



## Graceful Handling of Out of Resource Situations

Out of Resource Situation is an alarm or notification indicating that the resources of the router are used extensively and the resources are reaching their threshold limits. These situations can occur due to various reasons such as high number of routes, MAC addresses, interfaces, and Access Control List (ACEs). To exemplify, if the router fails to program high number of routes in its Network Processing Unit (NPU), OOR alarm can be triggered. The OOR situations ultimately leads to traffic loss. By handling the OOR situation gracefully, you can avoid the traffic loss in the router.

NPU is an integrated circuit which has a feature set targeted at a networking application domain. The role of NPU is similar to the role of CPU (Central Processing Unit) in the computer. Integrated circuits in NPU handle data packets transmission in the routers. To enable the transmission of data packets, NPU uses several internal resources such as Forwarding Information Base (FIB), Input Logical Interface (INLIF), INLIF1, INLIF2, and Router Interface (RIF).

To ensure optimum traffic forwarding without any loss, it is crucial to monitor and ensure that the NPU tables are not out of resources. The router maintains default OOR threshold levels to alert you of the NPU resource usage.

The default values for OOR threshold levels are as follows:

- The **Red** state occurs when 95% or more of the router's hardware resources are in-use.
- The **Yellow** state occurs when 80% or more of the router's hardware resources are in-use.
- The **Green** state indicates that less than 80% of the router's hardware resources are in-use and there's favorable utilization of hardware resources.
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## Out of Resource Handling of FIB Resources

The main function of the FIB within routers/line-cards is to map destination IP prefixes/labels to potential egress interfaces. In order to achieve this, the FIB maintains multiple databases or hardware tables, such as:

- Forward Equivalence Class (FEC) and the Equal Cost Multi-Path Forward Equivalence Class (ECMP FEC): This database mainly stores information related to the IPv4 and IPv6 prefixes that the router has learnt. When a traffic packet reaches the router, it performs a FIB lookup on the destination prefix of the incoming packet. This lookup results in the FEC or ECMP FEC object for that particular prefix and it provides information about the egress interface on the router through which the packet can reach its destination.

- Egress Encapsulation Data Base (EEDB): This database stores adjacency details such as the link-local details from Address Resolution Protocol (ARP) or Neighbor Discovery (ND) Protocol, Multiprotocol Label Switching (MPLS) labels, Generic Routing Encapsulation (GRE) headers and so on.

### OOB Protection Mode

When the FIB resource usage exceeds the red threshold, the system enters OOB protection mode.

In FEC OOB protection mode, the router doesn't allocate any FEC objects when it learns a new prefix, but assigns a pre-created drop FEC instead. The router drops incoming packets with destination IP addresses that were assigned the drop FEC.

In ECMP FEC OOB protection mode, the router chooses only the first path among multiple paths to forward traffic. When FEC or ECMP FEC usage drops below yellow threshold, the router reprograms the affected prefixes to normal FEC or ECMP FEC. Thereafter, the router resumes traffic flow.

In EEDB OOB protection mode, the router will not program any more egress encapsulation information. This in turn results in traffic drop. When EEDB usage drops below yellow threshold, the router resumes programming new egress encapsulation data as well as traffic flow.

### Configuration Steps to Change OOB Threshold Levels

The following section shows how to change the default threshold levels for OOB handling.

```
Router# conf t
Router(config)# oor hw threshold red 90
Router(config)# oor hw threshold yellow 75
Router(config)# commit
```

### Release Stale FEC Resources

To release the stale FEC resources, execute the following command:

```
Router# clear cef
```

## Verification of FEC Resources

Table 1: Feature History Table

Feature Name	Release Information	Feature Description
Hierarchical Forward Equivalence Class (HFEC) Out of Resource (OOR) Enhancements	Release 7.5.1	With this enhancement, you can view the details of the utilization of Forwarding Information Base (FIB) hardware resources, such as hierarchical FEC and hierarchical Equal Cost Multi-Path (ECMP) FEC, in the output of the command <a href="#">show controllers npu resources</a> . This feature also enables the router to display system logs on the console that alert you when FEC resources have crossed the OOR threshold levels. These logs help you to take corrective action and free up FEC resources, to minimize traffic loss. .

Use the **show controllers npu resources** command to verify FIB resources.

