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4G MOBILE BROADBAND – LTE

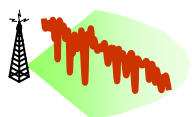
PART III

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RECAP



- › Fundamental principle – *adapt to* and *exploit* variations in...



...radio channel quality



...traffic pattern

- › LTE - some building blocks



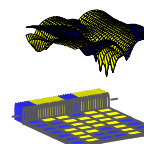
Bandwidth flexibility



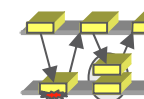
FDD and TDD



OFDM



Scheduling

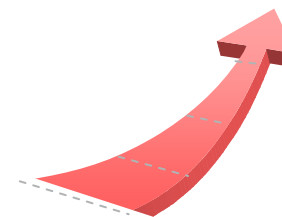


Hybrid ARQ



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?



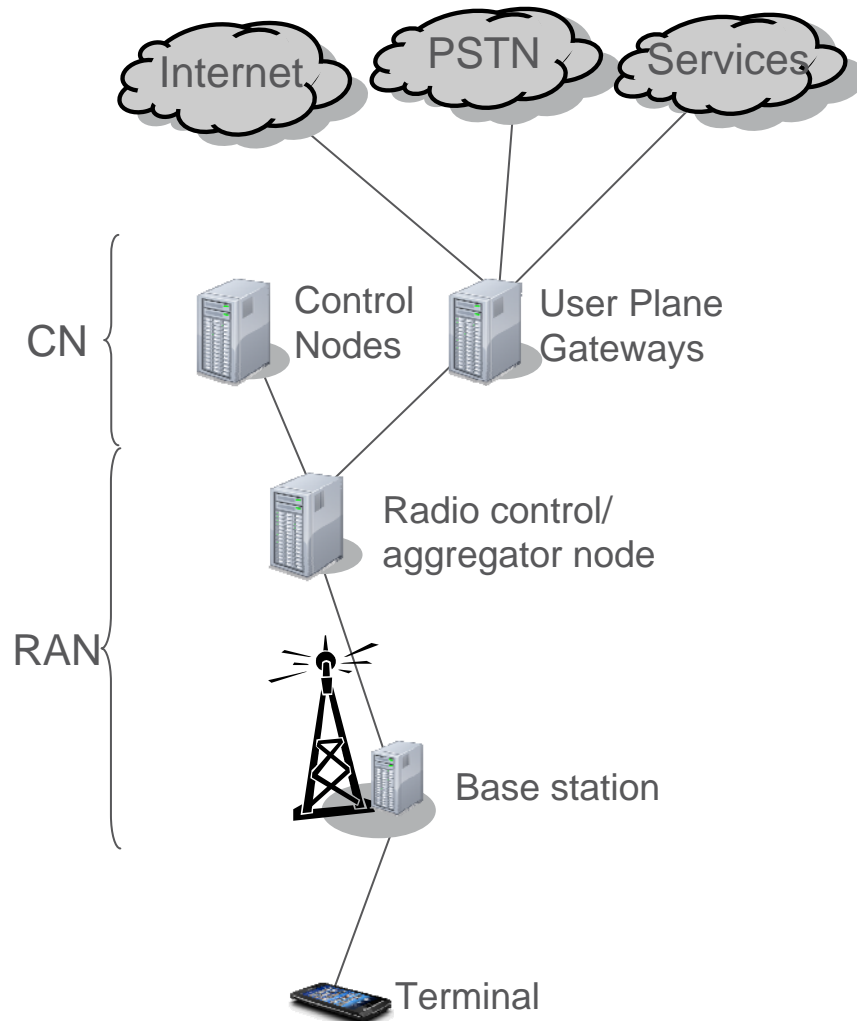
WHY STANDARDIZATION?



- › 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 STANDARDIZATION 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



GSM World



UMTS Forum



CDMA DEVELOPMENT GROUP



ngmn
the engine of broadband wireless innovation



WHERE – SOME STANDARDIZATION 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

