Fast Random Access Scheme for GERAN

1. INTRODUCTION

In GERAN standardization the need for and realization of a fast access scheme have been discussed [1], [2]. However, in the discussion some important aspects that should be taken into account for fast access have been omitted. In order to make the access fast, sufficient signaling capacity must be reserved. This reservation makes sense only if enough spectrum is available and a large enough portion of the traffic can benefit from fast access. IP based applications generate a lot of small packets which cause a lot of accesses in case fast access is used. If not enough signaling capacity is reserved (e.g. initial Compact deployment) delay requirements cannot be met and therefore fast access should not be used. For this reason, Fast Access should be an optional feature and used only when enough signaling capacity is allocated in the network. If fast access is not supported, polling or fixed allocation based solutions can be used to provide the requested QoS.

Two alternatives regarding to fast access can be considered:

- TBF is kept alive (TFI reserved) also during idle periods, fast reallocation through fast access (fast resource request) is used.
- TBFs are released and re-established through fast access.

2. FPRACH AND FAGCH

The following terminology is used throughout the document:

- FPCCH: Fast Packet Common Control CHannel
- FPRACH: Fast Packet Random Access CHannel
- FAGCH: Fast Access Grant Channel

The FAGCH is used to allocate resources that were requested on the FPRACH.

2.1 Conditions for fast access

Provided sufficient capacity is available, fast access may work only if a) FPRACH and FAGCH are close enough in time to be fast and the time between subsequent FPRACH and FAGCH blocks is short enough, and b) signalling on FPRACH and FAGCH is limited: typically one UL message for fast request and one DL message for fast assignment. It may be used in either of the approaches described above: fast reallocation or fast TBF setup.

2.1.1 New channels

It is expected that many applications (e.g. TCP based email applications, chat, etc) send a lot of small packets during a session. This leads to a high number of accesses and resource assignments. In order not to overload PCCCH/U and PCCCH/D and to guarantee large enough number space for access indentifiers (ARI) fast access should be carried out on separate channels from current random access channels. New fast random access and access grant channels (FPRACH and FAGCH respectively) should be accessible to R'0x MS only, to request and get resources fast.

The benefit of having new channels for fast messaging is that the traffic on PRACH would remain as is today, i.e. the use of PRACH is not extended to fast messaging. This way unnecessary deterioration of the performance of PCCCH/U (i.e. PRACH) is avoided. The efficiency of the new channels remains due to the limitation to fast messaging only.

There are two ways of introducing new channels for fast access:

1. New logical channels introduced on the current PCCCH_GROUPs.

Some blocks would be reserved to those logical channels with parameters broadcast on PBCCCH that would be visible only to R'0x MS and defined in a similar way as current parameters (e.g. BS_PRACH_BLKS). FPRACH would be mapped on PCCCH/U (note that current PCCCH/U contains only PRACH) and FAGCH on PCCCH/D. This implies that in existent networks the capacity reserved to PRACH is being reduced, resulting in an increase of the MS density, and therefore a decrease of the PRACH performance.

2. New FPCCCH_GROUPS defined in a similar way as PCCCH_GROUPS

New FPCCCH_GROUPS would be defined in a similar way as PCCCH_GROUPS (based on IMSI). New channels would be mapped on these groups (FPCCCH/U and FPCCCH/D) for fast messaging only. This would allow for FPCCCH messaging on same or different timeslots than the ones of PCCCH. If the same timeslots are used, the blocks allocated to FPCCCH shall be different from those of PCCCH. Similar parameters as those defined for PCCCH need to be defined and broadcast on PBCCH. FAGCH would be mapped on FPCCCH/D and FPRACH on FPCCCH/U.

In order for fast messaging to be efficient and hence useful, it is required that the time-closeness between (F)PCCCH/U and (F)PCCCH/D meets the QoS (delay) requirements of the traffic classes using fast messaging. The second of the above two alternatives is more flexible as it is not tied to the PCCCH allocation in the network (cell) and therefore allows for providing, if sufficient capacity is available, fast messaging to existing networks in a smooth way: PCCCH/U need not be redimensioned.

