Title

Paging Concept Paper (Version 5)

Source

AT&T Wireless

Abstract

This contribution proposes a concept paper for paging. It uses the following three-part template adopted in GAHW-010241 [16]: identify requirements, recommend concept, and identify impact on specifications.

The requirements section uses the model proposed by Alan Cooper in The Inmates are Running the Asylum – Why High-Tech Products Drive Us Crazy and How to Restore the Sanity.

Questions and comments appear in magenta within angled brackets, e.g., <comment>.

Proposals appear in blue, e.g., proposal.

This contribution is available in Acrobat and Word formats. The Acrobat format is smaller and has fewer display artifacts.

Recommendation

Review, amend, and adopt.

History

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<thead>
<tr>
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<th>Date</th>
<th>Description</th>
<th>Editor</th>
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<td>G2-010016</td>
<td>25 Jun 2001</td>
<td>First draft.</td>
<td>Lucent</td>
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<td>GP-011538</td>
<td>27 Aug 2001</td>
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<td>GAHW-010273</td>
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<td>GP-012335</td>
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<td>AWS</td>
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<td></td>
<td></td>
<td>Remove CCCH. Reduce number of sequences.</td>
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1. Requirements

This document presents paging-related requirements. Based on these requirements, it develops concepts, and from the concepts, assesses the impact on new and existing standards. To focus requirements, it proposes persona, as suggested by Alan Cooper in *The Inmates are Running the Asylum* [1].

1.1 Persona

Lloyd sells specialty automotive parts for Merit, a multinational supplier. His customers include autobody shops, garages, trucking companies, fleet operators, and auto-parts retailers.

Lloyd’s key objective is customer service: customers should be able to phone him at any time and get through to Lloyd or his voice mail. From 08:00 to 19:00, seven days a week, Lloyd returns calls within 2 hours.

Lloyd uses two wireless devices:

- A small handset exclusively used for voice.
  The handset is on 24 hours a day, 7 days a week. It is Lloyd’s key communication device. This handset complies with release-99 specifications for voice terminals. It does not support GPRS.

- A laptop computer for checking stock and processing orders.
  This laptop contains a GPRS PC card that allows wireless data access to Merit’s servers. The computer is only on when Lloyd is entering new orders or checking status of outstanding orders. Lloyd seldom uses e-mail: he prefers to talk to his customers by phone or meet with them in person.

In the future, Lloyd may want a single device that allows him to perform everything he does now. This document assumes the future is now.

1.2 User-based requirements

To increase battery life, paging shall support discontinuous reception.

Incoming voice calls shall be processed whether or not a data session is active.

Incoming data transfers shall be processed whether or not a voice call is active.

1.3 System-based requirements

Since the PCCCH has more signalling capacity than CCCH, any mobile station that is in *MAC-Idle* state and that supports *Iu mode* shall behave as follows:

- If a PCCCH is available, camp on PCCCH.
- Otherwise, camp on CCCH. *Iu-mode* shall not be available.

So the core network and GERAN can establish a signalling link with a mobile station, two types of paging shall be supported: GERAN-initiated and CN-initiated. The mobile station shall be able to determine which network (GERAN or CN) initiated the page.

For efficiency, a single packet paging request should be able to contain pages for *A/Gb-mode* and *Iu-mode* mobile stations.

For flexibility, a mobile station may respond to a page via a dedicated control channel or via a TBF. Note, however, that if a mobile station responds to a circuit page using a TBF, and it reselects to a new cell, it may loose the incoming call.

*Iu-mode* paging shall comply with the concepts in this document.

*A/Gb-mode* paging shall comply with the concepts in 43.064 [7].
1.4 User-based scenarios

The following scenarios will be used to develop the paging concepts in § 2:

• Lloyd receives a voice call. While engaged in the voice call, Lloyd receives an order confirmation.
• Lloyd receives an order confirmation. While engaged in the order confirmation, Lloyd receives a voice call.

1.5 System-based scenarios

GERAN shall initiate a page for the following purposes:

• Locate a mobile station to its serving cell.
• Activate radio bearers.

The CN shall initiate a page for the following purposes:

• Locate a mobile station to its serving BSS.
• Activate radio access bearers.
2. **Concept**

This section uses concepts from X.200 [11], X.210 [12], Z.100 [13], and Z.120 [14]. These concepts are not intended to unnecessarily constrain implementations.

Sequences in this section derive from the requirements and scenarios of § 1. Figures contain the sequence diagrams. A table following each figure describes message events in the sequence, including the values of directly relevant information elements.

<Until 44.118 stabilizes, information elements specified in the tables may be a strange mix of UTRAN and GERAN.>

Within each sequence diagram, the following conventions apply:

- Green arrows indicate unciphered messages.
- Red arrows indicate ciphered messages.
- Dashed arrows indicate optional messages.
- Heavy vertical or diagonal lines indicate a stimulus-response relationship between messages.
- Magenta hexagons indicate PMM and MM states.
- Cyan hexagons indicate RRC states and modes.
- Yellow hexagons indicate MAC states.
- Circles indicate an initiating event.

Unless stated otherwise, the following conditions apply for each sequence:

- The CN and GERAN operate in GERAN Network Operation Mode II: SGSN and MSC are not connected via a Gs interface; circuit pages arrive over the Iu-cs interface. See § A for a description of network-operation modes for GPRS, UMTS, and GERAN.
- The PCCCH supports discontinuous reception according to the formulas described in § B.2.
- MM, PMM, and RRC have the states described in § C.

### 2.1 Incoming circuit voice call – assign dedicated channel

This sequence corresponds to the following user-based scenario:

1. Lloyd receives a voice call. The core network routes the call via the Iu-cs interface. The GERAN RRC assigns a dedicated transport channel for the mobile station to respond to the voice-call page.
   a. No RRC connection exists.
   b. An RRC connection and a PMM connection exist as a result of a previous packet-data transaction.

2. While engaged in the voice call, Lloyd receives an order confirmation. The core network routes the data via the Iu-ps interface. The GERAN RRC uses the existing dedicated transport channel to initiate the data transaction.
   a. No PMM connection exists.
   b. A PMM connection exists as a result of a previous packet-data transaction.

Figure 1 shows the paging-related portions of this scenario.
Figure 1: Incoming circuit voice call

- Packet paging request
- Packet channel request
- Packet dedicated assignment
- RRC connection request
- RRC connection setup
- RRC connection setup complete
- Initial direct transfer
- Initial UE message
- MM Connected
- PMM-Idle
- MAC-Idle
- MAC-Dedicated
- Initial direct transfer
- Initial UE message
- MM Connected
Lloyd receives a voice call when no RRC connection exists. The following initial conditions apply:
- PMM is in PMM-Idle state.
- MM is in MM-Idle state.
- RRC is in RRC-Idle mode.
- MAC is in MAC-Idle state; the mobile station monitors a PCCCH.

The CN non-access stratum requests paging in each GERAN BSS (Base-Station Subsystem) in which the mobile station could be located, i.e., each BSS within the mobile station’s location area.
- CN domain indicator indicates circuit domain.
- Permanent NAS UE identity is the IMSI.
- Temporary UE identity, if included, is the TMSI.
- Paging area ID, if included, is the LAI. If the message contains no paging area ID, the GERAN BSS will page in all cells under its control.
- Paging cause, if included, indicates terminating conversational call.
- Non-searching indication, if included, indicates one of two values:
  - If a signalling connection exists for the other domain, send paging via the connection instead of via the paging channel. Otherwise, send paging via the paging channel. This is the default setting. Unless otherwise stated, this document assumes the default.
  - Always send paging via the paging channel.
- DRX cycle-length coefficient, if included, is used to calculate when the mobile station may be paged. This parameter should only apply to UTRAN mobile stations.

