Title

Paging Concept Paper (Version 3)

Source

Lucent

Abstract

This contribution proposes a concept paper for paging. It uses the following three-part template adopted in GAHW-010241[12]: 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

For information.

History

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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

This section incorporates agreements documented in GP-010975 [14].

<Each requirement in this section should indicate why the requirement exists.>

Any mobile station that supports *Iu mode* shall camp on a PCCCH if present. <Why?>

If a PCCCH is present, the mobile station shall monitor it in *RRC Idle* and *RRC Connected* modes. <Why should the mobile station always monitor PCCCH in *RRC Connected* mode? If GERAN supports coordinated paging, which it should, a mobile station with an active TBF should only have to monitor PACCH.>

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.

A single PACKET PAGING REQUEST shall be able to contain pages for *A/Gb-mode* and *Iu-mode* mobile stations. <Seems needlessly restrictive.>

A mobile station may respond to a page via a dedicated control channel or via a TBF. <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.
- Lloyd receives a voice call while checking the status of a customer’s order.
- Lloyd receives an e-mail order confirmation.
- Lloyd receives an e-mail order confirmation while engaged in 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

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 44.018 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.

  <Ciphered messages need to be confirmed when the concept paper on ciphering and integrity protection is ready.>
- Heavy vertical lines indicate a stimulus-response relationship between messages.

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 CCCH supports discontinuous reception according to the formulas described in § B.1. A mobile station operating in *Iu mode* will behave as a GPRS-attached mobile station described in § B.1.
- 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

In this section, a circuit voice call will arrive over the *Iu-cs* interface. The GERAN RRC assigns an SDCCH (Stand-Alone Dedicated Control Channel) for the mobile station to respond to the page.

2.1.1 *RRC-Idle*

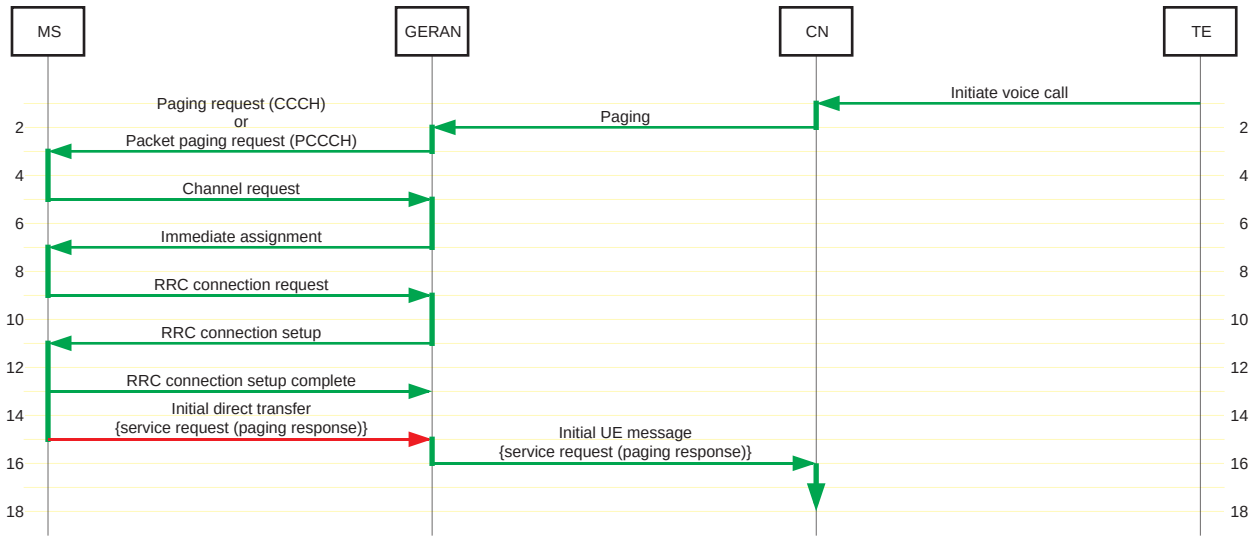
This sequence corresponds to the following user-based scenario:

- Lloyd receives a voice call.

Figure 1 shows the paging-related portion of an incoming circuit voice call under the following conditions:

- RRC is in *RRC-Idle* mode.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Idle* state.
- Mobile station camps on a CCCH or a PCCCH.

Figure 1: Incoming circuit voice call – *RRC-Idle*, assign dedicated channel



Line	Description	Direction Protocol Channel
1	Initiate voice call Lloyd's customer calls. The customer's terminal equipment initiates the voice call.	CN←TE
2	Paging *{CN domain indicator, permanent NAS UE identity, temporary UE identity, paging area ID, paging cause, non-searching indication, DRX cycle-length coefficient}* 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 signaling 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, sequences in this document assume 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. Presently, this parameter only applies to UTRAN mobile stations. The following should be added to the *paging* message: • *SPLIT_PG_CYCLE*. This parameter performs for GERAN a function similar to what *DRX cycle-length coefficient* performs for UTRAN. <The mobile station provides *SPLIT_PG_CYCLE* to the packet-domain core network during packet-domain attach and routing-area update. For split paging to work in the circuit domain, the mobile station will have to provide *SPLIT_PG_CYCLE* during circuit-domain attach and location-area update.> <For *Network Operation Mode I*, the circuit domain could page via the packet domain, eliminating the need for the circuit domain to know *SPLIT_PG_CYCLE*.>	GERAN←CN RANAP *Iu-cs*

3a	Paging request *{page mode, channel needed, mobile identity, P1 rest octets}* Since the GERAN RRC is in *RCC-Idle* mode for this IMSI, it does not know where the mobile station is. It therefore sends a CN-initiated *paging request* on all paging channels the mobile station could monitor. Upon receipt of the *paging request*, the MS RRC informs its non-access stratum that the core network has paged it. The MS NAS responds to the page. • *Channel needed* indicates SDCCH. It could also indicate TCH. • *Mobile identity* is the mobile station's IMSI, or if available, TMSI. • *P1 rest octets* indicates *paging procedure for RR connection establishment.* RRC only includes this information if *mobile identity* is IMSI. If mobile identity is TMSI, *paging procedure for RR connection establishment* is assumed. The following should be added to the *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. <A better alternative may be to explicitly signal whether GERAN or CN initiated the page. After all, it's only a bit.> • 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. <Why does the mobile station care what the paging cause is? What do the upper layer do with this information?>	MS←GERAN RRC CCCH (PCH)
3b	Packet paging request *{page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)}* 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. • *TBF or dedicated* indicates establishment of a dedicated connection. • *Mobile identity* is the mobile station's IMSI, or if available, TMSI. • *Channel needed* indicates SDCCH. It could also indicate TCH. The following should be added 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. <A better alternative may be to explicitly signal whether GERAN or CN initiated the page. After all, it's only a bit.> • 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.	MS←GERAN MAC PCCCH (PPCH)
5	Channel request *{establishment cause, random reference}* The MS RRC requests a channel to respond to the page. • *Establishment cause* indicates *answer to paging*.	MS→GERAN RRC CCCH (RACH)
7	Immediate assignment *{page mode, dedicated mode or TBF, channel description, request reference, timing advance, mobile allocation, starting time, IA rest octets (frequency parameters before time)}* The GERAN RRC assigns an SDCCH. • *Dedicated mode or TBF* indicates *dedicated mode*. • *Request reference* comprises the contents of the *channel request* message and the frame number in which the *channel request* message was received. It is used to address the mobile station. • *Channel description* specifies parameters for the SDCCH.	MS←GERAN RRC CCCH (AGCH)

9	RRC connection request *{initial UE identity, establishment cause}* 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.* • *Initial UE identity* indicates IMSI, or if available, TMSI. • *Establishment cause* indicates *terminating conversational call.* <Do we want to define an RB0 to carry the *RRC connection request* and *RRC connection setup*? Such a radio bearer would have an RLC instance, *e.g.*, acknowledged mode.>	MS→GERAN RRC SDCCH
11	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}* The GERAN RRC provides the information needed to support the RRC connection. • *Initial UE identity* indicates IMSI, or if available, TMSI. • *RRC transaction identifier* identifies the transaction. Subsequent messages in the transaction use this identifier. • *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. • *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 will not use this capability, *i.e.*, DRX cycle length will not change when the mobile station moves from *RRC Idle* mode to *RRC connected* mode. • *Signalling RB information setup list* configures the four signaling radio bearers.	MS←GERAN RRC SDCCH
13	RRC connection setup complete *{RRC transaction identifier, START list, UE radio access capability}* The MS RRC confirms setup of the RRC connection. RRC enters *RRC-Cell_Dedicated* 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). • *RRC transaction identifier* is the value sent in the *RRC connection setup* message. • *START list* identifies the CN domain (circuit) and initializes the 20 most-significant bits of the hyperframe numbers. <Is this initialization the first point where ciphering and integrity protection can operate?> • *UE radio-access capability* indicates the mobile station's capabilities with respect to the *Um* interface, *e.g.*, PDCP capability, RLC capability, RF capability.	MS→GERAN RRC RB2 (SDCCH)
15	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* The MS RRC initiates a signaling connection to the circuit CN and forwards the MS NAS paging response. • *CN domain identity* indicates *circuit domain*. • *Intra-domain NAS node selector* indicates the NAS node to which the MS wants to establish a connection. • *NAS message* contains the *service request* message indicating *paging response.*	MS→GERAN RRC RB3 (SDCCH)
16	Initial UE message *{CN domain indicator, LAI, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* GERAN forwards the page response to the CN. • *CN domain indicator* indicates *circuit domain*. • *LAI* indicates the location area in which the RRC connection exists. • *SAI* indicates the service area where the mobile station is consuming resources. • *Iu signalling-connection identifier* is assigned by GERAN and stored by the CN for the duration of the *Iu* connection. • *Global RNC-ID* uniquely identifies the GERAN BSS.	GERAN→CN RANAP *Iu-cs*

2.1.2 *RRC-Cell_Shared*

This sequence corresponds to the following user-based scenario:

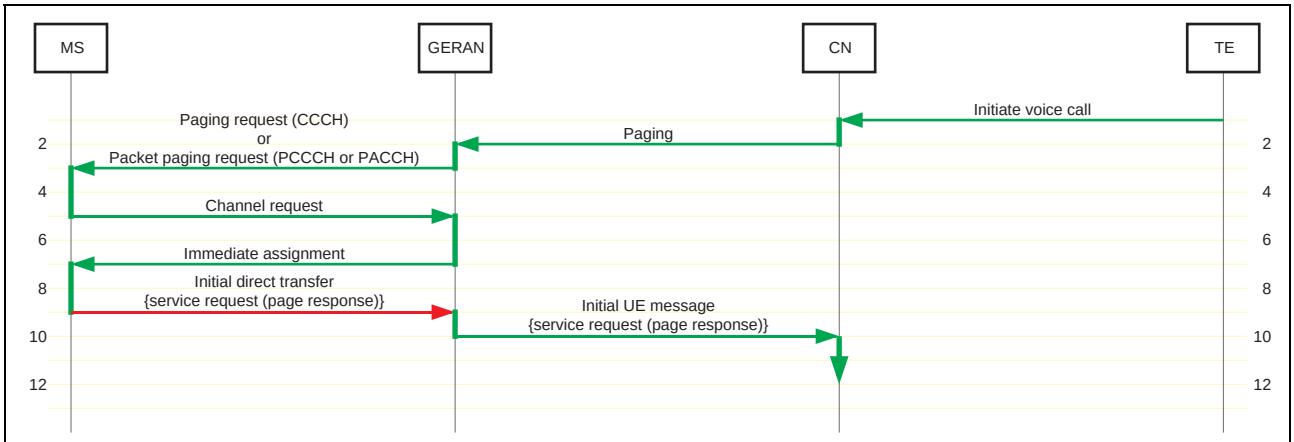
- Lloyd receives a voice call while checking the status of a customer's order.

Figure 2 shows the paging-related portion of an incoming circuit voice call under the following conditions:

- RRC is in *RRC-Cell_Shared* state.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Connected* state.
- Mobile station camps on a CCCH or a PCCCH (*i.e.*, it does not have an active TBF), or it monitors a PACCH (*i.e.*, it has an active TBF).

<GP-011545 [Siemens], *CS Paging in RRC Cell_Shared*, is being considered. If the contribution is adopted, this section will change.>

Figure 2: Incoming circuit voice call – *RRC-Cell_Shared,* assign dedicated channel



Line	Description	Direction Protocol Channel
1	Initiate voice call Lloyd's customer calls while Lloyd is checking the status of a customer order. The customer's terminal equipment initiates the voice call.	CN←TE
2	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 § 2.1.1 line 2 with the following exceptions: • *Paging area ID*, if included, can be ignored. GERAN knows the mobile station's location.	GERAN←CN RANAP *Iu-cs*
3a	Paging request *{page mode, channel needed, mobile identity, P1 rest octets}* Since the GERAN RRC is in *RRC-Cell_Shared* state for this IMSI, it knows where the mobile station is. It therefore sends a CN-initiated *paging request* on the paging channel the mobile station is monitoring. Upon receipt of the *paging request*, the MS RRC informs its non-access stratum that the core network has paged it. The MS NAS responds to the page. • *Channel needed* indicates SDCCH. It could also indicate TCH. • *Mobile identity* is the G-RNTI. • *P1 rest octets* indicates *paging procedure for RR connection establishment.* <Presently, RRC only includes this information if *mobile identity* is IMSI.> In addition to § 2.1.1, the following should be added to the *paging request:* • G-RNTI as a *mobile identity.* • *P1 rest octets* applies when paging with G-RNTI. This applies for *paging request type 1*. *P2 rest octets* should also be updated for *paging request type 2*.	MS←GERAN RRC CCCH (PCH)
3b	Packet paging request *{page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)}* Since the GERAN RRC is in *RRC-Cell_Shared* state for this IMSI, it knows where the mobile station is. It therefore has MAC send a CN-initiated *packet paging request* on the channel the mobile station is monitoring. 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. • *TBF or dedicated* indicates establishment of a dedicated connection. • *Mobile identity* is the G-RNTI. • *Channel needed* indicates SDCCH. It could also indicate TCH. In addition to § 2.1.1, the following should be added to the *packet paging request:* • G-RNTI as a *mobile identity.*	MS←GERAN MAC PCCCH (PPCH) or PACCH
5	Channel request *{establishment cause, random reference}* Same as § 2.1.1 line 5.	MS→GERAN RRC CCCH (RACH)

7	Immediate assignment *{page mode, dedicated mode or TBF, channel description, request reference, timing advance, mobile allocation, starting time, IA rest octets (frequency parameters before time)}* Same as § 2.1.1 line 7 except for the following: • RRC enters *RRC-Cell_Dedicated* state.	MS←GERAN RRC CCCH (AGCH)
	At this point, 25.331 § 8.1.2.3 specifies that the mobile station perform a cell update. Since GERAN knows exactly where the mobile station is and the signaling radio bearers are established, it doesn't need a cell update. One reason for a cell update would be to explicitly signal the RRC to enter *RRC-Cell_Dedicated* state.	
9	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* Same as § 2.1.1 line 15.	MS→GERAN RRC RB3 (SDCCH)
10	Initial UE message *{CN domain indicator, LAI, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* Same as § 2.1.1 line 16.	GERAN→CN RANAP *Iu-cs*

2.1.3 *RRC-GRA_PCH*

This sequence corresponds to the following user-based scenario:

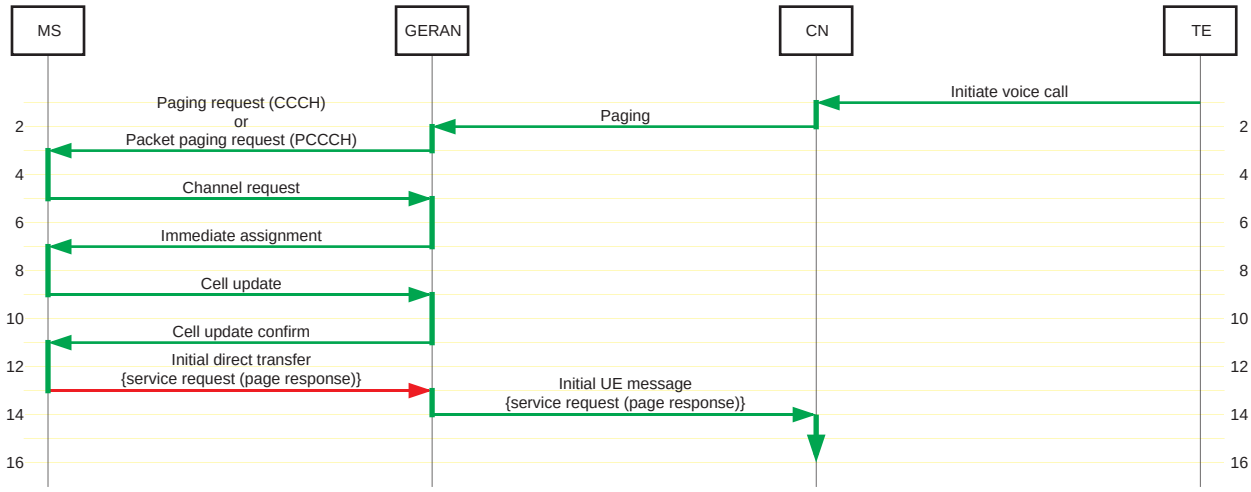
- Lloyd receives a voice call.

Figure 3 shows the paging-related portion of an incoming circuit voice call under the following conditions:

- RRC is in *RRC-GRA_PCH* state.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Connected* state.
- Mobile station monitors a CCCH or a PCCCH.

<This section has unresolved problems related to the *Iur-g* interface. G2-010075 [Nortel] and G2-010089 [Siemens] contain proposals. Should the mobile station perform a cell update?>

Figure 3: Incoming circuit voice call – *RRC-GRA_PCH*, assign dedicated channel



Line	Description	Direction Protocol Channel
1	Initiate voice call Lloyd's customer calls. The customer's terminal equipment initiates the voice call.	CN←TE
2	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 § 2.1.1 line 2 with the following exceptions: • *Paging area ID*, if included, can be ignored. GERAN knows the mobile station's location within a GRA (GERAN registration area).	GERAN←CN RANAP *Iu-cs*
3a	Paging request *{page mode, channel needed, mobile identity, P1 rest octets}* Since the GERAN RRC is in *RRC-GRA_PCH* state for this IMSI, it knows where the mobile station is within a GERAN registration area. It therefore sends a CN-initiated *paging request* on all paging channels in the GRA. Upon receipt of the *paging request*, the MS RRC informs its non-access stratum that the core network has paged it. The MS NAS responds to the page. • *Channel needed* indicates SDCCH. It could also indicate TCH. • *Mobile identity* is the mobile station's G-RNTI. • *P1 rest octets* indicates *paging procedure for RR connection establishment.* <Presently, RRC only includes this information if *mobile identity* is IMSI.> Change the *paging request* as specified in § 2.1.2.	MS←GERAN RRC CCCH (PCH)
3b	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 CN-initiated *packet paging request* on all paging channels in the GRA. 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. • *TBF or dedicated* indicates establishment of a dedicated connection. • *Mobile identity* is the mobile station's G-RNTI. • *Channel needed* indicates SDCCH. It could also indicate TCH. Change the *packet paging request* as specified in § 2.1.2.	MS←GERAN MAC PCCCH (PPCH)
5	Channel request *{establishment cause, random reference}* Same as § 2.1.1 line 5.	MS→GERAN RRC CCCH (RACH)

7	Immediate assignment *{page mode, dedicated mode or TBF, channel description, request reference, timing advance, mobile allocation, starting time, IA rest octets (frequency parameters before time)}* Same as § 2.1.1 line 7.	MS←GERAN RRC CCCH (AGCH)
9	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)
11	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 will not use this capability, *i.e.*, DRX cycle length will not 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)
13	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* The MS RRC initiates a signaling connection to the circuit CN and forwards the MS NAS paging response. If a connection to the circuit CN already exists (MM is in *MM-connected* state), the MS RRC sends a *direct transfer* message. • *CN domain identity* indicates *circuit domain*. • *Intra-domain NAS node selector* indicates the NAS node to which the MS wants to establish a connection. • *NAS message* contains the *service request* message indicating *paging response.*	MS→GERAN RRC RB3 (SDCCH)
14	Initial UE message *{CN domain indicator, LAI, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* GERAN forwards the page response to the CN. If a connection to the circuit CN already exists (MM is in *MM-connected* state), the MS RRC will send a *direct transfer* message. • *CN domain indicator* indicates *circuit domain*. • *LAI* indicates the location area in which the RRC connection exists. • *SAI* indicates the service area where the mobile station is consuming resources. • *Iu signalling-connection identifier* is assigned by GERAN and stored by the CN for the duration of the *Iu* connection. • *Global RNC-ID* uniquely identifies the GERAN BSS.	GERAN→CN RANAP *Iu-cs*

2.2 Incoming circuit voice call – assign shared channel

In this section, a circuit voice call will arrive over the *Iu-cs* interface. The GERAN RRC assigns a shared channel for the mobile station to respond to the page.

