

ISR with Circuit Switched Fallback

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ISR with CSFB - Feature Description

Idle-mode Signaling Reduction (ISR) feature allows the UE to move between LTE and 2G/3G without performing Tracking Area (TA) or Routing Area (RA) updates once it has been activated. A pre-requisite for ISR activation is that the UE, SGSN, MME, Serving GW and HSS all support ISR. At the first attach to the network, ISR is not activated. ISR can only be activated when the UE has first been registered in an RA on 2G/3G and then registers in a TA or vice versa.

If the UE first registers on GERAN/UTRAN and then moves into an LTE cell, the UE initiates a TA update procedure. In the TA update procedure, the SGSN, MME and Serving GW communicate their capabilities to support ISR, and if all the nodes support ISR, the MME indicates to the UE that ISR is activated in the TAU accept message.

Circuit-Switched Fallback (CSFB) is an alternative solution to using IMS and SRVCC to provide voice services to users of LTE. The IMS is not part of the solution, and voice calls are never served over LTE. Instead, the CSFB relies on a temporary inter-system that switches between LTE and a system where circuit-switched voice calls can be served.

The ISR feature must be enabled for the CSFB feature to work, the ISR feature is a license controlled feature.

The LTE terminals 'register' in the circuit switched domain when powered and attaching to LTE. This is handled through an interaction between the MME and the MSC-Server in the circuit-switched network domain over the SGs interface.

Consider the following scenarios:

- Voice calls initiated by the mobile user: If the user makes a voice call, the terminal switches from a LTE system to a system with circuit-switched voice support. Depending on where the UE latches on after completion of the voice call:
  - The packet-based services that are active on the end-user device at this time are handed over and continue to run in a system with circuit-switched voice support but with lower data speeds.

  OR

  - The packet-based services that are active on the end-user device at this time are suspended until the voice call is terminated and the terminal switches back to LTE again and the packet services are resumed.
- Voice calls received by the mobile user: If there is an incoming voice call to an end-user that is currently attached to the LTE system, the MSC-Server requests a paging in the LTE system for the specific user. This is done through the SGs interface between the MSC Server and the MME. The terminal receives the page, and temporarily switches from the LTE system to the system with circuit-switched voice support, where the voice call is received. Once the voice call is terminated, the terminal switches back to the LTE system.

Call Flows

To support CS fallback, existing procedures are modified and some additional CS fallback specific procedures added to the EPS. Additions are done to the "Attach" and "TA update" procedures which activate an interface called the SGs. This interface is between the MME and MSC. It is used by the MSC to send paging messages for CS calls to the UE on the LTE system.