As proposed at the November GERAN2 meeting, discontinuous reception could work as follows:
- The BSS broadcasts a default Split_PG_Cycle on PBCCH. The MS uses this value in RRC-Idle mode. During RRC connection setup, the MS provides to the BSS its specific GERAN split paging cycle. The MS and GERAN use this specific value in RRC-Connected mode.
- The MS would continue to send its Split_PG_Cycle during GPRS attach and routing-area update, but the core network and BSS wouldn’t use this value. Also, the DRX cycle coefficient in RANAP would be ignored. Therefore, RANAP need not be changed.
<table>
<thead>
<tr>
<th>Line</th>
<th>Packet paging request</th>
<th>MS→GERAN MAC PCCCH (PPCH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-10</td>
<td>Packet paging request {page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)}</td>
<td>Since the GERAN RRC is in Idle mode for this IMSI, it does not know where the mobile station is. It therefore has MAC send a CN-initiated packet paging request on all paging channels the mobile station could monitor. Upon receipt of the packet paging request, the MS MAC informs its non-access stratum that the core network has paged it. The MS NAS responds to the page.</td>
</tr>
<tr>
<td></td>
<td>• TBF or dedicated indicates establishment of a dedicated connection.</td>
<td>|  8-10</td>
</tr>
<tr>
<td>12</td>
<td>Packet channel request {establishment cause, random reference}</td>
<td>MS→GERAN MAC PCCCH (PRACH)</td>
</tr>
<tr>
<td>14</td>
<td>Packet dedicated assignment {&lt;parameters&gt;} {page mode, channel description, packet request reference, timing advance, mobile allocation, starting time, IA rest octets (frequency parameters before time)}</td>
<td>MS→GERAN MAC PCCCH (PAGCH)</td>
</tr>
<tr>
<td></td>
<td>The GERAN RRC has MAC assign a dedicated channel. This is a new message.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• &lt;specify parameter settings.&gt;</td>
<td></td>
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<tr>
<td></td>
<td>• Packet request reference comprises the contents of the packet channel request and the frame number in which the GERAN MAC received the packet channel request. It is used to address the mobile station.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>MAC-Dedicated</td>
<td>The MS and GERAN MACs enter MAC-Dedicated state.</td>
</tr>
<tr>
<td>18</td>
<td>RRC connection request {initial UE identity, establishment cause}</td>
<td>MS→GERAN MAC RB0 (SDCCH)</td>
</tr>
<tr>
<td></td>
<td>Since the MS RRC is in RCC-Idle mode, it needs to establish an RRC connection with its GERAN peer. It therefore sends an RRC connection request.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Initial UE identity indicates IMSI, or if available, TMSI.</td>
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<td></td>
<td>• Establishment cause indicates terminating conversational call.</td>
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<tr>
<td>20</td>
<td>RRC connection setup {initial UE identity, RRC transaction identifier, new U-RNTI, RRC state indicator, UTRAN DRX cycle-length coefficient, signalling RB information setup list}</td>
<td>MS→GERAN MAC RB0 (SDCCH)</td>
</tr>
<tr>
<td></td>
<td>The GERAN RRC provides the information needed to support the RRC connection.</td>
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<tr>
<td></td>
<td>• Initial UE identity indicates IMSI, or if available, TMSI.</td>
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<tr>
<td></td>
<td>• RRC transaction identifier identifies the transaction. Subsequent messages in the transaction use this identifier.</td>
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<tr>
<td></td>
<td>• New U-RNTI (in GERAN, G-RNTI) provides the new GERAN Radio Network Temporary Identifier. The identifier applies for the duration of the RRC connection.</td>
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<tr>
<td></td>
<td>• RRC state indicator specifies that the mobile station enter RRC-Cell_Dedicated state.</td>
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<tr>
<td></td>
<td>• UTRAN DRX cycle-length coefficient is used to calculate when the mobile station may be paged while connected to this UTRAN. GERAN will use GERAN split paging cycle. See line 9.</td>
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<td></td>
<td>• Signalling RB information setup list configures the four signaling radio bearers.</td>
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</tr>
<tr>
<td>22</td>
<td>RRC connection setup complete</td>
<td>MS→GERAN RRC RB2 (SDCCH)</td>
</tr>
<tr>
<td></td>
<td><strong>[RRC transaction identifier, START list, UE radio access capability]</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The MS RRC confirms setup of the RRC connection.</td>
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<tr>
<td>24</td>
<td>RRC-Cell_Dedicated</td>
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</tr>
<tr>
<td></td>
<td>The MS and GERAN RRCs enter <strong>RRC-Cell_Dedicated</strong> state. The following radio bearers now exist: RB1 (unacknowledged access-stratum signalling), RB2 (acknowledged access-stratum signalling), RB3 (acknowledged high-priority non-access-stratum signalling), and RB4 (acknowledged low-priority non-access-stratum signalling).</td>
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<td></td>
<td>MS→GERAN RRC RB3 (SDCCH)</td>
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<tr>
<td>27</td>
<td>Initial direct transfer</td>
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<td></td>
<td><strong>[CN domain identity, intra-domain NAS node selector, NAS message]</strong></td>
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<td></td>
<td>The MS RRC initiates a signaling connection to the circuit CN and forwards the MS NAS paging response.</td>
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<tr>
<td>28</td>
<td>Initial UE message</td>
<td>GERAN→CN RANAP Iu-cs</td>
</tr>
<tr>
<td></td>
<td><strong>[CN domain indicator, LAI, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID]</strong></td>
<td></td>
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<tr>
<td></td>
<td>GERAN forwards the page response to the CN.</td>
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<tr>
<td>29</td>
<td>MM-Connected</td>
<td></td>
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<tr>
<td></td>
<td>The core network enters <strong>MM-Connected state</strong>.</td>
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<tr>
<td>34</td>
<td>Sequence 1b</td>
<td></td>
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<tr>
<td></td>
<td>Lloyd receives a voice call when an RRC connection and a PMM connection exist as a result of a previous packet-data transaction. The following initial conditions apply:</td>
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</tr>
<tr>
<td>41</td>
<td>Initiate voice call</td>
<td>CN←TE</td>
</tr>
<tr>
<td></td>
<td>Same as line 8.</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Paging</td>
<td>GERAN→CN RANAP Iu-cs</td>
</tr>
<tr>
<td></td>
<td><strong>[CN domain indicator, permanent NAS UE identity, temporary UE identity, paging area ID, paging cause, non-searching indication, DRX cycle-length coefficient]</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 9.</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td>Description</td>
<td>Source/Target</td>
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<td>------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
</tbody>
</table>
| 43   | Packet paging request  
{page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)}  
Since the GERAN RRC is in RRC-GRA_PCH state for this IMSI, it knows where the mobile station is within a GRA. It therefore has MAC send a GERAN-initiated packet paging request on all paging channels in the GRA.  
- *TBF or dedicated* indicates establishment of a dedicated connection.  
- *Mobile identity* is the mobile station’s G-RNTI.  
- *Channel needed* indicates SDCCCH. It could also indicate TCH.  
*In addition to line 10, the following should be added to the packet paging request:*
- *G-RNTI* as a mobile identity. | MS→GERAN  
MAC  
PCCCH  
(PPCH) |
| 45   | Packet channel request  
{establishment cause, random reference}  
Same as line 12. | MS→GERAN  
MAC  
PCCCH  
(PRACH) |
| 47   | Packet dedicated assignment  
{<parameters>}  
Same as line 14. | MS→GERAN  
MAC  
PCCCH  
(PAGCH) |
| 49   | MAC-Dedicated  
The MS and GERAN MACs enter MAC-Dedicated state. |  |
| 51   | Cell update  
{U-RNTI, START list, AM_RLC error indication (RB2 or RB3), AM_RLC error indication (RB4 and upwards), cell-update cause, RB-timer indicator}  
The MS RRC updates its cell-location information in the GERAN RRC by sending a cell update. The GERAN RRC now knows the mobile station’s location to the cell level instead of the GRA level.  
- *U-RNTI* (in GERAN, G-RNTI) identifies the mobile station.  
- *START list* identifies the CN domain (circuit) and initializes the 20 most-significant bits of the hyperframe numbers.  
- *AM_RLC error indication (RB2 or RB3)* indicates no error.  
- *AM_RLC error indication (RB4 and upwards)* indicates no error.  
- *Cell-update cause* indicates paging response.  
- *RB-timer indicator* indicates if T314 or T315 have expired. These timers relate to radio-link failure. | MS→GERAN  
RRC  
RB1 (SDCCH) |
| 53   | Cell update confirm  
{RRC transaction identifier, activation time, RRC state indicator, UTRAN DRX cycle length coefficient, RLC re-establish indicator (RB2 and RB3), RLC re-establish indicator (RB4 and upwards), <channel and radio-resource configuration information elements (reams of information elements of dubious usefulness)>>}  
The GERAN RRC confirms that it has updated the cell-location information.  
- *RRC transaction identifier* identifies the transaction. Subsequent messages in the transaction use this identifier.  
- *Activation time* indicates when changes signaled by the message take effect. If not included, the default is now.  
- *RRC state indicator* specifies that the mobile station enter RRC-Cell_Dedicated state.  
- *UTRAN DRX cycle-length coefficient* is used to calculate when the mobile station may be paged while connected to this UTRAN. GERAN may use this capability, i.e., DRX cycle length may change when the mobile station moves from RRC Idle mode to RRC connected mode.  
- *RLC re-establish indicator (RB2 and RB3)* indicates that RB2 and RB3 should be re-established.  
- *RLC re-establish indicator (RB4 and upwards)* indicates that RB4 and higher radio bearers should be re-established. | MS→GERAN  
RRC  
RB1 (SDCCH) |
| 55   | RRC-Cell_Dedicated  
The MS and GERAN RRCs enter RRC-Cell_Dedicated state. |  |
<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
<th>Source Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>Initial direct transfer  &lt;br&gt; {CN domain identity, intra-domain NAS node selector, NAS message}  &lt;br&gt; Same as line 27.</td>
<td>MS→GERAN RRC RB3 (SDCCH)</td>
</tr>
<tr>
<td>59</td>
<td>Initial UE message  &lt;br&gt; {CN domain indicator, LAI, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}  &lt;br&gt; Same as line 28.</td>
<td>GERAN→CN RANAP Iu-ps</td>
</tr>
<tr>
<td>60</td>
<td>MM-Connected  &lt;br&gt; The core network enters <strong>MM-Connected state</strong>.</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td><strong>Sequence 2a</strong>  &lt;br&gt; While engaged in the voice call from sequence 1a, Lloyd receives an order confirmation. The following conditions apply:  &lt;br&gt; - PMM is in <strong>PMM-Idle state</strong>.  &lt;br&gt; - MM is in <strong>MM-Connected state</strong>.  &lt;br&gt; - RRC is in <strong>RRC-Cell_Dedicated state</strong>.  &lt;br&gt; - MAC is in <strong>MAC-Dedicated state</strong>.</td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>Initiate data transfer  &lt;br&gt; Lloyd’s server sends a customer-order confirmation.</td>
<td>CN←TE</td>
</tr>
<tr>
<td>77</td>
<td>Paging  &lt;br&gt; {CN domain indicator, permanent NAS UE identity, temporary UE identity, paging area ID, paging cause, non-searching indication, DRX cycle-length coefficient}  &lt;br&gt; Same as line 9 except for the following:  &lt;br&gt; - <strong>CN domain indicator</strong> indicates packet domain.  &lt;br&gt; - <strong>Temporary UE identity</strong>, if included, is the P-TMSI.  &lt;br&gt; - <strong>Paging area ID</strong>, if included, is the RAI. If the message contains no paging area ID, GERAN will page in all cells under its control.  &lt;br&gt; - <strong>Paging cause</strong>, if included, indicates terminating background call.</td>
<td>GERAN→CN RANAP Iu-ps</td>
</tr>
<tr>
<td>78</td>
<td>Dedicated paging request  &lt;br&gt; {RRC transaction identifier, paging cause, CN domain identity, paging record type identifier}  &lt;br&gt; Since the GERAN RRC is in <strong>RRC-Cell_Dedicated</strong> state for this IMSI, it knows where the mobile station is and it has radio bearers established to that mobile station. It therefore sends a CN-initiated <strong>dedicated paging request</strong> on RB2. Upon receipt of the <strong>dedicated paging request</strong>, the MS RRC informs its non-access stratum that the core network has paged it. The MS NAS responds to the page.  &lt;br&gt; - <strong>RRC transaction identifier</strong> identifies the transaction. Subsequent messages in the transaction use this identifier.  &lt;br&gt; - <strong>Paging cause</strong> indicates terminating background call.  &lt;br&gt; - <strong>CN domain identity</strong> indicates packet domain.  &lt;br&gt; - <strong>Paging record type identifier</strong> indicates P-TMSI.  &lt;br&gt; The following should be added to 44.018:  &lt;br&gt; - <strong>A dedicated paging request based on 25.331 paging type 2.</strong></td>
<td>MS→GERAN RRC RB2 (FACCH)</td>
</tr>
<tr>
<td>80</td>
<td>Initial direct transfer  &lt;br&gt; {CN domain identity, intra-domain NAS node selector, NAS message}  &lt;br&gt; The MS RRC initiates a signaling connection to the packet CN and forwards the MS NAS paging response.  &lt;br&gt; - <strong>CN domain identity</strong> indicates packet domain.  &lt;br&gt; - <strong>Intra-domain NAS node selector</strong> indicates the NAS node to which the MS wants to establish a connection.  &lt;br&gt; - <strong>NAS message</strong> contains the service request message indicating paging response.</td>
<td>MS→GERAN RRC RB3 (FACCH)</td>
</tr>
<tr>
<td>81</td>
<td>Initial UE message  &lt;br&gt; {CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}  &lt;br&gt; Same as line 28 except for the following:  &lt;br&gt; - <strong>CN domain indicator</strong> indicates packet domain.  &lt;br&gt; - <strong>RAC</strong> indicates the routing area in which the RRC connection exists.</td>
<td>GERAN→CN RANAP Iu-ps</td>
</tr>
</tbody>
</table>
The core network enters PMM-Connected state.

