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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document captures the agreements and evaluation criteria for the different techniques being considered for HSDPA with regards to the overall support of UTRAN for HSDPA.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 25.950 (Release 4, version 4): "UTRA High Speed Downlink Packet Access".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

Data block: The data transmitted to one UE on HS-DSCH in one TTI.

Priority class: One flow of data within a HS-DSCH transport channel. One HS-DSCH can transport several priority classes (only one priority class per TTI)

HARQ Process: Peer state machines capable of achieving error correction by retransmission. One process can be used only for one data block at a time.

HARQ Entity: Consists of all the HARQ processes of a UE, controlling all the available soft buffer capacity.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

HSDPA	High Speed Downlink Packet Access
MCS	Modulation and Coding scheme
NW	Network
TFRI	Transport Format and Resource Indicator
TSN	Transmission Sequence Number

4 Background and Introduction

In the TSG-RAN #11 plenary meeting a work item was approved for High Speed Downlink Packet Access. The work item includes techniques such as adaptive modulation and coding, hybrid ARQ and fast scheduling with the goal to increase throughput, reduce delay and achieve high peak rates.

5 Requirements for the evaluation of techniques for High Speed Downlink Packet Access

The following considerations should be taken into account in the evaluation of the different techniques proposed for HSDPA.

1. The focus shall be on the streaming, interactive and background services. It should be noted that it might not be possible to simultaneously optimise the performance of HSDPA for all of the above traffic classes.
2. System performance improvement shall be obtained with concomitant reduction in delay of service.
3. Priority shall be given to urban environments and then to indoor deployments. The techniques shall not be limited to these environments however.
4. The techniques accepted shall be optimised at speeds typical of urban environments but techniques should apply at other speeds also. Full mobility shall be supported, i.e., mobility should be supported for high-speed cases also, but optimisation should be for low-speed to medium-speed scenarios.
5. Features or group of features considered should demonstrate significant incremental gain.
6. Features accepted shall provide the benefit at reasonable cost to the operators. The value added per feature should be considered in the evaluation.
7. The techniques should be compatible with advanced antenna and receiver techniques.
8. The techniques should take into account the impact on Release '99 networks both from a protocol and hardware perspective.
9. The choice of techniques (such as HARQ) shall take into account UE processing time and memory requirements.
10. The UE complexity shall be minimised for a given level of system performance.
11. An evolutionary philosophy shall be adopted as opposed to a revolutionary one in adopting new techniques and architectures.

6 Basic structure of HS-DSCH

6.1 Architecture Issues

Two architectures were considered as part of the original study item: an RNC-based architecture consistent with Release '99 architecture and a Node B-based architecture for scheduling [1]. Moving the scheduling to the Node B enables a more efficient implementation of scheduling by allowing the scheduler to work with the most recent channel information. The scheduler can adapt the modulation to better match the current channel conditions and fading environment. Moreover, the scheduler can exploit the multi-user diversity by scheduling only those users in constructive fades. Furthermore, the HSDPA proposal has the additional potential to improve on the RNC-based HARQ architecture in both UE memory requirements and transmission delay. The scheduler for the HS-DSCH is therefore located in the Node B.

6.2 Protocol structure

Since the HSDPA functionality should be able to operate in an environment where certain cells are not updated with HSDPA functionality there is a need to as far as possible keep the Release '99 functional split between layers. Furthermore, since the HSDPA functionality is intended for transport of dedicated logical channels, it is logical to keep the layers above MAC intact from Release '99. Hence, it is proposed to keep the PDCP and RLC layers as is when using HSDPA functionality. This means that RLC can operate in either AM or UM mode (but not in TM mode due to ciphering) and PDCP can be configured either to do header compression or not. Furthermore, transport channel type switching is feasible if the MAC layer has similar functional split in UTRAN as for Release '99, i.e. retaining MAC-d in S-RNC.

The new functionality of hybrid ARQ and HSDPA scheduling are included in a MAC layer. In the UTRAN these functions are included in a new entity called MAC-hs terminated in Node B. The transport channel that the HSDPA functionality will use is called HS-DSCH (High Speed Downlink Shared Channel). The MAC entity controlling the transport channel is called MAC-hs.

Furthermore, the physical layer will have to be updated with signalling support for hybrid ARQ and HS-DSCH scheduling. Figure 1 shows the radio interface protocol architecture with termination points. MAC-hs in Node B is located below MAC-c/sh in CRNC. MAC-c/sh shall provide functions to HSDPA already included for DSCH in the Release '99 version of MAC-c/sh. Note that the HS-DSCH FP (frame protocol) will handle the data transport from SRNC to CRNC (if the Iur interface is involved) and between CRNC and the Node B.

NOTE: The possibility to connect directly the HS-DSCH user plane of the SRNC and Node B using the transport network, i.e. by-pass the DRNC for the HS-DSCH user plane, is under consideration.

The architecture supports both FDD and TDD modes of operation, though in the case of TDD, some details of the associated signalling for HS-DSCH are different.

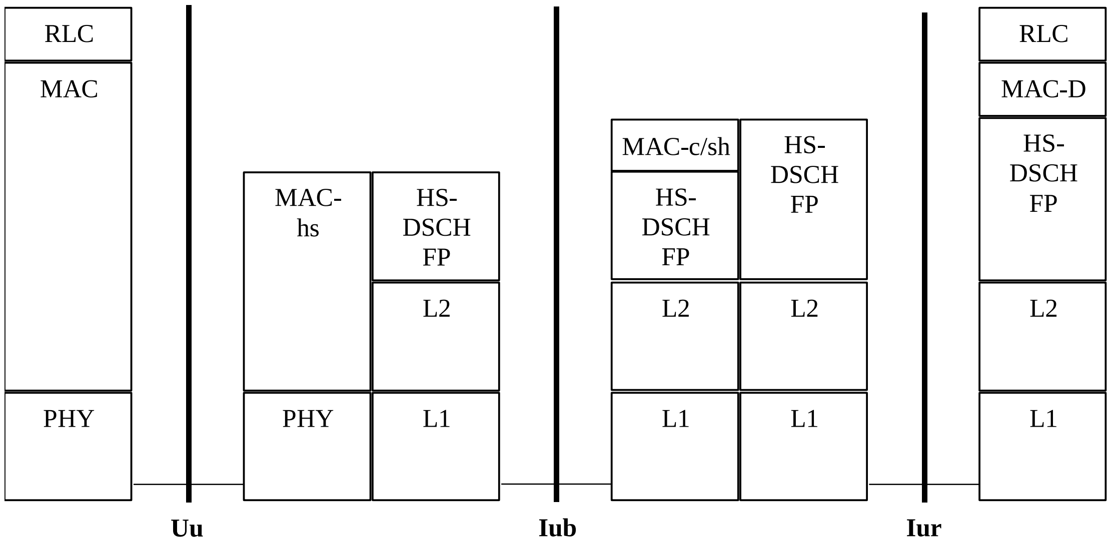

Figure 1: Radio Interface Protocol Architecture of HSDPA

6.3 Basic physical structure

6.3.1 HS-DSCH Characteristics

The HS-DSCH transport channel has the following characteristics:

- A HS-DSCH transport channel is processed and decoded from one CCTrCH.
- There is only one CCTrCH of HS-DSCH type per UE.
- The CCTrCH can be mapped to one or several physical channels.
- There may be multiple HS-DSCH per CCTrCH.
- If there are more than one HS-DSCH transport channels in a HS-DSCH CCTrCH, the transport format combinations are configured in such a way that for any transport format combination, there is a maximum of one transport channel having a transport format with one or more transport blocks.
- One HS-DSCH shall support one PDU size.

