



## ECMP Load Balancing

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Equal-cost multi-path routing (ECMP) is a routing strategy where next-hop packet forwarding to a single destination can occur over multiple "best paths" which tie for top place in routing metric calculations. Multipath routing can be used in conjunction with most routing protocols, since it is a per-hop decision that is limited to a single router. It potentially offers substantial increases in bandwidth by load-balancing traffic over multiple paths.

Various routing protocols, including Open Shortest Path First (OSPF), Intermediate System to Intermediate System (ISIS), Enhanced Interior Gateway Routing Protocol (EIGRP), and Border Gateway Protocol (BGP) allow ECMP routing.

Load balancing between ECMP paths is performed on IOS-XE based CEF object called loadbalance.

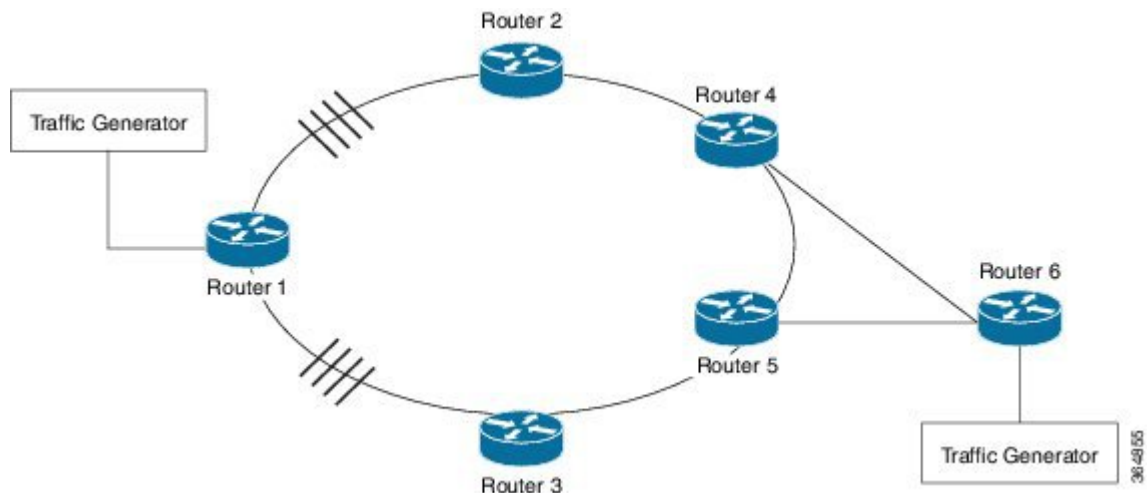
### ECMP Per-Flow Load Balancing

Load balancing is a forwarding mechanism that distributes traffic over multiple links based on certain parameters. ECMP Per-Flow Load Balancing distributes packets across multiple links based on Layer 3 routing information. If the router discovers multiple paths to a destination, the routing table is updated with multiple entries for that destination. Per-flow load balancing allows the router to use multiple paths to achieve load sharing across multiple source-destination host pairs. Packets for a given source-destination host pair are guaranteed to take the same path, even if multiple paths are available. Traffic streams destined for different pairs tend to take different paths.

### Benefits of Per-Flow Load Balancing

- Incoming data traffic is evenly distributed over multiple equal-cost connections.
- Incoming data traffic is evenly distributed over multiple equal-cost connections member links within a bundle interface.

Figure 1: ECMP Load Balancing with MPLS Enabled



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## Restrictions for ECMP Load Balancing

- Both 4 ECMP and 8 ECMP paths are supported.
- Load balancing is supported on global IPv4 and IPv6 traffic. For global IPv4 and IPv6 traffic, the traffic distribution can be equal among the available 8 links.
- Per packet load balancing is not supported.
- Label load balancing is supported.
- BGP multi-path is *not* supported with ECMP.
- BGP multi-path with PIC Edge is *not* supported
- When BGP PIC is configured, the L3VPN prefixes scale reduces by 1/4th of the supported value (Supported scale value/4), for better convergence value at the PIC core. For example, for RSP1A the supported L3VPN scale is 2000, if 4 ECMP path with PIC is enabled, then the maximum supported scale value is reduced to 5000 (20000/4).

## Configuring ECMP Load Balancing

Perform the following steps to configure ECMP load balancing.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>platform loadbalance max-paths 8</b> <b>Example:</b> Device(config)# platform loadbalance max-paths 8	Configures the loadbalance maximum paths. Select <b>Yes</b> to save the configuration and reload the router.  <b>Note</b> ISIS by default supports only 4 paths. To increase ISIS max-paths, use the command <b>config-maximum-paths 8</b> under router ISIS. IGP by default supports only 4 paths. To increase IGP max-paths, use the command <b>config-maximum-paths 8</b> under respective IGP (OSPF and ISIS) process.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config)#exit	Returns to privileged EXEC mode.

