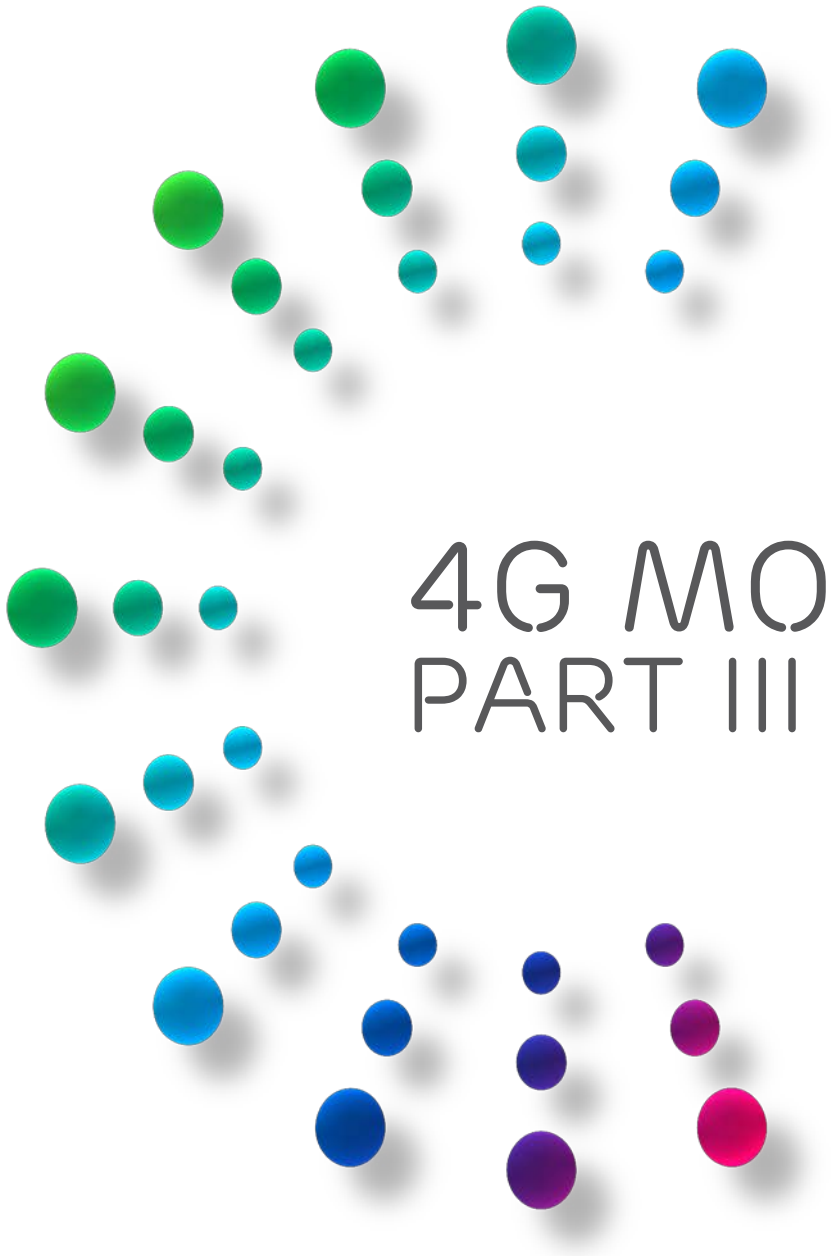

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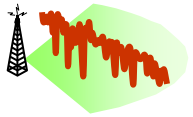
4G MOBILE BROADBAND – LTE
PART III

Dr Stefan Parkvall
Principal Researcher
Ericson Research

RECAP

› Fundamental principle – *adapt to* and *exploit* variations in…



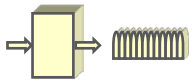
…radio channel quality

…traffic pattern

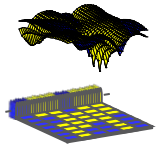
› LTE - some building blocks

Bandwidth flexibility

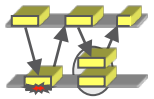
FDD *and* TDD



OFDM



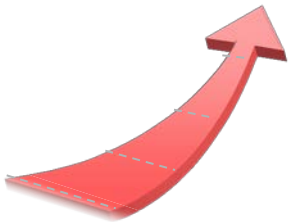
Scheduling



Hybrid ARQ

Multi-antenna

› Evolution continues



OUTLINE

Series of three seminars

I. Basic principles
- Channel and traffic behavior
- Link adaptation, scheduling, hybrid-ARQ
- Evolving 3G, inclusion of basic principles in WCDMA

