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Agenda item:
Source: **Golden Bridge Technology**
Title: **CPCH Access Procedures**
Document for: **Information**

Abstract: This contribution provides the system-wide view of operation of CPCH. GBT proposes to include this document as an informative Annex to TS document 25.301, Radio Interface Protocols

This update to this Annex contains new information including:

- CPCH Physical layer terminology consistent with discussions in WG1
- Modified list of CPCH parameters as currently proposed for TS25.331
- New list of CPCH measurements as currently proposed for TS25.331
- Better definition of MAC/PHY boundary for CPCH procedures
- Updated CPCH flowcharts
- Addition of new CPCH emergency stop control mechanism.

CPCH Access Procedure

1.1 Overview of PHY and MAC

- The Random Access procedure is based on a DSMA-CD multiple Access method..
- Access Preamble (AP) signatures are used to identify the particular CPCH resource which the UE ia attempting to access.
- The access preamble ramp-up is similar to the RACH mechanism. However, there is a collision detection/resolution mechanism that follows the access preamble ramp-up. The UEs receive AP-AICH indicating their success in ramp-up and granting access to the CPCH. The UEs will refrain requesting a busy CPCH channel. UEs may log and timestamp all received AP-AICHs in a recency table. This table allows the UE to estimate the probability that a given CPCH is unused at any particular time.. This models the DSMA-CD protocol.
- Layer 1 in Node B is responsible for Call Admission Control and resource management for the CPCH set assigned by the RNC to Node B. This permits Node B to respond immediately to CPCH channel access requests without the need for communication with higher layers.

1.2 Overview of RRC

- UTRAN assigns CPCH capacity to the base node based on the traffic volume measurement reports. It generates persistency parameters for each CPCH allocated to the Base Node. PV_{CPCH} persistency parameters for each CPCH channel are recalculated periodically to permit UTRAN (RNC) a quick means of controlling congestion and access to CPCH.
- UTRAN broadcasts the CPCH related parameters, including backoff control parameters, to the UEs in the cell.
- The UEs and the Base Nodes transmit the measurement reports (throughput reported by SRNC MAC-d, radio access delay and RLC buffer delay reported by UE) so that UTRAN can decide on the capacity allocation and persistency parameters.
- UTRAN transitions the UEs from RACH/FACH state to RACH+CPCH/FACH or DCH/DCH states based on UE traffic demand which is estimated from the measurement reports.

1.3 CPCH Parameters

For each CPCH physical channel allocated to a cell the following parameters are included in the System Information message:

- CPCH Set ID to which this CPCH belongs.
- UL Access Preamble (AP) code (256 chip)
- DL AP-AICH channelisation code (256 chip)
- UL CD preamble code (256 chip)
- DL CD-AICH channelisation code (256 chip)
- CPCH UL scrambling code (40,960 chip)
- CPCH UL channelisation code (variable, data rate dependant)
- DPCCH DL channelisation code (512 chip) [FFS]
- Data rate (spreading factor) (64, 128Kbps, 256Kbps, 384Kbps, or 2 Mbps)
- N_frames_max: Maximum packet length in frames [2-TBD] [FFS]
- Persistency value (PV_{cpch}): assigned by RNC to control congestion and for load balancing
- Signature set: set of preamble signatures (up to 16, 16 bits long) for AP to access this CPCH

The following parameters are set by RNC and control CPCH access, collision detection/resolution, backoff, and priority:

$\mathbf{N_{I\ P}}$ **=** Max number of slots for the initial priority delay for priority level I. The UE randomly selects a delay before beginning the preamble ramp-up.

$\mathbf{N_{AP\_retrans\_max}}$ **=** Maximum Number of allowed consecutive access attempts (retransmitted AP preambles) if there is no AP-AICH response. This is a CPCH parameter and is equivalent to Preamble_Retrans_Max in RACH.

$\mathbf{N_{access\_fails}}$ = Number of successive AP access ramp cycles without AICH before failure report.