Sequence 2b

While engaged in the voice call from sequence 1b, Lloyd receives an order confirmation. The following conditions apply:

- PMM is in PMM-Connected state.
- MM is in MM-Connected state.
- RRC is in RRC-Cell_Dedicated state.
- MAC is in MAC-Dedicated state.

Initiate data transfer

Same as line 76.

Data PDU

Since the CN still has an Iu connection for this mobile station, it sends the data PDU to GERAN via the RAB established for this purpose (RABx).

Radio bearer setup

Since the GERAN RRC is in RRC-Cell-Dedicated state for this IMSI, it does not have to page the mobile station. Since the sequence assumes no radio bearer exists for the radio access bearer, RRC configures a radio bearer (RBx) to carry the data.

Radio bearer setup complete

The MS RRC confirms configuration of the radio bearer.

Packet downlink assignment

Under control of the GERAN RRC, the GERAN MAC allocates a downlink TBF.

- G-RNTI is the identity assigned at RRC connection. It is used to address the mobile station.
- MAC mode indicates any of the four allocation modes: dynamic, extended dynamic, fixed, fixed half-duplex.
- RLC mode indicates acknowledged.
- Downlink TFI assignment assigns a TFI for the downlink TBF.

The following should be added to the packet downlink assignment:
- Radio-bearer identity.

MAC-DTM

The MS and GERAN MACs enter MAC-DTM state.
2.2 Incoming circuit voice call – assign shared channel

This sequence corresponds to the following user-based scenario:

1. Lloyd receives a voice call. The core network routes the call via the *Iu-cs* interface. The GERAN RRC assigns a shared transport channel for the mobile station to respond to the voice-call page.

2. While engaged in the voice call, Lloyd receives an order confirmation. The core network routes the data via the *Iu-ps* interface. The GERAN RRC uses the existing dedicated transport channel to initiate the data transaction.

Sequences in this section are deprecated for the following reasons:

- If the mobile station reselects a new cell, the incoming voice call will be lost. <Network control of cell reselection may mitigate this problem.>

Since the sequences are deprecated, they have been abandoned. GP-011538 contains the abandoned sequences.

2.3 Incoming packet voice call – assign dedicated channel

This sequence corresponds to the following user-based scenario:

1. Lloyd receives a voice call. The core network routes the call via the *Iu-ps* interface. The GERAN RRC assigns a dedicated transport channel for the mobile station to respond to the voice-call page.

   a. No RRC connection exists.

   b. An RRC connection and a PMM connection exist as a result of a previous packet-data transaction.

2. While engaged in the voice call, Lloyd receives an order confirmation. The core network routes the data via the *Iu-ps* interface. The GERAN RRC uses the existing dedicated transport channel to initiate the data transaction.

   a. No PMM connection exists.

   b. A PMM connection exists as a result of a previous packet-data transaction.

Figure 2 shows the paging-related portions of this scenario.
Figure 2: Incoming packet voice call
<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
<th>Direction Protocol Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Sequence 1a</strong>&lt;br&gt;Lloyd receives a voice call when no RRC connection exists. The following initial conditions apply:</td>
<td>Protocol Channel</td>
</tr>
<tr>
<td></td>
<td>• PMM is in PMM-Idle state.&lt;br&gt;• MM is in MM-Idle state.&lt;br&gt;• RRC is in RRC-Idle mode.&lt;br&gt;• MAC is in MAC-Idle state; the mobile station monitors a PCCCH.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><strong>INVITE request</strong>&lt;br&gt;Lloyd’s customer calls. The TE calling-user agent initiates the voice call by sending an INVITE request to Lloyd’s SIP URL (Session Initiation Protocol Uniform Resource Locator). Based on the context associated with the URL and the contents of the SIP message, the CN determines that it has to page the mobile station with a paging cause of terminating conversational call. The above has been simplified to protect the sanity of the reader.</td>
<td>CN→TE SIP</td>
</tr>
<tr>
<td>9</td>
<td><strong>Paging</strong>&lt;br&gt;<code>[CN domain indicator, permanent NAS UE identity, temporary UE identity, paging area ID, paging cause, non-searching indication, DRX cycle-length coefficient]</code>&lt;br&gt;Same as figure 1 line 9 with the following exceptions:&lt;br&gt;• The CN requests paging in the mobile station’s routing area, not its location area.&lt;br&gt;• <em>CN domain indicator</em> indicates packet domain.&lt;br&gt;• <em>Temporary UE identity</em>, if included, is the P-TMSI.&lt;br&gt;• <em>Paging area ID</em>, if included, is the RAI. If the message contains no <em>paging area ID</em>, the GERAN BSS will page in all cells under its control.</td>
<td>GERAN→CN RANAP Iu-ps</td>
</tr>
<tr>
<td>10</td>
<td><strong>Packet paging request</strong>&lt;br&gt;<code>[page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)]</code>&lt;br&gt;Same as figure 1 line 10 with the following exceptions:&lt;br&gt;• <em>TBF or dedicated</em> must indicate page request for RR connection establishment, even though P-TMSI may be used. 44.060 § 11.2.10 does not presently allow this.&lt;br&gt;• <em>Mobile identity</em> is the mobile station’s IMSI, or if available, P-TMSI.&lt;br&gt;The following should be changed in the packet paging request:&lt;br&gt;• Support paging with P-TSMI for RR connection establishment.</td>
<td>MS→GERAN MAC PCCCH (PPCH)</td>
</tr>
<tr>
<td>12</td>
<td><strong>Packet channel request</strong>&lt;br&gt;<code>[establishment cause, random reference]</code>&lt;br&gt;Same as figure 1 line 12.</td>
<td>MS→GERAN MAC PCCCH (PRACH)</td>
</tr>
<tr>
<td>14</td>
<td><strong>Packet dedicated assignment</strong>&lt;br&gt;<code>[&lt;parameters&gt;]</code>&lt;br&gt;Same as figure 1 line 14.</td>
<td>MS→GERAN MAC PCCCH (PAGCH)</td>
</tr>
<tr>
<td>16</td>
<td><strong>MAC-Dedicated</strong>&lt;br&gt;The MS and GERAN MACs enter MAC-Dedicated state.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td><strong>RRC connection request</strong>&lt;br&gt;<code>[initial UE identity, establishment cause]</code>&lt;br&gt;Same as figure 1 line 18 with the following exceptions:&lt;br&gt;• <em>Initial UE identity</em> indicates IMSI, or if available, P-TMSI.</td>
<td>MS→GERAN RRC RB0 (SDCCH)</td>
</tr>
<tr>
<td>20</td>
<td><strong>RRC connection setup</strong>&lt;br&gt;<code>[initial UE identity, RRC transaction identifier, new U-RNTI, RRC state indicator, UTRAN DRX cycle-length coefficient, signalling RB information setup list]</code>&lt;br&gt;Same as figure 1 line 20 with the following exceptions:&lt;br&gt;• <em>Initial UE identity</em> indicates IMSI, or if available, P-TMSI.</td>
<td>MS→GERAN RRC RB0 (SDCCH)</td>
</tr>
<tr>
<td>22</td>
<td><strong>RRC connection setup complete</strong>&lt;br&gt;<code>[RRC transaction identifier, START list, UE radio access capability]</code>&lt;br&gt;Same as figure 1 line 22.</td>
<td>MS→GERAN RRC RB2 (SDCCH)</td>
</tr>
<tr>
<td>Line</td>
<td>Description</td>
<td>Diagram</td>
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<tr>
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<tr>
<td>24</td>
<td><strong>RRC-Cell_Dedicated</strong>&lt;br&gt;The MS and GERAN RRCs enter <strong>RRC-Cell_Dedicated</strong> state. The following radio bearers now exist:&lt;br&gt;RB1 (unacknowledged access-stratum signalling), RB2 (acknowledged access-stratum signalling), RB3 (acknowledged high-priority non-access-stratum signalling), and RB4 (acknowledged low-priority non-access-stratum signalling).</td>
<td>MS→GERAN RRC&lt;br&gt;RB3 (SDCCH)</td>
</tr>
<tr>
<td>27</td>
<td><strong>Initial direct transfer</strong>&lt;br&gt;(\text{CN domain identity, intra-domain NAS node selector, NAS message})&lt;br&gt;Same as figure 1 line 27 with the following exceptions:&lt;br&gt;• CN domain identity indicates packet domain.</td>
<td>GERAN→CN&lt;br&gt;RANAP&lt;br&gt;Iu-ps</td>
</tr>
<tr>
<td>28</td>
<td><strong>Initial UE message</strong>&lt;br&gt;(\text{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID})&lt;br&gt;Same as figure 1 line 28 with the following exceptions:&lt;br&gt;• CN domain indicator indicates packet domain.&lt;br&gt;• RAC indicates the routing area in which the RRC connection exists.</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td><strong>PMM-Connected</strong>&lt;br&gt;The core network enters <strong>PMM-Connected state</strong>.</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td><strong>Sequence 1b</strong>&lt;br&gt;Lloyd receives a voice call when an RRC connection and a PMM connection exist as a result of a previous packet-data transaction. The following initial conditions apply:&lt;br&gt;• PMM is in <strong>PMM-Connected state</strong>.&lt;br&gt;• MM is in <strong>MM-Idle state</strong>.&lt;br&gt;• RRC is in <strong>RRC-GRA_PCH state</strong>.&lt;br&gt;• MAC is in <strong>MAC-Idle state</strong>; the mobile station monitors a PCCCH.</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td><strong>INVITE request</strong>&lt;br&gt;Same as line 8.</td>
<td>CN←TE&lt;br&gt;SIP</td>
</tr>
<tr>
<td>42</td>
<td><strong>INVITE request</strong>&lt;br&gt;Since the CN still has an Iu connection for this mobile station, it sends the <strong>INVITE request</strong> to GERAN via the RAB established for this purpose (RABx). The GERAN RRC determines it has no physical-layer resources assigned to the radio bearer that serves RABx.</td>
<td>GERAN←CN&lt;br&gt;GTP&lt;br&gt;RABx (Iu-ps)</td>
</tr>
<tr>
<td>43</td>
<td><strong>Packet paging request</strong>&lt;br&gt;(\text{page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)})&lt;br&gt;Same as figure 1 line 43.</td>
<td>MS←GERAN RRC&lt;br&gt;PCCCH (PPCH)</td>
</tr>
<tr>
<td>45</td>
<td><strong>Packet channel request</strong>&lt;br&gt;(\text{establishment cause, random reference})&lt;br&gt;Same as line 12.</td>
<td>MS→GERAN MAC&lt;br&gt;PCCCH (PRACH)</td>
</tr>
<tr>
<td>47</td>
<td><strong>Packet dedicated assignment</strong>&lt;br&gt;(\text{&lt;parameters}&gt;)&lt;br&gt;Same as line 14.</td>
<td>MS←GERAN MAC&lt;br&gt;PCCCH (PAGCH)</td>
</tr>
<tr>
<td>49</td>
<td><strong>MAC-Dedicated</strong>&lt;br&gt;The MS and GERAN MACs enter <strong>MAC-Dedicated state</strong>.</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td><strong>Cell update</strong>&lt;br&gt;(\text{U-RNTI, START list, AM_RLC error indication (RB2 or RB3), AM_RLC error indication (RB4 and upwards), cell-update cause, RB-timer indicator})&lt;br&gt;Same as figure 1 line 51.</td>
<td>MS→GERAN RRC&lt;br&gt;RB1 (SDCCH)</td>
</tr>
<tr>
<td>Line</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------</td>
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<td></td>
</tr>
</tbody>
</table>
| 53-54 | Cell update confirm  
{RRC transaction identifier, activation time, RRC state indicator, UTRAN DRX cycle length coefficient, RLC re-establish indicator (RB2 and RB3), RLC re-establish indicator (RB4 and upwards), channel and radio-resource configuration information elements (reams of information elements of dubious usefulness)}  
Same as figure 1 line 53 with the following exceptions:  
- Include parameters to configure the radio bearer that will carry RABx traffic (RBx) and to assign resources for that radio bearer. If this is not desirable, GERAN can use a packet dedicated assignment to assign resources for RBx. |
| 55 | RRC-Cell_Dedicated  
The MS and GERAN RRCs enter RRC-Cell_Dedicated state. |
| 57 | INVITE request  
GERAN delivers the INVITE request to the mobile station. |
| 61 | Sequence 2  
While engaged in the voice call from sequence 1a or 1b, Lloyd receives an order confirmation. The following conditions apply:  
- PMM is in PMM-Connected state.  
- MM is in MM-Idle state.  
- RRC is in RRC-Cell_Dedicated state.  
- MAC is in MAC-Dedicated state. |
| 62 | Initiate data transfer  
Same as figure 1 line 76. |
| 63 | RAB assignment request  
{RABs to be setup or modified}  
Since no RAB exists for this PDP context, the CN establishes a new RAB (RABx).  
- RABs to be setup or modified proposes configuration parameters for the new RAB. |
| 64 | Radio bearer setup  
{RRC transaction identifier, starting time, RRC state identifier, GERAN split paging cycle, RB parameters, physical-layer parameters, PDTCH parameters}  
Same as figure 1 line 90. |
| 66 | Radio bearer setup complete  
{RRC transaction identifier, RB parameters}  
Same as figure 1 line 92. |
| 67 | RAB assignment response  
{RABs setup or modified}  
GERAN responds that RABx has been setup.  
- RABs setup or modified confirms the configuration parameters used for the new RAB. |
| 69 | Data PDU  
The CN sends the data PDU to GERAN via the RAB established for this purpose (RABx). |
| 70 | Packet downlink assignment  
{page mode, persistence level, G-RNTI, MAC mode, RLC mode, control ack, timeslot allocation, packet timing advance, P0, BTS pwr-control mode, PR mode, frequency parameters, downlink TFI assignment, power-control parameters, TBF starting time, measurement mapping}  
Same as figure 1 line 94. |
| 72 | MAC-DTM  
The MS and GERAN MACs enter MAC-DTM state. |
| 74 | Data PDU  
GERAN forwards the data to the MS. |
2.4 Incoming packet voice call – assign shared channel

