OPTIMIZED SYSTEM ACCESS PROCEDURES

CLAIM OF PRIORITY

This application claims the benefit of U.S. Provisional Application Serial No. 61/535,509 filed on September 16, 2011. Furthermore, this application claims the benefit of U.S. Provisional Application Serial No. 61/620,696 filed on April 5, 2012. The contents of these documents are hereby incorporated by reference herein.

TECHNICAL FIELD

The present invention relates to a base station subsystem (BSS) and a method for improving an Access Grant Channel (AGCH) capacity when mobile stations establish an uplink Temporary Block Flow (TBF) triggered by a small data transmission (SDT) or an instant message transmission (IMT). Plus, the present invention relates to a mobile station (MS) and a method for improving the AGCH capacity when the mobile station establishes an uplink TBF triggered by a SDT or an IMT.

BACKGROUND

In the wireless telecommunications field it is anticipated that there will be an ever increasing Common Control Channel (CCCH) congestion problem due to the increase of small data transmissions (SDTs) and instant message transmissions (IMTs) as a result of the Machine-to-Machine (M2M) traffic and the frequent small packet transmissions which are going to be generated by mobile stations (e.g., smart phones). Various solutions to address the CCCH congestion problem and other problems are the subject of the present invention.

ABBREVIATIONS

The following abbreviations are herewith defined, at least some of which are referred to within the following description of the present invention.

AGCH	Access Grant Channel
ARFCN	Absolute Radio Frequency Channel Number
ATI	Additional TBF Information
BCCH	Broadcast Control Channel

BSS	Base Station Subsystem
CCCH	Common Control Channel
CS	Circuit Switched
DRX	Discontinuous Reception
EGPRS	Enhanced General Packet Radio Service
EPCR	Enhanced Packet Channel Request
eTFI	Enhanced Temporary Flow Identity
eUSF	Enhanced Uplink State Flag
FN	Frame Number
IA	Incoming Access
IE	Information Element
LAP	Low Access Priority
LLC	Logical Link Control
MAC	Media Access Control
M2M	Machine-to-Machine
OSAP	Optimized System Access Procedure
PACCH	Packet Associated Control Channel
PCH	Paging Channel
PDU	Packet Data Unit
PFC	Packet Flow Context
PRR	Packet Resource Request
PUA	Packet Uplink Assignment
PUAN	Packet Uplink Ack/Nack
RF	Radio Frequency
RLC	Radio Link Control
SI	System Information
TBF	Temporary Block Flow
TCH	Traffic Channel
TDMA	Time Division Multiple Access
TLLI	Temporary Logical Link Identity
TOI	Temporary OSAP Identity
TSC	Training Sequence Code

SUMMARY

A base station subsystem (BSS), a mobile terminal (MS) and methods that address the aforementioned CCCH congestion problem by improving the capacity on an AGCH are described in the independent claims of the present application. Advantageous embodiments of the BSS, the MS and methods have been described in the dependent claims of the present application.

In one aspect, the present invention provides a BSS configured to interact with a plurality of MSs and perform a procedure to improve an AGCH capacity. The BSS comprises a processor and a memory that stores processor-executable instructions where the processor interfaces with the memory and executes the processor-executable instructions to enable a broadcast operation, a receive operation, and a send operation. The broadcast operation includes broadcasting a new SI to the MSs, where the new SI includes static radio parameters which are to be used by any one of the MSs when establishing an uplink TBF to transmit a SDT or an IMT (note: the new SI indicates that the BSS is configured to perform an optimized system access procedure to improve the AGCH capacity). The receive operation including receiving at least one access request from at least one of the MSs, where the at least one MS is requesting to establish the uplink TBF to transmit the SDT or the IMT (note: the MS would send the access request only if the BSS is configured to perform the optimized system access procedure to improve the AGCH capacity). The send operation includes sending, in response to the received at least one access request, an immediate assignment message on the AGCH for the at least one MS. The immediate assignment message includes at least a portion of dynamic radio parameters which are to be used along with the static radio parameters by the at least one MS when establishing the uplink TBF to transmit the SDT or the IMT. This is an advantage over the prior art because the BSS by broadcasting the new SI which includes the static parameters is now able to send one immediate assignment message to multiple MSs thus improving the AGCH capacity.

In another aspect, the present invention provides a method implemented by a BSS, which interacts with a plurality of MSs, for performing a procedure to improve an AGCH capacity. The method comprises a broadcasting step, a receiving step, and a sending step. The broadcast step includes broadcasting a new SI to the MSs, where the

new SI includes static radio parameters which are to be used by any one of the MSs when establishing an uplink TBF to transmit a SDT or an IMT (note: the new SI indicates that the BSS is configured to perform an optimized system access procedure to improve the AGCH capacity). The receiving step includes receiving at least one access request from at least one of the MSs, where the at least one MS is requesting to establish the uplink TBF to transmit the SDT or the IMT (note: the MS would send the access request only if the BSS is configured to perform the optimized system access procedure to improve the AGCH capacity). The sending step includes sending, in response to the received at least one access request, an immediate assignment message on the AGCH for the at least one MS. The immediate assignment message includes at least a portion of dynamic radio parameters which are to be used along with the static radio parameters by the at least one MS when establishing the uplink TBF to transmit the SDT or the IMT. This is an advantage over the prior art because the BSS by broadcasting the new SI which includes the static parameters is now able to send one immediate assignment message to multiple MSs thus improving the AGCH capacity.

In another aspect, the present invention provides a MS configured to interact with a BSS and to improve an AGCH capacity. The MS comprising: a processor and a memory that stores processor-executable instructions where the processor interfaces with the memory and executes the processor-executable instructions to enable a first receiving operation, a sending operation, a second receiving operation, and a using operation. The first receiving operation includes receiving a new SI from the base station subsystem, where the new SI includes static radio parameters which are to be used by the MS whenever the MS establishes an uplink TBF to transmit a SDT or an IMT (note: the new SI indicates that the BSS is configured to perform an optimized system access procedure to improve the AGCH capacity). The sending operation includes sending an access request to the base station subsystem, where the access request is sent when the MS is requesting to establish the uplink TBF to transmit the SDT or the IMT (note: the MS would send the access request only if the BSS is configured to perform the optimized system access procedure to improve the AGCH capacity). The second receiving operation includes receiving an immediate assignment message on the AGCH from the base station substation, where the immediate assignment message includes at least a portion of dynamic radio parameters. The using operation includes using the static radio

parameters and the at least a portion of the dynamic radio parameters when establishing the uplink TBF to transmit the SDT or the IMT. This is an advantage over the prior art because the BSS by broadcasting the new SI which includes the static parameters is now able to send one immediate assignment message to multiple MSs thus improving the AGCH capacity.

In another aspect, the present invention provides a method implemented by a MS which interacts with a BSS for improving an AGCH capacity. The method comprises a first receiving step, a sending step, a second receiving step, and a using step. The first receiving step includes receiving a new SI from the base station subsystem, where the new SI includes static radio parameters which are to be used by the MS whenever the MS establishes an uplink TBF to transmit a SDT or an IMT (note: the new SI indicates that the BSS is configured to perform an optimized system access procedure to improve the AGCH capacity). The sending step includes sending an access request to the base station subsystem, where the access request is sent when the MS is requesting to establish the uplink TBF to transmit the SDT or the IMT (note: the MS would send the access request only if the BSS is configured to perform the optimized system access procedure to improve the AGCH capacity). The second receiving step includes receiving an immediate assignment message on the AGCH from the base station substation, where the immediate assignment message includes at least a portion of dynamic radio parameters. The using step includes using the static radio parameters and the at least a portion of the dynamic radio parameters when establishing the uplink TBF to transmit the SDT or the IMT.. This is an advantage over the prior art because the BSS by broadcasting the new SI which includes the static parameters is now able to send one immediate assignment message to multiple MSs thus improving the AGCH capacity.

Additional aspects of the invention will be set forth, in part, in the detailed description, figures and any claims which follow, and in part will be derived from the detailed description, or can be learned by practice of the invention. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention as disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention may be obtained by reference to the following detailed description when taken in conjunction with the accompanying drawings:

FIGURES 1A-1E are several diagrams uses to help explain the wireless signaling that occurs between the BSS and multiple MSs to improve the capacity of the AGCH in accordance with a first embodiment of the present invention;

FIGURES 2A-2C are several diagrams uses to help explain the wireless signaling that occurs between the BSS and multiple MSs to improve the capacity of the AGCH in accordance with a second embodiment of the present invention;

FIGURES 3A-3D are several diagrams associated with the disclosure in the aforementioned U.S. Provisional Application Serial No. 61/620,696 which are used to help explain the wireless signaling that occurs between the BSS and multiple MSs to improve the capacity of the AGCH in accordance with various embodiments of the present invention; and

FIGURES 4A-4C are several diagrams associated with an article entitled "Detailed OSAP Signalling Procedure" 3GPP TSG-GERAN #54, GP-120624 presented by the inventors in Sanya, China, May 14-18, 2012 which are used to further help explain the wireless signaling that occurs between the BSS and multiple MSs to improve the capacity of the AGCH in accordance with various embodiments of the present invention.

DETAILED DESCRIPTION

Referring to FIGURE 1A, there is a diagram illustrating the basic wireless signaling that occurs between a BSS 102 and multiple MSs 104_1, 104_2, 104_3, 104_4....104_n to improve the capacity of the AGCH 106 in accordance with a first embodiment of the present invention. As shown, the BSS 102 broadcasts a new SI 120 on the BCCH 122 to the MSs 104_1, 104_2, 104_3, 104_4....104_n (step 1). The new SI 120 includes a predetermined set of packet radio resources 134 (i.e., static radio parameters 134) which are to be used by the MSs 104_1, 104_2, 104_3, 104_4....104_n whenever any one of the MSs 104_1, 104_2, 104_3, 104_4....104_n establishes the uplink TBF 128 that is triggered by the SDT 130a or the IMT 130b (note: the new SI 120 indicates that the BSS 120 is

configured to perform an optimized system access procedure to improve the AGCH capacity). The BSS 102 receives one or more access requests 124 on the RACH 126 from one or more MSs 104_1 and 104_3 (for example) which now want to transmit the SDT 130a or the IMT 130b and are requesting to establish the uplink TBF 128 (step 2) (note: the MS would send the access request 124 only if the BSS 102 is configured to perform the optimized system access procedure to improve the AGCH capacity). In response to receiving the access requests 124, the BSS 102 sends the immediate assignment message 132 on the AGCH 106 to the requesting MSs 104_1 and 104_3 (step 3). The immediate assignment message 132 includes at least a portion of the dynamic radio parameters 136 which are to be used along with the previously sent static radio parameters 134 by the requesting MSs 104_1 and 104_3 to establish the corresponding uplink TBFs 128 and transmit the corresponding SDT 130a or IMT 130b (step 4). If only one MS 104_1 (for example) sends an access request 124 to the BSS 102 during an allowed access time interval, then the BSS 102 could choose to send a legacy immediate assignment message which includes the complete set of dynamic radio parameters 136 to the individual MS 104_1 so it can establish the uplink TBF 128 and transmit the SDT 130a or IMT 130b. Or, the BSS 102 could send the immediate assignment message 132 to the individual MS 104_1 so it can establish the uplink TBF 128 and transmit the SDT 130a or IMT 130b.

If desired, the BSS 102 does not need to include all of the dynamic radio parameters in the immediate assignment message 132 which are needed by the MSs 104_1 and 104_3 to establish the uplink TBFs 128. In this case, the BSS 102 would send a remaining portion of the dynamic radio parameters 136' in a message 138 on a PACCH 140 to the requesting MSs 104_1 and 104_3 which were addressed by the immediate assignment message 132 (step 5). Furthermore, the BSS 102 could send additional static radio parameters 134' in the message 138 (or some other PACCH message if the remaining dynamic radio parameters 136' are not sent) on the PACCH 140 to the requesting MSs 104_1 and 104_3 addressed by the immediate assignment message 132 (step 5). Then, the requesting MSs 104_1 and 104_3 would use the static radio parameters 134 (and the additional static radio parameters 134' if sent), the portion of dynamic radio parameters 136 (included in the immediate assignment message 132), and the remaining portion of the dynamic radio parameters 136' (if sent in message 138) to establish the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b

(step 6). In any case, this process is a marked improvement over the prior art since the traditional BSS was configured to send an immediate assignment message (which included the needed static and dynamic radio parameters) to only one MS at a time rather than being configured as in the present invention to send an immediate assignment message 132 to multiple MSs 104_1 and 104_3 (for example) at the same time which improves the capacity of the AGCH 106. A more detailed discussion is provided next about the various features and advantages of the first embodiment of the present invention.

The aforementioned basic concept of the first embodiment considered here is that of allowing for a network to identify a pre-determined set of packet radio resources 134 (i.e. default radio resources 134, static radio parameters 134) that are to be used whenever a MS access request 124 is triggered by a SDT 130a or an IMT 130b. These default radio resources 134 are identified by including them as a new SI 120 which can indicate a set of one or more static radio parameters 134 that the network would commonly assign when using a legacy packet access procedure to assign radio resources appropriate for the MS's SDT or IMT transmissions. This new SI 120 has the static radio parameters 134 where each set of static radio parameters 134 includes a corresponding Radio Assignment Identity (RAID) value (referenced by the enhanced immediate assignment message 132 on the AGCH 106) along with associated parameter values for the following Information Elements (IEs) (which can currently be included within a legacy immediate assignment message):

- Page Mode
- Packet Channel Description
- Mobile Allocation
- Starting Time
- IA Rest Octets

A network supporting the transmission of static radio parameters 134 as part of SI 120 should therefore include at least one complete set of these parameters. The MS 104_1, 104_2, 104_3, 104_4....104_n that receives these static radio parameters 134 via SI 120 will not need to be sent this same information on the AGCH 106 when attempting a system

access for an SDT or IMT transmission. As such, this packet radio resource pre-allocation procedure effectively frees up AGCH capacity by modifying the immediate assignment message 132 to only include the dynamic radio parameters 136 (e.g. timing advance and TFI) (not the static radio parameters 134) needed by the requesting MS 104_1 and 104_3 when establishing an uplink TBF 128. The modified immediate assignment message 132 (e.g., enhanced immediate assignment (EIA) message 132) allows for a greater number of MSs 104_1, 104_2, 104_3, 104_4....104_n to be addressed by any given instance of an EIA message 132 when compared to a legacy immediate assignment message which can only address a single MS.

The inclusion of static radio parameters 134 within SI 120 (e.g. using SI21) indicates the BSS 102 supports reception of a new RACH burst that includes a new training sequence (TS) that the MS 104_1 (for example) would send in the access request 124 to indicate that the SDT 130a or the IMT 130 has triggered the access attempt. The access request 124 will be 11 bits long as per the legacy EGPRS Packet Channel Request message but will use different code points and as such is referred to herein as an Enhanced Packet Channel request message 124 which can (for example) be coded as shown in TABLE 1:

TABLE 1: Enhanced Packet Channel Request Message 124's content

< Enhanced Packet channel request message content > ::=		
< **MO SDT - One Phase Access Request** :	000	< **RandomBits** : bit (8) > >
| < **MO IMT – One Phase Access Request** :	001	< **RandomBits** : bit (8) > >
| < **Paging Response – One Phase Access Request** :	010	< **RandomBits** : bit (8) > >;

The exemplary Enhanced Packet Channel request message 124 shown in TABLE 1 allows for five additional code points to be defined for any additional services for which a high volume of corresponding access attempts are anticipated and therefore can be better supported using the Enhanced Packet Channel request 124 – Enhanced Immediate assignment message 132 signaling exchange described herein (i.e. new code points can be defined to support services other than SDT 130a and IMT 130b). In addition, this signaling scheme is not limited to being used within the context of one phase access attempts but can also be used for two access attempts. The reason that the one phase access case is indicated in TABLE 1 is that it allows for the minimum amount

of control plane signaling to be used in support of SDT 130a and IMT 130b transmissions.