$\mathbf{NF\_{}_{bo\text{-}collision}}$ = Maximum number of frames that UE will back-off in case of a collision.. This parameter is a congestion control measure and relates to Bandwidth management

$\mathbf{NF\_{}_{bo\_no\_aich}}$ = Maximum number of frames that UE will back-off after sending $N_{AP\_retrans\_max}$ preambles without an AICH response. . This parameter is a congestion control measure and relates to Bandwidth management

$\mathbf{NS\_{}_{bo\text{-}busy}}$ = Maximum number of slots that UE will back-off in case of an access attemp to CPCH which is currently busy. This parameter is a congestion control measure and relates to Bandwidth management

$\mathbf{NF\_{}_{bo\text{-}all\_busy}}$ = Maximum number of frames that UE will back-off in case of an access attempt to the last available CPCH when all CPCHs are busy. This parameter is a congestion control measure and relates to Bandwidth management

NOTE: The random functions to be used for delay and back-off are TBD, pending WG1 decisions.

The following are power control and CPCH timing paramters set by RNC and used by PHY for CPCH and RACH transmission:

$\mathbf{P_{RACH} = P_{CPCH}}$ = Initial open loop power level for the first CPCH access preamble sent by the UE. [RACH/CPCH parameter]

$\mathbf{\Delta P_0}$ = Power step size for each successive CPCH access preamble.
[RACH/CPCH parameter]

$\mathbf{\Delta P_1}$ = Power step size for each successive RACH/CPCH access preamble in case of negative AICH
[RACH/CPCH parameter]

$\mathbf{T_{cpch}}$ = CPCH transmission timing parameter, an integer ranging from 0 to TBD. This parameter is similar to PRACH/AICH transmission timing parameter.

1.4 CPCH Measurements

In addition to the normal traffic volume measurements which UTRAN may implement, there are four new CPCH measurements proposed to quantify the delay performance of CPCH services:

1. Radio access delay average: average delay per access since last report.
2. Radio access delay max: maximum delay per access since last report.
3. RLC buffer delay average: average delay per access since last report. Includes radio access delay.
4. RLC buffer delay max: maximum delay per access since last report. Includes radio access delay.

Radio access delay is operationally defined to be the time between the first UE transmission of an AP until receipt of an CD-AICH which permits the UE to access the CPCH channel. This period may include multiple unsuccessful access attempts to busy CPCH channels, collision backoff s, etc. The time is rounded up to the next frame and quantified in number of frames. Each CPCH access is measured.

RLC buffer delay is operationally defined to be the time between the arrival of a byte of data in the RLC data buffer and the first output of that byte to MAC for uplink transmission. The time is rounded up to the next frame and quantified in number of frames. Sampling techniques may be used for this measurement.

1.5 CPCH Timing

Figure 1 shows the timing of the CPCH uplink transmission with the associated DPCCH control channel in the downlink.