Example of a CS fallback call

Figure 1: CS Fallback Call

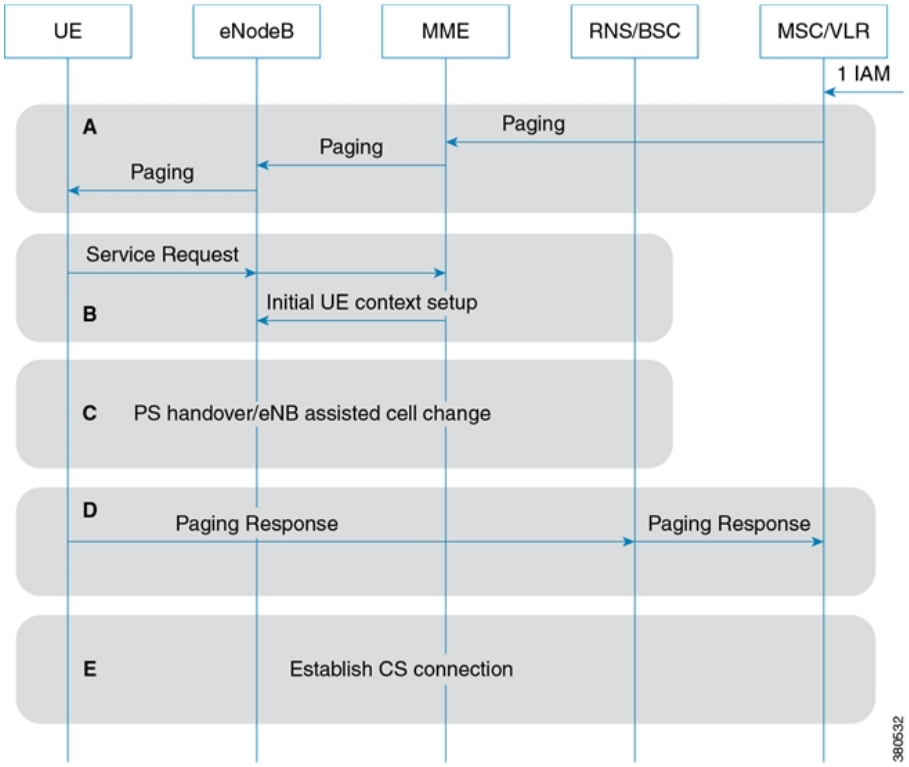


Table 1: Steps in a CS fallback call

Step	Description
1.	The MSC receives an incoming voice call and sends a CS page to the MME over a SGs interface.
2.	The MME uses the TMSI (or IMSI) received from the MSC to find the S-TMSI (which is used as the paging address on the LTE radio interface).
3.	The MME forwards the paging request to the eNodeB in the TAs where the UE is registered. The eNodeBs perform the paging procedures in all the cells in the indicated TAs.
4.	The paging message includes a special CS indicator that informs the UE that the incoming paging is for a terminating CS call.
5.	On receiving the paging message, the UE performs a service request procedure which establishes the RRC connection and sends a Service Request to the MME. The Service Request message includes a special CS Fall-back indicator that informs the MME that the CS fallback is required.

Step	Description
6.	This triggers the MME to activate the bearer context in the eNodeB with an indication to perform fallback to GERAN or UTRAN.
7.	The eNodeB selects a suitable target cell, by triggering the UE to send measurements on the neighbour cells, and initiates a handover or cell change procedure. The selection between handover or cell change procedure is based on the target cell capabilities and is configured in the eNodeB. **Note** If the target cell is a UTRAN cell, then MME can do subscriber context transfer using Forward Relocation Req / Rsp / Complete / Complete Ack messages and set up the radio contexts in UTRAN a-priori. However if the target cell is GERAN, then the SGSN currently does not support PS handover procedure and hence transfer of radio context from MME to 2G SGSN through Fwd reloc req / rsp /complete/complete ack procedure is not possible in the current release. In this scenario, CSFB is performed through a RRC release at the eNodeB and then a Suspend Request is sent to the SGSN.
8.	After a handover or cell change procedure, the UE detects the new cell and establishes a radio connection and sends a page response to the MSC, through the target RAN.
9.	When the page response arrives at the MSC, a normal mobile terminated call setup continues and CS call is activated towards the UE.

The CS fallback is primarily supports voice calls but it also supports other CS services. In the case of SMS services the UE need not switch to other radio interfaces. The UE can remain on LTE and still send and receive SMSes. The SMS messages are tunnelled between the UE and the MSC through the MME NAS signalling and the SGs interface.

When ISR is activated the UE is simultaneously registered at both SGSN and MME. So any paging for CS services occurs at both the SGSN and the MME. In a network if ISR is activated for an UE and CSFB is used in the network, the SGSN has to support additional call flows.

Relationships to Other Features

The CS Fallback feature is inter-works with the Idle Mode Signaling Reduction (ISR) feature. The CS Fallback feature is primarily for the EPS, but at the SGSN, it plays a role in deciding when the ISR feature should be activated or de-activated at the SGSN.

Relationships to Other Products

To enable ISR for subscriber peer nodes, the MME and SGW must support ISR functionality.

