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Scheduling in the UMTS enhanced uplink

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Problem Statement

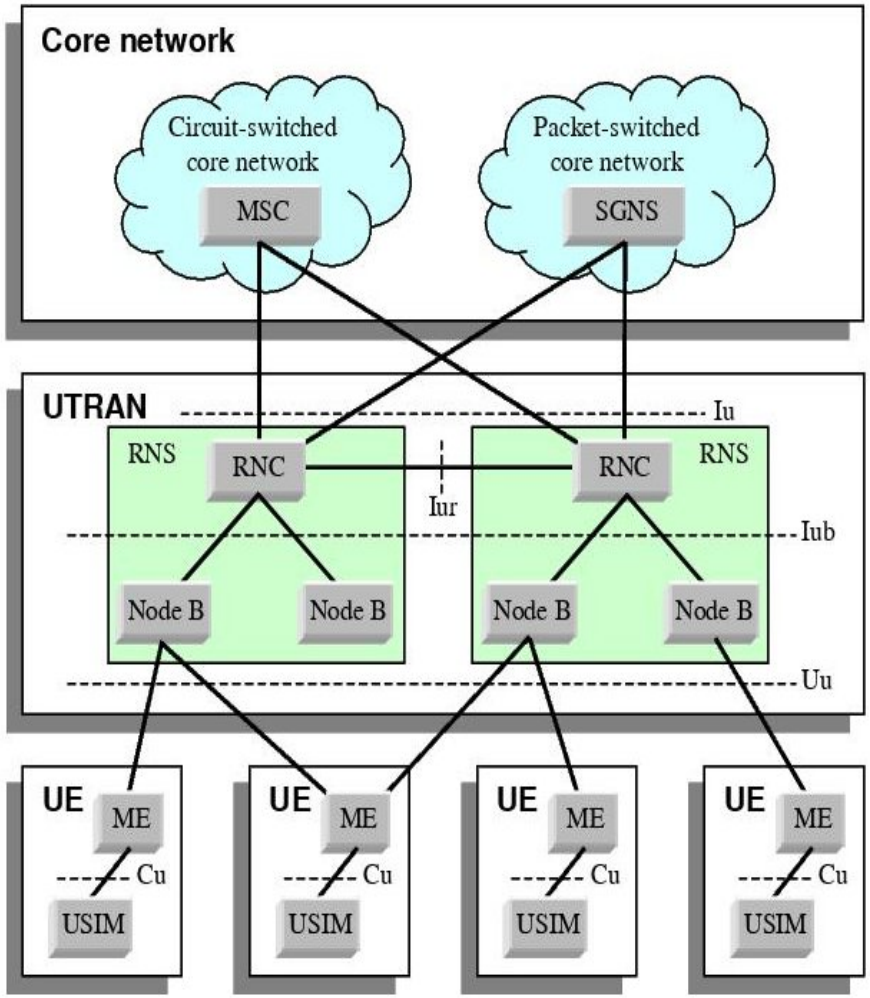
An important new technique for the UMTS enhanced uplink, as defined in 3GPP Release 6 , is **fast packet scheduling**.

- How do different schedulers for the enhanced uplink compare?
- What is the suitability of our current ns2-based simulator, for evaluating these schedulers?

Outline

- UMTS Enhanced Uplink
- Enhanced Uplink Schedulers
- Simulation
- Conclusions & Future Work