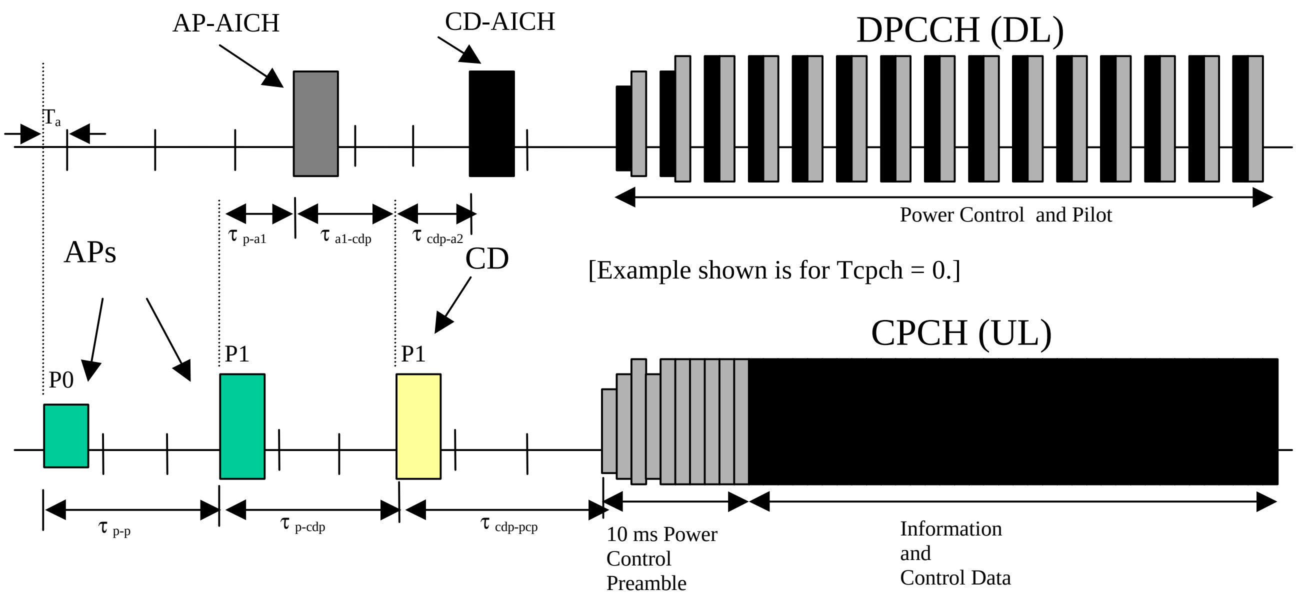


Figure 1. Common Packet Channel (CPCH) Timing Diagram

$\tau_{p\text{-}p}$ = Time between Access Preamble (AP) to the next AP.
= 3.75ms + 1.25ms X Tcpch (CPCH timing parameter)

$\tau_{p\text{-}a1}$ = Time between Access Preamble and AP-AICH
= 1.75 ms + 1.25ms X Tcpch

$\tau_{a1\text{-}cdp}$ = Time between receipt of AP-AICH and transmission of the CD Preamble.
= $\tau_{a2\text{-}pcp}$
= 2.0 ms

$\tau_{p\text{-}cdp}$ = Time between the last AP and CD Preamble.
= $\tau_{p\text{-}p}$
= 3.75ms + 1.25ms X Tcpch

$\tau_{cdp\text{-}a2}$ = Time between the CD Preamble and the CD-AICH
= $\tau_{p\text{-}a1}$
= 1.75 ms + 1.25ms X Tcpch

$\tau_{cdp\text{-}pcp}$= Time between CD Preamble and the start of the Power Control Preamble
= $\tau_{p\text{-}p}$
= 3.75ms + 1.25ms X Tcpch

T_a = fixed offset value between uplink and downlink access slots.
= 0.5 ms

1.6 Temporal Sequence of CPCH Events for Normal Access

This section describes the sequence of events for the operation of CPCH-UL/DPCCH-DL. Refer to the Flowcharts 1-2 for the CPCH Access Procedures in the UE and UTRAN. The following temporal description is normal access procedure and entails both the UE and UTRAN side.

1. UTRAN performs the following tasks periodically:
- Collect traffic and CPCH measurements from the UEs and the cells
- Reassign priorities to all UE CPCH transport channels to maintain QoS
- Allocates CPCHs to Cells based on traffic measurements (cell demand)
- The UTRAN calculates the Persistency values fro all CPCHs to balance loads and relieve congestion.
- UTRAN broadcasts all the CPCH parameters on BCCH.

2. The UE or UTRAN may initiate RRC connection request and transition the UE to the RRC connected state. When UE traffic demand increases, UTRAN will assign a CPCH set to UE. This then places the UE into the RACH+CPCH/FACH substate and permits the UE to access CPCH resources.

3. In the RACH+CPCH/FACH substate the UE performs the following background tasks:
- The UE monitors the CPCH set resources, persistency values, and other parameters in BCCH
- It executes the RLC ARQ procedure
- The UE reports traffic measurements as directed by UTRAN.

