Modifications to RRC messages and information elements required to support rapid DCH initialization procedures

1.0 Introduction

This paper introduces new parameters required to handle the procedure for the rapid initialization of a DCH as agreed for inclusion in Section 7.2 of S25.214 [1, 2]. This procedure greatly reduces the DCH set-up delay, with the magnitude of reduction in DCH set-up delay being dependent on the UE and Node B capability. To accommodate differences in UE and Node B capability the required RRC parameters will be negotiated independently per UE. The possibility will be provided for including a new information element 'Rapid DCH Initialisation Info' in most of the messages which result in the setting up of a DCH, these include RAB setup, RAB reconfiguration, Transport channel Reconfiguration and physical channel reconfiguration.   A new IE will also be required for the UE capability message.

2.0   Overview of Modifications

Packet data users in an active state will be required to make frequent transitions between the RACH/FACH and DCH/DCH+DSCH state. Therefore, it is critical that the transition between these states be swift.   At the physical layer, the DCH may be established and ready to transfer data within 10 ms following a FACH message assigning the downlink OVSF code or uplink TFCS.

2.1   Modification implications for 25.303

The physical channel reconfiguration switching times have a greater impact on the performance of data transfers than they do on circuit traffic. The impact is evident when you consider that packet data call hold times, which are on the order of seconds, as compared to voice call hold times, that are on the order of minutes.   If DCH set-up times are on the order of 100s of ms, a large data packet may experience a significant buffering delay waiting for the DCH to be set-up.

There are several opportunities to reduce the DCH set-up delay and improve throughout in the UMTS specification documents. For example, consider the Figure 1 below (reproduced from 25.303 Figure 20), two round trips over the Iub are required prior to data transmission by the UE on a DCH.   By some estimates, each round trip over the Iub can add a buffering delay of 40 ms! If the CPHY-RL-Setup-REQ message is piggybacked with the PHYSICAL CHANNEL RECONFIGURE message, delay can be significantly reduced. WG1 has defined a procedure for expediting the DCH set-up times in S25.214.
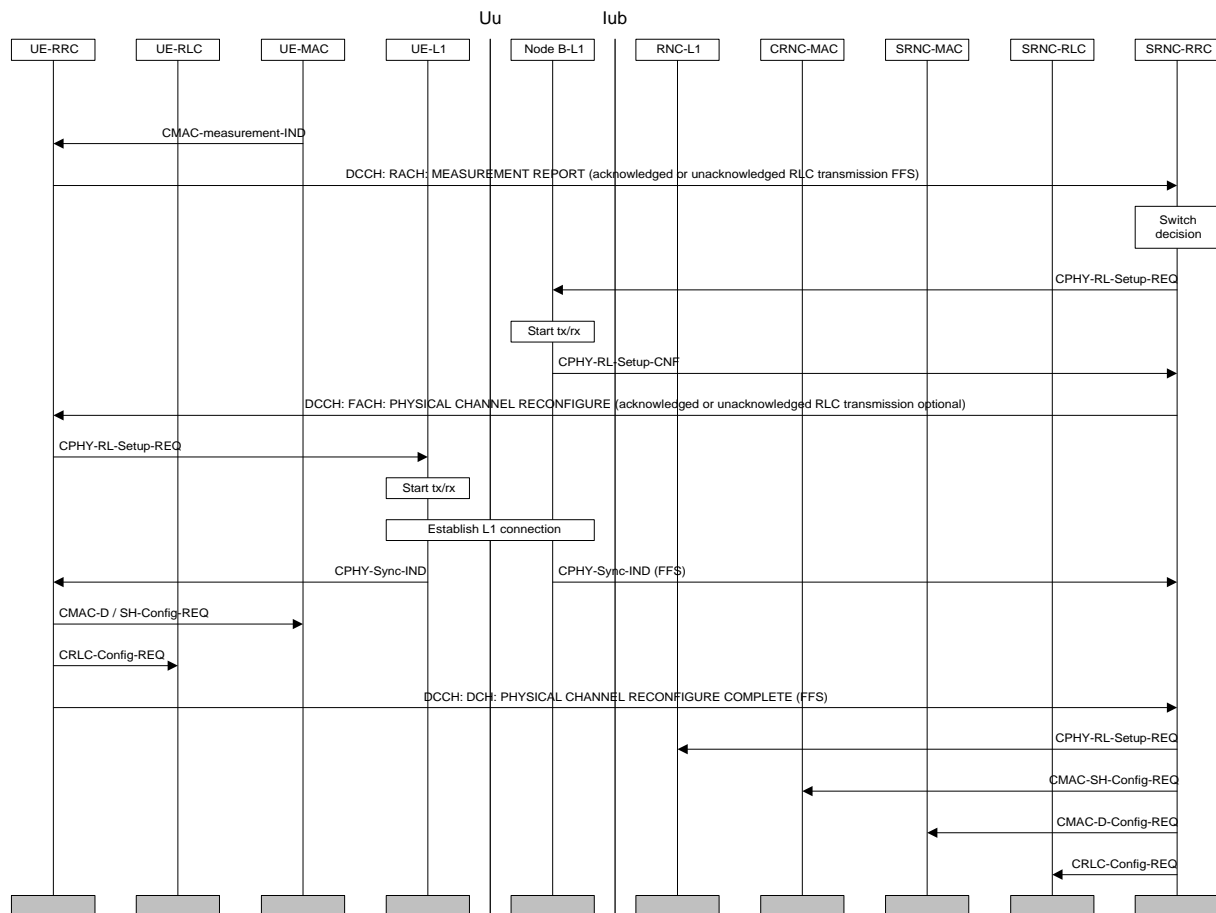
Uu Iub

