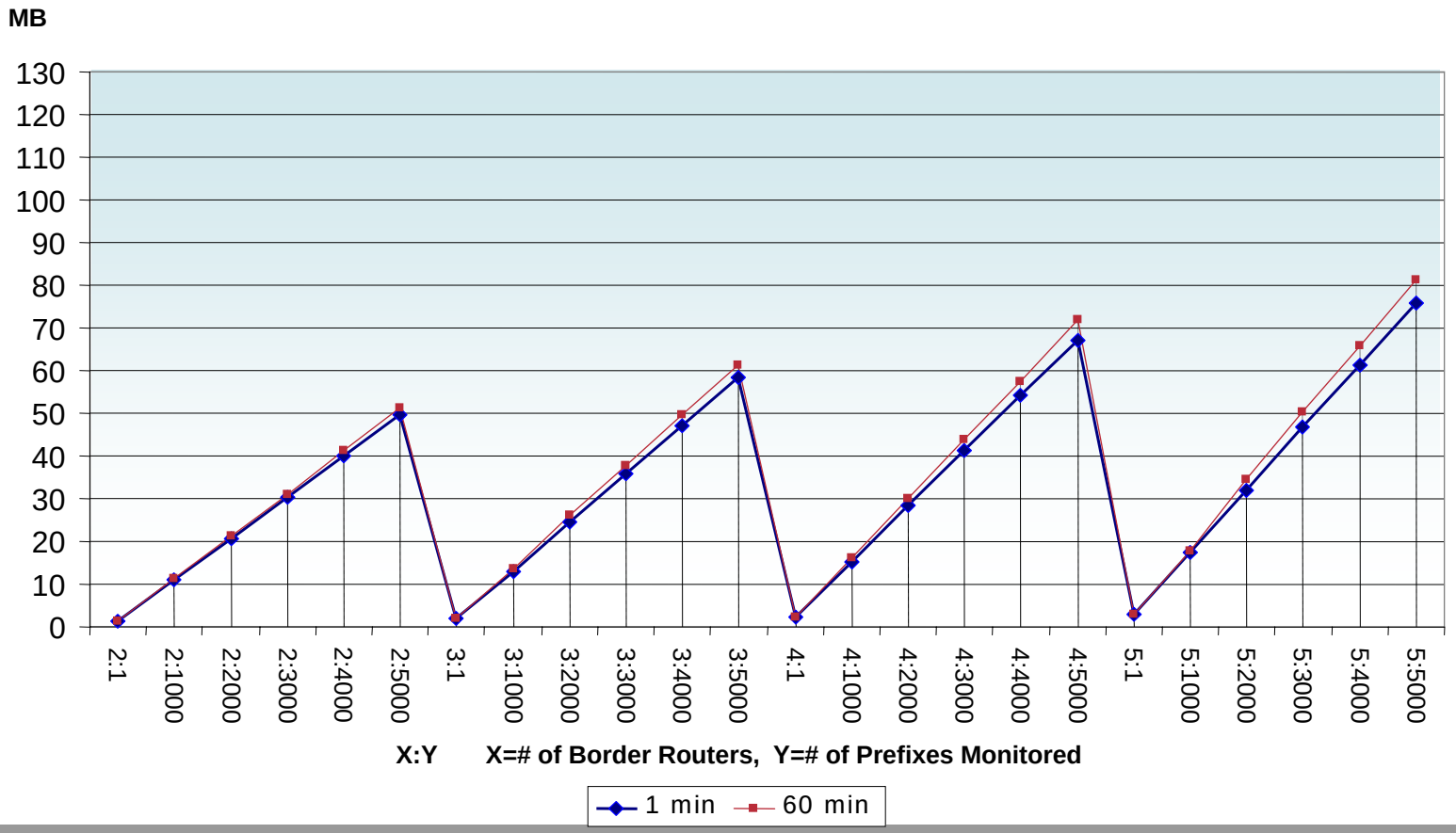
OER CPU Test Summary

	MC Average CPU	MC High CPU	BR Average CPU	BR High CPU
OER Process Learning Disabled	4.82%	20.51%	0.47%	2.17%
OER Process Learning Enabled	12.08%	20.15%	0.99%	2.15%
System Total Learning Enabled	6%	26%	2%	7%

Summary Points:

- MC High CPU peaks within first few minutes and afterwards is relatively low
- BR CPU is low across the board
- Determine number of BRs and prefixes in your network and then reference the previous graphs for CPU impact