4. UE may monitor the transmission of AP-AICH-acks to construct an Availability Table (recency) which stores the last time (timestamp) that each CPCH was assigned by the cell to any UE. This table is used to estimate the probability that a partcular CPCH is available at given time. Selecting CPCH channels which are likely to be available decreases the radio access delays experienced by the UE.

5. Once the MAC receives an indication that one of the RLC logical channels has a transport block to transmit, it will collect UL data from all of the RLC buffers. MAC muliplexes transport blocks from mulitple logical channels to build a packet for CPCH transmission.

6. The UE selects a CPCH from the assigned set of CPCHs. CPCH selection is based on the persistency parameters, the status of the CPCH in the Availability Table, the status of the CPCH Busy Table (records which CPCH channels have already been requested and denied during this access cycle), and the capacity of the CPCH vs the size of the packet to schedule. If several CPCHs are available with the same desired capacity, then the UE selects one of these CPCHs randomly. If there are several AP signatures assigned to the selected CPCH, the UE selects one of these signatures randomly

7. The UE executes a persistency test using the PV_{cphc} for the selected CPCH. If the UE fails the persistency test, the CPCH is marked busy in the Busy Table, the UE backs off a random number of slots and continues from step 6, above.

8. If the UE passes the persistency test, the UE executes an initial priority delay. In selecting the transmission time, the UE picks a random initial delay number from the [1, N_{IP}] range where N_{IP} is a number assigned by RNC for the Ith priority level of the highest priority transport block in the packet.

9. UE MAC then schedules the CPCH packet transmission with PHY. MAC passes to PHY the packet transport blocks along with the selected CPCH channel codes, initial access slot number, and Pcpch (intitial open loop power level). The UE Physical layer then transmits successive APs while waiting for an AP-AICH response from UTRAN.

10. UTRAN constantly monitors the access slots to detect AP preamble requests for CPCH access. The preamble signature used in the AP maps to a particular CPCH channel controlled by the Physical layer in Node B. Node B can detect multiple APs in each slot, similar to RACH detection. However, unlike RACH, Node B may only reply with a single AP-AICH_ack per access slot. This restriction is

necessary to permit the collision detection/resolution segment of CPCH access control to work properly. Node B may respond with mulitple AP-AICH_naks in each slot to indicate that the requested CPCH channel is currently busy. If the Node B receives several APs requesting different CPCH channels which are available, Node B selects one of the CPCH channels and send an AP-AICH_ack with a signature which matches the received AP preamble.

11. Upon reception of the AP-AICH_ack with a signature which matches the AP, the UE randomly selects one of 16 signatures and transmits a CD preamble, then waits for a CD_AICH response with a matching signature from Node B.

12. After sending an AP-AICH_ack, Node B monitors the next CD access slot to detect a CD preamble from all of the Ues which had sent an AP requesting the same CPCH channel in the previous access slot. Node B receives and decodes all CDs in the appropriate slot. If multiple CDs are received with different signatures, Node B selects one signature and uses it to reply by sending a CD-AICH_ack with a matching signature. This selection resolves the contention access.

13. Upon receipt of a CD-AICH_ack with matching signature, the Physical layer of UE begins packet transmission. The UE transmits 10 ms of power control preamble $\tau_{cdp\text{-}pcp}$ ms after the start of the CD preamble. At the same time Node B begins sending DPCCH in the DL and receives the CPCH power control proeamble in the UL. The UE and Node B use close loop power control for the duration of the CPCH packet transmission.

