TSG-RAN Working Group 1 (Radio Layer 1) meeting #2
SHIN YOKOHAMA 22nd to 25th February 1999

TSGR1#2(99)059 Rev

Agenda Item: 8.2

Source: Ad Hoc #7

Title: **Report from Ad Hoc #7: Slot structure**

Document for:

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1 Introduction

Based on the agreement in the 1st WG1 meeting, the temporary Ad Hoc #7 was established to resolve the issues related to physical channel slot structure, which include spreading factor and power offsets. Commonalities and differences between the ARIB and ETSI specifications, and pros and cons of the two specifications are intensively discussed via email. We also held a meeting on February 22 This document summaries the discussions.

2 Analysis and merge proposal

2.0 General

At first, the following things should be noted.

- Bit allocations for chip rates other than 4.096 Mcps is FFS.
- There is an opinion that all terminals should be able to support and understand ~~non-default~~ a limited set of values. But this issue is out of the scope of Ad Hoc #7.

2.1 Dedicated physical channel

2.1.1 Commonalities

The following commonalities are found.

- Super-frame / Frame / Slot structure in uplink/downlink:
  The lengths of Super-frame, Frame, and Slot are 720ms, 10ms, and 0.625ms, respectively.

- Uplink:
  DPDCH and DPCCH are I/Q code-multiplexed.
  DPCCH consists of Pilot, TPC, and ~~optional~~ TFCI bits.

- Downlink:
  DPDCH and DPCCH are time-multiplexed.
  DPCCH consists of Pilot, TPC, and ~~optional~~ TFCI bits.

2.1.2 Differences and suggested solutions

The differences and suggested solutions are summarised in Table 1. The argument summaries are described after Table 1.

Table 1 Differences of Dedicated physical channels

Channel	**Item**	**ETSI**	**ARIB**	**Proposal** (** see Note)
Uplink / Downlink	UE RX/TX offset (T_o)	TBD	Defined (cf. 3.2.2.4.3)	Should be optimized for UL/DL field structure
Uplink DPDCH	Gain factor	Undefined	Defined (cf. 3.2.6.7.1.2.1 (2))	~~Take ARIB~~Define a limited set
	Spreading factor	256 – 4 (16 – 1024 kbps)	256 – 1[*5] (16 – 4096 kbps)	256 – 4 ~~(SF 1 and 2 ffs**)~~
	Field option	Non	Option: Pilot, TPC fields[*4]	Non
Uplink DPCCH	Spreading factor	256 – 4 (16 – 1024 kbps)	256 (16kbps)	256 (128 ffs**)
	Field order	Pilot / TPC / FBI / TFCI Option: reserved field	Pilot / TFCI / TPC [*1]	Define a limited number of field structures. The ARIB set is ~~the start point~~a part of solutions.
	Bit allocation to each field	TBD Number of bits is negotiated during connection set up and may change during a connection via higher layer signalling.	Defined: Table 3.2.2-10	
	Pilot pattern	TBD	Defined: Table 3.2.2-11	
Downlink DPDCH / DPCCH	Gain factor	Undefined	Defined (cf. 3.2.6.7.2 (3))	Gain factors (The operator defines them)
	Spreading factor	256 – 4 (16 – 1024 ksps)	512[*2] – 1[*5] (8 – 4096 ksps)	512 ** – 4
	Field order	Pilot / TPC / TFCI / Data	TFCI / Data1 / TPC / Data2 / Pilot [*1]	Define a limited number of field structures. The ARIB set is ~~the start point~~a part of solutions.
	Bit allocation to each field	TBD Number of bits is negotiated during connection set up and may change during a connection via higher layer signalling.	Defined: Table 3.2.2-6 TFCI repetition[*3]	
	Pilot pattern	TBD	Defined: Table 3.2.2-7	

*1: DPCCH field order in ARIB
ARIB defines the field order in uplink and downlink to maximise the cell radius in which closed-loop transmitter power control with one slot delay can be achieved. See 3.2.2.4.3.