For further study.

2.5 Incoming packet-data transaction – assign shared channel

This sequence corresponds to the following user-based scenario:

1. Lloyd receives an order confirmation. The core network routes the order confirmation via the Iu-ps interface, i.e., the order confirmation is a packet-data transaction. The GERAN RRC assigns a shared transport channel for the mobile station to respond to the page.
   a. No RRC connection exists.
   b. An RRC connection and a PMM connection exist as a result of a previous packet-data transaction.

2. While engaged in the packet-data transaction, Lloyd receives a voice call. The GERAN RRC assigns a dedicated transport channel to process the voice call.
   a. MAC is in MAC-Shared state and the call arrives as packet voice.
   b. MAC is in MAC-Idle state and the call arrives as packet voice.
   c. MAC is in MAC-Shared state and the call arrives as circuit voice.
   d. MAC is in MAC-Idle state and the call arrives as packet voice.

Figure 3 shows the paging-related portions of this scenario.
Assume uplink TBF persists long enough for the MS to complete the transaction on RB2 and RB3. Also assume that RB2 and RB3 use FACCH/Shared on the shared physical channel that carries RB0.

Assume a radio bearer exists for this PDP context, i.e., RBx exists. Should we have multiple causes for GERAN-initiated pages?
Assume PDP context exists, but RABs do not.