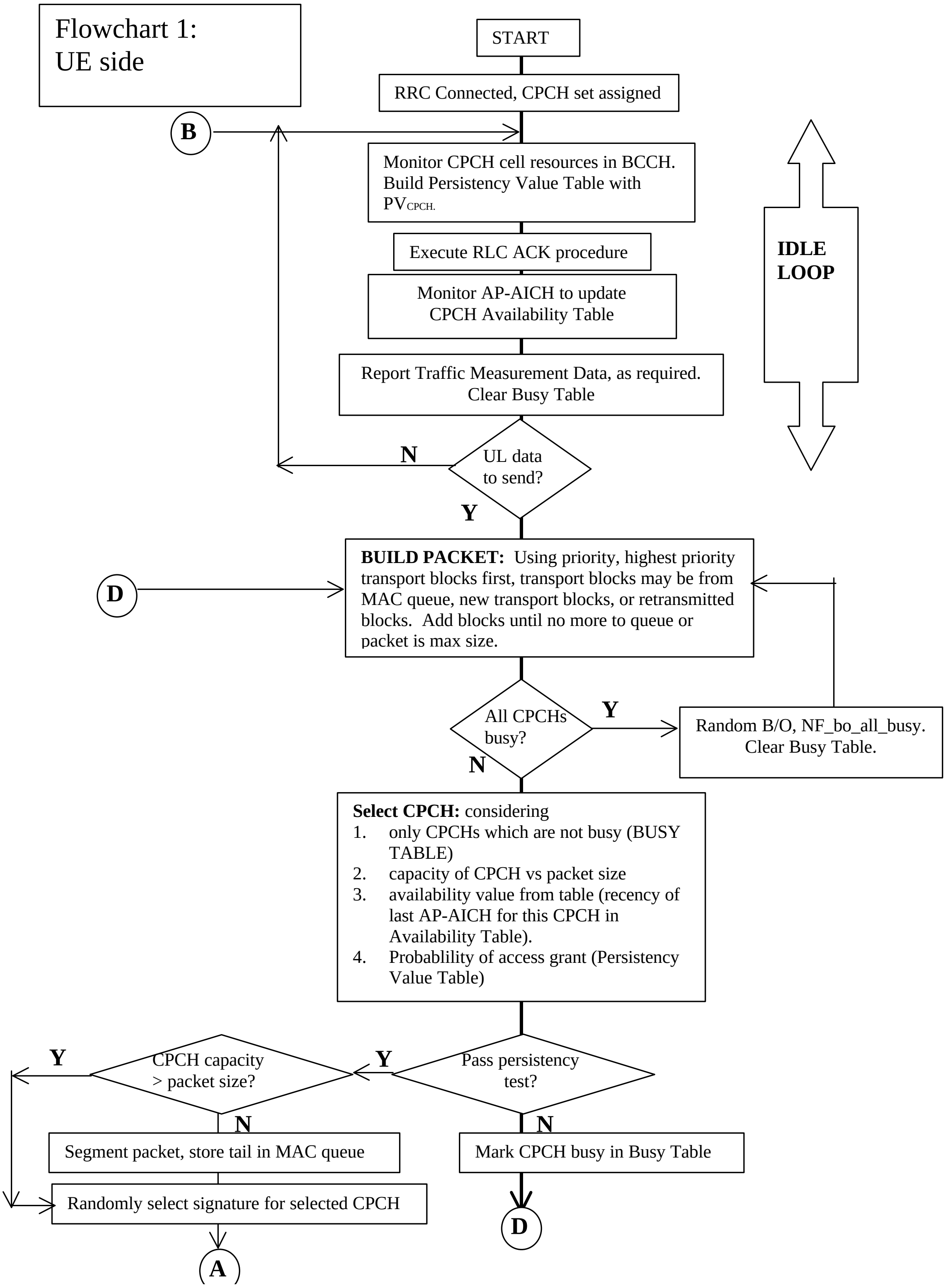
14. At the end of the 10 ms power control preamble period, the UE begins transmitting the CPCH packet data.

15. If during CPCH data transmission the UE detects loss of the DPCCH on the DL, it aborts CPCH transmission on the UL. This feature may be used by Node B as a mechanism to implement an emergency “stop” to handle temporary capacity overloads at the cell.