| UE-RRC | UE-RLC | UE-MAC | UE-L1 | Node B-L1 | RNC-L1 | CRNC-MAC | SRNC-MAC | SRNC-RLC | SRNC-RRC |

CMAC-measurement-IND

DCCH: RACH: MEASUREMENT REPORT (acknowledged or unacknowledged RLC transmission FFS)

Switch decision

CPHY-RL-Setup-REQ

Start tx/rx

CPHY-RL-Setup-CNF

DCCH: FACH: PHYSICAL CHANNEL RECONFIGURE (acknowledged or unacknowledged RLC transmission optional)

CPHY-RL-Setup-REQ

Start tx/rx

Establish L1 connection

CPHY-Sync-IND   CPHY-Sync-IND (FFS)

CMAC-D / SH-Config-REQ

CRLC-Config-REQ

DCCH: DCH: PHYSICAL CHANNEL RECONFIGURE COMPLETE (FFS)

CPHY-RL-Setup-REQ

CMAC-SH-Config-REQ

CMAC-D-Config-REQ

CRLC-Config-REQ

Figure 1 UE-Originated DCH Activation. (Reproduced from 25.303 Figure 20).

In order for the WG1 procedure to be effective inefficiencies in the Iub signalling must be eliminated. Three changes must be made:

#1   The number of round trips across the Iub must be reduced, unnecessary messaging across the Iub will contribute to the data buffering delays.

#2   The Node B must be able to reuse the channel estimate information from the previous RACH. The multipath profile changes slowly and the DCH acquisition time at the Node B may be minimised by re-using previous searcher information.

#3   The RRC must be aware of the UE's signaling response time. (i.e. How long does it take for a UE to demodulate the FACH and re-configure it's physical layer?) WG1 has defined a set of parameters that specify a UE's capability.