Assume PDP context exists, but RABs do not.
<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
<th>Direction Protocol Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Sequence 1a</strong>&lt;br&gt;Lloyd receives an order confirmation when no RRC connection exists. The following initial conditions apply:&lt;br&gt;• PMM is in <strong>PMM-Idle state</strong>.&lt;br&gt;• MM is in <strong>MM-Idle state</strong>.&lt;br&gt;• RRC is in <strong>RRC-Idle mode</strong>.&lt;br&gt;• MAC is in <strong>MAC-Idle state</strong>; the mobile station monitors a PCCCH.</td>
<td>CN←TE</td>
</tr>
<tr>
<td>8</td>
<td><strong>Initiate data transfer</strong>&lt;br&gt;Lloyd’s server sends data confirming a customer order.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><strong>Paging</strong> [CN domain indicator, permanent NAS UE identity, temporary UE identity, paging area ID, paging cause, non-searching indication, DRX cycle-length coefficient]&lt;br&gt;Same as figure 2 line 9 with the following exceptions:&lt;br&gt;• Paging cause indicates terminating background call.</td>
<td>GERAN←CN RANAP Iu-ps</td>
</tr>
<tr>
<td>10</td>
<td><strong>Packet paging request</strong> [page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)]&lt;br&gt;Same as figure 2 line 10 with the following exceptions:&lt;br&gt;• TBF or dedicated indicates TBF establishment.&lt;br&gt;• Channel needed is not sent because this information element only applies to dedicated assignments.</td>
<td>MS←GERAN MAC PCCCH (PPCH)</td>
</tr>
<tr>
<td>12</td>
<td><strong>Packet channel request</strong> [establishment cause, random reference]&lt;br&gt;Under control of the MS RRC, the MS MAC requests a channel to respond to the page.&lt;br&gt;• Establishment cause should indicate a low-priority access for which GERAN should assign a shared channel.</td>
<td>MS←GERAN MAC PCCCH (PRACH)</td>
</tr>
<tr>
<td>14</td>
<td><strong>Packet uplink assignment</strong> [page mode, persistence level, packet-request reference, channel-coding command, TLLI-block channel coding, packet timing advance, frequency parameters, allocation (uplink TFI assignment)]&lt;br&gt;Under control of the GERAN RRC, the GERAN MAC allocates an uplink TBF.&lt;br&gt;• Packet-request reference comprises the contents of the packet channel request and the frame number in which the GERAN MAC received the packet channel request. It is used to address the mobile station.&lt;br&gt;• Uplink TFI assignment assigns a TFI for the uplink TBF.</td>
<td>MS←GERAN MAC PCCCH (PAGCH)</td>
</tr>
<tr>
<td>16</td>
<td><strong>MAC-Shared</strong>&lt;br&gt;The MS and GERAN MACs enter <strong>MAC-Shared state</strong>.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td><strong>RRC connection request</strong> [initial UE identity, establishment cause]&lt;br&gt;Same as figure 2 line 18.</td>
<td>MS←GERAN RRC RB0 (PDTCH)</td>
</tr>
<tr>
<td>20</td>
<td><strong>Packet downlink assignment</strong> [page mode, persistence level, global TFI, MAC mode, RLC mode, control ack, timeslot allocation, packet timing advance, P0, BTS pwr-control mode, PR mode, frequency parameters, downlink TFI assignment, power-control parameters, TBF starting time, measurement mapping]&lt;br&gt;Under control of the GERAN RRC, the GERAN MAC allocates a downlink TBF so that the GERAN RRC can reply.&lt;br&gt;• Global TFI is the uplink TFI assigned in line 14. It is used to address the mobile station.&lt;br&gt;• MAC mode indicates any of the four allocation modes: dynamic, extended dynamic, fixed, fixed half-duplex.&lt;br&gt;• RLC mode indicates acknowledged.&lt;br&gt;• Downlink TFI assignment assigns a TFI for the downlink TBF.</td>
<td>MS←GERAN MAC PACCH</td>
</tr>
<tr>
<td>Line</td>
<td>Description</td>
<td>Message Flows</td>
</tr>
<tr>
<td>------</td>
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</tr>
</tbody>
</table>
| 22   | RRC connection setup  
\{initial UE identity, RRC transaction identifier, new U-RNTI, RRC state indicator, UTRAN DRX cycle-length coefficient, signalling RB information setup list\}  
Same as figure 2 line 20 with the following exceptions:  
\* RRC state indicator specifies that the mobile station enter RRC Cell-Shared state. | MS→GERAN RRC  
RB0 (PDTCH) |
| 24   | RRC connection setup complete  
\{RRC transaction identifier, START list, UE radio access capability\}  
Same as figure 2 line 22. | MS→GERAN RRC  
RB2 (FACCH/S) |
| 26   | RRC-Cell_Shared  
The MS and GERAN RRCs enter RRC-Cell_Shared state. The following radio bearers now exist: RB1 (unacknowledged access-stratum signalling), RB2 (acknowledged access-stratum signalling), RB3 (acknowledged high-priority non-access-stratum signalling), and RB4 (acknowledged low-priority non-access-stratum signalling). | |
| 29   | Initial direct transfer  
\{CN domain identity, intra-domain NAS node selector, NAS message\}  
Same as figure 2 line 27. | MS→GERAN RRC  
RB3 (FACCH/S) |
| 30   | Initial UE message  
\{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID\}  
Same as figure 2 line 28. | GERAN→CN RANAP  
Iu-ps |
| 31   | PMM-Connected  
The core network enters PMM-Connected state. | |
| 36   | Sequence 1b  
Lloyd receives an order confirmation when an RRC connection and a PMM connection exist as a result of a previous packet-data transaction. The following initial conditions apply:  
\* PMM is in PMM-Connected state.  
\* MM is in MM-Idle state.  
\* RRC is in RRC-GRA_PCH state.  
\* MAC is in MAC-Idle state; the mobile station monitors a PCCCH. | |
| 43   | Initiate data transfer  
Same as line 8. | CN→TE |
| 44   | Data PDU  
Since the CN still has an Iu connection for this mobile station, it sends the INVITE request to GERAN via the RAB established for this purpose (RABx). The GERAN RRC determines it has no physical-layer resources assigned to the radio bearer that serves RABx. | GERAN→CN RANAP  
Iu-cs |
| 45   | Packet paging request  
\{page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)\}  
Same as line 10 with the following exception:  
\* An indication that GERAN initiated the page, perhaps with an associated GERAN-initiated paging cause. | MS→GERAN RRC  
PCCCH (PPCH) |
| 47   | Packet channel request  
\{establishment cause, random reference\}  
Same as line 12. | MS→GERAN MAC  
PCCCH (PRACH) |
| 49   | Packet uplink assignment  
\{page mode, persistence level, packet-request reference, channel-coding command, TLLI-block channel coding, packet timing advance, frequency parameters, allocation (uplink TFI assignment)\}  
Same as line 14. | MS→GERAN MAC  
PCCCH (PAGCH) |
| 51   | MAC-Shared  
The MS and GERAN MACs enter MAC-Shared state. | |
<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
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</table>
| 53   | **Cell update**  
[U-RNTI, START list, AM_RLC error indication (RB2 or RB3), AM_RLC error indication (RB4 and upwards), cell-update cause, RB-timer indicator]  
Same as figure 2 line 51. | **MS→GERAN**  
RRC  
RB1  
(FACCH/S) |
| 55   | **Packet downlink assignment**  
[page mode, persistence level, global TFI, MAC mode, RLC mode, control ack, timeslot allocation, packet timing advance, P0, BTS pwr-control mode, PR mode, frequency parameters, downlink TFI assignment, power-control parameters, TBF starting time, measurement mapping]  
Same as line 20. | **MS→GERAN**  
MAC  
PACCH |
| 57   | **Cell update confirm**  
[RRC transaction identifier, activation time, RRC state indicator, UTRAN DRX cycle length coefficient, RLC re-establish indicator (RB2 and RB3), RLC re-establish indicator (RB4 and upwards), channel and radio-resource configuration information elements (reams of information elements of dubious usefulness)]  
Same as figure 1 line 53 with the following exceptions:  
• **RRC state indicator** specifies that the mobile station enter **RRC-Cell_Shared** state. | **MS→GERAN**  
RRC  
RB1  
(FACCH/S) |
| 59   | **RRC-Cell_Shared**  
The MS and GERAN RRCs enter **RRC-Cell_Shared state**. |
| 61   | **Packet downlink assignment**  
[page mode, persistence level, G-RNTI, MAC mode, RLC mode, control ack, timeslot allocation, packet timing advance, P0, BTS pwr-control mode, PR mode, frequency parameters, downlink TFI assignment, power-control parameters, TBF starting time, measurement mapping]  
Same as line 1 line 94.  
If the **packet downlink assignment** at line 55 assigned a TBF for RBx, and the assigned TBF was used by FACCH/S for the cell update, this **packet downlink assignment** could be omitted. | **MS→GERAN**  
MAC  
PACCH |
| 63   | **Data PDU**  
GERAN forwards the data to the MS. | **MS→GERAN**  
PDCP  
RBx (PDTCH) |
| 75   | **Sequence 2a**  
While engaged in the packet-data transaction from sequence 1a or 1b, Lloyd receives a packet voice call. The following conditions apply:  
• **PMM** is in **PMM-Connected state**.  
• **MM** is in **MM-Idle state**.  
• **RRC** is in **RRC-Cell_Shared state**.  
• **MAC** is in **MAC-Shared state**. |
| 76   | **INVITE request**  
Same as figure 2 line 8. | **CN→TE**  
SIP |
| 77   | **RAB assignment request**  
[RABs to be setup or modified]  
Since no RAB exists for this PDP context, the CN establishes a new RAB (RABx).  
• **RABs to be setup or modified** proposes configuration parameters for the new RAB. | **GERAN→CN**  
RANAP  
Iu-PS |
| 78   | **Radio bearer setup**  
[RRC transaction identifier, starting time, RRC state identifier, GERAN split paging cycle, RB parameters, physical-layer parameters, PDTCH parameters]  
Since the GERAN RRC is in **RRC-Cell_Shared state** for this IMSI, it does not have to page the mobile station. Since no radio bearer exists for the radio access bearer, RRC configures a radio bearer (RBx) to carry the data.  
• **<specify parameter settings.>** | **MS→GERAN**  
RRC  
RB2  
(FACCH/S) |
| 80   | **Radio bearer setup complete**  
[RRC transaction identifier, RB parameters]  
The MS RRC confirms configuration of the radio bearer.  
• **<specify parameter settings.>** | **MS→GERAN**  
RRC  
RB2  
(FACCH/S) |
<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
<th>Source/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>RAB assignment response [RABs setup or modified]</td>
<td>GERAN→CN RANAP Iu-ps</td>
</tr>
<tr>
<td></td>
<td>GERAN responds that RABx has been setup.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• RABs setup or modified confirms the configuration parameters used for the new RAB.</td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>INVITE request</td>
<td>GERAN←CN GTP RABx (Iu-ps)</td>
</tr>
<tr>
<td></td>
<td>The CN sends the INVITE request to GERAN via the RAB established for this purpose (RABs). The GERAN RRC determines it has no physical-layer resources assigned to the radio bearer that serves RABx.</td>
<td></td>
</tr>
<tr>
<td>83</td>
<td>Packet dedicated assignment [parameters]</td>
<td>MS←GERAN MAC PACCH</td>
</tr>
<tr>
<td></td>
<td>The GERAN RRC has MAC assign a dedicated channel.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• &lt;specify parameter settings.&gt;</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>RRC-Cell_Dedicated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The MS and GERAN RRCs enter RRC-Cell_Dedicated state.</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>MAC-DTM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The MS and GERAN MACs enter MAC-DTM state.</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>INVITE request</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GERAN delivers the INVITE request to the mobile station.</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>Sequence 2b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>While engaged in the packet-data transaction from sequence 1a or 1b, Lloyd receives a packet voice call. The following conditions apply:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PMM is in PMM-Connected state.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• MM is in MM-Idle state.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• RRC is in RRC-Cell_Shared state.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• MAC is in MAC-Idle state.</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>INVITE request</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 76.</td>
<td>CN←TE SIP</td>
</tr>
<tr>
<td>89</td>
<td>RAB assignment request [RABs to be setup or modified]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 77.</td>
<td>GERAN←CN RANAP Iu-ps</td>
</tr>
<tr>
<td>90</td>
<td>Packet dedicated assignment [parameters]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Based on information received in the RAB assignment request, the GERAN RRC determines that a dedicated channel is the best choice and has MAC assign a dedicated channel.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• &lt;specify parameter settings.&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;Can this message assign a dedicated channel for a radio bearer (RBx) that will be setup at line 103? Until RBs is setup, RRC could use the FACCH for RB2 signalling.&gt;</td>
<td></td>
</tr>
<tr>
<td>91</td>
<td>RRC-Cell_Dedicated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The MS and GERAN RRCs enter RRC-Cell_Dedicated state.</td>
<td></td>
</tr>
<tr>
<td>92</td>
<td>MAC-Dedicated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The MS and GERAN MACs enter MAC-Dedicated state.</td>
<td></td>
</tr>
<tr>
<td>93</td>
<td>Radio bearer setup [RRC transaction identifier, starting time, RRC state identifier, GERAN split paging cycle, RB parameters, physical-layer parameters, PDTCH parameters]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 78 with the following exceptions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• RRC is in RRC-Dedicated state.</td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>Radio bearer setup complete [RRC transaction identifier, RB parameters]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 80.</td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>INVITE request</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 76.</td>
<td></td>
</tr>
<tr>
<td>96</td>
<td>RAB assignment request [RABs to be setup or modified]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 77.</td>
<td></td>
</tr>
<tr>
<td>97</td>
<td>Packet dedicated assignment [parameters]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Based on information received in the RAB assignment request, the GERAN RRC determines that a dedicated channel is the best choice and has MAC assign a dedicated channel.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• &lt;specify parameter settings.&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;Can this message assign a dedicated channel for a radio bearer (RBx) that will be setup at line 103? Until RBs is setup, RRC could use the FACCH for RB2 signalling.&gt;</td>
<td></td>
</tr>
<tr>
<td>98</td>
<td>RRC-Cell_Dedicated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The MS and GERAN RRCs enter RRC-Cell_Dedicated state.</td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>MAC-Dedicated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The MS and GERAN MACs enter MAC-Dedicated state.</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>Radio bearer setup [RRC transaction identifier, starting time, RRC state identifier, GERAN split paging cycle, RB parameters, physical-layer parameters, PDTCH parameters]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 78 with the following exceptions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• RRC is in RRC-Dedicated state.</td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>Radio bearer setup complete [RRC transaction identifier, RB parameters]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as line 80.</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td></td>
</tr>
</tbody>
</table>
| 106  | RAB assignment response  
   ![RABs setup or modified]  
   Same as line 81.  
   | GERAN→CN  
   RANAP  
   Iu-ps |
| 108  | INVITE request  
   The CN sends the INVITE request to GERAN via the RAB established for this purpose (RABx).  
   | GERAN←CN  
   GTP  
   RABx (Iu-ps) |
| 109  | INVITE request  
   Same as line 90.  
   | MS←GERAN  
   PDCP  
   RBx (PDTCH) |
| 113  | **Sequence 2c**  
   While engaged in the packet-data transaction from sequence 1a or 1b, Lloyd receives a circuit voice call. The following conditions apply:  
   - PMM is in **PMM-Connected state**.  
   - MM is in **MM-Idle state**.  
   - RRC is in **RRC-Cell_Shared state**.  
   - MAC is in **MAC-Shared state**.  
   |  
| 114  | Initiate voice call  
   Same as figure 1 line 8.  
   | CN←TE |
| 115  | Paging  
   ![CN domain indicator, permanent NAS UE identity, temporary UE identity, paging area ID, paging cause, non-searching indication, DRX cycle-length coefficient]  
   Same as figure 1 line 9.  
   | GERAN←CN  
   RANAP  
   Iu-cs |
| 116  | Packet dedicated assignment  
   ![<parameters>]  
   Same as figure 1 line 14.  
   | MS←GERAN  
   MAC  
   PACCH |
| 118  | RRC-Cell_Dedicated  
   The MS and GERAN RRCs enter **RRC-Cell_Dedicated state**.  
   |  
| 120  | MAC-DTM  
   The MS and GERAN MACs enter **MAC-DTM state**.  
   |  
| 122  | Dedicated paging request  
   ![RRC transaction identifier, paging cause, CN domain identity, paging record type identifier]  
   Since the GERAN RRC is in **RRC-Cell_Dedicated state** for this IMSI, it knows where the mobile station is and it has radio bearers established to that mobile station. It therefore sends a CN-initiated **dedicated paging request** on RB2. Upon receipt of the **dedicated paging request**, the MS RRC informs its non-access stratum that the core network has paged it. The MS NAS responds to the page.  
   - **RRC transaction identifier** identifies the transaction. Subsequent messages in the transaction use this identifier.  
   - **Paging cause** indicates terminating conversational call.  
   - **CN domain identity** indicates circuit domain.  
   - **Paging record type identifier** indicates TMSI.  
   | MS←GERAN  
   RRC  
   RB2 (SDCCH) |
| 124  | Initial direct transfer  
   ![CN domain identity, intra-domain NAS node selector, NAS message]  
   Same as figure 1 line 27.  
   | MS→GERAN  
   RRC  
   RB3 (SDCCH) |
| 125  | Initial UE message  
   ![CN domain indicator, LAI, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID]  
   Same as figure 1 line 28.  
   | GERAN→CN  
   RANAP  
   Iu-cs |
| 126  | MM-Connected  
   The core network enters MM-Connected state.  
   |  