As in Release '99 it shall be possible to map certain logical channels to DCH and HS-DSCH simultaneously.

6.3.2 DL HSDPA Physical layer model

6.3.2.1 FDD Downlink Physical layer Model

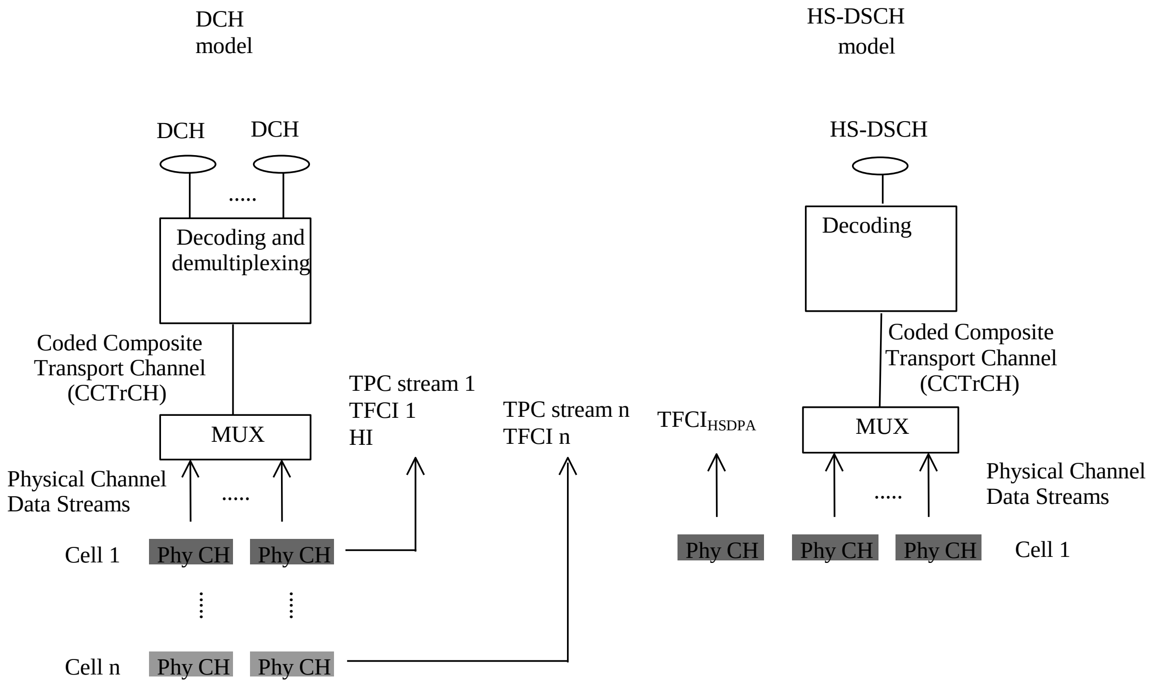

Figure 2: Model of the UE's Downlink physical layer - HS-PDSCH with associated DPCH. HS-PDSCH is transmitted from cell 1 in this figure

NOTE: In Figure 2 above the model for the DCH is included for completeness and to be consistent with the approach in TS 25.302.

The basic downlink channel configuration consists of an associated DPCH combined with a number of separate shared physical control channel in combination with the HS-PDSCH. The maximum number of shared control channels that a single UE needs to receive is four. The UTRAN may configure more than four shared control channels, but the UE needs to be provided at HS-DSCH configuration, the set of four HS-DSCH shared control channels of which it needs to monitor. The impacts of this on scheduling need to be studied further by RAN WG2.

A two-step signalling approach is used for indicating which UE has been scheduled and signalling the necessary information for the UE to decode the HS-PDSCH.

The associated DPCH carries a HI (HS-DSCH Indicator) pointing to the shared control channel the UE needs to decode. In order to support the scenario wherein a UE may be in soft handover on the DPCH between a HSDPA supporting cell and a Release '99/Release 4 cell, the Release '99/Release 4 Node B should not need to support new slot formats other than that needed for Release '99/Release 4 DPCH operation only.

The upper layer signalling on the DCCH can be mapped to the associated DPCH or the HS-DSCH, as in the case of Release '99.

For each HS-DSCH TTI, each Shared Control Channel carries HS-DSCH-related downlink signalling for one UE. The following information is carried on the Shared Control Channel:

- Transport Format and Resource Indicator (TFRI)
  The TFRI includes information about the dynamic part of the HS-DSCH transport format, including transport block set size-and modulation scheme. The TFRI also includes information about the set of physical channels (channelisation codes) onto which HS-DSCH is mapped in the corresponding HS-DSCH TTI;

- Hybrid-ARQ-related Information (HARQ information)
  This includes the HARQ protocol related information for the corresponding HS-DSCH TTI (subclause 8.2.1.2.1) and information about the redundancy version.

The shared control channel also carries the UE identification of the UE for which it is carrying the information necessary for decoding the HS-PDSCH - the precise means for achieving this are FFS. The type of UE identification to be used is FFS.

The time offset between the DL DPCH slot carrying the HI and the start of the Shared Control Channel information can vary in the interval [0, T_{slot}] depending on the timing of the downlink DPCH, where T_{slot} equals approximately 0.67ms. There is a fixed time offset between the start of the Shared Control Channel information and the start of the corresponding HS-DSCH TTI.

6.3.2.2 TDD Downlink Physical layer model

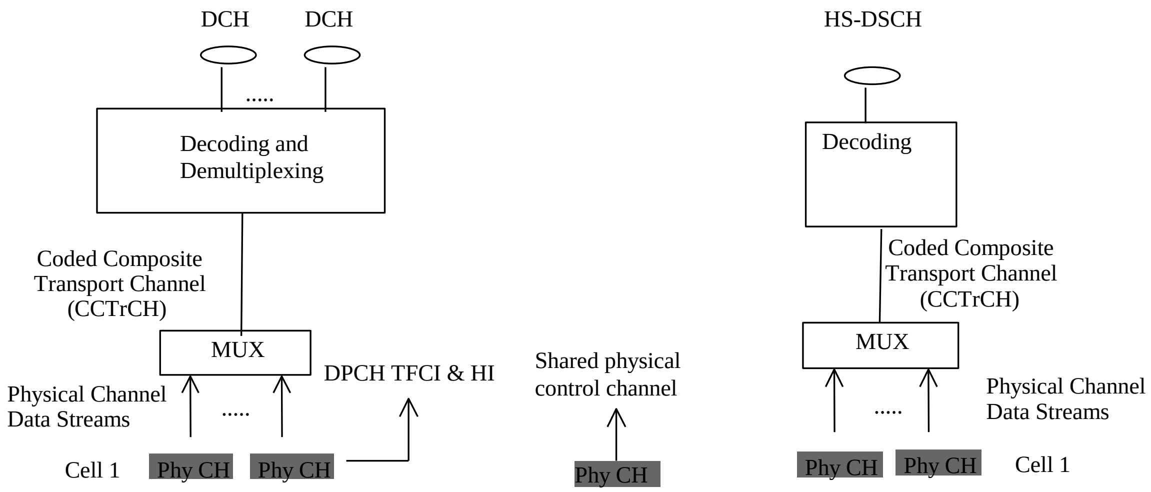

Figure 3: Model of the UE's physical layer (TDD)

The TDD overall downlink signalling structure is the two-step approach based on associated dedicated physical channels and shared physical control channels. The HS-DSCH indicator (HI) on the associated dedicated physical channel provides information to the UE about the need to read the shared control channel. The downlink signalling information for support of HS-DSCH is carried by a shared control channel. There may be multiple shared control channels in which case the HI also indicates which of the shared control channels the UE is to read.