With respect to change #1, Figure 2 below shows a modified version of Figure 1 that shows how the PHYSICAL CHANNEL RECONFIGURE message and physical layer primitives may be piggybacked to reduce the number of Iub round trips. With respect to change #2, the detailed description of the physical layer primitives must be extended so that RRC can reference previous RACH messages as part of CPHY-RL-Setup-REQ allowing the Node B to reuse channel information. The exact mechanism is FFS. Finally the next section identifies modifications to 25.331 to identify and configure aspects of the UE capability.
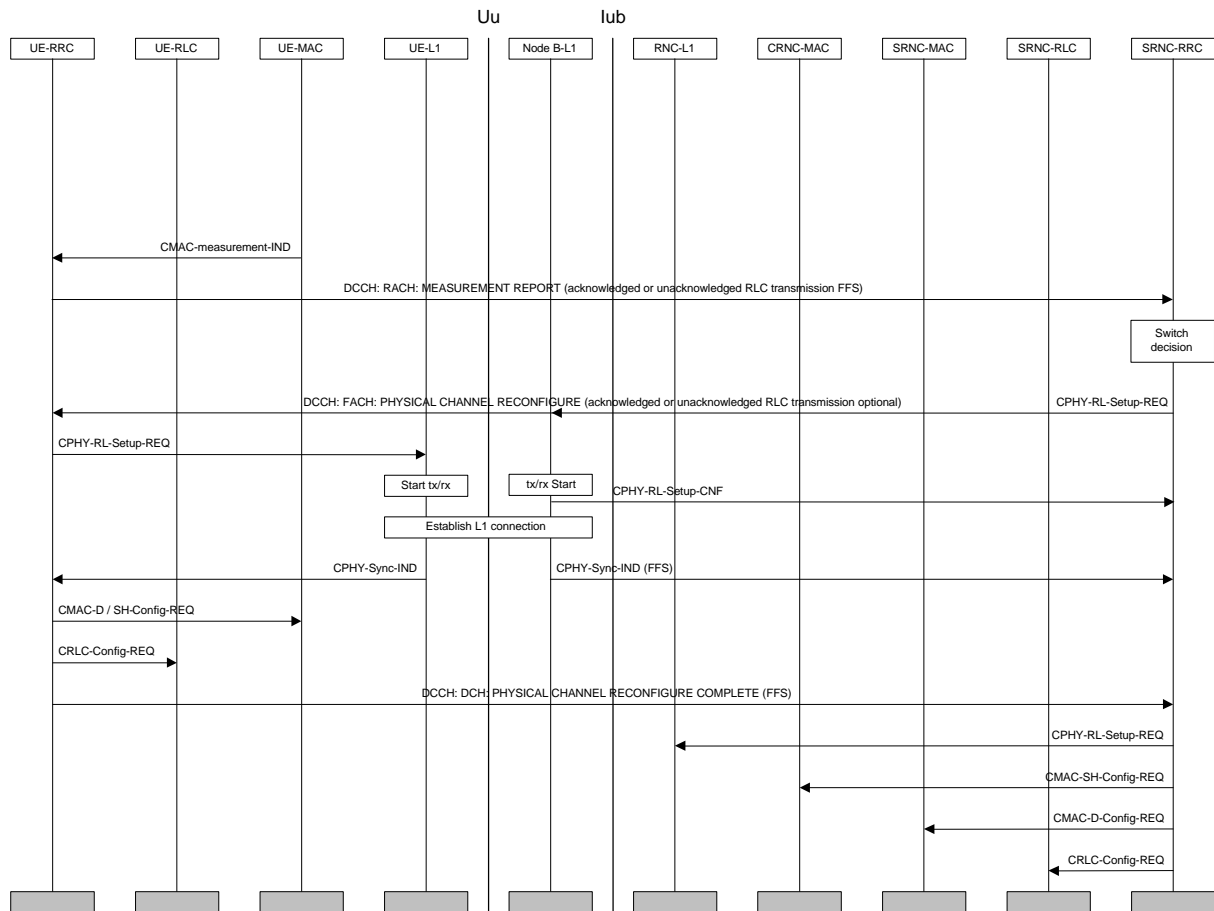
Figure 2 UE-Originated DCH Activation with the minimum Iub round trips.

