

# *3G Evolution – HSPA and LTE for Mobile Broadband*

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# Mobile Broadband

Om du har en bärbar dator,  
**varför har du  
 fast bredband?**

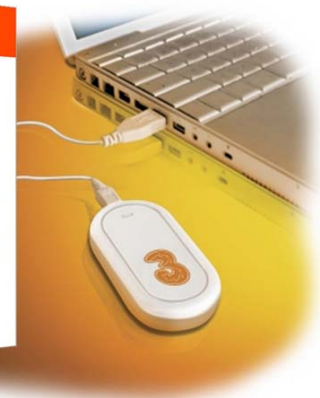
Surfa trådlöst i hastigheter upp till 7.2 Mbit/s



**mobil** Sveriges Bästas 3G-nät

3Bredband 3Bredband 3Bredband

- Sweden's sales Top 10 for September 2007
- 1 **HSPA USB Modem**
  - 2 ...
  - 3 Sony Ericsson K530i
  - 4 ...
  - 5 Sony Ericsson T650i Blue
  - 6 Sony Ericsson W660i RoseRed
  - 7 ...
  - 8 Sony Ericsson W880i Black/Red
  - 9 Sony Ericsson W880i Silver/Black
  - 10 **HSPA DataCard**



**HSPA**

**Turbo-3G**

Kids who surf faster  
 see more,  
 learn more,  
 do more.

**maxis.broadband**



Maxis Broadband

**LTE**

**3Data.**

Bis zu 4 Monate gratis surfen!  
 Kein Aktivierungsentgelt<sup>0</sup>

Surfen ohne Ende -  
 für Power User.

HSDPA  
 bis zu  
**7,2**  
 Mbit/Sek.



# More Than 400\* HSPA Devices!

- 203 HSPA phones, media players, camera (50%)
- 161 PC with embedded HSPA, PC cards, USB modems (40%)
- 39 wireless routers (10%)



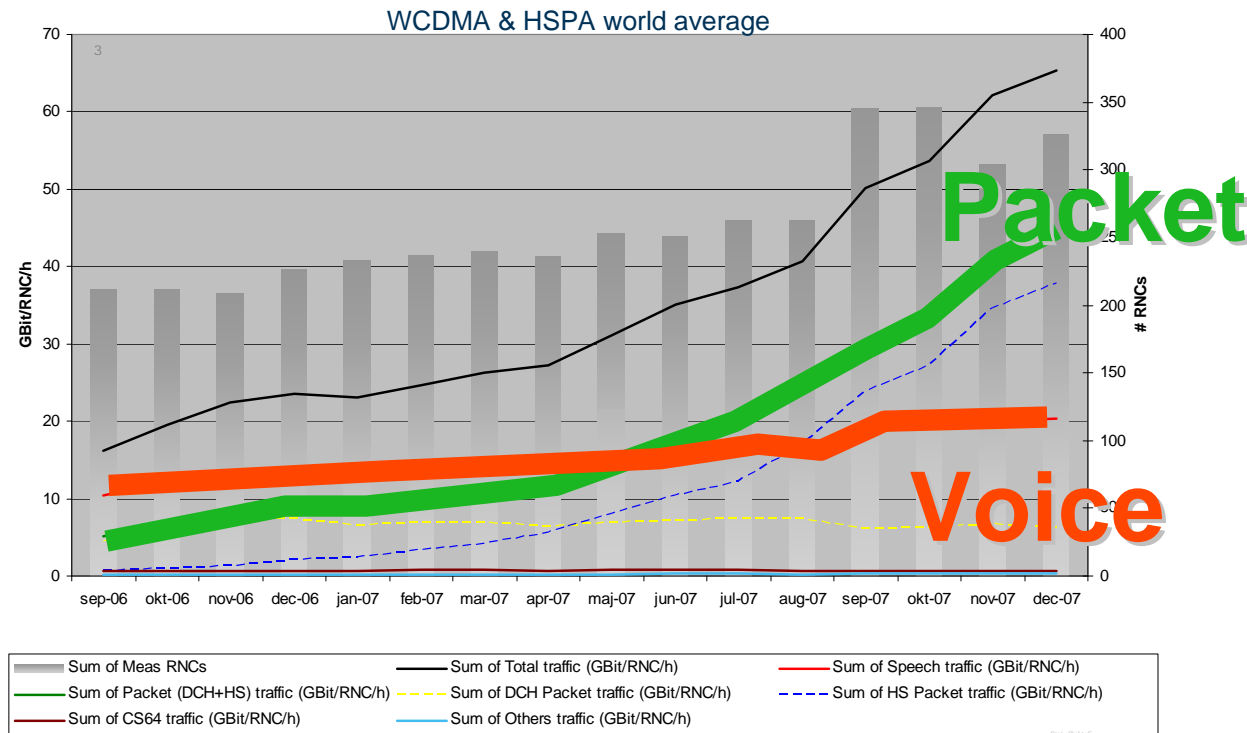
*\*Commercially launched as of August 2007*

