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Title: Physical layer aspects of HSDPA and text proposals for HSDPA Technical Reports

Document for: Discussion and decision

1 Introduction

The paper discusses some of the physical layer aspects of HSDPA transmission. More exactly, the paper discusses the basic physical-layer structure of the HSDPA Physical Channel (HS-PDSCH?) and physical-layer aspects of uplink and downlink signalling associated with HSDPA transmission. Based on this discussion, some initial text for the HSDPA Technical report is proposed.

2 Discussion and text proposals

2.1 Basic physical-layer structure for HSDPA

Several papers have discussed the basic physical-layer structure for HSDPA transmission, see e.g. [1,2,3]. Most of these papers have explicitly supported (and no paper has yet objected to) the proposal of [1] that HSDPA transmission should be based on multi-code transmission using a fixed spreading factor. As the exact choice of HSDPA spreading factor should not have a significant impact on the initial evaluation of the HSDPA concept, it does not seem to be necessary to make a final decision on the exact spreading factor to use for HSDPA transmission at this stage. Rather, this should be decided on based on an evaluation of the impact of HSDPA spreading factor on

- Performance
- UE complexity (should favour a lower spreading factor requiring less multi-code for a given data rate)
- Flexibility (should favour a higher spreading factor, allowing for better granularity in the allocation of overall capacity to HSDPA transmission)

Another issue that has been discussed in e.g. [1,2,3] is if code multiplex of different users should be supported for HSDPA transmission. Currently, there does not seem to be a consensus on this topic. Thus, further studies and discussions are needed before a decision can be made.

Regarding the HSDPA physical-layer time structure, several papers have proposed the use of a shorter frame length (<10 ms) for HSDPA transmission. In this context “HSDPA frame length” seems to be defined or rather characterised as

- the minimum time interval for which HSDPA capacity is allocated to a UE
- the minimum time interval for which the HSDPA transport format is constant
- the minimum time interval for which HSDPA transmission to a UE is done from a single cell

Thus, in this context the term “HSDPA frame length” should probably be replaced by the term “HSDPA TTI”.

It seems to make sense to restrict the set of alternatives to consider for a shorter (< 10 ms) HSDPA TTI to multiples of the slot length (T_{slot} ? 0.667 ms) and sub-multiples of the length of a radio frame (T_{frame} = 15? T_{slot} = 10 ms). Thus the set of alternatives to consider for the HSDPA TTI is {T_{slot}, 3? T_{slot}, 5? T_{slot}, 15? T_{slot}}. Once again, a final decision on the exact value does not need to be made at this stage but should be decided on based on an evaluation of the impact of HSDPA TTI on

- Performance
- Delay
- Complexity
- Flexibility (HSDPA payload granularity)

--- Proposed TR text on basic physical-layer structure ---

Basic Physical Layer Structure

On the physical layer, HSDPA transmission should be carried out on a set of downlink physical channels (codes) shared by users at least in the time domain and possibly also in the code domain.

HSDPA physical-layer structure in the code domain

In the code domain, HSDPA transmission should use a fixed spreading factor and multi-code transmission. The selection of HSDPA spreading factor should be based on an evaluation of the impact of HSDPA spreading factor on

- *Performance*
- *UE complexity*
- *Flexibility (granularity in the overall allocation of capacity for HSDPA transmission)*

HSDPA physical-layer structure in the time domain

In the time domain, the use of an HSDPA TTI shorter than one radio frame (10 ms) has been proposed. The exact length of the HSDPA TTI should be selected from the set {T_{slot}, 3?T_{slot}, 5?T_{slot}, 15?T_{slot}}. The selection of HSDPA TTI should be based on an evaluation of the impact of HSDPA TTI on

- *Performance*
- *Delay*
- *Network and UE complexity*
- *Flexibility (HSDPA payload granularity)*

The HSDPA TTI is related to the basic HSDPA technical features (fast scheduling, fast link adaptation, fast cell selection, and fast Hybrid ARQ) as follows:

- *The HSDPA TTI is the shortest time interval during which HSDPA capacity is allocated to a UE*
- *The HSDPA TTI is the shortest time interval during which the HSDPA transport format is constant*
- *The HSDPA TTI is the shortest time interval during which HSDPA transmission to a UE is done from a single cell*

2.2 Physical-layer aspects of associated signalling

2.2.1 Associated uplink signalling

The necessary uplink signalling associated with HSDPA transmission includes

- Measurement reports to support network (Node B) selection of modulation and coding scheme for HSDPA transmission if such measurements are needed. As an alternative, the transmit power of a power controlled associated DPCH can be used, as mentioned in [5].
- Signalling for fast cell selection
- Signalling related to fast Hybrid ARQ

At least a part of this signalling is obviously very similar to a part of the current uplink DPCCH signalling, e.g. current signalling for SSDT. Thus it seems reasonable that the uplink signalling associated with HSDPA transmission should be carried on the uplink DPCCH. The impacts on the uplink DPCCH to support this associated signalling are

- Need for additional slot formats for uplink DPCCH
- Probably need for support of a lower uplink DPCCH spreading factor ($SF_{UL\text{-}DPCCH} < 256$)

In neither case should there be a major impact on either UE or network complexity.

