



Broadband Wireless Access – HSPA and LTE

*Dr Stefan Parkvall
Senior Specialist, Adaptive Radio Access
Ericsson Research*

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
Bästa
 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

LTE

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

maxis.broadband



Maxis Broadband

3Data.

Bis zu 4 Monate gratis surfen!
 Kein Aktivierungsentgelt⁰

Surfen ohne Ende -
 für Power User.

HSDPA
 bis zu
7,2
 Mbit/Sek.



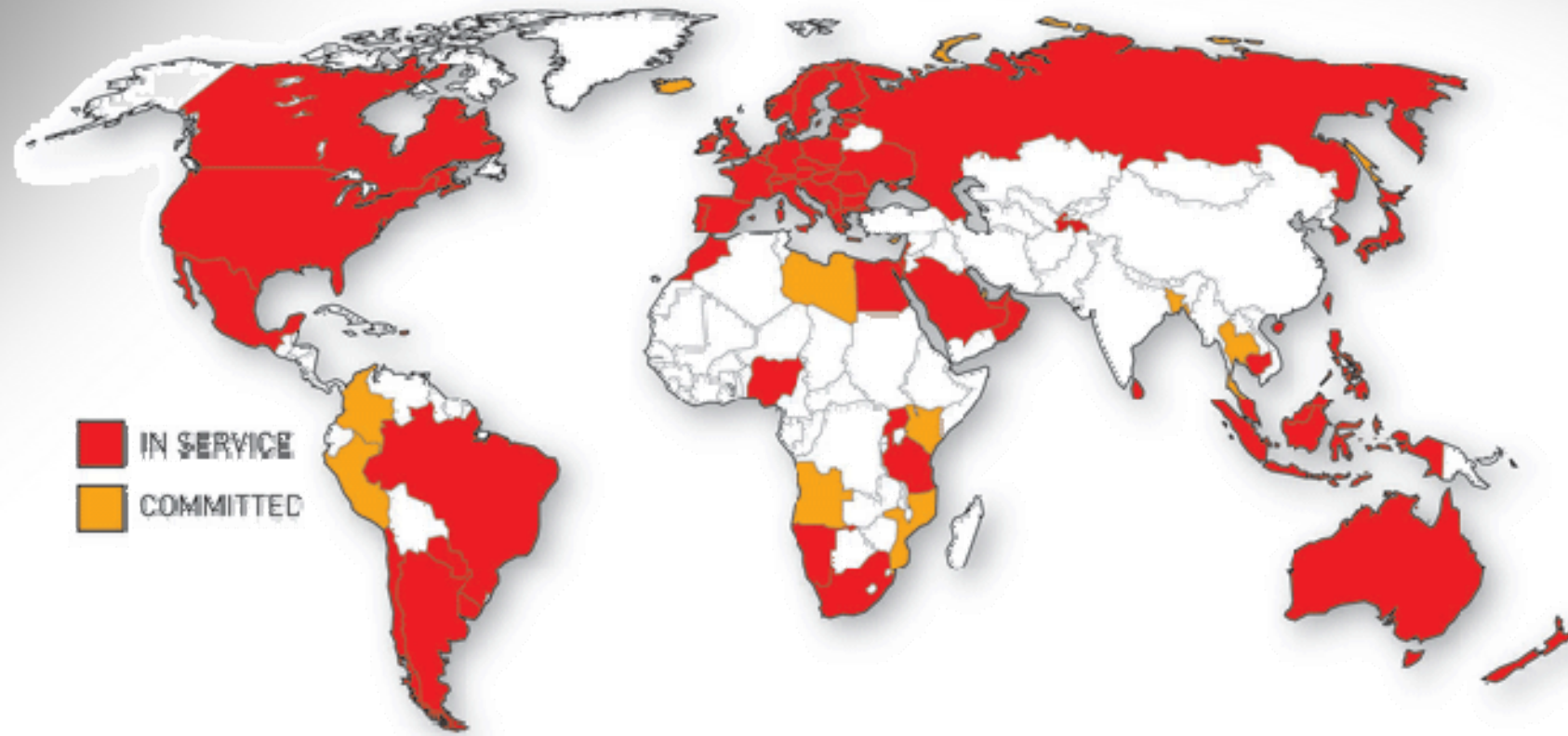
936 HSPA Devices from 120 Suppliers!



Source: GSMA, November 2008

HSPA – *The Global Broadband Standard*

- 278 Operators in 93 Countries



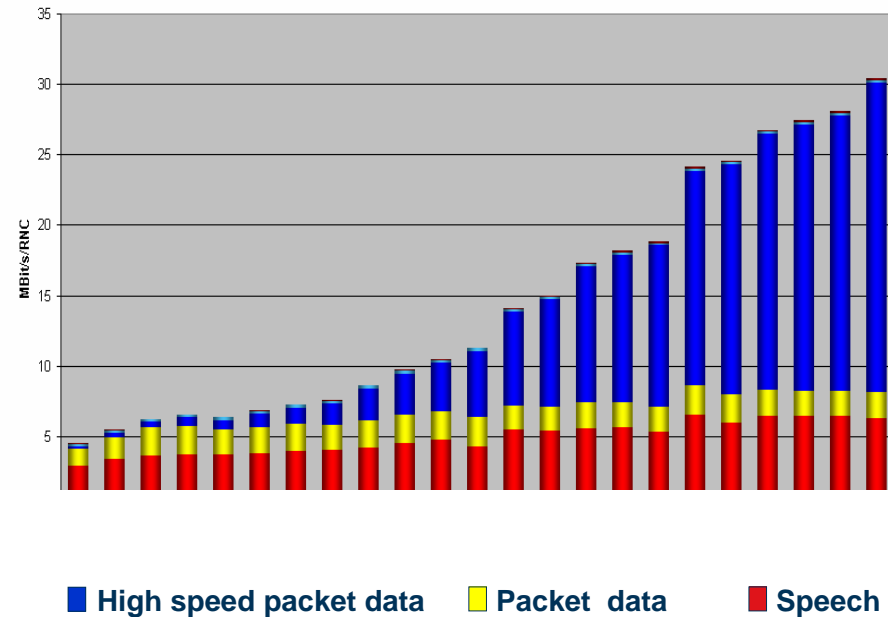
Source: GSMA, November 2008

So...what is HSPA and LTE?