*So...what is HSPA and LTE?*



# Trend – Data is overtaking Voice

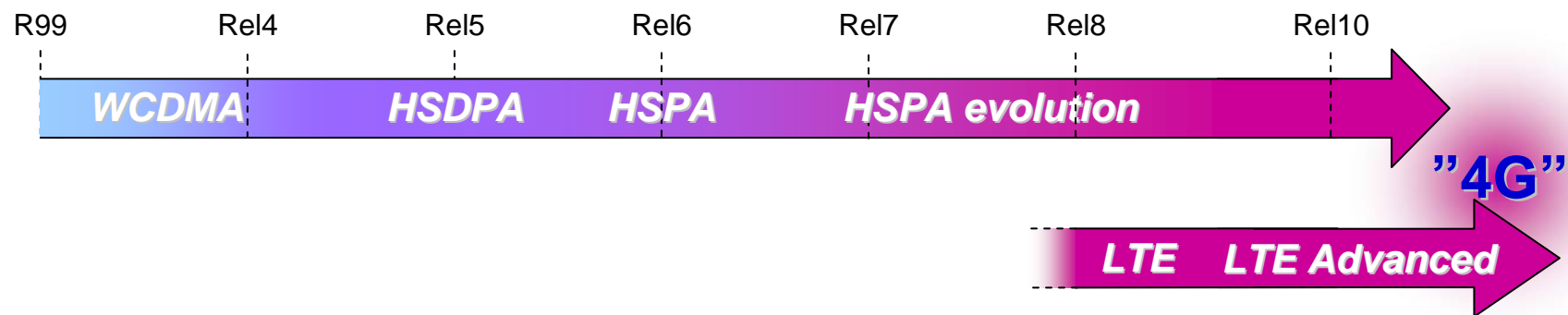
- Data is overtaking voice...  
...but previous cellular systems designed primarily for voice



Source: NetQB

# HSPA and LTE = Mobile Broadband

- HSPA – *High-Speed Packet Access*
  - Evolution of 3G/WCDMA
  - Gradually improved performance at a low additional cost
  - Data rates up to ~20 Mbit/s *in 5 MHz*



- LTE – *Long-Term Evolution*
  - Significantly improved performance *in a wide range of spectrum allocations*
  - Data rates up to ~300 Mbit/s in 20 MHz
  - First step towards IMT-Advanced ("4G")

Different systems – but many basic principles are similar!

# Wireless vs Wireline

- Wireless seems simple...

$$\nabla \cdot \mathbf{D} = \rho$$

$$\nabla \cdot \mathbf{B} = 0$$

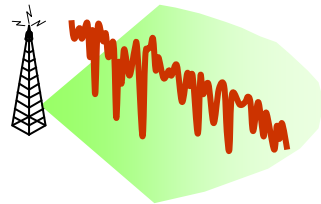
$$\nabla \times \mathbf{E} = - \frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

- ...so what's the problem?

# Radio Channels and Packet Data

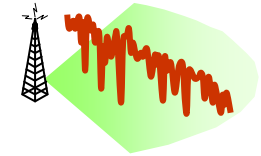
- Radio channel quality varies...
  - ...distance to base station
  - ... random variations in the environment
- Traffic pattern varies...
  - ...user behavior
  - ...server load



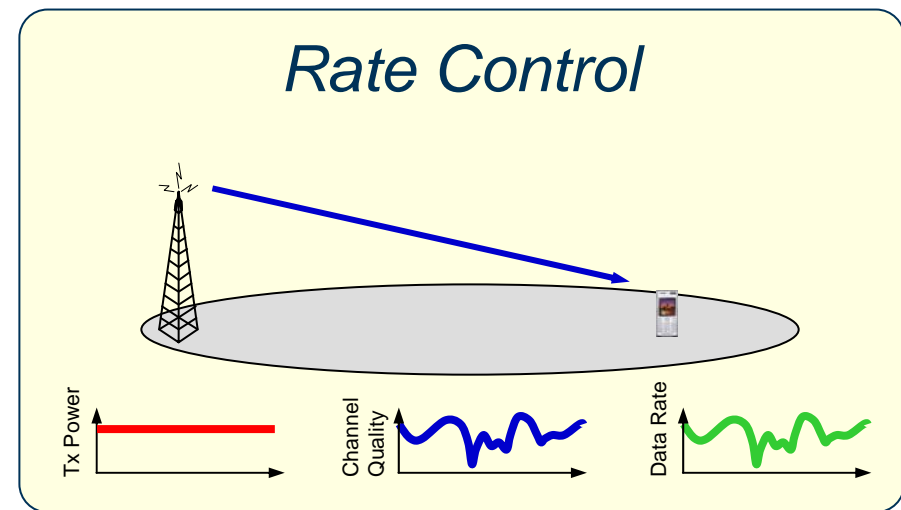
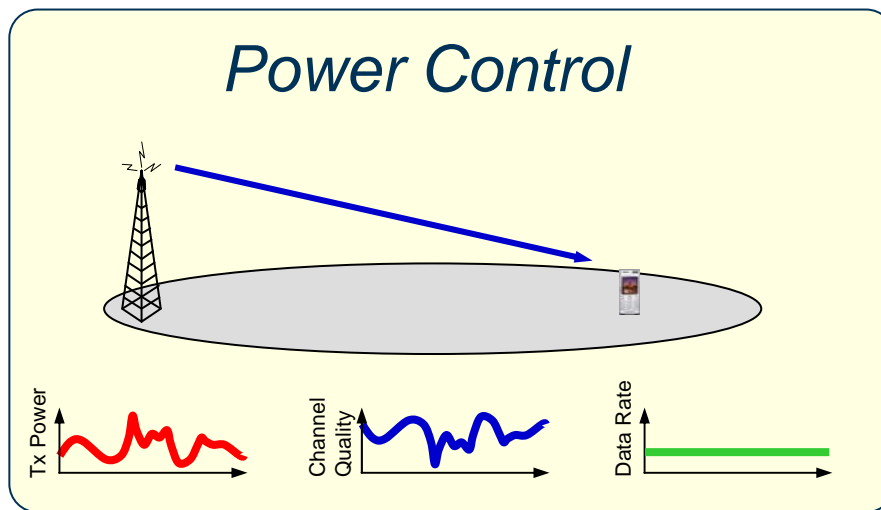
*Adapt to and exploit* channel and traffic variations!