II. LTE
- First step into 4G
- Path towards IMT-Advanced

III. Standardization
- How are HSPA and LTE created?
- 3GPP, ITU, ...

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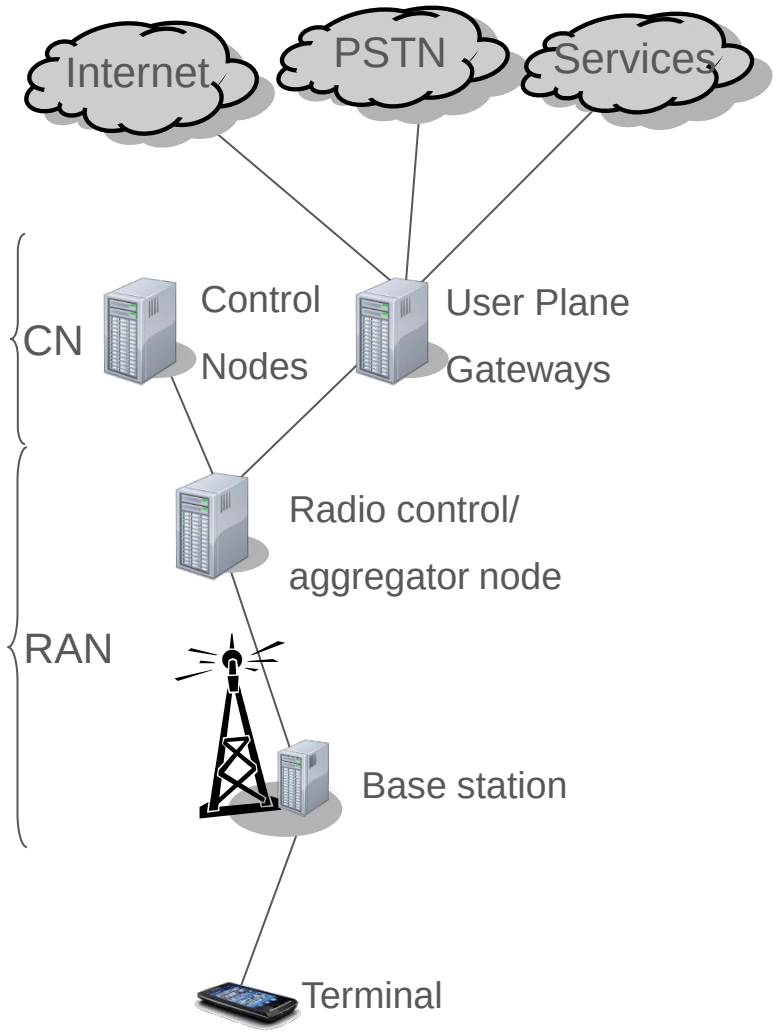
STANDARDIZATION
WHY, WHAT, WHERE, HOW?

WHY STANDARDIZATION?

- From Wikipedia
  - Standardization is the process of agreeing on technical standards
  - A standard is a document that establishes uniform engineering or technical specifications, criteria, methods, processes, or practices.
  - Standards can be
    - de facto standards – informal convention or dominant usage
    - de jure – legally binding contracts, laws or regulations
    - voluntary – published and available to consider for use
  - The goals of standardization can be to help with independence of single suppliers (commodification), compatibility, interoperability, safety, repeatability, or quality.
- Interoperability – e.g. Nokia phone in Ericsson network
- Creates mass market! Economy of scale!

WHAT IS STANDARDIZED?



Standardized – ensures interoperability

- Logical architecture
- Protocol on interfaces
- Radio transmitters (RF aspects)
  - required by regulations/law
- Behavior required to fulfill functionality
  - Terminals standardized according to ”master-slave principle”

Not standardized – vendor differentiation

- Physical implementation
- Algorithms
  - Scheduler, handover, admission, ...
  - Receiver algorithms – sufficient to fulfill requirements

WHERE – SOME FORA

- Standard Developing Organizations
  - Non-profit industrial organizations
  - Develops technical standards
  - Global/Regional/National

- Regulatory bodies
  - Governmental organizations
  - Spectrum usage, frequency management
  - Placing products on the market

- Industry fora
  - Promoting and lobbying for specific technologies

WHERE – SOME FORA

- 3GPP
  - Core Network and Radio Access Network for WCDMA/HSPA, LTE, GSM/GPRS/EDGE