The MS 104_1, 104_2, 104_3, 104_4....104_n (which is not a legacy MS) that supports the transmission of the enhanced packet channel request message 124 must of course be able to read the static radio parameters 134 sent as part of SI 120 before making such an access request 124. The rate at which the MS 104_1, 104_2, 104_3, 104_4....104_n is expected to refresh (i.e. re-read) the static radio parameters 134 information is nominally once every 30 seconds (i.e. as per the legacy periodicity for re-reading legacy SI). Note: The Page Mode information (proposed for inclusion in the static radio parameters 134) is not expected to change often and so allowing for a nominal 30 second refresh rate for the static radio parameters 134 (and therefore the Page Mode) is considered to be acceptable.

It should be noted that the static radio parameters 134 information includes the IA Rest Octets which, as currently defined, includes USF, TFI and Request Reference information which is dynamic by its very nature. As such, either a new IA Rest Octets that excludes all dynamic information can be defined or the legacy IA Rest Octets can still be used where it is understood that the MS 104_1, 104_2, 104_3, 104_4....104_n will simply ignore all dynamic information regardless of what it is set to.

The BSS 102's reception of an enhanced packet channel request message 124 on the RACH 126 indicates that the corresponding MS 104_1 (for example) supports the reception of the enhanced immediate assignment message 132 on the AGCH 106. The BSS 102 can therefore respond to the access request 124 by sending the enhanced immediate assignment message 132 that includes one instance of the following dynamic radio parameters 136 for each MS 104_1 and 104_3 (for example) addressed by this message:

- RAID corresponding to the applicable set of static radio parameters 134 (2 bits – allows for up to 4 sets of static radio parameters 134 to be included in the SI 120)
- Echoed enhanced packet channel request code point (11 bits) – see Note 1
- Assigned eTFI (8 bits) – See Note 2 and 3
- Assigned eUSF (8 bits) – See Note 2 and 3
- Timing Advance (8 bits) – See Note 4

- FN Information (16 bits) – See Note 5

Note 1: This information overrides the 11 bit access request code point value if provided when the IA Rest Octets IE is sent as part of the static radio parameters 134.

Note 2: This assumes the set of static radio parameters 134 indicated by RAID is only used for the MSs 104_1, 104_2, 104_3, 104_4....104_n that support RLC/MAC enhancements (i.e. having an RLC/MAC protocol that supports 8 bit TFI and USF values means backward compatibility will not be supported on these packet radio resources).

Note 3: It may be acceptable to leave eUSF information out of the enhanced immediate assignment message 132 if the BSS 102, after sending the MS 104_1 (for example) the enhanced immediate assignment message 132, waits for it to move to the assigned packet radio resource and then sends it a new PACCH message 138 containing the eUSF information 136'. In other words, if eUSF information 136 is missing from the enhanced immediate assignment message 132 then the MS 104_1 (for example) will wait to receive the eUSF information 136' in a new RLC/MAC control message 138 sent on the PACCH 140 before it can make any uplink transmissions on the allocated packet radio resource. Similarly, the enhanced immediate assignment message 132 can include a legacy TFI value (5 bits) instead of an eTFI value (8 bits) in which case the MS 104_1 (for example) will use the legacy TFI value until it receives an eTFI assignment 136' in the new RLC/MAC control message 138 sent on the PACCH 140. Whenever PACCH signaling is used to supplement the dynamic radio parameters 136 sent with the enhanced immediate assignment message 132 then the MS 104_1 (for example) must receive this RLC/MAC control message 138 before it can proceed to complete contention resolution as per the legacy one phase (or two phase) access procedure.

Note 4: It may be acceptable to leave Timing Advance information 136 out of the enhanced immediate assignment message 132 if the BSS 102, after sending the MS 104_1 (for example) the enhanced immediate assignment message 132, waits for it to move to the assigned packet radio resource and then sends it a RLC/MAC control message 138 on the PACCH 140 containing the Timing Advance information 136'. In

other words, if Timing Advance information is missing from the enhanced immediate assignment message 132, then the MS 104_1 (for example) will wait to receive this information on the PACCH 140 before it can make any uplink transmissions on the allocated packet radio resource.

Note 5: With an 8 bit "RandomBits" field included in the enhanced packet channel request message 124 (see TABLE 1) the need for the enhanced immediate assignment message 132 to include any FN related info may be eliminated (i.e. for the case of access collision between two or more MSs 104_1, 104_2, 104_3, 104_4....104_n all possible ambiguity will of course be cleaned up when contention resolution is completed but having an 8 bit "RandomBits" field can be viewed as being sufficient to ensure an acceptably low probability of having multiple MSs 104_1, 104_2, 104_3, 104_4....104_n still in contention after the enhanced packet channel request message 124 (RACH 126) – enhanced immediate assignment message 132 (AGCH 106) exchange. Alternatively, some portion of the FN (frame number) can be carried within the legacy Request Reference IE and could be included such as T1' (see FIGURE 1B). The purpose of the legacy Request Reference information element is to provide the random access information used in the access request message 124 sent on the RACH 126 and the frame number (FN) modulo 42432 in which the access request 124 was received. In this case, the legacy Request Reference information element shown in FIGURE 1B would be coded as follows.

- RA, Random Access Information (octet 2). This is an unformatted 8 bit field. Typically the contents of this field are coded the same as the CHANNEL REQUEST message shown in FIGURE 1C
- T1' (octet 2). The T1' field is coded as the binary representation of (FN div 1326) mod 32.
- T3 (octet 3 and 4). The T3 field is coded as the binary representation of FN mod 51. Bit 3 of octet 2 is the most significant bit and bit 6 of octet 3 is the least significant bit.

- T2 (octet 4). The T2 field is coded as the binary representation of FN mod 26.

NOTE: The frame number, FN modulo 42432 can be calculated as 51x((T3-T2) mod 26)+T3+51x26xT1'

It should be noted that the Extended RA (5 bit field) can be included within the IA Rest Octets IE of the legacy Immediate Assignment (IA) message and has a content consisting of the 5 least significant bits of the EGPRS PACKET CHANNEL REQUEST message defined in 3GPP TS 44.060 (the contents of which are incorporated herein by reference). It is included for the case of an 11-bit access request message 124 since the RA field of the Request Reference IE (also included within the legacy IA message) in FIGURE 1B only provides 8 bits of information and as such the full 11-bit access request message can only be echoed to a MS 104_1 (for example) using supplementary information provided by the Extended RA IE.

The dynamic radio parameters 136 described above could be carried within the EIA Rest Octets IE of the enhanced immediate assignment message 132 as shown below in TABLE 2:

TABLE 2: Enhanced Immediate Assignment message 132

IEI	Information element	Type / Reference	Presence	Format	length
	L2 Pseudo Length	L2 Pseudo Length 10.5.2.19	M	V	1
	RR management Protocol Discriminator	Protocol Discriminator 10.2	M	V	1/2
	Skip Indicator	Skip Indicator 10.3.1	M	V	1/2
	Immediate Assignment Message Type	Message Type 10.4	M	V	1
	EIA Rest Octets	EIA Rest Octets 10.5.2.xx	M	V	20

The sum of the length of the EIA Rest Octets IE and the L2 Pseudo Length IE equals 22 (see TABLE 2). The L2 pseudo length is the sum of lengths of all information elements present in the EIA message 132 except the EIA Rest Octets and L2 Pseudo

Length information elements (i.e. 2 octets). This leaves 20 octets of space for the EIA Rest Octets which can be used to provide dynamic radio parameters 136 for a variable number of MSs 104_1, 104_2, 104_3, 104_4....104_n as follows:

EIA Capacity Gain Case 1:

In this case all of the dynamic radio parameters 136 described above are included for each MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA Rest Octets IE. This translates into 6 octets + 5 bits per addressed MS 104_1, 104_2, 104_3, 104_4....104_n which therefore allows for 3 distinct MSs to be addressed by each instance of the enhanced immediate assignment message 132 which results in a three-fold increase in the capacity of the AGCH 106 when compared to using the legacy immediate assignment message (which provides radio resources for one MS).

EIA Capacity Gain Case 2:

In this case only a subset of the dynamic radio parameters 136 described above are included for each MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA Rest Octets IE as follows:

- RAID corresponding to the applicable set of SDT Radio Parameters 134 (2 bits)
- Echoed enhanced packet channel request code point (11 bits)
- Assigned eTFI (8 bits)

This translates into 2 octets + 5 bits per addressed MS 104_1, 104_2, 104_3, 104_4....104_n which allows for six distinct MSs to be addressed by each instance of the enhanced immediate assignment message 132 which results in a six-fold increase in the capacity of the AGCH 106 when compared to using the legacy immediate assignment message (which provides radio resources for one MS).

EIA Capacity Gain Case 3:

In this case only a subset of the dynamic radio parameters 136 described above are included for each MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA Rest Octets IE as follows:

- RAID corresponding to the applicable set of SDT Radio Parameters 134 (2 bits)
- Echoed enhanced packet channel request code point (11 bits)
- Assigned Legacy TFI (5 bits)

This translates into 2 octets + 2 bits per addressed MS 104_1, 104_2, 104_3, 104_4....104_n which allows for eight distinct MSs to be addressed by each instance of the enhanced immediate assignment message 132 which results in an eight-fold increase in the capacity of the AGCH 106 when compared to using the legacy immediate assignment message (which provides radio resources for one MS).

EIA Capacity Gain Case 4:

In this case only a subset of the dynamic radio parameters 136 described above are included for each MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA Rest Octets IE as follows:

- RAID corresponding to the applicable set of SDT Radio Parameters 134 (2 bits)
- Echoed enhanced packet channel request code point (11 bits)

A single instance of an eTFI (8 bits) is also included in the enhanced immediate assignment message 132 which the first addressed MS will consider as its assigned eTFI value. The 2nd addressed MS will consider eTFI + 1 as its assigned eTFI value and the 3rd addressed MS will consider eTFI + 2 as its assigned eTFI etc...

This translates into 1 octet + 5 bits per addressed MS + one instance of the 8 bit eTFI value which allows for 11 distinct MSs to be addressed by each instance of the enhanced immediate assignment message 132 which results in an eleven-fold increase in

the capacity of the AGCH 106 when compared to using the legacy immediate assignment message (which provides radio resources for one MS).

It should be noted that following contention resolution the BSS 102 can choose to use PACCH signaling 138 to send a MS 104_1, 104_2, 104_3, 104_4....104_n one or more additional sets of static radio parameters 134'. The BSS 102 can then refer to these static radio parameters 134' using RAID in subsequent enhanced immediate assignment messages it sends to that MS 104_1, 104_2, 104_3, 104_4....104_n. This therefore allows the BSS 102 to maintain MS specific static radio parameters 134' which may be of interest for certain classes of MSs (e.g. for stationary MSs) which may allow for minimizing the amount of SI 120 bandwidth used to convey static radio parameters 134. For example, only a single set of static radio parameters 134 may need to be included as part of SI 120 if the PACCH 140 is used to supplement this information as needed for specific subsets of MS 104_1, 104_2, 104_3, 104_4....104_n.

Referring to FIGURE 1D, there is a flowchart of an exemplary method 100d implemented by the BSS 102 which is configured to interact with multiple MSs 104_1, 104_2, 104_3, 104_4....104_n and perform a procedure to improve the capacity of the AGCH 106 in accordance with the first embodiment of the present invention. The BSS 102 includes the processor 110 and the memory 112 that stores processor-executable instructions where the processor 110 interfaces with the memory 112 and executes the processor-executable instructions to perform method 100d's steps as discussed next. At step 102d, the BSS 102 broadcasts the new SI 120 on the BCCH 122 to the MSs 104_1, 104_2, 104_3, 104_4....104_n. The new SI 120 includes a predetermined set of packet radio resources 134 (i.e., static radio parameters 134) which are to be used by the MSs 104_1, 104_2, 104_3, 104_4....104_n whenever any one of the MSs 104_1, 104_2, 104_3, 104_4....104_n establishes the uplink TBF 128 that is triggered by the SDT 130a or the IMT 130b. At step 104d, the BSS 102 receives one or more access requests 124 (within an allowed (i.e. restricted) access time interval) on the RACH 126 from one or more MSs 104_1 and 104_3 (for example) which now want to transmit the SDT 130a or the IMT 130b and are requesting to establish the uplink TBF 128. In response to receiving the access requests 124, the BSS 102 at step 206d sends the immediate assignment message 132 on the

AGCH 106 for the requesting MSs 104_1 and 104_3. The immediate assignment message 132 includes at least a portion of the dynamic radio parameters 136 which are to be used along with the static radio parameters 134 by the requesting MSs 104_1 and 104_3 (for example) when establishing the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b. In the event, the BSS 102 does not include all of the dynamic radio parameters in the immediate assignment message 132 sent during step 106d which are needed by the requesting MSs 104_1 and 104_3 to establish the uplink TBFs 128, then the BSS 102 at step 108d could send a remaining portion of the dynamic radio parameters 136' in a message 138 on a PACCH 140 to the requesting MSs 104_1 and 104_3. If desired, the BSS 102 at step 110d could send additional static radio parameters 134' in the message 138 (or some other message if the remaining dynamic radio parameters 136' are not sent) on the PACCH 140 to the MSs 104_1 and 104_3. Then, the MSs 104_1 and 104_3 would use the static radio parameters 134 (and the additional static radio parameters 134' if sent), the portion of dynamic radio parameters 136 (included in the immediate assignment message 132), and the remaining portion of the dynamic radio parameters 136' (if sent in message 138) to establish the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b.

Referring to FIGURE 1E, there is a flowchart of an exemplary method 100e implemented by MS 104_1 (for example) which is configured to interact with the BSS 102 and to improve the capacity of the AGCH 106 in accordance with the first embodiment of the present invention. The MS 104_1 includes the processor 116 and the memory 118 that stores processor-executable instructions where the processor 116 interfaces with the memory 118 and executes the processor-executable instructions to perform method 100e's steps as discussed next. At step 102e, the MS 104_1 receives the new SI 120 on the BCCH 122 from the BSS 102. The new SI 120 includes a predetermined set of packet radio resources 134 (i.e., static radio parameters 134) which are to be used by the MS 104_1 when establishing the uplink TBF 128 that is triggered by the SDT 130a or the IMT 130b. At step 104e, the MS 104_1 sends the access request 124 on the RACH 126 when requesting to establish the uplink TBF 128 that is triggered by the SDT 130a or the IMT 130b. At step 106e, the MS 104_1 receives the immediate assignment message 132 on the AGCH 106 from the BSS 102. The immediate assignment message 132 includes at least a portion of the dynamic radio parameters 136 which are to be used along with the static

radio parameters 134 by the MS 104_1 when establishing the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b. In the event, the BSS 102 does not include all of the dynamic radio parameters in the immediate assignment message 132 which are needed by the MS 104_1 to establish the uplink TBFs 128, then the MS 104_1 at step 108e would receive a remaining portion of the dynamic radio parameters 136' in a message 138 on a PACCH 140 from the BSS 102. Furthermore, the MS 104_1 at step 110e could receive additional static radio parameters 134' in the message 138 (or some other message if the remaining dynamic radio parameters 136' are not sent) on the PACCH 140 from the BSS 102. At step 112e, the MS 104_1 would use the static radio parameters 134 (and the additional static radio parameters 134' if sent), the portion of dynamic radio parameters 136 (included in the immediate assignment message 132), and the remaining portion of the dynamic radio parameters 136' (if sent in message 138) to establish the uplink TBF 128 to transmit the SDT 130a or IMT 130b.