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

In this section, a packet voice call will arrive over the *Iu-ps* interface. The GERAN RRC assigns an SDCCH (Stand-Alone Dedicated Control Channel) for the mobile station to respond to the page.

<Why would we want to do this? Perhaps the sequences in this section should be deprecated and the subsections deleted as in § 2.2.>

2.3.1 *RRC-Idle*

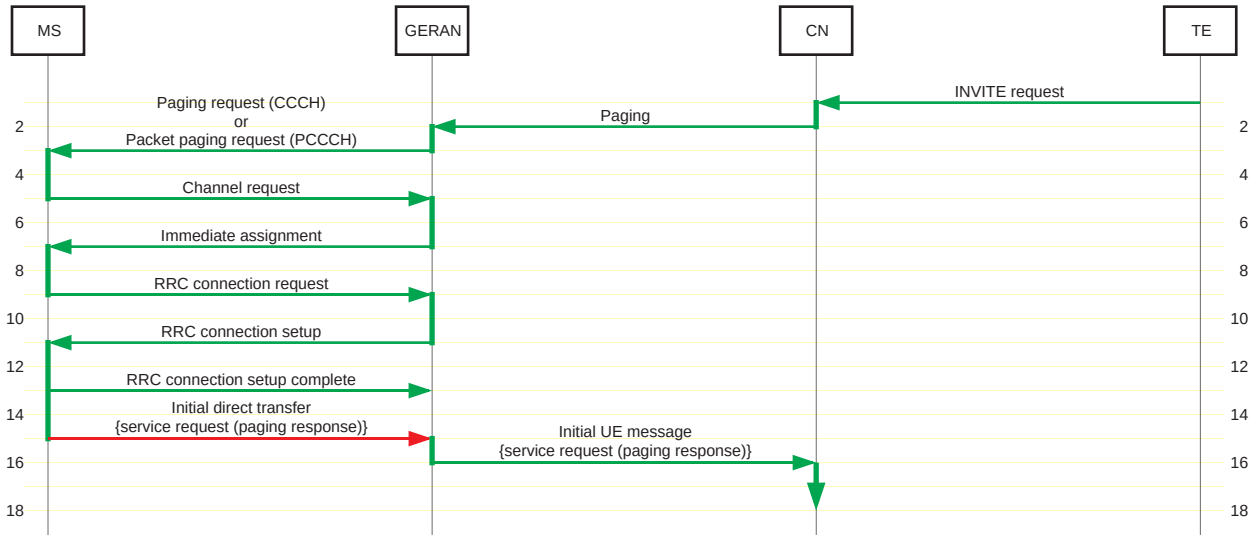
This sequence corresponds to the following user-based scenario:

- Lloyd receives a voice call.

Figure 4 shows the paging-related portion of an incoming packet voice call under the following conditions:

- RRC is in *RRC-Idle* mode.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Idle* state.
- Mobile station camps on a CCCH or a PCCCH.

Figure 4: Incoming packet voice call – *RRC-Idle*, assign dedicated channel



Line	Description	Direction Protocol Channel
1	INVITE request 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. <Should the *paging cause* indicate *terminating conversational call* (the eventual service) or *terminating high-priority signalling* (the immediate need to deliver the INVITE request)?>	CN←TE SIP
2	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 § 2.1.1 line 2 with the following exceptions: • The CN requests paging in the mobile station's routing area, not its location area. • *CN domain indicator* indicates *packet domain*. • *Temporary UE identity*, if included, is the P-TMSI. • *Paging area ID*, if included, is the RAI. If the message contains no *paging area ID*, the GERAN BSS will page in all cells under its control.	GERAN←CN RANAP *Iu-ps*
3a	Paging request *{page mode, channel needed, mobile identity, P1 rest octets}* Same as § 2.1.1 line 3a with the following exceptions: • *Mobile identity* is the mobile station's IMSI, or if available, P-TMSI. • *P1 rest octets* indicates *paging procedure for RR connection establishment.* Presently, RRC only includes this information if *mobile identity* is IMSI; if mobile identity is P-TMSI, *packet paging procedure* is assumed. This assumption is no longer correct. When paging with P-TMSI, *P1 rest octets* should not be ignored, contrary to what 44.018 § 10.5.2.23 presently specifies. *P1 rest octets* should be modified as follows: • Delete the requirement that *P1 rest octets* be ignored if mobile identity is not IMSI.	MS←GERAN RRC CCCH (PCH)

3b	Packet paging request *{page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)}* Same as § 2.1.1 line 3b with the following exceptions: • *Mobile identity* is the mobile station's IMSI, or if available, P-TMSI. • *TBF or dedicated* 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. The following should be changed in the *packet paging request:* • Support paging with P-TSMI for RR connection establishment.	MS←GERAN MAC PCCCH (PPCH)
5	Channel request *{establishment cause, random reference}* Same as § 2.1.1 line 5.	MS→GERAN RRC CCCH (RACH)
7	Immediate assignment *{page mode, dedicated mode or TBF, channel description, request reference, timing advance, mobile allocation, starting time, IA rest octets (frequency parameters before time)}* Same as § 2.1.1 line 7.	MS←GERAN RRC CCCH (AGCH)
9	RRC connection request *{initial UE identity, establishment cause}* Same as § 2.1.1 line 9 with the following exceptions: • *Initial UE identity* indicates IMSI, or if available, P-TMSI.	MS→GERAN RRC SDCCH
11	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 § 2.1.1 line 11 with the following exceptions: • *Initial UE identity* indicates IMSI, or if available, P-TMSI.	MS←GERAN RRC SDCCH
13	RRC connection setup complete *{RRC transaction identifier, START list, UE radio access capability}* Same as § 2.1.1 line 13.	MS→GERAN RRC RB2 (SDCCH)
15	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* Same as § 2.1.1 line 15 with the following exceptions: • *CN domain identity* indicates *packet domain*	MS→GERAN RRC RB3 (SDCCH)
16	Initial UE message *{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* Same as § 2.1.1 line 16 with the following exceptions: • *CN domain indicator* indicates *packet domain*. • *RAC* indicates the routing area in which the RRC connection exists.	GERAN→CN RANAP *Iu-ps*

2.3.2 *RRC-Cell_Shared*

<This sequence may only be of academic interest.>

2.3.3 *RRC-Cell_Dedicated*

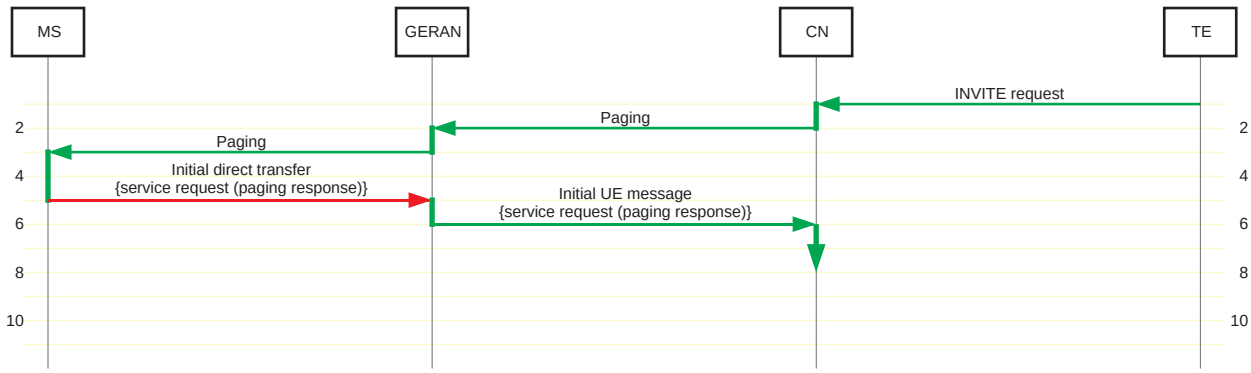
This sequence corresponds to the following user-based scenario:

- Lloyd receives a voice call while using a circuit data connection to check the status of a customer's order.

Figure 10 shows the paging-related portion of an incoming packet voice call under the following conditions:

- RRC is in *RRC-Cell_Dedicated* state.
- MM is in *MM-Connected* state.
- PMM is in *PMM-Idle* state.
- Mobile station is on a TCH.