<table>
<thead>
<tr>
<th>Line</th>
<th>Sequence 2d</th>
<th>While engaged in the packet-data transaction from sequence 1a or 1b, Lloyd receives a circuit voice call. The following conditions apply:</th>
</tr>
</thead>
</table>
|      |             | • PMM is in **PMM-Connected state**.  
|      |             | • MM is in **MM-Idle state**.  
|      |             | • RRC is in **RRC-Cell_Shared state**.  
|      |             | • MAC is in **MAC-Idle state**.  |
| 131  |             | **_initiate voice call**  
|      |             | Same as line 114.  |
| 132  |             | **paging**  
|      |             | Same as line 114.  |
| 133  |             | **packet dedicated assignment**  
|      |             | Same as line 115.  |
| 134  |             | **RRC-Cell_Dedicated**  
|      |             | The MS and GERAN RRCs enter **RRC-Cell_Dedicated state**.  |
| 136  |             | **MAC-DTM**  
|      |             | The MS and GERAN MACs enter **MAC-DTM state**.  |
| 140  |             | **Dedicated paging request**  
|      |             | Same as line 122.  |
| 142  |             | **Initial direct transfer**  
|      |             | Same as line 124.  |
| 143  |             | **Initial UE message**  
|      |             | Same as line 125.  |
| 144  |             | **MM-Connected**  
|      |             | The core network enters MM-Connected state.  |
3. Impact on specifications

This section is incomplete. This section should be revisited when previous sections stabilize.

3.1 Changes to 23.060 (GPRS stage 2)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;Are we going to update this standard or leave it alone?&gt;</td>
</tr>
</tbody>
</table>

3.2 Changes to 24.008 (CN protocols)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.2.15</td>
<td>Location updating request</td>
</tr>
<tr>
<td></td>
<td>Add DRX parameter. DRX parameter is already specified in § 10.5.5.6.</td>
</tr>
<tr>
<td>10.5.1.4</td>
<td>Mobile identity</td>
</tr>
<tr>
<td></td>
<td>Add G-RNTI as a mobile identity.</td>
</tr>
</tbody>
</table>

3.3 Changes to 25.413 (UTRAN RANAP)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3</td>
<td>Abbreviations</td>
</tr>
<tr>
<td></td>
<td>Add GERAN.</td>
</tr>
<tr>
<td></td>
<td>Add mobile station to definition of UE.</td>
</tr>
<tr>
<td>8.15</td>
<td>Paging</td>
</tr>
<tr>
<td></td>
<td>Update section to include GERAN paging. Add SPLIT_PG_CYCLE.</td>
</tr>
<tr>
<td>9.1.23</td>
<td>Paging</td>
</tr>
<tr>
<td></td>
<td>Add SPLIT_PG_CYCLE.</td>
</tr>
<tr>
<td>9.2</td>
<td>Information-element definitions</td>
</tr>
<tr>
<td></td>
<td>Add SPLIT_PG_CYCLE.</td>
</tr>
</tbody>
</table>
### 3.4 Changes to 44.018 (GERAN RRC)

This section proposes changes to GP-011262 (Draft CR to 44.018 due to RRC Part 1 [Nokia]) and GP-011196 (Draft CR to 44.018 due to RRC Part 2 [Nokia]).

This section will have to be updated to reflect the structure of 44.118.

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
</table>
| 3.3.2.1 | Paging initiation by the network  
<Do we need to specify what to do with new information elements in the paging requests?> |
| 3.3.2.2 | Paging response  
<Changes to this section specify the following: In Iu mode, the upper layer is informed that RRC entity entered the RRC-Cell_Dedicated state. RRC does not enter this state until the RRC connection is established, long after the paging response.> |
| 3.5.1.1 | Packet paging initiation by the network  
<Do we need to specify what to do with new information elements in the packet paging request?> |
| 3.4 | Procedures in RR dedicated mode  
Add subsection specifying paging in RRC-Cell_Dedicated state. See 25.331 § 8.1.11, UE dedicated paging.  
<How does this relate to 44.018 § 3.4.22.2, Packet notification procedure in dedicated mode?> |
| 9.1 | Paging  
Add a paging message based on 25.331 paging type 2. |
| 9.1.22 | Paging request type 1  
For both mobile identities, add the following to the paging request type 1:  
- An implicit indication of which network element initiated the page: CN or GERAN. The presence of paging cause indicates a CN-initiated page; the absence of paging cause indicates a GERAN-initiated page. This requires that GERAN fabricate a paging cause if the CN does not provide a paging cause in the RANAP paging message.  
- An indication of which core network initiated the page: circuit-domain or packet-domain. If paging with IMSI, include this element. If paging with P-TMSI or TMSI, omit the element since the identity implicitly indicates the network initiating the page.  
- Paging cause from the RANAP paging message.  
<Do we have enough message length to modify paging request type 1, type 2, and type 3? If not, we may want to define a new Iu-mode paging message.> |
| 9.1.23 | Paging request type 2  
Add the following to the paging request type 2:  
- For mobile identities 1 through 3, an implicit indication of which network element initiated the page: CN or GERAN.  
- For mobile identity 3, an indication of which core network initiated the page: circuit-domain or packet-domain. If paging with IMSI, include this element. If paging with P-TMSI or TMSI, omit the element since the identity implicitly indicates the network initiating the page.  
- For mobile identities 1 through 3, paging cause from the RANAP paging message. |
| 9.1.24 | Paging request type 3  
For all four mobile identities, add the following to the paging request type 3:  
- An implicit indication of which network element initiated the page: CN or GERAN.  
- Paging cause from the RANAP paging message. |
| 10.5.2.23 | P1 rest octets  
Packet page indication 1 applies when paging with G-RNTI.  
Delete the requirement that Packet page indication 1 be ignored if the mobile identity is not IMSI. |
| 10.5.2.24 | P2 rest octets  
Packet page indication 3 applies when paging with G-RNTI.  
Delete the requirement that Packet page indication 3 be ignored if the mobile identity is not IMSI. |
| | Add a procedure for physical-channel reconfiguration.  
Add a physical-channel reconfiguration message based on the 25.331 message of the same name.  
Add a physical-channel reconfiguration complete message based on the 25.331 message of the same name. |
### 3.5 Changes to 44.060 (GERAN RLC/MAC)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
</table>
| 6       | Paging procedures  
Change title to *Paging procedures in A/Gb mode.* |
| 6a      | Add new section: *Paging procedures in Iu mode.* |
| 11.2.10 | Packet paging request  
Add the following information elements to the *packet paging request*:  
- An implicit indication of which network element initiated the page: CN or GERAN. The presence of *paging cause* indicates a CN-initiated page; the absence of *paging cause* indicates a GERAN-initiated page. This requires that GERAN fabricate a *paging cause* if the CN does not provide a *paging cause* in the RANAP *paging* message.  
- An indication of which core network initiated the page: circuit-domain or packet-domain. If paging with IMSI, include this element. If paging with P-TMSI or TMSI, omit the element since the identity implicitly indicates the network initiating the page.  
- *Paging cause* from the RANAP *paging* message.  
- G-RNTI as a mobile identity.  
Change the following:  
- Support paging with P-TSMI for RR connection establishment. |
| 12      | Information-element coding |

### 3.6 Changes to 45.002 (L1 Multiplexing)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
</table>
| 6.5.6   | Determination of PCCCH_GROUP and PAGING_GROUP for MS in GPRS attached mode  
Specify that this section applies to mobile stations operating in *Iu mode.* |
4. References


2. 3GPP TS 23.060. *3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS); Service description; Stage 2.*

3. 3GPP TS 24.008. *3rd Generation Partnership Project; Technical Specification Group Core Network; Mobile radio interface layer 3 specification; Core Network Protocols - Stage 3.*


7. 3GPP TS 43.064. *3rd Generation Partnership Project; Technical Specification Group GERAN; Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Overall description of the GPRS radio interface; Stage 2.*


9. 3GPP TS 44.060. *3rd Generation Partnership Project; Technical Specification Group GSM EDGE Radio Access Network; General Packet Radio Service (GPRS); Mobile Station (MS) – Base Station System (BSS) interface; Radio Link Control / Medium Access Control (RLC/MAC) protocol.*

10. 3GPP TS 45.002. *3rd Generation Partnership Project; Technical Specification Group GERAN; Digital cellular telecommunications system (Phase 2+); Multiplexing and multiple access on the radio path.*


17. GP-010679. *Analysis of GERAN Iu-mode paging scenarios.* Biarritz: Lucent, 02 Apr 01.
A. Network-operation modes

A.1 GPRS

GPRS operates in one of three modes:

- **Mode I** has a Gs interface between MSC and SGSN. For mobile stations attached to both domains, the MSC sends circuit pages via the SGSN, i.e., a BSSGP paging message on the Gb interface. The SGSN sends packet pages directly to the BSS, i.e., a BSSGP paging message on the Gb interface. The BSS pages the mobile station via the following channel: PACCH if available, else PCCCH if available, else CCCH.