Referring to FIGURE 2A, there is a diagram illustrating the basic wireless signaling that occurs between the BSS 102 and the MSs 104_1, 104_2, 104_3, 104_4....104_n (multiple MSs 104 shown) to improve the capacity of the AGCH 106 in accordance with the second embodiment of the present invention. As shown, the BSS 102 broadcasts a new SI 120 on the BCCH 122 to the MSs 104_1, 104_2, 104_3, 104_4....104_n (step 1). The new SI 120 includes an indicator 302 which indicates to the MSs 104_1, 104_2, 104_3, 104_4....104_n that the BSS 102 is configured to perform the optimized system access procedure to improve the capacity of the AGCH 106. The content of the new SI 120 can be limited to providing this single indicator 302 if suitable static radio parameters 134 are provided by either the legacy SI 13 message or by the immediate assignment message 132. The BSS 102 receives one or more access requests 124 on the RACH 126 from one or more MSs 104_1 and 104_3 (for example) which now want to transmit the SDT 130a or the IMT 130b and are requesting to establish the uplink TBF 128 (step 2) (note: the MS would send the access request 124 only if the BSS 102 is configured to perform the optimized system access procedure to improve the AGCH capacity). In response to receiving the access requests 124, the BSS 102 sends the immediate assignment message 132 on the AGCH 106 to the requesting MSs 104_1 and 104_3 (step 3). The immediate assignment message 132 includes a predetermined set of packet radio resources 134 (i.e.,

static radio parameters 134—same as the ones described in the first embodiment), and at least a portion of the dynamic radio parameters 136 (same as described in the first embodiment) both of which are to be used by the requesting MSs 104_1 and 104_3 when establishing the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b (step 4). If only one MS 104_1 (for example) sends an access request 124 to the BSS 102 during an allowed access time interval, then the BSS 102 could choose to send a legacy immediate assignment message which includes the static radio parameters 134 and the dynamic radio parameters 136 to the individual MS 104_1 so it can establish the uplink TBF 128 and transmit the SDT 130a or IMT 130b. Or, the BSS 102 could send the immediate assignment message 132 to the individual MS 104_1 so it can establish the uplink TBF 128 and transmit the SDT 130a or IMT 130b.

If desired, the BSS 102 does not need to include all of the dynamic radio parameters in the immediate assignment message 132 which are needed by the requesting MSs 104_1 and 104_3 to establish the uplink TBFs 128. In this case, the BSS 102 would send a remaining portion of the dynamic radio parameters 136' in a message 138 on a PACCH 140 to the requesting MSs 104_1 and 104_3 which were addressed by the immediate assignment message 132 (step 5). Furthermore, the BSS 102 could send additional static radio parameters 134' in the message 138 (or some other message if the remaining dynamic radio parameters 136' are not sent) on the PACCH 140 to the requesting MSs 104_1 and 104_3 (step 5). Then, the requesting MSs 104_1 and 104_3 would use the static radio parameters 134 (and the additional static radio parameters 134' if sent), the portion of dynamic radio parameters 136 (included in the immediate assignment message 132), and the remaining portion of the dynamic radio parameters 136' (if sent in message 138) to establish the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b (step 6). In any case, this process is a marked improvement over the prior art since the traditional BSS was configured to send an immediate assignment message to only one MS at a time rather than being configured as in the present invention to send an immediate assignment message 132 to multiple MSs 104_1 and 104_3 (for example) at the same time which improves the capacity of the AGCH 106.

Referring to FIGURE 2B, there is a flowchart of an exemplary method 200b implemented by the BSS 102 which is configured to interact with multiple MSs 104_1,

104_2, 104_3, 104_4....104_n and perform a procedure to improve the capacity of the AGCH 106 in accordance with the second embodiment of the present invention. The BSS 102 includes the processor 110 and the memory 112 that stores processor-executable instructions where the processor 110 interfaces with the memory 112 and executes the processor-executable instructions to perform method 200b's steps as discussed next. At step 202b, the BSS 102 broadcasts the new SI 120 on the BCCH 122 to the MSs 104_1, 104_2, 104_3, 104_4....104_n. The new SI 120 includes an indicator 302 which indicates to the MSs 104_1, 104_2, 104_3, 104_4....104_n that the BSS 102 is configured to perform the procedure to improve the capacity of the AGCH 106. At step 204b, the BSS 102 receives one or more access requests 124 (within an allowed (i.e. restricted) access time interval) on the RACH 126 from one or more MSs 104_1 and 104_3 (for example) which now want to transmit the SDT 130a or the IMT 130b and are requesting to establish the uplink TBF 128. In response to receiving the access requests 124, the BSS 102 at step 206b sends the immediate assignment message 132 on the AGCH 106 for the requesting MSs 104_1 and 104_3. The immediate assignment message 132 includes a predetermined set of packet radio resources 134 (i.e., static radio parameters 134—same as the ones described in the first embodiment), and at least a portion of the dynamic radio parameters 136 (same as described in the first embodiment) both of which are to be used by the requesting MSs 104_1 and 104_3 when establishing the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b. In the event, the BSS 102 does not include all of the dynamic radio parameters in the immediate assignment message 132 which are needed by the requesting MSs 104_1 and 104_3 to establish the uplink TBFs 128, then the BSS 102 at step 208b would send a remaining portion of the dynamic radio parameters 136' in a message 138 on a PACCH 140 to the requesting MSs 104_1 and 104_3. If desired, the BSS 102 at step 210b could send additional static radio parameters 134' in the message 138 (or some other message if the remaining dynamic radio parameters 136' are not sent) on the PACCH 140 to the requesting MSs 104_1 and 104_3. Then, the requesting MSs 104_1 and 104_3 would use the static radio parameters 134 (and the additional static radio parameters 134' if sent), the portion of dynamic radio parameters 136 (included in the immediate assignment message 132), and the remaining portion of the dynamic radio parameters 136' (if sent in message 138) to establish the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b.

Referring to FIGURE 2C, there is a flowchart of an exemplary method 200c implemented by MS 104_1 (for example) which is configured to interact with the BSS 102 and to improve the capacity of the AGCH 106 in accordance with the second embodiment of the present invention. The MS 104_1 includes the processor 116 and the memory 118 that stores processor-executable instructions where the processor 116 interfaces with the memory 118 and executes the processor-executable instructions to perform method 200c's steps as discussed next. At step 202c, the MS 104_1 receives the new SI 120 on the BCCH 122 from the BSS 102. The new SI 120 includes an indicator 302 which indicates to the MSs 104_1, 104_2, 104_3, 104_4....104_n that the BSS 102 is configured to perform the procedure to improve the capacity of the AGCH 106. At step 204c, the MS 104_1 sends the access request 124 on the RACH 126 when requesting to establish the uplink TBF 128 that is triggered by the SDT 130a or the IMT 130b. At step 206c, the MS 104_1 receives the immediate assignment message 132 on the AGCH 106 from the BSS 102. The immediate assignment message 132 includes a predetermined set of packet radio resources 134 (i.e., static radio parameters 134—same as the ones described in the first embodiment), and at least a portion of the dynamic radio parameters 136 (same as described in the first embodiment) both of which are to be used by the requesting MSs 104_1 and 104_3 when establishing the corresponding uplink TBFs 128 to transmit the corresponding SDT 130a or IMT 130b. In the event, the BSS 102 does not include all of the dynamic radio parameters in the immediate assignment message 132 which are needed by the requesting MS 104_1 to establish the uplink TBFs 128, then the MS 104_1 at step 208c would receive a remaining portion of the dynamic radio parameters 136' in a message 138 on a PACCH 140 from the BSS 102. Furthermore, the MS 104_1 at step 210c could receive additional static radio parameters 134' in the message 138 (or some other message if the remaining dynamic radio parameters 136' are not sent) on the PACCH 140 from the BSS 102. At step 212c, the MS 104_1 would use the static radio parameters 134 (and the additional static radio parameters 134' if sent), the portion of dynamic radio parameters 136 (included in the immediate assignment message 132), and the remaining portion of the dynamic radio parameters 136' (if sent in message 138) to establish the uplink TBF 128 to transmit the SDT 130a or IMT 130b.

The following detailed discussion describes various features and advantages associated with the present invention. In particular, the following detailed discussion is based on the disclosure in the aforementioned U.S. Provisional Application Serial No. 61/620,696 filed on April 5, 2012. In addition, the underlined portions below highlight differences between the disclosure of U.S. Provisional Application Serial No. 61/620,696 and an article prepared by the inventors entitled "Optimized System Access Procedure" 3GPP TSG-GERAN #54, GP-120623 and presented in Sanya, China, May 14-18, 2012. Finally, reference numerals have been added to the disclosure of U.S. Provisional Application Serial No. 61/620,696.

"OSAP Assisted Downlink TBF Establishment"

Abstract

In light of increasing CCCH congestion problems anticipated as a result of M2M traffic and frequent small packet transmissions 130a and 130b generated by smart phones 104_1, 104_2, 104_3, 104_4....104_n an enhanced procedure for PS domain triggered system access referred to as Optimized System Access Procedure (OSAP) is considered herein. The key objective of OSAP is to increase AGCH 106 capacity by minimizing the size of the MS specific information carried within AGCH based assignment messages 132. This can be accomplished by offloading the transmission of certain radio parameters 134 to system information 120, limiting the content 136 of the assignment messages 132 to what is strictly necessary to direct a MS104_1 to a packet resource and using the PACCH 140 of the packet resource to assign the MS 104_1 any remaining information 134' and 136' it requires for uplink TBF 128 establishment. A detailed evaluation of OSAP shows that it can provide up to an eight-fold gain compared to legacy AGCH operation wherein a legacy Immediate Assignment message is assumed to assign packet resources for a single MS.

1. Introduction

Discussion of mechanisms for improving AGCH 106 capacity has been ongoing for a number of GERAN meetings with possible solutions as described in references [1]

and [2]. A reasonable operational example to consider that provides motivation for the OSAP feature described herein is as follows:

- The 51-multiframe format of a downlink CCCH could, for a given period of high system load, consist of an average of 4 PCH blocks and 5 AGCH blocks (i.e. in addition to the radio block used for BCCH Norm).
- For a single instance of this 51-multiframe format there would be 51 RACH bursts resulting in a RACH burst to AGCH block ratio of about 10 to 1 (reduced to about 5 to 1 when factoring in the degradation of RACH performance due to collisions inherent to slotted aloha operation) which strongly suggests the AGCH will be a bottleneck.
- Using IPA as a means to mitigate this imbalance results in achieving a 10 to 3 ratio (i.e. since IPA allows for up to 3 MS to be addressed by a single assignment message) but further mitigation of this imbalance is desirable if feasible (note: IPA is an alternative to OSAP and is discussed in reference [1] and later below).
- For DL TBF establishment when a MS is in READY STATE, the IPA feature provides no performance increase as DL TBFs will always be established using the legacy Immediate Assignment message.

The OSAP feature described herein allows for further reducing the RACH burst to AGCH block ratio as follows:

- Allowing for the inclusion of Mobile Allocation information 134 as new system information (SI) 120 to identify the subset of ARFCNs defined by the Cell Allocation to be used when frequency hopping is used in a given cell. The Mobile Allocation information 134 included as SI 120 can be referred to as "Static Radio Parameters" (SRP) 134 and would apply to packet resources assigned to mobile stations 104_1, 104_2, 104_3, 104_4....104_n using OSAP.
- Limiting the content of AGCH based assignment messages 132 to what is strictly necessary to direct a mobile station 104_1 to a packet resource where it waits for a downlink PACCH message 138.

- Sending a PACCH message 138 on the downlink of the assigned packet resource to provide a MS 104_1 with all additional information 134' and 136' needed to complete the establishment of either an uplink TBF 128 or downlink TBF.
- Introducing a new AGCH message 132 referred to as an Enhanced Immediate Assignment (EIA) message 132 and a new PACCH message 138 referred to as an Additional TBF Information (ATI) message 138.

FIGURE 3A shows an example according to the first embodiment of the present invention of how the content of 5 legacy IA messages 402 can be effectively distributed within (a) system information 120, (b) a single EIA message 132 and (c) a single instance of an ATI message 138 (i.e. whereby a RACH burst to AGCH block ratio of 10 to 5 is realized). Additional analysis within this discussion paper shows that a single EIA message 132 can be used to address up to 8 different MSs 104_1, 104_2, 104_3, 104_4....104_n thereby allowing for a 10 to 8 ratio to be realized using OSAP.

2. Optimized System Access Procedure - Overview

The SRP information 134 can be carried within SI 120 (e.g. using SI 21)(according to the first embodiment of the present invention). Or, the SI 120 will at minimum provide an indication 302 (according to the second embodiment of the present invention). In any case, the SI 120 indicates when a serving cell supports the Optimized System Access Procedure (OSAP) wherein the corresponding BSS 102 is capable of receiving a new RACH burst 124 that involves the use of a new training sequence code (TSC). The reception of an access request message 124 known as an Enhanced Packet Channel Request 124 (EPCR) sent using this new TSC allows for introducing new OSAP specific code points in the 11-bit EPCR message as per TABLE 3 below.

TABLE 3: ENHANCED PACKET CHANNEL REQUEST 124 message content

< Enhanced Packet channel request message content > ::=

< **OSAP Request – one phase access** : 00 < **Priority** : bit (2) >
< **MultislotClassGroup** : bit (3) >
< **RandomBits** : bit (4) > >

< **OSAP Request – signalling** : 01000 < **Priority** : bit (2) >
< **RandomBits** : bit (4) > >

< **OSAP Request – single block packet access** : 01001 < **Priority** : bit (2) >
< **RandomBits** : bit (4) > >

< **OSAP Request – two phase access** : 01010 < **Priority** : bit (2) >
< **RandomBits** : bit (4) > >;

The basic signaling events associated with an OSAP based system access for uplink TBF 128 establishment wherein a one phase access is used are shown in FIGURE 3B.

3. Analysis of the Legacy Immediate Assignment Message Content

The content of the legacy Immediate Assignment message is examined below on a per information element basis to identify which information must still be included within the OSAP specific EIA message 132 sent on the AGCH 106 and which information can be sent later using one or more OSAP specific ATI message 138 instances sent on the PACCH 140 (i.e. that supplements the packet resource information provided by the OSAP specific assignment message 132).

