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1 Introduction

HSDPA (High Speed Downlink Packet Access) is currently a study item within 3GPP. The basic technical features proposed for HSDPA are:

- Support for higher-order modulation in combination with Adaptive Modulation and Coding (AMC)
- Fast Hybrid ARQ
- Fast Cell Selecion
- Multi-input/multi-output antenna processing

RAN1 is currently preparing a technical report (TR) "Physical Layer Aspects of UTRA High Speed Downlink Packet Access". The TR should discuss and conclude on the benefits and feasibility of the basic technologies proposed for HSDPA.

In [1], a number of detailed proposals for HSDPA are presented, some of which are further elaborated on in [2] and [3]. TR text proposals, related to the proposals of [1], are also presented [4].

This paper discusses and comments on some of the proposals of [1].

2 Discussion on proposals in [1]

Signalling to support AMC (Explicit Rate Information from the UE)

There are different means by which the HS-DSCH transport format (basically the modulation and coding scheme) can be selected:

1. The UE may estimate/predict the downlink channel quality and calculate a suitable HS-DSCH transport format that is reported to the network as a *required transport format*. The network *must obey* the UE when transmitting data to this UE. This approach, i.e. *explicit rate requests*, is the preferred approach according to [1].

2. The UE may estimate/predict the downlink channel quality and calculate a suitable transport format that is reported to the network as a *recommended transport format*. However, the network decides on what transport format to actually use.

3. The UE may estimate/predict the downlink channel quality and report this to the network. Based on the channel-quality report, the network decides on what transport format to use.

In principle, the second and third alternatives are very similar i.e. the main question is not if the UE reports a rate or a channel-quality measure but rather whether the network or the UE controls the selection of the downlink transport-format.

As mentioned above, the first alternative, i.e. UE control of the downlink transport-format selection, is the preferred approach according to [1]. The argument is that the UE, based on knowledge of HS-DSCH power fraction, HS-DSCH code allocation, and future HS-DSCH activity of neighbour cells, may be able to predict the expected overall interference more accurately, thus permitting for a more accurate transport-format selection.

However:

- There seems to be no reason why explicit rate requests are needed in order to benefit from this kind of information. As mentioned in [1], the benefit is primarily more accurate interference estimates, i.e. more accurate channel-quality estimates. These more accurate channel-quality estimates can either be mapped to a transport format by the UE or be reported to the network where the transport format is selected

- The interference originating from the HS-DSCH of neighbour cells is only a fraction of the overall interference experienced by the UE. Thus the interference will anyway vary in an unpredictable way. In general, the interference variations are primarily taken care of by the fast Hybrid ARQ, i.e. the implicit AMC.

- Transport-format selection based on explicit UE reports, either rate requests/recommendations or channel-quality reports, is only one option. As pointed out in [4], an alternative is to base the transport-format selection on the transmit power of the power-controlled associated DPCH. This approach should always be an option even if explicit UE reports are supported. This speaks against a concept where the UE is in control of the downlink (HS-DSCH) transport-format selection.

Also note that, to acquire knowledge of the HS-DSCH activity of neighbour cells, the UE has to continuously read broadcast channels from multiple cells. This will clearly have a negative impact on the UE complexity and power-consumption.

The main advantage with explicit rate requests/recommendations is that a UE can directly benefit from a high-performance receiver, e.g. including interference-cancellation functionality, as it can then request a transport format with higher data rate. However, with fast Hybrid ARQ, as has been proposed for HSDPA, the UE will anyway be able to benefit from a high-performance receiver, as the number of retransmissions will be reduced.

To conclude, it is too early to conclude on the details of the HS-DSCH transport-format selection and no decision is needed for the RAN1 TR. However several arguments speak against UE-controlled transport-format selection.

Preamble Based User Identification on the HS-DSCH

In terms of basic principles, the proposal of [1] seems to be similar to the Shared Control Channel proposed in [5], i.e. control information associated with the information on the HS-DSCH is carried on a shared control channel instead of the associated DPCH. However, while the Shared Control Channel of [5] is code-division multiplexed (CDM), the proposal in [1] is to transmit the shared control information in form of a *preamble,* time-division multiplexed (TDM) with the HS-DSCH.

It is claimed in [1] that the use of TDM preserves code space, as no code resource is explicitly allocated for the shared control information. However, as the shared control information will “steal” some of the HS-DSCH payload more codes need to be allocated to HS-DSCH to support a given peak data rate. Thus, although we appreciate the basic principle of a Shared Control Channel to improve code-usage efficiency, it is difficult to see any clear advantages with the TDM approach (the preamble) proposed in [1].

On the other hand, the use of code multiplex for the shared control information, together with a pointer on the associated DPCH, as proposed in [4], seems to offer certain advantages.

- As the number of codes allocated to HS-DSCH, as well as the HS-DSCH transmit power, may vary in time, the structure of the preamble will vary, leading to more complex detection/decoding.