Figure 5: Incoming packet voice call – *RRC-Cell_Dedicated*, assign dedicated channel



Line	Description	Direction Protocol Channel
1	INVITE request 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.*	CN←TE SIP
2	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 § 2.1.1 line 2 except for the following: • *CN domain indicator* indicates *packet domain.* • *Temporary UE identity*, if included, is the P-TMSI. • *Paging area ID*, if included, is the RAI. If the message contains no *paging area ID*, GERAN will page in all cells under its control. • *Paging cause*, if included, indicates *terminating conversational call.*	GERAN←CN RANAP *Iu-ps*
3	Paging *{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 *paging* message on RB3. Upon receipt of the *paging* message, the MS MAC 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 *packet domain.* • *Paging record type identifier* indicates *P-TMSI.* <Does it really indicate P-TMSI, and if so, why?> The following should be added to 44.018: • A *paging* message based on 25.331 *paging type 2.*	MS←GERAN RRC RB3 (FACCH)
5	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* The MS RRC initiates a signaling connection to the packet CN and forwards the MS NAS paging response. • *CN domain identity* indicates *packet domain.* • *Intra-domain NAS node selector* indicates the NAS node to which the MS wants to establish a connection. • *NAS message* contains the *service request* message indicating *paging response.*	MS→GERAN RRC RB3 (FACCH)

6	Initial UE message *{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* Same as § 2.1.1 line 16 except for the following: • *CN domain indicator* indicates *packet domain*. • *RAC* indicates the routing area in which the RRC connection exists.	GERAN→CN RANAP *Iu-ps*

2.3.4 *RRC-GRA_PCH*

<This sequence may only be of academic interest.>

2.4 Incoming packet voice call – assign shared channel

In this section, a packet voice call will arrive over the *Iu-ps* interface. The GERAN RRC assigns a shared channel for the mobile station to respond to the page.

Sequences assume the following:

- TBFs persist long enough for transactions to proceed without multiple channel requests and assignments.
- Multiple signalling radio bearers can share a TBF.
- The MS and GERAN use one-phase packet access.

2.4.1 *RRC-Idle*, CCCH

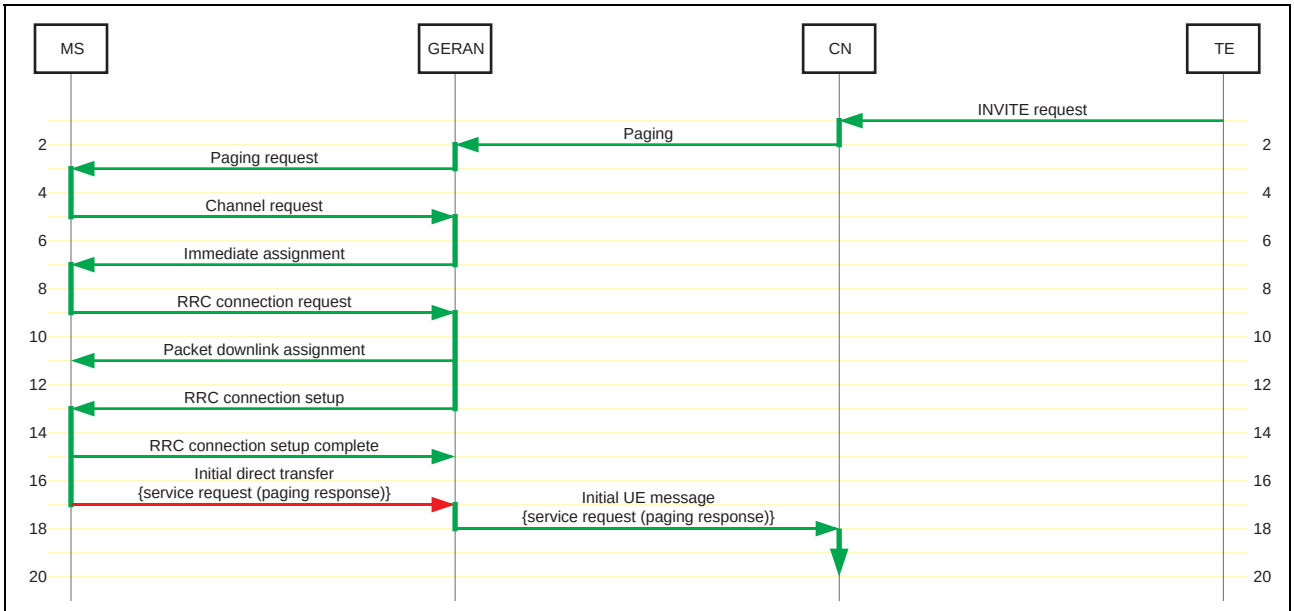
This sequence corresponds to the following user-based scenario:

- Lloyd receives a voice call.

Figure 6 shows the paging-related portion of an incoming packet voice call under the following conditions:

- RRC is in *RRC-Idle* mode.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Idle* state.
- Mobile station camps on a CCCH.

Figure 6: Incoming packet voice call – *RRC-Idle,* CCCH, assign shared channel



Line	Description	Direction Protocol Channel
1	INVITE request 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.*	CN←TE SIP
2	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 § 2.1.1 line 2 except for the following: • *CN domain indicator* indicates *packet domain.* • *Temporary UE identity*, if included, is the P-TMSI. • *Paging area ID*, if included, is the RAI. If the message contains no *paging area ID*, GERAN will page in all cells under its control.	GERAN←CN RANAP *Iu-ps*
3	Paging request *{page mode, channel needed, mobile identity, P1 rest octets}* Same as § 2.1.1 line 3 except for the following: • *Channel needed* indicates *any channel.* • *Mobile identity* is the mobile station's IMSI, or if available, P-TMSI. • *P1 rest octets* indicates *packet-paging procedure.* RRC only includes this information if *mobile identity* is IMSI. If mobile identity is P-TMSI, *packet-paging procedure* is assumed.	MS←GERAN RRC CCCH (PCH)
5	Channel request *{establishment cause, random reference}* Same as § 2.1.1 line 5 except for the following: • *Establishment cause* indicates *one-phase packet access.*	MS→GERAN RRC CCCH (RACH)
7	Immediate assignment *{page mode, dedicated mode or TBF, packet-channel description, request reference, timing advance, mobile allocation, starting time, IA rest octets (packet uplink assignment)}* The GERAN RRC assigns a PDCH. • *Dedicated mode or TBF* indicates TBF. • *Packet-channel description* specifies parameters for the PDCH. • *Request reference* comprises the contents of the *channel request* message and the frame number in which the *channel request* message was received. It is used to address the mobile station. • *IA rest octets* contains a *packet uplink assignment.*	MS←GERAN RRC CCCH (AGCH)

9	RRC connection request *{initial UE identity, establishment cause}* Same as § 2.1.1 line 9 except for the following: • *Initial UE identity* indicates IMSI, or if available, P-TMSI. • *Establishment cause* indicates *terminating conversational call.*	MS→GERAN RRC PDTCH
11	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}* Under control of the GERAN RRC, the GERAN MAC allocates a downlink TBF so that the GERAN RRC can reply. • *Global TFI* is the uplink TFI assigned in line 7. 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.	MS←GERAN MAC PACCH
13	RRC connection setup *{initial UE identity, RRC transaction identifier, new G-RNTI, RRC state indicator, UTRAN DRX cycle-length coefficient, signalling RB information setup list}* Same as § 2.1.1 line 11 except for the following: • *Initial UE identity* indicates IMSI, or if available, P-TMSI. • *RRC state indicator* specifies that the mobile station enter *RRC-Cell_Shared* state.	MS←GERAN RRC PDTCH
15	RRC connection setup complete *{RRC transaction identifier, START list, UE radio access capability}* Same as § 2.1.1 line 13 except for the following: • *START list* identifies the CN domain (packet) and initializes the 20 most-significant bits of the hyperframe numbers.	MS→GERAN RRC RB2 (PDTCH)
17	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* The MS RRC initiates a signaling connection to the packet CN and forwards the MS NAS paging response. • *CN domain identity* indicates *packet domain*. • *Intra-domain NAS node selector* indicates the NAS node to which the MS wants to establish a connection. • *NAS message* contains the *service request* message indicating *paging response*.	MS→GERAN RRC RB3 (PDTCH)
18	Initial UE message *{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* Same as § 2.1.1 line 16 except for the following: • *CN domain indicator* indicates *packet domain*. • *RAC* indicates the routing area in which the RRC connection exists.	GERAN→CN RANAP *Iu-ps*

2.4.2 *RRC-Idle*, PCCCH

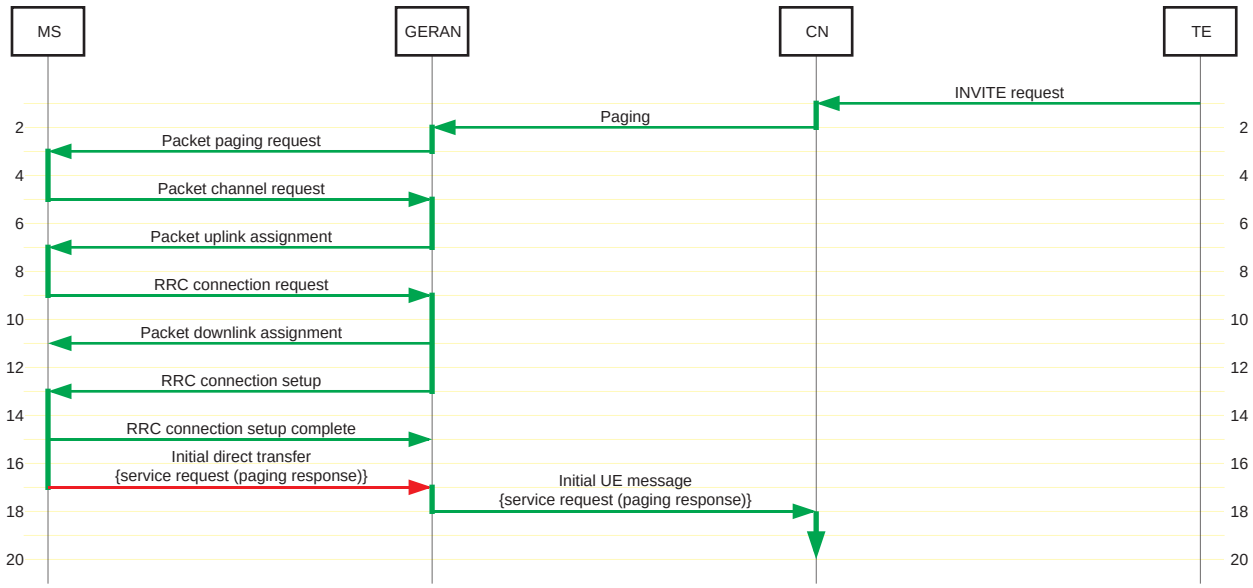
This sequence corresponds to the following user-based scenario:

- Lloyd receives a voice call.