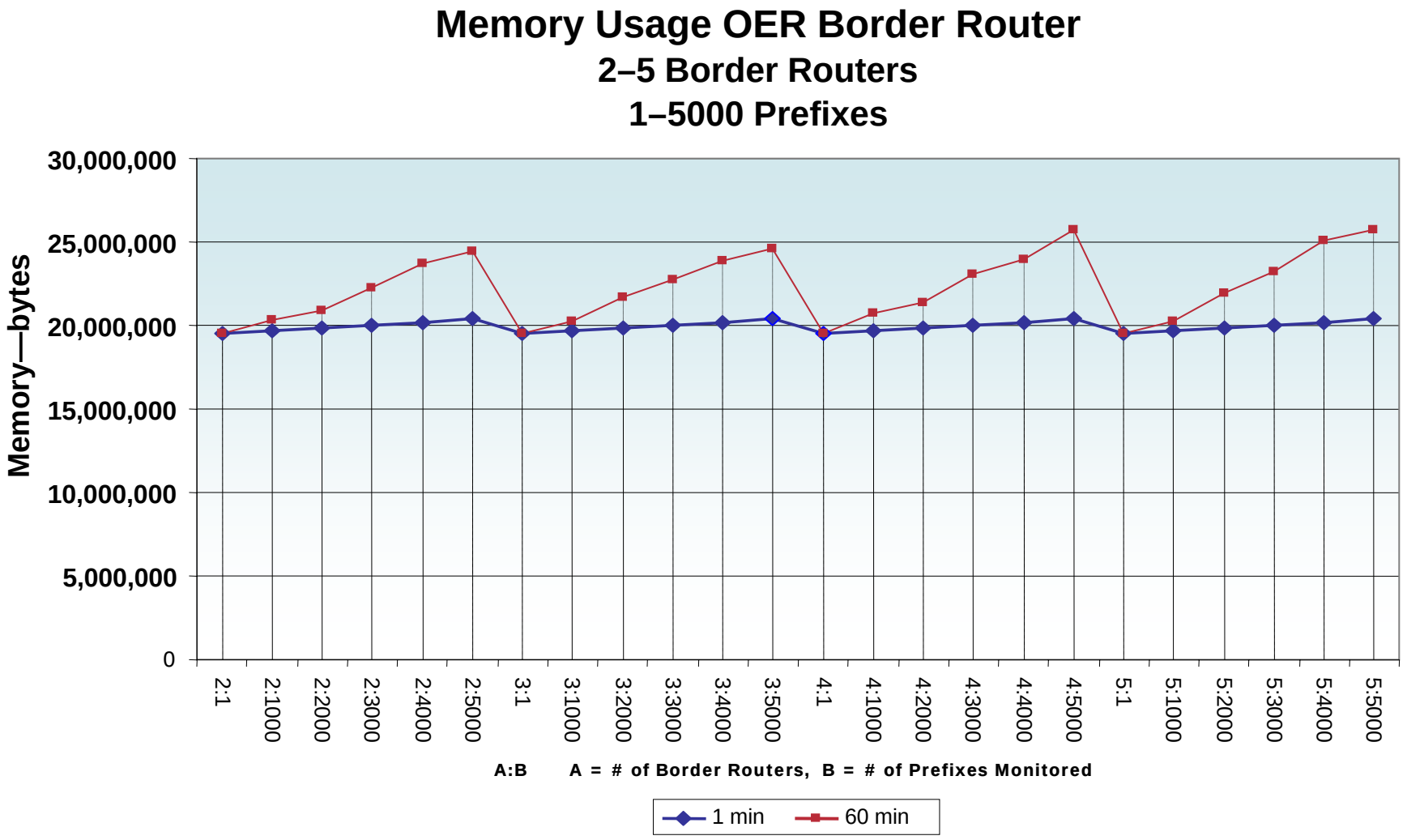
Master Controller Memory Usage



OER Scalability Memory Usage Summary

- **MC total memory usage:**
  - **Low 1.3 MB (2 BRs with 1 prefix)**
  - **High 124.9 MB (10 BRs with 5,000 prefixes)**
- **This is a dedicated MC**
- **Memory usage is influenced more by number of prefixes than BRs**

Border Router Memory Usage



Border Router Memory Usage Summary

- **BR total memory usage:**
  - **Low 19.5 MB (2 BRs with 1 prefix)**
  - **High 25.7 MB (10 BRs with 5,000 prefixes)**
- **Number of BRs has no influence on memory usage**
- **Number of prefixes slightly influences memory usage**

Co-Located MC and BR Memory Usage

- **MC and BR are running on the same router**
- **10 BRs, 5000 prefixes**
- **MC/BR Total Memory Usage:**

  High 152 MB

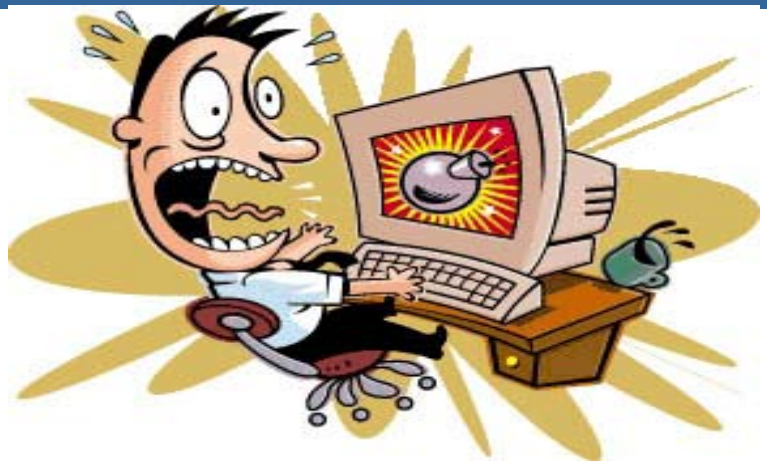
  Note1: stand-alone MC high 127 MB

  Note2: stand-alone BR high 25 MB
- **Therefore, use simple addition to determine the MC/BR co-located numbers**

Overall Performance Tests Summary

- **MC has more memory and CPU impact than BR**
- **Memory impact is more significant than CPU**
- **Overall performance test results have been very favorable!**

Deployment Suggestions



- **Measure performance impact on production BR during peak time (midday on a week day):**

  CPU: “show processes cpu”

  Memory: “show memory summary”

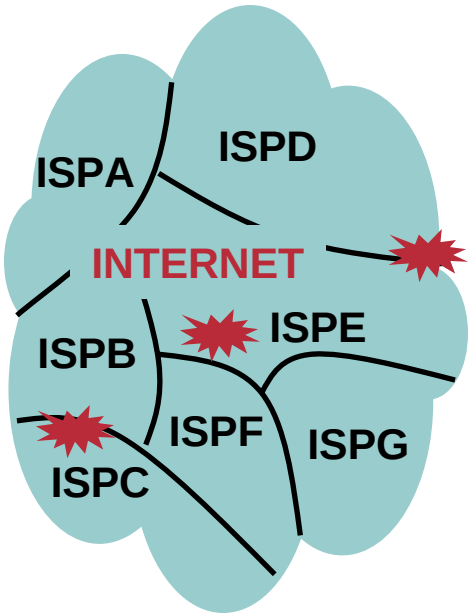
- **Determine viability of co-located MC/BR by a) referencing peak time data, and b) referencing graph test results from earlier**

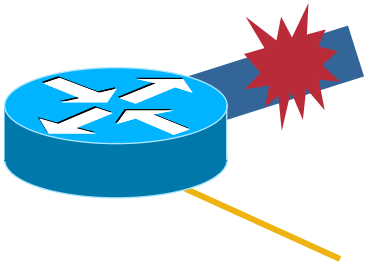
Agenda

- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Troubleshooting
- Conclusion
- Q & A

Conclusions

- **OER Choose Best Performing Path**
  - **Delay, MOS**
  - **Load Balancing**
  - **For prefix, traffic-class and application**
- **OER works around network issues**
  - **Blackouts**
  - **Brownouts**
- **OER Reports Issues**
  - **Syslog**
  - **`Show oer master prefix`**
  - **Troubleshoot issues during workaround instead of fire fighting**
- **$ Cost Management**
  - **OER saves $ on Tiered Pricing Links**





$$$$$$$

New Features
Not released

- **NBAR Aware – Dynamic Application Identification**
- **Fast Mode – Reroute within 3 seconds**
- **GUI – Easy Configuration & Detailed Reporting**

Agenda

- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Troubleshooting
- Conclusion
- Reference