- 3GPP2
  - Standardization of IS-95, cdma2000/HRPD

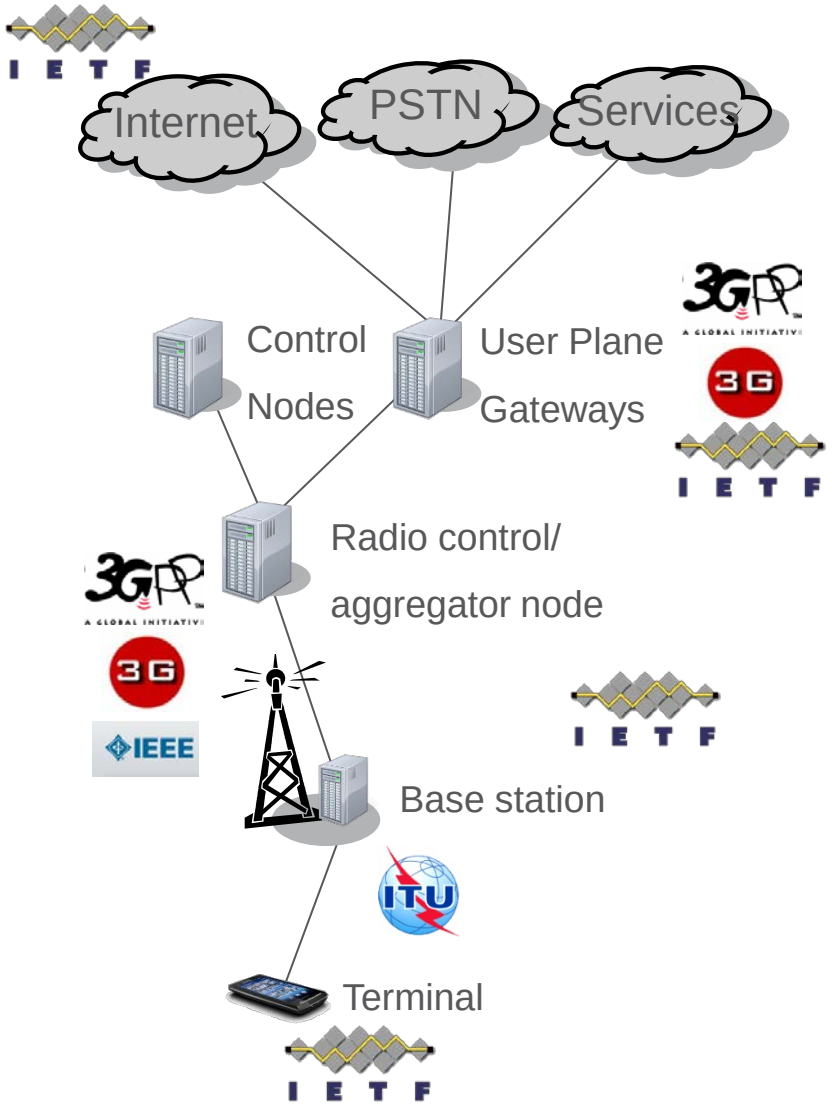
- IEEE
  - Large variety of stds, e.g. 802.11 (WiFi) and 802.16 (WiMAX)

- WiMAX Forum
  - Promote conformance and interoperability of 802.16 standards

- IETF
  - Develops/promotes internet standards (IP, TCP, FTP, ROHC, …)

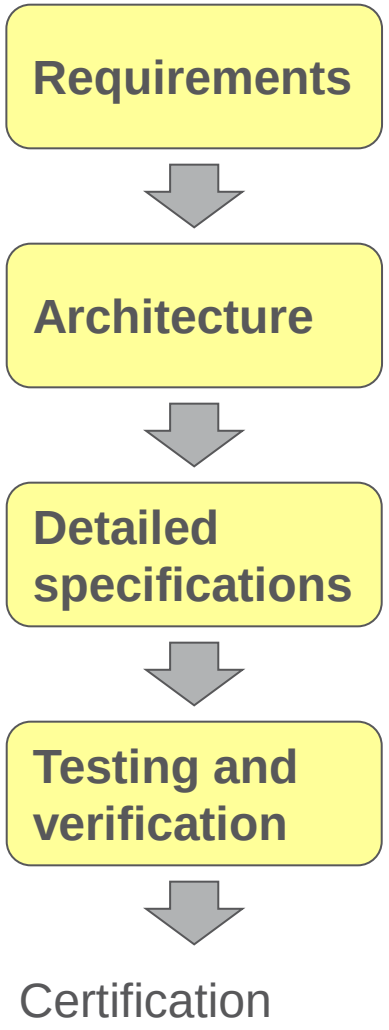
- ITU
  - International radio and telecommunications standards, allocation of spectrum. Part of UN.

WHERE IN THE NETWORK?



- IETF
  - Internet services/protocols end-to-end with the terminal (IP, TCP, …)
  - Transport protocols/functions in the CN (IP, MIP)
- 3GPP, 3GPP2
  - Architecture, functions, protocols for the complete RAN and CN
- IEEE
  - Architecture, functions, protocols for Radio Access Network
- ITU
  - Spectrum, radio regulations

STANDARDIZATION PROCESS



- Stage 1
  - Requirements, no detailed solutions
- Stage 2
  - Logical architecture, functional split, interfaces, protocol architecture, overall solutions
- Stage 3
  - All details, e.g., header formats, exact coding scheme, values in requirements, ...
- Test
  - Snapshots with test cases from standard to ensure proper operation

ITU

- United Nations agency for information and communication technologies
- Founded 1865
  - Second oldest international organization still in operation
- Main tasks
  - Standardization
  - Allocation of radio spectrum
  - Organizing interconnection arrangements to allow international phone calls

ITU SECTORS

- ITU-R
  - Management of radio-frequency spectrum and satellite orbits
    - fixed, mobile, broadcasting, amateur, meteorology, global positioning, systems, environmental monitoring, services that ensure safety of life
- ITU-T
  - International standards covering all fields of telecommunications
    - IP interworking, network aspects of mobility, network access technologies (xDSL), optical networking, technologies, service quality measurements and models
- ITU-D
  - Responsible for creating policies, regulation and providing training programs and financial strategies in developing countries