Trend – Data is overtaking Voice

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

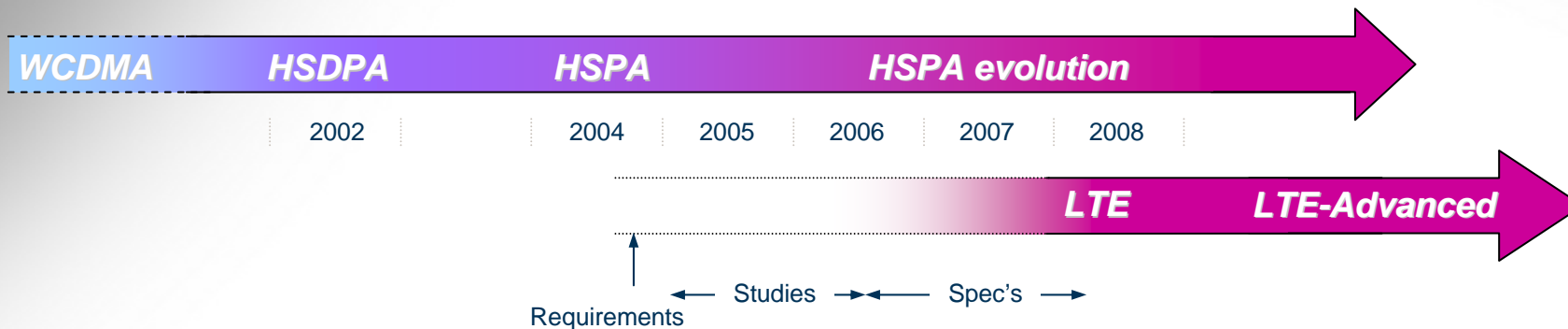
- 4 million new HSPA subscribers per month, 56 million in total
- >240 million WCDMA/HSPA subscribers world wide



Source: GSMA and NetQB, September 2008

HSPA and LTE = Mobile Broadband

- **HSPA – High-Speed Packet Access**
 - Evolution of 3G/WCDMA to enhance packet-data support
 - Gradually improved performance at a low additional cost
 - Data rates up to ~40 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
 - Takes Mobile Broadband into IMT-Advanced ("4G")

Different systems – but many basic principles are similar!

Wireless vs Wireline

- Wireless seems simple...

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

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

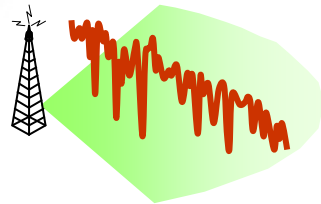
$$\nabla \times \mathbf{E} = - \frac{\partial \mathbf{B}}{\partial t}$$

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

- ...so what's the problem?

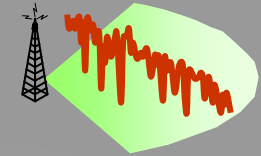
Radio Channels and Packet Data

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

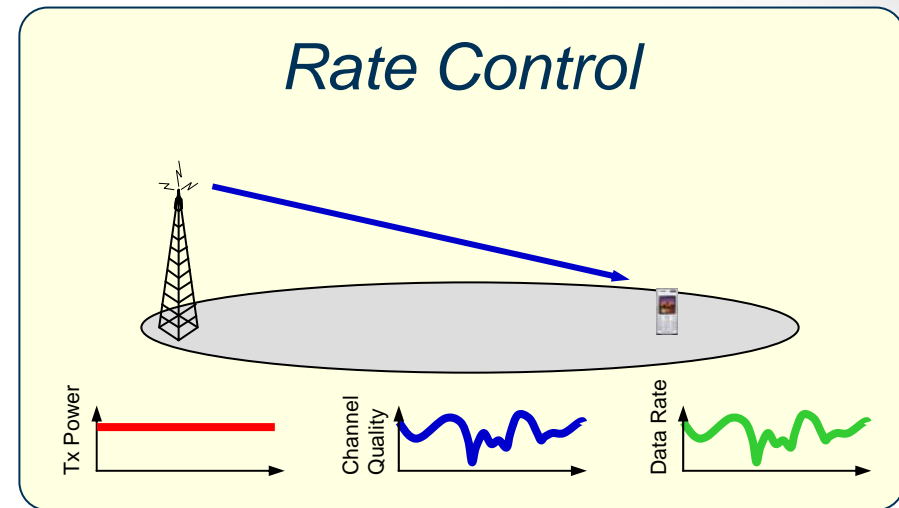
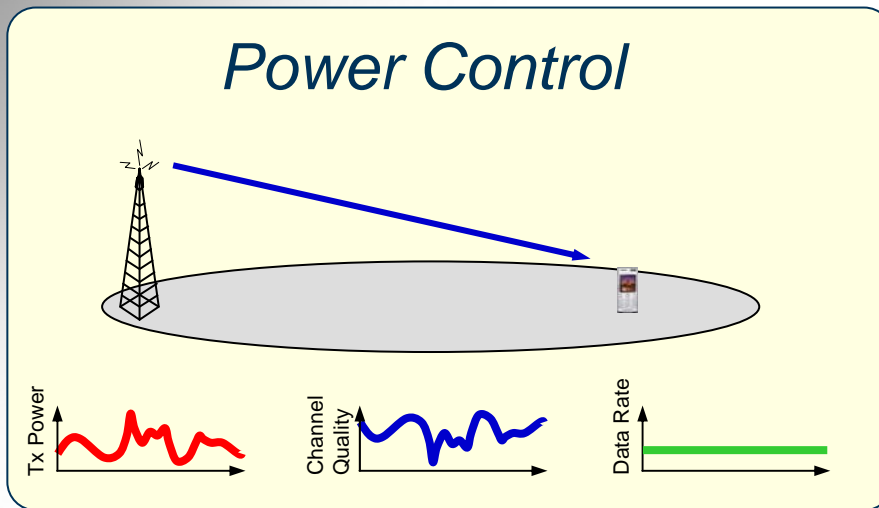