As in Release '99, the associated dedicated physical channel can also be a fractionated channel for efficient resource usage with a corresponding repetition period in terms of TTIs. The associated dedicated physical channel carries HI (HS-DSCH Indicator). This HI indicates, that the UE has to read the shared control channels of the same TTI. If the repetition period is larger than one, the UE has to read in addition the shared control channels of the following TTIs for the whole repetition period to provide full scheduling flexibility. For continuous dedicated physical channels, the repetition period is consequently set to one TTI. The HI has to be sent in parallel or prior to the shared control channels.

6.3.3 UL HSDPA Physical layer model

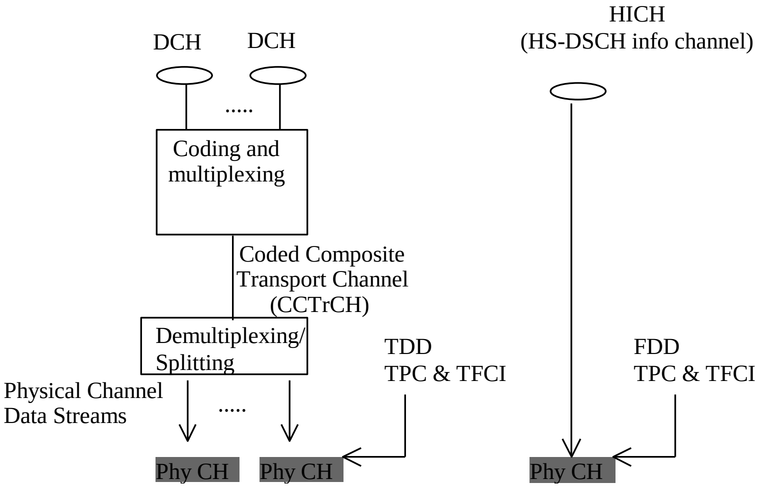

Figure 4: Model of the UE's Uplink physical layer

The uplink signalling uses an additional DPCCH with SF=256 that is code multiplexed with the existing dedicated uplink physical channels.

In contrast to FDD, the TDD UE does not use its dedicated channel in the uplink for transmitting ACK/NACK information, due to the associated fractionated dedicated channel option. To enable a SYNC UL scheme for HARQ, the UE will use a shared uplink resource for transmitting ACK/NACK information. The relation between the shared control channel in DL and shared UL resource can be pre-defined and is not signalled dynamically on the shared control channel.

6.3.4 HSDPA physical-layer structure in the code domain

6.3.4.1 FDD

HS-DSCH relies on channelisation codes at a fixed spreading factor, SF=16. A UE may be assigned multiple channelisation codes in the same TTI, depending on its UE capability. Furthermore, multiplexing of multiple UEs in the code domain within a HS-DSCH TTI is allowed.

6.3.4.2 TDD

HS-DSCH relies on one or more channelisation codes with SF 16. Transmission on one or more timeslots is also allowed. Furthermore, a combination of code multiplexing and time multiplexing by timeslot within a HS-DSCH TTI is allowed.

6.4 Transport channel structure

The HS-DSCH transport channel is characterised by the following:

- existence in downlink only;
- possibility to use beam forming;
- possibility of applying link adaptation techniques other than power control;
- possibility to be broadcast in the entire cell;
- always associated with a DPCH and one or more shared physical control channels.

The following is a list of transport channel attributes:

1. Transport block size - semi-static
2. Transport block set size - dynamic for 1st transmission. An identical transport block set size shall be applied for retransmission. There shall be no support for blind transport format detection.

NOTE: Depending on the granularity of the TB set size (FFS in RAN WG1) a dummy MAC-hs PDU may need to be supported with a corresponding indication in the header.

3. Transmission Time Interval (TTI). For FDD the HS-DSCH TTI is fixed and equal to 2ms. For 3.84 Mcps TDD the TTI length is FFS. For 1.28 Mcps TDD a fixed 5ms TTI shall apply.
4. Coding parameters
   a. Type of error protection - fixed turbo coding
   b. Coding rate - dynamic for 1st transmission. Different coding rates may apply for retransmissions.
   c. Rate matching parameters - FFS.
5. Modulation - dynamic for transmission and retransmission. There shall be mandatory support for QPSK and 16 QAM and optional support for 64 QAM based on UE capability.
6. Redundancy version - dynamic
7. CRC size - fixed size of 24 bits. There is one CRC per TTI, i.e. one CRC per TB set.

7 MAC Architecture

7.1 HSDPA MAC architecture– UE side

This section describes the architecture of the MAC and functional split required to support HSDPA on the UE side.

7.1.1 Overall architecture

Figure 5 shows the overall MAC architecture where the newly defined MAC-hs has been added to the Release '99 model. In case of HSDPA the data received on HS-DSCH is mapped to the MAC-c/sh. The MAC-hs is configured via the MAC Control SAP by RRC similar to the MAC-c/sh and MAC-d, to set the parameters in the MAC-hs like allowed transport format combinations for the HS-DSCH and so on.

The associated Downlink Signalling carries information for support of HS-DSCH while the associated Uplink Signalling carries feedback information.