Reference

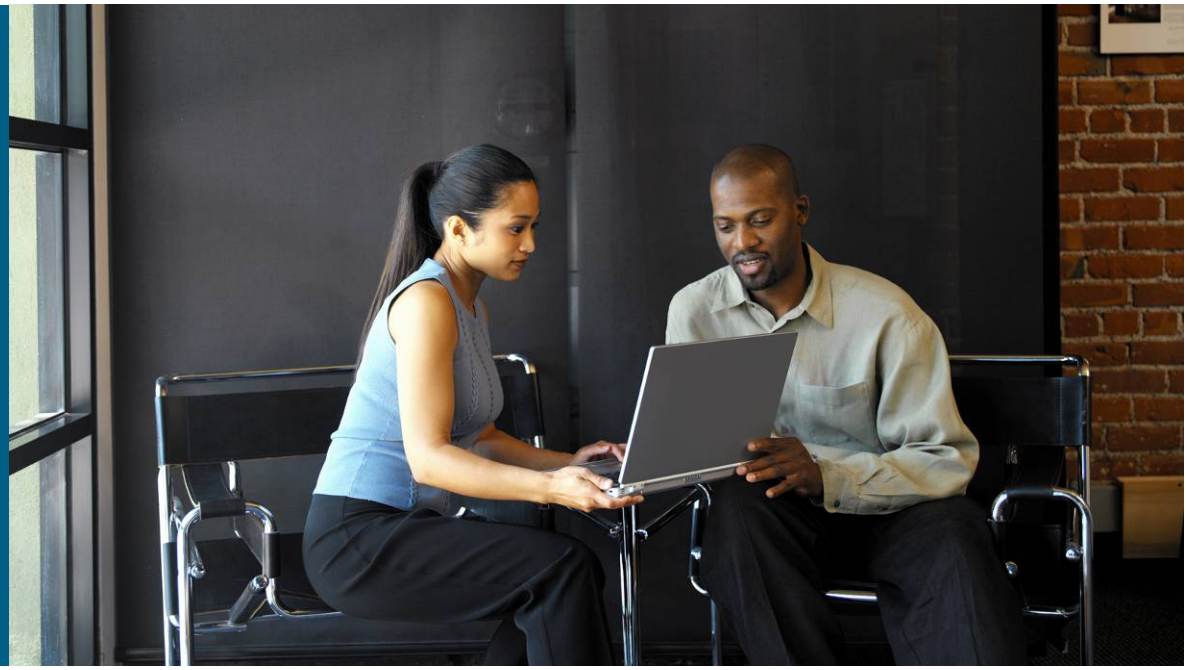
- **OER CCO**

  www.cisco.com/go/oer/

- **Cisco IOS® Software Release 12.3 12.4 12.4T**

  www.cisco.com/go/release124t/

Q and A

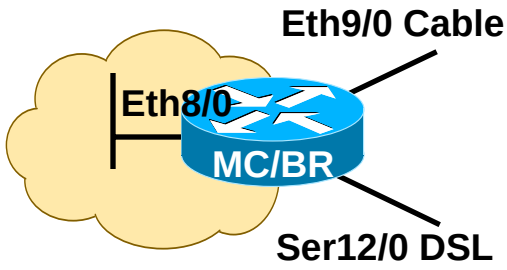


"That's a great question. Come to think of it, I'm not sure what is is I'm trying to sell you."


CISCO

Troubleshooting

1. Verify Master to Border Connection
2. Verify Master Operational
3. Verify Internal/External Interfaces Operational
4. Verify Prefix Learning
5. Verify Prefix Monitoring
6. Verify Prefix Control
7. Investigate Prefix History
8. Verify Traffic class Learning
9. Verify Traffic class Monitoring
10. Verify Traffic class Control

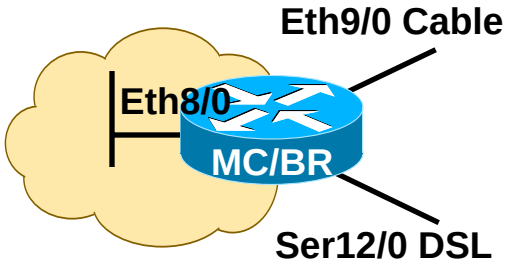


BR—Border Router, MC—Master Controller

Verify Master to Border Connection

```
sh oer master border
Border               Status    UP/DOWN              AuthFail
10.10.10.1           INACTIVE  DOWN                        0
```

- Key chain not configured or misconfigured
- OER Border `local interface` IP address and Master IP address mismatch
- OER Border `master` IP address not reachable or not Master



BR—Border Router, MC—Master Controller

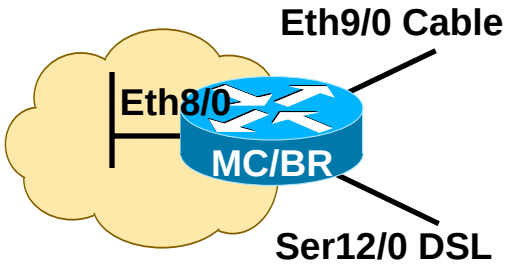
Verify Master Operational

- **At least 1 internal, and 2 external must be UP**

```
sh oer master border
Border               Status   UP/DOWN              AuthFail
10.10.10.1           INACTIVE UP       00:00:28           0

sh oer master border detail | i Down
 Se12/0              EXTERNAL Admin Down
 Se12/0                   1544          300          0        0 Admin Down
```

- **No shutdown Serial 12/0**

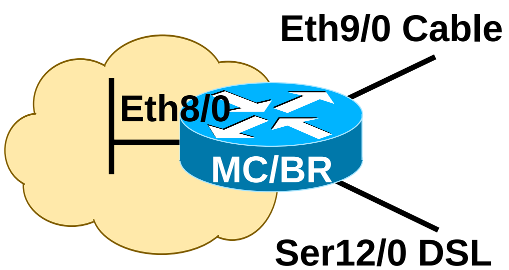
```
sh oer master border
Border               Status   UP/DOWN              AuthFail
10.10.10.1           ACTIVE   UP       00:17:06           0

sh oer master | i OER state
OER state: ENABLED and INACTIVE
```



BR—Border Router, MC—Master Controller

Verify Internal and External Interfaces Operational

```
sh oer master border detail

Border          Status    UP/DOWN               AuthFail
10.10.10.1      ACTIVE    UP       00:10:32           0
 Se12/0         EXTERNAL  UP
 Et9/0          EXTERNAL  UP
 Et8/0          INTERNAL  UP
```




```
 External         Capacity     Max BW   BW Used    Load Status          Exit Id
 Interface         (kbps)      (kbps)    (kbps)    (%)
 ---------        --------     ------   ------- ------- ------          ------
 Se12/0               1544        300       120       7 UP                   4
                                  300        78       3
 Et9/0               10000       1000       338       3 UP                   2
                                 1000       150       1
```

Egress

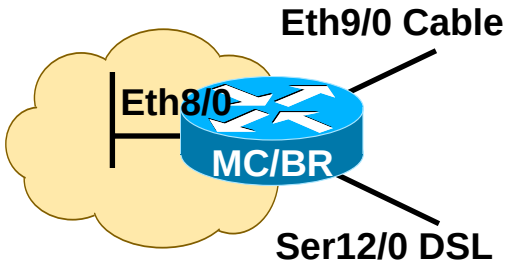
Egress

BR—Border Router, MC—Master Controller

Verify Prefix Learning

- **Learning Running on MC**

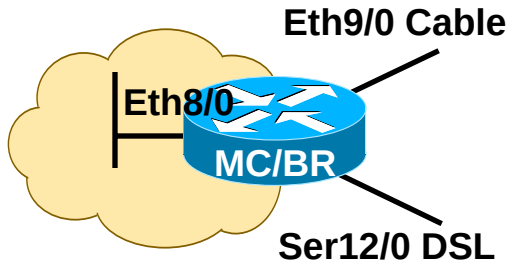
```
sh oer master | b Learn
Learn Settings:
  current state : STARTED
  time remaining in current state : 93 seconds
```



BR—Border Router, MC—Master Controller

Verify Prefix Learning…

- **Learning Running on BR**

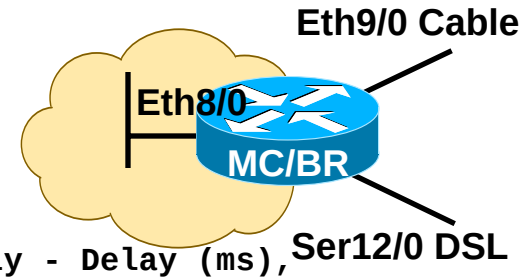



```
sh oer border pass cache learn
 OER Learn Cache:
    State is enabled
    Measurement type: throughput and delay, Duration: 1 min
    Aggregation type: prefix-length, Prefix length: 24
    4096 oer-flows per chunk,
    12 chunks allocated, 32 max chunks,
    1 allocated records, 49151 free records, 5767680 bytes allocated

Prefix          Mask      Pkts  B/Pk  Delay Samples   Active
Host1           Host2           Host3           Host4           Host5
dport1          dport2          dport3          dport4          dport5
100.1.1.0        /24     6870   743     20       1      11.4
100.1.1.1       0.0.0.0         0.0.0.0         0.0.0.0         0.0.0.0
80               0                0                0               0
```