Adapt to and exploit channel and traffic variations!

Rate Control



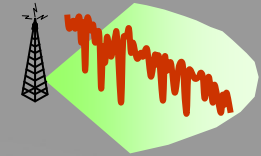
- Reliable reception requires a certain E_b/N_0
- How to control E_b ?
 - $E_b = P \cdot T$



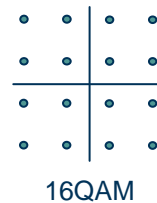
- Varying instantaneous data rate acceptable for packet-data services
 - *Rapid – tracks fast fading*

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

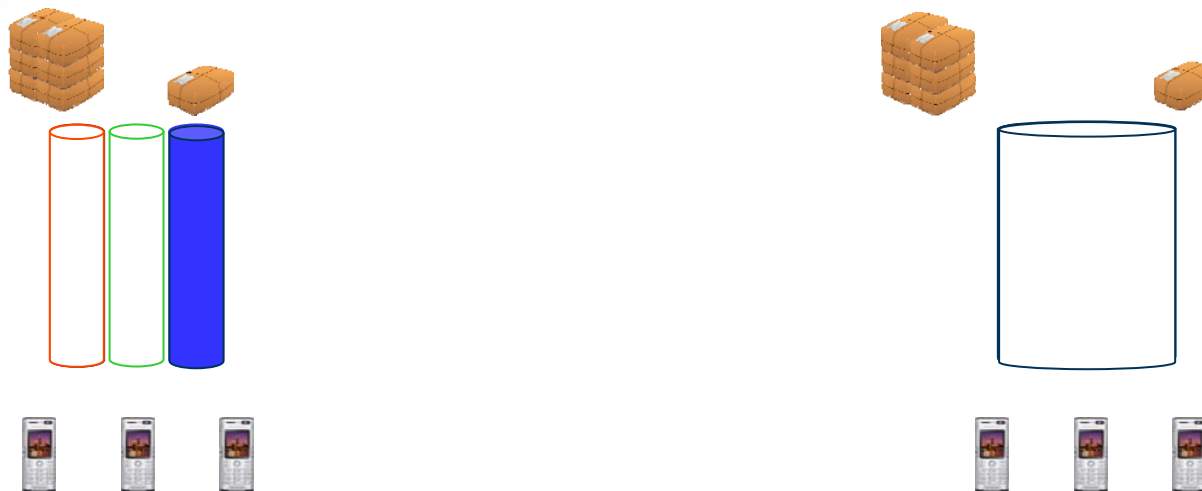
Shared-Channel Transmission

- **Dedicated channel**

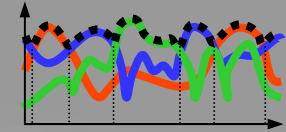
- *User resources assigned at "call setup"*
- *Independent of instantaneous traffic situation*

- **Shared channel**

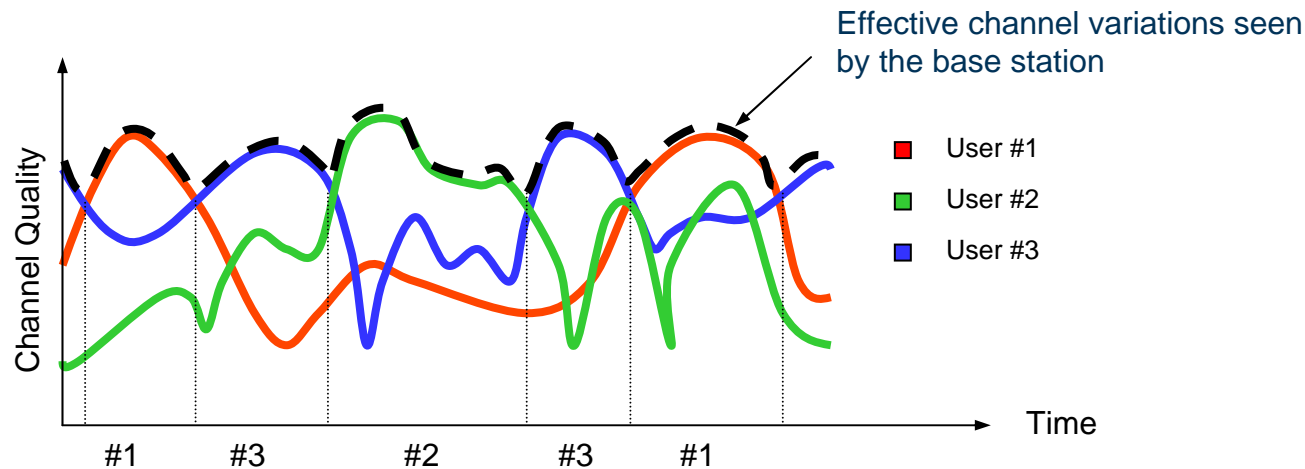
- *Dynamic sharing of common resource*
- *Adapts to instantaneous traffic situation*