How it Works

Listed below are the scenarios where ISR with CSFB is impacted by the SGSN, these scenarios are applicable to both 2G and 3G when ISR is enabled:

1. The ISR is de-activated (by not sending ISR active status indication in RAU Accept message sent to UE) in the following cases:
   - The SGSN will not sent the ISR activated indication at combined RAU/LAU procedure (As per 3GPP TS23.272, section 4.3.5 ,release 11.2)
   - When the UE sends a combined RAU and LAU to a S4-SGSN, the SGSN checks the "Combined EPS/IMSI Attach Capability" bit in the "MS Network Capability" IE received. If that bit indicates CSFB and/or SMS over SGs is enabled for this UE, then the SGSN de-activates the ISR by not indicating the "ISR Activated" status in RAU Accept message sent to the UE. The SGSN in a CSFB/SMS over SGs configuration never indicates "ISR Activated" in combined RAU procedures for CSFB/SMS over SGs enabled UEs.
2. If CS Paging Indication is received from MME for an ISR activated subscriber, the SGSN pages to the subscriber indicating that the paging is for a CS call. When a Mobile Terminating call arrives at the MSC/VLR (via the G-MSC) for a UE that is camped on an E-UTRAN (ISR is active and the SGs interface is active between MSC and MME), the MSC/VLR sends a Page Request (SGsAP-PAGING-REQUEST) to the MME.

   As ISR is active and the UE is in ECM_IDLE state, the MME forwards the CS paging message received from the MSC/VLR to the associated SGSN. The MME gets the SGSN information in the regular ISR activation process. The MME builds a "CS Paging Indication" message, which is a GTPv2 message, from the SGsAP-PAGING_REQUEST to the correct SGSN. The SGSN receives the CS Paging Indication message from the MME, and sends paging messages to RNS/BSSs. This information is described in detail in 3GPP TS 23.060.
3. In Receive and handle "Alert MME Notification" and send "Alert MME "Acknowledge" scenarios.
4. When the SGSN sends an UE Activity Notification message over the S3 interface, if the MME sends an Alert MME Notification earlier for the same subscriber and the SGSN detects any UE activity (like Iu connection established and so on).
5. Handling the problem of Mobile Terminated voice calls getting dropped due to NULL SGs or SGs association at MSC/VLR, when the implicit detach timer expires at MME. In this case, the flag "EMM Combined UE Waiting" is set at the SGSN, this ensures waiting for a combined procedure (Combined RAU). A Combined RAU is forced if we receive a normal periodic RAU (non-combined) by sending an IMSI Detach request to UE. When a MME detaches the UE locally from E-UTRAN (due to PTAU timer

expiry and no contact with UE at E-UTRAN till the implicit detach timer expiry at MME) it sends a Detach Notification with cause "local detach" to the SGSN. The SGSN sets the "EMM Combined UE Waiting" flag if UE is CSFB capable and this flag will be reset only after combined RAU is received.

ISR CSFB Procedures

CS Paging Procedure

The call flow below depicts a CS Paging example:

Figure 2: CS Paging

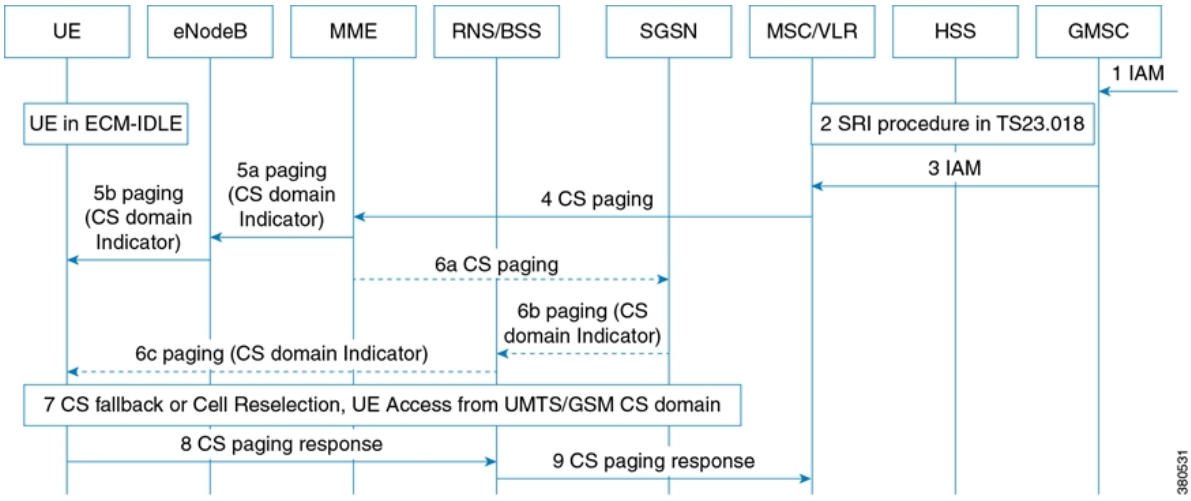


Table 2: Steps in a CS Paging Procedure

Step	Description
1.	A Mobile Terminating call arrives at MSC/VLR (via the G-MSC) for a UE which is camped on E-UTRAN.
2.	If the ISR is active and the SGs interface is active between MSC and MME, then the MSC/VLR sends a Page Request (SGsAP-PAGING-REQUEST) to the MME.
3.	As ISR is active and the UE is in ECM_IDLE state, the MME forwards the CS paging message received from the MSC/VLR to the associated SGSN. The MME receives the SGSN information in the regular ISR activation process. The MME builds a "CS Paging Indication" message, which is a GTPv2 message, from the SGsAP-PAGING_REQUEST to the correct SGSN.

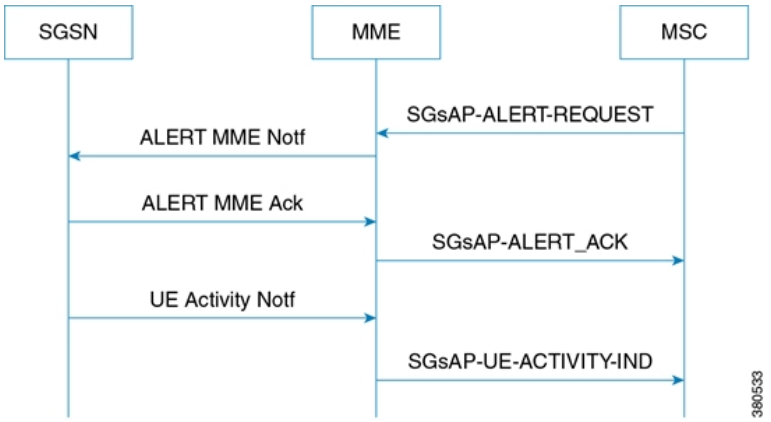
Step	Description
4.	The SGSN receives the CS Paging Indication message from the MME, and sends paging messages to RNS/BSSs.
5.	The RNS/BSS forwards the CS Paging Indication message to the UE.
6.	The CS fallback or Cell re-selection process progresses.
7.	Once the process is complete, the UE sends a CS Paging response to the RNS/BSS.
8.	The RNS/BSS forwards the CS Paging Response to the MSC/VLR.

For detailed information on CS paging procedure refer to 3GPP TS 23.060.

Alert and UE Notification Procedure

The call flow below depicts an Alert and UE Notification scenario:

Figure 3: Alert and UE Notification Procedure 0



1. The MSC/VLR requests the MME to report activity from a specific UE. The MSC/VLR sends a SGsAP Alert Request (IMSI) message to the MME where the UE is currently attached to an EPS network. On receiving the SGsAP Alert Request (IMSI) message, the MME sets a Non-EPS Alert Flag (NEAF). If NEAF is set for an UE, the MME informs the MSC/VLR of the next activity from that UE (and the UE is both IMSI and EPS attached) and clears the NEAF.
2. If ISR is activated for this UE, an "Alert MME Notification" message (GTPv2) is created based on above SGs message and sent on the S3 interface by the MME to the associated SGSN, in order to receive a notification when any activity from the UE is detected.
3. The SGSN sends an "Alert MME Acknowledge" and sets the SSAF flag, the "Alert MME Acknowledge" is a GTPv2 message to the MME in response to the Alert MME Notification message.
4. If any UE Activity is detected (UE is active, after an Iu connection is established), the SGSN sends a "UE Activity Notification message" to the MME over the S3 interface.