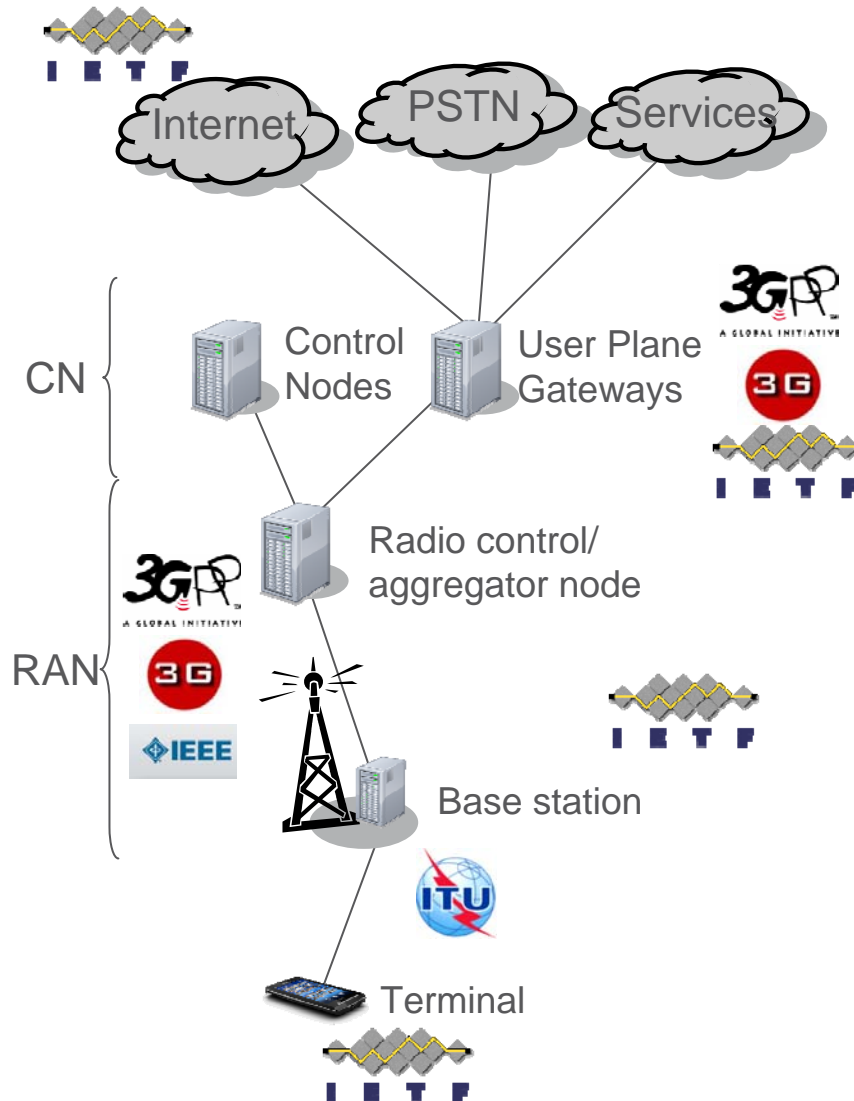


- › IETF
 - Develops/promotes internet standards (IP, TCP, FTP, ROHC, ...)



- › 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 (e.g. IP, TCP, ROHC)
- Transport protocols/functions in the CN (IP, MIP)

› 3GPP, 3GPP2

- Architecture, functions, protocols for the complete Radio Access and Core Network

› IEEE

- Architecture, functions, protocols for Radio Access Network

› ITU

- Spectrum, radio regulations

STANDARDIZATION PROCESS



Requirements



Architecture



Detailed specifications



Testing and verification



Certification

- › 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 – development

- responsible for creating policies, regulation and providing training programs and financial strategies in developing countries

ITU-R

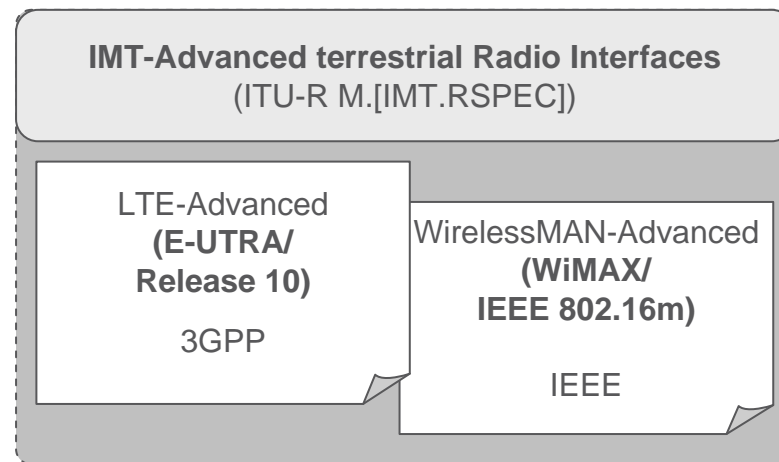
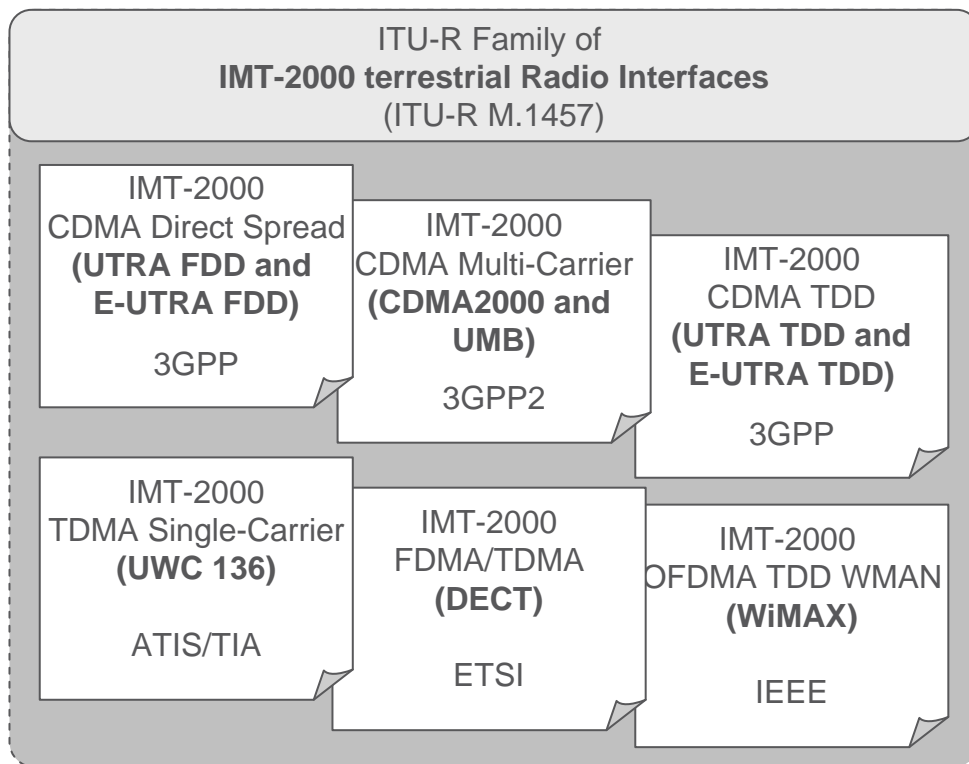


- › Radio regulations
 - allocation of different frequency bands
 - › WRC -93, -95, -97, -00, -03, -07, ...
 - mandatory technical parameters to be observed