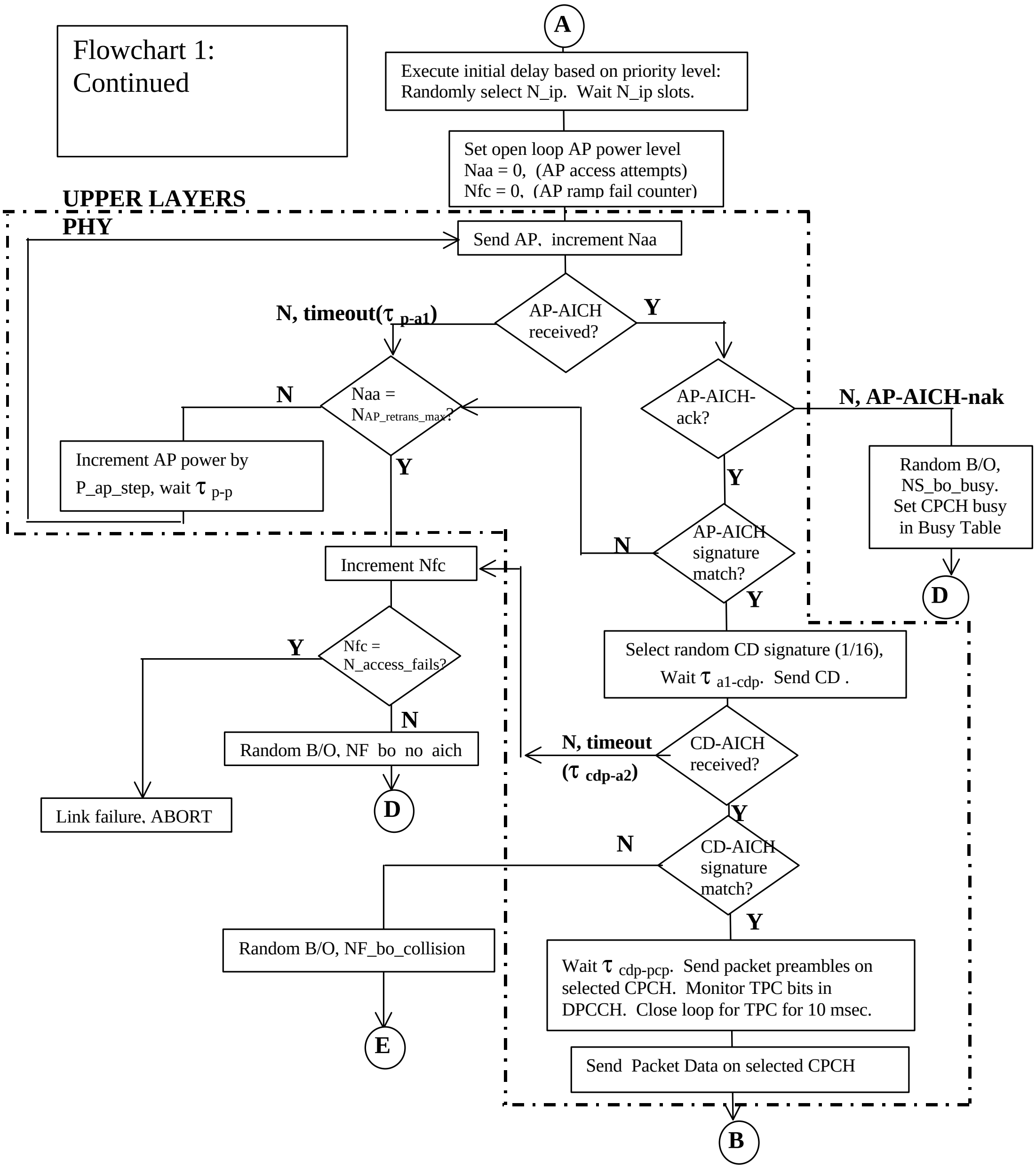
16. After CPCH packet data reception, the UTRAN provides ACK/NAK responses to the transmitting UE using the RLC algorithm appropriate for each transport block. The ACK/NAKs are sent using the FACH.

