**TSG RAN WG 2#4** **TSGR2#4(99)449**
**Berlin, Germany**
**May 25-28, 1999**

**Agenda item**: **6.7**
**Source:** **Golden Bridge Technology**
**Title:** **Overview of system-wide CPCH Access Procedures**
**Document for:** **Discussion and incorporation into S25.301 and S25.321 documents**

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Abstract: This contribution provides the system-wide view of operation of CPCH. GBT proposes to include this document as an informative Annex to S documents 25.301 and 25.321.

# CPCH Procedures / Elementary Procedures (PHY, MAC, RLC and RRC)

## 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 AICH indicating their success in ramp-up and granting accessing to the CPCH. The UEs will refrain requesting a busy CPCH channel. All UEs log and timestamp all received 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.
- The MAC in the Base Node is responsible to Call Admission Control and resource management in s short time window assigned by the RNC.

## 1.2 Overview of RLC

- Selective Repeat ARQ procedure is applied to CPCH transmission. The UE transmits a packet containing several frames and transport blocks on the CPCH. UE transmits W tx-unacked packets before halting transmission to wait for ACKs for the transmitted packets. UE should wait to receive an acknowledgement(ACK) from a BSS on the CPCH Control Channel (CPCCH) within $RTO_{tx\text{-}unacked}$.
- The receiving side ACKs $W_{rx\text{-}ack}$ at a time. If the receiving RLC does not receive $W_{rx\text{-}ack}$ transport blocks in $T_{rx\text{-}ack}$, it will ACK whatever, it has received in that time window.

## 1.3 Overview of RRC

- UTRAN assigns capacity to the base node every $T_{cpch}$ based on the traffic volume measurement reports. It generates persistency parameters for each CPCH allocated to the Base Node..
- UTRAN transmit a CPCH System Message which entails the CPCH related parameters to the UEs in the cell.
- The UEs and the Base Nodes transmit the measurement reports (throuhput-base node, delay-UE, queue depth-UE) so that UTRAN can decide on the capacity allocation and persistency parameters.
- UTRAN transitions the UEs from RACH/FACH state to CPCH/DSCH or DCH/DCH states based on the queue-depth measurement reports.

## 1.4 Temporal Sequence of CPCH Events for Normal Access

The sequence of events regarding the operation of CPCH-UL/CPCCH-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. The UE will initiate RRC connection procedure and transition to the RRC connection mode. Trasnport Format Sets will be assigned to the UE by UTRAN.
2. The UE enters the idle mode where it performs the following tasks:

- The UE monitors the CPCH cell resources and parameters in BCCH
- It executes the RLC ARQ procedure
- The UE monitors the AICH/ASSIGN to update CPCH availability table.
- The UE reports traffic measurement Data as required by UTRAN.

3. UTRAN will be performing the following tasks in the idle mode:

- Collect traffic measurements from the UEs and the cells
- Reassign priorities to all UE RABs 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 the CPCH parameters and resources on BCCH. The UTRAN transmits the system messages which contain the following information:

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

- Access Preamble (AP) code
- CD preamble code
- CPCH UL scrambling code
- CPCCH DL channelisation code
- Data rate (spreading factor)
- N_frames_max: Maximum packet length in frames
- Persistency value: assigned by RNC to coltrol congestion and for load balancing
- Signature set: set of preamble signatures (up to 16) for AP to access this CPCH

e. The following access, collision detection/resolution, prioritization and CPCH data transmission parameters:

$\mathbf{N_{I\ P}}$ = Number of slots for the initial priority delay that the UE shall use before beginning the preamble ramp-up.N_ip is randomly chosen and will depend on the assigned priority level, I. $\mathbf{PV_{cpch}}$ = The persistency value parameter which is transmitted in the BCCH for each CPCH.