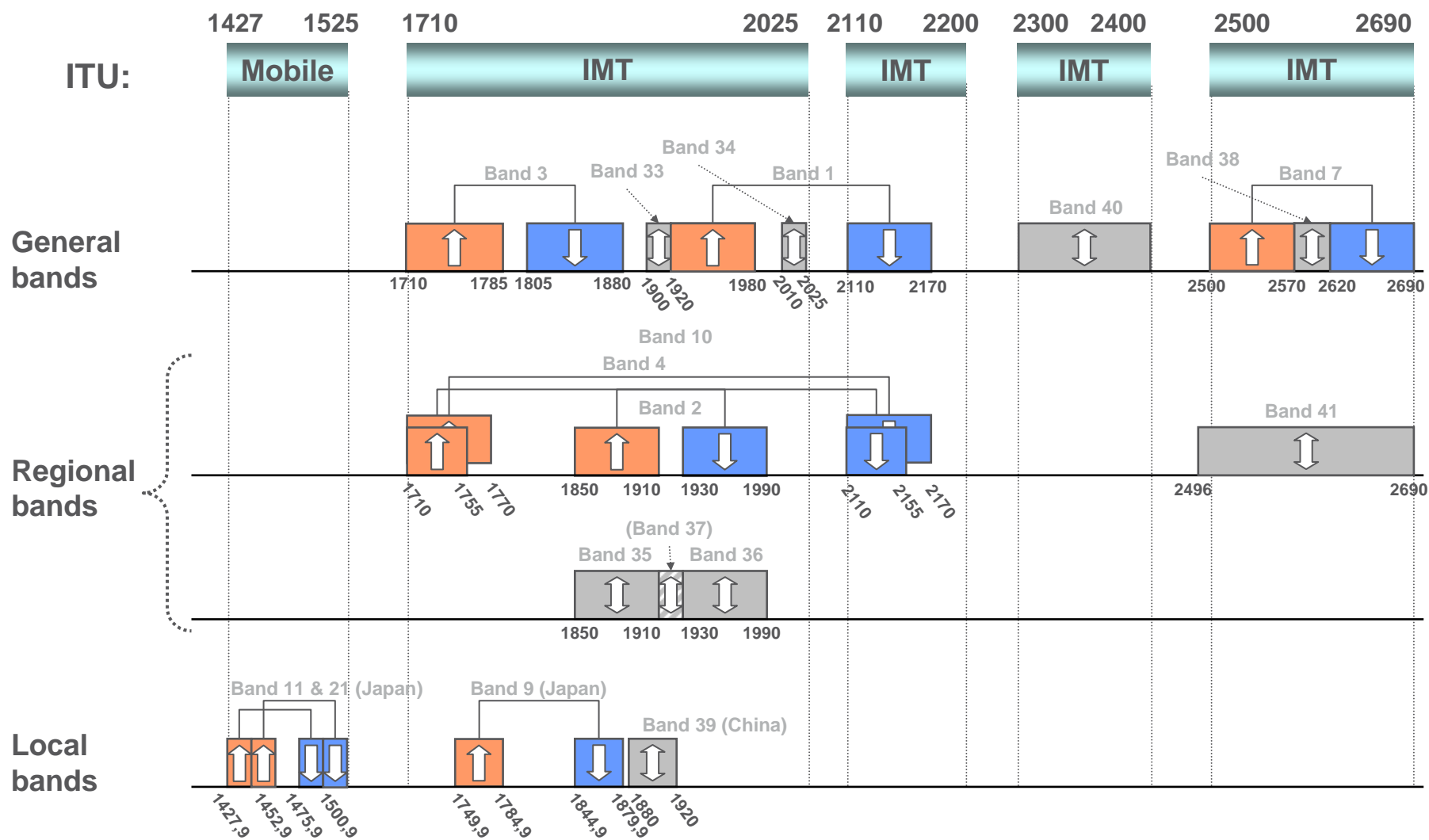
- › Reports

- › 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

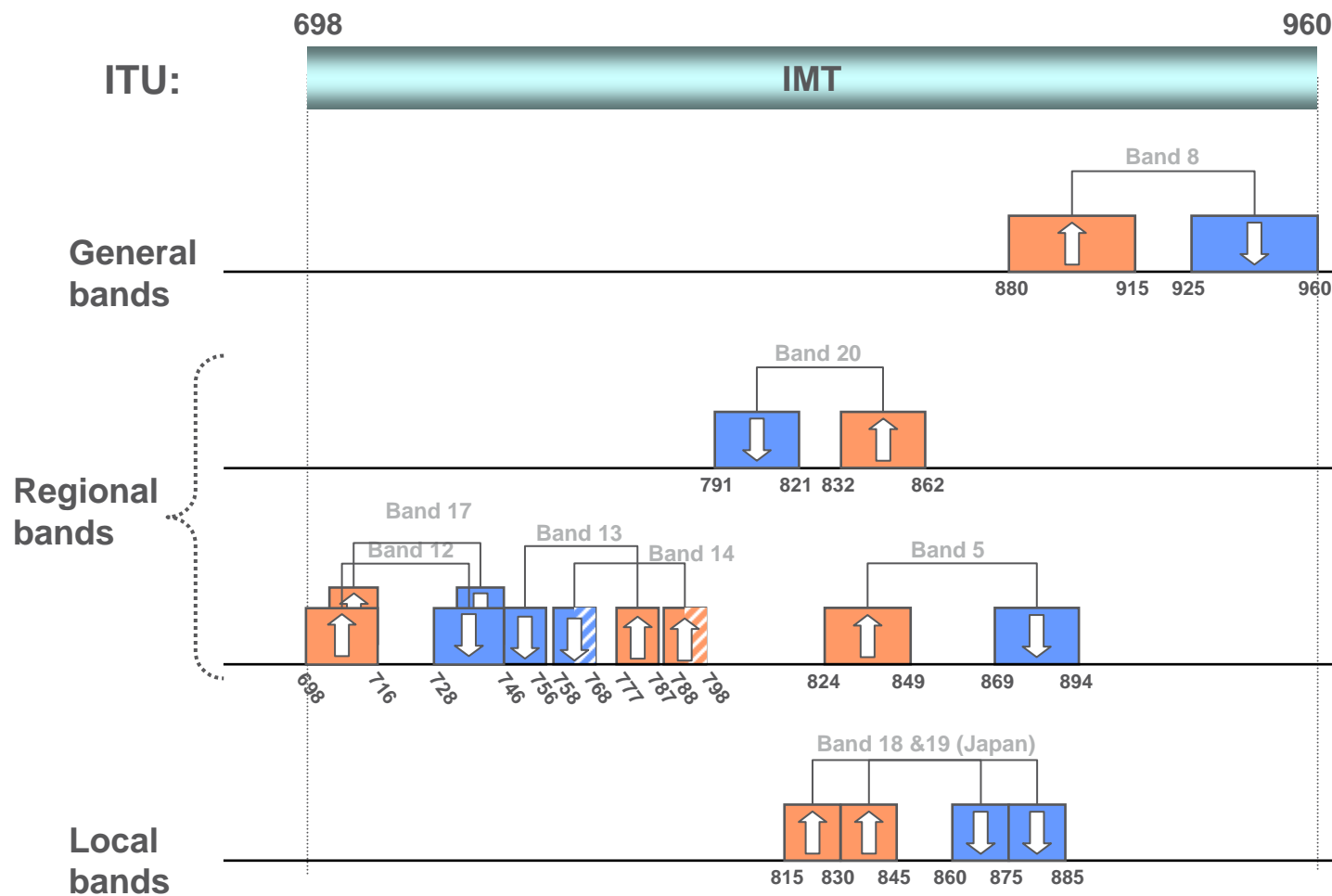
IMT RADIO INTERFACES



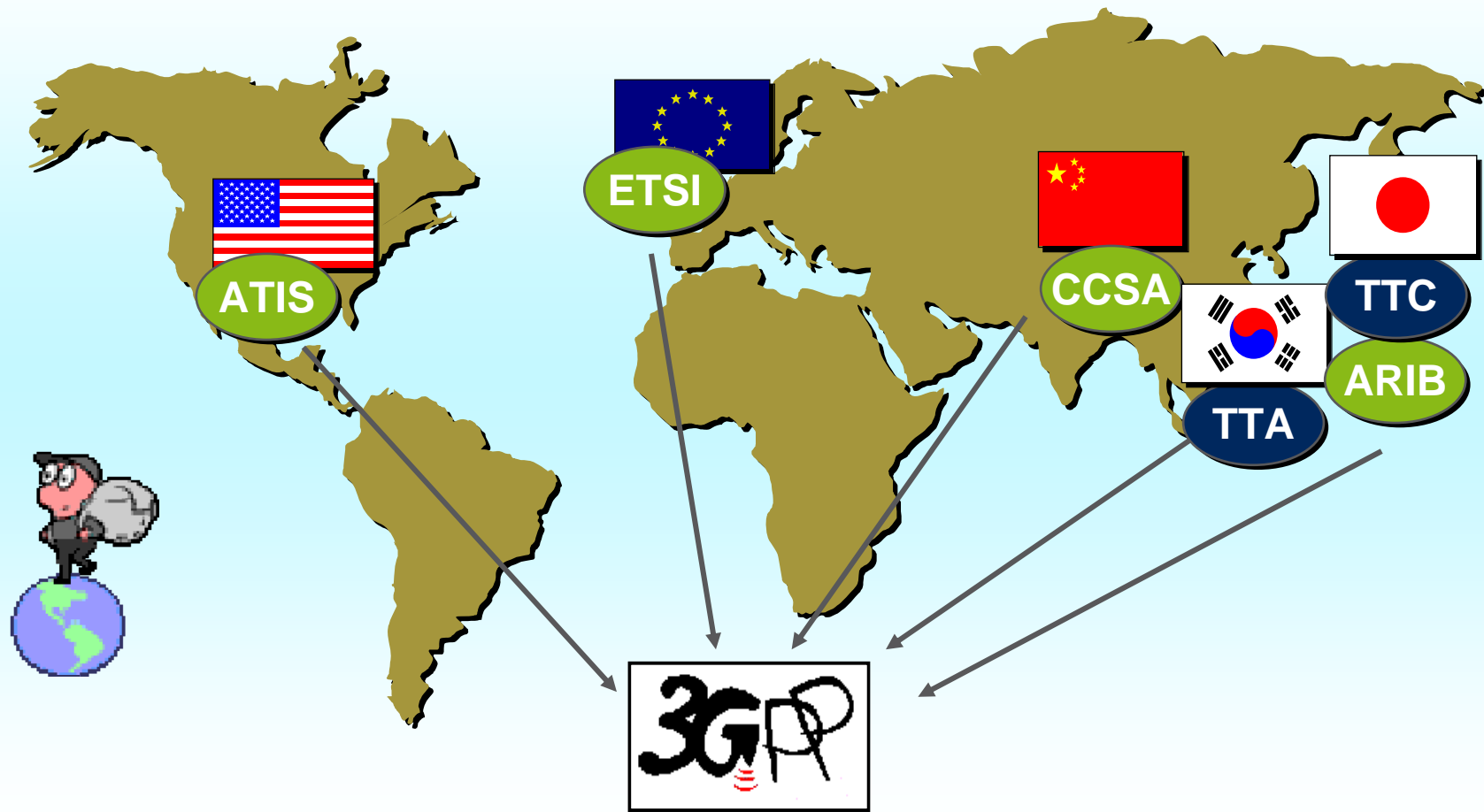
IMT SPECTRUM