*2: Downlink 8ksps channel in ARIB
This channel is defined to control uplink transmission power where there is no or almost no downlink data. For example, uplink packet transmission without downlink packets.

*3: Downlink TFCI repetition in ARIB
For bit error protection, TFCI is repeated four times at bit rates higher than 32ksps.

*4: Pilot and TPC fields in Uplink DPDCH in ARIB
These are defined for future extension, but they are not used in the current specification.

*5: DPDCH SF 1 and 2 in ARIB
This extension is for single code approach for high data rate transmission.

SF 1 and 2 for up/downlink DPDCH:

This issue was proposed as beneficial in isolated (or lightly loaded) pico-cells with low delay spread. It is also pointed out that these low SFs can reduce PAR for UE. The situations are different between uplink and downlink.

Downlink case:

SF 1 and 2 are presently not considered.

The PAR issue is already taken into account in BTS. In addition, these low SFs would cause problem since it would not be possible to transmit any other channels among which PCCPCH and SCCPCH are included. As for any subject, these can be further discussed if some new elements appear.

Uplink case:

SF 1 and 2 ~~is FFS and~~ are not ~~assumed~~ considered at this stage~~.~~ ~~SF 2 shall also be FFS~~.

The only benefit seems to be the PAR reduction. However, it was identified that SF 1 has a problem regarding the channel estimation, that is, the channel estimation can be "polluted" by the user bits, which leads to a situation where there are too many unknown variables. There could be some solutions (see Appendix) but this is not straightforward. These could be possible capabilities of a high performance UE and an option in Node B.

SF 512 for downlink DPCH:

~~**Ad hoc 7 leaves the decision to WG1**, because there are both agreements and objections.~~

Adopt SF 512. Liaison to WG2 is needed for its necessity.

The requirements expressed by Vodafone correspond to the provision of a physical channel able to support a transport channel able itself to support a logical channel similar to the SDCCH in GSM, such an SDCCH being used for resource allocation and location updates among other things. The question is whether a physical channel with SF 512 is the appropriate solution to offer such a service, in terms of resource usage, protection against errors and transmission time. The followings are pros and cons of SF 512, and also alternative approaches proposed.

Cons:

* One-slot TPC delay would be difficult if not impossible.
* The buffer size for the soft handover would be increased from 256 to 512.
* Ericsson indicated long transmission delay for SDCCH. However, this was questioned by Vodafone.

Pros:

* A physical channel with SF 512 can be used in Soft Handover.
* Given having a dedicated downlink, we can have also a dedicated uplink. RACH does not very easily offer the sufficient bit rate.
* This channel can use power control and the associated uplink dedicated can also use power control.

Alternative approaches:

Ericsson (Fredrik Ovesjo) expressed concerns for the SF 512 approach and mentioned an alternative approach that would be based on the FACH/RACH. The pro of this approach is using existing channels. The cons are; 1) FACH cannot use PC, and 2) RACH might not offer a sufficient bit rate. Another alternative is using the shared channels.

Downlink gain factors:

Adopt gain factors. Gain factors would be defined by the operator. ~~There should not be any assumptions made by UEs so that UE does not need to be aware of the gain factor applied.~~

It is important that in soft handover more power can be allocated to TPC bits. For lower rate, there is not any sense to extend DPCCH fields in time. WG1 should discuss with WG4 that the use of gain factors would be tested at the base station. The relating issue was also discussed in the WG1 plenary on February 23.

DPCCH field length in up/downlink:

There are many arguments concerning variable field length:

Merits:

- Bit error protection of TPC or TFCI by appropriate bit repetition
- Give FBI field without puncturing TPC bits

Comments:

- If we allow arbitrary DPCCH field, it has a great impact on terminal implementation and testing.
- Careful design is needed to achieve one-slot TPC delay.
- We have to prepare the channel interleaver of arbitrary sizes, if DPDCH size is variable.
- Re-negotiation would be extremely error-sensitive.
- All configurations should be supported by UEs.
- Define a general FBI field (of variable length) that included TPC, commands for TX diversity, and commands for site selection.
- It was pointed out at the Ad Hoc meeting that there are three cases:
  1. Fixed length DPCCH. All bits are transmitted (no DTX on DPCCH)
  2. Fixed length DPCCH. If no TFCI, DTX on DPCCH -> fixed length DPDCH.
  3. Different lengths for DPCCH. If no TFCI, then DPDCH length is increased.