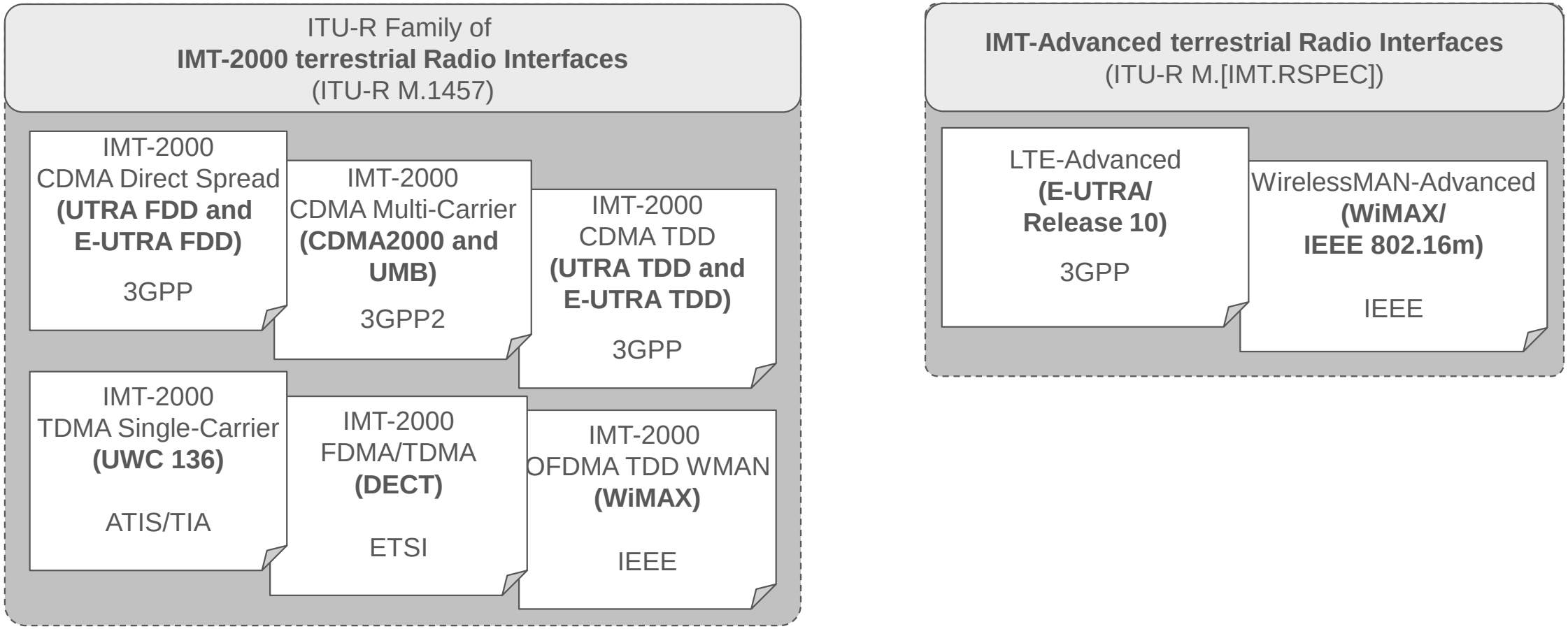
ITU-R

- Radio regulations
  - allocation of different frequency bands
    - WRC -93, -95, -97, -00, -03, -07, ...
  - mandatory technical parameters to be observed