An important aspect of the uplink associated signalling, is to what extent part of this signalling is required to be received and correctly detected/decoded by multiple Node B in case of soft handover. Such a requirement is obviously in contradiction to "normal" soft-handover operation where uplink power control ensures that the uplink DPCH is received with sufficient power by at least one Node B but not necessarily by all Node B in the active set. If such a requirement is requested, studies are needed to determine if/how they can be fulfilled. It should be noted that softer handover does not imply the same problem as, in that case, only one Node B is involved.

--- Proposed TR text related to physical aspects of associated uplink signaling ---

The uplink signalling associated with HSDPA transmission should include, but may not be restricted to

- *Signalling for measurement reports related to fast link adaptation (Adaptive modulation and coding, AMC), if such measurements are to be supported*
- *Signalling related to fast cell selection*
- *Uplink signalling related to fast Hybrid ARQ.*

This associated uplink signalling should be carried on the uplink DPCCH. The main impact on current specification is the need for additional uplink DPCCH slot formats and the possible need for lower spreading factor for the uplink DPCCH ($SF_{UL\text{-}DPCCH} < 256$). The impact on UE or network complexity is expected to be minimal.

2.2.2 Downlink signalling

The necessary downlink signalling associated with HSDPA transmission includes

- Signalling to identify to what UE(s) HSDPA data is transmitted in a given HSDPA TTI
- Information on what HSDPA codes to receive (if code multiplex is to be supported for HSDPA transmission)
- Information on the modulation and coding scheme used for HSDPA transmission in a given HSDPA TTI
- Information related to fast Hybrid ARQ

In the same way as the associated uplink signalling, the associated downlink signalling is similar to current downlink DPCCH signalling (compare e.g. modulation/coding information with current TFCI). One possibility is thus to carry the entire set of associated downlink signalling on the DPCCH part of the associated downlink DPCH.

On the other hand, a main part of the associated downlink signalling is only of interest for one or a few UEs, i.e. the UE(s) that is (are) to receive HSDPA data in a given HSDPA TTI. Transmitting this information on every associated downlink

DPCH leads to a waste of downlink capacity. An alternative is to carry part of associated downlink signalling on a shared signalling/control channel.

Thus, two alternatives for the associated downlink signalling can be identified

- The entire set of associated downlink signalling is carried on associated downlink dedicated physical channels
- Part of the associated downlink signalling is carried on an associated downlink shared signalling/control channel.

The selection between these two alternatives should be based on an evaluation in terms of

- Complexity differences
- Capacity differences (interference-limited as well as code-limited capacity)

--- Proposed TR text related to physical aspects of associated downlink signalling ---

The downlink signalling associated with HSDPA transmission includes, but may not be restricted to

- *Signalling to identify the UE(s) to which HSDPA data is transmitted in a given HSDPA TTI.*
- *Possibly information on what HSDPA codes to receive by a UE (if sharing in the code domain, i.e. code multiplex. is to be supported for HSDPA transmission)*
- *Signalling of what modulation and coding scheme is used for HSDPA transmission in a given HSDPA transmission*
- *Downlink signalling related to fast Hybrid ARQ*

Two alternatives have been proposed for the downlink signalling associated with HSDPA transmission:

- *The entire set of associated downlink signalling is carried on associated downlink dedicated physical channels*
- *Part of the associated downlink signalling is carried on an associated downlink shared signalling/control channel.*

The selection between these alternatives should be based on an evaluation differences in terms of

- *UE complexity*
- *Capacity (interference-limited capacity as well as code-limited capacity)*

3 References

[1] "Details of high speed downlink packet access", RP-000126, TSG-RAN #7

[2] "Some comments on High Speed Packet Data Access", R1-00-0764, 3GPP TSG RAN WG1 #13,

[3] "Considerations on High-Speed Downlink Packet Access (HSDPA)," R1-00-0868, 3GPP TSG RAN WG1 #14

[4] "Issues for consideration in the HSDPA report, " R1-00-1120, 3GPP TSG RAN WG1 #15

[5] "Fast DSCH scheduling function", R2-00-1053, 3GPP TSG RAN WG2 #13