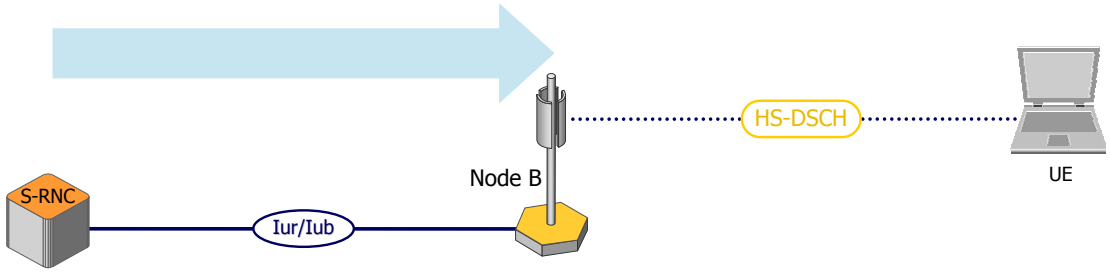
HSDPA Protocols & Resource Allocation: Contents

- HSDPA Transport Channel: HS-DSCH
- HSDPA Protocol Architecture
- **MAC-hs tasks / HSDPA Resource Allocation:**
  - Fast Packet Scheduling
  - Fast Link Adaptation
  - Fast H-ARQ

TS 25.321
MAC protocol specification

Node B (MAC-hs) controls resources/ HSDPA user

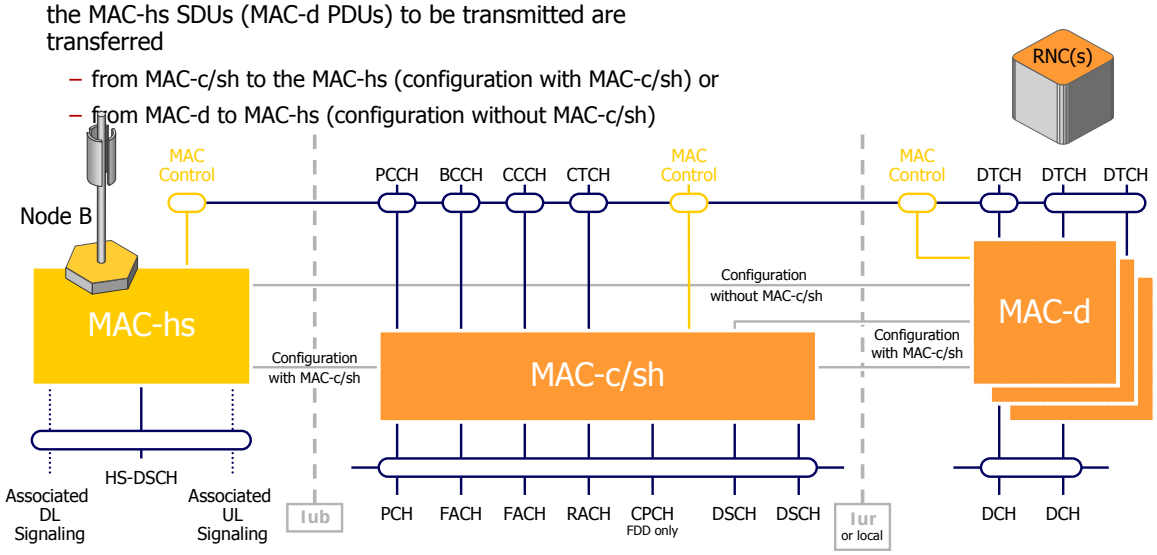


MAC-hs tasks and HSDPA resource allocation

These section of the chapter „HSDPA Protocols and Resource Allocation“ includes an overview about the tasks of the new MAC-hs protocol in general and the principles of the HSDPA radio interface resource allocation as one of the MAC-hs tasks.