2.2 Modifications required to 25.331

Section 7.2 of 25.214 [2] "Rapid Initialization of DCH for Packet Data Transfer" defines five parameters that are used to specify the timing and power-control ramp-up procedure for re-initializing the DCH. These parameters are:

T_B Specifies the period between the end of the FACH assignment message and the beginning of the downlink DPCCH transmission. The nominal value is one slot.

T_C Specifies the period between the end of the FACH assignment message and the beginning of the uplink DPCCH. The uplink DPCCH will start nominally one slot after the downlink DPCCH.

N_{slots} Specifies the number of slots that the downlink DPCCH will be transmitted prior downlink or uplink DPDCH transmission. Effectively this parameter defines the power control loop convergence time. The nominal value is 14 slots.

P_{offset} Specifies the power offset from the open loop estimate at which to begin the uplink DPCCH transmission. The nominal value is 4 dB.

P_{step} Specifies the power control step size to use prior to receiving the first power down command. The nominal value is 2 dB.

For further details of this procedure see Section 7.2 of S25.214, also see Figure 3.

A UE capable of rapidly decoding a FACH message may reduce the DCH set-up delay and therefore provide a greater quality of service to the user when transferring packet data. However, not all UEs will have the same capability, consequently a UE will specify its support of this procedure using a new parameter 'Rapid DCH initialization capability'.

3.0 Specific Proposals

3.1 New information element - Rapid DCH intialization Info

One new Physical Channel information element is required, it is proposed that the following should be inserted in 25.331 in a new section:

10.2.6.X Rapid DCH Initialization Info

This IE includes the parameters necessary in order to perform rapid DCH initialization.

Information Element/Group name	Presence	Range	IE type and reference	Semantics description
T_B	O			Specifies the period between the end of the FACH assignment message and the beginning of the downlink DPCCH transmission.
T_C	M			Specifies the period between the end of the FACH assignment message to the beginning of the uplink DPCCH.
N_{slots}	M			Specifies the number of slots that the downlink DPCCH will be transmitted prior downlink or uplink DPDCH transmission.
P_{offset}	M			Specifies the power offset from the open loop estimate at which to begin the uplink DPCCH transmission.
P_{step}	M			Specifies the power control step size to use prior to receiving the first power down command.

3.2 New information element - Rapid DCH intialization Capability

It is necessary for the network to be made aware of the UE's capability with regard to support for Rapid DCH initialization capability.   A new IE is required as detailed below:

10.2.3.X Rapid DCH initialization capability

This IE indicates the capability of the UE with regard to rapid DCH initialization.

Information Element/Group name	Presence	Range	IE type and reference	Semantics description
Rapid DCH initialization capability	M			

3.3   Modifications to RRC messages

The presence of the Rapid DCH Initialization Info IE should be marked as being conditional (as described in Table 1) in all of the following RRC messages:

➢ RAB setup

➢ RAB reconfiguration

➢ Transport channel Reconfiguration

➢ Physical channel reconfiguration

Information Element	Presence	Range	IE type and reference	Semantics description
⋮ ⋮				⋮ ⋮
Physical Channel information elements				
⋮ ⋮				⋮ ⋮
Rapid DCH initialization Info	C-fast DCH			

Condition	Explanation
fast DCH	This IE is only sent when a fast transition from use of common channels into a state in which a DCH is active is required.