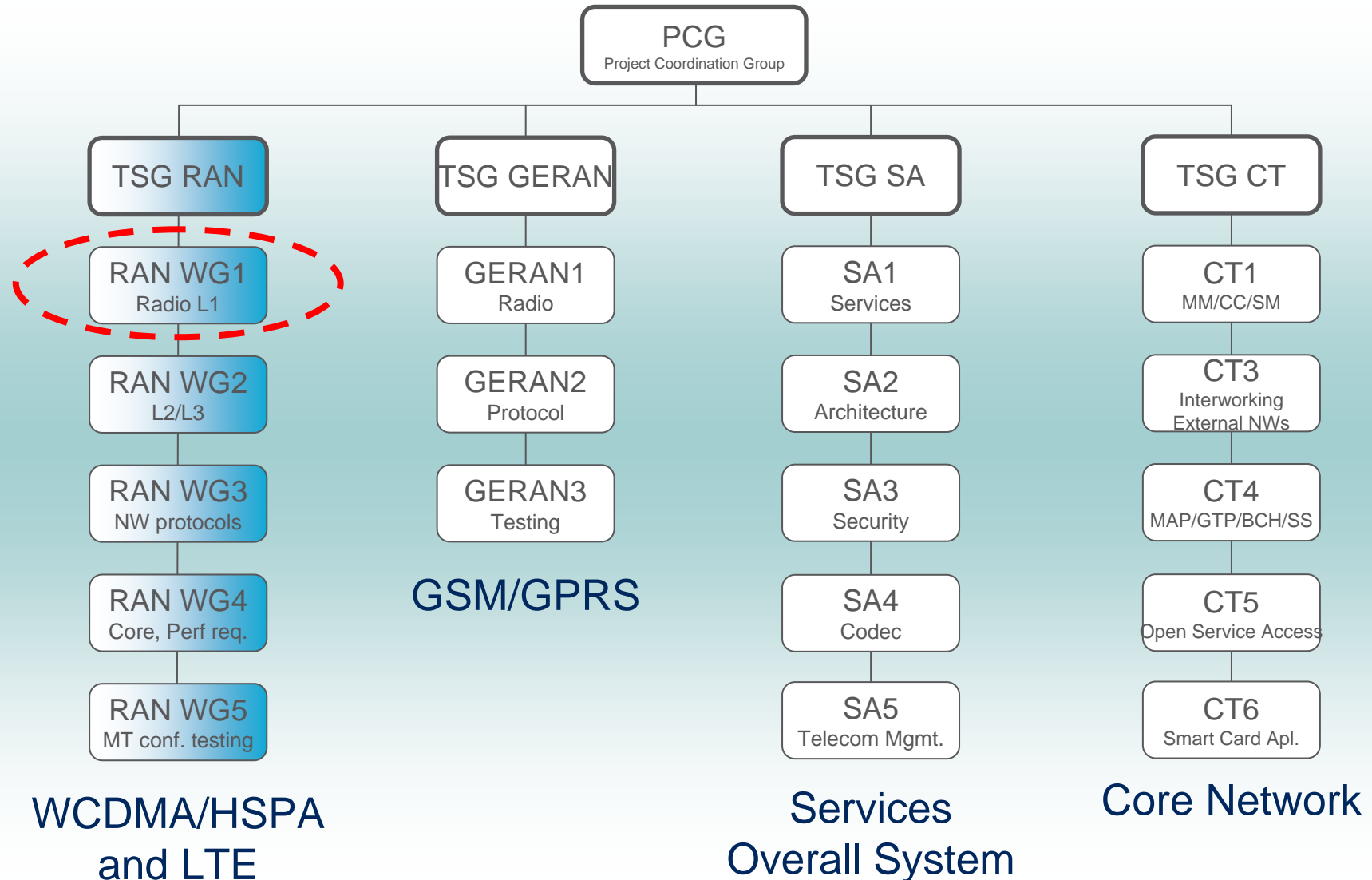
IMT SPECTRUM



3GPP ORGANIZATIONAL PARTNERS



3GPP ORGANIZATION



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,
- February 12-16, St Louis,
- March 26-30, St Juliens,
- April 17-20, Beijing,