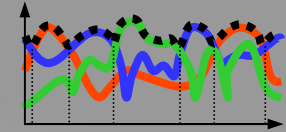
Channel-dependent Scheduling



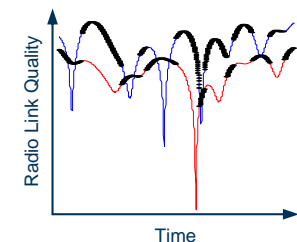
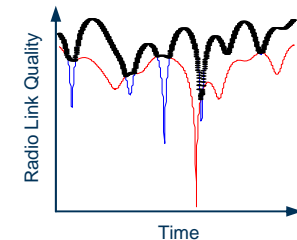
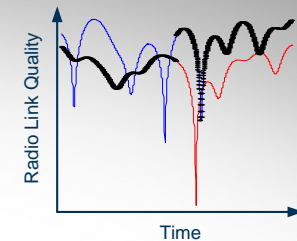
- Scheduling determines at each time instant...
 - ...to whom to assign the shared channel
 - ...which data rate to use
- Basic idea: transmit at fading peaks
 - May lead to large variations in data rate between users
 - Tradeoff: fairness vs cell throughput



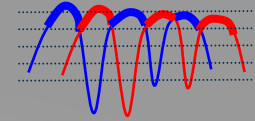
Channel-dependent Scheduling



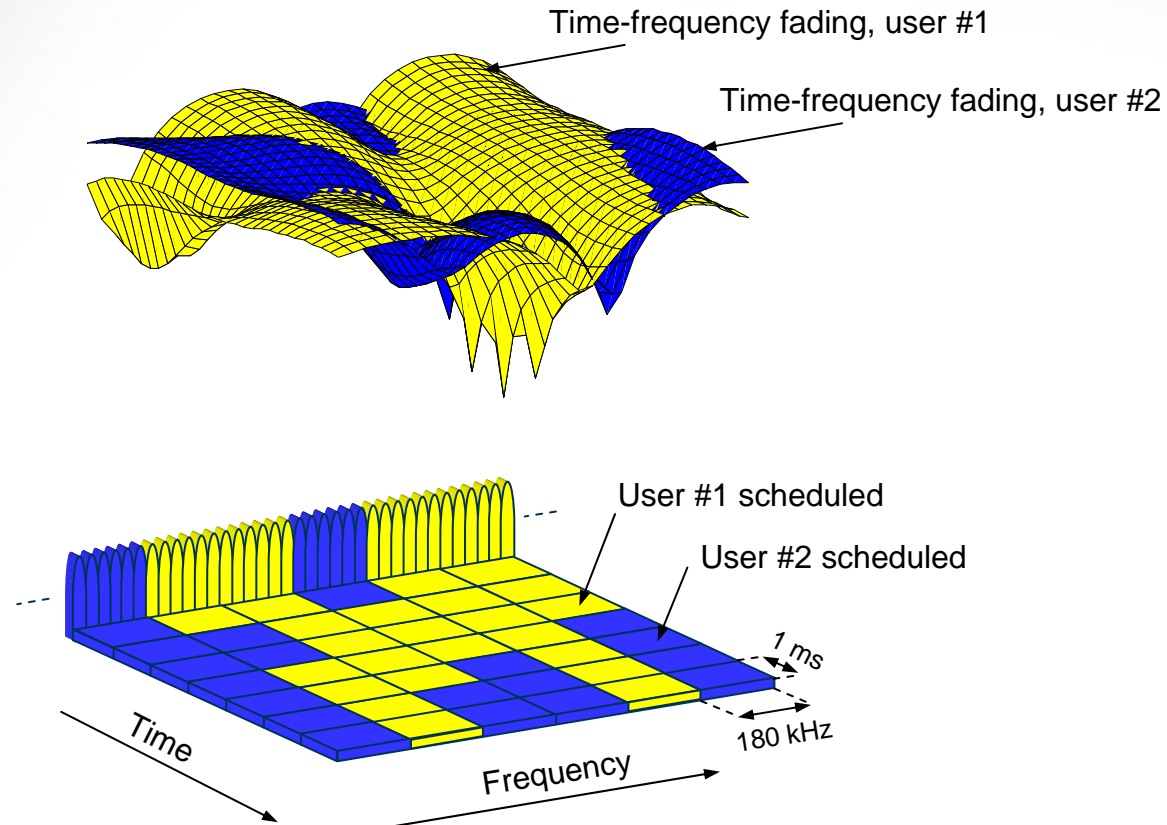
- Round Robin (RR)
 - *Cyclically assign the channel to users without taking channel conditions into account*
 - *Simple but poor performance*
- Max C/I
 - *Assign the channel to the user with the best channel quality*
 - *High system throughput but not fair*
- Proportional Fair (PF)
 - *Assign the channel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



Channel-dependent Scheduling



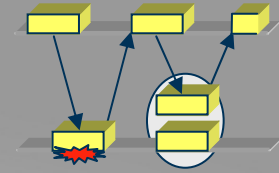
- HSPA – channel-dependent scheduling in time-domain only
- LTE – channel-dependent scheduling in time *and* frequency domains