MAC Architecture with HSDPA

- MAC-hs is located in the Node B (control by RRC)
- if an HS-DSCH is assigned to the UE
  the MAC-hs SDUs (MAC-d PDUs) to be transmitted are transferred
  - from MAC-c/sh to the MAC-hs (configuration with MAC-c/sh) or
  - from MAC-d to MAC-hs (configuration without MAC-c/sh)



MAC Architecture with HSDPA

The MAC-d is retained in the S-RNC. Transport channel type switching is therefore feasible. The new functionalities of H-ARQ and HS-DSCH scheduling are included in the MAC layer. In the UTRAN these functions are included in a new entity called MAC-hs located in the Node B.

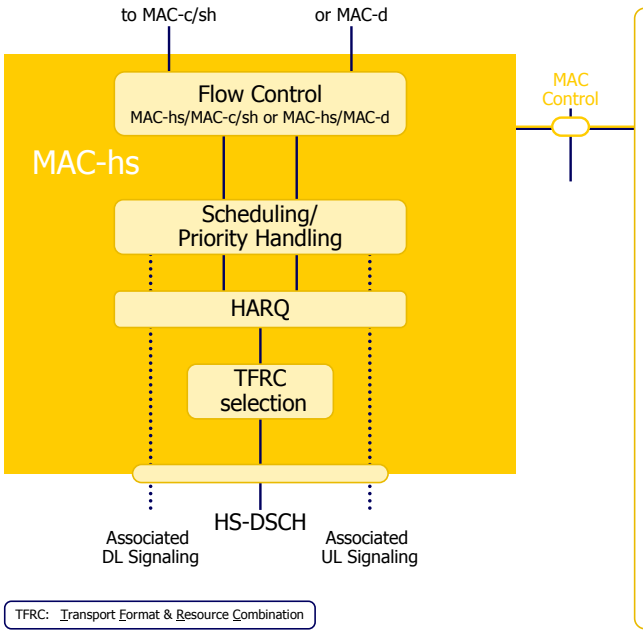
2 MAC protocol configurations are possible on the UTRAN side:

- Configuration with MAC-c/sh: In this case, the MAC-hs in Node B is located below MAC-c/sh in C-RNC. MAC-c/sh shall provide functions to HS-DSCH identical to those provided for the DSCH in the Release '99. The HS-DSCH FP (frame protocol) will handle the data transport from S-RNC to C-RNC (if the Iur interface is involved) and between C-RNC and the Node B.

- Configuration without MAC-c/sh: In this case, the C-RNC does not have any user plane function for the HS-DSCH. MAC-d in S-RNC is located directly above MAC-hs in Node B, i.e. in the HS-DSCH user plane the S-RNC is directly connected to the Node B, thus bypassing the C-RNC.

A detailed description of the MAC Architecture modified by HSDPA can be found in TS 25.321 and TS 25.308.

MAC-hs Tasks (UTRAN side)



MAC-hs functional entities:

Flow Control:

companion flow control function to the flow control function in the MAC-c/sh respectively MAC-d

Both entities together provide a controlled data flow taking the transmission capabilities of the air interface into account in a dynamic manner.

Scheduling/Priority Handling:

manages HS-DSCH resources according to their priority class; based on status report from associated UL-signaling either New Transmission or Retrans-mission is decided; scheduling is performed for each 2 ms TTI

HARQ:

1 HARQ entity handles the hybrid Automatic Repeat Request HARQ functionality for 1 user.

1 HARQ entity is capable of supporting multiple instances (HARQ process) of stop and wait HARQ protocols.

There shall be 1 HARQ process per TTI.