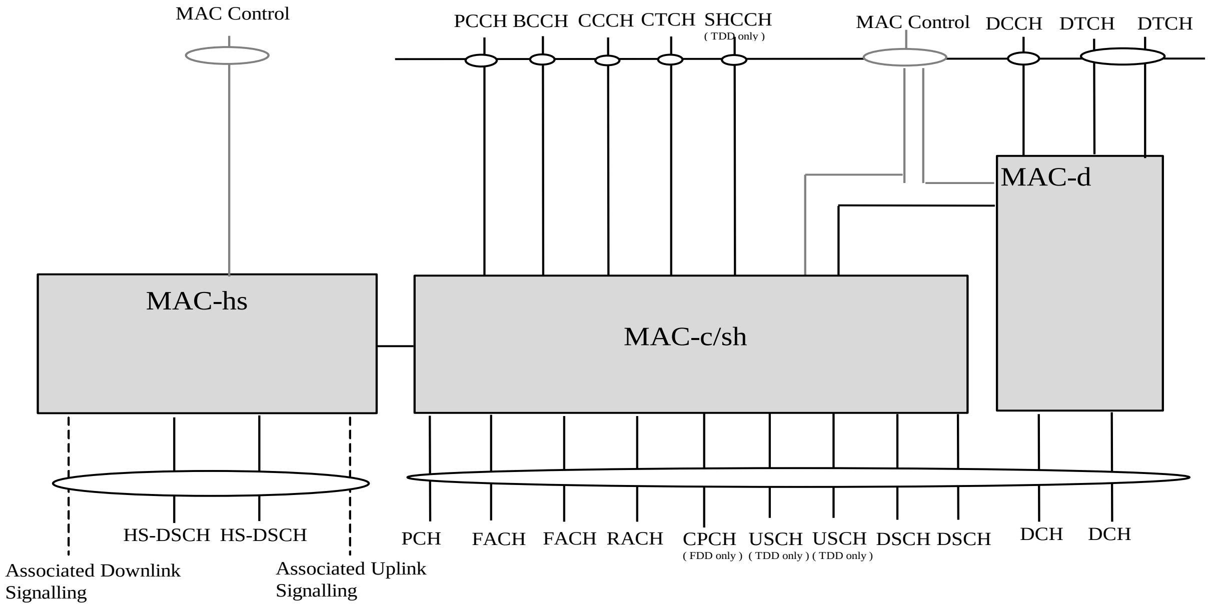

Figure 5: UE side MAC architecture with HSDPA

NOTE: The support of more than one HS-DSCH per UE is FFS.

7.1.2 Details of MAC-c/sh

The MAC-c/sh on the UE side retains its functionality as defined in Release '99 with minor additions for HSDPA.

NOTE: Newly defined parts are shown distinguished from Release '99 architecture in red.

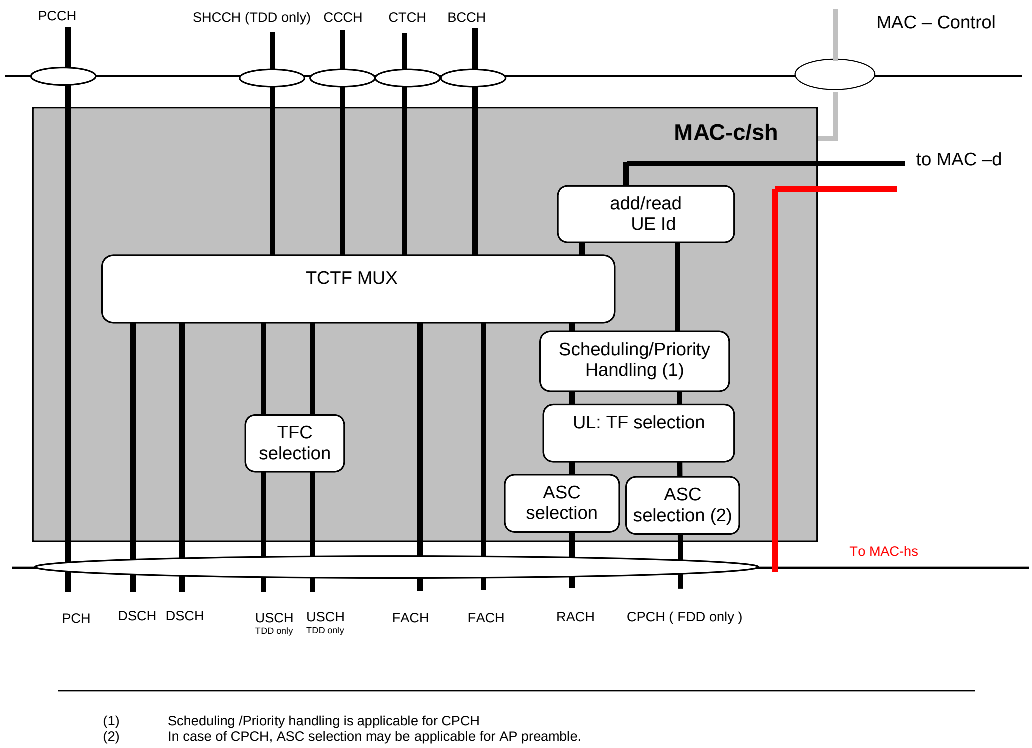

Figure 6: UE side MAC architecture / MAC-c/sh details

NOTE: The need for evaluation of the UE-Id within MAC-c/sh for HS-DSCH is FFS. The current working assumption is that there is sufficient reliability on the downlink signalling for the scheduling and thus the UE-Id is not required additionally on the HS-DSCH and its presence on the associated signalling channel is sufficient.

7.1.3 Details of MAC-hs

The MAC-hs handles the HSDPA specific functions. In the model below the MAC-hs comprises the following entity:

- HARQ:
  The HARQ entity is responsible for handling the HARQ protocol. There shall be one HARQ process per HS-DSCH per TTI. It is for example responsible for generating ACKs and/or NACKs. It should be noted that the HARQ functional entity handles all the tasks that are required for hybrid ARQ. The detailed configuration of the hybrid ARQ protocol is provided by RRC over the MAC-Control SAP.

NOTE: It is FFS whether a separate functional entity within MAC-hs needs to be added in order to model the handling of measurement results provided by physical layer, management of uplink resources (in case of TDD), etc., or whether these functions are described within HARQ functional entity.

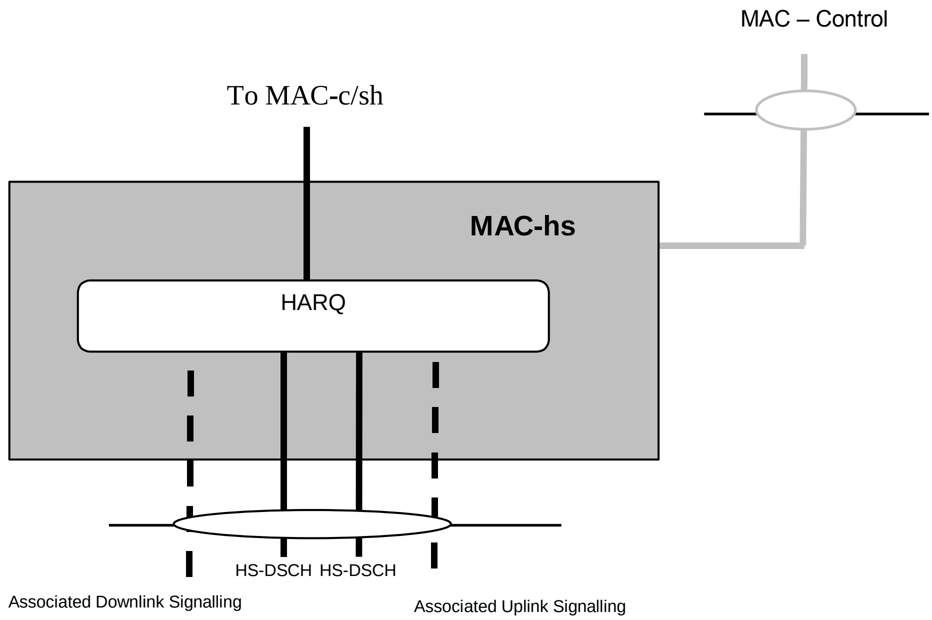

Figure 7: UE side MAC architecture / MAC-hs details

7.2 HSDPA MAC architecture – UTRAN side

This section describes the changes that are required to the MAC model to support the features for HSDPA on the UTRAN side

7.2.1 Overall architecture

One new MAC functional entity, the MAC-hs, is added to the Release '99 MAC architecture. The MAC-hs is located in the Node B. If one or more HS-DSCHs are in operation the MAC-hs SDUs to be transmitted are transferred from MAC-c/sh to the MAC-hs via the Iub interface. Details of the impacts on the Iub interface are FFS.

