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Initial Synchronization of the DCH for Packet Data

Abstract

This paper proposes changes to S1.14 specifying an expedited process for initializing the DCH based on channel and timing estimates from the FACH.

1.0 Introduction

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. The DCH may be established and ready to transfer data within 10 ms following a FACH message assigning the downlink OVSF code.

2.0 Problem

Packet data traffic such as WWW browsing typically consists of burst data transfers with long periods to peruse the data. The ETSI models specify that a user browsing the Internet will receive data with a duty cycle of only a few percent. On a DSCH of 384 kbps a few hundred users may be supported. At any moment, there may be a total of 366 active web browsing sessions while there are only 18 active packet calls (e.g. HTML downloads). It is obvious that assigning a DCH to all UEs in an active packet session would waste a significant amount of system capacity. Instead, DCHs should only be assigned for the duration of the packet call. However, packet calls are not long and last only a few seconds or less. Therefore, there will be frequent transitions from the RACH/FACH state to the DCH/DCH+DSCH state. The delay in making the transition will have an impact on higher layer network protocols such as TCP/IP.

Table 1 Number of active packet session and calls for various channel rates and utilization's.

	Channel Rate (kbps)	Utilization	Session Arrival Rate (sessions/sec)	Active Sessions	Active Calls
1	384	75%	*0.60*	***289***	***2***
2	384	85%	*0.68*	***327***	***5***
3	384	95%	*0.76*	***366***	***18***
4	128	95%	*0.25*	***123***	***18***
5	64	95%	*0.13*	***62***	***18***

3.0 Solution

The synchronization of the DCH may be expedited so that data transmission may commence in slightly over 10 ms following the FACH burst assigning the DCH. Figure 1 shows a timing diagram of RACH/FACH to DCH/DCH+DSCH state transition. The parameter T_A specifies the RACH/FACH response time. The parameters T_B, T_C and T_D are referenced relative to the FACH frame. T_B specifies the time period when the downlink DPCCH is started. The parameter T_C specifies the period at which the UE will start the uplink DPCCH. Finally,

T_D specifies the period that the DCH will be stable and the first frame of data may arrive. The parameters T_B, T_C, and T_D have the following relationship:

$$T_B < T_C << T_D$$

$$T_D = T_B + N*0.625$$

where N is a positive integer. The parameters T_B, T_C, and T_D may be negotiated with each individual UE or broadcast by the system so that the transition from RACH/FACH to DCH/DCH+DSCH substate is optimized.

This technique for rapidly synchronizing a DCH may be applied to the transfer of uplink packets. Figure 2 shows that the same parameters T_B, T_C, and T_D applied to an uplink packet data transfer. The UE, upon detecting data in its queue, transmits a RACH with measurement report. After the UTRAN assigns resource via the FACH message, the UE may begin transmitting the data on the DPDCH after the period T_D.

Finally, this technique may be extended to resume a DCH/DCH+DSCH connection that has been dropped for a short period. The procedure would be identical to the one shown in Figure 1, however, the first RACH may be omitted since the searcher data will not have grown stale and DPCCH may be safely acquired by the UTRAN. Figure 3 shows the case where the DCH has been discontinued based on an inactivity timer. The UTRAN, upon detecting data in the queue, may resume the DCH operation provided the period T_E has not elapsed.

4.0 Changes to S1.14

4.1.1 7.3.4 Rapid Initialization of DCH for Packet Data Transfer using DSCH

The DSCH provides a method for scheduling of downlink packets by sharing a low SF (high data rate) OVSF code between multiple packet data users. The scheduling of DSCH may be done on a frame-by-frame basis. As such, the synchronization of the DSCH/DCH pair may be expedited so that data transmission using DSCH can commence in slightly over 10 ms following the FACH burst assigning the TFCI using DCH. Figure 1 shows the timing diagram of RACH/FACH to DCH/DCH+DSCH state transition. The parameter T_A specifies the RACH/FACH response time. The parameters T_B, T_C and T_D are referenced relative to the FACH frame. T_B specifies the time period when the downlink DPCCH is started. The parameter T_C specifies the period at which the UE will start the uplink DPCCH. Finally, T_D specifies the period that the DCH will be stable and the first frame of data may arrive. The parameters T_B, T_C, and T_D have the following relationship:

$$T_B < T_C << T_D$$

$$T_D = T_B + N*0.625$$

where N is a positive integer. The parameters T_B, T_C, and T_D may be negotiated with each individual UE or broadcast by the system so that the transition from RACH/FACH to DCH/DCH+DSCH substate is optimized.

