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PEAK/AVERAGE MODE AND BIT RATES

Contents

1 Introduction

1.1 General

In the planning of WCDMA networks, the uplink and downlink traffic load in each cell are important parameters. The traffic is dependent on the distribution of different terminal types over the planned area. This distribution is not constant, but varies over time, more or less randomly. Therefore, several simulations are performed, each with a different random distribution of the terminals. The load parameters for every cell are then calculated as average values over all simulations. This is referred to as the Monte Carlo method.

During a packet call, the time when a packet switched terminal is connected to the network, the terminal receives and transmits a certain amount of data. The transmission of packets in the downlink and uplink takes place at the peak bit rates. The allowed peak bit rates are defined in WCDMA standards. The peak bit rate is used only during a fraction of the packet call, which means that the average bit rate becomes lower than the peak bit rate.

During a speech call, DTX can be used, which means that the transmission is shut off during silent periods. This can be taken into account by setting the average bit rate to a lower value than the peak bit rate for speech calls.

In Ascom's cell planning tool, TEMS CellPlanner Universal (TCPU), both the peak bit rates and the average bit rates of both circuit-switched and packet-switched WCDMA bearers have to be input by the network planner.

In the Monte Carlo simulations, packet calls can be modelled in different ways. One way is to let all connected packet terminals consume downlink and uplink power proportional to their average bit rates. In TCPU, this is called Average mode. Another way is to let only active terminals consume power, but proportional to their peak bit rates. With active terminals we mean those terminals that are actually transmitting or receiving packets at a given time.

This is called Peak mode.

This document describes and give some recommendations for the use of Average mode and Peak mode, as well as the use of peak and average bit rates, in TCPU.

1.2 Abbreviations

AF	Activity Factor
ASE	Air-interface Speech Equivalent
CE	Channel Element
CS	Circuit Switched
DCCH	Dedicated ControlChannel
DCH	Dedicated Channel (consists of DCCH and DTCH)
DL	Downlink (forward link)
DTCH	Dedicated Traffic Channel
DTX	Discontinuous Transmission
FACH	Forward Access Channel
PS	Packet Switched
RACH	Random Access Channel
UL	Uplink (reverse link)

2 WCDMA traffic model

The model for PS traffic used in this document is a simplified version of the model defined in [1]. Some information about CS traffic from [1] has been used, too.

2.1 Packet call and packet session

The period when a terminal is connected on a dedicated channel (DCH) in order to receive or transmit packet data is defined here as a packet session. Several packet sessions, separated by idle time, such as while the user is reading the received information, make up a packet call. The terminal remains connected, but on a shared channel (FACH/RACH), during the idle time. See the example in the figure below.

Please note that the terms packet call and packet session may be swapped in the terminology of other companies.

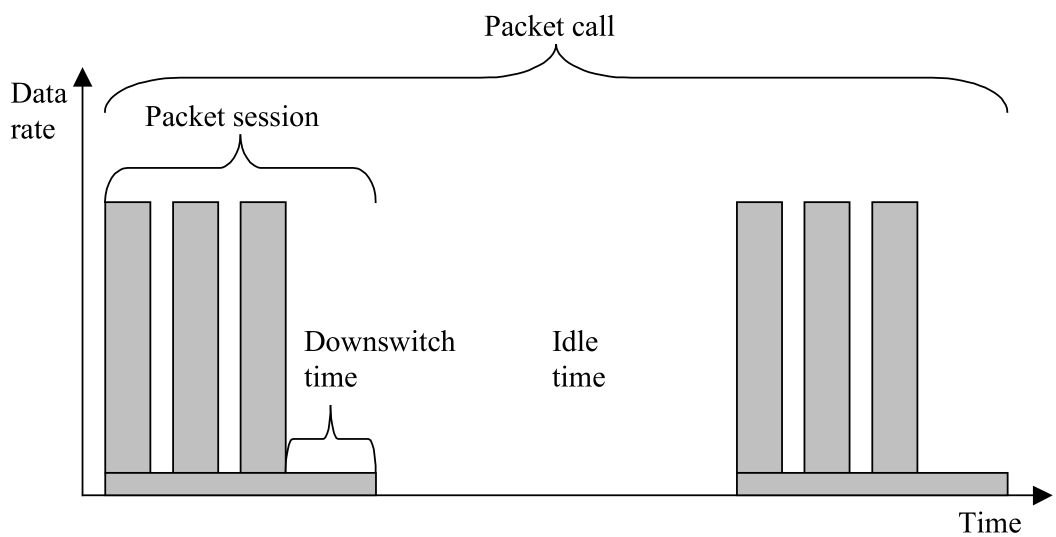

Figure 1. Example of a packet call

The figure shows the transmission of three packets in each session. The packets are transmitted on the DTCH at a high bit rate (64000 bit/s). Below the packets, the figure shows control information being transmitted on the DCCH at a low bit rate.

