3GPP TSG RAN WG1 #20 meeting **Tdoc R1-01-0462**
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Busan, Korea

Source : Nokia

Title: HSDPA UE Capability

Agenda Item : HSDPA

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1 Introduction

This paper analyses the terminal capabilities with HSDPA and especially the relationship with the UE classes in TS 25.306 and impact of introducing HSDPA for UTRAN. The focus is at this point in time for the FDD only.

2 Current Classes

The first assumption is that from the terminal class point of view, having HSDPA would make sense starting with 384 kbits/s class as an optional capability and then for other classes such as 768 kbps and 2 Mbps class + for one/two proposed new classes as "Yes" capability in 25.306.

For this consideration following assumptions have been taken, which need to be naturally discussed:

- 64 QAM is considered as extra capability, thus UE bit rates are evaluated with ¾ coding and 16 QAM for a data rate to be considered.
- SF 16 (fixed) is assumed for the HSDPA
- The TTI length as such does not have a direct impact, but the assumption here is a short TTI length of e.g. 3 slots or 5 slots.
- If HS-DSCH is used, UE shall not use simultaneous DSCH or FACH.

3 DCH capability vs. HS-DSCH capability

With the current UE capabilities there is a dependency with the amount of data on DCH and DSCH that can be transmitted in the downlink. It is also obvious that a terminal not using HSDPA can have higher data rates on DCH than a terminal having HSDPA allocated. These capabilities cannot have any dynamic dependency since the RNC takes care of DCH scheduling and Node B takes care of HSDCH scheduling.

What should be considered is a simple approach where any UE using HSDPA will only support DCH on one code with data rate equivalent to e.g. 64 kbps class. This allows e.g. AMR or video codec together with packet data on HSDPA.

4 Alternatives to limit the amount of data sent to a UE

4.1 General

Basically several approaches can be seen how the data flow to the UE could be restricted.

- Number of codes as UE capability
- Number of channels N as UE capability
- Frequency of used transmission time intervals as UE capability
- Modulation level support as UE capability

4.2 Number of codes as UE capability

The table below shows the data rates (approximations without tail bits or CRC fields) achievable with different coding and numbers of codes with SF=16. This table is used to map the UE capabilities for to the existing classes in TS 25.306 and proposing two/three new classes as well (e.g. 4 Mbits/s, 7 Mbits/s, 10 Mbits/s) for the downlink.

Table 1. Momentary data rates with code/coding/modulation adaptation and continuous transmission

	1 code	2 codes	5 codes	10 codes
QPSK ¼	120 kbps	240 kbps	600 kbps	1.2 Mbps
QPSK ½	240 kbps	480 kbps	1.2 Mbps	2.4 Mbps
QPSK ¾	360 kbps	720 kbps	1.8 Mbps	3.6 Mbps
16 QAM ¾	720 kbps	1.44 Mbps	3.6 Mbps	7.2 Mbps
64 QAM ¾	1.08 Mbps	2.16 Mbps	5.8 Mbps	10.8Mbps

Note that L2/L3 overhead is not include and thus some margin is needed for that.

It may not be desirable to have a HSDPA capability with support for only few multicodes. In case there are lots of users with only 1 or 2 codes in use the code multiplexing overhead can become excessive. This is because all code multiplexed UEs need a control channel which is allocated in semi static way. It is probably better to limit the minimum number of multicodes to 5 or so.

4.3 Number of channels as UE capability

Changing the number of active subchannels as part of UE capabilities is a method of adjusting the maximum buffer size in the receiver. The UE must have buffer memory reserved for all subchannels, so reducing the number of subchannels directly relaxes buffering requirements. However, since the available processing time for one subchannel stays the same regardless of the number of active subchannels, the peak-processing load does not become smaller if the number of N is lower (Figure 1). Even in the extreme case of one subchannel only, decoding and sending an acknowledgement would still take place as fast as with all N subchannels.