Table 1) Required modifications to downlink RRC messages

The presence of the Rapid DCH Initialization Capability IE should be marked as being included in the following message:

➢ UE Capability information

4.0 References

[1] Motorola, "Initial Synchronization of the DCH for Packet Data," TSGR1#5(99)5641.
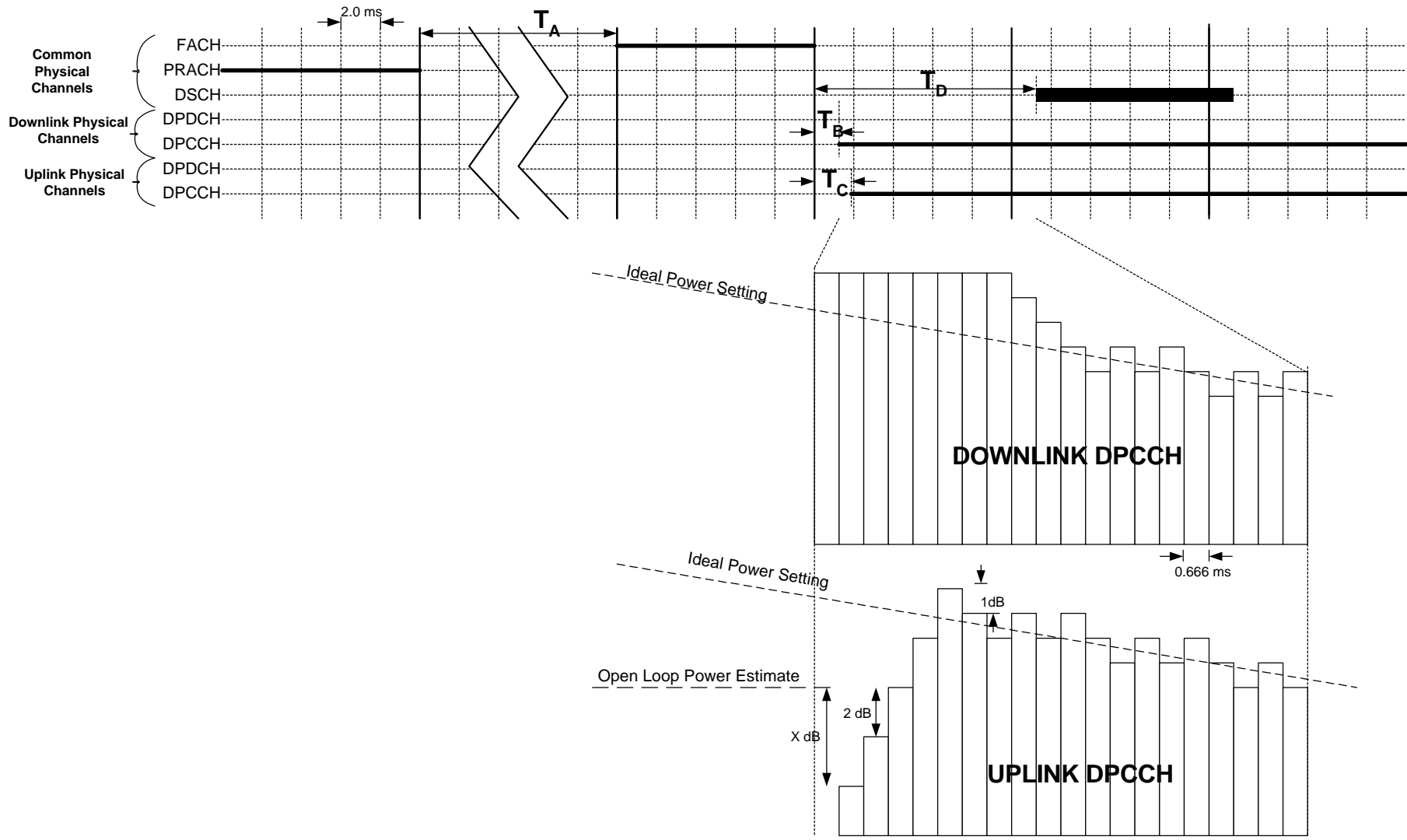[2] Motorola, NTT DoCoMo, Samsung, "Text proposal for section 7 in 25.214," TSGR1#6(99)A37.

Figure 3) Rapid Initialization of DCH for packet data transfer over the DSCH