The **OOR State** in the output of the **show controllers npu resources** command changes when the router reaches an OOR situation. The **OOR State** changes from **Green** to **Yellow**, and finally to **Red** depending on the utilization of FEC or ECMP FEC resources.

```
Router# show controllers npu resources fec location 0/0/CPU0
HW Resource Information
  Name                : fec
  Asic Type            : Qumran

NPU-0
OOR Summary
  Estimated Max Entries : 126976
  Red Threshold         : 95 %
  Yellow Threshold      : 80 %
  OOR State             : Green
  Bank Info            : FEC

OFA Table Information
(May not match HW usage)
  ipnhgroup           : 43058
  ip6nhgroup          : 2
  edpl                 : 0
  limd                 : 0
  punt                : 19
  iptunneldecap       : 0
  ipmcroute           : 1
  ip6mcroute          : 0
  ipnh                 : 0
  ip6nh               : 0
  mplsmdbud           : 0
  ipvrf               : 2
  ippbr               : 0
```

```

        redirectvrf          : 0
        l2protect            : 0
        l2bridgeport        : 0

Current Hardware Usage
  Name: fec
    Estimated Max Entries    : 126976
    Total In-Use            : 43082   (33 %)
    OOR State                : Green
    Bank Info                : FEC

  Name: hier_0
    Estimated Max Entries    : 126976
    Total In-Use            : 43082   (33 %)
    OOR State                : Green
    Bank Info                : FEC

```

FIB has three FEC hierarchies and 3 ECMP FEC hierarchies. From Cisco IOS XR Release 7.5.1 onwards, you can view these hierarchies in the output of the commands **show controllers npu resources fec** and **show controllers npu resources ecmpfec**. The router records the **OOOR State** of each of these hierarchies in the command outputs.

```
Router# show controllers npu resources fec location 1/0/CPU0
```

```
HW Resource Information
  Name          : fec
  Asic Type     : Jericho 2

```

```
NPU-0
OOOR Summary
  Estimated Max Entries    : 576704
  Red Threshold           : 95 %
  Yellow Threshold        : 80 %
  OOR State               : Green
  Bank Info               : FEC

```

```
OFA Table Information
(May not match HW usage)
  ipnhgroup             : 157800
  ip6nhgroup            : 17377
  edpl                  : 0
  limd                  : 0
  punt                  : 18
  iptunneldecap         : 0
  ipmcroute             : 1
  ip6mcroute            : 0
  ipnh                  : 0
  ip6nh                 : 0
  mplsmdbud             : 0
  ipvrf                 : 1053
  ippbr                 : 0
  redirectvrf          : 1
  l2protect             : 42
  l2bridgeport         : 58

```

```
Current Hardware Usage
  Name: fec
    Estimated Max Entries    : 576704
    Total In-Use            : 176350   (30 %)
    OOR State                : Green
    Bank Info                : FEC

```

```

Name: hier_0
  Estimated Max Entries      : 131072
  Total In-Use              : 3207      (2 %)
  OOR State                 : Green
  Bank Info                 : H1 FEC

Name: hier_1
  Estimated Max Entries      : 262144
  Total In-Use              : 63        (0 %)
  OOR State                 : Green
  Bank Info                 : H2 FEC

Name: hier_2
  Estimated Max Entries      : 183488
  Total In-Use              : 173080    (94 %)
  OOR State                 : Yellow
  OOR State Change Time     : 2021.Aug.29 22:14:16 PDT
  Bank Info                 : H3 FEC

```

Router# **show controllers npu resources ecmpfec location 0/0/CPU0**

HW Resource Information

```

Name           : ecmp_fec
Asic Type      : Jericho 2

```

NPU-0

OOB Summary

```

  Estimated Max Entries      : 32768
  Red Threshold             : 95 %
  Yellow Threshold          : 80 %
  OOR State                 : Yellow
  OOR State Change Time     : 2021.Aug.29 23:07:53 PDT
  Bank Info                 : ECMP

```

OFA Table Information

(May not match HW usage)

```

  ipnhgroup                : 30654
  ip6nhgroup                : 4

```

Current Hardware Usage

```

Name: ecmp_fec
  Estimated Max Entries      : 32768
  Total In-Use              : 30658    (93 %)
  OOR State                 : Yellow
  OOR State Change Time     : 2021.Aug.29 23:07:53 PDT
  Bank Info                 : ECMP