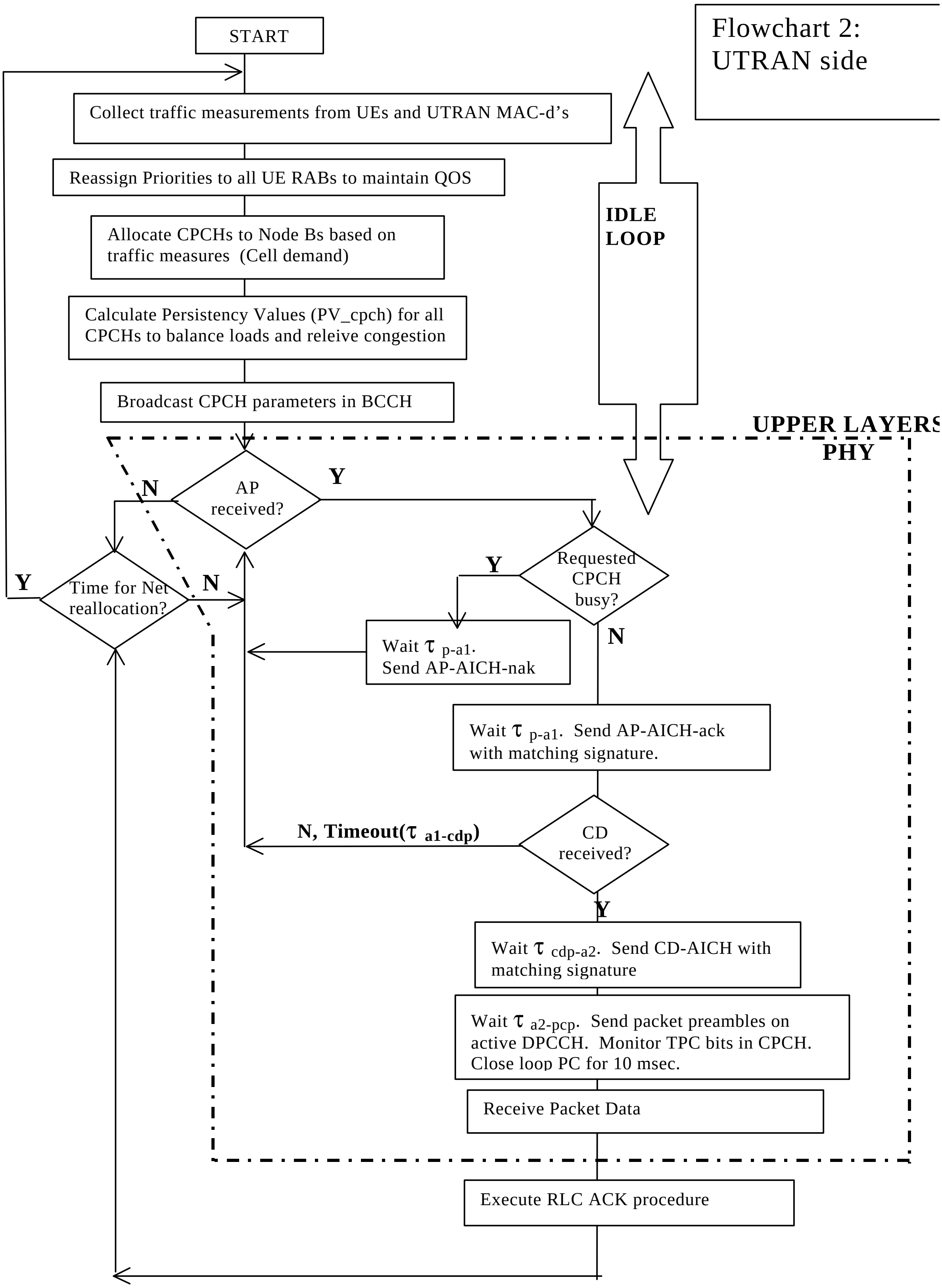
OTHER NOTES:

A. The UE backs off in cases of no AICH response after $N_{\_AP\_retrans\_max}$ preamble transmissions, called an unsuccessful preamble ramp . If there is no success after N_access_fails preamble ramps, the UE executes a link failure procedure.
B. There are many CPCH access failure modes which are not discussed here. For each failure mode there is a separate backoff parameter proposed to quantify the maximum backoff period for that failure mode. The UE would randomly select a backoff period which is less than the maximum specified in the parameter. Random functions to select backoff and backoff algorithms are FFS.