BR—Border Router, MC—Master Controller

Verify Prefix Learning …

- **Learned Prefixes in MC**

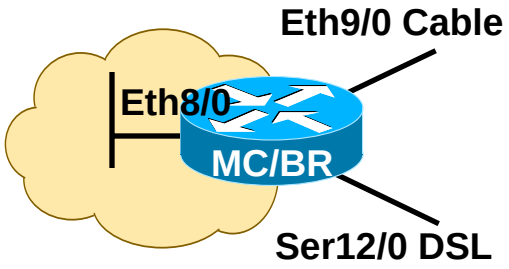



```
sh oer master prefix learned
OER Prefix Statistics:
 Pas - Passive, Act - Active, S - Short term, L - Long term, Dly - Delay (ms),
 Los - Packet Loss (packets-per-million), Un - Unreachable (flows-per-million),
 E - Egress, I - Ingress, Bw - Bandwidth (kbps), N - Not applicable
 U - unknown, * - uncontrolled, + - control more specific, @ - active probe all

Prefix                  State     Time Curr BR         CurrI/F         Protocol
                      PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos
                      ActSDly  ActLDly   ActSUn   ActLUn      EBw      IBw
--------------------------------------------------------------------------------
100.0.0.0/24        INPOLICY*        0 10.10.10.1      Et9/0           STATIC
                            U        U        0        0        0        0
                           12       12        0        0        1        0
100.1.1.0/24         HOLDDOWN       42 10.10.10.1      Et9/0           STATIC
                           16       16        0        0        0        0
                            U        U        0        0       55        2

100.1.2.0/24         DEFAULT*      105 U                U
```

BR—Border Router, MC—Master Controller

Verify Prefix Monitoring

- **Prefix passive monitoring on BR**

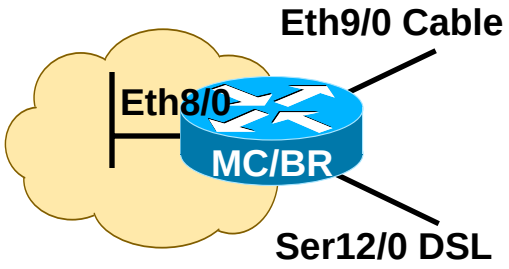



```
show oer border passive cache prefix
OER Passive Prefix Cache, State: enabled, 278544 bytes
  4 active, 4092 inactive, 41800 added
  2659290 ager polls, 0 flow alloc failures
  Active flows timeout in 1 minutes
  Inactive flows timeout in 15 seconds
IP Sub Flow Cache, 25800 bytes
  12 active, 1012 inactive, 125400 added, 41800 added to flow
  0 alloc failures, 0 force free
  1 chunk, 3 chunks added

Prefix              NextHop         Src If          Dst If          Flows
                      Pkts   B/Pk  Active   sDly   #Dly  PktLos  #UnRch
-----------------------------------------------------------------------
100.1.2.0/24        101.1.4.2       Et1/2           Fa5/1             134
                      748     675   44.5       0      0       0        0
100.1.1.0/24        101.1.4.2       Et1/2           Fa5/1              42
                      160     436   33.1       0      0       0        0
100.1.0.0/24        101.1.4.2       Et1/2           Fa5/1             121
                      628     663   22.7       0      0       0        0
```

BR—Border Router, MC—Master Controller

Verify Prefix Control

- **Verify Prefix Control on BR**



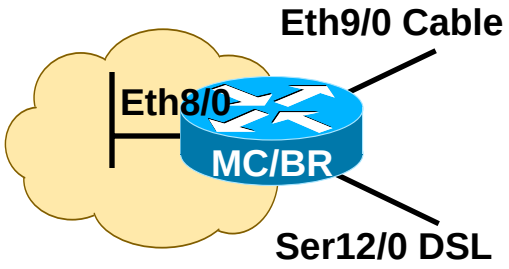
Static or bgp

```
show oer border routes bgp
BGP table version is 88, local router ID is 101.1.4.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
    internal,
              r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
OER Flags: C - Controlled, X - Excluded, E - Exact, N - Non-exact, I -
    Injected

   Network          Next Hop        OER    LocPrf Weight Path
*> 100.1.1.0/24     101.1.4.2       CE                0 300 50 ?
```

BR—Border Router, MC—Master Controller

Investigate Prefix History

- **Prefix Log**

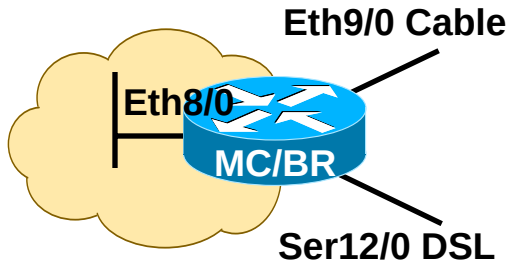



```
sh log | i 100.1.1.0

*Apr 26 22:58:20.919: %OER_MC-5-NOTICE: Discovered Exit for prefix
    100.1.1.0/24, BR 10.10.10.1, i/f Et9/0

*Apr 26 23:03:14.987: %OER_MC-5-NOTICE: Route changed 100.1.1.0/24, BR
    10.10.10.1, i/f Se12/0, Reason Delay, OOP Reason Timer Expired

*Apr 26 23:09:18.911: %OER_MC-5-NOTICE: Passive REL Loss OOP
    100.1.1.0/24, loss 133, BR 10.10.10.1, i/f Se12/0, relative loss
    23, prev BR Unknown i/f Unknown

*Apr 26 23:10:51.123: %OER_MC-5-NOTICE: Route changed 100.1.1.0/24, BR
    10.10.10.1, i/f Et9/0, Reason Delay, OOP Reason Loss

*Apr 26 23:19:18.919: %OER_MC-5-NOTICE: Passive REL Loss OOP
    100.1.1.0/24, loss 138, BR 10.10.10.1, i/f Et9/0, relative loss
    66, prev BR Unknown i/f Unknown
```

BR—Border Router, MC—Master Controller

Investigate Prefix History

- **Detailed Prefix History**



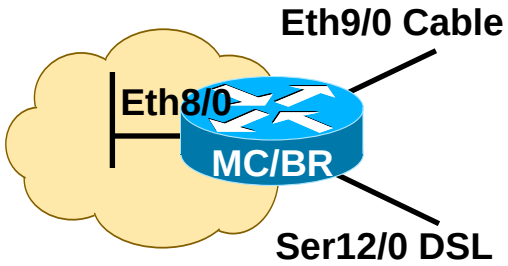

```
sh oer master prefix 100.1.1.0/24 detail
Prefix: 100.1.1.0/24
   State: INPOLICY    Time Remaining: 0
   Policy: Default

   Most recent data per exit
   Border          Interface          PasSDly  PasLDly  ActSDly  ActLDly
  *10.10.10.1      Et9/0                    0       16       35       35
   10.10.10.1      Se12/0                   0        0       38       38

   Latest Active Stats on Current Exit:
   Type     Target          TPort Attem Comps     DSum      Min      Max      Dly
   echo     100.1.1.1           N     2     2       88       40       48       44
```