2.1.2 Accessing the new channels

An MS[1] may send fast resource request on FPRACH (assuming the data connection is already alive) on PCCCH/U (resp. FPCCCH/U) of its corresponding PCCCH_GROUP (resp. FPCCCH_GROUP) only. If FPCCCH/D is available, fast assignment is sent on this channel. The fast assignment could be made also on the PCCCH/D of its corresponding PCCCH_GROUP provided it is sufficiently close in time to the (F)PCCCH/U and no FPCCCH/D is available.

The assignment message carried as fast assignment is likely to be the same as the current (E)GPRS assignment message, but a new message could be considered if needed. FPRACH should use the (extended) access burst for the same reason as the PRACH (no up-to-date timing advance). Because FPRACH occurs on different blocks than PRACH (in both alternatives presented in 2.1.1) all bits in the access burst (extended access burst) are available.

[1] Even though fast access would be available, the network may still allow or not an MS to use fast access. This could be done e.g. at initial assignment of resources.

2.2 Allocation methods and Associated signalling

2.2.1 Fixed allocation

The availability and location of FPCCCH/U and FPCCCH/D in the multiframe is informed in system information messages. As a preferred option it is proposed that the determination of the FPCCCH_GROUP be identical to that of PCCCH_GROUP (see GSM 05.02).

The indication of FPCCCH availability should be indicated in one message of the consistent set of PSI2 messages, in a similar way as for PCCCH. FPCCCH description structure should be defined in the same way as for the PCCCH description (see GSM 04.60 for details) as is shown below:

Note that the FPCCCH/D bit is required to indicate the availability of downlink FPCCCH: as said earlier, FPCCCH/D might not be allocated in case PCCCH/D is close enough in time to FPCCCH/U. However, it should be noticed that in this case PCCCH/D may be significantly loaded by fast access messages.

< FPCCCH Description Lists struct > ::= { 1 < FPCCCH Description struct > } ** 0 ;
< FPCCCH Description struct > ::=
< **FPCCCH/D** : bit >
< **TSC** : bit (3) >
{ 0 < **Non-hopping FPCCCH carriers** : < Non-Hopping FPCCCH Carriers Lists struct > >
| 1 < **MA_NUMBER** : bit (4) >
< **Hopping FPCCCH carriers** : < Hopping FPCCCH Carriers Lists struct > > } ;
< Non-hopping FPCCCH Carriers Lists struct > ::= { 1 < Non-Hopping FPCCCH Carriers struct > } ** 0 ;
< Non-Hopping FPCCCH Carriers struct > ::=
< **ARFCN** : bit (10) >
< **TIMESLOT_ALLOCATION** : bit (8) > ;
< Hopping FPCCCH Carriers Lists struct > ::= { 1< Hopping FPCCCH Carriers struct > } ** 0 ;
< Hopping FPCCCH Carriers struct > ::=
< **MAIO** : bit (6) >
< **TIMESLOT_ALLOCATION** : bit (8) > ;

Table 1. Example of FPCCCH description struct

PSI2[2] should also contain, in case of the second alternative presented in 2.1.1, the FPCCCH Organization parameters to control the organization of FPCCCHs present in the cell (fixed allocation), as an optional Information Element. If this IE is absent, no fast messaging is allowed in the cell. Note that if the PCCCH_GROUP and FPCCCH_GROUP are on the same timeslots, the blocks for PRACH and FPRACH must be different, as said earlier.

< FPCCCH Organization Parameters IE > ::=
< **BS_FPCC_REL** : bit >
< **BS_FPRACH_BLKS** : bit (4) > ;

Table 2. FPCCCH Organization Paramaters IE

BS_FPCC_REL: similar to the BS_PCC_REL: see GSM 04.60. This field controls the release of the FPCCCH.