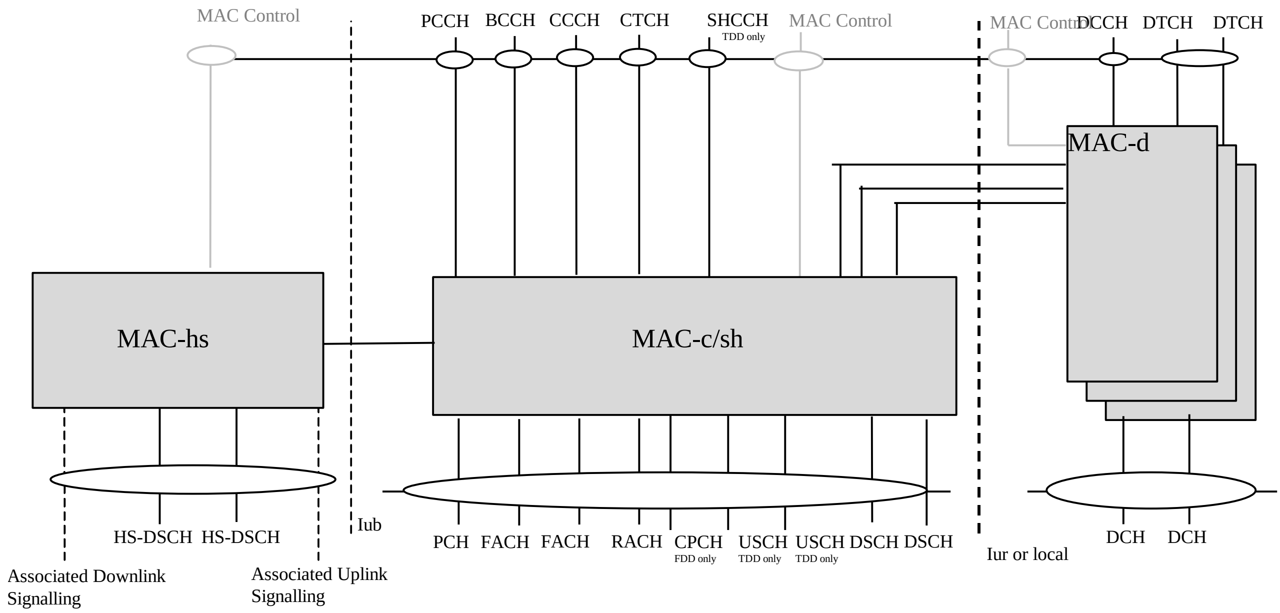

Figure 8: UTRAN side overall MAC architecture

7.2.2 Details of MAC-c/sh

Also on the UTRAN side the additions to the MAC-c/sh functional part are rather limited. The data for the HSDPA are also subject to flow control between the serving and the drift RNC. The impacts on the Iur are FFS.

A new flow control function is included to support the data transfer between MAC-d and MAC-hs. Details of this function are FFS.

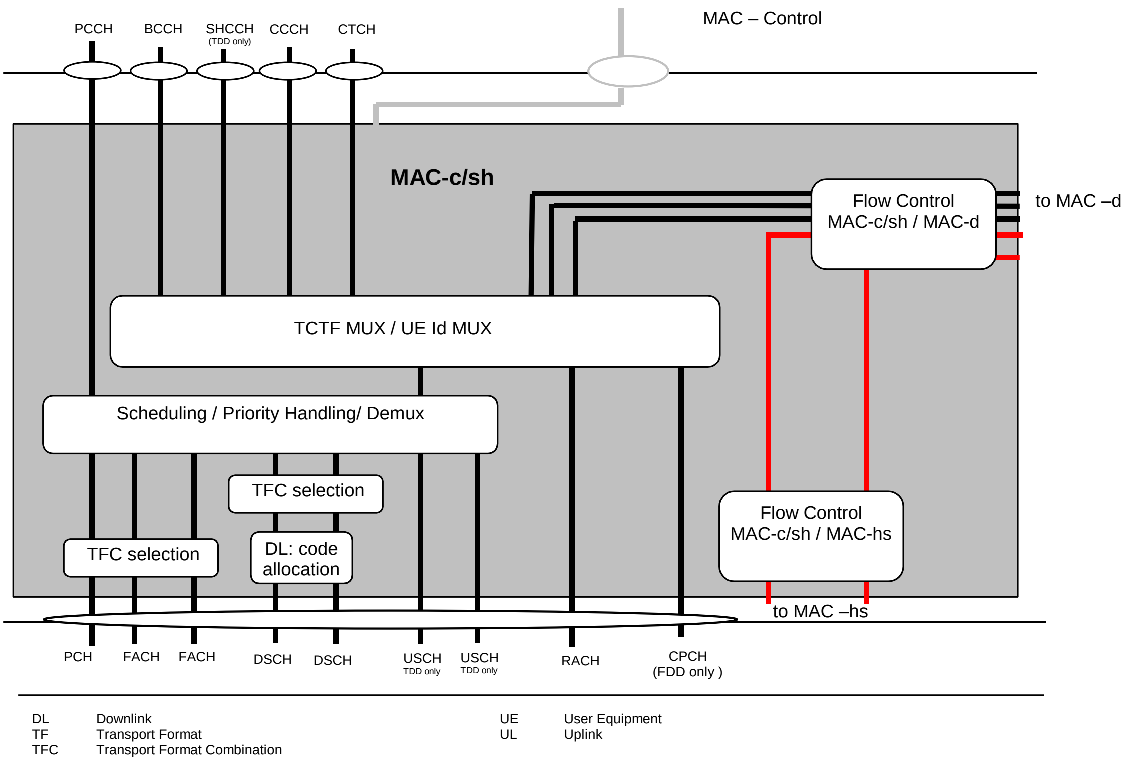

Figure 9: UTRAN side MAC architecture / MAC-c/sh details

NOTE: The need for insertion of the UE Id within MAC-c/sh for the HS-DSCH is FFS. The current working assumption is that there is sufficient reliability on the downlink signalling for the scheduling and thus the UE-Id is not required additionally on the HS-DSCH and its presence on the associated signalling channel is sufficient.

7.2.3 Details of MAC-hs

The MAC-hs is responsible for handling the data transmitted on the HS-DSCH. Furthermore it is its responsibility to manage the physical resources allocated to HSDPA. MAC-hs receives configuration parameters from the RRC layer via the MAC-Control SAP. There shall be per MAC-d PDU priority handling in the MAC-hs. The MAC-hs is comprised of four different functional entities:

- Flow Control:
  This is the companion flow control function to the flow control in the MAC-c/sh. Both entities together provide a controlled data flow between the MAC-c/sh and the MAC-hs taking the transmission capabilities of the air interface into account in a dynamic manner.