## Configuration Examples for ECMP Load Balancing

This section shows sample configurations for ECMP load balancing.

### Example: Configuring ECMP Load balancing

The following is a sample configuration for ECMP load balancing.

```
Router# show run-configuration | in platform loadbalance
platform loadbalance max-paths 8
```

```
Router# show ip cef 200.0.0.0 detail
200.0.0.0/24, epoch 2, per-destination sharing
  local label info: global/266
  nexthop 21.1.1.2 GigabitEthernet0/1/3 label 141
  nexthop 21.1.6.1 GigabitEthernet0/0/0 label 269
  nexthop 21.2.1.2 GigabitEthernet0/1/0 label 141
  nexthop 21.2.6.1 GigabitEthernet0/0/1 label 269
  nexthop 21.3.1.2 GigabitEthernet0/1/1 label 141
  nexthop 21.3.6.1 GigabitEthernet0/0/2 label 269
```

```

    nexthop 21.4.1.2 GigabitEthernet0/0/4 label 141
    nexthop 21.4.6.1 GigabitEthernet0/0/7 label 269
Router#

Router# show interface GigabitEthernet 0/1/3 | in output rate
  5 minute output rate 548000 bits/sec, 1009 packets/sec
Router# show interface GigabitEthernet 0/0/0 | in output rate
  5 minute output rate 547000 bits/sec, 1008 packets/sec
Router# show interface GigabitEthernet 0/1/0 | in output rate
  5 minute output rate 539000 bits/sec, 992 packets/sec
Router# show interface GigabitEthernet 0/0/1 | in output rate
  5 minute output rate 539000 bits/sec, 991 packets/sec
Router# show interface GigabitEthernet 0/1/1 | in output rate
  5 minute output rate 540000 bits/sec, 993 packets/sec
Router# show interface GigabitEthernet 0/0/2 | in output rate
  5 minute output rate 540000 bits/sec, 993 packets/sec
Router# show interface GigabitEthernet 0/0/4 | in output rate
  5 minute output rate 548000 bits/sec, 1009 packets/sec
Router# show interface GigabitEthernet 0/0/7 | in output rate
  5 minute output rate 548000 bits/sec, 1009 packets/sec
Router#

```

## Verifying ECMP Load Balancing

Use the following commands to verify ECMP load balancing.

Building configuration...

```

Current configuration : 10710 bytes
!
! Last configuration change at 00:29:01 IST Sat Jan 17 2015
!
version 15.5
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
platform loadbalance max-paths 8
no platform punt-keepalive disable-kernel-core
platform bfd-debug-trace 1
platform tcam-parity-error enable
platform tcam-threshold alarm-frequency 1
platform shell
!
hostname RM-PE1
!
boot-start-marker
boot-end-marker
!
!
vrf definition Mgmt-intf
!
address-family ipv4
exit-address-family
!
address-family ipv6
exit-address-family
!
!
no aaa new-model
clock timezone IST 5 30
facility-alarm critical exceed-action shutdown
no ip routing protocol purge interface