- **Mode II** has no Gs interface between MSC and SGSN. The MSC sends circuit pages directly to the BSS, i.e., a BSSAP paging message on the A interface. The SGSN sends circuit pages directly to the BSS, i.e., a BSSGP paging message on the Gb interface. The BSS pages the mobile station via the CCCH.

- **Mode III** has no Gs interface between MSC and SGSN. The MSC sends circuit pages directly to the BSS, i.e., a BSSAP paging message on the A interface. The SGSN sends circuit pages directly to the BSS, i.e., a BSSGP paging message on the Gb interface. The BSS sends circuit pages via the CCCH. It sends packet pages via the PCCCH if available, else CCCH.

A.2 UMTS

UMTS operates in one of two modes:

- **Mode I** has a Gs interface between MSC and SGSN. For mobile stations attached to both domains, the MSC sends circuit pages via the SGSN, i.e., a RANAP paging message on the Iu-ps interface. The SGSN sends packet pages directly to UTRAN, i.e., a RANAP paging message on the Iu-ps interface.

- **Mode II** has no Gs interface between MSC and SGSN. The MSC sends circuit pages directly to UTRAN, i.e., a RANAP paging message on the Iu-cs interface. The SGSN sends packet pages directly to UTRAN, i.e., a RANAP paging message on the Iu-ps interface.

A.3 GERAN

This concept paper proposes that GERAN operate in any one of the following modes:

- **Mode I** has a Gs interface between MSC and SGSN. For mobile stations attached to both domains, the MSC sends circuit pages via the SGSN, i.e., a RANAP paging message on the Iu-ps interface. The SGSN sends packet pages directly to the GERAN, i.e., a RANAP paging message on the Iu-ps interface. GERAN pages the mobile station via the following channel: PACCH if available, else PCCCH.

- **Mode II** has no Gs interface between MSC and SGSN. The MSC sends circuit pages directly to GERAN, i.e., a RANAP paging message on the Iu-cs interface. The SGSN sends packet pages directly to GERAN, i.e., a RANAP paging message on the Iu-ps interface. GERAN pages the mobile station via the following channel: PACCH if available, else PCCCH.

<If the mobile station signals DRX parameters at circuit-domain attach and location-area update, why do we need mode I?>
B. Paging equations

This annex describes several complicated methods of hashing mobile stations over available paging channels. Why wasn’t one simple method good enough? It’s not the ETSI/3GPP way: never use a nail when you can specify multidimensional impact-inserted flexible attachment functionality.

B.1 CCCH

3GPP TS 45.002 [10] specifies the information on which these equations are based.

B.1.1 Paging blocks per CCCH multiframe ($N_m$)

The following equation calculates the number of paging blocks per CCCH 51-multiframe.

$$N_m = 9 - 6 \times BS_{CCCH\_SDCCH\_COMB} - BS_{AG\_BLKS\_RES}$$

where:

- $N_m$ = number of paging blocks per CCCH 51-multiframe.
- $BS_{CCCH\_SDCCH\_COMB}$ = SDCCH combined with CCCH (1) or not (0). Broadcast variable ($CCCH\_CONF$).
- $BS_{AG\_BLKS\_RES}$ = number of blocks per common control channel not available for paging (0 to 7). Broadcast variable.

B.1.2 Paging blocks per CCCH ($N_c$, $M_c$)

For GPRS-detached mobile stations, the following equation calculates the number of paging blocks per CCCH.

$$N_c = BS_{PA\_MFRMS} \times N_m$$

where:

- $N_c$ = number of paging blocks per common control channel.
- $BS_{PA\_MFRMS}$ = number of 51-multiframes between pages to the same mobile station (2 to 9). Broadcast variable.
- $N_m$ = number of paging blocks per CCCH 51-multiframe.

For GPRS-attached mobile stations, the following equation calculates the number of packet paging blocks per CCCH. If the CCCH does not support this type of paging, the preceding equation applies.

$$M_c = 64 \times N_m$$

where:

- $M_c$ = number of packet paging blocks per common control channel.
- $N_m$ = number of paging blocks per CCCH 51-multiframe.
B.1.3 Paging blocks per cell ($N_t$, $M_t$)

For GPRS-detached mobile stations, the following equation calculates the number of paging blocks for all common control channels in a cell.

$$N_t = BS\_CC\_CHANS \ast N_c$$

where:

- $N_t$ = total number of paging blocks per cell.
- $BS\_CC\_CHANS$ = number of common control channels (1 to 4). Broadcast variable ($CCCH\_CONF$).
- $N_c$ = number of paging blocks per common control channel.

For GPRS-attached mobile stations, the following equation calculates the number of packet paging blocks for all common control channels in a cell. If the CCCH does not support this type of paging, the preceding equation applies.

$$M_t = BS\_CC\_CHANS \ast M_c$$

where:

- $M_t$ = total number of packet paging blocks per cell.
- $BS\_CC\_CHANS$ = number of common control channels (1 to 4). Broadcast variable ($CCCH\_CONF$).
- $M_c$ = number of packet paging blocks per common control channel.

B.1.4 Monitored CCCH

The following equation calculates which CCCH a mobile station shall monitor.

$$CCCH\_GROUP = \left(\left[IMSI \mod 1000\right] \mod N_t\right) \div N_c$$

where:

- $CCCH\_GROUP$ = the common control channel to be monitored by the mobile station (0 to $BS\_CC\_CHANS - 1$).
- $IMSI$ = international mobile-subscriber identity.
- $N_t$ = total number of paging blocks per cell.
- $N_c$ = number of paging blocks per common control channel.

Why does this hash function require three modulo or div operations instead of just one modulo operation based on the number of CCCHs, i.e., $CCCH\_GROUP = IMSI \mod BS\_CC\_CHANS$?
B.1.5 Monitored paging block on CCCH

For GPRS-detached mobile stations, the following equation calculates which paging block to monitor on the monitored common control channel.

\[
PAGING\_GROUP = \left(\left(IMS\, \text{mod} \, 1000\right) \text{mod} \, N_c\right) \text{mod} \, N_c
\]

where:

- \(PAGING\_GROUP\) = the group of paging blocks the mobile station shall monitor.
- \(IMS\) = international mobile-subscriber identity.
- \(N_t\) = total number of paging blocks per cell.
- \(N_c\) = number of paging blocks per common control channel.

For GPRS-attached mobile stations, the following equation calculates which paging block to monitor on the monitored common control channel. If the CCCH does not support this type of paging, the preceding equation applies.

\[
PAGING\_GROUP = \left(\left(\left(IMS\, \text{mod} \, 1000\right) \text{div} \, N_t + N_c + \max\{m * N_c \text{ div } SPLIT\_PG\_CYCLE, m\}\right) \text{mod} \, M_c\right)
\]

where:

- \(PAGING\_GROUP\) = the group of paging blocks the mobile station shall monitor.
- \(IMS\) = international mobile-subscriber identity.
- \(N_t\) = total number of paging blocks per cell.
- \(N_c\) = number of paging blocks per common control channel.
- \(m\) = 0, 1 … \(\min\{M_c, SPLIT\_PG\_CYCLE\} - 1\).
- \(M_c\) = number of packet paging blocks per common control channel.

\(SPLIT\_PG\_CYCLE\) = the divisor for the period between pages to a mobile station, where the period is expressed in \(M_c\) packet paging blocks, e.g.: if \(SPLIT\_PG\_CYCLE = 1\), GERAN will page the mobile station every \(M_c\) blocks (every 64 multiframes); if \(SPLIT\_PG\_CYCLE = 2\), GERAN will page the mobile station every \(M_c/2\) blocks (every 32 multiframes); if \(SPLIT\_PG\_CYCLE = 64\), GERAN will page the mobile station every \(M_c/64\) blocks (every multiframe). Any time \(SPLIT\_PG\_CYCLE\) is set greater than or equal to \(M_c\), GERAN will page the mobile station in every packet paging block. GERAN and the mobile station establish the value of \(SPLIT\_PG\_CYCLE\) during GPRS attach. \(SPLIT\_PG\_CYCLE\) can take one of the following values: 1 to 64, 71, 72, 74 … 352, 704. For the CCCH, \(SPLIT\_PG\_CYCLE\) is not allowed to exceed 32.
B.1.6 Paging multiframe

For GPRS-detached mobile stations, when the following equation is true, the mobile station may be paged within the multiframe containing \( FN \).

\[
PAGING\_GROUP \div N_{m} = (FN \div 51) \mod (BS\_PA\_MFRMS)
\]

where:

- \( PAGING\_GROUP \): the group of paging blocks the mobile station shall monitor.
- \( N_{m} \): number of paging blocks per CCCH 51-multiframe.
- \( FN \): frame number.
- \( BS\_PA\_MFRMS \): number of 51-multiframes between pages to the same mobile station (2 to 9). Broadcast variable.

For GPRS-attached mobile stations, when the following equation is true, the mobile station may be paged within the multiframe containing \( FN \). If the CCCH does not support this type of paging, the preceding equation applies.

\[
PAGING\_GROUP \div N_{m} = (FN \div 51) \mod 64
\]

where:

- \( PAGING\_GROUP \): the group of paging blocks the mobile station shall monitor.
- \( N_{m} \): number of paging blocks per CCCH 51-multiframe.
- \( FN \): frame number.

B.1.7 Paging-block index \((i)\)

The following equation calculates the index to the paging block in which the mobile station may be paged, \( i.e., \) a calculated value of 0 indicates B0 (block 0).

\[
i = PAGING\_GROUP \mod N_{m}
\]

where:

- \( i \): the index to the paging block within the 51-multiframe.
- \( PAGING\_GROUP \): the group of paging blocks the mobile station shall monitor.
- \( N_{m} \): number of paging blocks per CCCH 51-multiframe.
B.2  PCCCH

3GPP TS 45.002 [10] specifies the information on which these equations are based.