Through the discussion, the following consensus seems to be reached.

The set of DPCCH fields should be limited sufficiently small. It shall be able to be extended if needed.

In addition, the followings are agreed. <These will be confirmed in Ad Hoc meeting on Feb 22.>

- There is an opinion that the sentence "(the DPCCH field lengths are) variable as described in XX.03 5.2.1/5.3.1" should be included. However, that sentence should be modified to reflect the above consensus if included.
- The operator can select the field lengths from the predetermined set. The selection is informed via L2/L3 signalling. The selection must be changed during a call, but the change is not on frame-by-frame basis. These are matters of WG2.
- The ARIB set is the start pointrecognized as a part of solutions, where the ARIB set means the set of field lengths, field orders, pilot patterns, and the UE RX/TX offset.
- A new field structure could be adopted if it would be agreed to provide better performance than any of the existing structures, or if its necessity would be agreed among the members..
- It is agreed that the field structure to allow for one-slot TPC delay is important. However, the one-slot TPC delay can not be made mandatory. This would impose some reaction times, and might be outside the scope of WG1.
- It would beneficial if some convenient mechanism could be provided for extending the set of the DPCCH fields.
- The uplink GF is not need to be linked to SF.

FBI field in uplink DPCCH:

- FBI field should be described explicitly in the format. The following is a proposed modification of the ARIB table, where the FBI field punctures the TPC field by 1 bit. The order of DPCCH fields is {Pilot, TFCI, FBI, TPC} or {Pilot, TFCI, TPC, FBI}. This table is a part of limited set.

Table 2 DPCCH fields

Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits / Frame	Bits / Slot	N_{pilot}	N_{TPC}	N_{TFCI}	N_{FBI}
16	16	256	160	10	8	2	0	0
16	16	256	160	10	6	2	2	0
16	16	256	160	10	8	1	0	1
16	16	256	160	10	6	1	2	1

- **SF 128 shall be FFS**, because there is no explicit format proposed at this stage. SF 128 could provide FBI field without puncturing Pilot or TPC field, and it could be useful to keep the transmission powers of Pilot and TPC bits. However, it should be noted that DPCCH should fill. **It is recommended the proponents who want to use SF 128 should submit how should it be used.**

FBI field in downlink DPCCH:

Watch RSTS status.

At this time, the uplink synchronous transmission (RSTS) only sends such information, and its data rate is 1 bit per every 20 ms. Therefore, it would be wise to not have it until we have decided what is the status of the RSTS (described as alternative technology) or if having it there now with clearly indicating that it is meant to puncture 1 TPC bit every 20 ms and not to have FBI field in every slot in the downlink. Also a comment for the notes, the uplink synchronisation scheme in ARIB (RSTS) is said to utilise the uplink FBI field, which is not the case, as timing control information is sent for the UE using downlink direction.

2.2 Common physical channel

2.2.1 Area of Ad Hoc #7

Because some issues are treated by other Ad Hocs, Ad Hoc #7 does not treat them; The multiplexing method in SCH is treated by Ad Hoc #2, and PRACH and AICH are treated by Ad Hoc #3. Moreover, Ad Hoc #7 does not treat PDSCH and PSCCCH, because they are defined only in ETSI.

2.2.2 Commonalities

The following commonalities are found.

- SCH
  Two-subchannel structure, and Synchronisation codes used.
  Code length: 256 chips

- Primary CCPCH (ETSI) vs Perch channel (ARIB)
  Super-frame / Frame / Slot structure
  Spreading factor: 256 (16ksps)
  Pilot and data are time-multiplexed. The number of Pilot symbols is the same, 4 symbols.