```

```
!  
ip vrf test  
rd 100:100  
route-target export 1000:1000  
route-target import 1000:1000  
!  
no ip domain lookup  
  
!  
!  
!  
!  
!  
!  
!  
!  
mpls label protocol ldp  
mpls ldp explicit-null  
mpls ldp session protection  
mpls ldp discovery targeted-hello accept  
multilink bundle-name authenticated  
!  
!  
license udi pid ASR-903 sn FOX1551P04E  
license accept end user agreement  
license boot level metroaggrservices  
sdm prefer default  
!  
!  
redundancy  
mode sso  
!  
!  
!  
!  
transceiver type all  
monitoring  
!  
ip tftp source-interface GigabitEthernet0  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
interface Loopback0  
ip address 100.111.14.1 255.255.255.255  
!  
interface Loopback101  
ip address 65.1.101.1 255.255.255.255  
!  
interface Loopback102  
ip address 65.1.102.1 255.255.255.255  
!  
interface Loopback103
```

```
ip address 65.1.103.1 255.255.255.255
!
interface Loopback104
ip address 65.1.104.1 255.255.255.255
!
interface Loopback105
ip address 65.1.105.1 255.255.255.255
!
interface Loopback106
ip address 65.1.106.1 255.255.255.255
!
interface Loopback107
ip address 65.1.107.1 255.255.255.255
!
interface Loopback108
ip address 65.1.108.1 255.255.255.255
!
interface Loopback109
ip address 65.1.109.1 255.255.255.255
!
interface Loopback110
ip address 65.1.110.1 255.255.255.255
!
interface Loopback111
ip address 65.1.111.1 255.255.255.255
!
interface Loopback112
ip address 65.1.112.1 255.255.255.255
!
interface Loopback113
ip address 65.1.113.1 255.255.255.255
!
interface Loopback114
ip address 65.1.114.1 255.255.255.255
!
interface Loopback115
ip address 65.1.115.1 255.255.255.255
!
interface Loopback116
ip address 65.1.116.1 255.255.255.255
!
interface Loopback117
ip address 65.1.117.1 255.255.255.255
!
interface Loopback118
ip address 65.1.118.1 255.255.255.255
!
interface Loopback119
ip address 65.1.119.1 255.255.255.255
!
interface Loopback120
ip address 65.1.120.1 255.255.255.255
!
interface Loopback121
ip address 65.1.121.1 255.255.255.255
!
interface Loopback122
ip address 65.1.122.1 255.255.255.255
!
interface Loopback123
ip address 65.1.123.1 255.255.255.255
!
interface Loopback124
ip address 65.1.124.1 255.255.255.255
```

```
!  
interface Loopback125  
ip address 65.1.125.1 255.255.255.255  
!  
interface Loopback126  
ip address 65.1.126.1 255.255.255.255  
!  
interface Loopback127  
ip address 65.1.127.1 255.255.255.255  
!  
interface Loopback128  
ip address 65.1.128.1 255.255.255.255  
!  
interface Loopback129  
ip address 65.1.129.1 255.255.255.255  
!  
interface Loopback130  
ip address 65.1.130.1 255.255.255.255  
!  
interface Loopback131  
ip address 65.1.131.1 255.255.255.255  
!  
interface Loopback132  
ip address 65.1.132.1 255.255.255.255  
!  
interface Loopback133  
ip address 65.1.133.1 255.255.255.255  
!  
interface Loopback134  
ip address 65.1.134.1 255.255.255.255  
!  
interface Loopback135  
ip address 65.1.135.1 255.255.255.255  
!  
interface Loopback136  
ip address 65.1.136.1 255.255.255.255  
!  
interface Loopback137  
ip address 65.1.137.1 255.255.255.255  
!  
interface Loopback138  
ip address 65.1.138.1 255.255.255.255  
!  
interface Loopback139  
ip address 65.1.139.1 255.255.255.255  
!  
interface Loopback140  
ip address 65.1.140.1 255.255.255.255  
!  
interface Loopback141  
ip address 65.1.141.1 255.255.255.255  
!  
interface Loopback142  
ip address 65.1.142.1 255.255.255.255  
!  
interface Loopback143  
ip address 65.1.143.1 255.255.255.255  
!  
interface Loopback144  
ip address 65.1.144.1 255.255.255.255  
!  
interface Loopback145  
ip address 65.1.145.1 255.255.255.255  
!
```

```
interface Loopback146
ip address 65.1.146.1 255.255.255.255
!
interface Loopback147
ip address 65.1.147.1 255.255.255.255
!
interface Loopback148
ip address 65.1.148.1 255.255.255.255
!
interface Loopback149
ip address 65.1.149.1 255.255.255.255
!
interface Loopback150
ip address 65.1.150.1 255.255.255.255
!
interface Loopback151
ip address 65.1.151.1 255.255.255.255
!
interface Loopback152
ip address 65.1.152.1 255.255.255.255
!
interface Loopback153
ip address 65.1.153.1 255.255.255.255
!
interface Loopback154
ip address 65.1.154.1 255.255.255.255
!
interface Loopback155
ip address 65.1.155.1 255.255.255.255
!
interface Loopback156
ip address 65.1.156.1 255.255.255.255
!
interface Loopback157
ip address 65.1.157.1 255.255.255.255
!
interface Loopback158
ip address 65.1.158.1 255.255.255.255
!
interface Loopback159
ip address 65.1.159.1 255.255.255.255
!
interface Loopback160
ip address 65.1.160.1 255.255.255.255
!
interface GigabitEthernet0/0/0
ip address 21.1.6.2 255.255.255.0
ip router isis core-agg
negotiation auto
mpls ip
!
interface GigabitEthernet0/0/1
ip address 21.2.6.2 255.255.255.0
ip router isis core-agg
negotiation auto
mpls ip
!
interface GigabitEthernet0/0/2
ip address 21.3.6.2 255.255.255.0
ip router isis core-agg
negotiation auto
mpls ip
!
interface GigabitEthernet0/0/3
```



```
no ip address
shutdown
negotiation auto
!
interface GigabitEthernet0/0/4
ip address 21.4.1.1 255.255.255.0
ip router isis core-agg
shutdown