- HARQ:
  One HARQ entity handles the hybrid ARQ functionality for one user. One HARQ entity is capable of supporting multiple instances(process) of stop and wait HARQ protocols. There shall be one HARQ process per HS-DSCH. Based on restrictions on the TFCS of the HS-DSCH CCTrCH, HARQ processes shall not operate in a simultaneous fashion in the transmitter. Details of the HARQ functionality require further study.

- Scheduling/Priority Handling
  Due to the restrictions in the physical layer combining process, it is not permitted to schedule new transmissions, including retransmissions originating in the RLC layer, within the same TTI, along with retransmissions originating from the HARQ layer.

- TFC selection:
  Selection of an appropriate transport format combination for the data to be transmitted on HS-DSCH.

NOTE: It is FFS whether a separate functional entity within MAC-hs needs to be added in order to model the handling of feedback information, modulation and coding rate selection, allocation of uplink resources (in case of TDD), provisioning of flow control information, etc., or whether these functions are described within the above-mentioned functional entities.

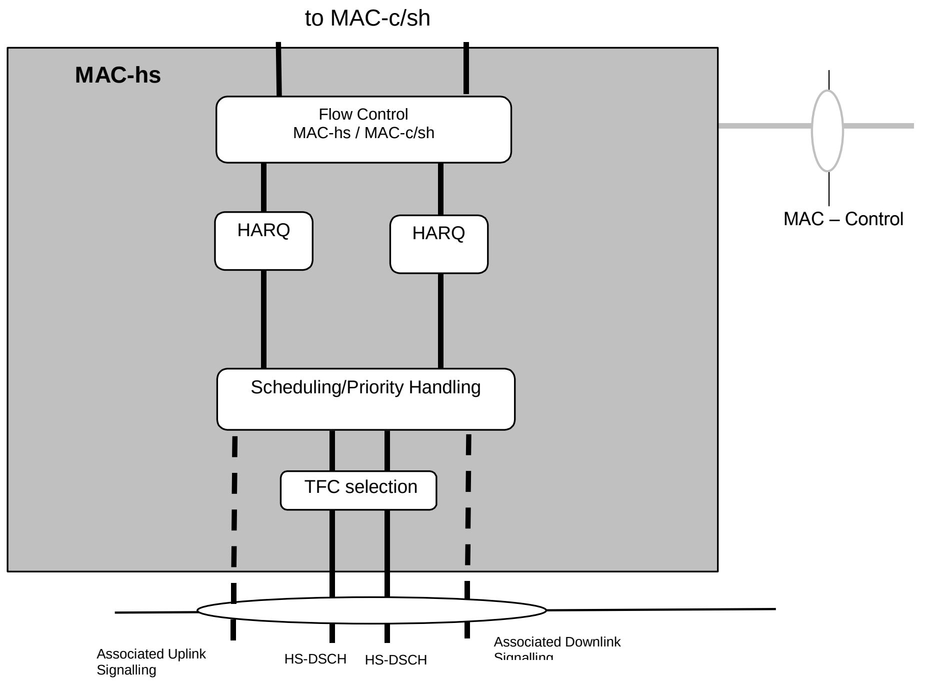

Figure 10: UTRAN side MAC architecture / MAC-hs details

8 HARQ Protocol

8.1 Requirements and Comparison criteria for HARQ protocols

Several potential retransmission schemes exist for the HARQ operation for HSDPA. One example is the N-channel stop and wait protocol described in [1]. The N-channel stop and wait protocol have several variations, e.g. synchronous, asynchronous and partly asynchronous operation. Other alternatives include variations of selective repeat and go-back-N schemes. In order to conclude on an appropriate HARQ protocol, it would be beneficial to agree on a set of requirements and relevant comparison criteria for the HARQ protocol retransmission scheme.

The following are the agreed requirements and criteria for comparison of HARQ protocols.

8.1.1 In-sequence delivery

If the HARQ receiver deliver each correctly received data block to the RLC receiver, the data blocks will not be delivered to the RLC receiver in the same order as the data blocks was originally transmitted, due to retransmissions by the HARQ layer. An RLC PDU delivered to the RLC layer before another RLC PDU with lower sequence number is here denoted *out-of-sequence PDU.*

The current Release '99 RLC protocol layer is not designed for reception of out-of sequence PDUs. In UM RLC, the reception of an out-of sequence RLC PDU will cause the corresponding higher layer SDU to be discarded. In AM RLC, the reception of out-of-sequence RLC PDUs will cause gaps in the received sequence numbers. When a status report is triggered, the out-of sequence PDUs will be requested for retransmission by the RLC receiver, even if these RLC PDUs are not lost, only delayed due to HARQ retransmissions. These unnecessary retransmissions will lead to poor protocol performance.

In-sequence delivery can be achieved either in the HARQ protocol or through modifications of the RLC protocol; but this needs to be considered in the protocol design.

8.1.2 Memory requirement

The buffer memory requirement in both the transmitter (Node B) and the receiver (UE) entity of the HARQ protocol should be considered. In the receiver entity, it is important to distinguish between two different requirements:

The number of received data blocks that needs to be stored to provide in-sequence delivery

The number of received data blocks from which soft samples need to be stored while the data blocks are retransmitted by the HARQ layer.

The latter is parameter requires significantly more memory for each data block. Note that these values are also dependent on the method used for soft combining, which is however not targeted here.

8.1.3 Robustness

The HARQ protocol needs to be robust towards various protocol error situations, like lost signalling (e.g. read flags, sequence numbers or status information) and corrupt signalling due to undetected bit errors. The ability to recover from these error situations needs to be considered.

8.1.4 Protocol overhead

The protocol overhead required to signal sequence numbers, status information (positive and negative acknowledgements), read flags and other data fields should be considered for both uplink and downlink transmission.

The resources required to transfer a given protocol variable depends e.g. on the amount of information that needs to be transferred, the reliability required for the information (error correcting coding and transmit power), and the frequency of the transmission of the information. Thus, a potential parameter for comparison could be the power needed to transmit the information.

8.1.5 Complexity

The complexity in terms of both processing requirements and implementation complexity should be considered. The implementation complexity may be difficult to calculate accurately but estimations could be sufficient for a comparison.

8.1.6 SDU delay

An important performance measure is the SDU delay caused by the HARQ protocol. The average delay for an SDU calculated from the point the SDU is submitted to the HARQ transmitter until it is delivered to the RLC layer at the receiver should be used to compare the performance between HARQ retransmission schemes. The SDU delay would implicitly include aspects such as scheduling flexibility, since a HARQ scheme with limited scheduling flexibility would experience a higher average SDU delay.

In addition the SDU delay variation should be considered.

8.1.7 Link Throughput

The link throughput could be considered as an additional performance measure.

8.2 Protocol Details

The HARQ protocol is based on an asynchronous downlink and synchronous uplink scheme. The ARQ combining scheme is based on Incremental redundancy. Chase Combining is considered to be a particular case of Incremental Redundancy. The UE soft memory capability shall be defined according to the needs for Chase combining. The UTRAN will take into account the UE soft memory capability when configuring the different transport formats (including possibly multiple redundancy versions for the same effective code rate) and when selecting transport formats for transmission and retransmission.

8.2.1 Signalling

8.2.1.1 Uplink

In the uplink, a report is used indicating either ACK (positive acknowledgement) or NACK (negative acknowledgement).