Flowchart 1:
UE side
START
RRC Connected, CPCH set assigned
B
Monitor CPCH cell resources in BCCH. Build Persistency Value Table with PVCPCH.
Execute RLC ACK procedure
Monitor AP-AICH to update CPCH Availability Table
Report Traffic Measurement Data, as required. Clear Busy Table
IDLE LOOP
N
UL data to send?
Y
BUILD PACKET: Using priority, highest priority transport blocks first, transport blocks may be from MAC queue, new transport blocks, or retransmitted blocks. Add blocks until no more to queue or packet is max size.
D
All CPCHs busy?
Y
Random B/O, NF_bo_all_busy. Clear Busy Table.
N
Select CPCH: considering
1. only CPCHs which are not busy (BUSY TABLE)
2. capacity of CPCH vs packet size
3. availability value from table (recency of last AP-AICH for this CPCH in Availability Table).
4. Probablility of access grant (Persistency Value Table)
Y
CPCH capacity > packet size?
Y
Pass persistency test?
N
Segment packet, store tail in MAC queue
N
Mark CPCH busy in Busy Table
Randomly select signature for selected CPCH
A
D


Flowchart 1:
Continued
A
Execute initial delay based on priority level:
Randomly select N_ip. Wait N_ip slots.
Set open loop AP power level
Naa = 0, (AP access attempts)
Nfc = 0, (AP ramp fail counter)
UPPER LAYERS
PHY
Send AP, increment Naa
AP-AICH received?
N, timeout(τ p-a1)
Y
Naa = NAP_retrans_max?
N
Y
Increment AP power by
P_ap_step, wait τ p-p
AP-AICH-ack?
N, AP-AICH-nak
Random B/O,
NS_bo_busy.
Set CPCH busy
in Busy Table
D
Y
AP-AICH signature match?
N
Y
Increment Nfc
Nfc = N_access_fails?
Y
N
Random B/O, NF_bo_no_aich
D
Link failure, ABORT
Select random CD signature (1/16),
Wait τ a1-cdp. Send CD .
CD-AICH received?
N, timeout
(τ cdp-a2)
Y
CD-AICH signature match?
N
Y
Random B/O, NF_bo_collision
E
Wait τ cdp-pcp. Send packet preambles on
selected CPCH. Monitor TPC bits in
DPCCH. Close loop for TPC for 10 msec.
Send Packet Data on selected CPCH
B


Flowchart 2:
UTRAN side
START
Collect traffic measurements from UEs and UTRAN MAC-d's
Reassign Priorities to all UE RABs to maintain QOS
Allocate CPCHs to Node Bs based on traffic measures (Cell demand)
Calculate Persistency Values (PV_cpch) for all CPCHs to balance loads and releive congestion
Broadcast CPCH parameters in BCCH
IDLE LOOP
UPPER LAYERS
PHY
AP received?
Y
N
Time for Net reallocation?
Y
N
Requested CPCH busy?
Y
N
Wait τ p-a1.
Send AP-AICH-nak
Wait τ p-a1. Send AP-AICH-ack with matching signature.
CD received?
N, Timeout(τ a1-cdp)
Y
Wait τ cdp-a2. Send CD-AICH with matching signature
Wait τ a2-pcp. Send packet preambles on active DPCCH. Monitor TPC bits in CPCH. Close loop PC for 10 msec.
Receive Packet Data
Execute RLC ACK procedure