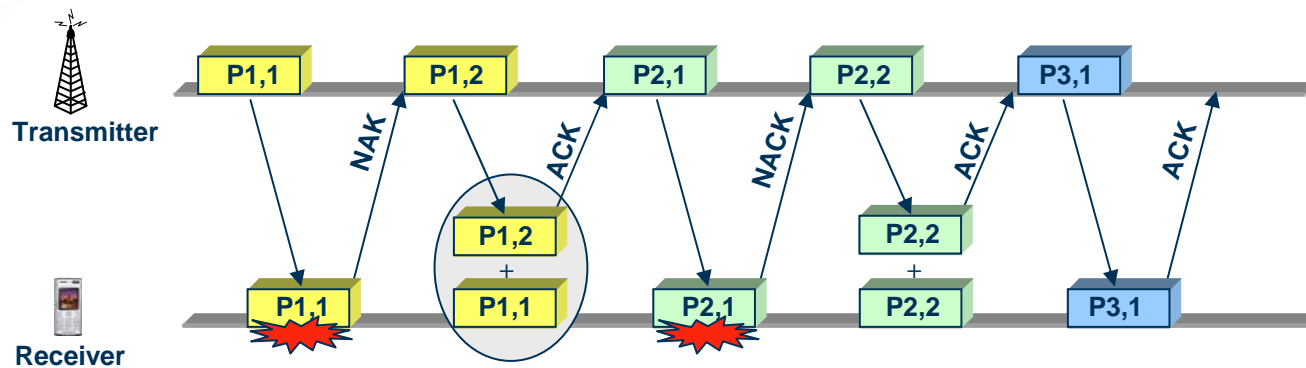
Channel Quality Indication

- 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*

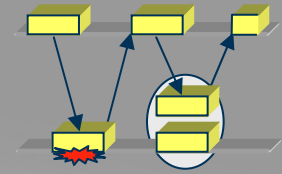
Hybrid ARQ with Soft Combining



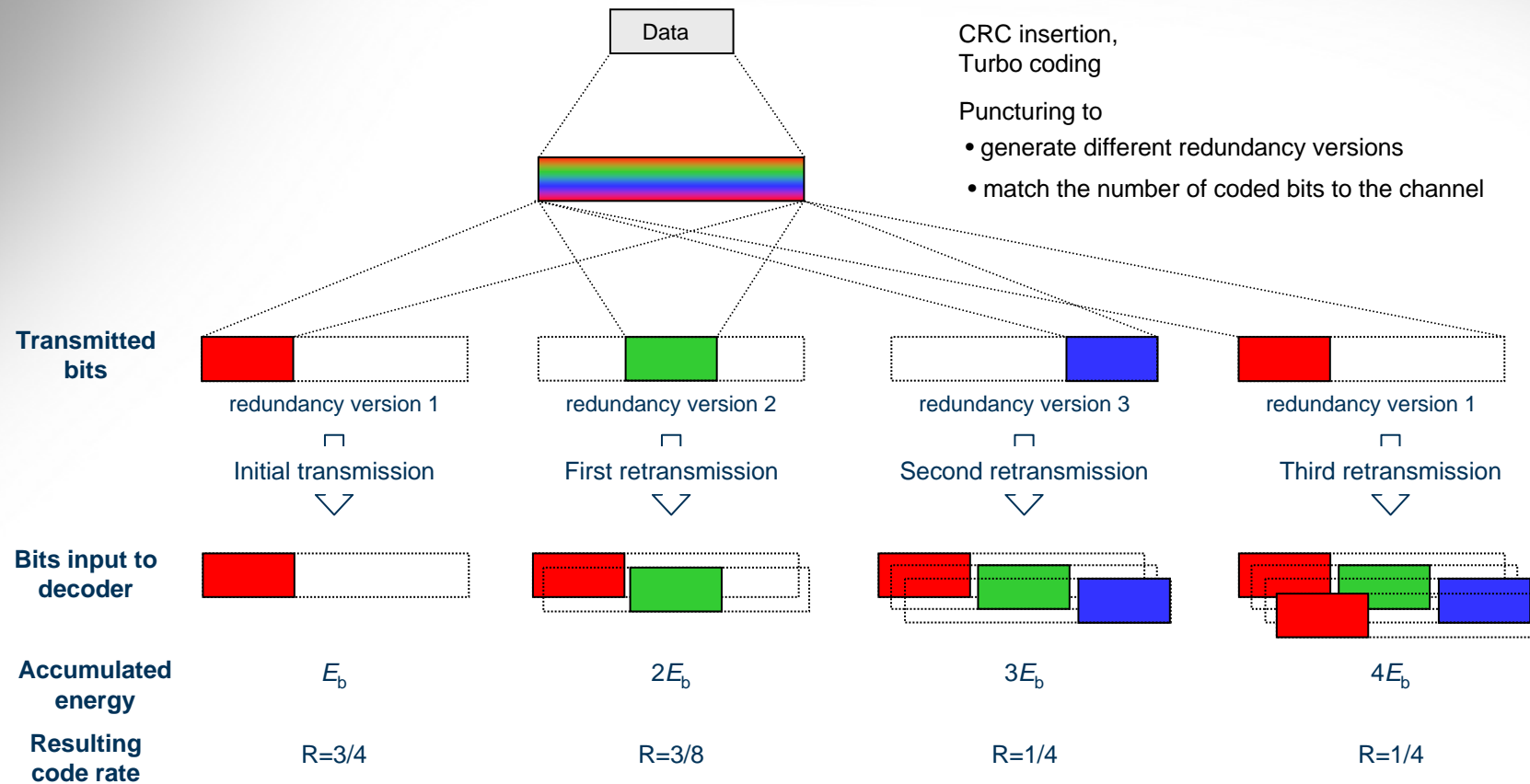
- Retransmission of erroneously received packets
 - *Fast* ➔ *no disturbance of TCP behavior*
- Soft combining of multiple transmission attempts
 - *Soft combining* ➔ *improved performance*