8.2.1.2 Downlink

8.2.1.2.1 Shared control channel

- HARQ process identifier

  Every HARQ process is assigned an identifier, which is used to couple the processes in the transmitter and the receiver.

- New data indicator

  It is used to distinguish between data blocks. It is specific to the HARQ process. It is incremented for each new data block.

8.2.1.2.2 In-band signalling on HS-DSCH

- Priority class identifier

  It is used to separate different priority classes in order to differentiate between logical channel priorities multiplexed in the same transport channel.

- Transmission sequence number

It is incremented for each new data block within a priority class. It is used for reordering to support in-sequence delivery.

- Protected by same CRC as TBSet.

8.2.2 Network operation

8.2.2.1 Scheduler

- Schedules all UEs within a cell
- Services priority class queues

 The scheduler receives MAC-hs SDUs based on information from the Iub frame protocol.

- Determines the HARQ Entity and the queue to be serviced
- Schedules new transmissions and retransmissions

 Based on the status reports from HARQ Processes the scheduler determines either new transmission or retransmission. A new transmission can be initiated also on a HARQ process at any time.

8.2.2.2 HARQ Entity (one per UE)

- There is one HARQ entity per UE
- Priority class identifier setting

 It sets the priority class identifier based on priority class of the queue being serviced.

- Transmission sequence number setting

 The TSN is incremented for each new data block within the same HS-DSCH and priority class. TSN is initiated at value 0.

- HARQ process identifier setting

 The HARQ process to service the request is determined and the HARQ process identifier is set accordingly.

8.2.2.3 HARQ process

- New Data Indicator setting

 The New data indicator is incremented each time when there is new data for this HARQ process.

- Processes ACK / NACK from the receiver

 The status report from the UE is passed to the scheduler.

8.2.3 UE operation

8.2.3.1 HARQ Entity

- Processes HARQ process identifiers

 It allocates received data blocks to different HARQ processes based on the HARQ process identifiers.

8.2.3.2 HARQ process

- New Data Indicator processing

If the New Data Indicator has been incremented compared to the value in the previous transmission, if any, the data currently in the soft buffer can be replaced with the received data block.

If the New Data Indicator is identical to the value used in the previous transmission, the received data is combined with the data currently in the soft buffer.

- Error detection result processing

  The physical layer decodes the data in the soft buffer and checks for errors

  If no error was detected, the decoded data is forwarded to the reordering entity and an ACK is generated.

  If an error was detected a NACK is generated.

- Status report transmission

  The status report is scheduled for transmission based on predetermined configuration.

- Priority class identifier processing

  Received data is arranged in queues based on priority class identifiers.

8.2.3.3 Reordering entity (for each priority class and transport channel)

- There is a re-ordering entity for each priority class and transport channel
- Reordering of received data based on transmission sequence numbers

  A received data block is inserted to its appropriate position in the queue according to the TSN.

- Forwarding data to higher layer

  If the received data block is the next to be delivered to higher layer, all data blocks with consecutive TSNs up to the first not received data block are delivered to higher layer.

  A timer mechanism determines the delivery of non-consecutive data blocks to higher layer.

8.2.4 Error handling

Most frequent error cases:

- NACK is detected as an ACK. The NW starts afresh with new data in the HARQ process. The data block is discarded in the NW and lost. Retransmission is left up to higher layers.
- ACK is detected as a NACK: If the network retransmits the data block, the UE will re-send an ACK to the network. If in this case the transmitter at the network sends an abort indicator by incrementing the New Packet Indicator, the receiver at the UE will continue to process the data block as in the normal case.
- [A threshold to detect lost status message is up to NW implementation. If detection is possible, better performance is achieved by defaulting to a NACK.]
- If a CRC error on the shared control channel is detected, UE receives no data and sends no status report. If the absence of the status report is detected, NW can retransmit the block.

9 Signalling Requirements

9.1 Downlink Signalling Parameters

9.1.1 UE identification

This identifies the UE (or UEs) for which data is transmitted in the corresponding HS-DSCH TTI. The exact mechanism of indicating the UE identification is FFS.

NOTE: There is sufficient reliability on the downlink signalling for the scheduling and thus the UE-Id is not required additionally on the HS-DSCH and its presence on the shared control channel is sufficient.

NOTE: For TDD, UE identification is needed on shared control channel. The possibility of a UE-specific CRC on the shared control channel to increase the signalling channel efficiency and maybe eliminate the UE ID on shared control channel is FFS.

9.1.2 Transport Format

This defines what transport format is used in the corresponding HS-DSCH TTI.

9.1.3 HS-DSCH power level

For FDD, this defines the relationship of HS-PDSCH and CPICH code power level. The UE may need to know this in order to perform N-QAM demodulation. The need for this parameter is FFS.

NOTE: An offset to the CPICH may not be sufficient in case of for e.g. beam forming.

The need of this parameter for TDD defining the P-CCPCH to HS-PDSCH power ratio is FFS.

9.1.4 Code channels in case of code multiplexing (FDD only)

This identifies to the UE (or UEs) the codes it (they) should receive and decode.

9.1.5 HS-DSCH physical channel configuration (TDD only)

This identifies to a UE (or UEs) the timeslots and codes it (they) should receive and decode.

Additionally, which transport formats are applied on HS-DSCH needs to be signalled. The exact number of additional bits are FFS (these are denoted as "x" in Table 3 below).

9.1.6 HARQ

Details of signalling parameters for the HARQ Protocol can be found in subclause 8.2.1.2. In addition, in support of the Incremental Redundancy combining scheme the Redundancy version is also signalled on the shared control channel.

9.1.7 Power offset for uplink control channel

This informs the UE what kind of power offset it should use in the uplink, when sending e.g. ACK during soft handover. Node B could estimate the SIR from the uplink, and calculate the needed power offset in the uplink, in order to make sure that an ACK can be decoded reliably. This information may be sent at a much lower rate than the other parameters described in this section.

In TDD, it is FFS whether a power level needs to be signalled for the uplink shared control channel and / or for 1.28 Mcps TDD SYNC1 ACK/NACK signalling.

9.1.8 Measurement feedback rate (FDD only)

This identifies the feedback rate for downlink quality measurement. It is FFS what measurements need to be fed back to the UTRAN. This information may be sent at a much lower rate than the other parameters described in this section.

9.1.9 Request for Measurement Report (TDD only, FFS)

a. HS UE-Id - Identifies UE that is informed about request for measurement report

b. Power offset for uplink shared control channel - need of this parameter is FFS

c. Request for DL channel quality measurement report on the uplink shared control channel - This parameter indicates which DL timeslots to measure.

9.1.10 Message Type

If several independent signalling messages exist in TDD, explicate identities are required.

NOTE: The need of this parameter is FFS.