BR—Border Router, MC—Master Controller

Verify Traffic Class Learning

- **Learning Running on MC**

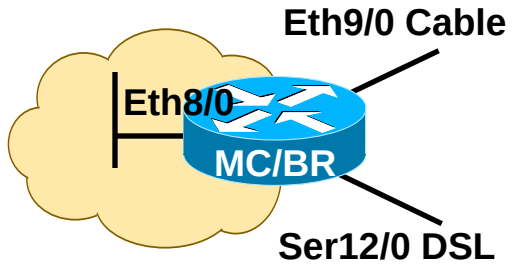
```
sh oer master | b Learn
Learn Settings:
  current state : STARTED
  time remaining in current state : 93 seconds
aggregation-type prefix-length 22
```



BR—Border Router, MC—Master Controller

Verify Traffic Class Learning

- **Learning running on BR (configuration)**

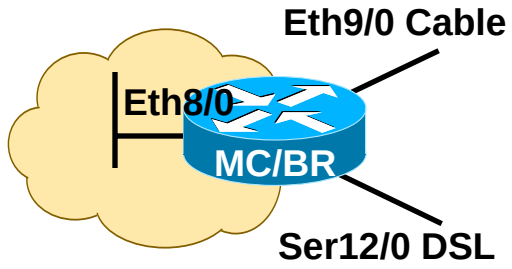



```
sh oer border pass learn appl
 OER Border Learn Configuration :
    State is enabled
    Measurement type: throughput, Duration: 1 min
    Aggregation type: prefix-length, Prefix length: 22
    No port protocol config

 Traffic Class Filter List:
   List: SrcPrefix       SrcMask DstPrefix       DstMask
         Prot  DSCP  sport_opr sport_range    dport_opr dport_range     Grant
      1: 0.0.0.0          0       100.0.0.0       8
         256   defa  0         [1, 65535]      0         [1, 65535]      Permit
      2: 0.0.0.0          0       0.0.0.0         0
         256   defa  0         [1, 65535]      0         [1, 65535]      Deny

 Keys:  protocol dport
```

BR—Border Router, MC—Master Controller

Verify Traffic Class Learning

- **Learning running on BR**

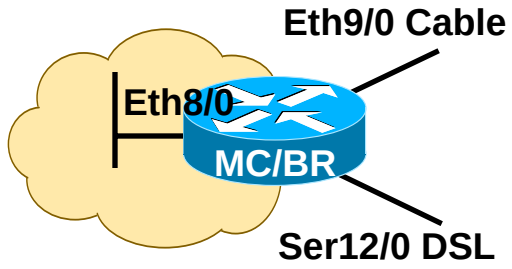



```
sh oer border pass cache learn appl
 OER Learn Cache:
    State is enabled
    …

Prefix          Mask      Pkts  B/Pk  Delay Samples   Active
Prot  Dscp  SrcPort           DstPort         Appl ID
Host1           Host2           Host3           Host4           Host5
dport1          dport2          dport3          dport4          dport5
---------------------------------------------------------------------
100.1.1.0        /24       30     53       0       0       17.7
256   defa [1, 65535]        [23, 23]
100.1.1.2       0.0.0.0         0.0.0.0         0.0.0.0         0.0.0.0
1001             0                0               0               0
---------------------------------------------------------------------
100.1.0.0        /22      599    696       0       0       21.7
256   defa [1, 65535]        [21, 21]
100.1.3.2       100.1.2.2       100.1.0.2       0.0.0.0         0.0.0.0
3007             2009             10              0               0
```

BR—Border Router, MC—Master Controller

Verify Traffic Class Learning …

- **Learned Traffic Class in MC**

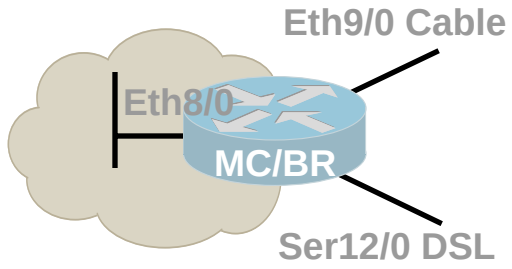



```
MC#show oer mas appl learned
OER Prefix Statistics:
 …

Prefix                Prot Port [src][dst]/ApplId        DSCP Source Prefix
                         State     Time Curr BR          CurrI/F          Protocol
                       PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos
                       ActSDly  ActLDly   ActSUn   ActLUn      EBw      IBw
                       ActSJit  ActPMOS
------------------------------------------------------------------------------
100.1.0.0/22          256 [1, 65535] [23, 23]           defa 0.0.0.0/0
                      INPOLICY      @31 101.1.1.4       Et9/0            PBR
                            12       12        0       0        0        0
                           105       76        0       0       62        1
                             N        N
100.1.1.0/24          256 [1, 65535] [21, 21]           defa 0.0.0.0/0
                      OOPOLICY      @23 101.1.1.4       Et9/0            PBR
                            14       14        0       0        0        0
                           169      142        0       0       61        1
                             N        N
```

BR—Border Router, MC—Master Controller

Verify Traffic Class Monitoring

- **Passive monitoring on BR**

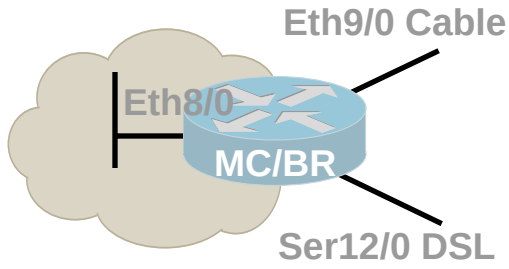



```
show oer border passive cache appl

OER Passive Prefix Cache, State: enabled, 278544 bytes
  …

Prefix              NextHop         Src If          Dst If          Flows
 Prot  DSCP SrcPort          DstPort           Appl_ID
                      Pkts    B/Pk  Active    sDly    #Dly  PktLos  #UnRch
-------------------------------------------------------------------------
100.1.0.0/24        101.1.4.2       Et8/0           Et9/0               9
256    defa [1, 65535]      [23, 23]       9
                       72     669    19.7       0       0       0       0
100.1.0.0/22        101.1.4.2       Et8/0           Et9/0              15
256    defa [1, 65535]      [21, 21]      10
                      113     124    20.7       0       0       0       0
```