[2] No IE can be introduced in PSI1: no spare bits available

BS_FPRACH_BLKS: indicates the number of blocks reserved in a fixed way to the FPRACH channel on *any* PDCH carrying FPCCCH. Similar range as BS_PRACH_BLKS: see GSM 05.02 and the figure below: if one block is allocated to PRACH, it must be B0 in the multiframe. If two blocks are allocated to PRACH, they must be B0 and B6 in the multiframe and so on.

B0	B1	B2	B3	B4	B5
1	5	9	3	7	11

B6	B7	B8	B9	B10	B11
2	6	10	4	8	12

Table 3. Example of PRACH Allocation on a 52 multiframe

If the FPRACH is on the same PDCH (timeslot) as the PRACH, the FPRACH allocation should be made relatively to the blocks allocated to PRACH. This implies that a maximum of 12 – number of PRACH blocks can be allocated on *any* PDCH for FPRACH in a fixed manner. A per-PDCH allocation could be made instead but would require more signalling.

B0	B1	B2	B3	B4	B5
1 (shaded)	2	6	3 (shaded)	4	8

B6	B7	B8	B9	B10	B11
2 (shaded)	3	7	1	5	9

n (shaded)	: PRACH block
n	: possible FPRACH block

Table 4. Example of FPRACH allocation relatively to PRACH (on the same PDCH).

2.2.2 Dynamic allocation

Dynamic allocation in downlink and uplink may be realized using the same principles as used currently for PCCCH.

Dynamic uplink allocation may be realized using the same principle as for PRACH: through USF. (E)GPRS MS as well as Rel'0x MS monitoring all DL blocks, the FPRACH blocks must be indicated in DL with the USF. A USF value has to be reserved and must be different from the value "FREE" so that (E)GPRS MS do not consider the FPRACH as PRACH. Also this USF value must not be allocated to any MS for data transfer on any timeslots where FPRACH occurs (timeslots of the (F)PCCCH_GROUPs). This implies that all Rel'0x MS on a given carrier know which timeslots are allocated to the entire (F)PCCCH_GROUPs. Elsewhere, this USF value could be allocated to some MS for data transfer. The use of USF allows for dynamic allocation of the FPRACH.

For dynamic downlink allocation, the FPCCCH may occur on the PDCH of the corresponding FPCCCH_GROUP. FPCCCH/D blocks would be allocated in a dynamic manner, similarly to PCCCH/D: see GSM 05.02. The message_type field of the control messages sent on PCCCH/D identifies the associated logical channel. The same principle may be applied on FPCCCH/D.

2.3 Targeted traffic classes

Fast access is meant to be used mainly for applications of interactive traffic class having real-time (or tight) delay requirements. Also other traffic classes in shared mode of operation may use fast access. In dedicated mode fast access is not used.

2.4 Operation when fast access is not supported

When fast access is not supported, the same QoS can be provided either through dedicated MAC mode or through shared MAC mode keeping the TBF alive also during temporary silent periods. In the latter case the network schedules uplink resources based on required QoS level. In case of real-time applications, the scheduling should be frequent (e.g. every second or third block) while for non real-time applications the scheduling period can be longer.

3. CONCLUSIONS

A fast access scheme has been presented. It is used only when the network has sufficient capacity allocated for signaling to meet delay requirements of the supported services. In GERAN there will be a lot of TBF setup and resource assignment traffic, therefore, in order not to decrease the performance of (P)RACH fast access should be carried out on separate channels. In many cases, for example due to low bandwidth (Compact), fast access scheme would not meet the required delay performance. For such cases there must be another way to provide the service. It is proposed that in such cases the TBF is kept alive (TFI allocated) also during temporary inactive period and network would allocate uplink sending permissions according to required QoS.

4. REFERENCES

[1] 3GPP TSG GERAN AdHoc#1, 2g00-051, "Fast Access based on Access Request Identifier", AT&T, Ericsson, Helsinki, 7-11 August, 2000

[2] 3GPP TSG GERAN AdHoc#1, 2g00-083, "Discussion of Fast Access Proposals for GERAN R2000", Lucent Technologies, Helsinki, 7-11 August, 2000

[3] GSM 05.02

[4] GSM 04.60