Table 1: Parameters and range for consideration in signalling approach evaluation

<table>
<tr><th colspan="2" rowspan="2">Parameter</th><th colspan="3">Before the HSDSCH data packet</th><th colspan="3">Simultaneously with HSDSCH data packet</th></tr>
<tr><th>Min</th><th>Prop</th><th>Max</th><th>Min</th><th>Prop</th><th>Max</th></tr>
<tr><td colspan="2">UE identification</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">MCS</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">HS-DSCH power level</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Code channels</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">HARQ process #</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">HARQ redundancy version</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">New Data Indicator</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Power offset for uplink</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Measurement feedback rate</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">UL Resource ID for HS-PUSCH (TDD)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Resource Allocation Information for PUSCH (TDD)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3"></td><td>HS UE-Id</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>UL Resource ID for PUSCH</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Synchronisation shift (Low chip rate TDD)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Resource Allocation Information for PUCCH (TDD)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4"></td><td>HS UE-Id</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>UL Resource ID for PUCCH</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>UL Resource ID for PUCCH</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Synchronisation shift (Low chip rate TDD)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

The current working assumption is a range of 10-20 bits for FDD for the various downlink signalling fields irrespective of the precise final list of parameters and their placement or splitting of the parameters across the various downlink signalling channels (i.e. dedicated control channel and shared control channel).

For TDD, Table 2 and 3 below captures the present status; details need to be verified by both RAN WG1 and RAN WG2 along with a comparison of the work on FDD.

Table 2: Summary of downlink signalling for TDD Resource Allocation Information for HS-DSCH

TDD Resource Allocation Information for HS-DSCH:	Before the HSDSCH data packet			Simultaneously with HS-DSCH data packet		
	Min	Prop	Max	Min	Prop	Max
HI (on associated DPCH)	1	1	1			
UE identification	0	1.28 Mcps TDD: 6 3.84 Mcps TDD: 8	16			
Message Type	1	1.28 Mcps TDD: 1 3.84 Mcps TDD: 2	3			
MCS	2	3	3			
HS-DSCH physical channel configuration	0	1.28 Mcps TDD: 6+x 3.84 Mcps TDD: 20+x	1.28 Mcps TDD: 64 3.84 Mcps TDD: 96			
Power Offset for Uplink	0	1.28 Mcps TDD: 2 3.84 Mcps TDD: 3	1.28 Mcps TDD: 12 3.84 Mcps TDD: 12			
HARQ process number				0	2	2
HARQ redundancy version				0	2	2
HARQ packet number				0	6	12
Total (1.28 Mcps TDD)	4	19+x	99	0	10	16
Total (3.84 Mcps TDD)	3	37+x	131	0	10	16

Table 3: Summary of downlink signalling for TDD DL Channel Quality Measurement Request

TDD DL Channel Quality Measurement Request:						
	Min	Prop	Max			
HI (on associated DPCH)	1	1	1			
UE identification	0	1.28 Mcps TDD: 6 3.84 Mcps TDD: 8	16			
Message Type	1	1.28 Mcps TDD: 1 3.84 Mcps TDD: 2	3			
DL Channel Quality Measurement Request	0	1.28 Mcps TDD: 5 3.84 Mcps TDD: 12	1.28 Mcps TDD: 6 3.84 Mcps TDD: 14			
Power Offset for Uplink	0	1.28 Mcps TDD: 2 3.84 Mcps TDD: 3	1.28 Mcps TDD: 12 3.84 Mcps TDD: 12			
Total (1.28 Mcps TDD)	2	15	38			
Total (3.84 Mcps TDD)	2	26	46			

NOTE: The need of the TDD DL Channel quality Measurement Request is FFS.

9.2 Uplink Signalling Parameters

9.2.1 ACK/NACK

This will be used by the HARQ technique for indicating a successful/unsuccessful transmission on the HS-DSCH.

9.2.2 Measurement Report

It is FFS what measurements need to be included in the measurement report. This may be used in the choice of modulation and coding rate by the network. The rate of the measurement report to the network can be configured by higher layer signalling. In TDD, measurement reports may be specifically requested in DL signalling, and downlink channel quality measurements may be reported for specifically requested timeslots.

Table 4 contains the summary of the uplink signalling parameters for TDD.

Table 4: Summary of parameters and suggested range for uplink signalling in TDD

UL Acknowledgement/Measurement Report			
Parameter			
	Min	Prop	Max
H-ARQ ack/nack	[1]	[1]	[FFS]
Downlink channel quality	[7]	[38]	[60]
Total Bits → (Note1)	[8]	[39]	[60 + FFS bits]

NOTE 1: UL signalling parameters are optional in individual UL acknowledgement/measurement reports.

10 Resource Management

For HSDPA the resources shall be:

- Number of Codes and power that can be used for the codes;
- Managed on a cell basis.

More precise management of power is FFS.

11 Open Issues to be considered in the evaluation of HSDPA functionality

In order to aid the discussion regarding the introduction of HSDPA into UTRA a number of issues need to be carefully considered.

11.1 General Impacts

11.1.1 Mobility in HSDPA

11.1.1.1 Interaction between compressed mode and HSDPA

Compressed mode is used by UE in order to handover to an inter-frequency carrier. How is the scheduling handled between the compressed mode and the scheduler within the Node B for the HS-DSCH?

11.1.1.2 Speed and HSDPA

In order to assess the services that may be provided using HSDPA, an understanding is required for which user mobility speeds are best suited and applicable. Can HSDPA be used for user at 0 km/h, 3 km/h, 50km/h, 120km/h, 250km/h?

11.1.2 Interactions between RNC and Node B scheduler

11.1.2.1 Allocation of power to the HS-DSCH scheduler

What feedback is required in the RNC in order that the "outer loop" allocation of power for the "inner loop" HS-DSCH can be made in an efficient manner? How frequently can this be expected to change?

11.1.2.2 Impacts of high mobility and handovers in HSDPA

What feedback is required in the RNC and Node B in the case that not all packets that have been moved to a Node B can be delivered?

11.1.2.3 Admission/Load control between all RNC resources and channels

What interactions are envisaged in the case of load sharing between the RNC and standard DCH/DSCH users? How will the power budget be handled?

11.1.3 Uplink channel used for feedback

A clear definition is required of the uplink feedback information that is used in order to perform link adaptation.

11.1.4 Measurements

Which parameter measurements are made that can be used to perform the fast link adaptation? What type of accuracy can be expected for these channel condition measurements?

11.1.5 Others

The interaction of HSDPA with IPDL needs to be considered i.e. can both of them be operational simultaneously?

11.2 Network Infrastructure Impact

11.2.1 Impact of existing infrastructure hardware

11.2.1.1 Estimate the impact on the current interfaces due to the introduction of HSDPA.

In order to ensure interoperability between existing and future features, the issue of interoperability needs to be considered so that ubiquitous service may be provided. Further clarification is required of the handling of HS-DSCH traffic across the Iub FP.

11.2.1.2 Impact on the Node B hardware

What will be the overall impact on the Node B cell hardware? Is a new power amplifier required?

11.2.1.3 Impact on the RNC hardware

Does the introduction of HSDPA require substantial upgrades to existing Release '99 RNCs?

11.3 Impacts on User Equipment

11.3.1 Impact of existing User Equipment

11.3.1.1 Increase in UE memory/buffering

Given the potential high data rate transmissions, what is the impact in terms of UE memory/buffering.

11.3.1.2 Impact of receiving multiple codes

Is there a significant increase in the complexity of the UE hardware and processing required in order to be able to receive 20 simultaneous codes?

Annex A: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
09/2001	RP-13	RP-010562	-		Approved at TSG-RAN #13 and placed under Change Control	-	5.0.0