BR—Border Router, MC—Master Controller

Verify Traffic Class Control

- **Traffic Class control on MC**

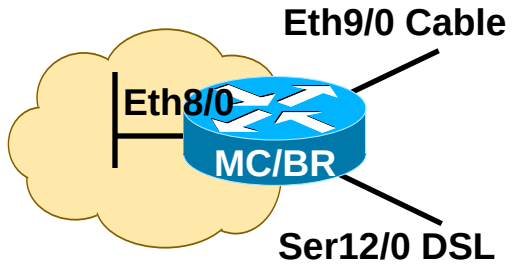



```
show oer master appl
OER Prefix Statistics:
 …

Prefix                  Prot Port [src][dst]              DSCP Source Prefix
                           State     Time Curr BR         CurrI/F          Proto
                         PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos
                         ActSDly  ActLDly   ActSUn   ActLUn      EBw      IBw
                         ActSJit  ActPMOS
-------------------------------------------------------------------------------
100.1.0.0/22             256 [1, 65535] [23, 23]          defa 0.0.0.0/0
                         INPOLICY       0 2.2.2.2         Et9/0            PBR
                                N       N        N        N        N        N
                                2       2        0        0        N        N
                                N       N
```

BR—Border Router, MC—Master Controller

Verify Traffic Class Controlled

- **Traffic class control on BR**




```
show ip access-list dynamic
Extended IP access list oer#1
    536870911 permit tcp any 100.1.0.0 0.0.255.255 eq telnet

show route-map dynamic
route-map OER-02/21/06-04:27:44.419-1-OER, permit, sequence 0, identifier 1706070788
  Match clauses:
    ip address (access-lists): oer#1
  Set clauses:
    interface Ethernet9/0
    ip next-hop 40.40.40.2
  Policy routing matches: 0 packets, 0 bytes
 Current active dynamic routemaps = 1
```

External Interface

BR—Border Router, MC—Master Controller

Why Is Prefix Always in Default State ?

Active Probes Are Not Responding

- **Verify Active Probes Enabled**

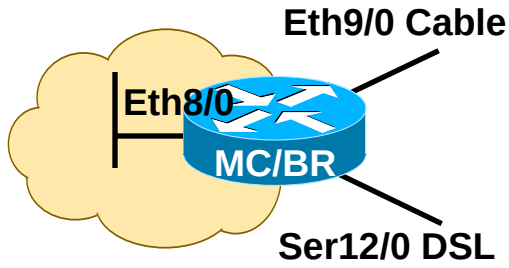
```
sh oer master | i mode monitor
  mode monitor both
```

Should Be Both or Active

- **`clear oer master prefix 100.1.1.0/24`**

  This will remove learned prefixes

- **Wait for probe all to complete**
- **Verify active probes responding**




```
sh oer master prefix 100.1.1.0/24 detail
Prefix: 100.1.1.0/24
   State: DEFAULT*   Time Remaining: @65
   Policy: Default

   Most recent data per exit
   Border          Interface         PasSDly  PasLDly  ActSDly  ActLDly
  *10.10.10.1      Et9/0                   0        0        0        0
   10.10.10.1      Se12/0                  0        0        0        0
```

@ Indicates Probe All

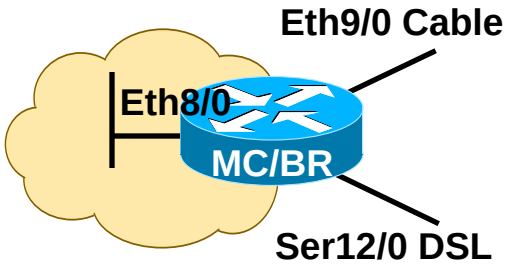
No Probes Responding

Why Are Active Probes Not Responding?

- **Is Prefix Configured?**
  - Probes must be configured for configured prefixes
  - Probe assigned to prefix with longest match of probe target

```
oer master
        active-probe echo 100.1.1.9
sh oer master active-probes
State      Prefix            Type     Target          TPort   How     Codec
Assigned   100.1.1.0/24      echo     100.1.1.9           N  Cfgd         N
```

- **No Parent Route for Prefix**
  - BGP or static tables must include a route which includes prefix
- **Target is Turned Off, Disabled**
- **Target does not respond to echo probes**
  - Try configuring `tcp-conn` or `udp-echo` probes
- **Firewall is blocking probes**
  - Try traceroute to determine block point
  - `show oer master prefix 100.1.1.0/24 traceroute now`



Why No Passive Measurements ?

- **No Traffic**

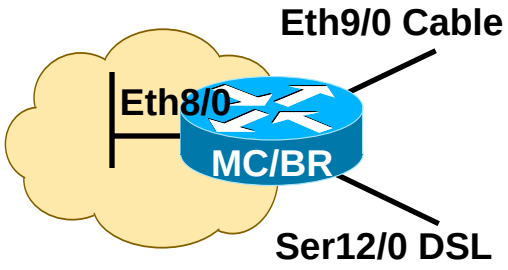
  Check EBw in show oer master prefix

- **No TCP traffic**

  Passive Delay, Loss, and Reachability rely on TCP traffic

- **Long lived TCP flows**

  Passive Delay and Reachability rely on TCP SYN, TCP ACK



Agenda

- Challenge
- Solution
- OER Overview
- Product Overview
- Deployment
- Troubleshooting
- Performance
- Command Reference*
- Conclusion
- Q & A

Advanced Master Controller Configuration

```
MC(config-oer-mc)#?
OER master controller configuration commands:
  active-probe          Manually create an active probe for a known target
  backoff               Specify backoff timer parameters
  border                Enter OER managed border router configuration submode
  default               Set a command to its defaults
  delay                 Specify delay parameters
  exit                  Exit from OER master controller configuration submode
  holddown              Specify hold-down timer parameter
  keepalive             Specify keepalive interval
  learn                 Enter Top Talker and Delay learning submode
  logging               Event Logging
  loss                  Specify loss parameters
  max-range-utilization  Configure the maximum range for utilization of all exits
  mode                  Specify OER operating mode settings
  no                    Negate a command or set its defaults
  periodic              Specify periodic rotation timer value
  resolve               Specify OER policy resolver settings
  shutdown              Disable OER master controller functionality
  unreachable           Specify unreachable parameters
```

Active Probe Configuration
Master Submode

active-probe {echo ip-address **| tcp-conn** ip-address **target-port** number **| udp-echo** ip-address **target-port** number | **jitter** ip-address **target-port** number **codec** {g729a | g711ulaw | g711alaw } **}**

- **Configure ICMP, UDP, TCP, or jitter Probes**
- ip-address

  IP address of host to probe
- number

  Port number for UDP or TCP probes
- codec

  Encoding used on packet to simulate voice traffic for jitter probes.
- **udp-echo and jitter requires IOS rtr responder on target**
- **Probes sent ~1 per minute by default**
- **Up to 5 probes per prefix**
- **Probes assigned according to longest match**

Active Probe Configuration
oer-map Submode

Set active-probe {echo ip-address **| tcp-conn** ip-address **target-port** number **| udp-echo** ip-address **target-port** number | **jitter** ip-address **target-port** number **codec** {g729a | g711ulaw | g711alaw } **}**

- **Configure ICMP, UDP, TCP, or jitter Probes**
- ip-address

  IP address of host to probe
- number

  Port number for UDP or TCP probes
- codec

  Encoding used on packet to simulate voice traffic for jitter probes.
- **udp-echo and jitter requires IOS rtr responder on target**
- **Probes sent ~1 per minute by default**
- **Up to 5 probes per prefix**
- **Probes assigned prefix/traffic-class using this policy**