- May 7-11, Kobe,
- June 25-29, Orlando,
- August 20-24, Athens,
- October 8-12, Shanghai,
- November 5-9, Seoul

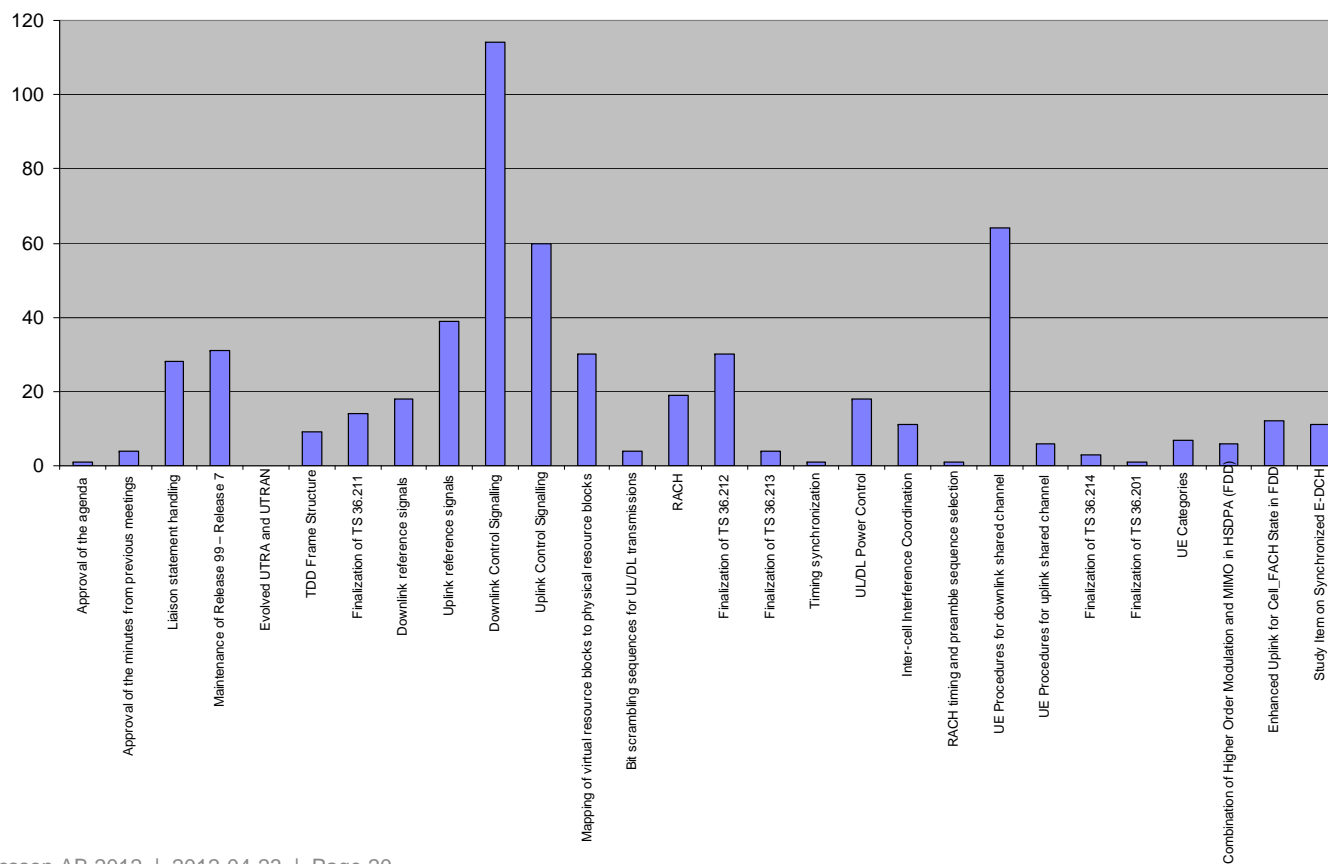
- Italy
- USA
- Malta
- China
- Japan
- USA
- Greece
- China
- Korea