TABLE 4: Legacy IMMEDIATE ASSIGNMENT message content

IEI	Information element	Type / Reference	Presence	Format	length
	L2 Pseudo Length	L2 Pseudo Length 10.5.2.19	M	V	1
	RR management Protocol Discriminator	Protocol Discriminator 10.2	M	V	½
	Skip Indicator	Skip Indicator 10.3.1	M	V	½
	Immediate Assignment Message Type	Message Type 10.4	M	V	1
	Page Mode	Page Mode 10.5.2.26	M	V	½
	Dedicated mode or TBF	Dedicated mode or TBF 10.5.2.25b	M	V	½
	Channel Description	Channel Description 10.5.2.5	C	V	3
	Packet Channel Description	Packet Channel Description 10.5.2.25a	C	V	3

IEI	Information element	Type / Reference	Presence	Format	length
	Request Reference	Request Reference 10.5.2.30	M	V	3
	Timing Advance	Timing Advance 10.5.2.40	M	V	1
	Mobile Allocation	Mobile Allocation 10.5.2.21	M	LV	1-9
7C	Starting Time	Starting Time 10.5.2.38	O	TV	3
	IA Rest Octets	IA Rest Octets 10.5.2.16	M	V	0-11

- Page Mode: This content of this legacy IE is included within the Page Mode IE of the EIA message 132 shown in TABLE 6. This IE allows for informing a MS not addressed by the EIA message 132 about possible extended paging operation and is therefore not deferrable to an ATI message 124.
- Dedicated mode or TBF: Not required since the system access scenario considered herein is always associated with TBF establishment.
- Channel Description: Not required since it is associated with identifying a TCH.
- Packet Channel Description: An enhanced version of this legacy IE is included within the Packet Channel Description IE of the EIA message 132 as shown in TABLE 6 (i.e. the enhanced version consists of the legacy IE with the Channel type field and the spare bits removed). This IE provides the basic amount of information required by a mobile station 104_1 to identify the assigned packet resources and is therefore not deferrable to an ATI message 138.
- Request Reference: An enhanced version of this legacy IE is included in the EIA message 132 where similar information is carried using the MS Specific EIA Parameters IE as shown in TABLE 6. This information is used for the purpose of contention resolution and is therefore not deferrable to an ATI message 138.
- Timing Advance: Included in an ATI message 138 instance sent on the PACCH 140.
- Mobile Allocation: Can be included in the SRP information 134 sent on BCCH 122 or included in the EIA message 132. If frequency hopping is

applied, the mobile station 104_1 uses the last Cell Allocation received on SI1 to decode the Mobile Allocation.

- Starting Time: Included in an ATI message 138 instance sent on the PACCH 140.
- IA Rest Octets: An enhanced version of this legacy IE is included in an ATI message 138 instance where similar information is carried using the MS Specific TBF Parameters IE as shown in TABLE 7 (i.e. the enhanced version of this legacy IE eliminates the CSN.1 extension mechanism used for indicating information on a per release basis).

4. SRP Information Content

The SRP information 134 can be carried within SI 120 (e.g. using SI 21)(according to the first embodiment of the present invention). Or, the SI 120 will at minimum provide an indication 302 (according to the second embodiment of the present invention). In any case, the SI 120 indicates that a serving cell supports OSAP based system access and Mobile Allocation information (optional). If frequency hopping is used then the Mobile Allocation information indicates the subset of RF channels belonging to the Cell Allocation used in the frequency hopping sequence.

- A maximum of 8 octets is needed to include SRP information 134 within an SI message 120 (i.e. a cell allocation can at most consist of 64 ARFCNs).
- When SRP 134 information or the indicator 302 is included within an SI message 120 a single instance of OSAP Mobile Allocation information is seen as being sufficient for the packet radio resources that can be assigned using the OSAP procedure.
- For example, the following structure could be added as a Rel-12 extension to the SI 21 message 120.

{ 0 | 1 -- OSAP based system access procedure supported

{ 0 -- OSAP Mobile Allocation not included as part of system information

```
                    | 1  < Number of Octets : bit (3) >
                { < OSAP Mobile Allocation : bit (8) > } * (val(Number of Octets)+1)
                }
        } ;
```

Each bit of each OSAP Mobile Allocation octet corresponds to a specific frequency in the Cell Allocation frequency list as currently described for the legacy Mobile Allocation information element.

5. Enhanced Immediate Assignment (EIA) Message 132 Content

This message 132 is formatted as shown in TABLE 5 below and is sent on the AGCH 106 by the network to provide mobile stations 104_1, 104_2, 104_3, 104_4....104_n with a minimum amount of packet resource information 134 (i.e. as a result of receiving this information a MS 104_1 can only receive PACCH messages 138 on the packet resources assigned by the EIA message 132 and must therefore wait until it receives additional TBF related information 134' and 136' on the PACCH 138 before an uplink TBF 128 can be used for payload transmission or payload can be received on a downlink TBF).

TABLE 5: ENHANCED IMMEDIATE ASSIGNMENT message 132 content

IEI	Information element	Type / Reference	Presence	Format	length
	L2 Pseudo Length	L2 Pseudo Length 10.5.2.19	M	V	1
	RR management Protocol Discriminator	Protocol Discriminator 10.2	M	V	1/2
	Skip Indicator	Skip Indicator 10.3.1	M	V	1/2
	Enhanced Immediate Assignment Message Type	Message Type 10.4	M	V	1
	EIA Rest Octets	EIA Rest Octets 10.5.2.xx	M	V	1...20

The length (in octets) of all information provided by the EIA Rest Octets IE and the value provided by the L2 Pseudo Length IE has a maximum value of 22 (see TABLE 5 above). The L2 pseudo length indicates the sum of the lengths of all information elements present in the EIA message 132 except the EIA Rest Octets IE and the L2

Pseudo Length IE itself and as such has a value of 2. This leaves a maximum of 20 octets (160 bits) of space available for the EIA Rest Octets IE.

One instance of the EIA Rest Octets IE is included per EIA message 132 and consists of the fields shown in TABLE 6 below where these fields are used as follows:

- Page Mode (2 bits): One instance is included per EIA message 132.
- Implicit Reject CS (1 bit): One instance is included per EIA message 132. Note that this is included so that an OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n configured for LAP can detect an Implicit Reject for the CS domain when it happens to read an EIA message 132 on the AGCH 106 while attempting a non-OSAP system access for the CS domain.
- Implicit Reject PS (1 bit): One instance is included per EIA message 132. Note that this is included so that an OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n configured for LAP can detect an Implicit Reject for the PS domain when it reads an EIA message 132 on the AGCH 106 that does not provide matching FN Information + Random Bits.
- Message Reference ID (2 bits): One instance is included per EIA message 132. This information is included so that a MS 104_1, 104_2, 104_3, 104_4....104_n can compare the value of the Message Reference ID received in a subsequent ATI message 138 instance against the value received in the EIA message 132 and thereby verify when it has received an ATI message 138 instance that supplements a previously received EIA message 132.
- Packet Channel Description (18 or 19): One instance is included per EIA message 132 (i.e. it is common to all MSs 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA message 132) and its content is the same as per the legacy Packet Channel Description IE (see TABLE 6 below).
- Mobile Allocation (1, 11, 19, 27 or 35): One instance may be included per EIA message 132 (i.e. when included it is common to all MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA message 132) and it is limited to providing 32 bits Mobile Allocation information. If more than 32 bits of Mobile Allocation information are needed or Mobile Allocation information is sent using system

information 120 (i.e. SRP 134) then this information is not included in the EIA message 132.

- FN Information Length (2 bits): One instance is included per EIA message 132 and allows for 4 different lengths of FN Information to be indicated.
- Temporary OSAP Identity Length (2 bits): One instance is included per EIA message 132 and allows for 4 different lengths of Temporary OSAP Identity to be indicated.
- FN Information (Z bits = val(FN Information Length) + 9): One instance is included per MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA message 132 for the purpose of uplink TBF 128 establishment.
    - FN Information = the binary value of 'FN modulo X' where FN = the TDMA frame number of the burst in which an Enhanced Packet Channel Request 124 was received on the RACH 126 by the BSS 102.
    - X can be set to reflect an acceptable probability for TDMA frame number collision. For example, for X = 256 (Z = 8 bits) the time between uplink bursts for which FN mod 256 has the same value is 1.18 sec (i.e. each TDMA frame = 4.615ms, 256* 4.615 = 1.18).
    - This means there will be some degree of uncertainty on behalf of mobile stations 104_1, 104_2, 104_3, 104_4....104_n regarding whether or not matching 'FN Information' they receive in an EIA message 132 really reflects the specific burst in which they sent their access request message on the RACH 126.
    - The length of the MS specific FN information (Z bits) included in an EIA message 132 is variable allowing for operators to increase/decrease the probability of TDMA FN collision to a level they are comfortable with.
- Random Bits (4 bits): One instance is included per MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA message 132 and has a corresponding instance of the FN Information field (i.e. corresponding instances of FN Information and Random Bits sent in an EIA message 132 are a reflection of the "Z" least

significant bits of the TDMA FN and Random Bits received by the BSS 102 within an earlier EPCR message 124).

- Temporary OSAP Identity (Y bits = val(Temporary OSAP Identity Length) + 9): One instance is included per MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA message 132 for the purpose of downlink TBF establishment. It allows for an EIA message 132 to identify each mobile station 104_1, 104_2, 104_3, 104_4....104_n based on its specific Temporary OSAP Identity. If a MS 104_1, 104_2, 104_3, 104_4....104_n has not been assigned a Temporary OSAP Identity then legacy procedures are used for downlink TBF establishment.

TABLE 6: EIA Rest Octets Information Element

```
< EIA Rest Octets > ::=
< Page Mode : bit (2) >
< Implicit Reject CS : bit >
< Implicit Reject PS : bit >
< Message Reference ID : bit (2) >
< Packet Channel Description : < Packet Channel Description struct > >
{ 0 | 1  < Mobile Allocation Length : bit (2) >
        < Mobile Allocation : bit (8 * ( val(Mobile Allocation Length) + 1)) > }
< FN Information Length : bit (2) >
< Temporary OSAP Identity Length : bit (2) >
{ 1     < MS Specific EIA Parameters : < MS Specific EIA Parameters struct > >  } ** 0
<spare padding> ;

< Packet Channel Description struct> ::=
< TN : bit (3) >
< TSC : bit (3) >
{  0
        { 0     < ARFCN : bit (10) >    -- non-hopping RF channel configuraion
                | 1     < MAIO : bit (6) >      -- indirect encoding of hopping RF channel
configuration
                        < MA_NUMBER_IND : bit >
                        { 0 | 1  < CHANGE_MARK_1 : bit (2) > }
        }
        | 1
                < MAIO : bit (6) >              -- direct encoding of hopping RF channel
configuration
                < HSN : bit (6) >
} ;
```

```
< MS Specific EIA Parameters struct> ::=
{ 0     < FN Information : bit (val(FN Information Length) + 9) >
        < Random Bits : bit (4) >
        | 1     < Temporary OSAP Identity : bit (val(Temporary OSAP Identity Length) +
9) >
} ;
```

EIA Example 1: The EIA message 132 is used only for the case of uplink TBF 128 establishment where FN Information provided for each MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA message 132 is 9 bits long (i.e. Z = 9, X = 512). In this case all MS 104_1, 104_2, 104_3, 104_4....104_n making access requests 124 within a TDMA frame where the 9 least significant bits of that TDMA frame matches the FN Information sent in the EIA message 132 will then look at the corresponding Random Bits field to determine if they have received a response that matches their access request 124. Note that in this case the TDMA frames having the same 9 least significant bits will be a multiple of 2.36 sec apart (i.e. 512 * 4.615ms = 2.36s).

- The EIA message 132 content specific to each addressed MS = FN Information (9) + Random Bits (4) + MS ID Discriminator (1) = 14 bits.
- The EIA message 132 content for which a single instance is included (regardless of how many MS 104_1, 104_2, 104_3, 104_4....104_n are addressed) = Page Mode (2) + Implicit Reject CS (1) + Implicit Reject PS (1) + Message Reference ID (2) + Packet Channel Description (19) + Mobile Allocation (1) + FN Information Length (2) + Temporary OSAP Identity Length (2) = 30 bits.
- The maximum number of MS 104_1, 104_2, 104_3, 104_4....104_n addressed per EIA message 132 = 8 (i.e. 8*14 + 30 = 142).
- According to TABLE 6 above 10 bits of CSN.1 overhead are required for the EIA message 132 (1 bit to indicate no mobile allocation is included, 1 bit for each of the 8 instances of the MS Specific EIA Parameters IE included in the message and 1 bit to indicate the "direct encoding of hopping RF channel configuration" is used).
- The resulting EIA message 132 has a total length of 152 bits.

EIA Example 2: This example builds on EIA example 1 above except that it allows for

10 bits of FN Information (i.e. Z = 10, X = 1024) for each MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the EIA message 132. In this case all MS 104_1, 104_2, 104_3, 104_4....104_n making access requests 124 within a TDMA frame where the 10 least significant bits of that TDMA frame matches the FN Information sent in the EIA message 132 will then look at the corresponding Random Bits field to determine they have received a response that matches their access request 124. Note that in this case the TDMA frames having the same 10 least significant bits will be a multiple of 4.72 sec apart (i.e. 1024* 4.615ms = 4.72s).

- The EIA message 132 content specific to each addressed MS = FN Information (10) + Random Bits (4) + MS ID Discriminator (1) = 15 bits.
- The EIA message 132 content for which a single instance is included (regardless of how many MS are addressed) = Page Mode (2) + Implicit Reject CS (1) + Implicit Reject PS (1) + Message Reference ID (2) + Packet Channel Description (19) + Mobile Allocation (1) + FN Information Length (2) + Temporary OSAP Identity Length (2) = 30 bits.
- The maximum number of MS 104_1, 104_2, 104_3, 104_4....104_n addressed per EIA message 132 = 8 (i.e. 8*15 + 30 = 150).
- According to TABLE 6 above 10 bits of CSN.1 overhead are required for the EIA message 132 (1 bit to indicate no mobile allocation is included, 1 bit for each of the 8 instances of the MS Specific EIA Parameters IE included in the message and 1 bit to indicate the "direct encoding of hopping RF channel configuration" is used).
- The resulting EIA message 132 has a total length of 160 bits.

EIA Example 3: This example builds on example 2 above except that it allows for 24 bits of Mobile Allocation information to be included within the EIA message 132.

- The EIA message 132 content specific to each addressed MS = FN Information (10) + Random Bits (4) + MS ID Discriminator (1) = 15 bits.
- The EIA message 132 content for which a single instance is included (regardless of how many MS are addressed) = Page Mode (2) + Implicit Reject CS (1) +

Implicit Reject PS (1) + Message Reference ID (2) + Packet Channel Description (19) + Mobile Allocation (27) + FN Information Length (2) + Temporary OSAP Identity Length (2) = 56 bits.