```

```

Name: hier_0
  Total In-Use              : 0
  OOR State                 : Green
  Bank Info                 : H1 ECMP

```

```

Name: hier_1
  Total In-Use              : 1
  OOR State                 : Green
  Bank Info                 : H2 ECMP

```

```

Name: hier_2
  Total In-Use              : 30657

```

```

OOB State                : Yellow
OOB State Change Time   : 2021.Aug.29 23:07:53 PDT
Bank Info                : H3 ECMP

```

### System Log Alerts for HFEC OOR

When utilization of any of the FEC or ECMP FEC hierarchies transition from the current OOR state to another state, the router generates system logs to alert the user. You can then take corrective action if the router is approaching OOR state to ensure that FEC resources get freed up before traffic loss takes place.

```

LC/0/0/CPU0: fia_driver[170]: %PLATFORM-OFA-1-OOR_RED : NPU 0, Table ipnhgroup, Resource
fec
LC/0/0/CPU0: fia_driver[170]: %PLATFORM-OFA-4-OOR_YELLOW : NPU 0, Table ipnhgroup, Resource
fec
LC/0/0/CPU0: fia_driver[170]: %PLATFORM-OFA-5-OOR_GREEN : NPU 0, Table ipnhgroup, Resource
fec
LC/0/0/CPU0: fia_driver[140]: %PLATFORM-OFA-4-OOR_YELLOW : NPU 0, Table ipnhgroup, Resource
ecmp_fec
LC/0/0/CPU0: fib_mgr[133]: %PLATFORM-PLAT_FIB-4-OOR_PROT_STOP_WARNING : ECMP_FEC resources
are now available. OOR protection stopped
LC/0/0/CPU0: fia_driver[140]: %PLATFORM-OFA-5-OOR_GREEN : NPU 0, Table ipnhgroup, Resource
ecmp_fec

```

## Verification of EEDB Resources

**Table 2: Feature History Table**

Feature Name	Release Information	Feature Description
Verification of EEDB OOR	Release 7.6.1	<p>If the Egress Encapsulation Database (EEDB) resources exceed the Out of Resource (OOR) threshold levels, the router generates system logs that indicate the resource utilization of EEDB hardware. With these details, you can take corrective action by freeing up EEDB resources, thereby minimizing traffic loss.</p> <p>This feature also updates the show output of the following command to display utilization of EEDB hardware resources:</p> <p><a href="#">show controllers npu resources</a></p>

The router processes several entries and often stores these entries in the form of tables. These tables are further divided into smaller tables. These smaller tables are called as banks. The banks are often named as bank\_0, bank\_1, bank\_2, and so on. Router segregates the entries through these banks.



**Note** **bank\_0** will always be indicated as completely utilized and in Red OOR state on the following routers and line cards:

- NCS-5501
- NCS-5501-SE
- NCS-5502
- NCS-5502-SE
- NC55-36x100G
- NC55-18H18F
- NC55-24x100G-SE
- NC55-24H12F-SE
- NC55-36x100G-S
- NC55-6x200-DWDM-S

This complete utilization of **bank\_0** must be ignored since it is reserved for internal usage regardless of the router configuration.

Use **show controllers npu resources encap** command to verify the usage of EEDB resources.

The **OOOR State** in the output of the **show controllers npu resources encap** command changes when the router reaches an OOR situation. The **OOOR State** changes from **Green** to **Yellow**, and finally to **Red** depending on the utilization of the EEDB resources.

```
Router# show controllers npu resources encap location 1/0/CPU0
```

```
HW Resource Information
```

```
Name                : encap
Asic Type            : Jericho
```

```
NPU-0
```

```
OOOR Summary
```

```
Red Threshold       : 95 %
Yellow Threshold    : 80 %
```

```
OFA Table Information
```

```
(May not match HW usage)
```

```
ipnh                : 13
ip6nh               : 0
mplsnh              : 0
llnh                : 0
srv6nh              : 0
ipvrf               : 0
mplsmdtbud          : 0
iptunnelencap       : 0
tep                 : 0
```

```
Current Hardware Usage
```

```
Name: encap
```

```

Name: bank_0
Estimated Max Entries      : 4096
Total In-Use               : 4096      (100 %)
OOB State                 : Red
OOB State Change Time   : 2022.Mar.15 05:33:14 UTC
Bank Info                  : phase=2 extended=no