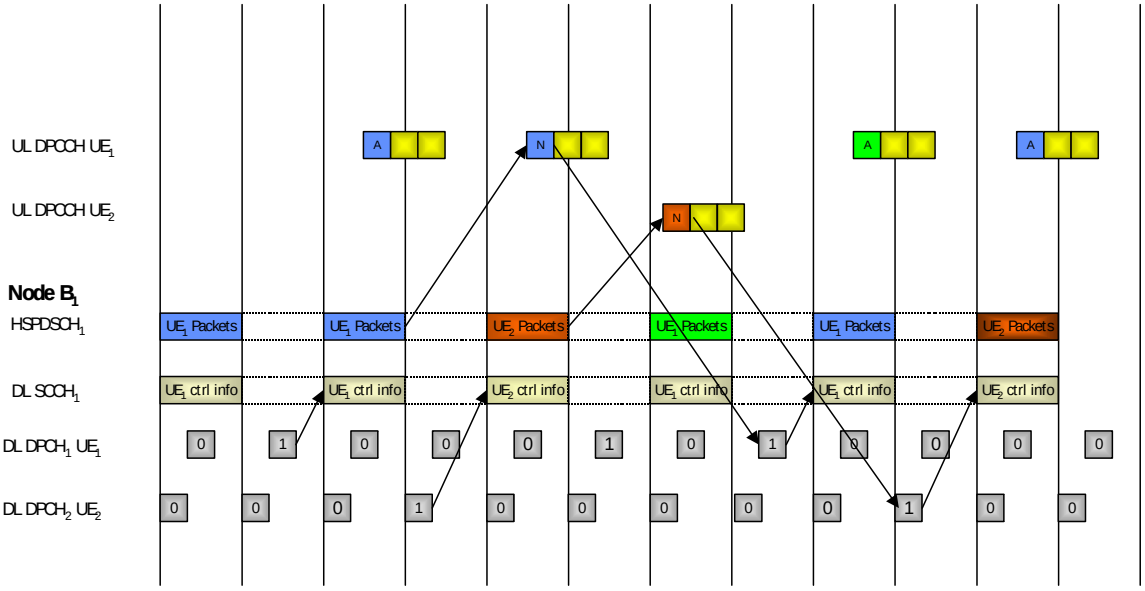

Figure 1. Using three subchannels out of six (N/2)

Table 2. Momentary data rates with subchannel adaptation and continuous transmission (10 codes)

	N=1	N=2	N=3	N = 6
QPSK ¼	200 kbps	400 kbps	600 kbps	1.2 Mbps
QPSK ½	400 kbps	800 kbps	1.2 Mbps	2.4 Mbps
QPSK ¾	600 kbps	1.2 Mbps	1.8 Mbps	3.6 Mbps
16 QAM ¾	1.2 Mbps	2.4 Mbps	3.6 Mbps	7.2 Mbps
64 QAM ¾	1.8 Mbps	3.6 Mbps	5.4 Mbps	10.8Mbps

Table 3. Momentary data rates with subchannel adaptation and continuous transmission (5 codes)

	N=1	N=2	N=3	N = 6
QPSK ¼	100 kbps	200 kbps	300 kbps	600 kbps
QPSK ½	200 kbps	400 kbps	600 kbps	1.2 Mbps
QPSK ¾	300 kbps	600 kbps	900 kbps	1.8 Mbps
16 QAM ¾	600 kbps	1.2 Mbps	1.8 Mbps	3.6 Mbps
64 QAM ¾	900 kbps	1.8 Mbps	2.7 Mbps	5.4Mbps

4.4 Frequency of used transmission time intervals for a subchannel

Processing time requirements could be loosened by e.g. using only every other transmission interval in an individual subchannel (Figure 2). One could interleave active transmission intervals of different subchannels in this method but scheduling in Node B would be further complicated. However, compensating for the drawback of increasing delays there is a marked loosening in processing time requirements. On the other hand, this method does not reduce the UE buffer size.