- The maximum number of MS 104_1, 104_2, 104_3, 104_4....104_n addressed per EIA message 132 = 6 (i.e. 6*15 + 56 = 146).
- According to TABLE 6 above 8 bits of CSN.1 overhead are required for the EIA message 132 (1 bit to indicate a mobile allocation is included, 1 bit for each of the 6 instances of the MS Specific EIA Parameters IE included in the message and 1 bit to indicate the "direct encoding of hopping RF channel configuration" is used).
- The resulting EIA message 132 has a total length of 154 bits

6. Additional TBF Information (ATI) Message 138 Content

This message 138 is formatted as shown in TABLE 7 below and is sent on the PACCH 140 by the network to provide mobile stations 104_1, 104_2, 104_3, 104_4....104_n with additional information 134' and 136' required for uplink TBF 128 or downlink TBF establishment. A set of one or more ATI message 138 instances can be sent by the BSS 102 where each instance in the set corresponds to the same EIA message 132 and is carried within a single PACCH block. This will minimize the amount of information any given MS 104_1, 104_2, 104_3, 104_4....104_n addressed by a given EIA message 132 must receive within the EIA message 132. Note that until a MS receives an ATI message 138 instance containing information that supplements the information it previously received in an EIA message 132 it can only receive on the downlink PACCH 140 the packet resources assigned by the EIA message 132. The content of this message 138 consists of the following:

- MS Specific TBF Parameters (X bits): One instance is included per MS 104_1, 104_2, 104_3, 104_4....104_n addressed by an ATI message 138.
- Page Mode (2 bits): One instance is included per ATI message 138.
- Message Reference ID (2 bits): One instance is included per ATI message 138. This information is included so that a MS 104_1, 104_2, 104_3, 104_4....104_n can

compare it to the value in the previously received EIA message 132 and thereby verify when it has received an ATI message 138 that corresponds to the EIA message 132 in which it detected matching FN Information and Random Bits.

- MS Assignment Bitmap (8 bits): One instance is included per ATI message 138. This bitmap indicates which subset of MS addressed by a given EIA message 132 are assigned resources by a received ATI message 138. Depending on the amount of MS specific information required, multiple ATI messages 138 corresponding to the same EIA message 132 can be sent. The net result is that the "Nth" MS 104_1, 104_2, 104_3, 104_4....104_n addressed by an EIA message 132 will only have to correctly receive one corresponding ATI message 132 instance (i.e. the ATI message instance having a MS Assignment Bitmap with a "1" in bit position "N").

  For example, if we assume that 5 MS 104_1, 104_2, 104_3, 104_4, 104_5 are addressed in a given EIA message 132 then 2 corresponding ATI message 138 instances can be sent where ATI message instance 1 addresses MS1, MS2 and MS3 and ATI message instance 2 addresses MS4 and MS5 as per FIGURE 3C. Thus any combination of up to 8 MSs 104_1, 104_2, 104_3, 104_4....104_n can be addressed in the set of ATI message 138 instances corresponding to the same EIA message 132.

The number of MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the MS Specific TBF Parameters IE included in a given ATI message 138 instance can therefore be a subset of the total number of MS 104_1, 104_2, 104_3, 104_4....104_n addressed by the MS Specific EIA Parameters IE included in the EIA Rest Octets IE (see TABLE 6) carried within the corresponding EIA message 132. The ordering of MS addressed by the MS Specific TBF Parameters IE included in a given ATI message 138 instance will therefore be determined by the MS Assignment Bitmap IE.

Table 7: Additional TBF Information (ATI) Message 138

< Additional TBF Information message content > ::=
< PAGE_MODE : bit (2) >
< Message Reference ID : bit (2) >
< MS Assignment Bitmap : bit (8) >
{ 1 < MS Specific TBF Parameters : < MS Specific TBF Parameters struct > > } ** 0
<spare padding>;

```
< MS Specific TBF Parameters struct> ::=
{ 00          < EGPRS Packet Uplink Assignment >
      | 01    < Packet Uplink Assignment >
      | 10    < Packet Downlink Assignment >
      | 11    - reserved
} ;
< EGPRS Packet Uplink Assignment > : :=
{ 0 | 1  < Access Technologies Request : Access Technologies Request struct > }
{ 0      -- one phase access indication
      < TFI_ASSIGNMENT : bit (5) >
      < POLLING : bit >
      < USF: bit (3) >
      < USF_GRANULARITY : bit >
      { 0 | 1  < P0 : bit (4) >
      < PR_MODE : bit (1) > }
      < EGPRS CHANNEL_CODING_COMMAND : < EGPRS Modulation and
Coding Scheme IE >>
      < TLLI_BLOCK_CHANNEL_CODING : bit (1) >
      { 0 | 1 < BEP_PERIOD2 : bit (4) > }
      < RESEGMENT : bit (1) >
      < EGPRS Window Size : < EGPRS Window Size IE >>  -- 5 bits
      { 0 | 1  < ALPHA : bit (4) > }
      < GAMMA : bit (5) >
      { 0 | 1  < TIMING_ADVANCE_INDEX : bit (4) > }
      { 0 | 1  < TBF_STARTING_TIME : bit (16) > }
            { 0          -- '0' indicates that FANR is not activated
                  | 1    -- '1' indicates that FANR is  activated
                        { 0          -- SSN-based encoding is selected
                              | 1    -- Time-based encoding is selected
                                    < REPORTED TIMESLOTS : bit (8) >
                                    < TSH : bit (2) > } }
            | 1    -- An uplink RTTI TBF is assigned
                  < RTTI USF Mode :  bit(1) >
                  < PDCH PAIR INDICATION: bit(3) >
                        < Additional_USF : bit (3) >*(1-val(RTTI USF
MODE))
                  { 0                                    -- One PDCH Pair assigned
                        | 1    < USF2 : bit(3)>          -- Two PDCH Pairs
assigned
                        < Additional_USF2 : bit (3) >*(1-val(RTTI USF
MODE)) }
```

```
                    { 0          -- SSN-based encoding is selected
                      | 1        -- Time-based encoding is selected

                                 < REPORTED TIMESLOTS : bit (8) >
                                 < TSH : bit (2) > }
        | 1      -- two phase access indication (Multi Block Allocation)
                 { 0 | 1 < ALPHA : bit (4) > }
                 < GAMMA : bit (5) >
                 < TBF_STARTING_TIME : bit (16) >
                 < NUMBER OF RADIO BLOCKS ALLOCATED : bit (2) >
                 { 0 | 1  < P0 : bit (4) >
                          < PR_MODE : bit (1) > }
}
{ 0 | 1 < PFI : bit (7) > } ;

<Access Technologies Request struct> ::=
        -- recursive structure allows any combination of Access technologies
        < Access Technology Type : bit (4) >
        { 0 | 1 <Access Technologies Request struct> } ;
< Packet Uplink Assignment > ::=
{ 0      -- one phase access
        < TFI_ASSIGNMENT : bit (5) >
        < POLLING : bit >
        < USF: bit (3) >
        < USF_GRANULARITY : bit >
        { 0 | 1  < P0 : bit (4) >
                 PR_MODE : bit (1) > }
        < CHANNEL_CODING_COMMAND : bit (2) >
        < TLLI_BLOCK_CHANNEL_CODING : bit >
        { 0 | 1  < ALPHA : bit (4) > }
        < GAMMA : bit (5) >
        { 0 | 1 < TIMING_ADVANCE_INDEX : bit (4) > }
        { 0 | 1 < TBF_STARTING_TIME : bit (16) > }
        | 1      -- two phase access indication (Single Block Allocation)
                 { 0 | 1 < ALPHA : bit (4) > }
                 < GAMMA : bit (5) >
                 < TBF_STARTING_TIME : bit (16) >
                 { L | H < P0 : bit (4) >
                          < PR_MODE : bit (1) > }
}
```

```
{ 0 | 1 < PFI : bit (7) > } ;

< Packet Downlink Assignment > ::=
        { 0 | 1  < TFI_ASSIGNMENT : bit (5) >
                 < RLC_MODE : bit >
                 { 0 | 1 < ALPHA : bit (4) > }
                 < GAMMA : bit (5) >
                 < POLLING : bit >
                 < TA_VALID : bit (1) > }
        { 0 | 1  < TIMING_ADVANCE_INDEX : bit (4) > }
        { 0 | 1  < TBF_STARTING_TIME : bit (16) > }
        { 0 | 1  < P0 : bit (4) >
                 < PR_MODE : bit (1) > }
        { 0 | 1  -- indicates EGPRS TBF mode, see 44.060
                 < EGPRS Window Size : < EGPRS Window Size IE >>
                 < LINK_QUALITY_MEASUREMENT_MODE : bit (2) >
                 { 0 | 1 < BEP_PERIOD2 : bit (4) > } }

        { 0 | 1 < PFI : bit (7) > }
        { 0 | 1 < NPM Transfer Time : bit (5) > }
        { 0      - A downlink  BTTI TBF is assigned
                 { 0             -- FANR is not activated for the assigned TBF
                         | 1     -- FANR is activated for the assigned TBF
                                 < EVENT_BASED_FANR: bit (1) > }
                 | 1     -- A downlink  RTTI TBF is assigned
                         < EVENT_BASED_FANR: bit (1) >
                         < PDCH PAIR INDICATION: bit(3) > }
        < Downlink EGPRS Level: < EGPRS Level IE > > ;
```

ATI Example 1: In this example a one phase access assignment is considered where all MS 104_1, 104_2, 104_3, 104_4,…104_n are assigned uplink TBF 128 resources using the Packet Uplink Assignment IE of TABLE 7 above:

- MS Specific TBF Parameters = 1 + Packet Uplink Assignment (2) + One Phase Access (1) + TFI_ASSIGNMENT (5) + POLLING (1) + USF (3) + USF_GRANULARITY (1) + {1 + P0 (4) + PR_MODE (1)} + CHANNEL_CODING_COMMAND (2) + TLLI_BLOCK_CHANNEL_CODING (1) + {1 + ALPHA (4)} + GAMMA (5) + {1 + TIMING_ADVANCE_INDEX (4)} + {1 + TBF_STARTING_TIME (0)} + {1 + PFI(7)} = 47 bits
- ATI message 138 instance 1 addresses 3 MS as per FIGURE 3C = Page Mode (2)

+ Message Reference ID (2) + MS Assignment Bitmap (8) + 3 * (MS Specific TBF Parameters) = 12 + 3 * (47) = 153 bits = 1 PACCH block.

- ATI message 138 instance 2 addresses 2 MS as per FIGURE 3C = Page Mode (2) + Message Reference ID (2) + MS Assignment Bitmap (8) + 2 * (MS Specific TBF Parameters) = 12 + 2 * (47) = 106 bits = 1 PACCH block.

ATI Example 2: In this example a two phase access assignment is considered where all MS 104_1, 104_2, 104_3, 104_4....104_n are assigned uplink TBF 128 resources using the Packet Uplink Assignment IE of TABLE 7 above:

- MS Specific TBF Parameters = 1 + Packet Uplink Assignment (2) + Two Phase Access (1) + {1 + ALPHA (4)} + GAMMA (5) + TBF_STARTING_TIME (16) + {1 + P0 (4) + PR_MODE (1)} + {1 + PFI(7)} = 44 bits
- ATI message 138 instance 1 addresses 3 MS as per FIGURE 3C = Page Mode (2) + Message Reference ID (2) + MS Assignment Bitmap (8) + 3 * (MS Specific TBF Parameters) = 12 + 3 * (44) = 144 bits = 1 PACCH block.
- ATI message 138 instance 2 addresses 2 MS as per FIGURE 3C = Page Mode (2) + Message Reference ID (2) + MS Assignment Bitmap (8) + 2 * (MS Specific TBF Parameters) = 12 + 2 * (44) = 100 bits = 1 PACCH block.

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ATI Example 3: In this example a two phase access assignment is considered where all MS 104_1, 104_2, 104_3, 104_4....104_n are assigned uplink TBF 128 resources using the EGPRS Packet Uplink Assignment IE of TABLE 7 above:

- MS Specific TBF Parameters = 1 + EGPRS Packet Uplink Assignment (2) + {1 + Access Technologies Request (0)} + Two Phase Access (1) + {1 + ALPHA (4)} + GAMMA (5) + TBF_STARTING_TIME (16) + NUMBER OF RADIO BLOCKS ALLOCATED (2) + {1 + P0 (4) + PR_MODE (1)} + {1 + PFI(7)} = 47 bits
- ATI message 138 instance 1 addresses 3 MS as per FIGURE 3C = Page Mode (2) + Message Reference ID (2) + MS Assignment Bitmap (8) + 3 * (MS Specific

TBF Parameters) = 12 + 3 * (47) = 153 bits = 1 PACCH block.

- ATI message 138 instance 2 addresses 2 MS as per FIGURE 3C = Page Mode (2) + Message Reference ID (2) + MS Assignment Bitmap (8) + 2 * (MS Specific TBF Parameters) = 12 + 2 * (47) = 106 bits = 1 PACCH block.

7. Downlink TBF Establishment Using OSAP Messages

Here we consider the case where a MS 104_1, 104_2, 104_3, 104_4....104_n in Idle mode can be assigned a downlink TBF without first performing the paging procedure (i.e. the Ready timer is running and the network knows the MS location at the cell level). According to legacy operation, downlink TBF establishment is performed by sending an Immediate Assignment message that includes a Packet Downlink TBF Assignment on its paging group (if in DRX mode) or on any AGCH occurrence (if in non-DRX mode immediately following TBF release).

When considering an OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n the network has the option of using the EIA 132 and ATI 138 messages defined for OSAP to allocate such a MS packet resources for a downlink TBF as follows:

- The network must assign the OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n an alternate identity (called a Temporary OSAP Identity) on a per cell basis that remains valid while the Ready timer is running. This requires a BSS 102 to have knowledge of the length of the Ready timer which can be realized in a number of ways (e.g. through the support of PFCs).

- The BSS 102 can use PACCH 140 signaling to assign a MS 104_1, 104_2, 104_3, 104_4....104_n a Temporary OSAP Identity (TOI) at any time while a TBF is ongoing for an OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n.

- Once a MS 104_1, 104_2, 104_3, 104_4....104_n has been assigned a TOI then as long as it remains valid it can be included in an EIA message 132 that includes DL TBF related information for that MS (see the Temporary OSAP Identity field in TABLE 6).

- Since the use of FN Information + Random Bits (for UL TBF 128 establishment) or Temporary OSAP Identity (for DL TBF establishment) is indicated per

instance of MS 104_1, 104_2, 104_3, 104_4....104_n addressed by an EIA message 132, any given instance of an EIA message can support any combination of MSs 104_1, 104_2, 104_3, 104_4....104_n for which either UL or DL TBF establishment is needed (see FIGURE 3D—which shows 5 MSs).

- The Temporary OSAP Identity can be from 9 to 12 bits in length allowing for up to a maximum of 4096 such identities to be maintained per cell.
- It should be noted that this mechanism for DL TBF establishment reduces the overall DL CCCH load, thus providing additional CCCH capacity for non-OSAP mobile stations.

The net benefit of having the OSAP messages also allow for DL TBF establishment is of course that a single EIA message 132 sent on the AGCH 106 can address up to 8 MS 104_1, 104_2, 104_3, 104_4....104_n for which DL TBF establishment is needed. An OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n that has been assigned a Temporary OSAP Identity will acquire SRP information 134/indicator 302 from SI 120, receive an EIA message 132 and a supplemental ATI message 138 instance to establish a DL TBF following the same steps used for UL TBF 128 establishment except that it is addressed using the Temporary OSAP Identity in the EIA message 132 (i.e. it cannot be addressed using FN Information + Random Bits since the RACH 126 is not used during DL TBF establishment for a MS 104_1, 104_2, 104_3, 104_4....104_n having a Temporary OSAP Identity in Idle mode).

