S-GW Paging Enhancements

- Feature Description, on page 1
- How It Works, on page 2
- Limitations, on page 3
- Configuring High Priority DDN Interaction Feature, on page 4
- Monitoring and Troubleshooting High Priority DDN Interaction Feature, on page 5

Feature Description

S-GW Paging includes the following scenarios:

Scenario 1: S-GW sends a DDN message to the MME/S4-SGSN nodes. MME/S4-SGSN responds to the S-GW with a DDN Ack message. While waiting for the DDN Ack message from the MME/S4-SGSN, if the S-GW receives a high priority downlink data, it does not resend a DDN to the MME/S4-SGSN.

Scenario 2: If a DDN is sent to an MME/S4-SGSN and TAU/RAU MBR is received from another MME/S4-SGSN, S-GW does not send DDN.

Scenario 3: DDN is sent to an MME/S4-SGSN and DDN Ack with Cause #110 is received. DDN Ack with cause 110 is treated as DDN failure and standard DDN failure action procedure is initiated.

To handle these scenarios, the following two enhancements have been added to the DDN functionality:

- High Priority DDN at S-GW
- MBR-DDN Collision Handling

These enhancements support the following:

- Higher priority DDN on S-GW and SAEGW, which helps MME/S4-SGSN to prioritize paging.
- Enhanced paging KPI and VoLTE services.
- DDN message and mobility procedure so that DDN is not lost.
- MBR guard timer, which is started when DDN Ack with temporary HO is received. A new CLI command **ddn temp-ho-rejection mbr-guard-timer** has been introduced to enable the guard timer to wait for MBR once the DDN Ack with cause #110 (Temporary Handover In Progress) is received.
- TAU/RAU with control node change triggered DDNs.

In addition to the above functionality, to be compliant with 3GPP standards, support has been enhanced for Downlink Data Notification message and Mobility procedures. As a result, DDN message and downlink data which triggers DDN is not lost. This helps improve paging KPI and VoLTE success rates in scenarios where DDN is initiated because of SIP invite data.

Licensing

This is a license-controlled feature. Contact your Cisco account or support representative for detailed licensing information.

How It Works

This section describes working of these features related to S-GW Paging.

High Priority DDN at S-GW

High Priority DDN at S-GW

1. S-GW sends a Downlink Data Notification message to the MME/S4-SGSN node for which it has control plane connectivity for the given UE.
2. The MME/S4-SGSN responds to the S-GW with a Downlink Data Notification Ack message.
3. The S-GW, while waiting for the user plane to be established, might send a second Download Data Notification based on the priority of received data. The following table lists the cases when it will happen.
4. The following table lists different scenarios with different DDN priorities and the action taken by the S-GW.

Table 1: DDN Priority Scenarios

Scenario	Action Taken by S-GW Action Taken by S-GW Prior This Feature	Action Taken by S-GW Action Taken by S-GW Post This Feature
ARP Priority of second bearer is higher than the first bearer on which first DDN was sent.	No DDN was sent.	Sends DDN message with higher priority to the MME/S4-SGSN.
ARP Priority of second bearer is higher than the first bearer on which first DDN was sent.	Buffers these downlink data packets and the does not send a new DDN. However, separate Paging DDN is always sent out and this restriction does not apply to it.	Buffers these downlink data packets and the does not send a new DDN. However, separate Paging DDN is always sent out and this restriction does not apply to it.
S-GW has sent the second DDN message indicating higher priority and receives extra downlink data packets for this UE.	Buffers these downlink data packets and the does not send a new DDN.	Buffers these downlink data packets and the does not send a new DDN.

Important Separate paging is always sent.

MBR-DDN Collision Handling

The following table lists different MBR-DDN collision scenarios and action taken by S-GW to handle these scenarios:

Table 2: MBR-DDN Collision Handling Scenarios

Scenario	Action Taken by S-GW Action Taken by S-GW Prior This Feature	Action Taken by S-GW Action Taken by S-GW Post This Feature
DDN is sent to an MME/S4-SGSN and TAU/RAU MBR is received from another MME/S4-SGSN without any data TEIDs.	No DDN was sent.	DDN is triggered to this new control node as part of mobility handover process.
DDN is sent to an MME/S4-SGSN and DDN Ack with Cause #110 is received.	DDN Ack with cause 110 is treated as DDN failure and standard DDN failure action procedure is initiated.	S-GW starts a guard timer and wait for TAU/RAU MBR from the new MME/S4-SGSN. The timer is stopped if any MBR or DDN failure indication is received. But, if none of them is received, and the timer expires all buffered downlink data packets are flushed. If this is followed by mobility handover without any data TEIDs, DDN is resent to this new control node as well.
MBR received with bearer context to be removed.	There is a possibility that DDN could be sent with EBIs corresponding to bearers marked for deletion.	Bearers marked for deletion are not included in any of the DDN messages.

Limitations

High Priority DDN at S-GW

This section lists the limitations for High Priority DDN at S-GW feature.