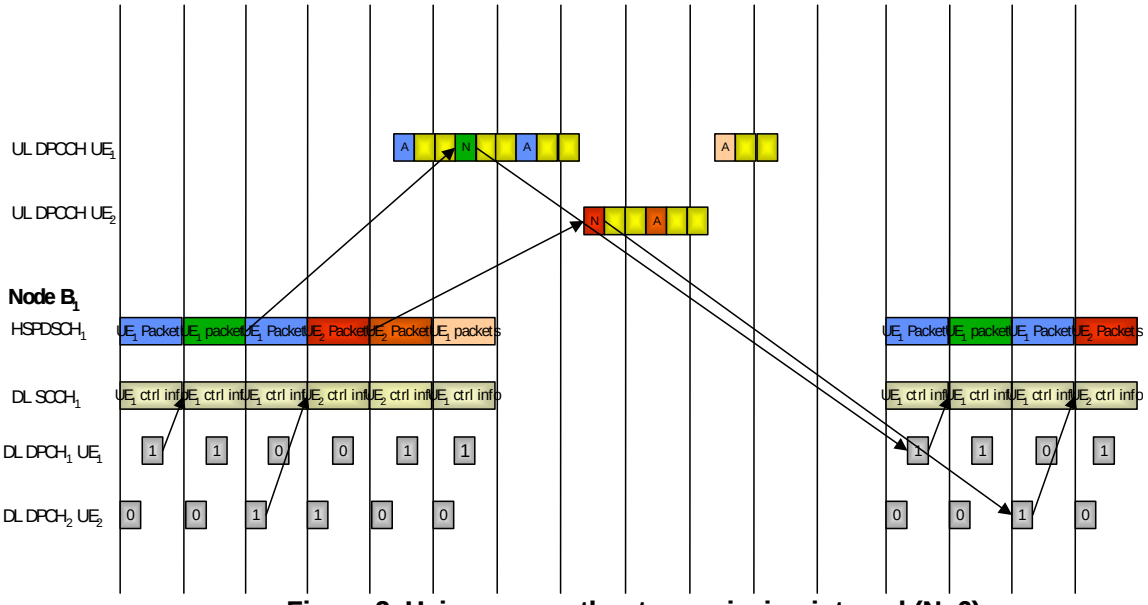

Figure 2. Using every other transmission interval (N=6)

A combination of flexible number of subchannels and omitting transmission intervals is naturally possible. This way a balance between buffer size and processing time requirements could be achieved.

4.5 Pros and cons of the different possibilities

The different approaches can be considered to have the following pros and cons:

Number of codes:

Pro: UE implementation complexity follows the data rate rather linearly (bits to decode in TTI etc)

Con: The more granularity in this, the more complications for the DL signalling.

Number of channels as UE capability:

Pro: Less signalling impacts, i.e. bits to indicate which codes to despread

Pro: Scheduling does not become more complicated

Con: In a TTI, processing time requirements same for all UEs regardless of the data rate

Con: Increased delay in some cases (possible time instants when UE can receive data occur more seldom)

Frequency of transmission time intervals

Pro: Less signalling impacts, i.e. bits to indicate which codes to despread

Pro: Processing time requirements loosened

Con: Even more increased delay in some cases (possible time instants when UE can receive data occur more seldom)

All in all, instead of defining UE capabilities based on a single method it seems to be better to use a combination of them. Because of signalling and code multiplexing problems the granularity of multicode selection should be rather small. Thus, transmitting all the subchannels and only adjusting the number of codes is not desirable. A better trade-off would be for example 10 or 5 codes with further granularity achieved by changing the number of subchannels.

5 Example on UE capability class with HSDPA

Table 4. Example of terminal radio access capability parameter for downlink decoding

Reference combination	384kbps class
Physical channel parameters	
Maximum number of DPCH/PDSCH codes simultaneously received	3
Maximum number of HS-DSCH codes received (assumed SF=16)	5 (16-QAM) 5 (QPSK)
Maximum receiver buffer size (X =max with 10 codes HS-DSCH with 16-QAM, N = number of subchannels [max = 6])	X/6 (N=1)
Maximum number of physical channel bits received in any 10 ms interval (DPCH, PDSCH, S-CCPCH), higher value with DSCH support.	19200
Support of Physical DSCH	Yes
Support of Physical HS-DSCH	Yes/No
Support of 64 QAM modulation	No

6 Conclusions

This contribution is intended for starting the discussions on the UE capabilities with HSDPA. From the paper it could be concluded that UE capability would need to be tied at least to some degree to the number of codes the UE is able to receive. It is proposed that the number of codes (min) and the granularity should be considered carefully by taking into account the UE processing issues as well as the resulting signalling (in TFCI or DPCCH or L1 in general) when operating HSDPA with UEs of different capability.

Based on the outcome of the discussions, more detailed proposal could be drafted for the WG1 TR and eventually for the TS 25.306 on the issue. Some common WG1 views would be beneficial to be communicated for the WG2 during the joint session on HSDPA as well.