UMTS Architecture



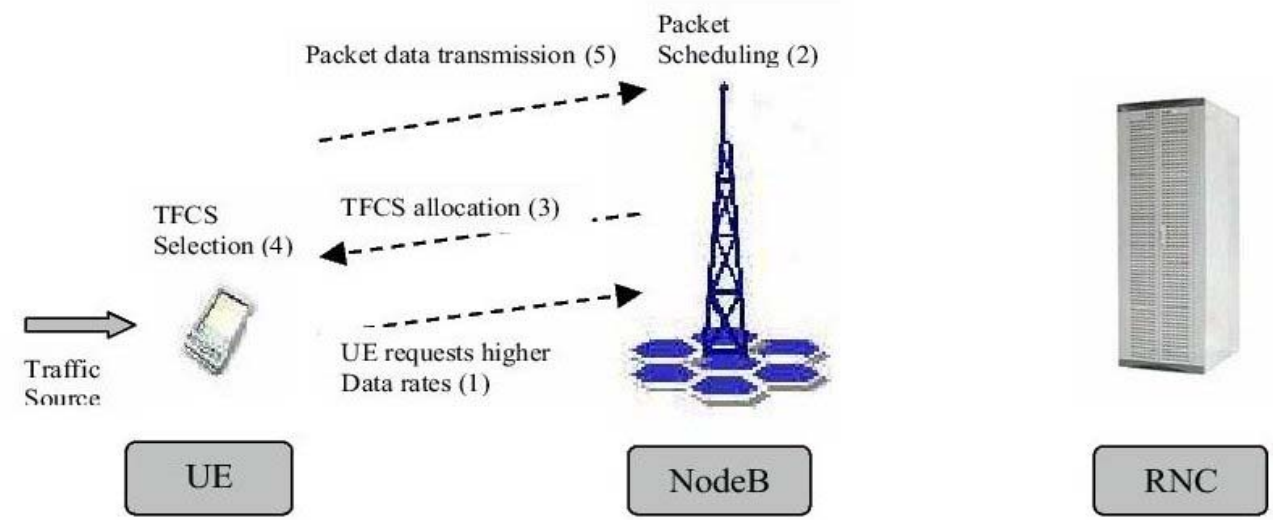
Enhanced Uplink

High Speed Uplink Packet Access (HSUPA)

- Defined for 3GPP R6
  (HSDPA already in R5)

- Main features
  - increases throughput (→5.76 Mbps)
  - reduces latency
- Main new tecniques used:
  - Hybrid Automatic Retransmission Request (HARQ)
  - Fast Packet Scheduling
    (No higher order modulation)

Fast Packet Scheduling



- Based at the NodeB
  - reduces the delay
  - allows faster reaction than when residing at the RNC
  - controls the received power which is distributed among all the users in the cell.

Scheduling Signalling

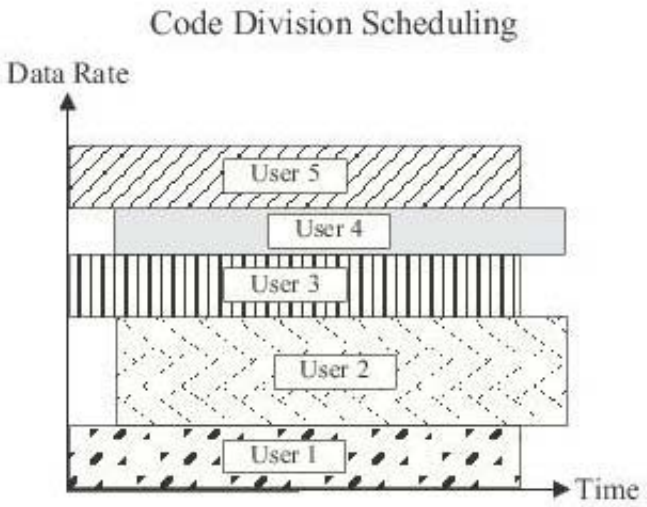
Uplink:

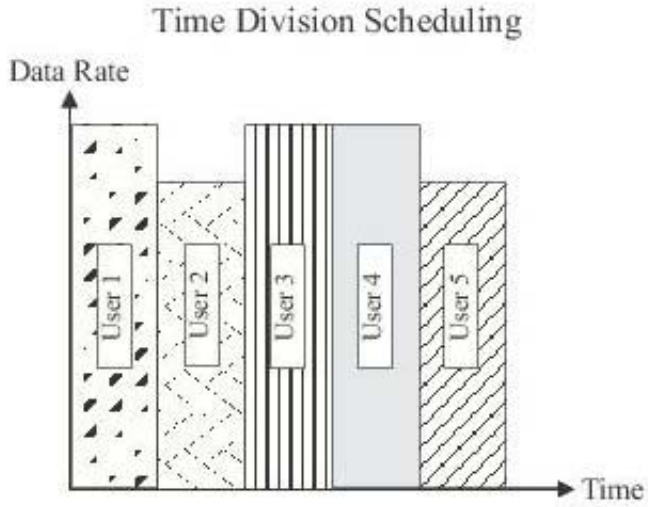
- Happy bit:
  A single bit field indicates whether the UE could use more resources or not.
- Total E-DCH buffer status
- Highest priority logical channel ID
- UE power headroom
- *Used transmit power?*

Downlink:

- Relative Grants:
  “up”, “down” or “hold”, indicating the UE to step up, step down or hold the index of its allowed TFC
- Absolute Grants:
  allows the NodeB scheduler to directly adjust the resources of UEs under its control in one single command

2 extreme scheduling schemes





- Users perform uplink transmissions in parallel, with a low rate, so that the noise rise level at the NodeB does not exceed the established threshold.

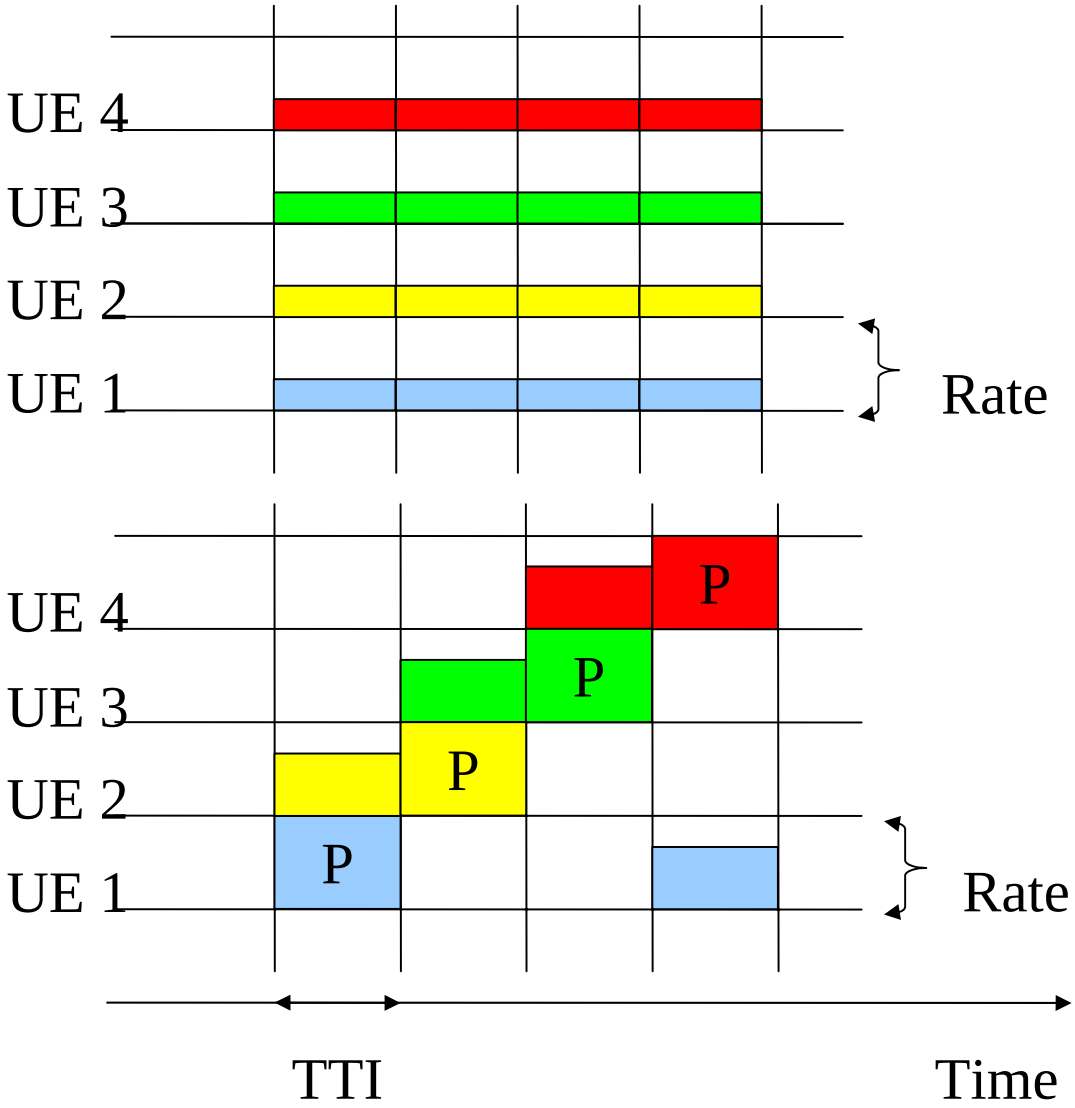
- Only one or a set of UEs are allowed to transmit at a given time so that the noise rise level at the NodeB does not exceed the established threshold.