In case of transmission of data generated at the network using DSCH, the fast reverse link power control loop, searcher and channel estimator needs to be primed. As such, the transmission of reverse link DPCCH starts Ns slots (Ns: 1 to 16 slots) prior to the scheduled downlink packet data transmission using DSCH. The DPCCH is transmitted with an additional negative power offset (0 to P_{offset} dB) from the computed open loop estimate. The initial power control step size for transmitting the DPCCH can be set at a higher value (typically: 2dB) so that the power control loop converges faster if the UE is in a deep fade. On the receipt of the first down power control command at the UE during the uplink DPCCH transmission phase, the step size reverts back to the normal power control (PC) step size (typically: 1dB). The step size always goes back to its nominal setting in the beginning of DSCH transmission.

4.1.2 7.3.5 Rapid Initialization of DCH for Uplink Packet Data Transfer

The concept of fat-pipe scheduling and rapidly synchronizing a DCH can also be applied for transfer of uplink data packets. This facilitates short leases on the radio resource, typically on a frame-by-frame basis. Figure 2 shows the same parameters T_B, T_C, and T_D applied to an uplink packet data transfer. The UE, upon detecting data in its queue, transmits a RACH with measurement report. After the UTRAN assigns resource (SF for uplink and TFCI for downlink) via the FACH message, the downlink DPCCH is started after a time period T_B. The UE then begins transmission of the uplink DPCCH for reasons as outlined in section 7.3.4 at time period T_C. T_C is measured relative to the FACH transmit timing. Finally, the UE begins transmitting the data on the DPDCH after the period T_D which typically is set to T_C+10msec. The procedure for starting the uplink DPCCH transmission will be similar to Section 7.3.4.

4.1.3 7.3.5 Resumption of DCH for Downlink or Uplink Packet Data Transfer

Since packet data transmission is discontinuous, there is no need to Re-RACH if the discontinuity between packets does not exceed a preset threshold. This can reduce the delay significantly for uplink/downlink packet data transfer. As such, this technique can be extended to resume a DCH/DCH+DSCH connection that has been dropped for a short period, since the channel estimator and search parameters did not change significantly within the inactivity period. This is applicable for packet data transfer using DSCH or uplink DPDCH or bi-directional data transfer using DSCH/Uplink DPDCH. Figure 3 shows the case where the DCH has been discontinued based on an inactivity timer T_E. The UTRAN, upon detecting data in the queue, may resume the DCH operation provided the period T_E has not elapsed. Typically T_E is set to 1000msec.

5.0 Conclusion

In this contribution, a method of packet data transmission for downlink and uplink using RACH/FACH and DCH/DCH+DSCH is presented. It was shown that this method supports fat pipe scheduling and takes advantages of discontinuities, which is inherent in a packet data system. The proposed text changes in S1.14 are also presented. It is recommended that the proposed changes be adopted for Release-99 of the S1 document.

6.0 References

[1] UMTS 30.03 v3.20, “Selection procedures for the choice of radio transmission technologies of the UMTS,” April 1998.
[2] Motorola, “Searcher Performance for USCH,” TSGR1#4(99)381.
[3] Motorola, “Operation of the Uplink Shared Channel,” TSGR1#2(99)064.
[4] Motorola, “Discontinuous Packet Data Transmission – Simulation Results,” TSGR1#3(99)176.