TFRC selection:

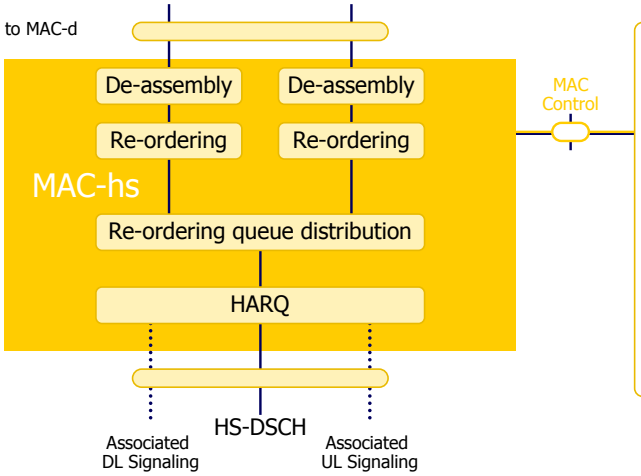
Selection of an appropriate Transport Format & Resource Combination (Modulation & Coding)

MAC-hs tasks: UTRAN side

There is 1 MAC-hs entity in the UTRAN for each cell that supports HS-DSCH transmission. MAC-hs is responsible for handling the data transmitted on the HS-DSCH, i.e. for the HSDPA physical resources management. MAC-hs is comprised of 4 different functional entities:

- Flow Control
- Scheduling and Priority Handling
- H-ARQ
- TFRC selection

MAC-hs tasks (UE side)



MAC-hs functional entities (UE):

HARQ:

1 HARQ process per HS-DSCH per TTI

HARQ functional entity handles all H-ARQ tasks, e.g. generating ACKs/NACKs.

Reordering:

Reordering entity organises received data blocks according to the received Transmission Sequence Number TSN;

Data blocks with consecutive TSNs are delivered to higher layer;

1 Reordering entity for each priority class.

MAC-hs tasks: UE side

The MAC-hs handles the HSDPA specific functions. For the UE this comprises the following entities:

- H-ARQ

- Reordering Queue distribution

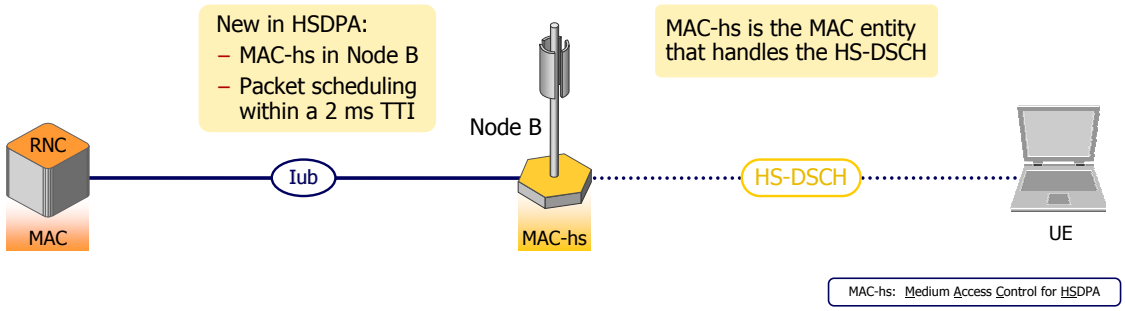
- Reordering

- Disassembly

MAC-hs: Fast Scheduling, Link Adaptation & H-ARQ

MAC-hs tasks:

- Fast Packet Scheduling & priority handling:
  - Manages HS-DSCH resources (in Time & Code Domain)
  - Buffering of PS data in priority queues
- Fast Link Adaptation:
  - selecting Modulation & Coding Scheme/transport format & resource combination
- Fast H-ARQ (Hybrid Automatic Request)
  - rapid & efficient retransmission of incorrect received data entities + Re-ordering



New Node B functionalities: MAC-hs for Fast Scheduling, Link Adaptation & H-ARQ

For HSDPA a new protocol is added to the Node B - the MAC-hs.
The MAC-hs is responsible for:
- Fast Packet Scheduling & priority handling. It manages the HS-DSCH resources in the Time and Code Domain and buffers PS data in priority queues.
- Fast Link Adaptation. The MAC-hs is selecting Modulation & Coding Scheme i.e. the transport format & resource combination
- Fast H-ARQ (Hybrid Automatic Request). The MAC-hs is responsible for the rapid and efficient retransmission of incorrect received data entities + Re-ordering.