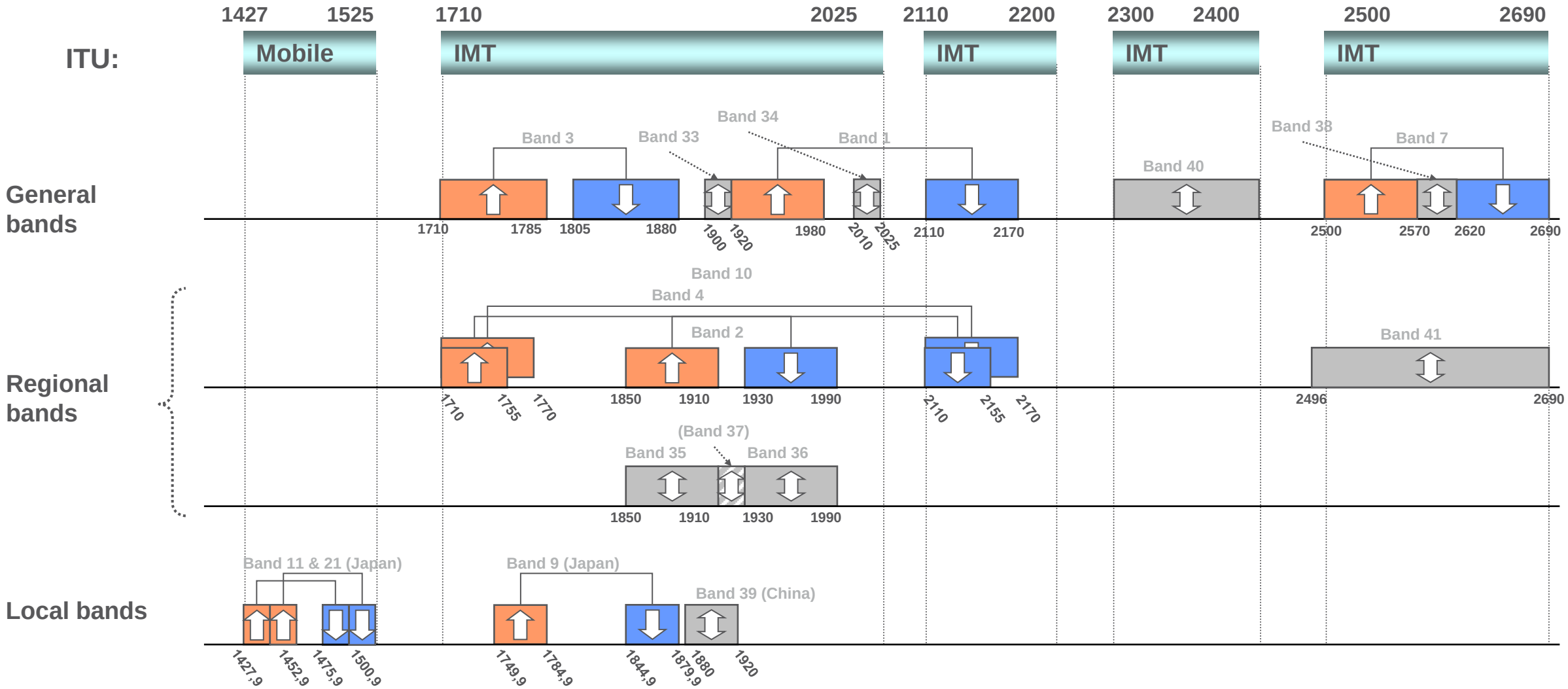
- Reports

- Recommendations
  - Approves standards fulfilling the ITU requirements
    - Specifications developed outside ITU (e.g. in 3GPP)
  - Examples of ITU-R families of standards
    - IMT-2000
    - IMT-Advanced