# Rate Control



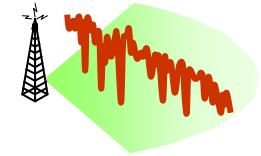
- Reliable reception requires a certain  $E_b/N_0$
- How to control  $E_b$ ?
  - $E_b = P \cdot T$



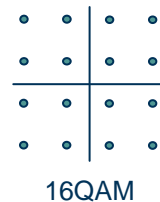
- Varying instantaneous data rate acceptable for packet-data services
  - Rapid – tracks fast fading

Rate control more efficient than power control!

# Rate Control



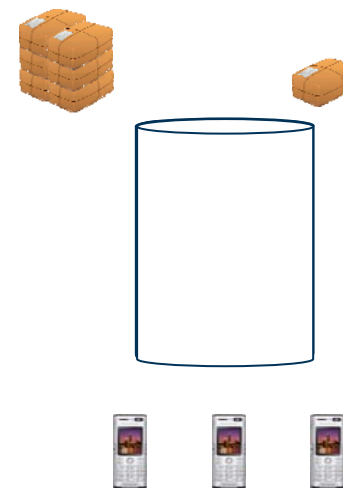
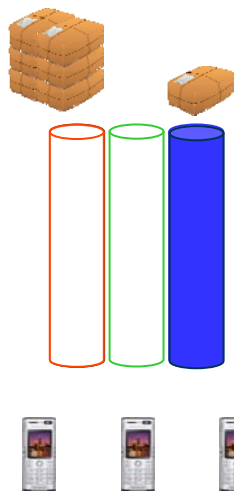
- Data rate controlled through...
- ...different channel coding rates
  - Advantageous channel conditions ➔ high code rate
  - Code rates from 1/3 to ~1
- ...different modulation schemes
  - Advantageous channel conditions ➔ higher-order modulation



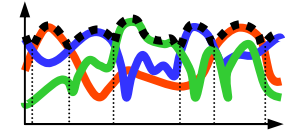
- ...different multi-antenna schemes

# Shared-Channel Transmission

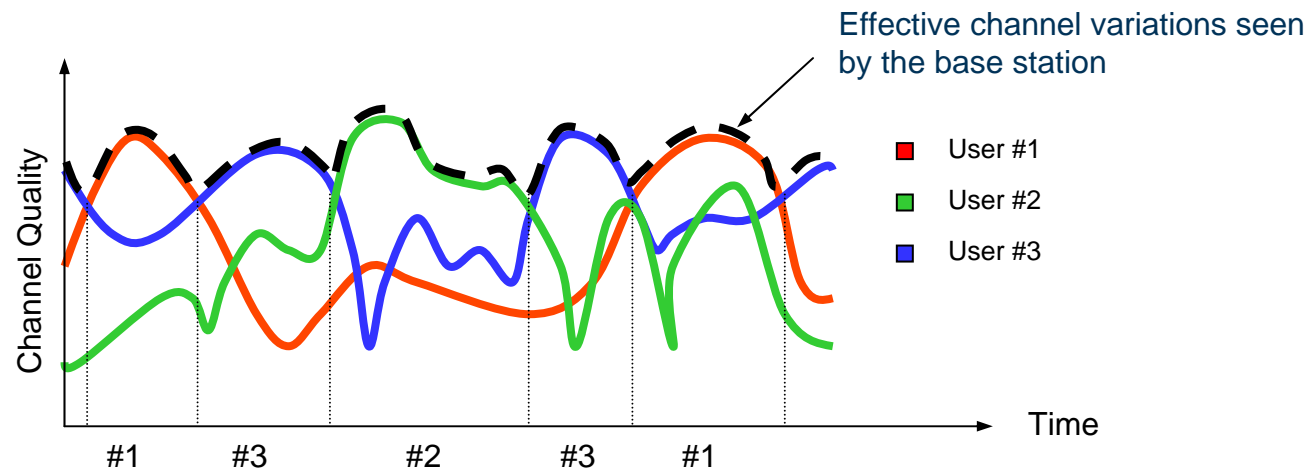
- Dedicated channel
  - User resources assigned at "call setup"
  - Independent of instantaneous traffic situation
- Shared channel
  - Dynamic sharing of common resource
  - Adapts to instantaneous traffic situation



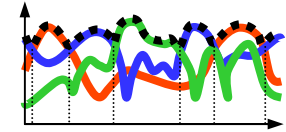
# Channel-dependent Scheduling



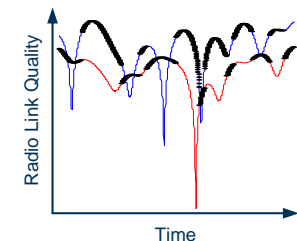
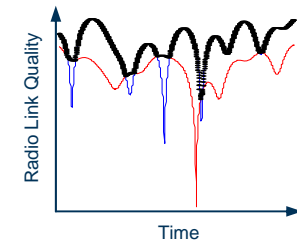
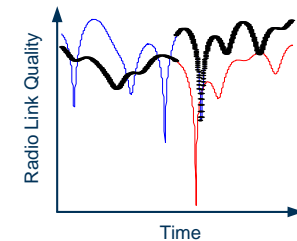
- Scheduling determines at each time instant...
  - ...to whom to assign the shared channel
  - ...which data rate to use
- Basic idea: transmit at fading peaks
  - May lead to large variations in data rate between users
  - Tradeoff: fairness vs cell throughput