TYPICAL RAN1 MEETING

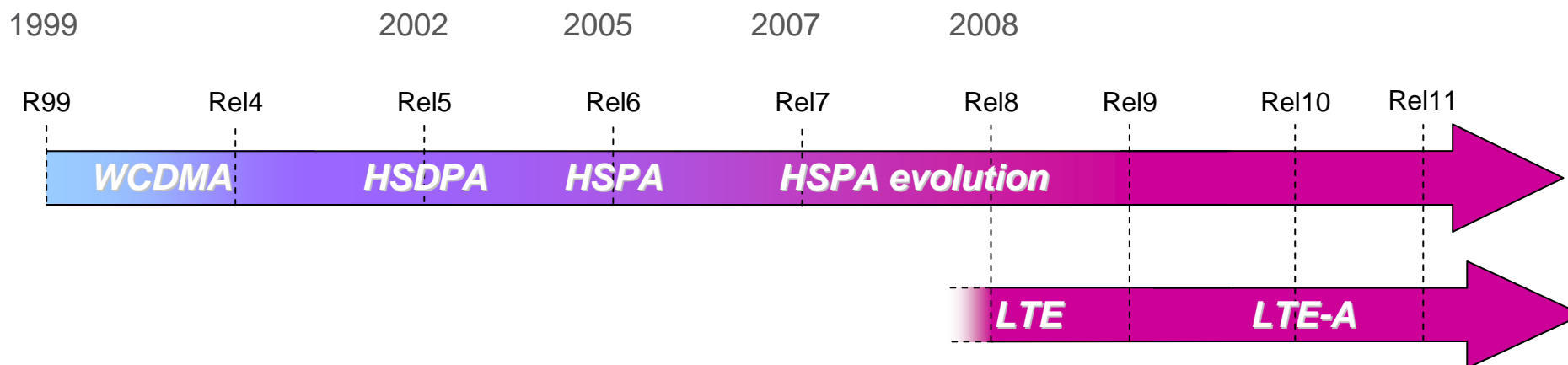


› Approx 250 delegates attending and ~800 documents submitted...

Number of Contributions per Agenda Item



3GPP RELEASES



› HSPA evolution

- Gradually improved performance at a low additional cost
in (multiples of) 5MHz spectrum allocation

› LTE

- Significantly improved performance *in a wide range of spectrum allocations*

STANDARDIZATION IN PRACTICE

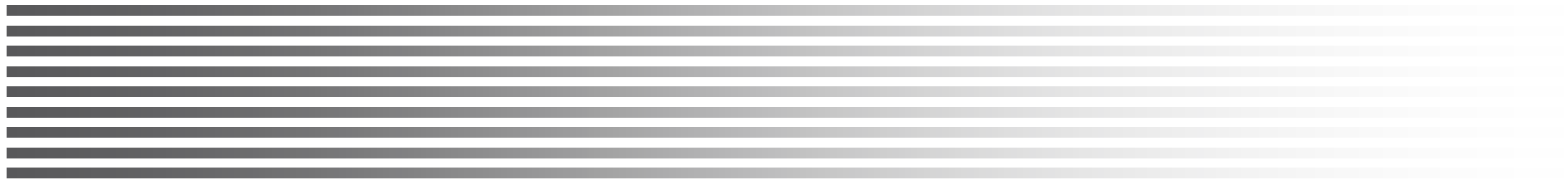


- › Contribution driven
- › Decision by consensus
 - Coffee-breaks important part of meetings (off-line)
- › Good relations important
 - Social relations across cultural borders
 - Mutual respect and co-operation
- › One week meetings ➔ Long meeting days



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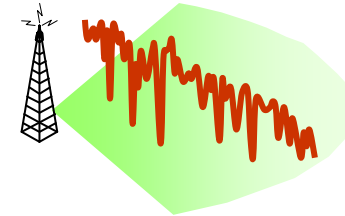
SUMMARY



SUMMARY – BASIC PRINCIPLES



- › Radio-channel quality is time varying



- › Traffic pattern is time varying

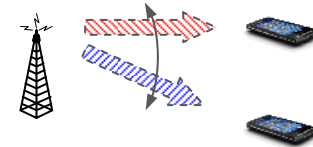


- › **Adapt to** and **exploit...**
 - variations in radio channel quality
 - variations in the traffic pattern...instead of combating them!