8. Conclusion

A mechanism for enhancing AGCH 106 capacity has been described based on introducing an optimized system access procedure (OSAP) whereby the amount of MS specific information within an assignment message 132 sent on the AGCH 106 can be minimized by using new BCCH information and PACCH 140 signaling to provide supplemental MS specific information. As indicated by the examples provided in section 5 above, a significant AGCH 106 capacity gain is possible when using OSAP (e.g. 8 mobile stations 104_1, 104_2, 104_3, 104_4....104_n can be addressed by a single assignment message 132 sent on the AGCH 106). The OSAP related signaling used for UL TBF 128

establishment can also be used for DL TBF establishment for a MS 104_1, 104_2, 104_3, 104_4....104_n whose location is known at the cell level. Thereby the same AGCH 106 capacity gain can be achieved for any combination of UL and DL TBF establishment. Considering that the AGCH 106 capacity is seen as becoming increasingly problematic if the load offered by devices supporting delay tolerant applications increases significantly over the next few years, the introduction of OSAP as a new GERAN Rel-12 feature as described herein is seen as being beneficial towards minimizing the potential for the AGCH 106 to become a bottleneck.

References

[1] GP-111202 - Continued discussion for IPA parameters - Huawei Technologies Co., Ltd.

[2] GP-111065 - Usage of Higher MCSs on CCCH Downlink - Telefon AB LM Ericsson, ST-Ericsson SA

[3] GP-111708 - Improved AGCH Capacity using Static Radio Parameters - Telefon AB LM Ericsson, ST-Ericsson SA

[4] GP-111709 - Calculating the Probability of Access Collision - Telefon AB LM Ericsson, ST-Ericsson SA

[5] GP-111085 - Analysis on Traffic Characteristic of IM Service in China - CMCC

The references can be found at www.3GPP.org.

The following detailed discussion describes various features and advantages associated with the present invention. In particular, the following detailed discussion is based on an article prepared by the inventors which is entitled "Detailed OSAP Signalling Procedure" 3GPP TSG-GERAN #54, GP-120624 and was presented by the inventors in Sanya, China, May 14-18, 2012.

Detailed OSAP Signalling Procedures

1. Introduction

The OSAP feature described in a companion discussion paper (the aforementioned GP-120623) involves the introduction of new signaling procedures for more efficiently establishing both uplink and downlink TBFs. The detailed signaling procedures associated with the OSAP feature used for establishing uplink and downlink TBFs are examined in greater detail herein where it can be seen that this signaling essentially consists of a combination of new signaling combined with legacy signaling as follows:

- New BCCH information 120 that indicates the OSAP feature is supported by the network and which provides information about the packet data resources that can be assigned using OSAP based signaling.
- A new RACH message 124 that allows a BSS 102 to uniquely determine that a MS 104_1, 104_2, 104_3, 104_4....104_n is requesting OSAP based signaling for uplink TBF 128 establishment.
- New AGCH and PACCH signaling 132 and 138 supporting the establishment of uplink and downlink TBFs used for uplink and downlink user data transmission (e.g. 130a and 130b for the case of uplink data transmission).
- The legacy one phase and two phase contention resolution procedure for uplink TBF 128 establishment.
- Legacy TBF management and release procedures for uplink and downlink TBFs established using OSAP based signaling.

2. OSAP – Detailed Operation for UL TBF 128 Establishment

A serving cell that supports OSAP based signaling is managed by a corresponding BSS 102 that is capable of receiving a new 11-bit RACH message 124 consisting of an access burst that involves the use of a new training sequence code (TSC). Upon reading all OSAP related system information, an OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n will use this new TSC along with the signaling procedures shown in FIGURE 4A (OSAP Signalling Procedures for UL TBF Establishment-Part 1) and

FIGURE 4B (OSAP Signalling Procedures for UL TBF Establishment-Part 2) below whenever it has uplink payload to send for the PS domain.

- The structures within the box labeled with the numeral "A" in FIGURES 4A-4B indicate the use of new procedures and timers whereas the remaining structures indicate the use of legacy procedure and timers.
- The OSAP based signalling described below allows for both one phase and two phase system access procedures and corresponding contention resolution as per legacy operation.
- The code points supported by the new 11-bit RACH message 124 allow for indicating the same basic types of access requests as can be requested using legacy RACH messages (i.e. “one phase access”, “two phase access”, “signaling” and “single block packet access”).
- OSAP based signaling described below allows a BSS 102 to respond to a new RACH burst 124 by directing a MS 104_1, 104_2, 104_3, 104_4....104_n to use either a one phase or two phase system access according to the flexibility supported by legacy operation.

1) An OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n reads OSAP specific system information 120 once every 30 seconds as per the legacy SI refresh rate and then enters Idle mode.

2) All PS domain access attempts triggered by a MS 104_1, 104_2, 104_3, 104_4....104_n capable of OSAP are subject to using OSAP procedures whereas all CS domain access attempts triggered by such a MS 104_1, 104_2, 104_3, 104_4....104_n will be managed using legacy CS domain related procedures. An OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n attempting a PS domain access therefore schedules and starts sending new RACH bursts referred to as Enhanced Packet Channel Request (EPCR) messages 124 which support 11 bits of payload space and a training sequence code (TSC) that allows a BSS 102 to uniquely detect reception of an EPCR message 124.

The code points supported by the EPCR message 124 allow for a MS 104_1, 104_2, 104_3, 104_4....104_n to indicate "one phase access", "two phase access", "signaling" and "single block packet access" as per PS domain related code points supported by the legacy EGPRS Packet Channel Request message (see TABLE 8).

3) After starting the access procedure by transmitting an EPCR message 124 the MS 104_1, 104_2, 104_3, 104_4....104_n starts looking for an Enhanced Immediate Assignment (EIA) message 132 with matching "FN Information" and "Random Bits". T3146 (legacy) is only started after the maximum number of EPCR messages 124 have been transmitted.

4) Upon receiving an Enhanced Immediate Assignment (EIA) message 132 with matching "FN Information" and "Random Bits" (carried within the MS Specific EIA Parameters IE) the MS 104_1, 104_2, 104_3, 104_4....104_n stops T3146 (if running), starts T3226 (new), moves to the indicated PDCH resources and monitors the downlink PACCH 140 for a matching Additional TBF Information (ATI) message 138. Note that this means a BSS 102 must respond to an EPCR message 124 by sending an EIA message 132 since a MS 104_1, 104_2, 104_3, 104_4....104_n performing an OSAP based system access will only consider EIA messages 132 as potentially containing a matching response.

5) Upon receiving an ATI message 138 instance the MS 104_1, 104_2, 104_3, 104_4....104_n reads the "MS Assignment Bitmap" therein to determine if it is addressed by that ATI message instance. In other words, if it considered the Nth instance of information carried within the MS Specific EIA Parameters IE of the EIA message 132 to contain matching information then it checks to see if the Nth bit of this bitmap is set to "1". If the Nth bit is set to "1" then the MS 104_1, 104_2, 104_3, 104_4....104_n concludes that the corresponding instance of the MS Specific TBF Parameters IE in the received ATI message 138 provides it with all remaining information 134' and 136' needed for uplink TBF 128 establishment including whether or not it is to proceed using the one phase access or the two phase access procedure (see FIGURE 4B).

A small Message Reference ID field (2 bits long) is present within both the EIA message 132 and ATI message 138 so that a MS 104_1, 104_2, 104_3, 104_4....104_n can

precisely associate a received ATI message 138 instance to the specific EIA message 132 that has the same Message ID value:

- Note that the EIA message 132 will not include any TFI information (as it will instead be included in the ATI message 138) and as such a MS 104_1, 104_2, 104_3, 104_4....104_n assumes that if it received a match in the Nth instance of the MS specific information in an EIA message 132 then it is to use the Nth instance of the MS specific information in the ATI message 138 corresponding to that EIA message 132.
- Since an ATI message 138 instance may potentially be missed by a mobile station 104_1, 104_2, 104_3, 104_4....104_n (i.e. even though it is sent using CS-1 coding) a BSS 102 may choose to make limited pre-emptive re-transmissions of these messages.
- During times of heavy system access load a BSS 102 may need to send different sets of one or more ATI message 138 instances (i.e. each set of one or more ATI message 138 instances is unique in that it addresses the specific group of mobile stations 104_1, 104_2, 104_3, 104_4....104_n addressed by its corresponding EIA message 132) in relatively quick succession on the PACCH 140 of a specific packet resource while also making use of pre-emptive ATI message re-transmissions.
- As such, to avoid the potential for a MS 104_1, 104_2, 104_3, 104_4....104_n to incorrectly associate an ATI message 138 instance with a previously received EIA message 132 (and thereby apply incorrect additional TBF information), the introduction of a two bit Message Reference ID field in both the EIA and ATI messages 132 and 138 is seen as being sufficient.

6) If T3146 expires prior to receiving a matching EIA message 132 or T3226 expires before receiving a matching ATI message 138 then the MS 104_1, 104_2, 104_3, 104_4....104_n aborts the packet access attempt and returns to Idle mode.

7) If the ATI message 138 indicates a one phase access is to be used the MS 104_1, 104_2, 104_3, 104_4....104_n stops T3226, starts T3164 and waits for the first instance of its assigned USF. Upon receiving the first instance of its assigned USF, the MS 104_1,

104_2, 104_3, 104_4....104_n stops T3164, sends its first RLC data block and proceeds with one phase access contention resolution according to legacy procedures. Note that even if a MS 104_1, 104_2, 104_3, 104_4....104_n indicates a one phase within an EPCR message 124 (see TABLE 8) the BSS 102 can still send an ATI message 138 that forces the MS 104_1, 104_2, 104_3, 104_4....104_n to perform a two phase access (see step 10 below).

8) If contention resolution is successful the MS 104_1, 104_2, 104_3, 104_4....104_n completes the transmission of its user data (LLC PDU) according to legacy operation. After completing the transmission of its user data the uplink TBF 128 is released according to legacy procedures.

9) If T3164 expires before the MS 104_1, 104_2, 104_3, 104_4....104_n receives the first instance of its assigned USF or it experiences unsuccessful one phase contention resolution it may either retry the packet access or abort the uplink TBF 128 as per legacy procedures.

10) If the ATI message 138 indicates a two phase access is to be used then the MS 104_1, 104_2, 104_3, 104_4....104_n stops T3226, sends a PRR, starts T3168 and waits for a PUA in response to the PRR. Upon receiving the PUA the MS 104_1, 104_2, 104_3, 104_4....104_n proceeds with two phase contention resolution according to legacy procedures.

Note that, similar to legacy operation, if the establishment cause in the EPCR message 124 indicates a request for a one phase packet access or signaling the network may send an ATI message 138 that grants either a one phase access or a two phase access. If a Multi Block allocation is granted by the ATI message 138 it forces the mobile station 104_1, 104_2, 104_3, 104_4....104_n to perform a two phase access.

11) If contention resolution is successful the MS 104_1, 104_2, 104_3, 104_4....104_n stops T3168, starts T3164 and waits for the first instance of its assigned USF. Upon receiving the first instance of its assigned USF then the MS 104_1, 104_2, 104_3, 104_4....104_n stops T3164 and begins transmitting its user data (LLC PDU) according to legacy operation. After completing the transmission of its user data the TBF 128 is released according to legacy procedures.

12) If T3168 expires before the MS 104_1, 104_2, 104_3, 104_4....104_n receives a PUA in response to the PRR or T3164 expires before the MS 104_1, 104_2, 104_3, 104_4....104_n receives the first instance of its assigned USF or it experiences unsuccessful two phase contention resolution then the MS 104_1, 104_2, 104_3, 104_4....104_n may either retry the packet access or abort the uplink TBF 128 as per legacy procedures.

TABLE 8: ENHANCED PACKET CHANNEL REQUEST message 124 content

< Enhanced Packet channel request message content > ::=
< **OSAP Request – one phase access** : 000 < **RandomBits** : bit (8) >
>
< **OSAP Request – signalling** : 001 < **RandomBits** : bit (8) >
>
< **OSAP Request – single block packet access** : 010 < **RandomBits** : bit (8) >
>
< **OSAP Request – two phase access** : 011 < **RandomBits** : bit (8) >
>;

2. OSAP – Detailed Operation for DL TBF Establishment

The scenario addressed is where an OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n is in Idle mode and can be assigned a downlink TBF without first performing the paging procedure because its corresponding Ready timer is running and the network therefore knows the MS location at the cell level. In this case downlink TBF establishment is performed as shown in FIGURE 4C (OSAP Signalling Procedures for DL TBF Establishment).

1) During an ongoing TBF the BSS 102 may at any time use PACCH 140 signaling assign a Temporary OSAP Identity (TOI) to an OSAP capable MS 104_1, 104_2, 104_3, 104_4....104_n . The assigned TOI remains valid for as long as the Ready timer is running and therefore requires a BSS 102 to have knowledge of the length of the Ready timer (e.g. this can be realized if PFC procedures are supported by the network).

2) Upon receiving downlink payload (i.e. LLC PDUs) for a MS 104_1, 104_2, 104_3, 104_4....104_n in Idle mode having a valid TOI the BSS 102 initiates downlink TBF establishment by sending an EIA message 132 that includes the TOI of that MS (i.e. instead of FN Information + Random Bits):

- If the non-DRX mode feature is not supported (i.e. at TBF release the MS 104_1, 104_2, 104_3, 104_4....104_n immediately enters the DRX mode) the BSS 102 sends the EIA message 132 on the CCCH of the corresponding serving cell using any of the radio blocks defined by the paging group of that MS as defined in 3GPP TS 45.002 (the contents of which are incorporated herein by reference).

- If the non-DRX mode feature is supported (i.e. at TBF release the MS 104_1, 104_2, 104_3, 104_4....104_n immediately enters the non-DRX mode for a period of time determined by the non-DRX timer) and the BSS 102 determines that the MS 104_1, 104_2, 104_3, 104_4....104_n is in the non-DRX mode it may send the EIA message 132 on the CCCH of the corresponding serving cell using any non-BCCH blocks. Otherwise, it sends the EIA message 132 on the CCCH of the corresponding serving cell using any of the radio blocks defined by the paging group of that MS).

3) Upon receiving an Enhanced Immediate Assignment (EIA) message 132 with matching TOI (carried within the MS Specific EIA Parameters IE) the MS 104_1, 104_2, 104_3, 104_4....104_n stops the non-DRX timer (if running), starts T3226 (new), moves to the indicated PDCH resources and monitors the downlink PACCH 140 for a matching Additional TBF Information (ATI) message 138.

4) Upon receiving an ATI message 138 instance the MS 104_1, 104_2, 104_3, 104_4....104_n reads the "MS Assignment Bitmap" therein to determine if it is addressed by that ATI message instance. In other words, if it considered the Nth instance of information carried within the MS Specific EIA Parameters IE of the EIA message 132 to contain matching information then it checks to see if the Nth bit of this bitmap is set to "1". If the Nth bit is set to "1" then the MS 104_1, 104_2, 104_3, 104_4....104_n concludes that the corresponding instance of the MS Specific TBF Parameters IE in the received ATI message 138 provides it with all remaining information needed for downlink TBF establishment.

5) If T3226 expires before receiving a matching ATI message 138 then the MS 104_1, 104_2, 104_3, 104_4....104_n aborts the downlink TBF establishment attempt and returns to Idle mode.