ISR De-activation Procedure

When the UE wants to perform a combined RAU/LAU, the SGSN verifies the "combined EPS/IMSI attach capability" bit in MS Network Capability and if it indicates that CSFB and/or SMS over SGs is enabled, then the SGSN de-activates ISR. The SGSN does not indicate that ISR is activated in the RAU Accept message.

Detach Procedures for CSFB Capable UEs

If the MME clears a subscriber then SGs association with the MSC is closed and leads to a drop of voice calls from the MSC. To avoid this issue a few changes are done in SGSN to establish the Gs association between the MSC and the SGSN on ISR de-activation.

If "Detach Notification" is received from the MME with Detach Type set as "Local Detach" and if the UE supports EMM Combined procedures then, the SGSN sends an IMSI Detach request to the UE and sets the "EMM Combined UE Waiting" flag.

If the SGSN then receives a Periodic RAU Request and the flag "EMM Combined UE Waiting" is set, an IMSI Detach is sent to the UE in order to ensure that next time the UE performs a Combined RAU. This enables Gs association between the SGSN and the MSC/VLR and the MT voice calls are not lost.

If the SGSN receives a Combined RAU Request when the flag "EMM Combined UE Waiting" is set, then this flag is cleared and Gs association is activated.

MS Initiated Last PDN De-activation Procedure

The MS initiated last PDN de-activation procedure is listed below:

1. The SGSN sends a DSR with OI=1, the cause not set to ISR deactivated.
2. PDP is deleted from the SGW and the PGW.
3. In SGSN all PDPs are de-activated. The S4 association is cleared.
4. In SGW all PDPs are de-activated. Both the S4 and S11 associations at the SGW are cleared.
5. The MME continues to retain the S11 tunnel.
6. Both the SGSN and MME retain the ISR and S3 tunnel active. The active S3 tunnel serves incoming voice calls if SGs association is retained at the MME.
7. If MME has a SGs association and if periodic TAU timer from UE expires, the MME performs the following actions:
   - The MME starts an implicit detach timer. If voice call is received at MSC/VLR when this timer is running then:
     a. The MSC/VLR sends a SGs page to the MME.
     b. The MME sends an S3 page to the SGSN.
     c. The SGSN pages the UE with the "CN Domain Indicator = CS domain", and if the UE responds to the page by doing a cell re-selection to CS domain, the MSC/VLR stops paging.
     d. The voice call is completed.
   - If the implicit detach timer expires:
     - The MME sends an EPS Detach Notification (IMSI detach) to the MSC/VLR.
     - The MME sends a Detach Notification with cause "Local detach" to the SGSN (Refer to 3GPP TS 23.272v10.08, section 5.3.2 point no. 3).
     - If the UE is "combined EPS/IMSI attach capable" (as derived from MS Network capability) and if ISR is active, the SGSN sends an IMSI detach request to the UE on receiving Detach Notification with cause "local detach".

- The SGSN sets a flag called "EMM Combined UE waiting" (Refer to 3GPP TS 23.272v10.08, section 5.5)
- If the IMSI detach request reaches the UE, the UE performs a Combined RAU, the "EMM Combined UE waiting" flag is cleared at the SGSN and Gs association is established between SGSN and MSC/VLR. ISR is deactivated at the UE.
- If the IMSI detach request does not reach the UE, then on next signaling from the UE based on the "EMM Combined UE waiting" flag being set, following action is taken:

  If an UE performs a periodic RAU or NAS Service Request, then the UE is forced to do an IMSI detach so that the UE does a Combined RAU again to establish Gs association.