Hybrid ARQ with Soft Combining

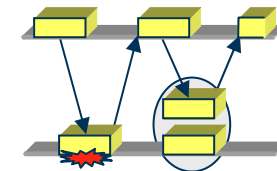
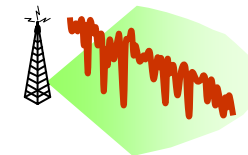
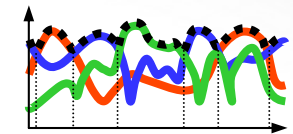


- Incremental redundancy



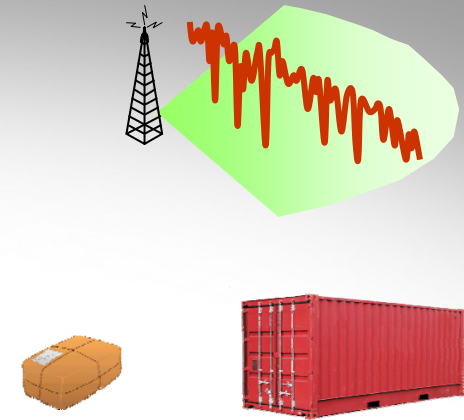
Basic Principles – Summary

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



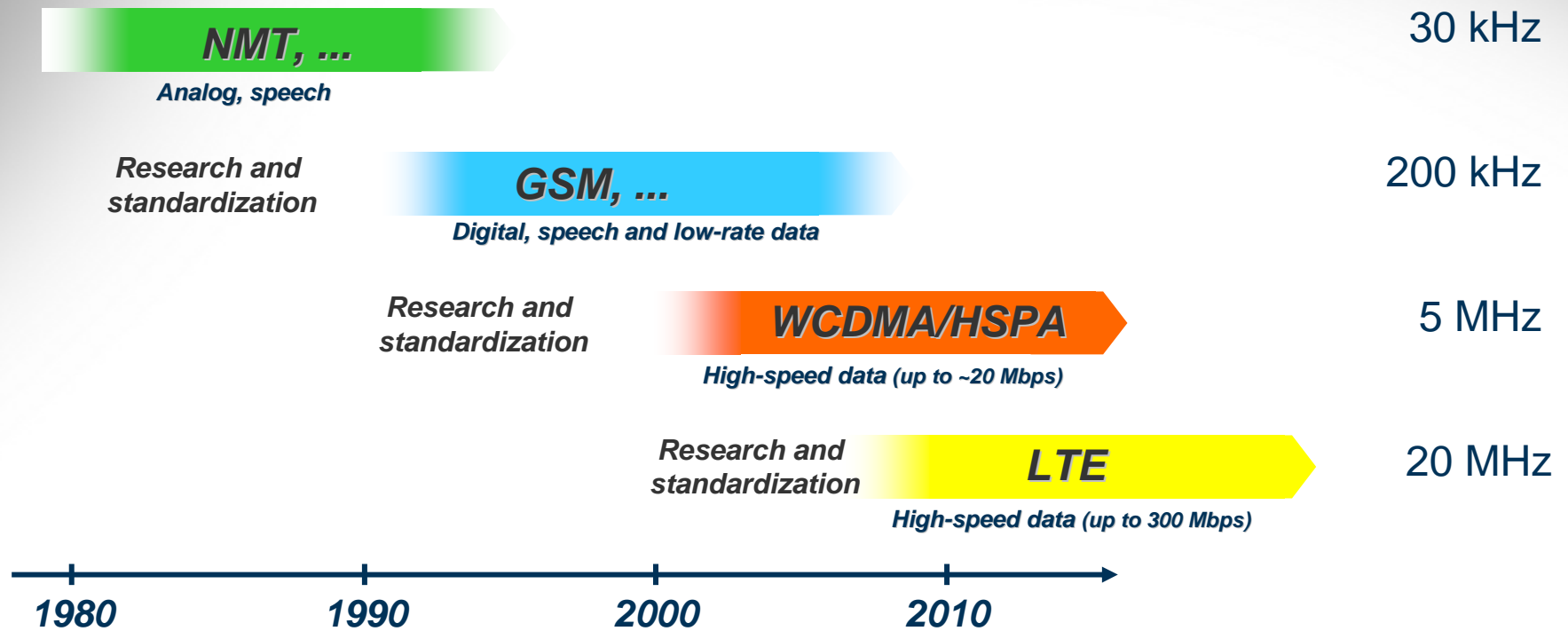
Summary

- 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!