4. Conclusion

The detailed operation of the OSAP procedure as described above effectively involves the distribution of uplink TBF 128 specific information over the BCCH 122, AGCH 106 and PACCH 140 (as compared to just the AGCH for legacy operation). This allows the MS specific portion of this distributed information sent on the AGCH 106 to be significantly reduced compared to legacy operation and an AGCH gain is thereby realized in that the number of MS 104_1, 104_2, 104_3, 104_4....104_n addressed per OSAP specific AGCH assignment message 132 can be significantly increased compared to legacy AGCH assignment messages. Considering that AGCH 106 capacity is seen as becoming increasingly more problematic as system access load increases (e.g. due to the increased traffic load by MTC as well as increased use of instant messaging type applications) the introduction of OSAP as a new GERAN Rel-12 feature as described herein is seen as providing an essential AGCH capacity improvement.

The following discussion describes the various advantages that the OSAP procedure of the present invention has over the IPA procedure that has been presented by Huawei Technologies Co., Ltd. The first detailed discussion is based on an article prepared by the inventors which is entitled "IPA Analysis for Uplink Assignments" 3GPP TSG-GERAN #55, GP-120979 and was presented in Vienna, Austria, August 27-31, 2012. And, the second detailed discussion is based on an article prepared by the inventors which is entitled "IPA Analysis for Downlink Assignments" 3GPP TSG-GERAN #55, GP-120980 and was presented in Vienna, Austria, August 27-31, 2012.

IPA Analysis for Uplink Assignments (see GP-120979)

1. Introduction

The IPA feature was included in the Rel-11 GERAN specifications in light of operator networks that experience a high CCCH load and thus have typically made use of Multiple CCCH (MCCCH) as a means for dealing with this load. However, when considering IPA as an alternative mechanism for alleviating high CCCH load for the case

of uplink TBF establishment, additional consideration must be given to network scenarios with high load where the use of one phase system access is prioritized.

It is shown in this paper that for the case of one phase access IPA will at best be able to support the assignment of two uplink TBFs, because IPA must provide more MS specific information than it does for the case of a two phase access. As such, the IPA capabilities as indicated by reference [1] have been further considered resulting in the following findings:

- For the one phase access case, a maximum of two MS can be addressed within an IPA message regardless if hopping is used or not (as opposed to 3 MS being addressable for the non-hopping case as suggested by reference [1]).
- For the one or two phase access cases where the Direct Encoding option is used there is no gain as only one MS can be addressed within an IPA message (this is not discussed in reference [1]).

2. IPA Message Space Analysis

Considering the 19 octet payload space limitation of the "IPA Rest Octets IE" (see Annex A.1 below) and analyzing the proposed content for this IE for the case of uplink TBF assignments where the BCCH carrier is not used, the following should be noted:

2.1 One Phase Access

- A best case scenario for IPA message space utilization for the one phase access case (the IPA Uplink Assignment struct is used) when no frequency hopping is used in which case the Frequency Parameters struct provides information on a ARFCN (see highlighted text in Annex A.2 below). When uplink TBF resources are assigned for this best case scenario we get the following bit space utilization:
    - Total bits = 1 + [N*(1+43) + 1] + 3 + 1 + (3 + 2 + 10) + 1 + 1 where N = the number of MS addressed by the IPA message → maximum value for N = 2 (total bits = 1 + [2*44 + 1] + 4 + 15 + 2 = 111 bits).

- This means only 41 bits of payload space will remain according to the 152 bit limit which is not enough to support uplink resource assignments for a 3rd mobile station.

- A worst case scenario for IPA message space utilization for the one phase access case when frequency hopping is used in which case the Frequency Parameters struct can be provided using Direct encoding 2 information (see magenta shaded text in Annex A.2 below). When uplink TBF resources are assigned for this worst case scenario we get the following bit space utilization:
  - Total bits = 1 + [N*(1+43) + 1] + 3 + 1 + (3 + 2 + 6 + 6 + 4 + 64) + 1 + 1 where N = the number of MS addressed by the IPA message → maximum value for N = 1 (total bits = 1 + [1*44 + 1] + 4 + 85 + 2 = 137 bits).
  - This means only 15 bits of payload space will remain according to the 152 bit limit which is not enough to support uplink resource assignments for a 2nd mobile station.

2.2 Two Phase Access

- A best case scenario for IPA message space utilization for the two phase access case (the IPA Single Block Uplink Assignment struct is used) is where the Frequency Parameters struct provides ARFCN information (see highlighted text in Annex A.2 below). When uplink TBF resources are assigned for this best case scenario we get the following bit space utilization:
  - Total bits = 1 + 1 + [N*(1+36) + 1] + 3 + 1 + (3 + 2 + 10) where N = the number of MS addressed by the IPA message → maximum value for N = 3 (total bits = 2 + [3*37 + 1] + 4 + 15 = 133 bits).
  - This means only 19 bits of payload space will remain according to the 152 bit limit which is not enough to support uplink resource assignments for a 4th mobile station.

- A worst case scenario for IPA message space utilization for the two phase access case is where the Frequency Parameters struct provides the Direct encoding 2 information (see **bold** text in Annex A.2 below). When uplink TBF resources are assigned for this worst case scenario we get the following bit space utilization:

- Total bits = 1 + 1 + [N*(1+36) + 1] + 3 + 1 + (3 + 2 + 6 + 6 + 4 + 64) where N = the number of MS addressed by the IPA message → maximum value for N = 1 (total bits = 2 + [1*37 + 1] + 4 + 85 = 129 bits).
- This means only 23 bits of payload space will remain according to the 152 bit limit which is not enough to support uplink resource assignments for a 2nd mobile station.

2.3 Baseband Frequency Hopping Used

- A common deployment scenario is where baseband frequency hopping is used and the BCCH frequency is within the hopping set in which case the Frequency Parameters IE needs to be included since MAIO and HSN type information will be needed by a mobile station. For this scenario, when the Frequency Parameters IE provides this information using either the Direct Encoding 1 or Direct Encoding 2 option the worst case scenarios identified in 2.1 and 2.2 above will apply. However, when the Frequency Parameters IE provides this information using the Indirect Encoding option the best case scenarios identified in 2.1 and 2.2 above will apply.

2.4 Baseband Frequency Hopping Not Used

- Another deployment scenario may be that where baseband hopping is not used and the BCCH carrier is not preferred for PS resource allocations (e.g. due to the reduced efficiency of PDCH resource utilization resulting from non-contiguous PDCHs when MCCCH is used on the BCCH carrier or when SDCCHs are allocated on the BCCH carrier). This will require ARFCN information to be provided by the Frequency Parameters IE which corresponds to the best case scenarios identified in 2.1 and 2.2 above.

2.5 Implicit Reject Information

- Though not currently specified, the "IPA Rest Octets IE" needs to include a bit for indicating "Implicit Reject CS" and a bit for indicating "Implicit Reject PS" since the IPA message can be sent on the AGCH and should therefore be able to

convey implicit reject information for IPA capable mobile stations. Adding these 2 bits will make the IPA Rest Octets bit shortage problem even worse.

3. Conclusion

When considering the case of system operation where IPA is used as an alterative mechanism for alleviating high CCCH load, even if the best case scenario of IPA message space utilization is considered, IPA will only be able to support the assignment of uplink TBFs for a maximum of 2 mobile stations when the use of one phase access is prioritized. As such, the use of the IPA feature may in practice only provide a very limited improvement in AGCH signalling capacity regarding uplink TBF assignments which may not be sufficient for longer term AGCH loading scenarios.

References

[1] GP-110616, "Further discussion on IPA message", source Huawei Technologies Co. Ltd, Qualcomm Incorporated. GERAN#50.

The reference can be found at www.3GPP.org.

Annex A.1

9.1.18a Immediate packet assignment

This message is sent on the CCCH by the network to multiple mobile stations in idle mode to assign either an uplink or a downlink packet data channel configuration in the cell. See table 9.

The L2 pseudo length of this message is the sum of lengths of all information elements present in the message except the IPA Rest Octets and L2 Pseudo Length information elements.

NOTE: The network should take into account limitations of certain mobile stations to understand IMMEDIATE PACKET ASSIGNMENT message as these mobile stations may not be able to decode the Page Mode information element.

Message type: IMMEDIATE PACKET ASSIGNMENT

Significance: dual

Direction: network to mobile station

Table 9: IMMEDIATE PACKET ASSIGNMENT message content

IEI	Information element	Type / Reference	Presence	Format	length
	L2 Pseudo Length	L2 Pseudo Length 10.5.2.19	M	V	1
	RR management Protocol Discriminator	Protocol Discriminator 10.2	M	V	1/2
	Skip Indicator	Skip Indicator 10.3.1	M	V	1/2
	Immediate Assignment Message Type	Message Type 10.4	M	V	1
	Page Mode	Page Mode 10.5.2.26	M	V	1/2
	Spare	Spare	M	V	1/2
	IPA Rest Octets	IPA Rest Octets 10.5.2.78	M	V	19

Annex A.2

10.5.2.78 IPA Rest Octets

The IPA Rest Octets information element contains spare bits and possibly at leaste one of the IPA Uplink Assignment struct, the IPA Downlink Assignment struct, and the IPA Single Block Uplink Assignment struct.

The IPA Rest Octets information element is coded according to the syntax specified below and described in table 10.

The IPA Rest Octets information element is a type 5 information element with 0-19 octets length.

Table 10: *IPA Rest Octet* information element

```
<IPA Rest Octets> ::=
        { 0 | 1    < IPA Uplink Assignment struct >}
        { 0 | 1    < IPA Downlink Assignment struct >}
        { 0 | 1    < IPA Single Block Uplink Assignment struct >}
        <spare padding>;

<IPA Uplink Assignment struct> : :=
        { 1        < Random Reference : bit (11) >
                   < FN_OFFSET: bit (8) >
                   < GAMMA : bit (5) >
                   < TIMING_ADVANCE_VALUE : bit (6) >
                   < TFI_ASSIGNMENT : bit (5) >
                   < USF: bit (3) >
                   < EGPRS_CHANNEL_CODING_COMMAND : bit (4) >
                   < Radio Access Capabilities Request: bit (1) >
        } ** 0;
```

```
                                        --Repeated as many times as necessary, once for each addressed
device
        < TN : bit (3) >
        { 0     ;                                   --'0' indicates that BCCH frequency shall be used
        | 1     {< Frequency Parameters: Frequency Parameters struct >}
        }

<IPA Single Block Uplink Assignment struct> ::=
        { 1     < Random Reference : bit (11) >
                < FN_OFFSET: bit (8) >
                < GAMMA : bit (5) >
                < TIMING_ADVANCE_VALUE : bit (6) >
                < STARTING_TIME_OFFSET: bit (6) >,
        } ** 0;                                 --Repeated as many times as necessary, limited by the
space in the message
        < TN : bit (3) >
        { 0     ;                                   --'0' indicates that BCCH frequency shall be used
        | 1 {< Frequency Parameters: Frequency Parameters struct >}
        }


< Frequency Parameters struct > ::=
        < TSC : bit (3) >
        { 00 < ARFCN : bit (10) >
        | 01 < Indirect encoding : < Indirect encoding struct > >
        | 10 < Direct encoding 1 : < Direct encoding 1 struct > >
        | 11 < Direct encoding 2 : < Direct encoding 2 struct > > } ;
< Indirect encoding struct > ::=
        < MAIO : bit (6) >
        < MA_NUMBER : bit (4) >
        { 0 | 1   < CHANGE_MARK_1 : bit (2) >
                        { 0 | 1 < CHANGE_MARK_2 : bit (2) > } } ;
< Direct encoding 1 struct > ::=
        < MAIO : bit (6) >
        < GPRS Mobile Allocation : < GPRS Mobile Allocation IE > > ;
< Direct encoding 2 struct > ::=
        < MAIO : bit (6) >
        < HSN : bit (6) >
        < Length of MA Frequency List contents : bit (4) >
        < MA Frequency List contents : octet (val(Length of MA Frequency List contents) + 3) > ;
< GPRS Mobile Allocation IE > ::=
        < HSN : bit (6) >
        { 0 | 1   < RFL number list : < RFL number list struct > > }
        { 0     < MA_LENGTH : bit (6) >
                < MA_BITMAP : bit (val(MA_LENGTH) + 1) >
        | 1     { 0 | 1   < ARFCN index list : < ARFCN index list struct > > } } ;
< RFL number list struct > ::=
        < RFL_NUMBER : bit (4) >
        { 0 | 1   < RFL number list struct > } ;
< ARFCN index list struct > ::=
        < ARFCN_INDEX : bit (6) >
        { 0 | 1   < ARFCN index list struct > } ;
```

IPA Analysis for Downlink Assignments (see GP-120980)

1. Introduction

The IPA feature was included in the Rel-11 GERAN specifications in light of operator networks that experience a high CCCH load and thus have typically made use of Multiple CCCH (MCCCH) as a means for dealing with this load. However, when considering IPA as an alternative mechanism for alleviating high CCCH load for the case of downlink TBF establishment, IPA will at best be able to support the assignment of downlink TBFs for 2 mobile stations using the "IPA Downlink Assignment struct". As such, the IPA capabilities as indicated by reference [1] have been further considered resulting in the following findings:

- When the Direct Encoding option is used for IPA there is no gain as only one MS can be addressed within an IPA message (this is not discussed by reference [1]).

2. IPA Message Space Analysis

Considering the 19 octet payload space limitation of the "IPA Rest Octets IE" (see Annex A.1 below) and analyzing the proposed content for this IE for the case of downlink TBF assignments where the BCCH carrier is not used, the following should be noted:

- A best case scenario for IPA message space utilization is where the Frequency Parameters struct provides ARFCN information (see highlighted text in Annex A.2 below). When downlink TBF resources are assigned for this best case scenario we get the following bit space utilization:
    - Total bits = 1 + [N*(1+49) + 1] + 1 + 1 + 3 + 1 + (3 + 2 + 10) + 1 where N = the number of MS addressed by the IPA message → maximum value for N = 2 (total bits = 1 + [2*50 + 1] + 6 + 15 + 1 = 124 bits).
    - This means only 28 bits of payload space will remain according to the 152 bit limit which is not enough to support downlink resource assignments for a 3rd mobile station.

- A worst case scenario for IPA message space utilization is where the Frequency Parameters struct provides the Direct encoding 2 information (see **bold** text in Annex A.2 below). When downlink TBF resources are assigned for this worst case scenario (64 bits of Mobile Allocation information provided) we get the following bit space utilization:
    - Total bits = 1 + [N*(1+49) + 1] + 1 + 1 + 3 + 1 + (3 + 2 + 6 + 6 + 4 + 64) + 1 where N = the number of MS addressed by the IPA message → maximum value for N = 1 (total bits = 1 + [1*50 + 1] + 6 + 85 + 1 = 144 bits).
    - This means only 8 bits of payload space will remain according to the 152 bit limit which is not enough to support downlink resource assignments for a 2nd mobile station.
    - It should also be noted that the Direct encoding 2 struct allows for more than 64 bits of Mobile Allocation information in which case an IPA message will not even be able to assign downlink TBF resources for even 1 mobile station.
- A common deployment scenario is where baseband frequency hopping is used and the BCCH frequency is within the hopping set in which case the Frequency Parameters IE needs to be included since MAIO and HSN type information will be needed by a mobile station. For this scenario, when the Frequency Parameters IE provides this information using either the Direct Encoding 1 or Direct Encoding 2 option the worst case scenario above will apply. However, when the Frequency Parameters IE provides this information using the Indirect Encoding option the best case scenario above will apply.
- Another deployment scenario may be that where baseband hopping is not used and the BCCH carrier is not preferred for PS resource allocations (e.g. due to the reduced efficiency of PDCH resource utilization resulting from non-contiguous PDCHs when MCCCH is used on the BCCH carrier or when SDCCHs are allocated on the BCCH carrier). This will require ARFCN information to be provided by the Frequency Parameters IE which corresponds to the best case scenario above.