$\mathbf{NF\_{bo\text{-}collision}}$ = 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

$\mathbf{NS\_{bo\_no\_aich}}$ = Maximum number of slots that UE will back-off after sendin N_access_attempts preambles without an AICH response. . This parameter is a congestion control measure and relates to Bandwidth management

**NS_**$_{\text{bo-busy}}$ = 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

**NF_**$_{\text{bo-all\_busy}}$ = 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

**P_** $_{\text{cpch-open-loop}}$ = Initial open loop power level for the first CPCH access preamble sent by the UE.

**P_ap_step** = Power step size for each successive CPCH access preamble.

**NS_**$_{\text{p-p}}$ = Number of slots between two successive access preambles

**NS_**$_{\text{aich-cd}}$**=** Number of slots between start of of AICH and start of CD preamble

**N**$_{\text{\_aa\_max}}$ = Number of allowed successive access attempts (preambles) if there is no AICH response.

**N** $_{\text{access\_fails}}$ = Number of successive AP access ramp cycles without AICH before failure report.
4. Once the UE enters a cell, it transmits a RR-Connection-Request message to UTRAN reporting the following traffic measurement parameters: average packet data bit rate in bps, average packet length in bytes. UTRAN will send the available TFCS to the UE. Once assigned to a particular CPCH set in a cell, , the UE will occasionally report other packet related traffic measurements such as queue-depth for UTRAN to decide whether to change the UE's assignement or not. CPCH assignments are provided to UEs in the RRC connected state, in the RACH/FACH substate.
5. Persistency parameters (PV_cpch) are transmitted by UTRAN in the BCCH System Information Message.
6. UE monitors the CPCCH DL transmission of AICHs and ASSIGNs once it is in an active session state. UE constructs an Availability Table (recency) which stores the last time (timestamp) that the CPCH was assigned by the cell to any UE. The UE also knows the available capacity of each CPCH (data rate X max packet length). .
7. Once the MAC receives an indication that one of the RLC logical connections has a transport block to transmit, it will poll all of the RLC buffers. MAC builds the transport blocks from all of the logical RLC buffers. The Packet Building function in MAC forms a packet within the allowed packet size range.

8. The UE selects a CPCH from a set of available CPCHs 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 9. The ramp-up procedure is similar to the RACH ramp-up procedure. In selecting the transmission offset 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. The UE backs off based on the result of a random test using the persistency parameter. If the UE fails the persistency test, the CPCH is marked busy in the Busy Table. The UE then transmits successive APs while waiting for an AICH response from UTRAN.

10. Upon reception of AICH, the access segment ends and the contention resolution segment begins. In this segment, the UE randomly selects one of 15 signatures and transmits a CD preamble, then waits for an ASSIGN preamble from the base Node.

11. The UE transmit the packet NS_assign_pkt slots after the start of the ASSIGN preamble from the Base Node. In transmitting the packet portion of the burst, the UE has constructed a TFCS based on the received TF's from the MAC.

12. During CPCH Packet Data transmission, the UE and UTRAN perform closed loop power control on both the CPCH UL and the CPCCH DL.

13. During CPCH Packet Data transmission, 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 either the CPCCH DL channel or the FACH.

OTHER NOTES:

A. The UE backs off in cases of no AICH response after N_aa_max preamble transmissions, called an unsuccessful preamble ramp . If there is no success after N_access_failspreamble ramps, the UE enters a failure procedure state.

B. The UE reports the Queuing delay (RLC+MAC) and the Radio Access Delay to UTRAN.

C. If there are errors in the packet, the receiving side will NAK by indicating which transport blocks were in error. This is done on the CPCCH-DL during transmission of the uplink packet. At the end of the packet transmission, the UE will switch to FACH to listen to other RLC messages.

D. If there are no errors after $W_{rx\text{-}ack}$ packets or $T_{ack\text{-}rx}$, the receiving side will send an ACK back to the transmitting side.

E. The receiving side will transfer the ACKed packets to the Packet Re-Assembly state where the longer segmented packets are re-constructed before they are relayed to the higher application layers.

F. The UE transmits $W_{tx\text{-}unacked}$ packets even if it does not receive any RLC ARQ messages. The transmitting RLC waits for a $RTO_{tx\text{-}unacked}$. Upon expiry of the time-out, the transmitting RLC re-transmit the unACKed packet.

G. If there are errors after $N_{RLC\text{-}RT}$ consecutive transport blocks re-transmissions, the entire packet is re-transmitted. A NAK-all RLC message is sent to the transmitting side.