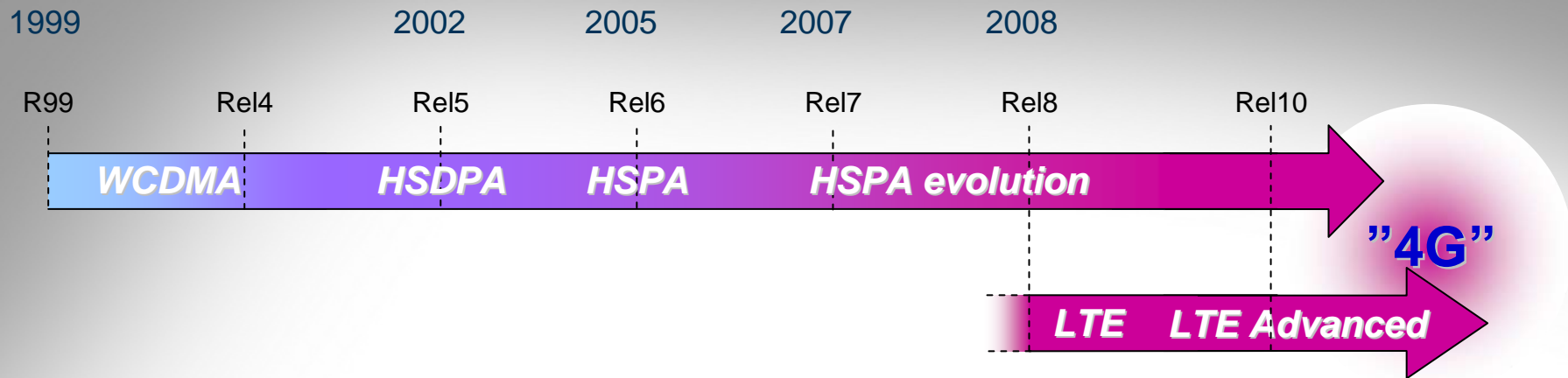


Work in 3GPP

History



3G Evolution



- HSPA evolution

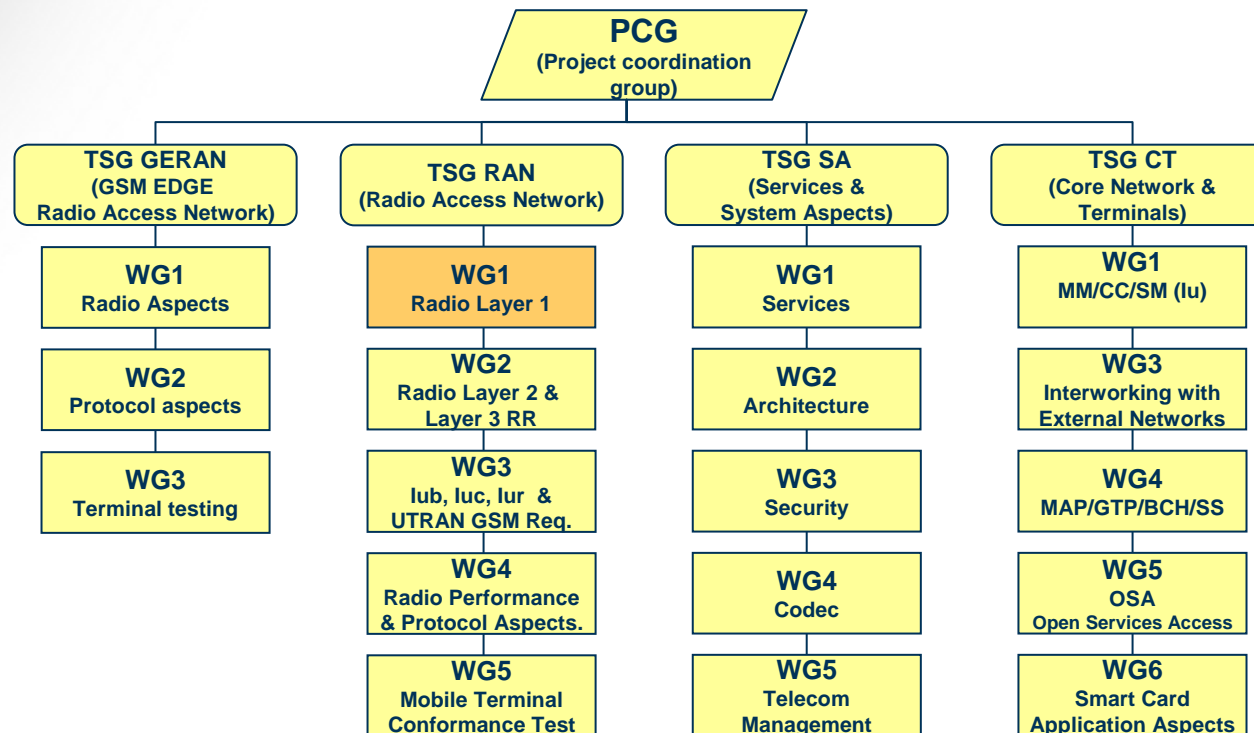
- *gradually improved performance at a low additional cost in 5MHz spectrum allocation*