PGW Initiated Last PDN De-activation Procedure

Listed below are the sequence of events which occur, if an UE is "combined EPS/IMSI attach capable" and the last PDN is de-activated due to PGW initiated de-activation or HSS initiated de-activation:

1. The SGW forwards the DBR to both the SGSN and the MME.
2. Both MME and SGSN de-activate the PDN, and locally de-activate ISR (Refer to 3GPP TS 23.401 v10.08, section 5.4.4.1 (Note 2 and 3) and 3GPP TS 23.060 v10.801, section 9.2.4.3B).
3. The MME need not send a Detach Notification to the SGSN.
4. Consider the scenario, where the SGSN is aware that it is a PGW initiated last PDN de-activation, the UE is "combined EPS/IMSI attach capable" (as derived from MS Network capability) and ISR was active earlier, the SGSN performs the following actions:
   - If the UE is in a PMM-CONNECTED state at the SGSN, then SGSN sends an IMSI detach request. The SGSN sets a flag called "EMM Combined UE waiting". If the UE receives this IMSI detach request, it performs a combined RAU into SGSN and at that point the Gs association is established and the "EMM Combined UE Waiting" flag is cleared by the SGSN.
   - If the UE is in an IDLE state at the SGSN, then the SGSN pages the UE to deliver the PDP de-activation request. If paging fails, the SGSN sets the "EMM Combined UE Waiting" flag. When this UE performs a combined RAU to SGSN at a later time or attaches to the SGSN, this flag is cleared.
5. If the UE is in an E-UTRAN coverage area then, the MME detaches the UE and the UE is re-attached to the network. If the UE is not in an UTRAN/GERAN coverage area, then the SGSN pages the UE prior to sending IMSI detach. This paging request fails.
6. If the UE does not receive an E-UTRAN detach request or a paging request from the SGSN, and at a later point if the UE returns to the SGSN with a periodic RAU / NAS Service Request, then the SGSN performs the following:
   - The "EMM Combined UE waiting" flag is set, this forces the UE to perform a IMSI detach so that the UE does a Combined RAU again to establish a Gs association.
7. If the UE receives the IMSI detach request sent in step (4), the UE performs a Combined RAU to establish Gs association. On receiving a Combined RAU, the SGSN clears the "EMM Combined UE waiting" flag.

Standards Compliance

The Idle mode signaling reduction complies with the following standards:

- 3GPP TS 23.060, version 10

- 3GPP TS 23.401, version 10
- 3GPP TS 23.272, version 10
- 3GPP TS 29.274, version 10

Configuring ISR with Circuit Switched Fallback

The following commands are used to configure 3G paging cause for CSFB:

```
config
    context context_name
      iups-service iups_service_name
         rnc id rnc_id
            [default | no ] ranap paging-cause-ie mme-signalling
paging_cause_value
          end
```

Where:

- The command **ranap paging-cause-ie mme-signalling** *paging_cause_value* is used to set the Paging Cause IE value for paging from MME due to Circuit Switch Fallback (CSFB). Listed below are the paging cause values which can be set:
  - 0 - Terminating conversational call
  - 1 - Terminating streaming call
  - 2 - Terminating interactive call
  - 3 - Terminating background call
  - 4 - Terminating low priority signaling
  - 5 - Terminating high priority signaling
- The default command resets the specific parameters value to default. In this case it is set to "5 - Terminating high priority signaling".
- The no form of the command suppresses the Paging Cause IE so that it is not included in responses to Paging Requests.

Monitoring and trouble-shooting the CSFB feature

The configuration can be verified by executing the show command **show iups-service**, the following parameter is displayed on executing the command:

- **MME-Signalling : Terminating Low Priority Signalling (4)**

The show command **show subscriber sgsn-only full all** has been updated to include a display for "SSAF" and "Emm_combined_ue_waiting" flags. The new parameters are displayed as below:

- **SSAF : False**
- **EMM Combined UE Waiting Flag : False**