Backoff Timer Configuration
Master Submode, oer-map

backoff min-timer max-timer **[**step-timer**]**

- **Time to wait after failing to find good or best exit**
- min-timer **is starting value**
- max-timer **is maximum value**
- **Increase Backoff by** step-timer **if no best exit**
- **If good or best exit found, reset to** min-timer

Border Configuration
Master Submode

border ip-address **[key-chain** key-name**]**

- **Identify an OER border router and enter border configuration mode**
- **key-chain**

  Required only on initial configuration
- ip-address **must be reachable from Master Controller**
- **Border submode configuration options**

```
MC(config-oer-mc)#border 2.2.2.3
MC(config-oer-mc-br)#?
OER managed border router configuration commands:
  default    Set a command to its defaults
  exit       Exit from OER managed border router configuration submode
  interface  Specify an OER managed border router interface
  no         Negate a command or set its defaults
```

Interface Config
Master-Border Submode

interface type number **external | internal**

- **Identify interesting interfaces on the Border Router**
- **external**

  Interface connects outside Area
- **internal**

  Interface connects inside Area
- **Passive measurements on flows to/from internal/external**
- **Other interfaces ignored**
- **external enters external interface submode**

```
MC(config-oer-mc-br-if)#?
OER Interface/Exit subcommands:
 max-xmit-utilization  Specify the threshold utilization for an external
                       interface
 no                    Negate or set default values of a command
```

Maximum Transmit Utilization Policy
Master-Border-Interface-External Submode

max-xmit-utilization absolute kbps **| percentage** value

- **Highest In-Policy transmit throughput**
- **5 minute output rate > absolute** kbps **, exit is OOP**
- **Tx Load > percentage** value**, exit is OOP**
- **Move prefixes away from exit to achieve In-Policy**

Holddown Timer Configuration
Master Submode, oer-map

holddown timer

- **Minimum time between exit changes**
- **Enforces route dampening**
- **If prefix unreachable, holddown is ignored**

Keepalive Timer Configuration
Master Submode

keepalive timer

- **Time between sending keepalives**
- **No keepalive config required on Border**
- **Keepalives sent from Master Controller and Border Router**
- **no keepalive disables keepalives**
- **If no keepalive received for 3 *** timer **seconds, teardown the Master to Border communications**
- **Default keepalive enabled with 5 seconds.**

Learn Configuration
Master Submode

learn

- **Learn prefixes**
  - **Enter learn configuration submode**
- **OER learns prefixes based on:**
  - **Highest Throughput**
  - **Longest Delay**
- **learn configuration submode commands**

```
MC(config-oer-mc-learn)#?
OER Top Talker and Delay learning subcommands:
 aggregation-type   Type of prefix to aggregate
 delay              Learn top prefixes based on delay
 exit               Exit from Top Talker configuration submode
 monitor-period     Period to monitor prefix for learning
 no                 Negate or set default values of a command
 periodic-interval  Interval before learning restarts
 prefixes           Number of prefixes to learn
 protocol           Learn top prefixes based on protocol
 throughput         Learn top prefixes based on throughput
```

Learned Prefix Boundaries
Master-Learn Submode

aggregation-type bgp | non-bgp | prefix-length prefix-length

- **Identify aggregation boundaries**
- **All flows monitored**
- **Learn prefixes according to prefix-length**
  - **Flows aggregated into prefixes of length 1 to 32**
  - **If routing table has more specific match, aggregate to it.**
- **Learn prefixes according to bgp routes**
- **Learn prefixes according to non-bgp routes**
- **Default is prefix-length 24**

Learn Prefixes by Delay
Master-Learn Submode

delay

- **Learn N longest delay prefixes**
  - **N specified by prefixes in learn submode**
- **Both ingress and egress flows are aggregated**
- **Delay is determined by TCP SYN to TCP ACK delay**
- **Enables netflow on border routers**

How Long to Learn?
Master-Learn Submode

monitor-period minutes

- **Specify the prefix learning interval**
- **Aggregate all flows for** minutes **on border router**
- **At the end, report top prefixes to master controller**
- **Default is 5 minutes**

How Often to Learn?
Master-Learn Submode

periodic-interval minutes

- **Specify the interval between learning periods**
- **No prefixes are learned during this time**
- **At the end, monitoring period begins**
- **Default is 120 minutes**

How Many Prefixes to Learn?
Master-Learn Submode

prefixes number

- **Specify how many prefixes to learn**
- **Each Border router reports** number **prefixes**
- **Master Controller receives N reports**

  N is number of Border Routers
- **Master Controller sorts (N *** number**) >>** number
- **Delay and throughput reported seperately**
- **Default is 100 prefixes**

Learn Prefixes by Throughput
Master-Learn Submode

throughput

- **Learn N highest throughput prefixes**
  - **N specified by prefixes in learn submode**
- **Only egress flows are aggregated**
- **Throughput is # of bytes transmitted during monitor-period**
- **Enables NetFlow on border routers**

Learn Traffic Class by Throughput
Master-Learn Submode

Traffic-class keys [protocol [sport] [dport]]

- **Aggregates traffic using above keys and prefix**
- **Learned Prefix and learned Traffic class are ranked together and top n are selected.**
- **Max limit applies to learned prefix and learned traffic class combined.**

Traffic-class filter access-list ACL

- **Filter allows to exclude undesired traffic based on dscp, protocol or port.**
- **Uses standard access-list configuration**

Learn Application by Throughput
Master-Learn Submode

List <seq> refname <name>

throughput

traffic-class application <name> [filter <prefix-list>]

- **Aggregates using application id and prefix**
- **Learned Prefix, Traffic class and Application are ranked together and top n are selected.**
- **Max limit applies to combined count.**
- **Filter allows to exclude undesired traffic based on prefix**

Loss Policy Configuration
Master Submode, oer-map

loss relative average **| threshold** maximum

- **Configure absolute or relative loss policy**
- **Track TCP Sequence number**
- **absolute**

  short term > maximum packets-per-million, prefix is OOP
- **Relative**

  ((short term / long term) - 1) * 100) > average , prefix is OOP
- **Short term is 5 minute average loss in packets-per-million**
- **Long term is 60 minute average loss in packets-per-million**
- **No active loss measurement**
- **Default is loss relative 10**

Load Distribution Policy
Master Submode, oer-map

max-range-utilization maximum

- **Configure maximum range of transmit utilization**
- **(max-util - min-util) >** maximum**, max-exit is OOP**
- **max-util is % utilization of highest utilized exit (max-exit)**
- **min-util is % utilization of lowest utilized exit**
- **Supports exits with different bandwidths**
  - **Comparing % utilization not actual throughput**

Configure OER Modes of Operation
Master Submode, oer-map

mode monitor {active | both | passive}

- **How to monitor a prefix?**
- **both**
  - **Passively monitor current exit**
  - **When needed, actively probe all exits**
  - **Default value**
- **active**
  - **Actively probe current exit**
  - **When needed, actively probe all exits**
  - **No passive monitoring (no NetFlow)**

Configure OER Modes of Operation
Master Submode, oer-map

mode monitor {active | both | passive}

- **passive**

  Passively monitor current exit

  When needed, passively monitor all exits by changing route through all exits

  No active probing (no SAA)