- To continuously decode the preamble, the UE has to continuously de-spread up to 31 codes (assuming SF_{HSDPA}=32)

The proposal in [1] that the preamble should be of variable length and depend on the HS-DSCH transport format selection would further complicate the detection /decoding and would effectively prevent the use of network controlled transport-format selection.

In general, the CDM Shared Control Channel seems to be a much more straightforward extension of the current UTRA/FDD channel structure.

HSDPA TTI and Uplink Feedback Rate

It is correctly argued in [1] that a HSDPA TTI as short as possible, i.e. $TTI_{HSDPA} = T_{slot}$, is preferred as this gives the best granularity for the HS-DSCH payload. It should be noted that a further benefit with a shorter HSDPA TTI is a better delay/complexity trade-off.

As pointed out in [1], it also seems reasonable to use a reporting rate of the uplink signalling (FCS selection and possible channel-quality information for AMC) lower than once per HSDPA TTI. Current SSDT and TX diversity uses a maximum reporting rate of 500 Hz (once every fifth slot) which should be sufficient also for HSDPA.

Fast Cell Selection (FCS)

In [1] it is proposed that cell selection should be based on channelization-code cover of the rate information, i.e. the channelization code of the uplink DPCCH during the slot and depends on the selected cell. This seems to imply significant and unnecessary modifications to the overall uplink structure.

From a Layer 1 point-of-view FCS is very similar to current SSDT. Thus it seems most straightforward to reuse as much SSDT functionality as possible for FCS. Especially, there does not seem to be any strong reason why one should not reuse the current SSDT signalling to signal the selected cell also for FCS.

Dynamic power and code sharing

In [1] it is proposed that the number of codes allocated to HS-DSCH as well as the HS-DSCH transmit power is broadcast on a special channel, the PCBCH.

Clearly, the UE has to know the set of codes that carries the HS-DSCH. As the number of codes allocated to HS-DSCH may vary, e.g. depending on the amount of capacity allocated to the HS-DSCH, this information obviously has to be broadcast. However, it seems to be unnecessary flexibility to assume that the number of codes allocated to HS-DSCH should vary on a 10 ms basis. Rather, the rate of variations should be of the same order as the variations in the long-term traffic situation. Thus the code-allocation information could be transmitted as Layer 3 information on the ordinary BCCH and no special physical channel is needed for this information.

Whether the HS-DSCH transmit power needs to be broadcast requires further considerations. Furthermore, it remains to be decided to what extent fast downlink reporting of the HS-DSCH relative power is needed or if the BCCH can be used for this information as well.

Transport-Channel multiplexing

We support the view expressed in [1] that the HS-DSCH coding/multiplexing scheme should focus on simplicity and low complexity and should avoid unnecessary flexibility. This is especially important taking into account the high data rates that are to be transmitted using HSDPA.

In [1], time division of multiple transport channels (multiple HS-DSCH onto one HS-PDSCH) is recommended. In principle we agree to this. However, at this stage it is not clear that such multiplexing of multiple HS-DSCH onto a shared set of codes should be supported at all. The simplest solution is to carry one and only one HS-DSCH on an HS-PDSCH. Multiple users would then share the HS-DSCH by means of MAC multiplexing of logical channels in the same way as for current DSCH. This needs further considerations.

DACCH

In [1], the proposed DACCH is assumed to carry downlink TPC and pilot bits in case the UE does not have an associated DPCH. However, as there anyway is defined downlink DPCH with SF=512, the definition of a new type of channel (the DACCH) seems unnecessary. In addition, the inclusion of a DL DPCH flag that indicates that the UE should read the Shared Control Channel (as proposed in [5]) seems beneficial, as the UE does then not have to continuously de-spread the Shared Control Channel. Thus it is our view that HS-DSCH transmission should always be associated with the transmission of a associated downlink DPCH (SF?512), i.e. the DACCH is not needed.

3 Conclusions

[1] includes a number of technical proposals for HSDPA. Some of these proposals are clearly of interest. On the other hand, some of the proposals also seem to imply unnecessary deviations from current UTRA/FDD framework and functionality.

In general, the text proposals of [4] are much to detailed to be included in the RAN1 TR at this stage.

4 References

[1] TSGR1#17(00) 1381, "Downlink and Uplink Channel Structures for HSDPA”, Lucent Technologies

[2] TSGR1#17(00) 1382, "Asynchronous and Adaptive Incremental Redundancy (A2IR) Proposal for HSDPA”, Lucent Technologies

[3] TSGR1#17(00) 1383, "Downlink Transport Channel Multiplexing Structure for HSDPA”, Lucent Technologies

[4] TSGR1#15(00) 1120, “Issues for consideration in the HSDPA report”, Qualcomm

[5] TSGR1#16(00) 1242, “Control Channel Structure for High Speed DSCH (HS-DSCH)”, Motorola