Scheduling Procedure

- UE requests resources (bit rate)
- NodeB determines allowed rates for UEs, based on scheduling scheme (see next slides) Condition:
  - UEs must meet their required BLER
  - total received power below threshold (noise rise target)
- NodeB sends grant (allowed rate) to UE
- UE sends at granted rate
  - Or at lower rate if max power reached, lower grant from other nodeB, or not enough data
  - Delay from request to sending typically a few TTI (we assume 7, i.e. 14 ms)

Schedulers (1/2)

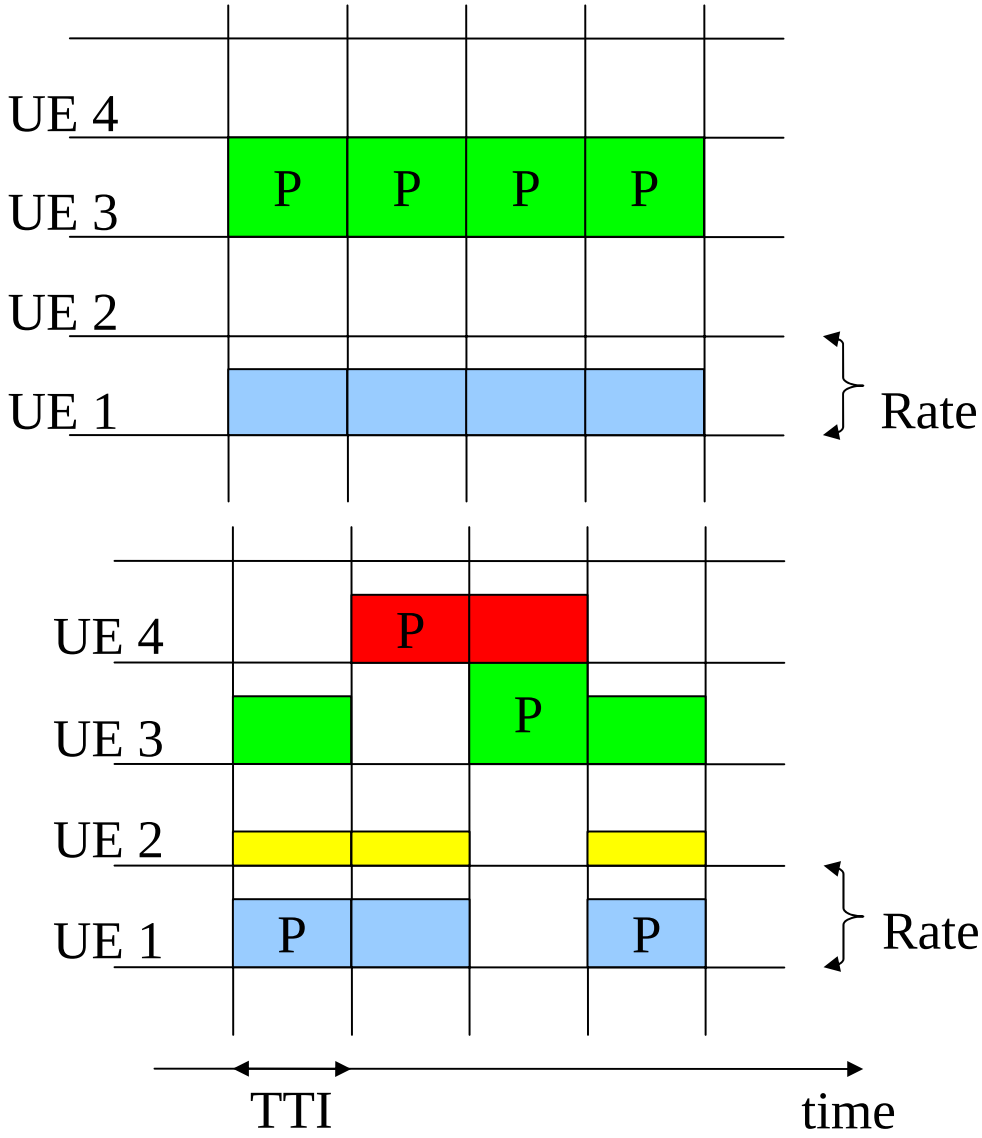
- **Rate Scheduling**: Try to grant to all active UEs, assigning them low rates.
- **Round Robin Scheduling**: Try to grant to a few UEs with the maximum rate.