Figure 7 shows the paging-related portion of an incoming packet voice call under the following conditions:

- RRC is in *RRC-Idle* mode.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Idle* state.
- Mobile station camps on a PCCCH.

Figure 7: Incoming packet voice call – *RRC Idle,* PCCCH, assign shared channel



Line	Description	Direction Protocol Channel
1	INVITE request 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.*	CN←TE SIP
2	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 § 2.4.1 line 2.	GERAN←CN RANAP *Iu-ps*
3	Packet paging request *{page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)}* Same as 2.1.1 line 3b except for the following: • *TBF or dedicated* indicates TBF establishment. • *Mobile identity* is the mobile station's IMSI, or if available, P-TMSI. • *Channel needed* is not sent because this information element only applies to circuit calls.	MS←GERAN RRC PCCCH (PPCH)
5	Packet channel request *{establishment cause, random bits}* Under control of the MS RRC, the MS MAC requests a channel to respond to the page. • *Establishment cause* indicates *page response*. <Should *establishment cause* indicate *one-phase access*?>	MS→GERAN RRC PCCCH (PRACH)
7	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)}* Under control of the GERAN RRC, the GERAN MAC allocates an uplink TBF. • *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. • *Uplink TFI assignment* assigns a TFI for the uplink TBF.	MS←GERAN RRC PCCCH (PAGCH)
9	RRC connection request *{initial UE identity, establishment cause}* Same as § 2.4.1 line 9.	MS→GERAN RRC PDTCH

11	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 § 2.4.1 line 11.	MS←GERAN MAC PACCH
13	RRC connection setup *{initial UE identity, RRC transaction identifier, new G-RNTI, RRC state indicator, UTRAN DRX cycle-length coefficient, signalling RB information setup list}* Same as § 2.4.1 line 13.	MS←GERAN RRC PDTCH
15	RRC connection setup complete *{RRC transaction identifier, START list, UE radio access capability}* Same as § 2.4.1 line 15.	MS→GERAN RRC RB2 (PDTCH)
17	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* Same as § 2.4.1 line 17.	MS→GERAN RRC RB3 (PDTCH)
18	Initial UE message *{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* Same as § 2.4.1 line 18.	GERAN→CN RANAP *Iu-ps*

2.4.3 *RRC-GRA_PCH*, CCCH

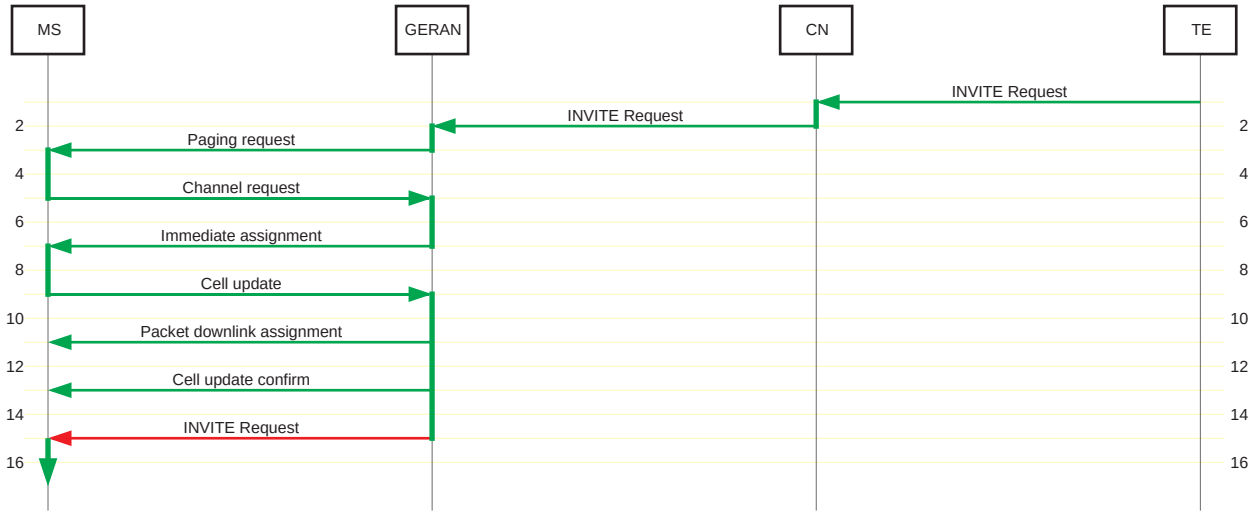
This sequence corresponds to the following user-based scenario:

- Lloyd receives a voice call.

Figure 8 shows the paging-related portion of an incoming packet voice call under the following conditions:

- RRC is in *RRC-GRA_PCH* state.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Connected* state.
- Mobile station is monitoring a CCCH.

Figure 8: Incoming packet voice call – *RRC-GRA_PCH,* CCCH, assign shared channel



Line	Description	Direction Protocol Channel
1	INVITE request 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).	CN←TE SIP
2	INVITE request Since the CN still has an *Iu* connection for this mobile station, it forwards the *INVITE request* to GERAN.	GERAN←CN GTP *Iu-ps*
3	Paging request *{page mode, channel needed, mobile identity, P1 rest octets}* Since the GERAN RRC is in *GRA_PCH* state for this IMSI, it knows where the mobile station is within a GERAN registration area. It therefore sends a GERAN-initiated *paging request* on all paging channels in the GRA. • *Channel needed* indicates *any channel.* • *Mobile identity* is the mobile station's G-RNTI. • *P1 rest octets* indicates *packet-paging procedure.* <Presently, RRC only includes this information if *mobile identity* is IMSI.> Change the *paging request* as specified in § 2.1.2.	MS←GERAN RRC CCCH (PCH)
5	Channel request *{establishment cause, random reference}* Same as § 2.4.1 line 5.	MS→GERAN RRC CCCH (RACH)
7	Immediate assignment *{page mode, dedicated mode or TBF, packet-channel description, request reference, timing advance, mobile allocation, starting time, IA rest octets (packet uplink assignment)}* Same as § 2.4.1 line 7.	MS←GERAN RRC CCCH (AGCH)
9	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 § 2.1.3 line 9 except for the following: • *START list* identifies the CN domain (packet) and initializes the 20 most-significant bits of the hyperframe numbers.	MS→GERAN RRC RB1 (PDTCH)
11	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 § 2.4.1 line 11.	MS←GERAN MAC PACCH

13	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 § 2.1.3 line 11 except for the following: • *RRC state indicator* specifies that the mobile station enter *RRC-Cell_Shared* state.	MS←GERAN RRC RB1 (PDTCH)
15	INVITE request GERAN forwards the *INVITE request* to the MS.	MS←GERAN PDCP RB5 (PDTCH)

2.4.4 *RRC-GRA_PCH*, PCCCH

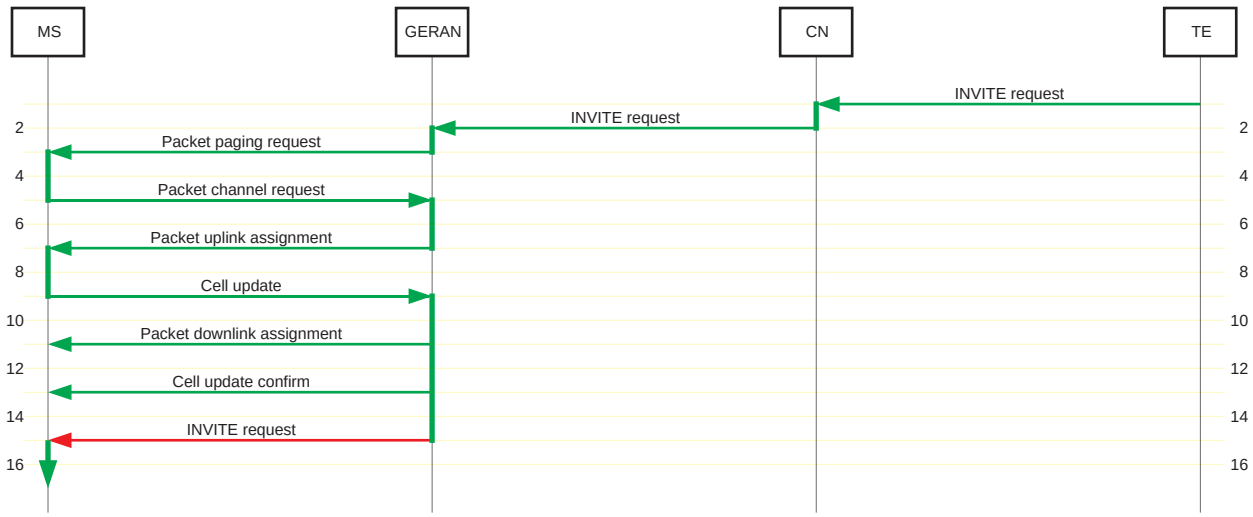
This sequence corresponds to the following user-based scenario:

- Lloyd receives a voice call.

Figure 9 shows the paging-related portion of an incoming packet voice call under the following conditions:

- RRC is in *RRC-GRA_PCH* state.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Connected* state.
- Mobile station is monitoring a PCCCH.