- 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

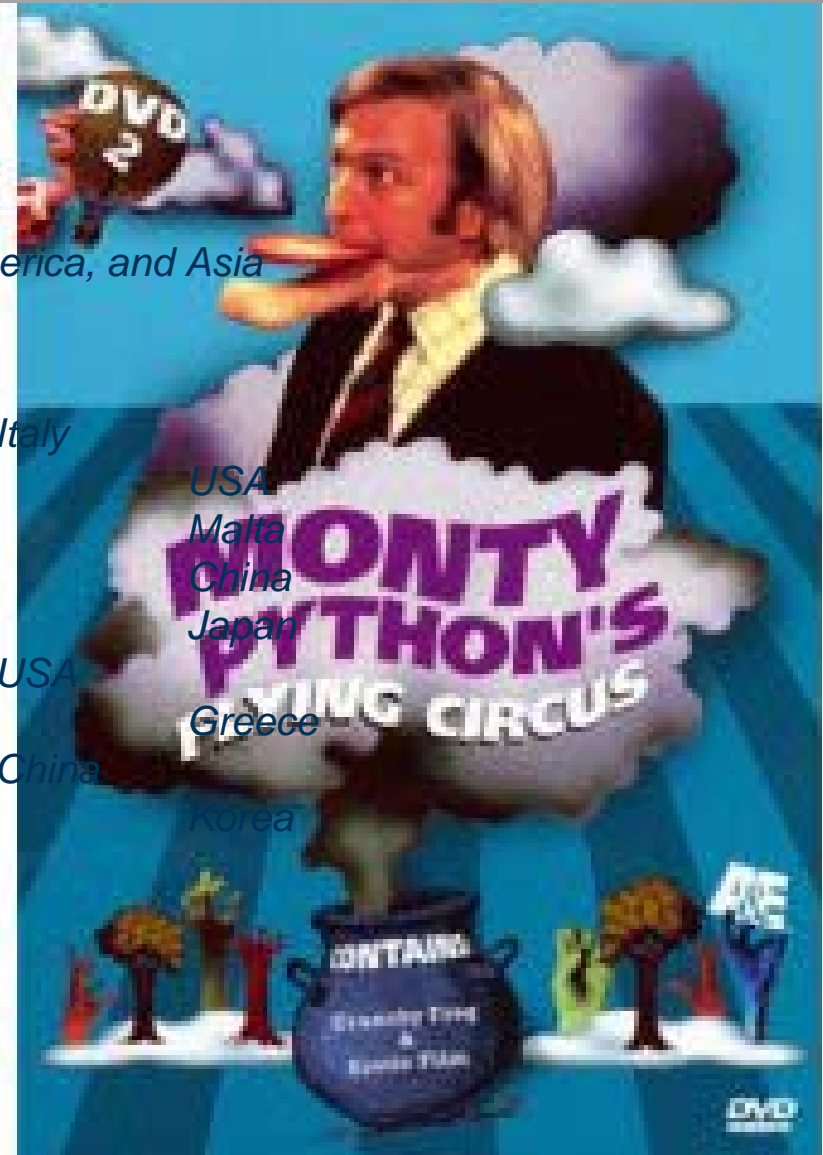


Standardization – a Flying Circus?

- 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

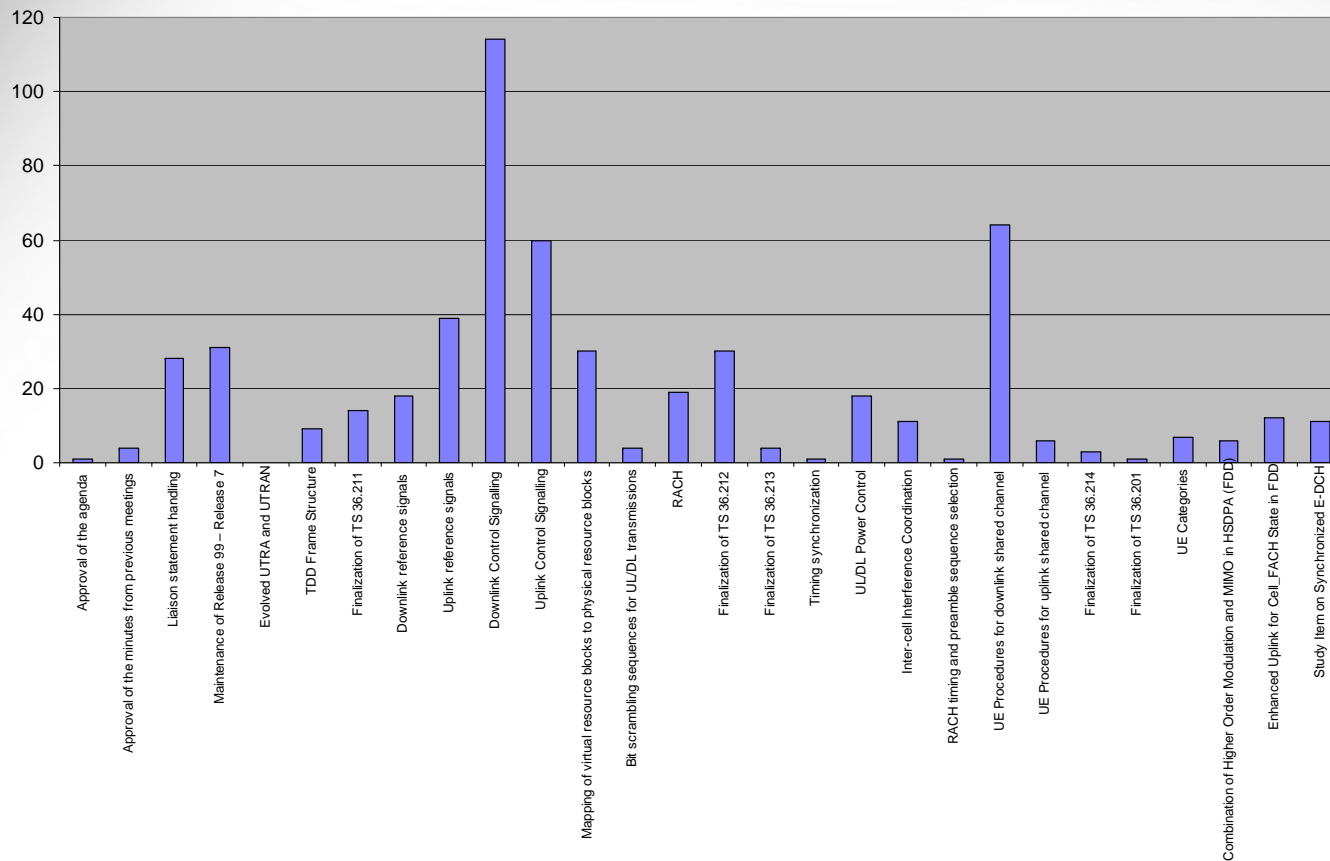
- January 15-19, Sorrento, Italy
- February 12-16, St Louis, USA
- March 26-30, St Juliens, Malta
- April 17-20, Beijing, China
- May 7-11, Kobe, Japan
- June 25-29, Orlando, USA
- August 20-24, Athens, Greece
- October 8-12, Shanghai China
- November 5-9, Seoul, Korea



Typical RAN1 Meeting

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

Number of Contributions per Agenda Item



Thank You for the Attention!

For further details...