Schedulers (2/2)

- **Uplink CQI**:
  Always selects the UE with best UCQI and grants it with the maximum rate.

- **Rate Estimation**:
  Estimate the rate capabilities of the UEs to assign a rate.



Simulator

- Ns2-based
- Detailed implementation of HARQ and fast scheduling
- Single cell
  (fixed other-to-own cell interference ratio)
- Link-level included by means of AVI:
  (Actual Value Interface:
  look-up tables for E_b/N_0 → BLER)
- Path loss and shadowing based on position
- Multi-path fading precalculated

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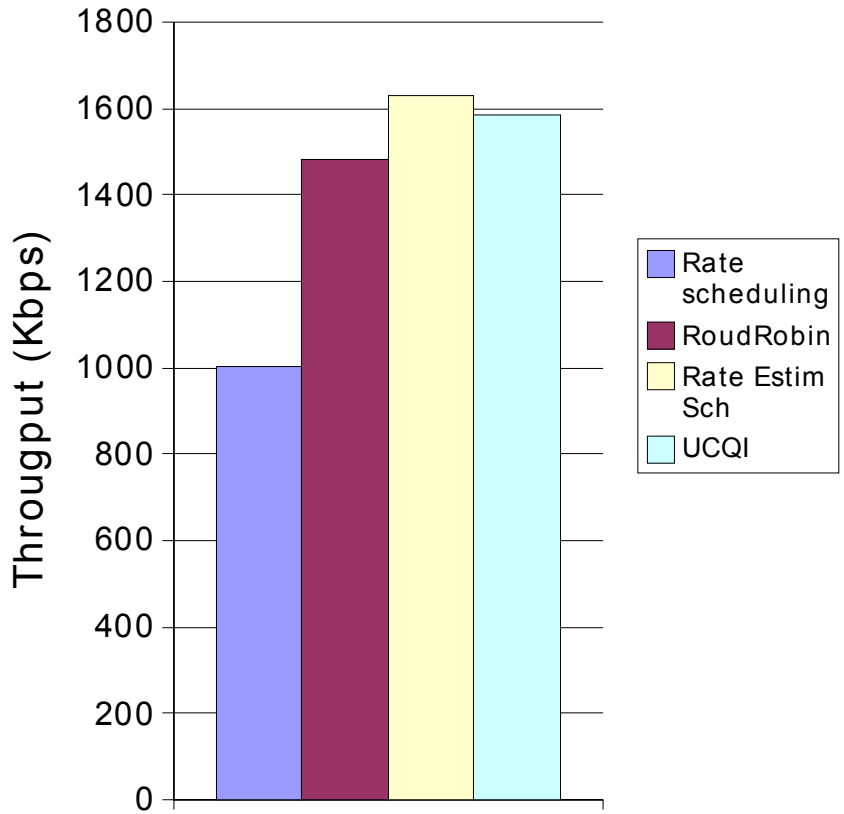
Simulation Parameters