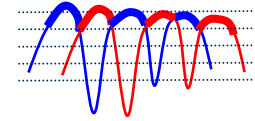
# Channel-dependent Scheduling



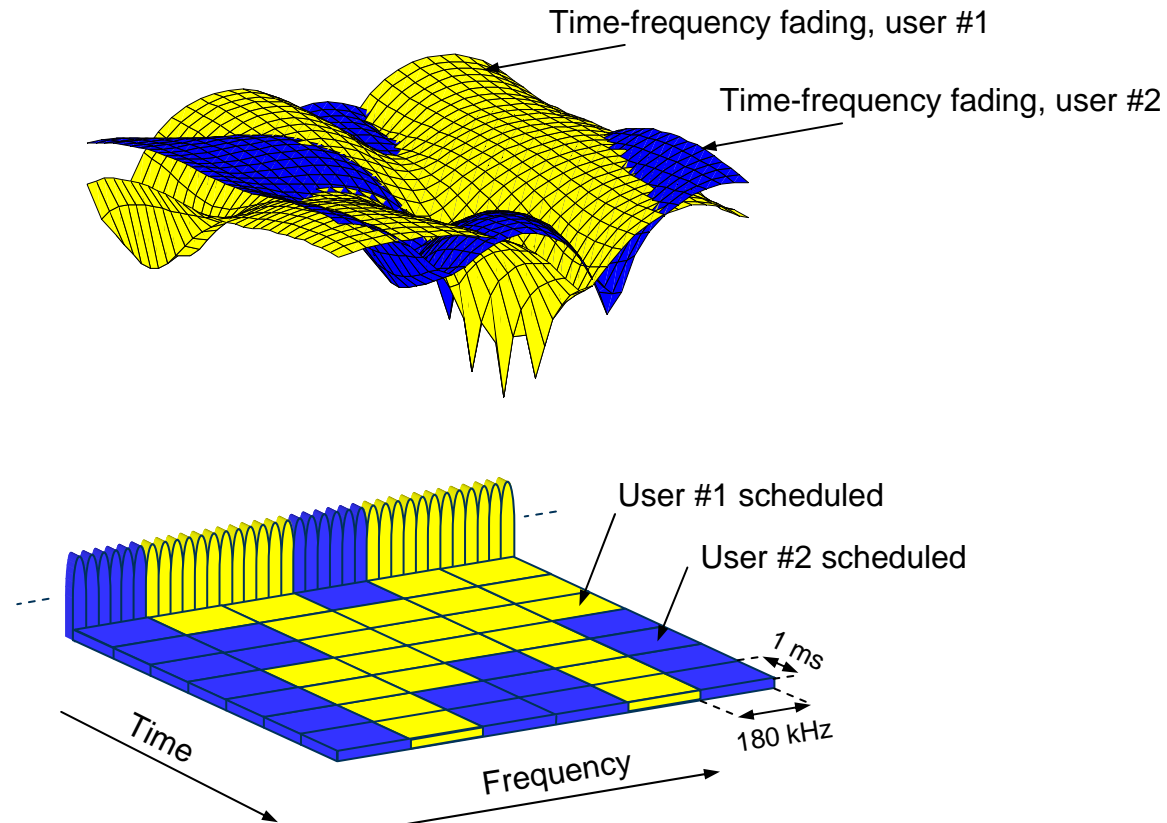
- Round Robin (RR)
  - Cyclically assign the channel to users without taking channel conditions into account
  - Simple but poor performance
- Max C/I
  - Assign the channel to the user with the best channel quality
  - High system throughput but not fair
- Proportional Fair (PF)
  - Assign the channel to the user with the best relative channel quality
  - High throughput, fair



# Channel-dependent Scheduling



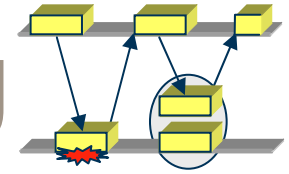
- HSPA – channel-dependent scheduling in time-domain only
- LTE – channel-dependent scheduling in time *and* frequency domains