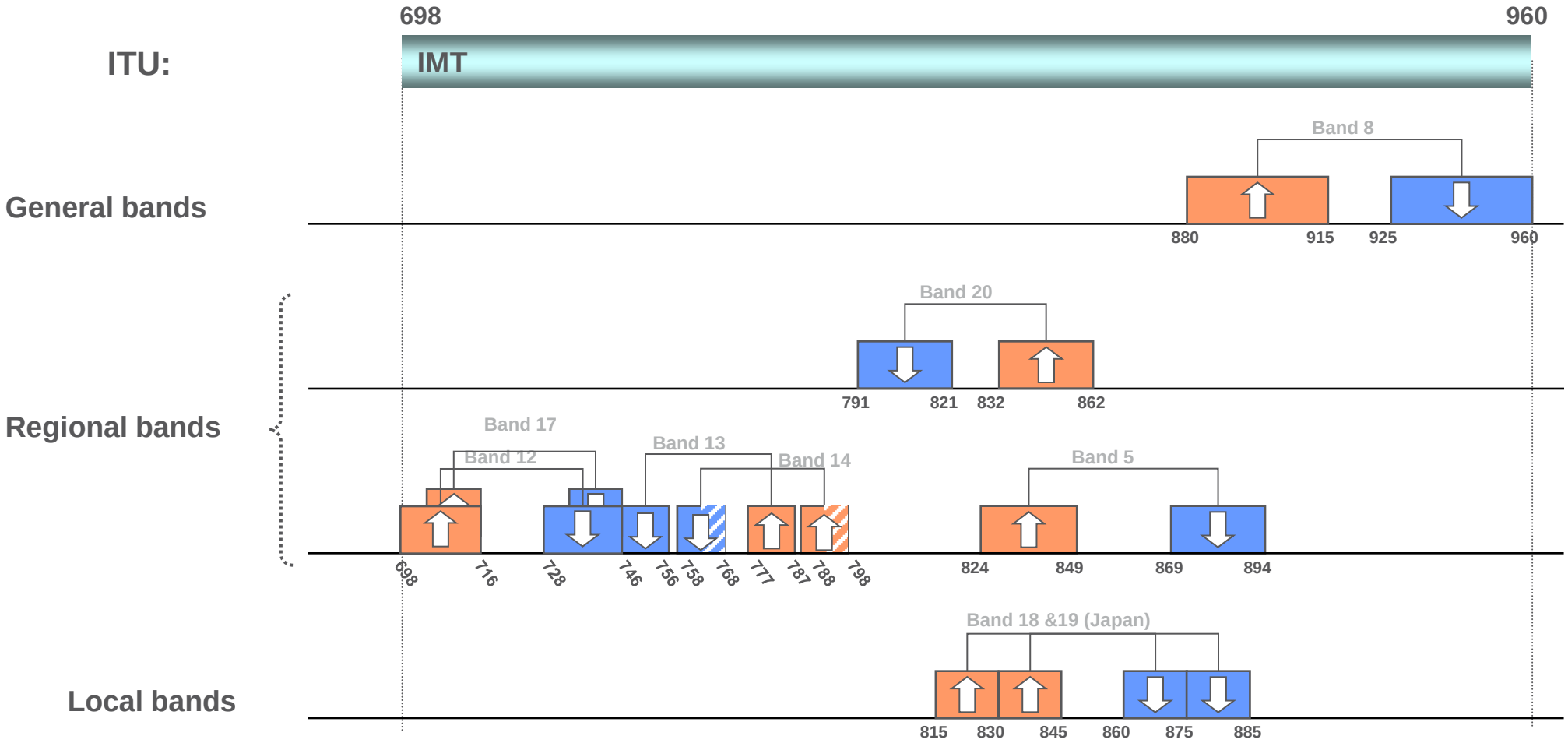
IMT RADIO INTERFACES



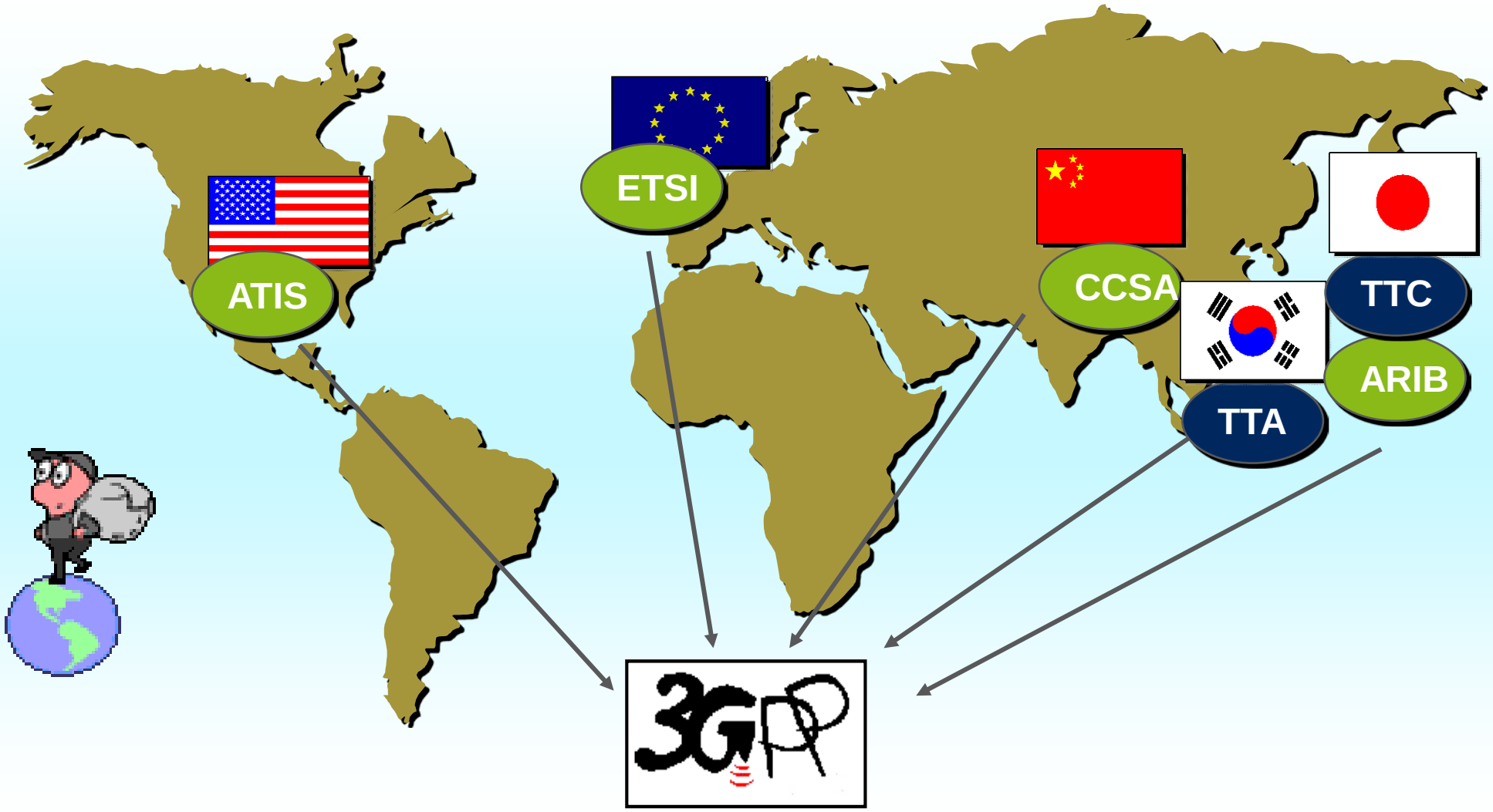
IMT SPECTRUM



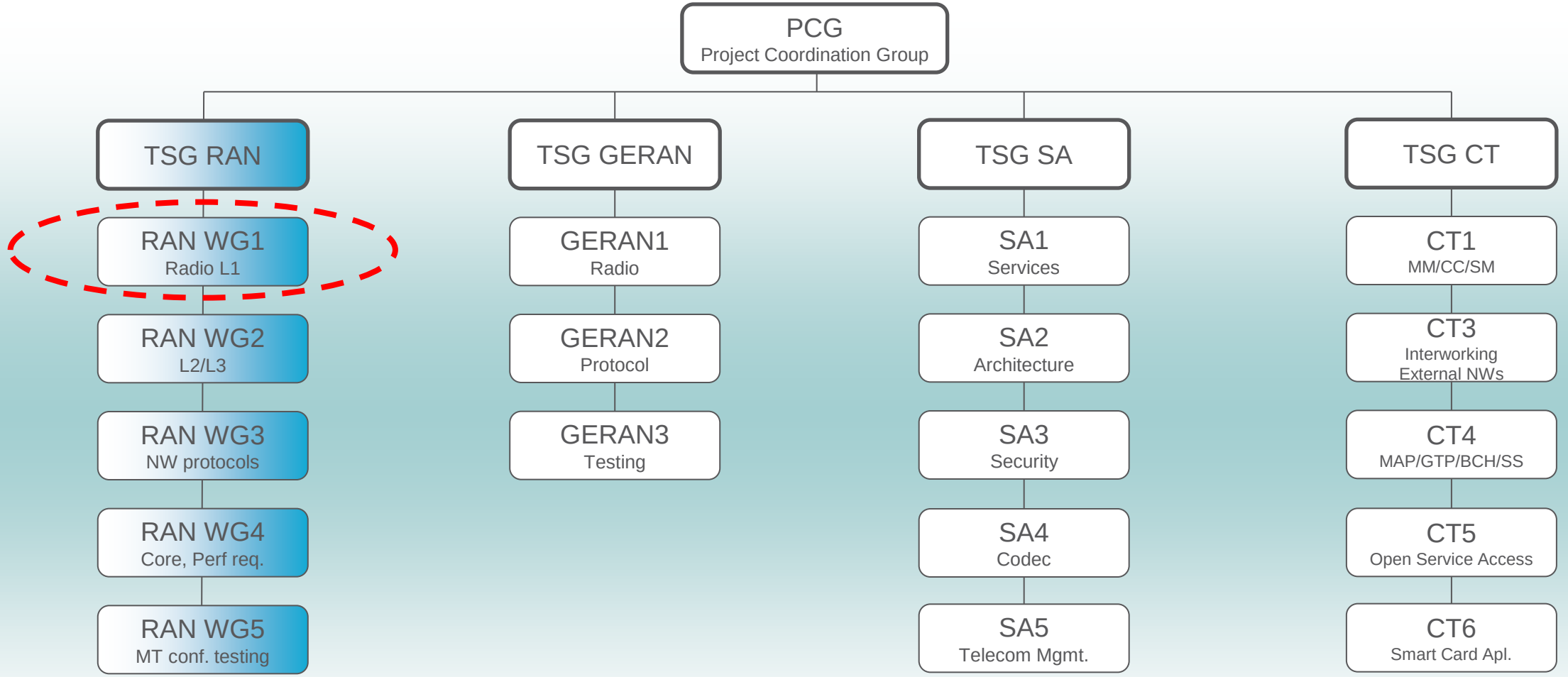
IMT SPECTRUM



3GPP ORGANIZATIONAL PARTNERS



3GPP ORGANIZATION



WCDMA/HSPA and LTE

GSM/GPRS

Services,
Overall System

Core Network

STANDARDIZATION – A FLYING CIRCUS?

