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Agenda item: **6.7**
Source: **Golden Bridge Technology**
Title: **Overview of RNC-based bandwidth management for CPCH**
Document for: **Discussion**

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Abstract: This contribution is intended for discussion of the bandwidth management issues related to CPCH. This document is intended to form a basis for changes to 25.331 in the upcoming meetings.

1.0 Overview of Bandwidth Management (Flowchart)

- As the UEs enter a cell, they register indicating type of service, i.e., IP type, average packet size, queue-depth and average data rate. This means that the RRC in RNC updates the total required bandwidth from these users. This information can be updated as UEs move in and out of a cell.

- The UE will initiate RRC connection procedure and transition to the RRC connection mode. Transport Format Sets will be assigned to the UE by UTRAN.

- UTRAN transitions the UEs from RACH/FACH state to CPCH/DSCH substate or DCH/DCH states based on the queue-depth measurement reports. This will be followed by RAB set up procedure by UTRAN.

- UTRAN transmit a CPCH System Message, which entails the CPCH related parameters to the UEs in the cell. This message also includes the common physical resources assigned to each 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 CPCH set size and persistency parameters.

- UTRAN generates and transmits persistency parameters for each CPCH allocated to the Base Node. Once every $T_{periodicity}$.

- UTRAN assigns capacity to the base node every T_{cpch} based on the traffic volume measurement reports.

2.0 RRC related tasks for UE and UTRAN in idle mode

1. 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.

2. 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 for 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:

3.0 CPCH System Message and parameters

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 channelization code
- Data rate (spreading factor)
- N_frames_max: Maximum packet length in frames
- Persistency value: assigned by RNC to control congestion and for load balancing
- Signature set: set of preamble signatures (up to 16) for AP to access this CPCH

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

$N_{I\ P}$ = 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. PV_{cpch} = The persistency value parameter which is transmitted in the BCCH for each CPCH.

$NF_{\_bo\text{-}collision}$ = 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

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

NS_bo-busy = Maximum number of slots that UE will back-off in case of an access attempt to CPCH which is currently busy. This parameter is a congestion control measure and relates to Bandwidth management

NF_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_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_p-p = Number of slots between two successive access preambles

NS_aich-cd = Number of slots between start of AICH and start of CD preamble

N_aa_max = Number of allowed successive access attempts (preambles) if there is no AICH response.

N_access_fails = Number of successive AP access ramp cycles without AICH before failure report.

4.0 RAB re-configuration

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 and the Delay statistics. UTRAN will send the available TFCS, priority and the CPCH set. 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 assignment or not. CPCH assignments are provided to UEs in the RRC connected state, in the RACH/FACH substate.

5. Persistency Parameters

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 CPCH set size and persistency parameters per CPCH channel.

The new CPCH set size determined based on the traffic volume measurements by UTRAN. This information will be transmitted once every T_{cpch}.

Based on the traffic volume information, the RNC can send a System Info message once every, $T_{periodicity}$ to all UEs indicating the persistency parameters per CPCH. Persistency parameters (PV_cpch) are transmitted by UTRAN in the BCCH System Information Message once every $T_{periodicity}$.

6.0 Call Admission Control

Several mechanisms are associated with Call Admission Control. Congestion Control, Prioritization, Collision back off mechanism and finally call rejection by UTRAN based on resource availability. At the Base Node, there will be an L1 NACK, which will indicate non-availability of resource at the Base Node. At the RNC level, the RNC has the control over RAB assignment and can reject calls or reconfigure calls during RAB set up or RAB re-configuration. Congestion Control is another form of call admission, which is controlled by SRNC via transmission of persistency parameters.

6.1 Congestion Control

UTRAN transmits the persistency parameters for each CPCH physical channels, P_{cpch1}, Pcpch2, Pcpch3, ..., $P_{cpch(n)}$. The persistency parameters are for congestion control of the CPCH channels operating at various rates. These parameters are sent over the Downlink Common Channels every $T_{periodicity}$. This information is passed on by a RRC message over the Common channel. So, the UE shall transmit the packet in the buffer with the probabilities given by persistency parameters, which is a form of congestion control. This method allows distribution of load between different data rates and multiple CPCH per data rate. The key factor is for the RNC to transmit persistency parameters per CPCH .

6.2 Prioritization

UE shall pick a random number between [1, L_I], which corresponds to the access slot that the UE shall begin the preamble ramp-up. There are I prioritization levels and UTRAN assigns that level to the UE based on the service profile and application during the RRC-connection procedure.

6.3 Base Node Call Admission Control

The call rejection by UTRAN can be invoked when there is no resource available in the Base Node to assign to the UEs. The Base Node receives information on the size of the CPCH set every T_{cpch}. The number of physical CPCH Channels shall be indicated to the Base Node by the RNC.
Base Node can reject a call with L1 nack. There is also a possibility of using L23 signaling messages transmitted over the CPCCH to force a UE to abort transmission if there was an error in the length field or there is a undetected collision condition which is causing too much errors, or the power ramp-up by a single user is uncontrolled.
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At any short time window T_{cpch}, there will be a certain amount of common physical resource available at the Base Node assigned by CRNC upon request from SRNC. The management of these resources will be the Base Node responsibility. The main objective is to prevent exceeding the maximum allowed capacity.

The physical resources in the base node are not pre-assigned to a single user as a logical connection. The Base Node will have the task of assigning the upcoming users to the existing physical resources in the Base node. Any physical resource (CPCH card) could operate in various rates and need not be configured for one rate a-priori. The UE can monitor the assignment of various rates to other UEs, before it ramps up and during ramp up to figure out the maximum allowable bit rate at any instant. This is done based on monitoring the AICH channel and channel selection algorithm inside UE.