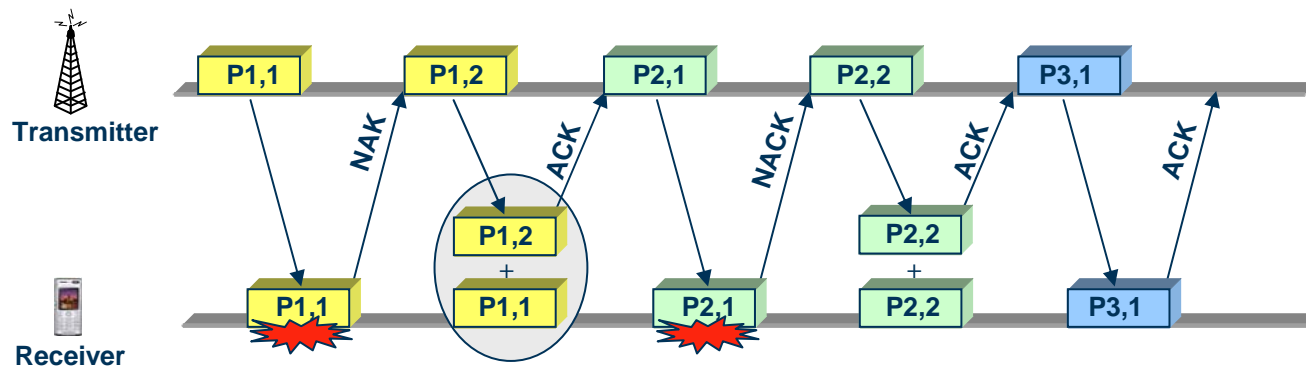
# Channel Quality Indication

- Scheduling and rate control adapts to channel variations
- Problem: need channel knowledge at the base station
- Solution: terminals transmit channel-quality reports to base station
- Reporting rate configurable
  - HSPA – reports as often as every 2 ms
  - LTE – reports as often as every 1 ms

# Hybrid ARQ with Soft Combining

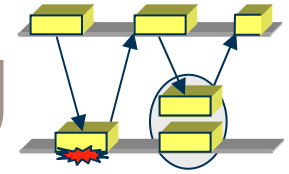


- Retransmission of erroneously received packets
  - Fast ➔ no disturbance of TCP behavior
- Soft combining of multiple transmission attempts
  - Soft combining ➔ improved performance

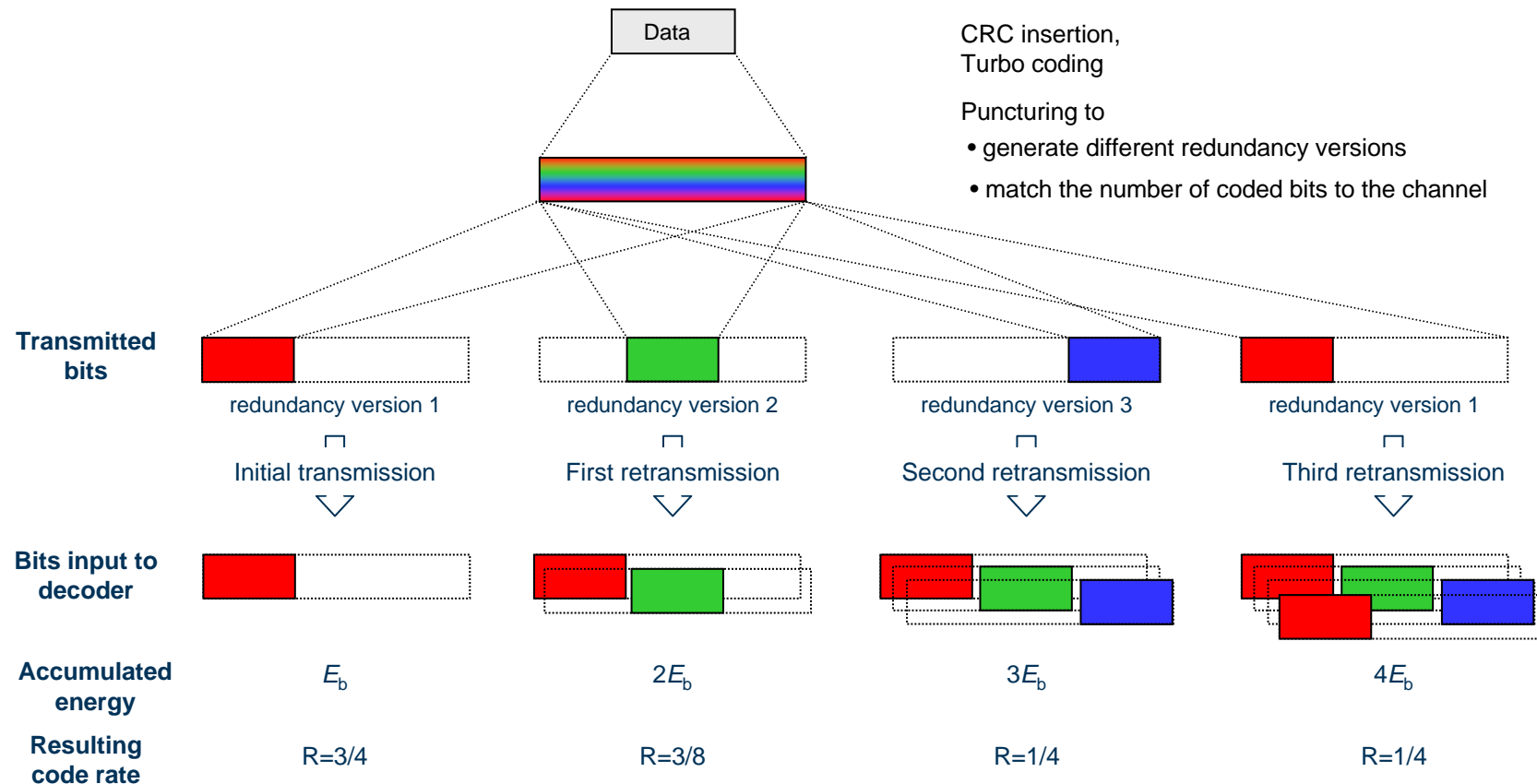




# Hybrid ARQ with Soft Combining

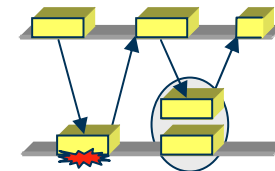
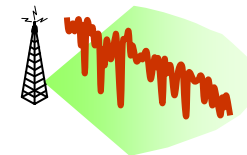
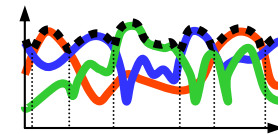
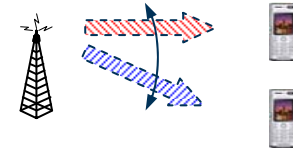