The average bit rate during a session is input, together with the peak bit rate, into TCPU. The input parameters are found in the rate set dialogue below WCDMA bearers in System explorer. The peak bit rates are called downlink bit rate and uplink bit rate, and are followed by the respective average rates.

Thus the TCPU user should calculate the average bit rate, $R_{average}$ [bit/s], for either the DL or UL as:

$$R_{average} = b_{packet} * n_{packet} / t_{session} + R_{DCCH}$$

where:

b_{packet}	number of bits per packet
n_{packet}	number of packets in a session
$t_{session}$	session time, including downswitch time [s]
R_{DCCH}	bit rate of the DCCH [bit/s]

Assuming that the space between the packets can be neglected, we get:

$$t_{session} = b_{packet} * n_{packet} / R_{DTCH} + t_{downswitch}$$

where:

R_{DTCH}	bit rate of the DTCH [bit/s]
$t_{downswitch}$	downswitch time [s]

The peak bit rate, R_{peak} [bit/s], to be input by the user is:

$$R_{peak} = R_{DTCH} + R_{DCCH}$$

2.2 PS terminal density

In order to get a good estimate of the consumption of ASEs and orthogonal codes, it is important to model the number of PS terminals as accurately as possible. Even if a terminal is connected in a packet call, it does not consume any ASEs or orthogonal codes during idle time. Only terminals engaged in a packet session (as defined above) consume ASEs and codes and shall be included in the simulations. Thus the value of the terminal density that is input into TCPU shall not include the idle PS terminals.

In TCPU, the user defines a terminal density by creating a Traffic demand in System explorer. The terminal density can either be set per clutter code by means of a Traffic density map, or be uniform (default $1/km^2$). In both cases, the terminal density is multiplied by the Scale factor that is set in the Traffic demand.

The user shall thus calculate the terminal density to be input into TCPU, D_{net} [$terminals/km^2$], according to:

$$D_{net} = D_{gross} * (p_{connect} / 100) * [t_{session} / (t_{session} + t_{idle})]$$

where:

D_{gross}	gross density of terminals capable of using the bearer [$terminals/km^2$]

$p_{connect}$ percentage of the terminals that are making a call, or are trying to make a call, at a given point of time [%]

t_{idle} average idle time between packet sessions in a call [s]

2.3 Circuit-switched calls

A speech call can use DTX, which means that the transmission is shut off during silent periods. The activity factor is about 50 % in each direction. Other types of CS calls have an activity factor of 100 %, however.

For speech with a DTCH bit rate of 12200 bit/s, the DCCH is transmitted both during the active and the silent periods. Since the DCCH bit rate is 3400 bit/s, the peak bit rate becomes 15600 bit/s and the average bit rate becomes about 9500 bit/s.

2.4 Activity constants

Downlink and uplink activity constants are automatically calculated by TCPU. For a CS or PS call in average mode, the activity constant is used to scale the power used by each radio link. In Peak mode, the activity constant is used to calculate the number of transmitting or receiving terminals. The activity constant can be different in the uplink and downlink.

TCPU calculates the DL or UL activity constant, C, as follows from the peak and average bit rates input by the user:

$$C = R_{average} / R_{peak}$$

The following resources are assumed to be occupied during the whole packet session (including the downswitch time), and are thus not influenced by the activity constant:

- Downlink ASEs
- Uplink ASEs
- Downlink CEs
- Uplink CEs
- Downlink orthogonal codes
- Spreading factors 8, 16 and 32

This applies also to CS terminals, which are assumed to occupy these resources during the whole call, regardless of their activity constant.

2.5 DTX gain

The DTX gain can be calculated both for CS and PS terminals when the activity constant is known. The DTX gain, G_{DTX} [%], is defined as:

$G_{DTX} = (100 / C) – 100$

If the DTX gain is given, we get the activity constant from:

$C = 100 / (G_{DTX} + 100)$

In this case we can calculate the average bit rate from:

$R_{average} = C * R_{peak}$

2.6 Numerical example of a packet call

Assume that the following data is given for a typical packet session:

$b_{packet} = 424$

$n_{packet} = 120$

$R_{DTCH} = 64000$ bit/s

$t_{downswitch} = 1.0$ s

$R_{DCCH} = 3400$ bit/s

Then we can calculate:

$t_{session} = 424 * 120 / 64000 + 1.0 = 1.795$

$R_{average} = 424 * 120 / 1.795 + 3400 = 31745$

$R_{peak} = 64000 + 3400 = 67400$

The activity constant that is calculated by TCPU becomes:

$C = 31745 / 67400 = 0.471$

The DTX gain would become:

$G_{DTX} = (100 / 0.471) – 100 = 112.3$ %

For the terminal density calculation, we assume that the following data is known:

$D_{gross} = 50$ terminals/km^2

$p_{connect} = 20$ %

$t_{idle} = 60$ s

Then the terminal density to be input into TCPU becomes:

$D_{net} = 50 * (20 / 100) * [1.795 / (1.795 + 60)] = 0.29$ terminals/km^2

3 Traffic modelling in TEMS CellPlanner Universal

Both in Average mode and Peak mode, TCPU simulates all packet sessions that can be set up, i.e. all non-idle PS terminals that fulfil the conditions for connecting them to one or more cells. In both modes, all CS connections are also simulated.

In order to get a good estimate of the consumption of ASEs, CEs and orthogonal codes, it is important to model the number of PS terminals as accurately as possible. Even if a terminal is connected in a packet call, it does not consume any ASEs or orthogonal codes during idle time. Only terminals engaged in a packet session (as defined above) consume ASEs, CEs and codes and shall be included in the simulations. Thus the value of the terminal density that is input by the user shall not include the idle PS terminals.

The user must calculate and input the average and peak bit rates as described above (section 2.1).

3.1 Average mode

In Average mode, all non-idle PS terminals and all CS terminals, which can be connected, are assumed to consume downlink and uplink power proportional to their average DL and UL bit rates.

Compared to the power consumed by a terminal receiving or transmitting at its peak bit rate, the power consumed by a terminal in Average mode is scaled down by the activity constant. This allows a higher number of CS and PS terminals to become connected than if they were consuming full power.

To prevent a terminal situated too far from the cell site from becoming connected, TCPU also checks that the full (unscaled) DL power and UL power required by the WCDMA bearer do not exceed the upper limits valid for an individual link.

3.2 Peak mode

In Peak mode, DL or UL power is assumed to be consumed only by the PS and CS terminals that are actually receiving or transmitting packets at the point of time represented by the specific simulation (also called snapshot).

A terminal is active in the uplink or downlink only during a fraction of the duration of a packet session. TCPU sets this fraction equal to the activity constant, see above. When the average bit rate is calculated as described above, the bit rate used by the DCCH between the packets and during the downswitch time will result in a small increase of the activity constant compared to the true active fraction of the session. However, this increase is needed in order to take into account all of the DCCH transmission.

During the Monte Carlo simulations, TCPU uses a random procedure to decide which of the PS terminals that shall be active in the DL or UL. The fraction of users that become active in the DL or UL will, on the average, be equal to the respective activity constant.

3.3 Comparison of Average mode and Peak mode

Since the DL power required by each terminal is scaled down in Average mode, the available DL power in the cell can be shared between a higher number of CS and PS terminals than in Peak mode. The UL noise rise caused by each terminal is also scaled down in Average mode, so a higher number of terminals can be connected before the noise rise limit is reached.

The figure below shows an example of DL transmitter power allocation in a cell in Average mode and in Peak mode.

Average mode

CS #1	CS #2	CS #3	CS #4	CS #5	CS #6	PS #7	PS #8	PS #9	PS #10	PS #11	PS #12	

Peak mode

CS #1	CS #3	CS #5	PS #8	PS #10	

Figure 2. Example of power allocation in Average mode and Peak mode

The advantage of Peak mode is that it gives a fairly exact model of the traffic load and resource utilisation at a specific moment of time.

A possible disadvantage of Peak mode is that an active terminal using a high bit rate and high power may block other active terminals from being connected, although in real life these terminals would become connected but forced into inactive state by queueing their transmission. These terminals would become active as soon as the needed resources become available.

In Average mode, it is possible to connect more terminals, as long as the sum of their average power demand does not exceed the limit. This can be regarded as a better model of the queueing, but it does not model the real fluctuations of the used power. The DL and UL interference becomes more “evened out” than in real life.

In TCPU, the user must select, for every WCDMA bearer created in System explorer, a Quality of Service (Background, Conversational, Interactive or Streaming) and a Power mode (Peak or Average). The normal choice should be Average mode for Conversational and Streaming bearers, and Peak mode for Background and Interactive bearers.

4 Reference

1. Traffic Modelling Guideline. 61/1551 – HSD 10102/1.