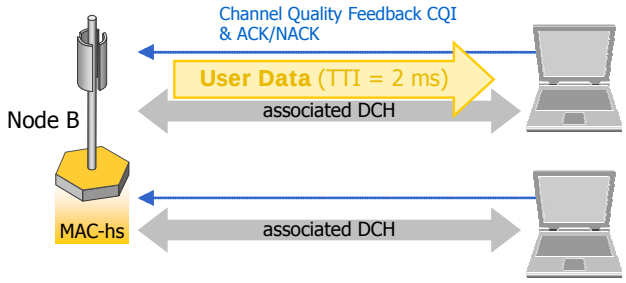
MAC-hs: Fast Link Adaptation

MAC-hs decides:

- Packet Scheduling
- Link Adaptation AMC (TFRC)

on basis of channel quality estimates →

- UL Channel Quality Feedback CQI



Fast Link Adaptation
instead of R'99 Fast Power Control

Fast Link Adaptation:
tracking & compensation of Fast Fading (optimum TFRC)
→ resource efficiency

2 ms TTI
(R`99: typically 10/20 ms)
& **MAC-hs** in Node B

CQI:	Channel Quality Indicator
TFRC:	Transport Format & Resource Combination
TRFC low	→ QPSK & high redundancy
TFRC high	→ 16QAM & low redundancy

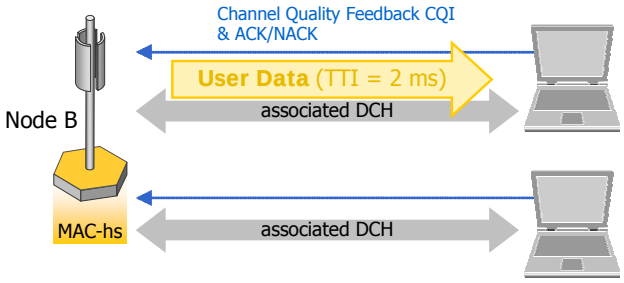
MAC-hs: Fast Link Adaptation

The MAC-hs in the Node B is managing the Fast Link Adaptation. Modulation and Coding are adapted every 2 ms according to the quality of the air interface. The quality of the air interface is estimated by the UE and delivered as Channel Quality Indicator CQI via Layer 1 to the Node B. The HSDPA Fast Link Adaptation is performed instead of Rel. 99 Fast Power Control to compensate the effects of Fast Fading and optimise the usage of the radio resources.

MAC-hs: Fast Scheduling

MAC-hs decides:

- Packet Scheduling
  (HS-DSCH code & power resources) &
- Link Adaptation AMC (TFRC)



2 ms TTI
(R`99: typically 10/20 ms)
& **MAC-hs** in Node B

Fast Packet Scheduling:

Resource Allocation to UE with momentary best channel quality → resource efficiency

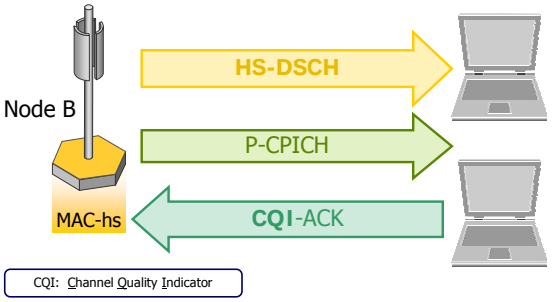
Improves granularity in scheduling process

MAC-hs: Fast Packet Scheduling

The MAC-hs in the Node B is managing the Fast Packet Scheduling. The radio resources are allocated to the HSDPA users requiring data transmission according to the quality of the air interface. The decision how many codes are allocated to which user is performed every TTI (2 ms). Taking the momentary air interface quality into account and allocation the resources to the user with the actual best radio conditions improves the resource efficiency furthermore.