- Incremental redundancy



# Basic Principles – Summary

- Shared channel transmission
- Channel-dependent scheduling
- Rate control
- Hybrid-ARQ with soft combining



# Summary

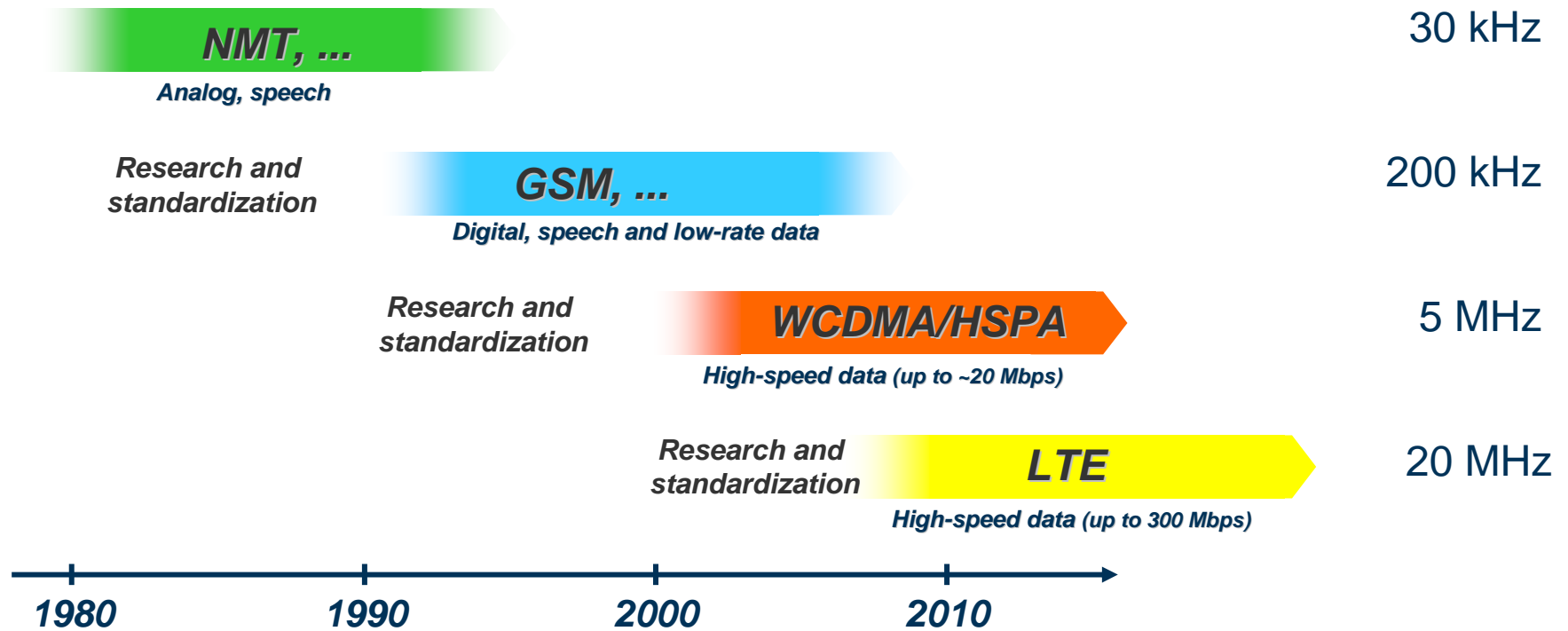
- Radio channel quality is time varying
- Traffic pattern is time varying
- ***Adapt to*** and ***exploit***
  - variations in radio channel quality
  - variations in the traffic pattern...instead of combating them!