```

```

Name: bank_1
Estimated Max Entries      : 4096
Total In-Use               : 4          (0 %)
OOB State                  : Green
Bank Info                  : phase=8 extended=no

```

```

Name: bank_2
Estimated Max Entries      : 4096
Total In-Use               : 0          (0 %)
OOB State                  : Green
Bank Info                  : phase=0 extended=no

```

```

Name: bank_3
Estimated Max Entries      : 4096
Total In-Use               : 0          (0 %)
OOB State                  : Green
Bank Info                  : phase=0 extended=no

```

From Cisco IOS XR Release 7.6.1 onwards, the output of the command **show controllers npu resources encap** has been enhanced to provide more fields such as **Current Hardware Usage** and **Cluster Bank Pair** details.

```
Router# show controllers npu resources encap location 1/0/CPU0
```

```

HW Resource Information
Name                : encap
Asic Type           : Jericho Two

```

```
NPU-0
```

```

OOB Summary
Red Threshold       : 95 %
Yellow Threshold    : 80 %

```

```

OFA Table Information
(May not match HW usage)
ipnh                 : 13
ip6nh                : 0
mplsnh              : 0
llnh                 : 0
srv6nh              : 0
ipvrf                : 0
mplsmdtbud          : 0
iptunnelencap       : 0
tep                  : 0

```

```
Current J2 Hardware Usage
```

```

Cluster Bank Pair: EEDB_S2_XL
Max-Entries        : 163840
Total In-use       : 0

Logical_phase      : 1 (Encap_Rif)
Cluster Bank

```



```

Bank Size                : S2
Estimated Max Entries    : 163840
OOB State              : Green
Total In-Use             : 0

EEDB Bank:
Estimated Max Entries    : 8192
OOB State              : Green
Total In-Use             : 0

Logical_phase            : 6 (Tunnel4)
Cluster Bank
  Bank Size              : XL
  Estimated Max Entries  : 122880
  OOB State              : Green
  Total In-Use           : 0

EEDB Bank:
Estimated Max Entries    : 61440
OOB State              : Green
Total In-Use             : 0

Cluster Bank Pair: EEDB_L1_S1
Max-Entries              : 98304
Total In-use             : 26

Logical_phase            : 2 (Encap_NativeArp)
Cluster Bank
  Bank Size              : L1
  Estimated Max Entries  : 81920
  OOB State              : Green
  Total In-Use           : 0

EEDB Bank:
Estimated Max Entries    : 30720
OOB State                : Green
Total In-Use             : 0

Logical_phase            : 8 (Encap_Ac)
Cluster Bank
  Bank Size              : S1
  Estimated Max Entries  : 98304
  OOB State              : Green
  Total In-Use           : 26

EEDB Bank:
Estimated Max Entries    : 8192
OOB State                : Green
Total In-Use             : 0

Cluster Bank Pair: EEDB_M1_M2
Max-Entries              : 131072
Total In-use             : 62

Logical_phase            : 3 (Encap_NativeAc or Tunnel1)
Cluster Bank
  Bank Size              : M1
  Estimated Max Entries  : 122880
  OOB State              : Green
  Total In-Use           : 0

EEDB Bank:

```

```
Estimated Max Entries : 16384
OOR State             : Green
Total In-Use         : 0
```

### System Log Alerts for EEDB OOR

When utilization of EEDB resources transition from the current OOR state to another state, the router generates system logs to alert the user. You can then take corrective action if the router is approaching OOR state to ensure that EEDB resources get freed up before traffic loss takes place.

The router logs the following log messages to inform you of the OOR state of the encap resource when it exceeds thresholds. The syslog also indicates the Network Processing Unit (NPU) of the affected encap resource, which is NPU0, in this case.

```
LC/0/0/CPU0: fia_driver[164]: %PLATFORM-OFA-4-OOR_YELLOW : NPU 0, Table mplsnh, Resource encap
LC/0/0/CPU0: fia_driver[164]: %PLATFORM-OFA-1-OOR_RED : NPU 0, Table mplsnh, Resource encap
```