B.2.1  Paging blocks per PCCCH multiframe ($N_{pm}$)

The following equation calculates the number of paging blocks per PCCCH 52-multiframe.

\[ N_{pm} = 12 - BS\_PAG\_BLKS\_RES - BS\_PBCCH\_BLKS \]

where:

- $N_{pm}$ = number of paging blocks per PCCCH 52-multiframe.
- $BS\_PAG\_BLKS\_RES$ = number of blocks per PCCCH not available for paging (0 to 12). Broadcast variable.
- $BS\_PBCCH\_BLKS$ = number of blocks per 52-multiframe reserved for PBCCH. Broadcast variable.

B.2.2  Paging blocks per PCCCH ($M_{pc}$)

The following equation calculates the number of paging blocks per PCCCH.

\[ M_{pc} = 64 \times N_{pm} \]

where:

- $M_{pc}$ = number of paging blocks per PCCCH.
- $N_{pm}$ = number of paging blocks per PCCCH 52-multiframe.

B.2.3  Paging blocks per cell ($N_{pt}$)

The following equation calculates the number of paging blocks for all PCCCHs in a cell.

\[ N_{pt} = BS\_PCC\_CHANS \times M_{pc} \]

where:

- $N_{pt}$ = total number of paging blocks per cell.
- $BS\_PCC\_CHANS$ = number of PCCCHs (1 to 16). Broadcast variable.
- $M_{pc}$ = number of paging blocks per PCCCH.

B.2.4  Monitored PCCCH

The following equation calculates which PCCCH a mobile station shall monitor.

\[ PCCCH\_GROUP = (IMSI \mod 1000) \mod BS\_PCC\_CHANS \]

where:

- $PCCCH\_GROUP$ = the PCCCH to be monitored by the mobile station (0 to $BS\_PCC\_CHANS - 1$).
- $BS\_PCC\_CHANS$ = number of PCCCHs (1 to 16). Broadcast variable.
B.2.5 Monitored paging block on PCCCH

The following equation calculates which paging block a GPRS-attached mobile station shall monitor on the monitored PCCCH.

\[
PAGING\_GROUP = \left( \left\lfloor \frac{IMSI \mod 1000}{N_{pt}} \right\rfloor \ast N_{pc} + \left( \frac{IMSI \mod 1000}{N_{pc}} \right) \ast \left( \text{max} \left[ \left( m \ast M_{pc} \right) \div SPLIT\_PG\_CYCLE, m \right] \right) \mod M_{pc} \right) \mod M_{pc}
\]

where:

- \( PAGING\_GROUP \) = the group of packet paging blocks the mobile station shall monitor.
- \( IMSI \) = international mobile-subscriber identity.
- \( N_{pt} \) = total number of packet paging blocks per cell.
- \( N_{pc} \) = number of paging blocks per PCCCH.
- \( m \) = 0, 1 … \( \min \left( M_{pc}, SPLIT\_PG\_CYCLE \right) - 1 \).
- \( M_{pc} \) = number of paging blocks per PCCCH.
- \( SPLIT\_PG\_CYCLE \) = the divisor for the period between pages to a mobile station, where the period is expressed in \( M_{pc} \) packet paging blocks.

B.2.6 Paging multiframe

When the following equation is true, the mobile station may be paged within the multiframe containing \( FN \).

\[
PAGING\_GROUP \mod N_{pm} = \left( FN \div 52 \right) \mod 64
\]

where:

- \( PAGING\_GROUP \) = the group of paging blocks the mobile station shall monitor.
- \( N_{pm} \) = number of paging blocks per PCCCH 52-multiframe.
- \( FN \) = frame number.

B.2.7 Paging-block index (\( i \))

The following equation calculates the index to the paging block in which the mobile station may be paged, i.e., a calculated value of 0 indicates B0 (block 0).

\[
i = PAGING\_GROUP \mod N_{pm}
\]

where:

- \( i \) = the index to the paging block within the 52-multiframe.
- \( PAGING\_GROUP \) = the group of paging blocks the mobile station shall monitor.
- \( N_{pm} \) = number of paging blocks per PCCCH 52-multiframe.
B.3 UTRAN

The following equation calculates the system frame number of the first frame of the paging block in which the mobile station will be paged [4].

\[ P = \left( \text{IMSI} \div K \right) \mod (\text{DRX} \div \text{PBP}) \ast \text{PBP} + \left[ n \ast \text{DRX} \right] + \text{Fo} \]

where:

\[ P \quad \text{system frame number of the first frame of the paging block in which the mobile station will be paged.} \]

\[ \text{IMSI} \quad \text{international mobile-subscriber identity.} \]

\[ K \quad \text{number of paging channels.} \]

\[ \text{DRX} \quad \text{DRX cycle length calculated as follows: } \text{DRX} = \max (2^k, \text{PBP}), \text{ where } k \text{ is the DRX cycle-length coefficient (an integer from 6 to 9) and PBP is the paging block period specified below. Also, see the discussion in § B.4.} \]

\[ \text{PBP} \quad \text{paging block period. } \text{PBP} = 1 \text{ for frequency-division duplex.} \]

\[ n \quad \text{non-negative integer.} \]

\[ \text{Fo} \quad \text{frame offset.} \]

B.4 DRX values for UTRAN

In **RRC Idle** mode, the UE shall use the following for DRX:

- The stored DRX cycle length for any CN domain to which the UE is attached.  
  <Shouldn’t the UE use the shortest DRX cycle length?>

In **RRC Connected** mode, the UE shall use the shortest of the following for DRX:

- The UTRAN DRX cycle length calculated using the **UTRAN DRX cycle-length coefficient**. This coefficient appears in several RRC messages, e.g., **Radio-Bearer Setup** and **Radio-Bearer Reconfiguration**.

- The stored DRX cycle length for any CN domain to which the UE is attached but not connected.  
  <Shouldn’t this be the shortest stored DRX cycle length, not any stored value?>

The UE could be attached to two CN domains, circuit and packet, each having their own DRX cycle lengths. For the circuit domain, the UE uses the circuit-domain **CN-domain-specific DRX cycle-length coefficient** broadcast in system information. For the packet domain, the UE negotiates the DRX cycle length during attachment. If no DRX cycle length has been negotiated, the UE uses the packet-domain **CN-domain-specific DRX cycle-length coefficient** broadcast in system information.
C. States

This annex plagiarizes GP-010679 [17] and G2-010063 [15].

C.1 MM states

Mobility management applies to the circuit domain. One MM state machine resides in each mobile station. For each mobile station, one MM state machine resides in the core network. The MM state machine has the following states:

- **MM-Detached.**
  The core network cannot reach the mobile station for circuit services.

- **MM-Idle.**
  The core network can reach the mobile station via paging. No $Iu-cs$ or RRC connection exists.

- **MM-Connected.**
  The core network supplies circuit services via a signalling connection between the core network and the mobile station. A signalling connection comprises a RRC connection between MS and GERAN and an $Iu-cs$ connection between GERAN and CN.

C.2 PMM states

Packet mobility management applies to the packet domain. One PMM state machine resides in each mobile station. For each mobile station, one PMM state machine resides in the core network. The PMM state machine has the following states:

- **PMM-Detached.**
  The core network cannot reach the mobile station for packet services.

- **PMM-Idle.**
  The core network can reach the mobile station via paging. No $Iu-ps$ or RRC connection exists.

- **PMM-Connected.**
  The core network supplies packet services via a signalling connection between the core network and the mobile station. A signalling connection comprises a RRC connection between MS and GERAN and an $Iu-ps$ connection between GERAN and CN.

C.3 RCC modes

Radio-resource control applies to the circuit and packet domains. One RRC state machine resides in each mobile station. For each mobile station, one RRC state machine resides in the GERAN. The RRC state machine has two high-level states — for some obscure reason, called modes:

- **RRC-Idle.**
  No RRC connection exists between mobile station and GERAN. GERAN may be able to reach the mobile station via paging. In this state (mode), both of the following will be true: MM is not in $MM$-Connected state; PMM is not in $PMM$-Connected state.

  Upon receipt of a RANAP paging message, GERAN pages the mobile station using a core-network identifier (IMSI, TSMI, or P-TMSI). Paging triggers the mobile station to establish an RRC connection and then send an NAS (non-access stratum) paging response to the core network.

  If the mobile station camps on a CCCH, RRC pages the mobile station. If the mobile station camps on PCCCH, RRC requests that MAC page the mobile station.

- **RRC-Connected.**
  A signalling connection exists between mobile station and GERAN. In this state (mode), one or more of the following will be true: MM is in $MM$-Connected state; PMM is in $PMM$-Connected state.
In **RRC Connected** mode, RRC is in one of the following states:

- **RRC-GRA_PCH.**
  GERAN knows the mobile-station location to a GRA (GERAN registration area). RRC has allocated no physical subchannels.
  
  Upon receipt of a RANAP *paging* message, GERAN pages the mobile station using a GERAN identifier (G-RNTI). Paging triggers the mobile station to perform a cell update and then send an NAS paging response to the core network.
  
  Upon receipt of a downlink PDU, GERAN pages the mobile station using a GERAN identifier (G-RNTI). Paging triggers the mobile station to perform a cell update. Once GERAN knows which cell serves the mobile station, it forwards the downlink PDU.
  
  If the mobile station camps on a CCCH, RRC pages the mobile station. If the mobile station camps on PCCCH, RRC requests that MAC page the mobile station.

- **RRC-Cell_Shared.**
  GERAN knows the mobile-station location to the cell where the mobile station last performed a cell update. RRC has allocated no dedicated physical subchannels. It has allocated zero (MAC Idle state), one (MAC Shared state), or more (MAC Shared state) shared physical subchannels.
  
  Upon receipt of a RANAP *paging* message, GERAN pages the mobile station using a GERAN identifier (G-RNTI). Paging triggers the mobile station to send an NAS paging response to the core network. *Should the mobile station perform a cell update? If so, why?*
  
  Upon receipt of a downlink PDU, GERAN forwards the downlink PDU.
  
  If the mobile station is in **MAC Shared** state, it monitors PACCH, and RRC performs paging. If the mobile station is in **MAC Idle** state and it camps on a CCCH, RRC performs paging. If the mobile station is in **MAC Idle** state and it camps on a PCCCH, RRC requests that MAC page.

- **RRC-Cell_Dedicated.**
  GERAN knows the mobile-station location to a cell. RRC has allocated one or more dedicated physical subchannels and zero or more shared physical subchannels.
  
  Upon receipt of a RANAP *paging* message, GERAN pages the mobile station using a GERAN identifier (G-RNTI). Paging triggers the mobile station to send an NAS paging response to the core network.
  
  Upon receipt of a downlink PDU, GERAN forwards the downlink PDU.
  
  RRC pages the mobile station using a dedicated control channel.