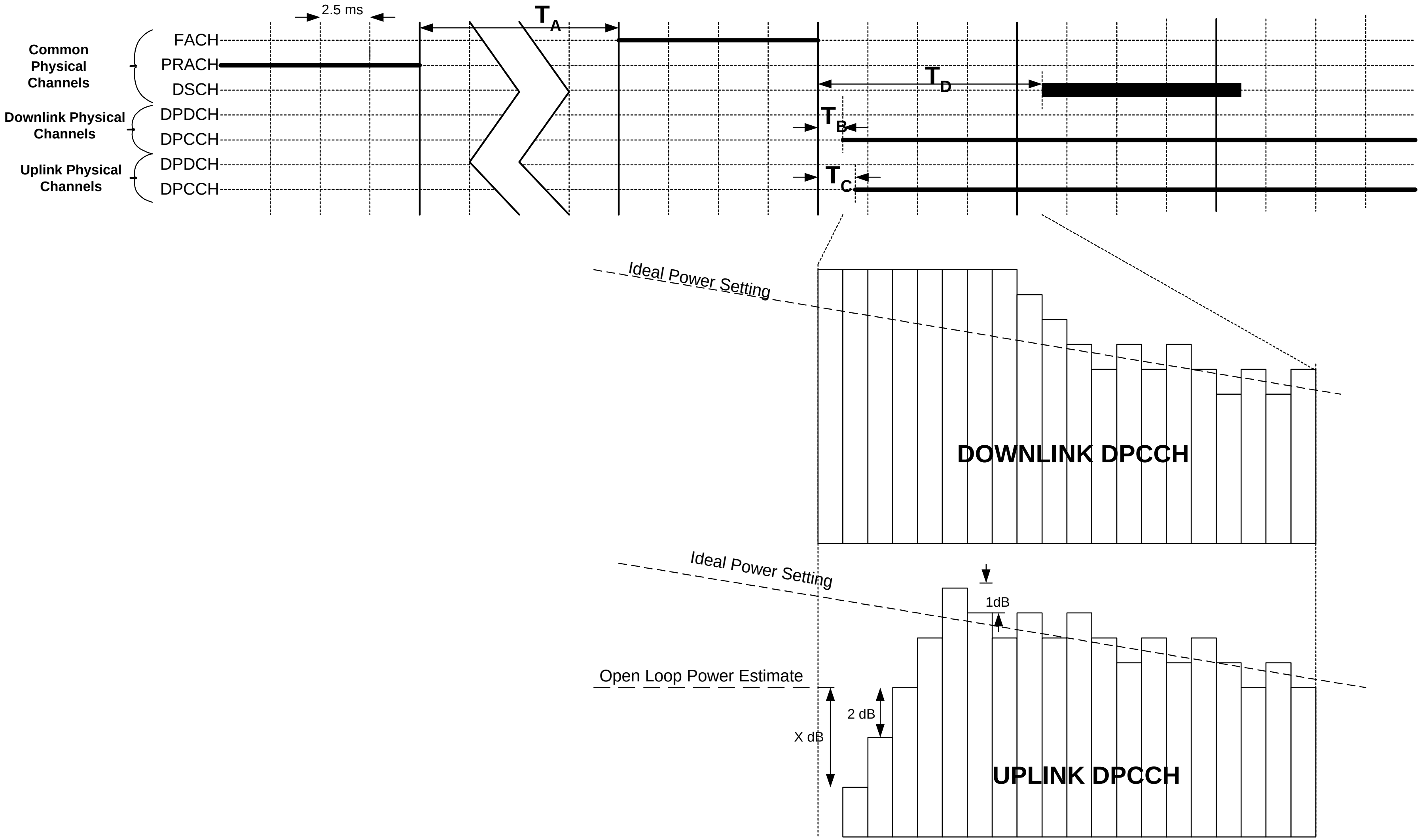

Figure 1 Rapid Initialization of DCH for packet data transfer over the DSCH.

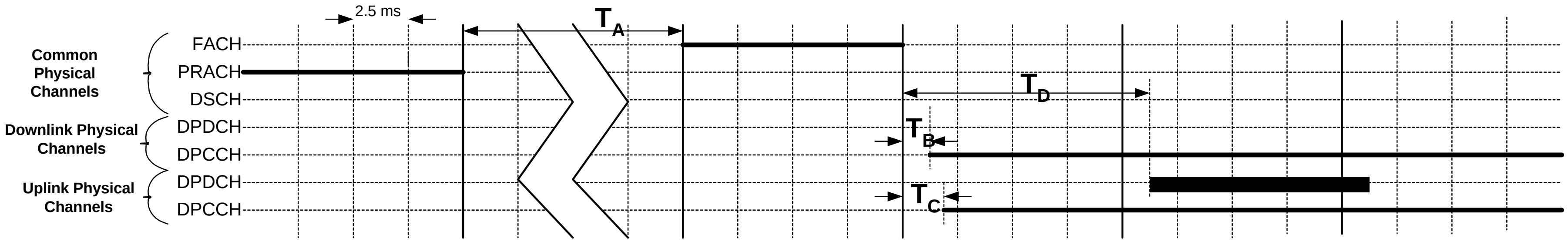

Figure 2 Rapid initialization of the DCH for transfer of uplink packet data.

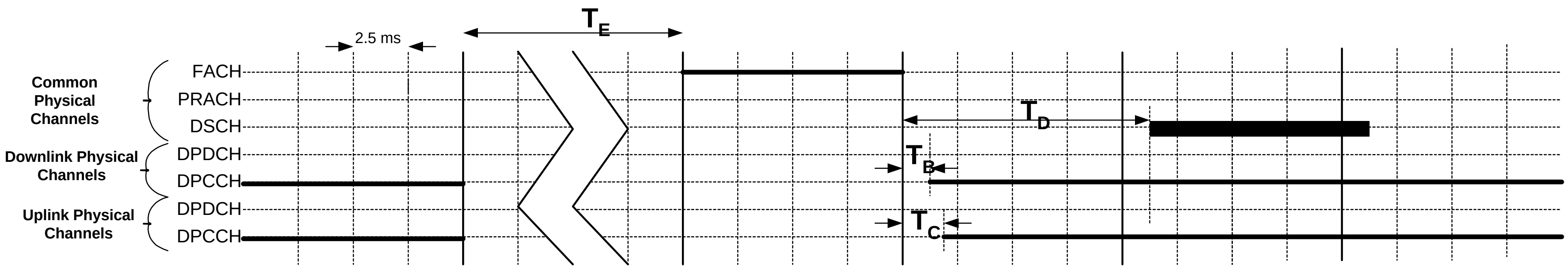

Figure 3 Resumption of the DCH for transmission of downlink packet data.