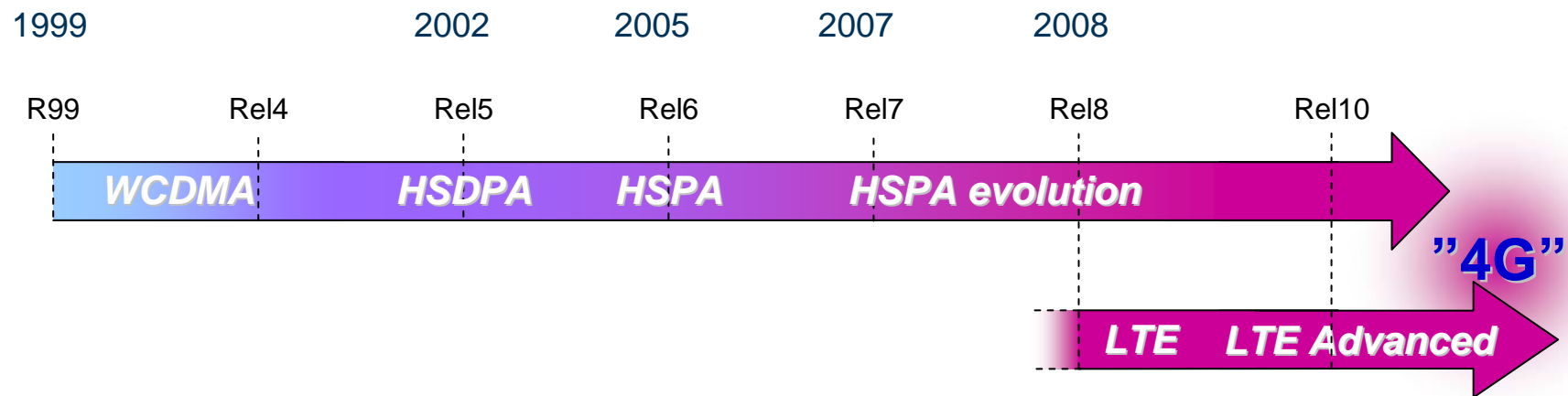
# *Work in 3GPP*



# History



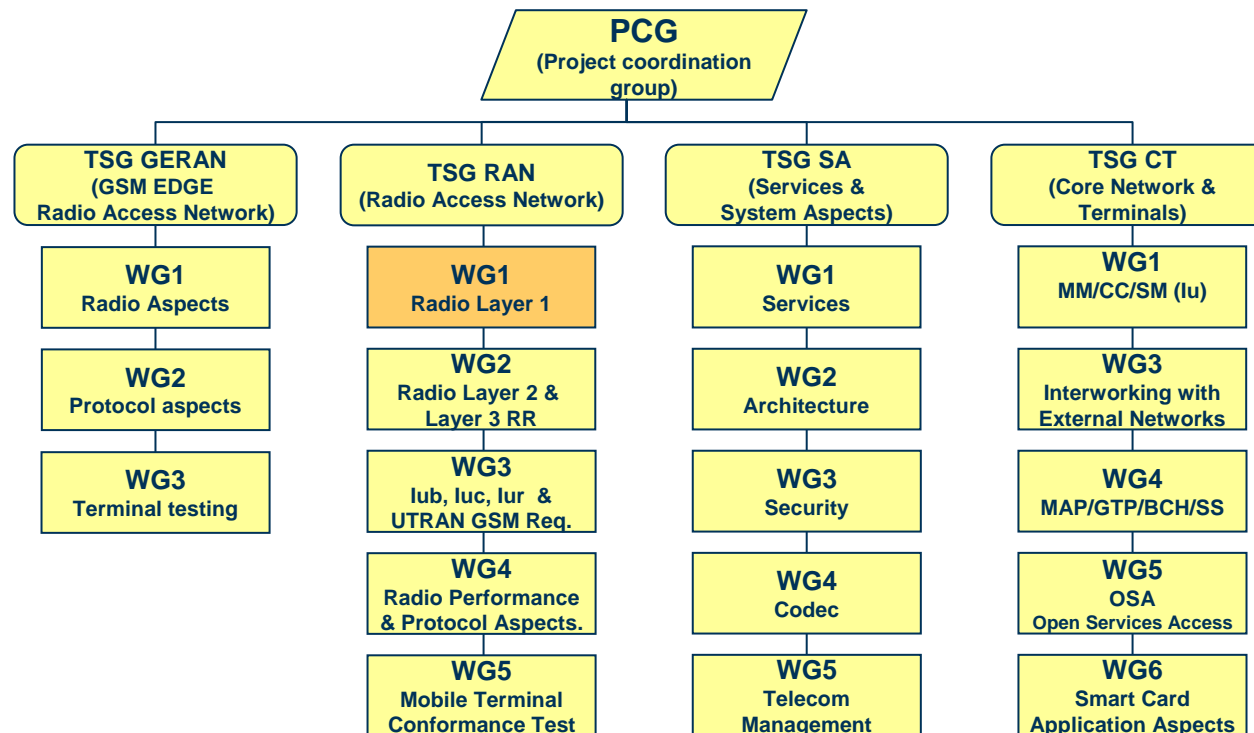
# 3G Evolution



- HSPA evolution
  - gradually improved performance at a low additional cost *in 5MHz spectrum allocation*
- LTE
  - significantly improved performance *in a wide range of spectrum allocations*
  - further evolved into *IMT-Advanced*

# 3GPP

- International organization
  - Vendors and operators co-operate
  - Develop specifications for GSM, WCDMA/HSPA, LTE