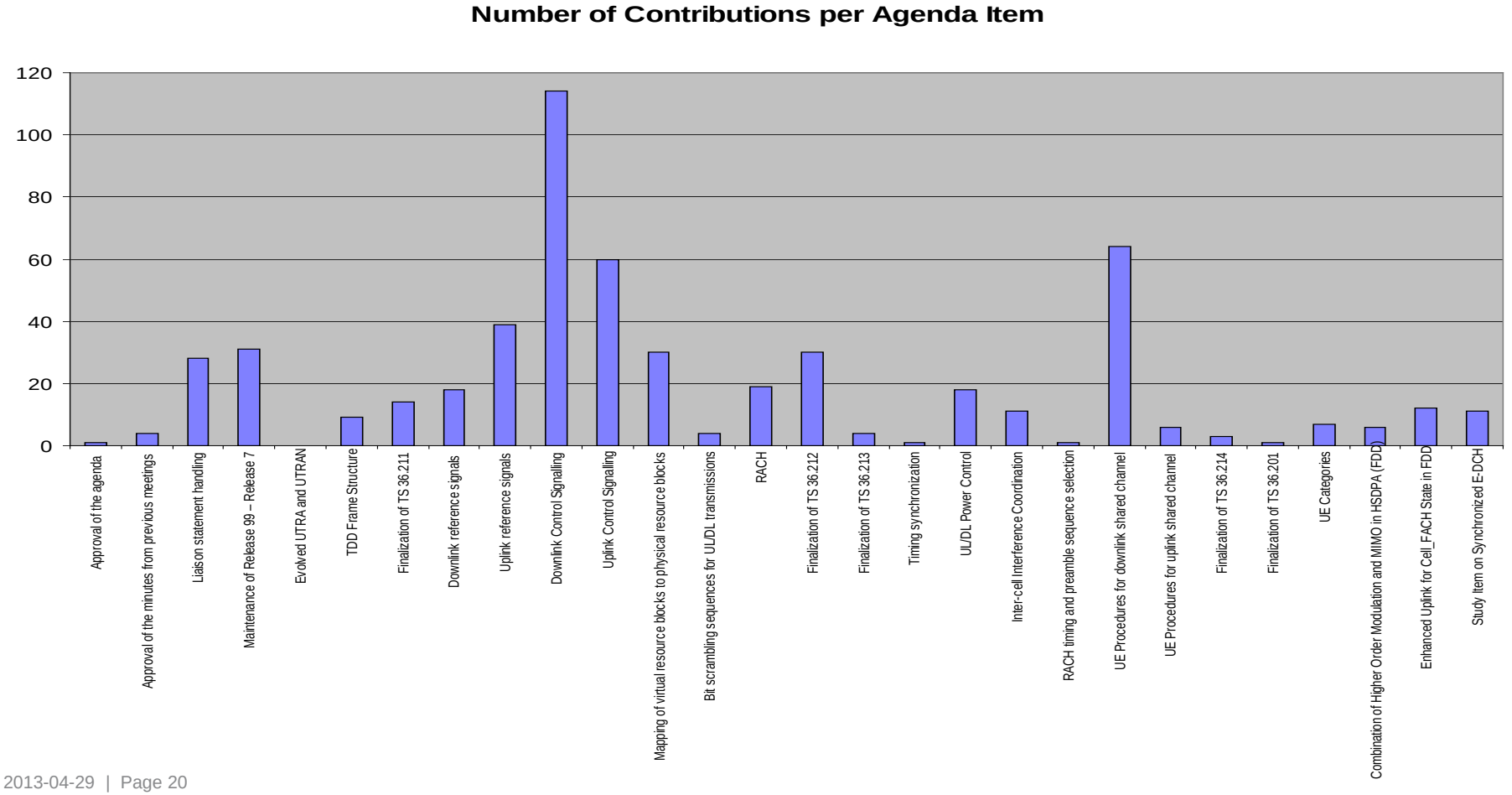
- RAN1 meetings held ~8 times a year
  - Meetings run from Monday to Friday
  - Held in various countries in Europe, North America, and Asia

- 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 250 delegates attending and ~800 documents submitted...



NICE TO WORK WITH STANDARDIZATION...

Cheju, Korea

...WELL MAYBE NOT ALWAYS!

Cheju, Korea

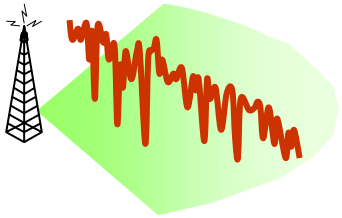
STANDARDIZATION IN PRACTICE

- Contribution driven
- Decision by consensus
  - Coffee-breaks important part of meetings (off-line)
- Good relations important
  - Social relations across cultural borders
  - Mutual respect and co-operation
- One week meetings ➡ Long meeting days

SUMMARY

SUMMARY – BASIC PRINCIPLES

- Radio channel quality is time varying

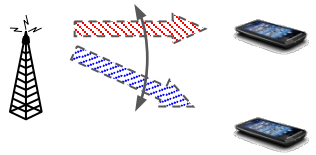


- Traffic pattern is time varying

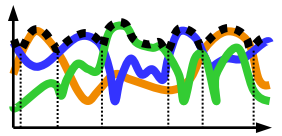
- ***Adapt to*** and ***exploit***…
  - variations in the radio channel quality
  - variations in the traffic pattern

SUMMARY – BASIC PRINCIPLES

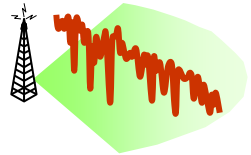
- Shared channel transmission



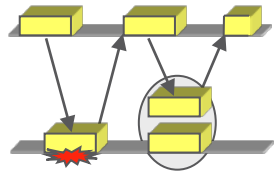
- Channel-dependent scheduling



- Rate control



- Hybrid-ARQ with soft combining



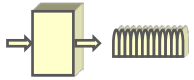
SUMMARY – LTE

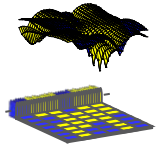
› LTE – global 4G standard for mobile broadband

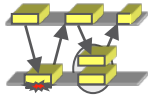
› LTE – some building blocks


Bandwidth flexibility


FDD *and* TDD


OFDM


Scheduling


Hybrid ARQ


Multi-antenna

› Evolution continues

SUMMARY – STANDARDIZATION

- Interfaces and protocols standardized
  - Implementation is not

- 3GPP
  - Standardization of radio-access and core network for the major mobile technologies

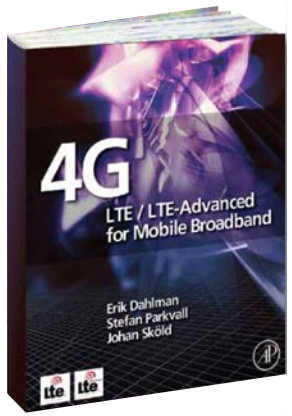
- ITU
  - Radio regulations, spectrum allocations

FOR FURTHER INFORMATION...

Open the 3GPP specifications...

...or read The Book!

Available in English, Chinese, Korean and Japanese.



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