negotiation auto
mpls ip
!
interface GigabitEthernet0/0/5
no ip address
shutdown
negotiation auto
!
interface GigabitEthernet0/0/6
ip address 51.1.0.1 255.255.255.0
negotiation auto
!
interface GigabitEthernet0/0/7
ip address 21.4.6.2 255.255.255.0
ip router isis core-agg
shutdown
negotiation auto
mpls ip
!
interface GigabitEthernet0/1/0
ip address 21.2.1.1 255.255.255.0
ip router isis core-agg
negotiation auto
mpls ip
!
interface GigabitEthernet0/1/1
ip address 21.3.1.1 255.255.255.0
ip router isis core-agg
negotiation auto
mpls ip
!
interface GigabitEthernet0/1/2
no ip address
shutdown
negotiation auto
!
interface GigabitEthernet0/1/3
ip address 21.1.1.1 255.255.255.0
ip router isis core-agg
negotiation auto
mpls ip
!
interface GigabitEthernet0/1/4
no ip address
shutdown
negotiation auto
!
interface GigabitEthernet0/1/5
no ip address
shutdown
negotiation auto
!
interface GigabitEthernet0/1/6
no ip address
shutdown
negotiation auto
```

```
!  
interface GigabitEthernet0/1/7  
no ip address  
shutdown  
negotiation auto  
!  
interface GigabitEthernet0  
vrf forwarding Mgmt-intf  
ip address 7.43.21.101 255.255.0.0  
shutdown  
negotiation auto  
!  
router isis core-agg  
net 49.0000.0000.1111.00  
is-type level-1  
metric-style wide  
fast-flood 10  
ip route priority high tag 10000  
set-overload-bit on-startup 360  
max-lsp-lifetime 65535  
lsp-refresh-interval 65000  
spf-interval 5 50 200  
prc-interval 5 50 200  
lsp-gen-interval 5 50 200  
log-adjacency-changes  
passive-interface Loopback0  
passive-interface Loopback101  
passive-interface Loopback102  
passive-interface Loopback103  
passive-interface Loopback104  
passive-interface Loopback105  
passive-interface Loopback106  
passive-interface Loopback107  
passive-interface Loopback108  
passive-interface Loopback109  
passive-interface Loopback110  
passive-interface Loopback111  
passive-interface Loopback112  
passive-interface Loopback113  
passive-interface Loopback114  
passive-interface Loopback115  
passive-interface Loopback116  
passive-interface Loopback117  
passive-interface Loopback118  
passive-interface Loopback119  
passive-interface Loopback120  
passive-interface Loopback121  
passive-interface Loopback122  
passive-interface Loopback123  
passive-interface Loopback124  
passive-interface Loopback125  
passive-interface Loopback126  
passive-interface Loopback127  
passive-interface Loopback128  
passive-interface Loopback129  
passive-interface Loopback130  
passive-interface Loopback131  
passive-interface Loopback132  
passive-interface Loopback133  
passive-interface Loopback134  
passive-interface Loopback135  
passive-interface Loopback136  
passive-interface Loopback137  
passive-interface Loopback138
```

```
passive-interface Loopback139
passive-interface Loopback140
passive-interface Loopback141
passive-interface Loopback142
passive-interface Loopback143
passive-interface Loopback144
passive-interface Loopback145
passive-interface Loopback146
passive-interface Loopback147
passive-interface Loopback148
passive-interface Loopback149
passive-interface Loopback150
passive-interface Loopback151
passive-interface Loopback152
passive-interface Loopback153
passive-interface Loopback154
passive-interface Loopback155
passive-interface Loopback156
passive-interface Loopback157
passive-interface Loopback158
passive-interface Loopback159
passive-interface Loopback160
maximum-paths 8
mpls ldp sync
!
router bgp 100
  bgp router-id 100.111.14.1
  bgp log-neighbor-changes
  neighbor ABR peer-group
  neighbor ABR remote-as 100
  neighbor ABR update-source Loopback0
  neighbor 100.111.10.1 peer-group ABR
  neighbor 100.111.10.1 shutdown
  neighbor 100.111.10.2 peer-group ABR
  neighbor 100.111.10.2 shutdown
!
address-family ipv4
  bgp additional-paths install
  network 100.111.14.1 mask 255.255.255.255 route-map set-PAN-comm
  neighbor ABR send-community both
  neighbor ABR next-hop-self all
  neighbor ABR route-map deny-PAN-loopbacks in
  neighbor ABR send-label
  neighbor 100.111.10.1 activate
  neighbor 100.111.10.2 activate
exit-address-family
!
address-family vpnv4
  neighbor ABR send-community both
  neighbor 100.111.10.1 activate
  neighbor 100.111.10.2 activate
exit-address-family
!
address-family ipv4 vrf test
  redistribute connected
exit-address-family
!
ip forward-protocol nd
!
ip bgp-community new-format
ip community-list 1 permit 100:100
no ip http server
no ip http secure-server
ip route vrf Mgmt-intf 10.0.0.0 255.0.0.0 7.43.0.1
```

```

ip route vrf Mgmt-intf 202.153.144.0 255.255.255.0 7.43.0.1
!
!
route-map set-service-nh permit 10
!
route-map deny-PAN-loopbacks deny 10
match community 1
!
route-map deny-PAN-loopbacks permit 20
!
route-map set-PAN-comm permit 10
set community 100:100
!
mpls ldp router-id Loopback0
!
!
control-plane
!
alias exec psh reques plat soft sys shell
alias exec shpp6 sh platform hard pp act fea cef da ipv6
alias exec shpp sh platform hard pp act fea cef da ipv4
!
line con 0
exec-timeout 0 0
logging synchronous
stopbits 1
line aux 0
stopbits 1
line vty 0
exec-timeout 0 0
password lab
login
line vty 1 4
login
!
!
!
end