Configure OER Modes of Operation (Cont.)
Master Submode, oer-map

mode route {observe | control | metric {bgp local-pref preference **| static tag** value**}}**

- **Control a prefix exit? How?**
- **observe**
  - **Choose exit according to select-exit mode**
  - **Don't change any routing**
  - **Default value**
- **control**
  - **Choose exit according to select-exit mode**
  - **Change route if better exit found**
  - **Try BGP first, then static route**

Configure OER Modes of Operation (Cont.)
Master Submode, oer-map

mode route {observe | control | metric {bgp local-pref preference **| static tag** value**}}**

- preference

  Local pref value when controlling using BGP

  Default is 5000

- value

  Associates route-map with static route using match tag value

  Default is 5000

Configure OER Modes of Operation (Cont.)
Master Submode, oer-map

mode select-exit {best | good}

- **Exit selection method**
- **best**
  - **Choose the best performing exit of all exits**
  - **Prefix may not be In-Policy on the exit**
- **good**
  - **Choose first exit which is In-Policy**
  - **May not be the best exit**
  - **No In-Policy exit found? Don't control the Prefix**
- **resolve identifies priority of exit selection criteria**

Periodic Timer Configuration
Master Submode, oer-map

periodic timer

- **Check for best exit every** timer **seconds**
- **Typically OOP event or backoff expiration initiates best exit selection**
- **Periodic timer forces best exit selection**
- **mode select-exit good**

  Is prefix is In-Policy ? Do nothing
- **mode select-exit best**

  Search for best exit

Probe Frequency Configuration
oer-map Submode

set **frequency** seconds

- **Allowed under specific policy (oer-map) only.**
- seconds **is time interval in seconds between two consecutive probes.**
- **Probe frequency is applied to all the prefix/traffic-class using this policy.**

TCP Port Configuration
Master Submode

port port-number

- **Configure on master controller and border router**
- port-number **is a TCP port number**
- **Used for Master to Border communication**
- **Make sure** port-number **is not used by other applications**

Identify Policy Priorities
Master Submode, oer-map

resolve {delay priority value **variance** percentage **| loss priority** value **variance** percentage **| jitter priority** value **| mos priority** value **| range priority** value **| utilization priority** value **variance** percentage**}**

- **Examine policies starting with highest priority**
  - **If single exit identified, then use it**
  - **If multiple exits, go to next lower priority**
  - **If multiple exits after all, randomly choose one**
    - **Favor the current exit**
- **priority 1 is highest configurable priority**
- **Unreachable is highest priority**
  - **priority 0, not configurable**

Identify Policy Priorities
Master Submode, oer-map

resolve {delay priority value **variance** percentage **| loss priority** value **variance** percentage **| jitter priority** value **| mos priority** value **| range priority** value **| utilization priority** value **variance** percentage**}**

- **variance** percentage **identifies range of equivalency**

  Exits within the range are treated equivalently

- **Delay range = [lowest delay, (lowest delay * (1 +** percentage**/100))]**
- **Loss range = [lowest loss, (lowest loss * (1 +** percentage **/100))]**
- **Utilization range = [lowest utilization, (lowest utilization * (1 +** percentage**/100)]**

Shutdown OER Operation
Master Submode, Border submode

shutdown

- **Stop OER operation**
- **Free CPU and dynamic memory resources**
- **Configuration unchanged**
- **Support on master controller and border router**

Unreachable Policy Configuration
Master Submode, oer-map

unreachable relative average **| threshold** maximum

- **Configure absolute or relative policy**
- **Absolute**

  short term > maximum flows-per-million, prefix is OOP
- **Relative**

  ((short term / long term) - 1) * 100) > average , prefix is OOP
- **Short term is 5 minute avg of unreachable flows-per-million**
- **Long term is 60 minute avg of unreachable flows-per-million**
- **All exits In-Policy are considered for best exit**
- **Default is unreachable relative 50**

MOS Policy Configuration
Master Submode, oer-map

Mos percentage percent **threshold** minimum

- **MOS values cannot be averaged.**
- **Several MOS values are quantified into a single number as percentage of sample that are below minimum threshold.**

  MOS percentage 30 threshold 4.00

  ISP1 has 40 sample where MOS is below 4.00 out of 100 sample

  i.e. 40% > 30% - ISP1 is OOP with respect to MOS.

  ISP2 has 10 sample where MOS is below 4.00 out of 100 sample

  i.e. 10% < 30% - ISP2 is INPOLICY with respect to MOS.

Identify a Monitored Prefix
Global Configuration

oer-map MAP sequence-number

- **Prepare to identify specific Monitored Prefix**
- **Apply per-prefix policy**
- **Enter oer-map submode configuration**
- **oer-map configuration subcommands:**

```
default  Set a command to its defaults
exit     Exit from oer-map  configuration submode
match    Match values for OER policy
no       Negate a command or set its defaults
set      Set values for OER policy
```

- **Only one** map-name **is recognized in 12.3(8)T**

Identify a Monitored Prefix (Cont.)
oer-map Submode

match ip address prefix-list prefix-list-name

match oer learn delay | throughput

- **Identify a prefix for OER to Monitor**
- **Uses standard prefix-list configuration**
- **Single match statement per oer-map**
- **Multiple oer-maps for different policies for different prefixes**

```
ip prefix-list LIST2 seq 5 permit 100.1.0.0/16
ip prefix-list foo seq 5 permit 20.0.0.0/8
ip prefix-list foo seq 10 permit 22.1.0.0/16 le 32
ip prefix-list foo seq 15 deny 10.1.0.0/16
oer-map MAP 20
 match ip address prefix-list LIST2
 set delay threshold 100
oer-map MAP 30
 match ip address prefix-list foo
 set holddown 600
```

Prefix Specific Policy Configuration
oer-map Submode

```
MC(config-oer-map)#set ?
  backoff      Specify backoff timer parameters
  delay        Specify delay parameters
  holddown     Specify hold-down timer parameter
  loss         Specify loss parameters
  mode         Specify OER operating mode settings
  periodic     Specify periodic rotation timer value
  resolve      Specify OER policy resolver settings
  traceroute   Enable traceroute
  unreachable  Specify unreachable parameters
```

```
oer-map MAP 20
 match ip address prefix-list LIST2
 set delay threshold 100
oer-map MAP 30
 match ip address prefix-list foo
 set holddown 600
```

Identify an Application Traffic Class
oer-map Submode

match ip address access-list access-list-name

- **Identify an application traffic class for OER to Monitor**
- **Uses standard access-list configuration**
- **Single match statement per oer-map**
- **Multiple oer-maps for different policies for different application traffic class**

```
ip access-list extended APPL-LIST1
 permit udp any gt 999 100.1.0.0 0.0.255.255
 permit tcp any 100.1.0.0 0.0.255.255 eq telnet
ip access-list extended APPL-LIST2
 permit tcp any 100.1.1.0 0.0.0.255 eq 24
ip access-list extended APPL-LIST3
 permit tcp any eq telnet 100.1.0.0 0.0.255.255
```

```
oer-map MAP 10
 match ip address access-list APPL-LIST1
 set delay threshold 100
oer-map MAP 20
 match ip address access-list APPL-LIST2
set holddown 600
oer-map MAP 30
 match ip address access-list APPL-LIST3
set holddown 600
```


CISCO