- Secondary CCPCH (ETSI) vs Forward link common physical channel (ARIB)
  Super-frame / Frame / Slot structure
  Pilot and data are time-multiplexed.

2.2.3 Differences and suggested solutions

The differences and suggested solutions are summarised in Table 2. For the commonality with dedicated physical channels, the ARIB order is recommended as the field orders of PCCPCH and SCCPCH.

Table 3 Differences of Common physical channels

Channel	Item	ETSI	ARIB	Proposal
PCCPCH vs Perch CH	Field order	Pilot / Data	TX Off / Data / Pilot *1	~~Await Ad Hoc #2~~ Take ARIB ("TX Off" is Ad Hoc #2 issue)
	Pilot pattern	TBD	Defined: Table 3.2.2-2	Take ARIB
SCCPCH vs FL common physical channel	Spreading factor	256 – 4 (32 – 2048 kbps) SF broadcast on BCH.	64 (128 kbps)	256 – 4
	Filed order	Pilot / Data	Data / Pilot *1	Take ARIB ~~?~~
	Number of Pilot and Data bits	TBD	Defined (4:36)	TBD (Take ARIB for SF 64)
	Pilot pattern	TBD	Defined: Table 3.2.2-3	

*1: Field order in ARIB
The same field order of downlink DPCH is used.

Note:
Although it is assumed that the secondary CCPCH does not contain any TFCI bit, this is not in line with the assumption of L23 and WG2 as can be seen in YY.02, and S2.02. Indeed one of the characteristics of the FACH is indicated as "possibility to change rate fast (each 10ms)". This would require the use of a TFCI. WG1 should keep this in mind and may liaise with WG2 on this aspect.

3 FFS items

The following items are identified to be studied further.

1. **Modification and extension of the field sets for downlink DPCH and uplink DPCCH.**
2. **SF 128 for uplink DPCCH**
   It is recommended the proponents who want to use SF 128 should submit how should it be used.
3. **Bit allocation in SCCPCH for SFs other than 64.**
4. **The pilot patterns not defined in ARIB, ie. pilot patterns for different field lengths from ARIB.**
   (The ARIB patterns need to be reviewed by ETSI members.)
5. **Bit allocation for chip rates other than 4.096 Mcps.**

4 Liaison items

The following items are identified to be liaised with WG2.

1. **SF 512 in downlink DPCH for its need**
2. **TFCI for SCCPCH ? (if variable rate)**
3. **There may be a need for signalling where there are sets for a similar result.**

Appendix :

Channel estimation method when SF = 1 (by Nicolas Voyer)

It sounds difficult to estimates 2 unknown parameters, such as I (DPDCH) and channel_response. However, you can use the fact that I is (hopefully) a +/-1 random variable with zero means. Assuming that the channel is stable during some data symbols (this is the case for very low SF), then you will use many of these symbols to make your channel estimate. Actually, you can take as many as 2560 symbols (one slot), and average the received signal. What you get is (sum(I) + sum(j)) * scr_code * channel_response / 2560. sum(j)=2560j; sum(I)=x; Since I is +/-1 uniformly distributed, the variance of x is in sqr(2560) ~= 50. So, what you get is (j+y) * scr_code * channel_response with y~1/50 << 1. Then you can get the channel_response, I guess. [I am not sure the use of scr_code makes any sense for SF=1]

I agree that the assumption (I being uniformly distributed with zero means) is a bit direct. Assuming that I stands for coded information, I guess it makes sense, however. Anyway, I agree with you that information will be part of your channel estimate, and this is useless, and harmful. So the channel estimate will be slightly degraded. But the term y is so small compared to 1 that the effect on performance is negligible. The reason is that pilot power is same as data power (which actually makes maybe too much power for pilots). In multicode, I guess you would use 4 times less power for the DPCCH (SF=4). Anyway, with SF=1, power of DPCCH can be decreased by a factor 4 (unbalanced QPSK). Then y~1/12 <<1 still hold, and effect on performance would still is marginal (but I agree this should be verified by simulation).