H. The UE is in the RACH/FACH substate using CPCH/CPCCH resources while transmitting an ulpink packet. The UE uses CPCH/FACH resources while waiting for an ACK from the Base Node, The CPCH resource may be used with DSCH in case of a DSCH Downlink transmission while in the RACH/FACH sub-state. When using these CPCH/DSCH resources, the uplink RLC messages can be quickly sent over the CPCH channel.

I. Figure 1 illustrates the physical layer procedure associated with CPCH while the flowcharts show the functional overview of the CPCH access procedure from the UE and UTRAN sides.

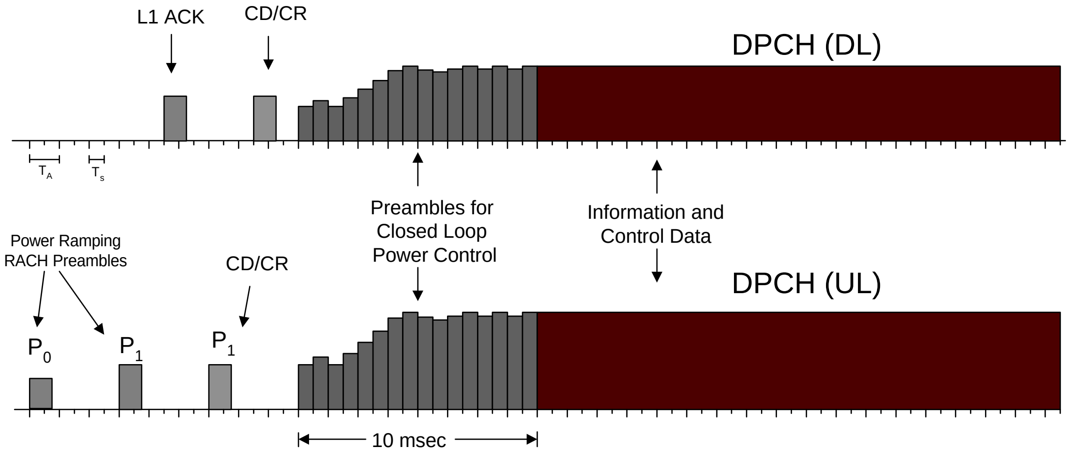
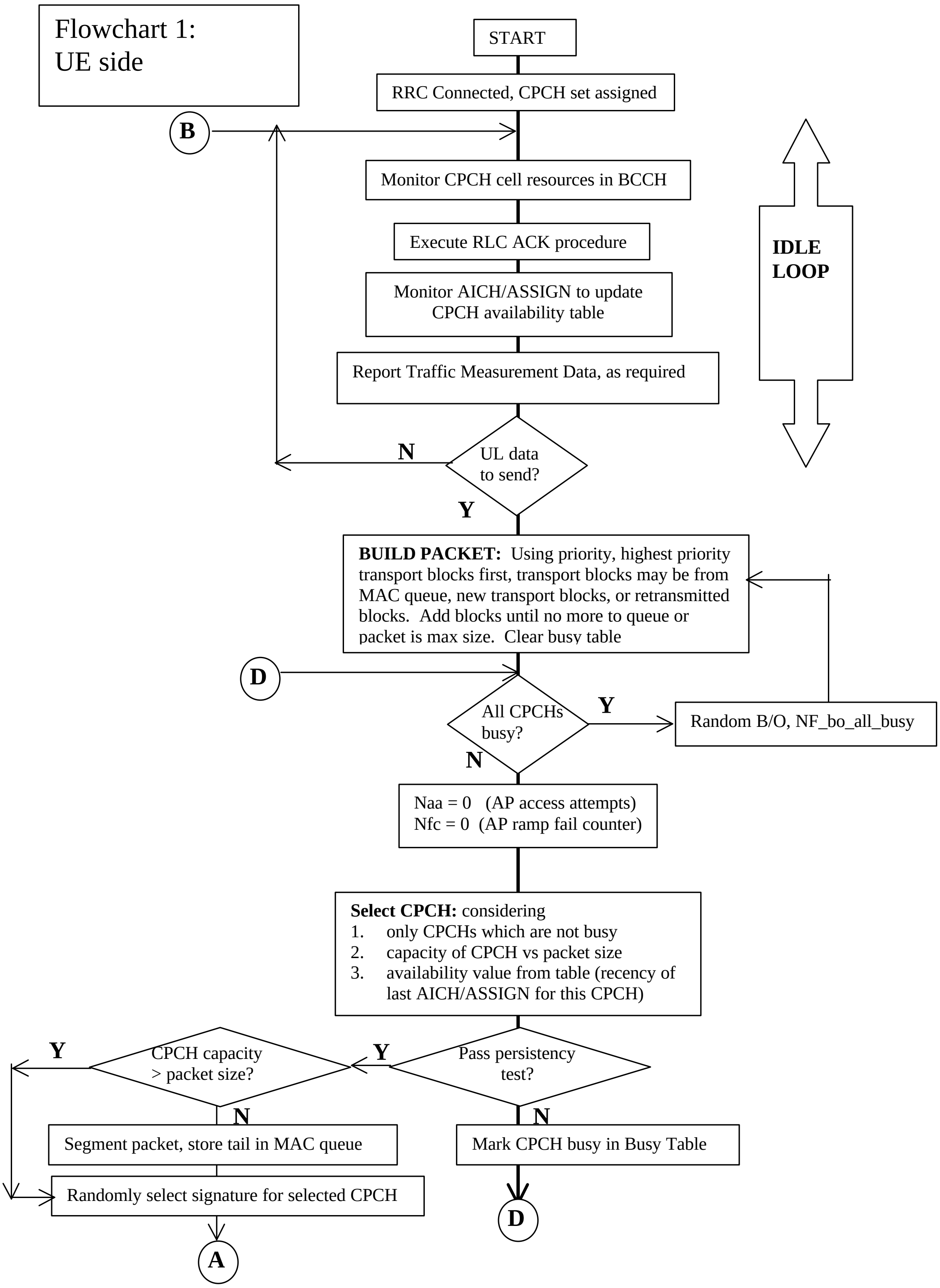
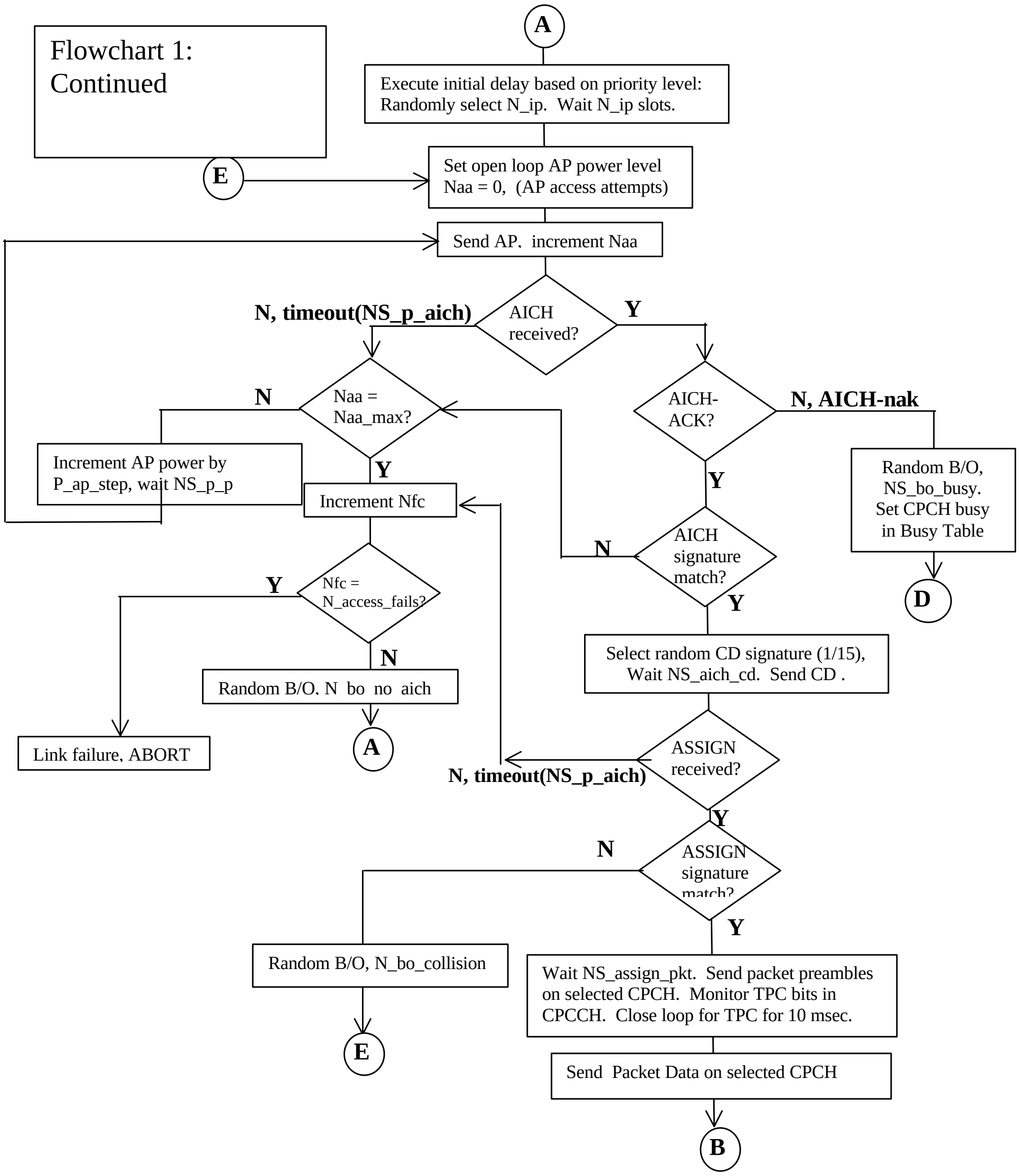
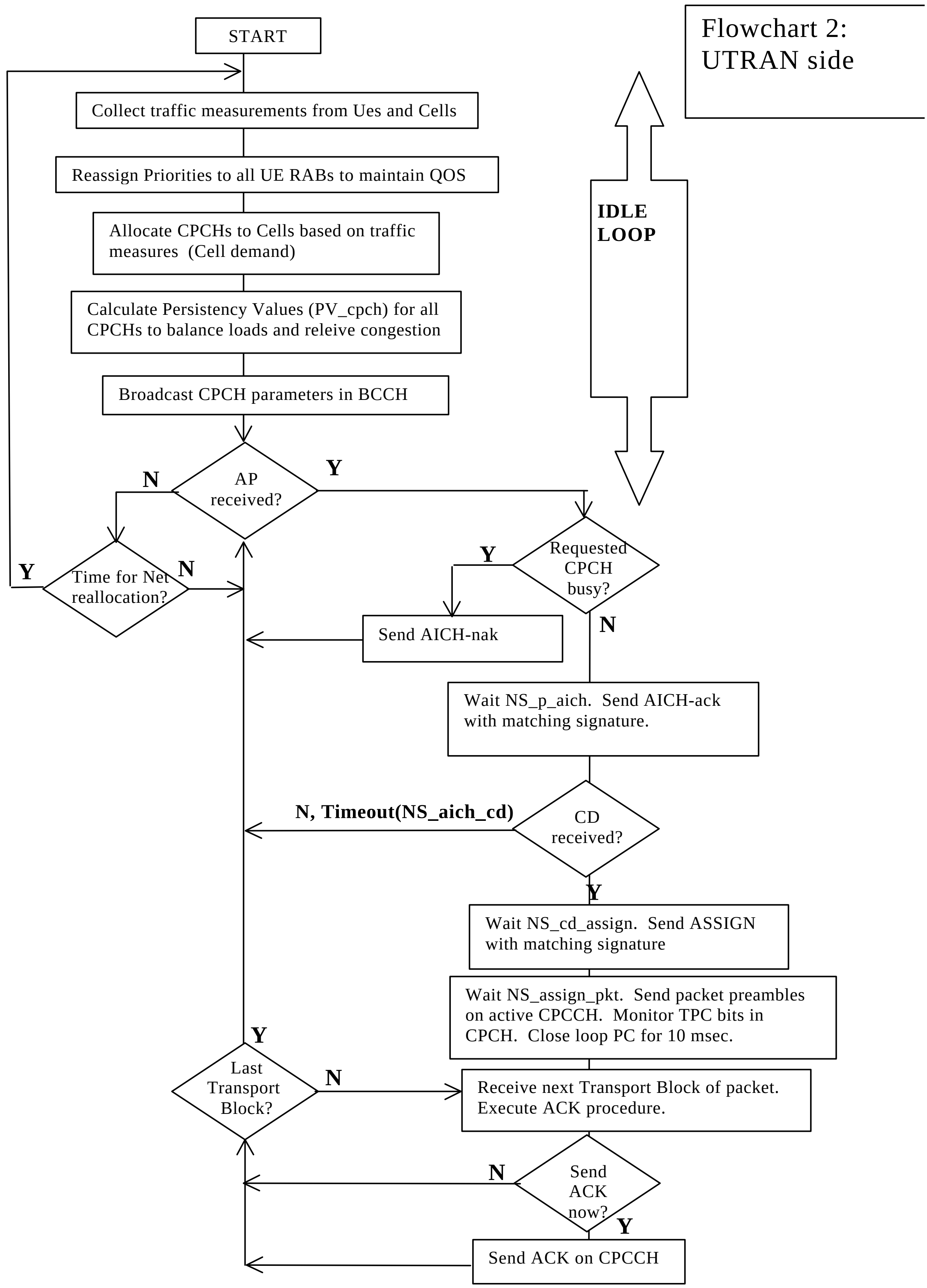