# Standardization – a Flying Circus?

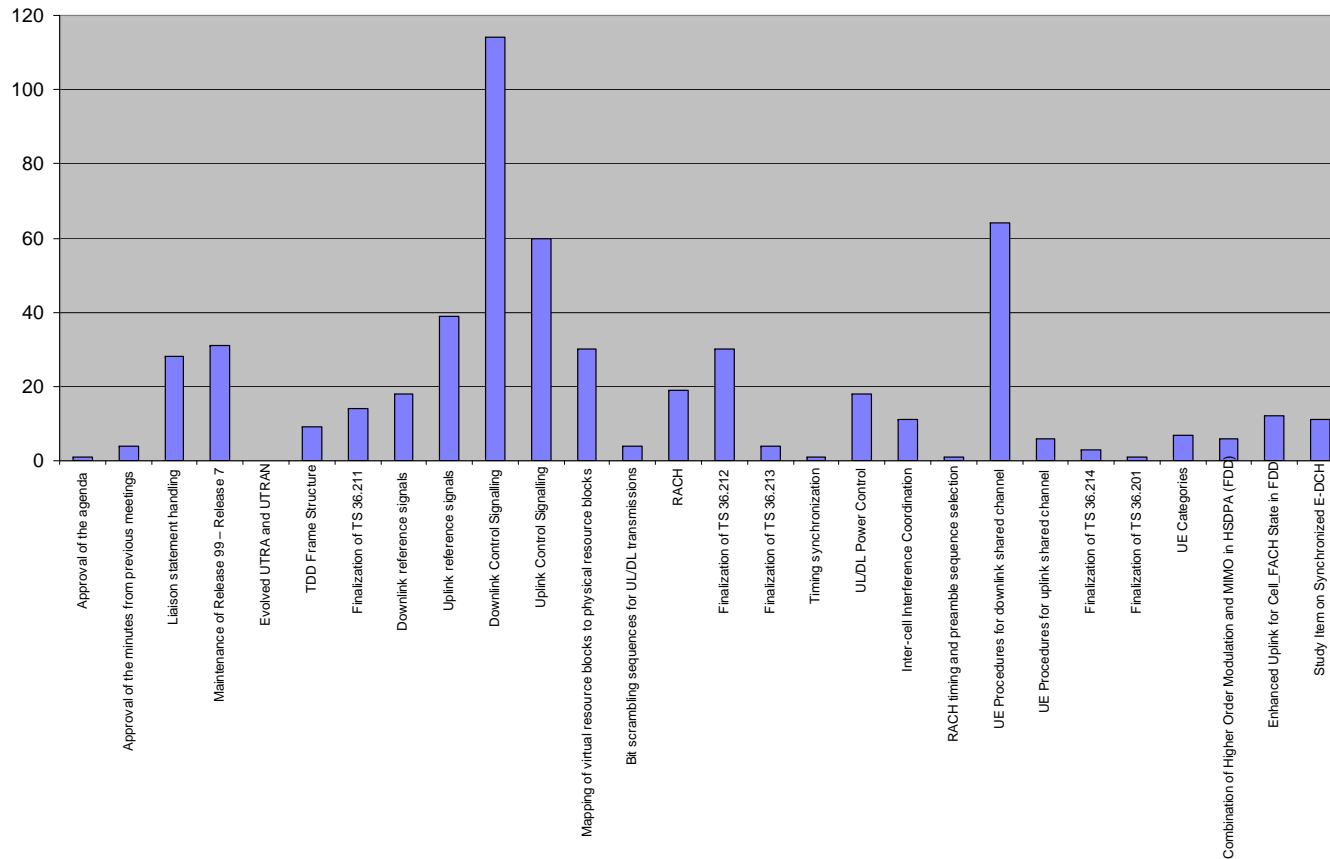
- RAN1 meetings held ~8 times a year
  - Meetings run from Monday to Friday
  - Held in various countries in Europe, North America, and Asia
- Meeting schedule 2007
  - January 15-19, Sorrento, Italy
  - February 12-16, St Louis, USA
  - March 26-30, St Juliens, Malta
  - April 17-20, Beijing, China
  - May 7-11, Kobe, Japan
  - June 25-29, Orlando, USA
  - August 20-24, Athens, Greece
  - October 8-12, Shanghai, China
  - November 5-9, Seoul, Korea



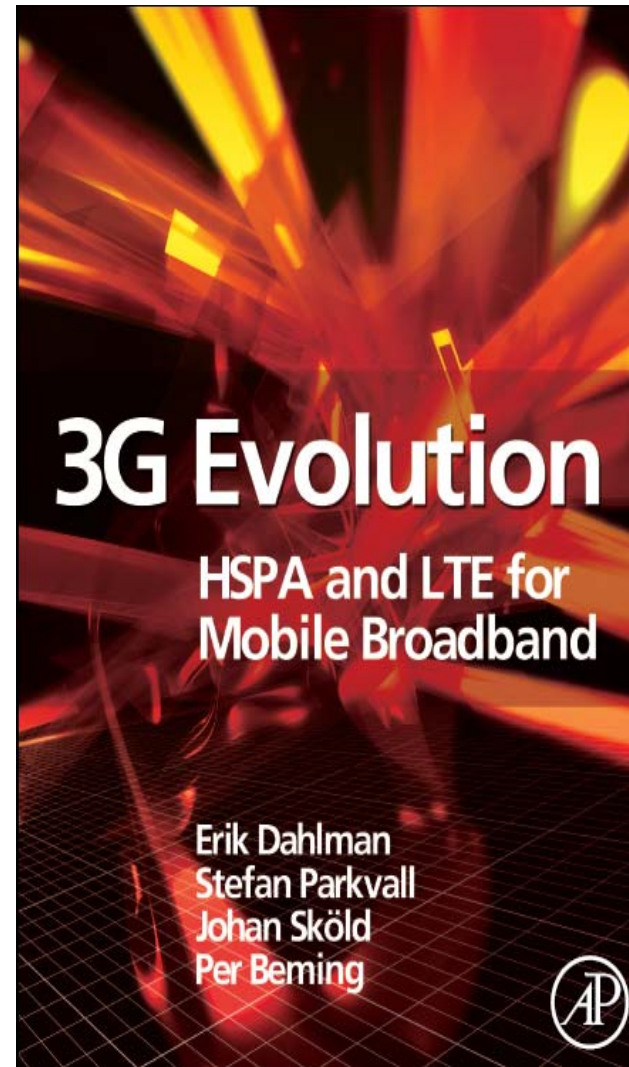
# Typical RAN1 Meeting

- Approx 200 delegates attending and ~550 documents submitted...

Number of Contributions per Agenda Item



# Taking You Forward...



**ERICSSON** 

**TAKING YOU FORWARD**