MAC-hs: Fast Scheduling

- sharing **HS-DSCH** resources among different UE's
- operates on 2 ms TTI basis avoiding data packet scheduling during destructive channel fades
- based on knowledge of instantaneous channel quality:
  UE observes **P-CPICH** (Ec/No) → **CQI**



Types of Schedulers:

- C/I Scheduler:
  - allocates resources to users with best channel conditions (CQI)
  - highest possible throughput (highest effective coding rate)
  - „unfair" resource allocation
- Round Robin RR:
  - cycles through list of active users
  - „fair" resource allocation
  - lowest throughput
- Proportional Fair PF:
  - schedules user with currently highest ratio between instantaneous CI & average transmission rate
    - short-term channel variation
    - maintains long-term throughput for all users
  - average throughput

Types of Packet Scheduler

The resource allocation principles are vendor-specific. Different types of packet schedulers are known from literature.

The Round Robin RR scheduler is a comparable simple scheduler where HSDPA user are scheduled with an equal probability – independent of the momentary radio conditions. It delivers the lowest throughput.

The maximum Carrier-to-Interference C/I scheduler allocates the resources to the user(s) with the best radio conditions per 2 ms TTI. The C/I is designed to maximise the HSDPA cell throughput. But it is comparable unfair because users with very permanent bad radio conditions (e.g. at cell edge) may never be scheduled.

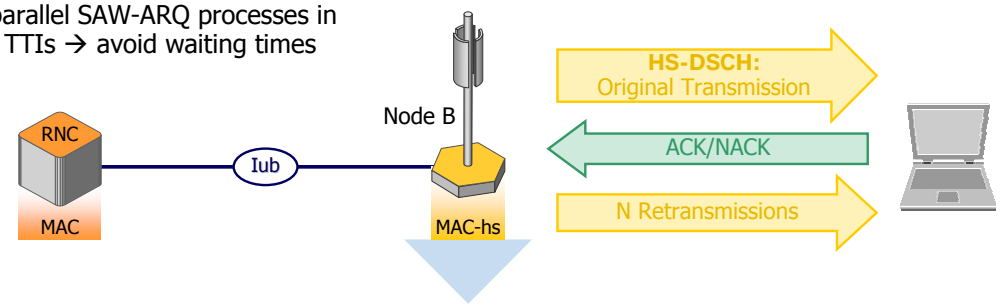
The Proportional Fair PF scheduler provides a compromise between fairness and throughput. Basically the Node B allocates the resources to the user(s) with the momentary best radio conditions. But every user is getting a certain priority level. The priority level is increasing if traffic for a user is waiting for transmission in the Node B. Therefore, after a certain waiting time the priority to be served of a user with bad radio conditions is exceeding the priority of users with good radio conditions. As a result everyone is served comparable fair and the throughput is enhanced, to.

Fast H-ARQ

Stop and Wait“ SAW protocol:

- Retransmission with lower TFRC until successfully received by UE
- 1st Retransmission ≈ 8 – 12 ms after original transmission
- up to 8 parallel SAW-ARQ processes in separate TTIs → avoid waiting times

Retransmission strategies:
- Incremental Redundancy IR
- Chase Combining CC



MAC-hs controls L1 H-ARQ:
- RNC not involved
- Iub signaling avoided

- speeds up BEC
- reduces DL delay e.g. to support Streaming Class services

TFRC: Transport Format & Resource Combination
TRFC low → QPSK & high redundancy

Fast H-ARQ: Fast Hybrid Automatic Repeat Request

To facilitate more aggressive & spectrally efficient scheduling, a fast L1 based retransmission strategy is embedded into the HSDPA concept. Facilitated by the Node-B based MAC-hs, soft-combining and incremental redundancy (IR) retransmission strategies ensure that past transmissions are effectively utilized.