BLER	0.1
Noise Rise Target	6dB
TTI duration	2ms - 10ms
Max UE transmission power	26dBm (-4dB)
UE speed	3Kmph
Cell radius	1.5Km
Number of UEs	24
Traffic rate per burst	250Kbps
Burst period	5 sec
Idle period	5 sec

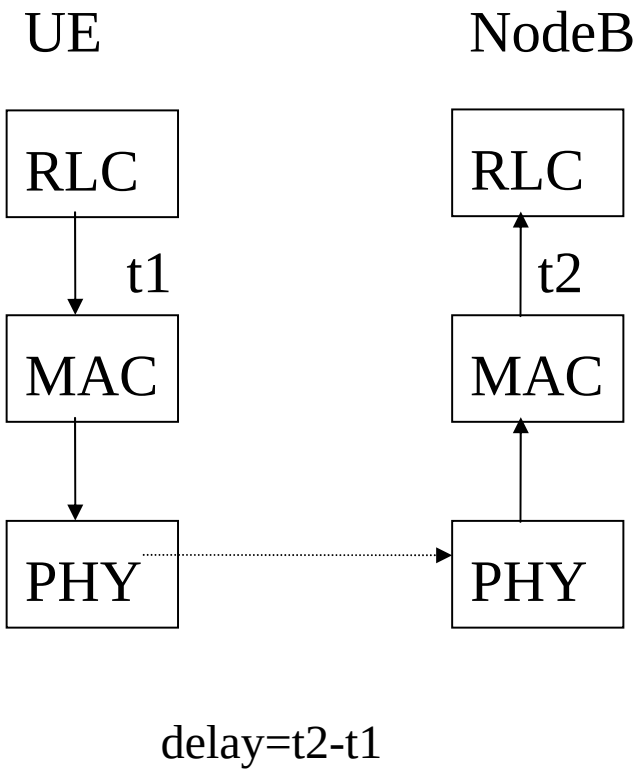
Total Transmitted Power (dB)

	Mean	Std
Rate scheduling	-3.59	2.5
Round Robin	-5.46	3.05
Rate Estimation	-5.36	3.04
UCQI	-9.58	7.1

Average Cell Throughput (kbps)



Delay (sec)



	Mean	Std
Rate scheduling	0.36	0.22
Round Robin	0.22	0.16
Rate Estimation	0.21	0.14
UCQUI	0.16	1.72

Conclusions & Future Work

- Fast packet scheduling for the UMTS enhanced uplink can benefit from:
  - Scheduling few users at the same time with high bit rates.
  - Using the channel condition as a scheduling parameter to take advantage of the rapid reaction to channel variations.
  - Estimating the maximum rate that the UEs are able to support
- To reliably compare and quantify the performance of schedulers, a multi-cell simulator is a necessity

More info:

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