FIG 1. Common Packet Channel (CPCH) Timing Diagram with its Associated Downlink Dedicated Physical Channel.


Flowchart 1:
UE side
START
RRC Connected, CPCH set assigned
B
Monitor CPCH cell resources in BCCH
Execute RLC ACK procedure
Monitor AICH/ASSIGN to update CPCH availability table
Report Traffic Measurement Data, as required
IDLE LOOP
UL data to send?
N
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. Clear busy table
D
All CPCHs busy?
Y
Random B/O, NF_bo_all_busy
N
Naa = 0 (AP access attempts)
Nfc = 0 (AP ramp fail counter)
Select CPCH: considering
1. only CPCHs which are not busy
2. capacity of CPCH vs packet size
3. availability value from table (recency of last AICH/ASSIGN for this CPCH)
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
D
A


Flowchart 1:
Continued
A
Execute initial delay based on priority level:
Randomly select N_ip. Wait N_ip slots.
E
Set open loop AP power level
Naa = 0, (AP access attempts)
Send AP. increment Naa
N, timeout(NS_p_aich)
AICH
received?
Y
Naa =
Naa_max?
N
Increment AP power by
P_ap_step, wait NS_p_p
Y
Increment Nfc
Y
Nfc =
N_access_fails?
N
Random B/O, N_bo_no_aich
A
Link failure, ABORT
AICH-
ACK?
N, AICH-nak
Random B/O,
NS_bo_busy.
Set CPCH busy
in Busy Table
D
Y
N
AICH
signature
match?
Y
Select random CD signature (1/15),
Wait NS_aich_cd. Send CD .
ASSIGN
received?
N, timeout(NS_p_aich)
Y
N
ASSIGN
signature
match?
Y
Random B/O, N_bo_collision
E
Wait NS_assign_pkt. Send packet preambles
on selected CPCH. Monitor TPC bits in
CPCCH. 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 Cells
Reassign Priorities to all UE RABs to maintain QOS
Allocate CPCHs to Cells 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
AP received?
Y
N
Time for Net reallocation?
Y
N
Requested CPCH busy?
Y
N
Send AICH-nak
Wait NS_p_aich. Send AICH-ack with matching signature.
N, Timeout(NS_aich_cd)
CD received?
Y
Wait NS_cd_assign. Send ASSIGN with matching signature
Wait NS_assign_pkt. Send packet preambles on active CPCCH. Monitor TPC bits in CPCH. Close loop PC for 10 msec.
Last Transport Block?
Y
N
Receive next Transport Block of packet. Execute ACK procedure.
Send ACK now?
N
Y
Send ACK on CPCCH