6.4 Collision-Back-off

In case of preamble collision, the UE Backs off N back-off slots in order to relieve some of the loading pressure. This is an UE-MAC function.

7.0 Code Management and CPCH set size assignment

RRC in the RNC will send a map of the existing signature codes (16) over the common channel (BCCH/FACH). Each preamble code is tied to a downlink channelization code (SF=512) and a specific Pipe in the Base Node Each preamble code is also tied to an uplink scrambling code. The RNC notifies the Base Node to set aside N x8 kbps = for the NRT services utilizing CPCH.
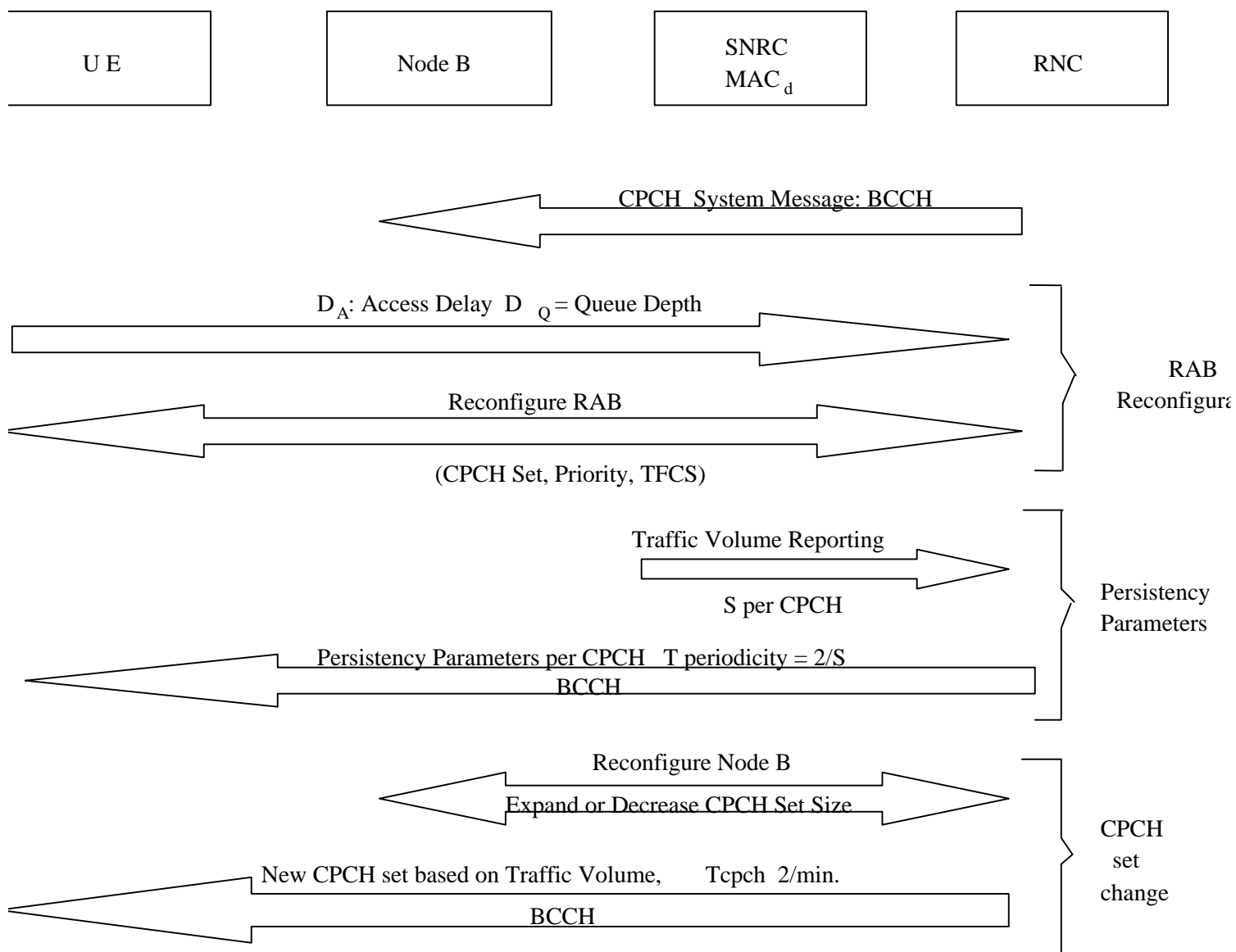The Downlink Control Channel only operates at 8 kbps. There will be up to 16 signature codes: N_{384} for 384 kbps, N_{144} for 144 kbps and N_{64} for 64 kbps. These codes could be mapped to N < 16 Physical CPCH

Channels in the Base Node. This mapping is done by the RNC based on total allocated capacity and the real time demanded data rates.

For capacity expansion purposes, the RNC may allocate a new CPCH-Signature-Set and re-assign some of the UEs to the new CPCH-Signature-Set from the existing CPCH-Signature-Set to relieve congestion and balance the loading.

RC Connected State with RAB

S = Throughput
D = Delay

| U E | Node B | SNRC MAC$_d$ | RNC |

CPCH System Message: BCCH

D_A: Access Delay D_Q = Queue Depth

Reconfigure RAB

(CPCH Set, Priority, TFCS)

RAB Reconfigura

Traffic Volume Reporting

S per CPCH

Persistency Parameters per CPCH T periodicity = 2/S
BCCH

Persistency Parameters

Reconfigure Node B

Expand or Decrease CPCH Set Size

New CPCH set based on Traffic Volume,   Tcpch 2/min.
BCCH

CPCH set change

RNC-based Bandwidth Management for CPCH