1. High Priority DDN is always enabled whenever the license is available.
2. High priority DDN is sent only once. Any further higher priority data does not trigger another DDN.
3. DDN delay timer and DDN throttling is not applicable to High Priority DDN.
4. Separate Paging DDN is always sent out and above restriction does not apply to it.
5. No-user-connect behavior restarts the moment high priority DDN is sent out.

MBR-DDN Collision Handling

This section lists the limitations for MBR-DDN Collision Handling feature.

1. EBI of a bearer marked for removal is not sent in any of the DDN messages.
2. TAU/RAU triggered DDN is sent only once and is never reattempted even if aborted due to the collision of MBR with DDN at the S-GW Ingress.
3. DDN delay and throttling are not applicable to the TAU/RAU triggered DDN.
4. No-user-connect behavior restarts the moment high priority DDN is sent out.
5. High Priority DDN is not sent if high priority downlink data is received:
   - After DDN Ack with Cause #110 is received
   - Before any MBR is received
6. Separate paging IE is not supported for TAU/RAU triggered DDN.
7. If DDN Ack with cause #110 is received and then later a downlink packet matches the configured 3-tuple of "Separate Paging", then also "Separate Paging DDN" is not sent as the UE is undergoing handoff.
8. The MBR guard timer is not restarted when the DDN Ack with cause #110 is received while the MBR guard timer is running.

Configuring High Priority DDN Interaction Feature

Operators can use this CLI command to enable guard timer to wait for MBR once the DDN Ack with cause #110 (Temporary Handover In Progress) is received.

Configuring mbr-guard-timer

This CLI sets the guard timer to wait for a MBR when DDN Ack with Cause #110 temp-ho-rejection) is received.

If the guard timer expires and if no MBR of any type or DDN Failure Indication is received, all the buffered downlink data is flushed out and paging flags are reset.

If the guard timer is running and any MBR is received, the timer is stopped and no further action is taken.

If the guard timer is running and DDN Failure Indication is received, the timer is stopped and standard DDN failure action is taken.

By default, this CLI command is always enabled.

```
configure
     context context_name
        sgw-service service_name
           ddn temp-ho-rejection mbr-guard-timer time_in_seconds
           { no | default } ddn temp-ho-rejection mbr-guard-timer
           end
```

Notes:

- **no:** Disables the guard timer.
- **default:** Enables the guard timer and sets it to the default value, 60 seconds.

- **temp-ho-rejection:** Action to be taken when peer node indicates temporary rejection of paging due to handover-in-progress.
- **mbr-guard-timer:** Sets the guard timer for a MBR when DDN Ack with Cause #110 (temp-ho-rejection) is received. When the timer expires, S-GW flushes all the buffered downlink data packets. The range of this timer is from 60 seconds to 300 seconds. Default timer value is 60 seconds.

Verifying the Configuration

The configuration of this feature can be verified using the following commands from the `exec` mode:

- **show sgw-service statistics all**
- **show sgw-service [name <service-name> | all]**
- **show saegw-service statistics all function sgw**

See the section Monitoring and Troubleshooting High Priority DDN Interaction Feature, on page 5 for the command output.

Monitoring and Troubleshooting High Priority DDN Interaction Feature

The following section describes commands available to monitor and troubleshoot "High Priority DDN" & "DDN-MBR Collision Handling" Features .

Show Commands for High Priority DDN Interaction Feature

show sgw-service [name <service-name> | all]

This CLI is enhanced to show the MBR-guard-timer configuration which can be a value between "60-300 Seconds" when enabled OR "Disabled". The MBR-guard-timer is started when a DDN Ack with Temporary-HO-Rejection (Cause #110) is received.

Important If the MBR-guard-timer is disabled, DDN Ack with Temporary-HO-Rejection is treated as DDN Failure Indication.

This command displays the following output:

```
show sgw-service name sgw-srv
Service name                    : sgw-srv
  Service-Id                    : 18
  Context                       : ingress
  Accounting context            : ingress
  Accounting gtpp group         : default
  Accounting mode               : Gtpp
  Accounting stop-trigger       : Default
  Status                        : STARTED
  Egress protocol               : gtp-pmip
```

```
Ingress EGTP service          : egtp-sgw-ingress
Egress context                : ingress
Egress EGTP service           : egtp-sgw-egress
Egress MAG service            : n/a
IMS auth. service             : n/a
Peer Map                      : n/a
Access Peer Map               : n/a
Accounting policy             : n/a
Newcall policy                : n/a
Internal QOS Application      : Backward-compatible
QCI-QOS mapping table         : n/a
Event Reporting               : Disabled
DDN Throttling                : Disabled
Page UE for PGW initiated proc: Disabled
Temp-Failure Handling for DBR proc: Disabled
PGW Ctrl FTEID in Relocation Create Session Response: Enabled
...
....
ddn success-action no-user-connect ddn-retry-timer: 60
ddn failure-action pkt-drop-time: 300
ddn isr-sequential-paging delay-time: 10
MBR Guard Timer for DDN Ack with Temporary-HO-Rejection: 60-300 seconds/Disabled

Idle timeout                  : n/a
PLMN ID List                  : Not defined
Subscriber Map Name: smap
SAEGW service                 : saegw
EGTP NTSR: Disabled
 Session Hold Timer: n/a
   Timeout: n/a

GTP-C Load Control Profile        : Not Defined
GTP-C Overload Control Profile    : Not Defined
```

show sgw-service statistics all

This CLI command has been enhanced to show the following:

- Number of times 'High Priority Paging' is triggered and number of times it could not be triggered as it was already sent. This shows data corresponding to only S-GW service(s) which is part of SAEGW service(s).
- Number of times DDN Ack with a cause #110 is received and number of times TAU/RAU MBR with control node change triggers a DDN automatically.
- Number of packets and bytes discarded when MBR-guard-timer expires; this timer is started when a DDN Ack with Temporary-HO-Rejection (Cause #110) is received.
- This CLI shows data only corresponding to standalone sgw-service(s).

This command displays the following output:

```
show sgw-service statistics all
…
…
Paging Statistics:
  Requests:                          3    Success :                          2
  Rejects:                           1    Failures:                          0
  UE State Transitions:
    Idle-to-Active:                  0    Active-to-Idle:                    1
```

```
Data Statistics Related To Paging:
  Packets Buffered:                  3    Bytes Buffered:                   15
  Packets Discarded:                 9    Bytes Discarded:                  45
  Idle Mode ACL Statistics:
    Packets Discarded:               0    Bytes Discarded:                   0

Data Discarded By Reason-Type:
  Shared Buffer Full:
    Packets Discarded:               0    Bytes Discarded:                   0
  Dedicated Buffer Full:
    Packets Discarded:               0    Bytes Discarded:                   0
  S1U State Inactive:
    Packets Discarded:               0    Bytes Discarded:                   0
  Paging Throttled:
    Packets Discarded:               0    Bytes Discarded:                   0
  Paging Failure:
    Packets Discarded:               9    Bytes Discarded:                  45
  No User Connect Data Flushed:
    Packets Discarded:               0    Bytes Discarded:                   0
  MBR Guard Timer Expiry Flushed Data:
    Packets Discarded:           0    Bytes Discarded:                  0
  Buffered Data Flushed:
    Packets Discarded:               0    Bytes Discarded:                   0

 High Priority Paging Statistics:
   Initiated:                    1    Suppressed:                       1

 Handover Paging Statistics:
   DDN Ack with Temporary-HO-Rejection (Cause #110):                    0
   TAU/RAU MBR Triggered DDN:                                           1
...
...
```

show saegw-service statistics all function sgw

This CLI is enhanced to show the following:

- Number of times 'High Priority Paging' was triggered and number of times it could not be as it was already sent.
- Number of times DDN Ack with a cause #110 is received and number of times TAU/RAU MBR with control node change triggers a DDN automatically.
- Data only corresponding to the S-GW service(s) which is associated with a SAEGW service(s).
- Number of packets and bytes discarded when MBR-guard-timer expires; this timer is started when a DDN Ack with Temporary-HO-Rejection (Cause #110) is received
- Number of packets and bytes discarded when MBR-guard-timer expires; this timer is started when a DDN Ack with Temporary-HO-Rejection (Cause #110) is received
- Packets/Bytes dropped due to MBR-guard-timer expiry are not shown for collapsed calls.

Important Paging packets dropped statistics are not incremented for collapsed calls and hence the newly added counter of "MBR Guard timer Expiry Flushed Data" is also not updated in that case.

This command displays the following output:

```
 show saegw-service statistics all function sgw
Paging Statistics:
  Requests:                          3    Success :                          2
  Rejects:                           1    Failures:                          0
  UE State Transitions:
    Idle-to-Active:                  0    Active-to-Idle:                    1

  Data Statistics Related To Paging:
    Packets Buffered:                3    Bytes Buffered:                   15
    Packets Discarded:               9    Bytes Discarded:                  45
    Idle Mode ACL Statistics:
      Packets Discarded:             0    Bytes Discarded:                   0

  Data Discarded By Reason-Type:
    Shared Buffer Full:
      Packets Discarded:             0    Bytes Discarded:                   0
    Dedicated Buffer Full:
      Packets Discarded:             0    Bytes Discarded:                   0
    S1U State Inactive:
      Packets Discarded:             0    Bytes Discarded:                   0
    Paging Throttled:
      Packets Discarded:             0    Bytes Discarded:                   0
    Paging Failure:
      Packets Discarded:             9    Bytes Discarded:                  45
    No User Connect Data Flushed:
      Packets Discarded:             0    Bytes Discarded:                   0
    MBR Guard Timer Expiry Flushed Data:
      Packets Discarded:             0    Bytes Discarded:                   0
    Buffered Data Flushed:
    Packets Discarded:             0    Bytes Discarded:                   0

    High Priority Paging Statistics:
      Initiated:                     1    Suppressed:                        1

    Handover Paging Statistics:
      DDN Ack with Temporary-HO-Rejection (Cause #110):                      0
      TAU/RAU MBR Triggered DDN:                                             1
```