Figure 9: Incoming packet voice call – *RRC-GRA_PCH,* PCCCH, assign shared channel



Line	Description	Direction Protocol Channel
1	INVITE request 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).	CN←TE SIP
2	INVITE request Same as § 2.4.3 line 2.	GERAN←CN GTP *Iu-ps*
3	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 TBF establishment. • *Mobile identity* is the mobile station's G-RNTI. • *Channel needed* is not sent because this information element only applies to circuit calls. Change the *packet paging request* as specified in § 2.1.2.	MS←GERAN RRC PCCCH (PPCH)
5	Packet channel request *{establishment cause, random bits}* Same as § 2.4.2 line 5.	MS→GERAN RRC PCCCH (PRACH)
7	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 § 2.4.2 line 7.	MS←GERAN RRC PCCCH (PAGCH)
9	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 § 2.4.3 line 9.	MS→GERAN RRC RB1 (PDTCH)
11	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 § 2.4.3 line 11.	MS←GERAN MAC PACCH

13	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 § 2.4.3 line 13.	MS←GERAN RRC RB1 (PDTCH)
15	INVITE request GERAN forwards the *INVITE request* to the MS.	MS←GERAN PDCP RB5 (PDTCH)

2.5 Incoming packet data transfer – assign dedicated channel

In this section, packet data will arrive over the *Iu-ps* interface. The GERAN RRC assigns a dedicated channel for the mobile station to respond to the page.

Sequences assume the following:

- The server initiates transfer of the e-mail; the client does not poll for e-mail.

2.5.1 *RRC-Cell_Dedicated*

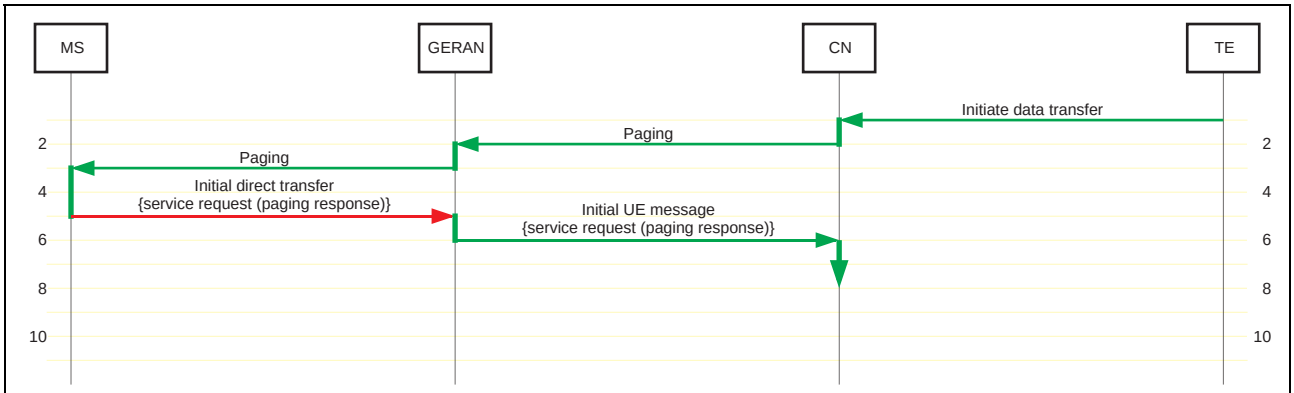
This sequence corresponds to the following user-based scenario:

- Lloyd receives an e-mail order confirmation while engaged in a voice call.

Figure 10 shows the paging-related portion of an incoming data transfer under the following conditions:

- RRC is in *RRC-Cell_Dedicated* state.
- MM is in *MM-Connected* state.
- PMM is in *PMM-Idle* state.
- Mobile station is on a TCH.

Figure 10: Incoming packet data transfer – *RRC-Cell_Dedicated*, assign dedicated channel



Line	Description	Direction Protocol Channel
1	Initiate data transfer Lloyd's server sends an e-mail confirming a customer order. Lloyd is talking to one of his customers.	CN←TE
2	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 § 2.1.1 line 2 except for the following: • *CN domain indicator* indicates *packet domain.* • *Temporary UE identity*, if included, is the P-TMSI. • *Paging area ID*, if included, is the RAI. If the message contains no *paging area ID*, GERAN will page in all cells under its control. • *Paging cause*, if included, indicates *terminating background call*.	GERAN←CN RANAP *Iu-ps*
3	Paging *{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 *paging* message on RB3. Upon receipt of the *paging* message, the MS MAC 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 background call.* • *CN domain identity* indicates *packet domain.* • *Paging record type identifier* indicates *P-TMSI.* <Does it really indicate P-TMSI, and if so, why?> The following should be added to 44.018: • A *paging* message based on 25.331 *paging type 2*.	MS←GERAN RRC RB3 (FACCH)
5	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* The MS RRC initiates a signaling connection to the packet CN and forwards the MS NAS paging response. • *CN domain identity* indicates *packet domain.* • *Intra-domain NAS node selector* indicates the NAS node to which the MS wants to establish a connection. • *NAS message* contains the *service request* message indicating *paging response.*	MS→GERAN RRC RB3 (FACCH)
6	Initial UE message *{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* Same as § 2.1.1 line 16 except for the following: • *CN domain indicator* indicates *packet domain*. • *RAC* indicates the routing area in which the RRC connection exists.	GERAN→CN RANAP *Iu-ps*

2.6 Incoming packet data transfer – assign shared channel

In this section, the GERAN RRC assigns a shared channel for the mobile station to respond to the page.

Sequences assume the following:

- The server initiates transfer of the e-mail; the client does not poll for e-mail.
- TBFs persist long enough for transactions to proceed without multiple channel requests and assignments.
- Multiple signalling radio bearers can share a TBF.
- The MS and GERAN use one-phase packet access.

2.6.1 *RRC-Idle*, CCCH

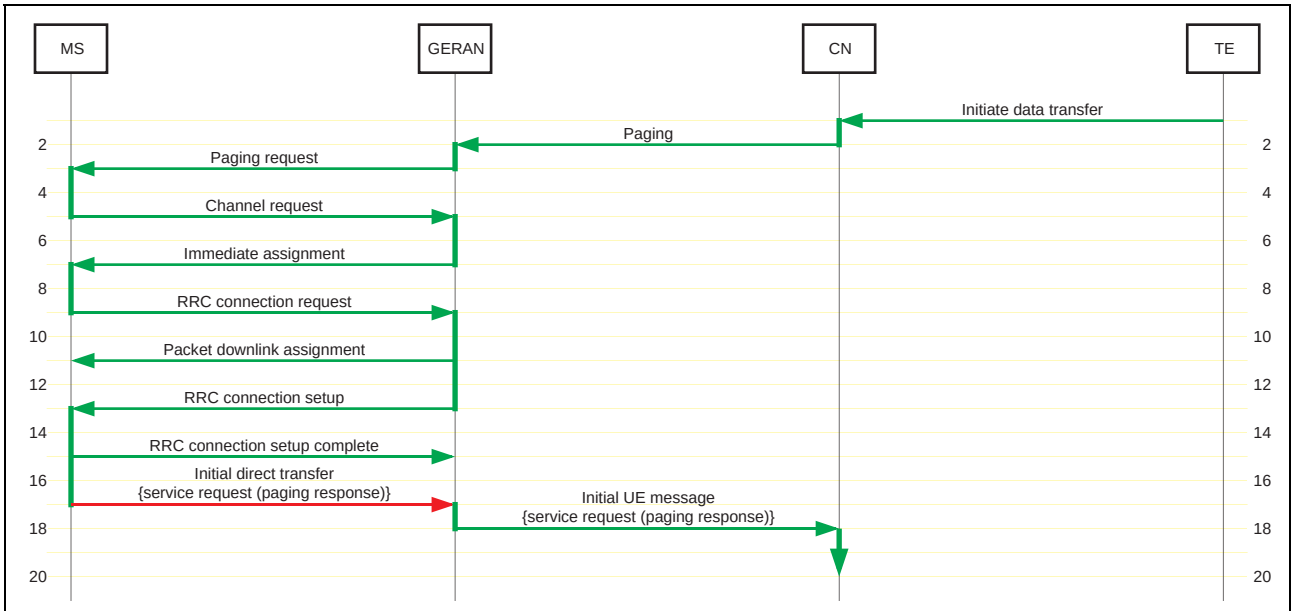
This sequence corresponds to the following user-based scenario:

- Lloyd receives an e-mail order confirmation.

Figure 11 shows the paging-related portion of an incoming data transfer under the following conditions:

- RRC is in *RRC-Idle* mode.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Idle* state.
- Mobile station is camped on a CCCH.

Figure 11: Incoming packet data transfer – *RRC-Idle,* CCCH, assign shared channel



Line	Description	Direction Protocol Channel
1	Initiate data transfer Lloyd's server sends an e-mail confirming a customer order.	CN←TE
2	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 § 2.5.1 line 2.	GERAN←CN RANAP *Iu-ps*
3	Paging request *{page mode, channel needed, mobile identity, P1 rest octets}* Same as § 2.1.1 line 3 except for the following: • *Channel needed* indicates *any channel.* • *Mobile identity* is the mobile station's IMSI, or if available, P-TMSI. • *P1 rest octets* indicates *packet-paging procedure.* RRC only includes this information if *mobile identity* is IMSI.	MS←GERAN RRC CCCH (PCH)
5	Channel request *{establishment cause, random reference}* Same as § 2.1.1 line 5 except for the following: • *Establishment cause* indicates *one-phase packet access.*	MS→GERAN RRC CCCH (RACH)
7	Immediate assignment *{page mode, dedicated mode or TBF, packet-channel description, request reference, timing advance, mobile allocation, starting time, IA rest octets (packet uplink assignment)}* The GERAN RRC assigns a PDCH. • *Dedicated mode or TBF* indicates TBF. • *Packet-channel description* specifies parameters for the PDCH. • *Request reference* comprises the contents of the *channel request* message and the frame number in which the *channel request* message was received. It is used to address the mobile station. • *IA rest octets* contains a *packet uplink assignment.*	MS←GERAN RRC CCCH (AGCH)
9	RRC connection request *{initial UE identity, establishment cause}* Same as § 2.1.1 line 9 except for the following: • *Initial UE identity* indicates IMSI, or if available, P-TMSI. • *Establishment cause* indicates *terminating background call.*	MS→GERAN RRC PDTCH