- Though not currently specified, the "IPA Rest Octets IE" needs to include a bit for indicating "Implicit Reject CS" and a bit for indicating "Implicit Reject PS" since the IPA message can be sent on the AGCH and should therefore be able to convey implicit reject information for IPA capable mobile stations. Adding these 2 bits will make the IPA Rest Octets bit shortage problem even worse.

3. Conclusion

When considering the case of system operation where IPA is used as an alterative mechanism for alleviating high CCCH load, even if the best case scenario of IPA message space utilization is considered IPA will only be able to support the assignment of downlink TBFs for a maximum of 2 mobile stations. As such, the use of the IPA feature may in practice only provide a very limited improvement in AGCH signalling capacity regarding uplink TBF assignments which may not be sufficient for longer term AGCH loading scenarios.

Reference

[1] GP-110616, "Further discussion on IPA message", source Huawei Technologies Co. Ltd, Qualcomm Incorporated. GERAN#50.

The reference can be found at www.3GPP.org.

Annex A.1

9.1.18a Immediate packet assignment

This message is sent on the CCCH by the network to multiple mobile stations in idle mode to assign either an uplink or a downlink packet data channel configuration in the cell. See table 11.

The L2 pseudo length of this message is the sum of lengths of all information elements present in the message except the IPA Rest Octets and L2 Pseudo Length information elements.

NOTE: The network should take into account limitations of certain mobile stations to understand IMMEDIATE PACKET ASSIGNMENT message as these mobile stations may not be able to decode the Page Mode information element.

Message type: IMMEDIATE PACKET ASSIGNMENT

Significance: dual

Direction: network to mobile station

Table 11: IMMEDIATE PACKET ASSIGNMENT message content

IEI	Information element	Type / Reference	Presence	Format	length
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	RR management Protocol Discriminator	Protocol Discriminator 10.2	M	V	1/2
	Skip Indicator	Skip Indicator 10.3.1	M	V	1/2
	Immediate Assignment Message Type	Message Type 10.4	M	V	1
	Page Mode	Page Mode 10.5.2.26	M	V	1/2
	Spare	Spare	M	V	1/2
	IPA Rest Octets	IPA Rest Octets 10.5.2.78	M	V	19

Annex A.2

10.5.2.78 IPA Rest Octets

The IPA Rest Octets information element contains spare bits and possibly at leaste one of the IPA Uplink Assignment struct, the IPA Downlink Assignment struct, and the IPA Single Block Uplink Assignment struct.

The IPA Rest Octets information element is coded according to the syntax specified below and described in table 12.

The IPA Rest Octets information element is a type 5 information element with 0-19 octets length.

Table 12: IPA Rest Octet information element

```
<IPA Rest Octets> ::=
        { 0 | 1    < IPA Uplink Assignment struct >}
        { 0 | 1    < IPA Downlink Assignment struct >}
        { 0 | 1    < IPA Single Block Uplink Assignment struct >}
        <spare padding>;


< IPA Downlink Assignment struct> ::=
        { 1        < TLLI : bit (32) >
                   < TFI_ASSIGNMENT : bit (5) >
                   < GAMMA : bit (5) >
                   { 0 |1 < TIMING_ADVANCE_VALUE : bit (6) > }
        } ** 0;                                  --Repeated as many times as necessary, limited by the
space in the message
        { 0 | 1    < LINK_QUALITY_MEASUREMENT_MODE: bit (2) > }
        < RLC_MODE : bit >
        < TN : bit (3) >
        { 0                                                  --'0' indicates that BCCH frequency shall be used
        | 1        {< Frequency Parameters: Frequency Parameters struct >}
        }


< Frequency Parameters struct > ::=
        < TSC : bit (3) >
        { 00 < ARFCN : bit (10) >
        | 01 < Indirect encoding : < Indirect encoding struct > >
        | 10 < Direct encoding 1 : < Direct encoding 1 struct > >
        | 11 < Direct encoding 2 : < Direct encoding 2 struct > > } ;
< Indirect encoding struct > ::=
        < MAIO : bit (6) >
        < MA_NUMBER : bit (4) >
        { 0 | 1    < CHANGE_MARK_1 : bit (2) >
                        { 0 | 1 < CHANGE_MARK_2 : bit (2) > } } ;
< Direct encoding 1 struct > ::=
        < MAIO : bit (6) >
        < GPRS Mobile Allocation : < GPRS Mobile Allocation IE > > ;
< Direct encoding 2 struct > ::=
        < MAIO : bit (6) >
        < HSN : bit (6) >
        < Length of MA Frequency List contents : bit (4) >
        < MA Frequency List contents : octet (val(Length of MA Frequency List contents) + 3) > ;
< GPRS Mobile Allocation IE > ::=
        < HSN : bit (6) >
        { 0 | 1    < RFL number list : < RFL number list struct > > }
        { 0        < MA_LENGTH : bit (6) >
                   < MA_BITMAP : bit (val(MA_LENGTH) + 1) >
        | 1        { 0 | 1    < ARFCN index list : < ARFCN index list struct > > } } ;
< RFL number list struct > ::=
        < RFL_NUMBER : bit (4) >
        { 0 | 1    < RFL number list struct > } ;
< ARFCN index list struct > ::=
        < ARFCN_INDEX : bit (6) >
        { 0 | 1    < ARFCN index list struct > } ;
```

Although multiple embodiments of the present invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it

should be understood that the invention is not limited to the disclosed embodiments, but instead is also capable of numerous rearrangements, modifications and substitutions without departing from the present invention that as has been set forth and defined within the following claims.

CLAIMS:

1. A base station subsystem (BSS) (102) configured to interact with a plurality of mobile stations (104_1, 104_2, 104_3, 104_4....104_n) and perform a procedure to improve an Access Grant Channel (AGCH) (106) capacity, the BSS comprising:

a processor (110); and

a memory (112) that stores processor-executable instructions where the processor interfaces with the memory and executes the processor-executable instructions to enable the following operations:

broadcast (102d) a new system information (SI) (120) to the plurality of mobile stations, where the new SI includes static radio parameters (134) which are to be used by any one of the plurality of mobile stations when establishing an uplink Temporary Block Flow (TBF) (128) to transmit a small data transmission (SDT) (130a) or an instant message transmission (IMT) (130b);

receive (104d) at least one access request (124) from at least one of the plurality of mobile stations (104_1 and104_3), where the at least one mobile station is requesting to establish the uplink TBF to transmit the SDT or the IMT; and

in response to the received at least one access request, send (106d) an immediate assignment message (132) on the AGCH for the at least one mobile station, where the immediate assignment message (132) includes at least a portion of dynamic radio parameters (136) which are to be used along with the static radio parameters by the at least one mobile station when establishing the uplink TBF to transmit the SDT or the IMT.

2. The BSS of claim 1, wherein the processor further executes the processor-executable instructions to send (108d) a remaining portion of the dynamic radio parameters (136') in a message (138) on a Packet Associated Control Channel (PACCH) (140) to the at least one mobile station addressed by the immediate assignment message, where the remaining portion of the dynamic radio parameters are to be used by the at least one mobile station along with the static radio parameters and the portion of dynamic radio parameters included in the immediate assignment message when establishing the uplink TBF to transmit the SDT or the IMT.

3. The BSS of claim 1, wherein the processor further executes the processor-executable instructions to send (110d) additional static radio parameters (134') in a message (138) on a Packet Associated Control Channel (PACCH) (140) to the at least one mobile station addressed by the immediate assignment message.

4. The BSS of claim 1, wherein the static radio parameters comprise a radio assignment identity (RAID) value along with parameter values for following information elements (IEs):

a page mode;

a packet channel description;

a mobile allocation;

a starting time; and

Immediate Assignment (IA) rest octets.

5. The BSS of claim 4, wherein the IA rest octet comprises dynamic information but the at least one mobile station ignore the dynamic information.

6. The BSS of claim 4, wherein the IA rest octet does not comprise dynamic information.

7. The BSS of claim 1, wherein the at least one access request includes code points to support the SDT service or to support the IMT service.

8. The BSS of claim 1, wherein the immediate assignment message comprises a code point indicating an enhanced immediate assignment (EIA) message that includes an EIA Rest Octets Information Element (IE) which contains at least a portion of dynamic radio parameters for each of the at least one mobile station.

9. The BSS of claim 8, wherein the EIA Rest Octets IE includes three instances of the dynamic radio parameters for three mobile stations, where each dynamic radio parameter for each mobile station comprises:

a radio assignment identity (RAID) value corresponding to applicable set of static radio parameters when included in the new SI;

an echoed access request message;

an assigned eTFI parameter;

an assigned eUSF parameter;

a timing advance parameter; and

a frame number (FN) parameter.

10. The BSS of claim 8, wherein the EIA Rest Octets IE includes six instances of the dynamic radio parameters for six mobile stations, where each dynamic radio parameter for each mobile station comprises:

a radio assignment identity (RAID) value corresponding to applicable set of static radio parameters when included in the new SI;

an echoed access request message; and

an assigned eTFI parameter.

11. The BSS of claim 8, wherein the EIA Rest Octets IE includes eight instances of the dynamic radio parameters for eight mobile stations, where each dynamic radio parameter for each mobile station comprises:

a radio assignment identity (RAID) value corresponding to applicable set of static radio parameters when included in the new SI;

an echoed access request message; and

an assigned legacy TFI parameter.

12. The BSS of claim 8, wherein the EIA Rest Octets IE includes eleven instances of the dynamic radio parameters for eleven mobile stations, where the EIA Rest Octets IE includes a single instance of an eTFI parameter and each dynamic radio parameter for each mobile station comprises:

a radio assignment identity (RAID) value corresponding to applicable set of static radio parameters when included in the new SI; and

an echoed access request message.

13. The BSS of claim 1, wherein the immediate assignment message further includes a packet channel description for each of the at least one mobile station.

14. A method (100d) implemented by a base station subsystem (BSS) (102), which interacts with a plurality of mobile stations (104_1, 104_2, 104_3, 104_4....104_n), for performing a procedure to improve an Access Grant Channel (AGCH) (106) capacity, the method comprising the steps of:

broadcasting (102d) a new system information (SI) (120) to the plurality of mobile stations, where the new SI includes static radio parameters (134) which are to be used by any one of the plurality of mobile stations when establishing an uplink Temporary Block Flow (TBF) (128) to transmit a small data transmission (SDT) (130a) or an instant message transmission (IMT) (130b);

receiving (104d) at least one access request (124) from at least one of the plurality of mobile stations (104_1, 104_3), where the at least one mobile station is requesting to establish the uplink TBF to transmit the SDT or the IMT; and

in response to the received at least one access request, sending (106d) an immediate assignment message (132) on the AGCH for the at least one mobile station, where the immediate assignment message includes at least a portion of dynamic radio parameters (136) which are to be used along with the static radio parameters by the at least one mobile station when establishing the uplink TBF to transmit the SDT or the IMT.

15. The method of claim 14, further comprising a step of sending (108d) a remaining portion of the dynamic radio parameters (136') in a message (138) on a Packet Associated Control Channel (PACCH) (140) to the at least one mobile station addressed by the immediate assignment message, where the remaining portion of the dynamic radio parameters are to be used by the at least one mobile station along with the static radio parameters and the portion of dynamic radio parameters included in the immediate assignment message when establishing the uplink TBF to transmit the SDT or the IMT.

16. The method of claim 14, further comprising a step of sending (110d) additional static radio parameters (134') in a message (138) on a Packet Associated

Control Channel (PACCH) (140) to the at least one mobile station addressed by the immediate assignment message.

17. The method of claim 14, wherein the static radio parameters comprise a radio assignment identity (RAID) value along with parameter values for following information elements (IEs):

a page mode;

a packet channel description;

a mobile allocation;

a starting time; and

Immediate Assignment (IA) rest octets.

18. The method of claim 14, wherein the at least one access request includes code points to support the SDT service or to support the IMT service.

19. A mobile station (104_1) configured to interact with a base station subsystem (102) and to improve an Access Grant Channel (AGCH) (106) capacity, the mobile station comprising:

a processor (116); and

a memory (118) that stores processor-executable instructions where the processor interfaces with the memory and executes the processor-executable instructions to enable the following operations:

receive (102e) a new system information (SI) (120), from the base station subsystem, where the new SI includes static radio parameters (134) which are to be used by the mobile station whenever the mobile station establishes an uplink Temporary Block Flow (TBF) (128) to transmit a small data transmission (SDT) (130a) or an instant message transmission (IMT) (130b);

send (104e) an access request (124) to the base station subsystem, where the access request is sent when the mobile station is requesting to establish the uplink TBF (128) to transmit the SDT or the IMT;

receive (106e) an immediate assignment message (132) on the AGCH from the base station substation, where the immediate assignment message (132) includes at least a portion of dynamic radio parameters (136); and

use (112e) the static radio parameters and the at least a portion of the dynamic radio parameters when establishing the uplink TBF to transmit the SDT or the IMT .

20. The mobile station of claim 19, wherein the processor further executes the processor-executable instructions to receive (108e) a remaining portion of the dynamic radio parameters (136') in a message (138) on a Packet Associated Control Channel (PACCH) (140) from the base station subsystem, where the remaining portion of the dynamic radio parameters are to be used by the mobile station along with the static radio parameters and the portion of dynamic radio parameters received in the immediate assignment message when establishing the uplink TBF to transmit the SDT or the IMT.

21. The mobile station of claim 19, wherein the processor further executes the processor-executable instructions to receive (110e) additional static radio parameters (134') on a Packet Associated Control Channel (PACCH) (140) from the base station subsystem.

22. A method (100e) implemented by a mobile station (104_1) which interacts with a base station subsystem (102) for improving an Access Grant Channel (AGCH) (106) capacity, the method comprising the steps of:

receiving (102e) a new system information (SI) (120) from the base station subsystem, where the new SI includes static radio parameters (134) which are to be used by the mobile station whenever the mobile station establishes an uplink Temporary Block Flow (TBF) (128) to transmit a small data transmission (SDT) (130a), or an instant message transmission (IMT) (130b);

sending (104e) an access request (124) to the base station subsystem, where the access request is sent when the mobile station is requesting to establish the uplink TBF to transmit the SDT or the IMT;

receiving (106e) an immediate assignment message (132) on the AGCH from the base station substation, where the immediate assignment message includes at least a portion of dynamic radio parameters (136); and

use (112e) the static radio parameters and the at least a portion of the dynamic radio parameters when establishing the uplink TBF to transmit the SDT or the IMT.

23. The method of claim 22, further comprising a step of receiving (108e) a remaining portion of the dynamic radio parameters (136') in a message (138) on a Packet Associated Control Channel (PACCH) (140) from the base station subsystem, where the remaining portion of the dynamic radio parameters are to be used by the mobile station along with the static radio parameters and the portion of dynamic radio parameters received in the immediate assignment message when establishing the uplink TBF to transmit the SDT or the IMT.

24. The method of claim 22, wherein the processor further executes the processor-executable instructions to receive (110e) additional static radio parameters (134') on a Packet Associated Control Channel (PACCH) (140) from the base station subsystem.