```

## CLAC Mode for ECMP Load Balancing

By default, ECMP load balancing is based on hash values computed by considering the forwarding headers (MPLS Labels) or the headers above it. However, the inner headers can be added for enhanced load balancing. Enabling the inner headers for load-balancing computation provides finer granularity of traffic flow separation.

Typically, only the first three MPLS labels are used for load-balancing computation. To add the fourth label for load balancing computation, enable the CLAC mode.

Following is the difference in the load-balancing computation when CLAC mode is OFF and ON:

MPLS Label Stack	CLAC mode OFF	CLAC mode ON
L3VPN with 1, 2, or 3 MPLS labels	Load-balancing is based on MPLS labels + Inner IP Header + Inner Transport Header	Load-balancing is based on MPLS labels + Inner IP Header + Inner Transport Header
L3VPN with 4 MPLS labels	Load-balancing is based on 3 MPLS labels	Load-balancing is based on 4 MPLS labels

MPLS Label Stack	CLAC mode OFF	CLAC mode ON
L2VPN with 1, 2, or 3 MPLS labels	Load-balancing is based on MPLS labels	Load-balancing based on MPLS labels + Inner L2 Header
L2VPN with 4 MPLS labels	Load-balancing is based on 3 MPLS labels	Load-balancing is based on 4 MPLS labels

Use the following command to enable or disable the CLAC mode:

```
platform loadbalance Enhanced
```



**Note** CLAC mode is disabled by default.

## Enabling Platform Load Balancing CLAC Mode

Perform the following steps to enable CLAC mode.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>platform loadbalance Enhanced</b> <b>Example:</b> Device(config)# platform loadbalance Enhanced	Enables CLAC mode. After enabling CLAC mode, the system will perform enhanced load balancing based on more than 3 MPLS labels. <b>Note</b> To disable CLAC mode, enter the following command: <b>no platform loadbalance Enhanced</b>
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config)#exit	Returns to privileged EXEC mode.

## Configuring Platform Load Balancing Control-Word-Expect

You can enable Control-Word-Expect to enhance load balancing for L2VPN traffic with 1,2, or 3 MPLS labels with CLAC mode ON. This command is designed to enhance load balancing by searching for the control word in EthoMPLS packets and including it for load-balancing computation.

Use the following command to enable *Control-Word-Expect*:

```
platform loadbalance Control-Word-Expect
```



**Note** *Control-Word-Expect* is disabled by default.

## Configuring Control-Word-Expect

Perform the following steps to configure Control-Word-Expect for load balancing.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>platform loadbalance Control-Word-Expect</b> <b>Example:</b> Device(config)# platform loadbalance Control-Word-Expect	Enables Control-Word-Expect. After enabling Control-Word-Expect, the system will search for control word (CW) and perform accurate offset calculation for load balancing. <b>Note</b> To disable Control-Word-Expect, enter the following command: <b>no platform loadbalance            Control-Word-Expect</b>
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config)#exit	Returns to privileged EXEC mode.