11	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}* Under control of the GERAN RRC, the GERAN MAC allocates a downlink TBF so that the GERAN RRC can reply. • *Global TFI* is the uplink TFI assigned in line 7. 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.	MS←GERAN MAC PACCH
13	RRC connection setup *{initial UE identity, RRC transaction identifier, new G-RNTI, RRC state indicator, UTRAN DRX cycle-length coefficient, signalling RB information setup list}* Same as § 2.1.1 line 11 except for the following: • *Initial UE identity* indicates IMSI, or if available, P-TMSI. • *RRC state indicator* specifies that the mobile station enter *RRC-Cell_Shared* state.	MS←GERAN RRC PDTCH
15	RRC connection setup complete *{RRC transaction identifier, START list, UE radio access capability}* Same as § 2.1.1 line 13 except for the following: • *START list* identifies the CN domain (packet) and initializes the 20 most-significant bits of the hyperframe numbers.	MS→GERAN RRC RB2 (PDTCH)
17	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* The MS RRC initiates a signaling connection to the packet CN and forwards the MS NAS paging response. • *CN domain identity* indicates *packet domain*. • *Intra-domain NAS node selector* indicates the NAS node to which the MS wants to establish a connection. • *NAS message* contains the *service request* message indicating *paging response*.	MS→GERAN RRC RB3 (PDTCH)
18	Initial UE message *{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* Same as § 2.1.1 line 16 except for the following: • *CN domain indicator* indicates *packet domain*. • *RAC* indicates the routing area in which the RRC connection exists.	GERAN→CN RANAP *Iu-ps*

2.6.2 *RRC-Idle*, PCCCH

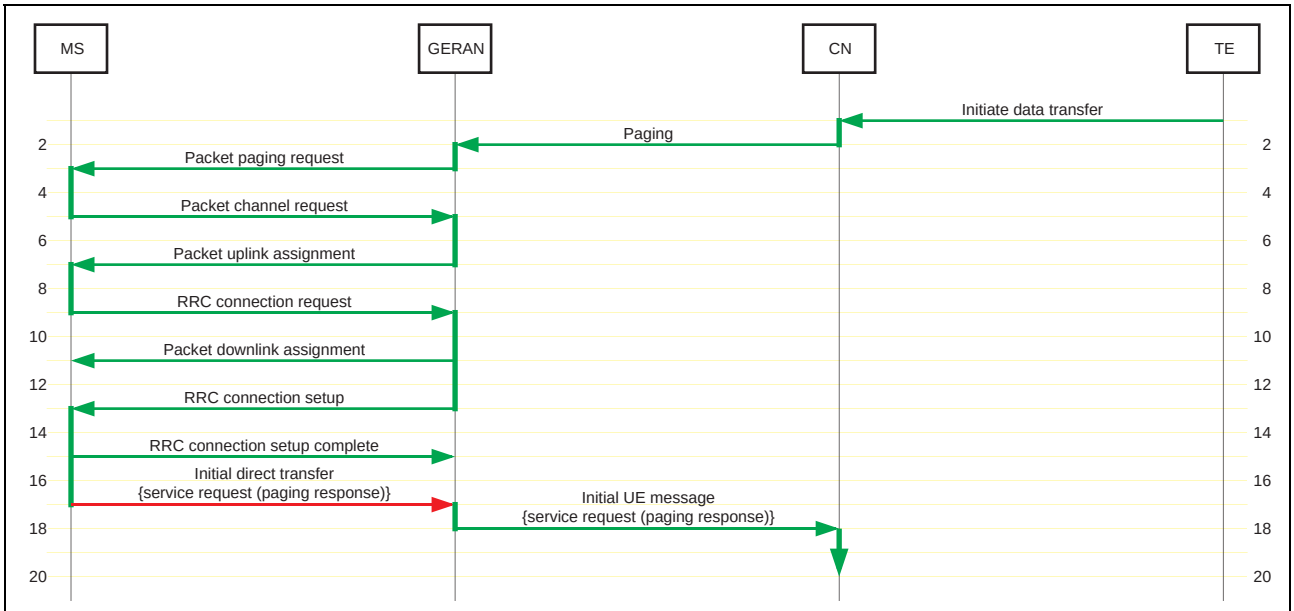
This sequence corresponds to the following user-based scenario:

- Lloyd receives an e-mail order confirmation.

Figure 12 shows the paging-related portion of an incoming data transfer under the following conditions:

- RRC is in *RRC-Idle* mode.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Idle* state.
- Mobile station is camped on a PCCCH.

Figure 12: Incoming packet data transfer – *RRC Idle,* PCCCH, assign shared channel



Line	Description	Direction Protocol Channel
1	Initiate data transfer Lloyd's server sends an e-mail confirming a customer order.	CN←TE
2	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 § 2.6.1 line 2.	GERAN←CN RANAP *Iu-ps*
3	Packet paging request *{page mode, persistence level, NLN, page info (TBF or dedicated, mobile identity, channel needed)}* Same as 2.1.1 line 3b except for the following: • *TBF or dedicated* indicates TBF establishment. • *Mobile identity* is the mobile station's IMSI, or if available, P-TMSI. • *Channel needed* is not sent because this information element only applies to circuit calls.	MS←GERAN RRC PCCCH (PPCH)
5	Packet channel request *{establishment cause, random bits}* Under control of the MS RRC, the MS MAC requests a channel to respond to the page. • *Establishment cause* indicates *page response*. <Should *establishment cause* indicate *one-phase access*?>	MS→GERAN RRC PCCCH (PRACH)
7	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)}* Under control of the GERAN RRC, the GERAN MAC allocates an uplink TBF. • *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. • *Uplink TFI assignment* assigns a TFI for the uplink TBF.	MS←GERAN RRC PCCCH (PAGCH)
9	RRC connection request *{initial UE identity, establishment cause}* Same as § 2.6.1 line 9.	MS→GERAN RRC PDTCH
11	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 § 2.6.1 line 11.	MS←GERAN MAC PACCH

13	RRC connection setup *{initial UE identity, RRC transaction identifier, new G-RNTI, RRC state indicator, UTRAN DRX cycle-length coefficient, signalling RB information setup list}* Same as § 2.6.1 line 13.	MS←GERAN RRC PDTCH
15	RRC connection setup complete *{RRC transaction identifier, START list, UE radio access capability}* Same as § 2.6.1 line 15.	MS→GERAN RRC RB2 (PDTCH)
17	Initial direct transfer *{CN domain identity, intra-domain NAS node selector, NAS message}* Same as § 2.6.1 line 17.	MS→GERAN RRC RB3 (PDTCH)
18	Initial UE message *{CN domain indicator, LAI, RAC, SAI, NAS-PDU, Iu signalling-connection identifier, Global RNC-ID}* Same as § 2.6.1 line 18.	GERAN→CN RANAP *Iu-ps*

2.6.3 *RRC-GRA_PCH*, CCCH

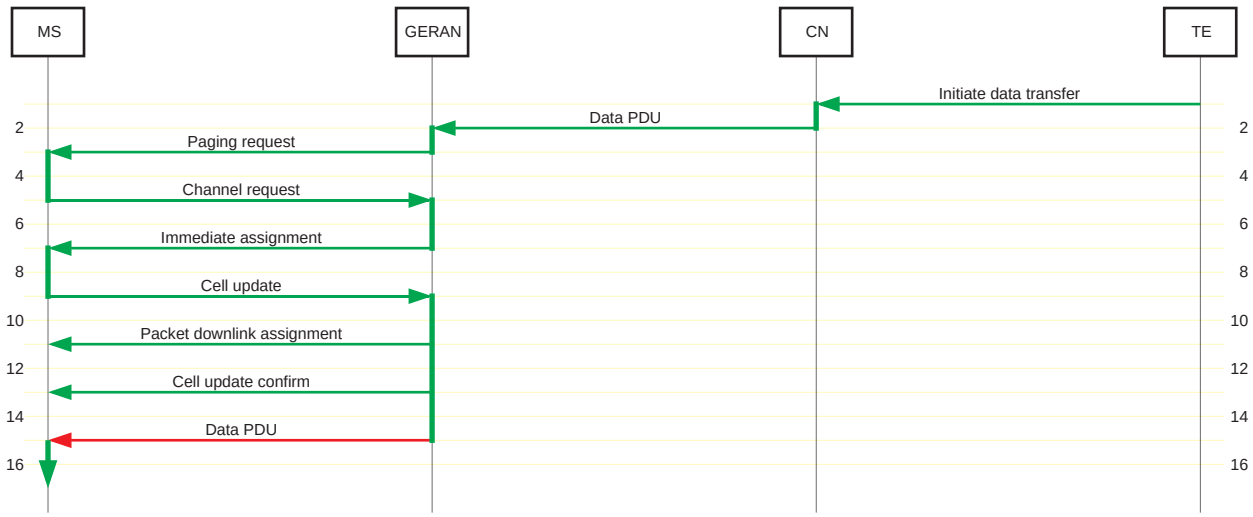
This sequence corresponds to the following user-based scenario:

- Lloyd receives an e-mail order confirmation.

Figure 13 shows the paging-related portion of an incoming data transfer under the following conditions:

- RRC is in *RRC-GRA_PCH* state.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Connected* state.
- Mobile station is monitoring a CCCH.

Figure 13: Incoming packet data transfer – *RRC-GRA_PCH,* CCCH, assign shared channel



Line	Description	Direction Protocol Channel
1	Initiate data transfer Lloyd's server sends an e-mail confirming a customer order.	CN←TE
2	Data PDU Since the CN still has an *Iu* connection for this mobile station, it forwards the data to GERAN.	GERAN←CN GTP *Iu-ps*
3	Paging request *{page mode, channel needed, mobile identity, P1 rest octets}* Since the GERAN RRC is in *GRA_PCH* state for this IMSI, it knows where the mobile station is within a GERAN registration area. It therefore sends a GERAN-initiated *paging request* on all paging channels in the GRA. • *Channel needed* indicates *any channel.* • *Mobile identity* is the mobile station's G-RNTI. • *P1 rest octets* indicates *packet-paging procedure.* <Presently, RRC only includes this information if *mobile identity* is IMSI.> Change the *paging request* as specified in § 2.1.2.	MS←GERAN RRC CCCH (PCH)
5	Channel request *{establishment cause, random reference}* Same as § 2.6.1 line 5.	MS→GERAN RRC CCCH (RACH)
7	Immediate assignment *{page mode, dedicated mode or TBF, packet-channel description, request reference, timing advance, mobile allocation, starting time, IA rest octets (packet uplink assignment)}* Same as § 2.6.1 line 7.	MS←GERAN RRC CCCH (AGCH)
9	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 § 2.1.3 line 9 except for the following: • *START list* identifies the CN domain (packet) and initializes the 20 most-significant bits of the hyperframe numbers.	MS→GERAN RRC RB1 (PDTCH)
11	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 § 2.6.1 line 11.	MS←GERAN MAC PACCH

13	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 § 2.1.3 line 11 except for the following: • *RRC state indicator* specifies that the mobile station enter *RRC-Cell_Shared* state.	MS←GERAN RRC RB1 (PDTCH)
15	Data PDU GERAN forwards the data to the MS.	MS←GERAN PDCP RB5 (PDTCH)

2.6.4 *RRC-GRA_PCH*, PCCCH

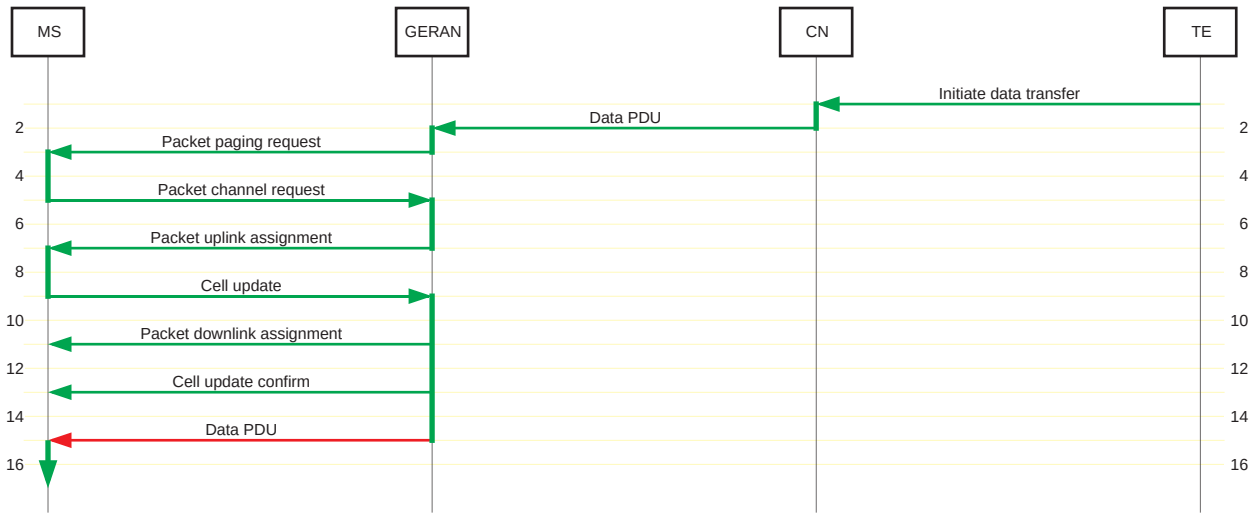
This sequence corresponds to the following user-based scenario:

- Lloyd receives an e-mail order confirmation.

Figure 14 shows the paging-related portion of an incoming data transfer under the following conditions:

- RRC is in *RRC-GRA_PCH* state.
- MM is in *MM-Idle* state.
- PMM is in *PMM-Connected* state.
- Mobile station is monitoring a PCCCH.

Figure 14: Incoming packet data transfer – *RRC-GRA_PCH,* PCCCH, assign shared channel



Line	Description	Direction Protocol Channel
1	Initiate data transfer Lloyd's server sends an e-mail confirming a customer order.	CN←TE
2	Data PDU Same as § 2.6.3 line 2.	GERAN←CN GTP *Iu-ps*
3	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 TBF establishment. • *Mobile identity* is the mobile station's G-RNTI. • *Channel needed* is not sent because this information element only applies to circuit calls. Change the *packet paging request* as specified in § 2.1.2.	MS←GERAN RRC PCCCH (PPCH)
5	Packet channel request *{establishment cause, random bits}* Same as § 2.6.2 line 5.	MS→GERAN RRC PCCCH (PRACH)
7	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 § 2.6.2 line 7.	MS←GERAN RRC PCCCH (PAGCH)
9	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 § 2.6.3 line 9.	MS→GERAN RRC RB1 (PDTCH)
11	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 § 2.6.3 line 11.	MS←GERAN MAC PACCH

13	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 § 2.6.3 line 13.	MS←GERAN RRC RB1 (PDTCH)
15	Data PDU GERAN forwards the data to the MS.	MS←GERAN PDCP RB5 (PDTCH)

3. Impact on specifications

This section is incomplete.

3.1 Changes to 23.060 (GPRS stage 2)

Section	Description

3.2 Changes to 24.008 (CN protocols)

Section	Description
9.2.15	Location updating request Add *DRX parameter*. *DRX parameter* is already specified in § 10.5.5.6.
10.5.1.4	Mobile identity Add G-RNTI as a *mobile identity*.

3.3 Changes to 25.413 (UTRAN RANAP)

Section	Description
3.3	Abbreviations Add GERAN. Add *mobile station* to definition of UE.
8.15	Paging Update section to include GERAN paging. Add *SPLIT_PG_CYCLE*.
9.1.23	Paging Add *SPLIT_PG_CYCLE*.
9.2	Information-element definitions Add *SPLIT_PG_CYCLE*.

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]).

Section	Description
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, p*aging 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 i* applies when paging with G-RNTI. Delete the requirement that *Packet page indication i* 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.

3.5 Changes to 44.060 (GERAN RLC/MAC)

Section	Description
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)

Section	Description
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

1. Cooper, Alan. *The Inmates are Running the Asylum – Why High-Tech Products Drive Us Crazy and How to Restore the Sanity.* Indianapolis: SAMS, 1999.

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.*

4. 3GPP TS 25.304. *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UE Procedures in Idle mode and Procedures for Cell Reselection in Connected Mode.*

5. 3GPP TS 25.331. *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; RRC Protocol Specification.*

6. 3GPP TS 25.413. *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu interface RANAP signalling.*

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.*

8. 3GPP TS 44.018. *3rd Generation Partnership Project; Technical Specification Group GSM EDGE Radio Access Network; Mobile radio interface layer 3 specification; Radio Resource Control Protocol.*

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.*

11. G2-010063. *GERAN Iu paging procedures.* Helsinki: Ericsson, 25 Jun 01.

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A. Network-operation modes

A.1 GPRS

GRPS 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 available, else CCCH.

  <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.

$$N_m = 9 - 6 * BS\_CCCH\_SDCCH\_COMB - BS\_AG\_BLKS\_RES$$

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.

$$N_c = BS\_PA\_MFRMS * N_m$$

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.

$$M_c = 64 * N_m$$

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.

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

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.

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

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.

$$CCCH\_GROUP = \left[(IMSI \bmod 1000) \bmod N_t\right] \operatorname{div} N_c$$

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.*, $CCCH\_GROUP = IMSI \bmod BS\_CC\_CHANS$?>

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.

$$PAGING\_GROUP = \left[(IMSI \bmod 1000) \bmod N_t\right] \bmod N_c$$

where:

$PAGING\_GROUP$ = the group of paging blocks the mobile station shall monitor.

$IMSI$ = 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.

$$PAGING\_GROUP = \begin{pmatrix} \left[(IMSI \bmod 1000) \operatorname{div} N_t\right] * N_c + \\ (IMSI \bmod 1000) \bmod N_c + \\ \max\left[(m * M_c) \operatorname{div} SPLIT\_PG\_CYCLE, m\right] \end{pmatrix} \bmod M_c$$

where:

$PAGING\_GROUP$ = the group of paging blocks the mobile station shall monitor.

$IMSI$ = 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*.

$$PAGING\_GROUP \text{ div } N_{m} = (FN \text{ div } 51) \bmod (BS\_PA\_MFRMS)$$

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.

$$PAGING\_GROUP \text{ div } N_{m} = (FN \text{ div } 51) \bmod 64$$

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).

$$i = PAGING\_GROUP \bmod N_{m}$$

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.

$$M_{pc} = 64 * N_{pm}$$

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.

$$N_{pt} = BS\_PCC\_CHANS * M_{pc}$$

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.

$$PCCCH\_GROUP = (IMSI \bmod 1000) \bmod BS\_PCC\_CHANS$$

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.

$$PAGING\_GROUP = \begin{pmatrix} \left[(IMSI \bmod 1000) \operatorname{div} N_{pt}\right] * N_{pc} + \\ (IMSI \bmod 1000) \bmod N_{pc} + \\ \max\left[\left(m * M_{pc}\right) \operatorname{div} SPLIT\_PG\_CYCLE, m\right] \end{pmatrix} \bmod M_{pc}$$

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 (M_{pc}, SPLIT_*PG_CYCLE*) – 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*.

$$PAGING\_GROUP \operatorname{div} N_{pm} = (FN \operatorname{div} 52) \bmod 64$$

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).

$$i = PAGING\_GROUP \bmod N_{pm}$$

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].

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

where:

P	=	system frame number of the first frame of the paging block in which the mobile station will be paged.
$IMSI$	=	international mobile-subscriber identity.
K	=	number of paging channels.
DRX	=	DRX cycle length calculated as follows: DRX = max (2^k, PBP), where k 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.
PBP	=	paging block period. PBP = 1 for frequency-division duplex.
n	=	non-negative integer.
Fo	=	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 [13] and G2-010063 [11].

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*.

C.4 RRC states

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.