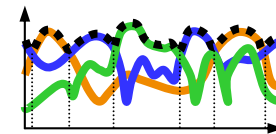
SUMMARY – BASIC PRINCIPLES



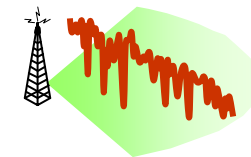
- › Shared channel transmission



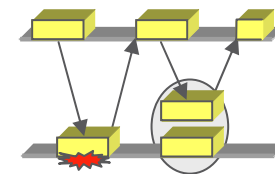
- › Channel-dependent scheduling



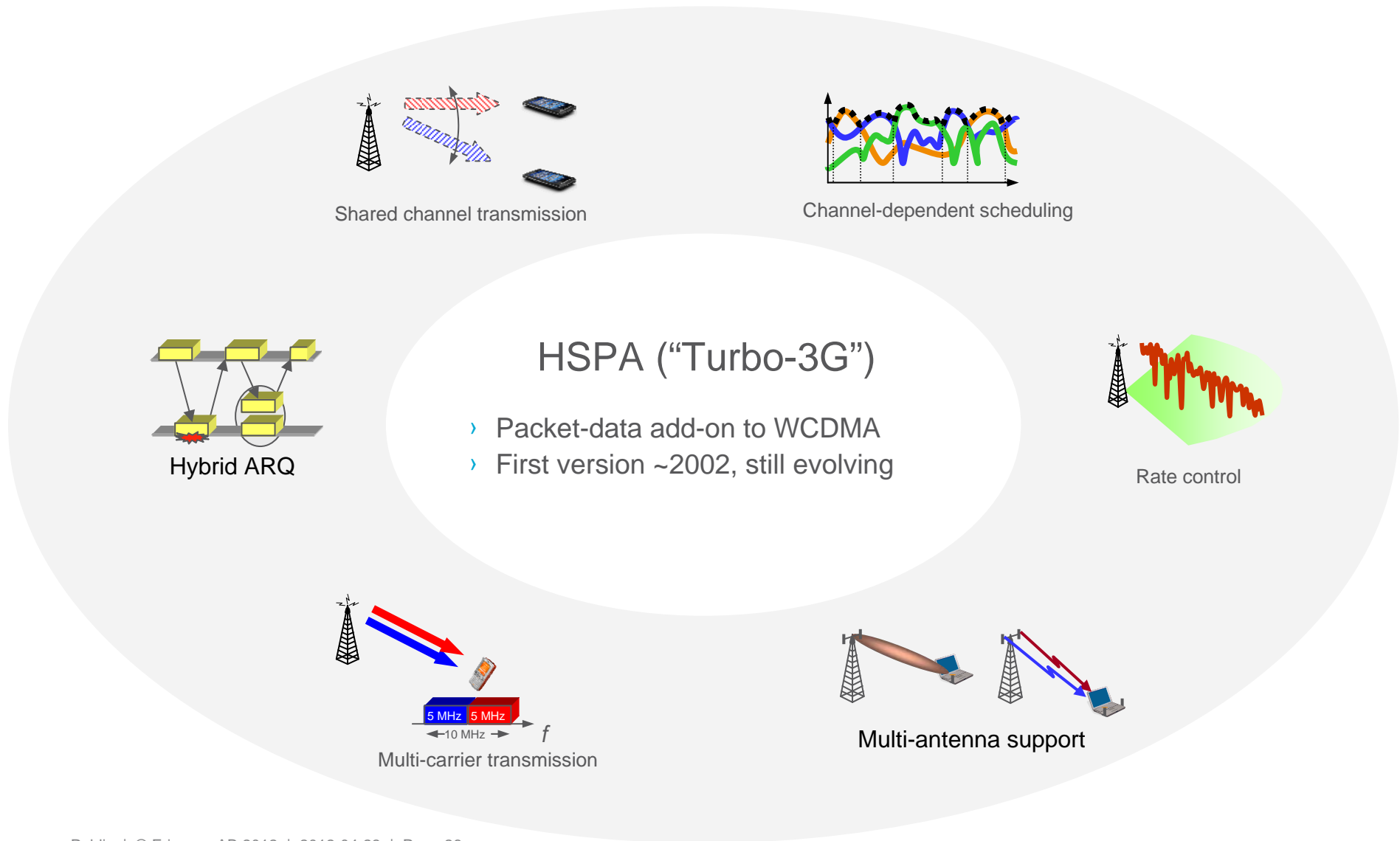
- › Rate control



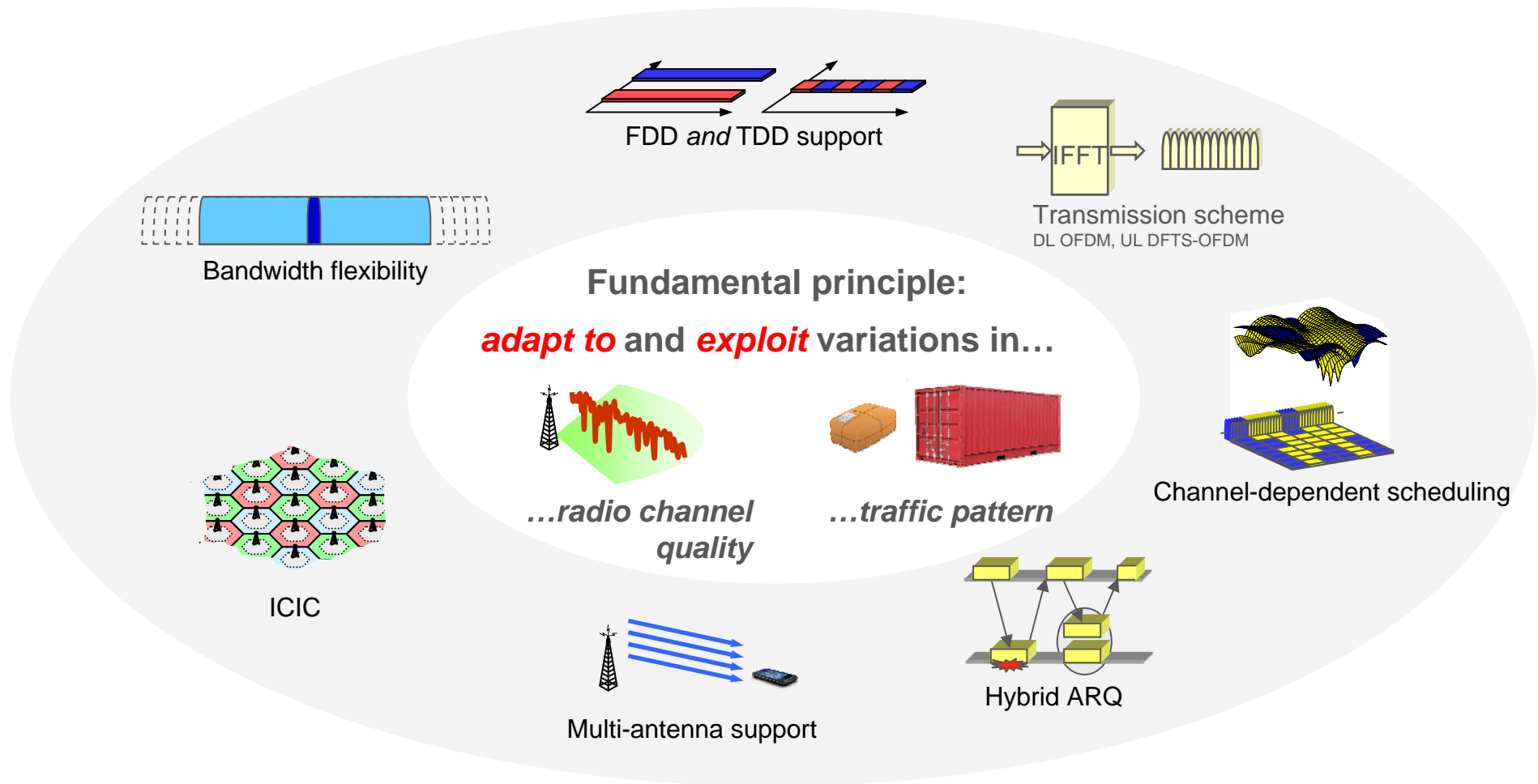
- › Hybrid-ARQ with soft combining



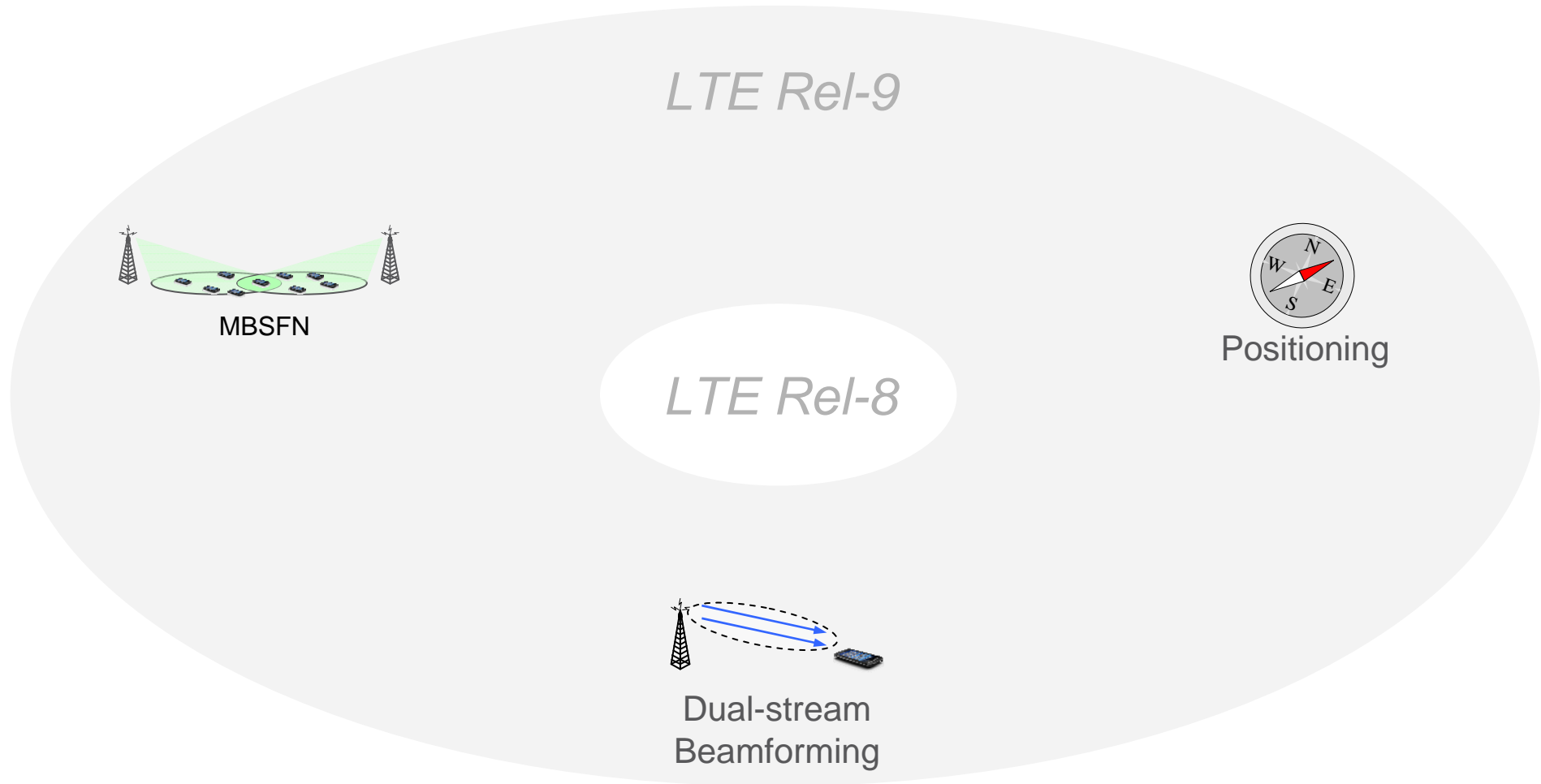
SUMMARY – HSPA



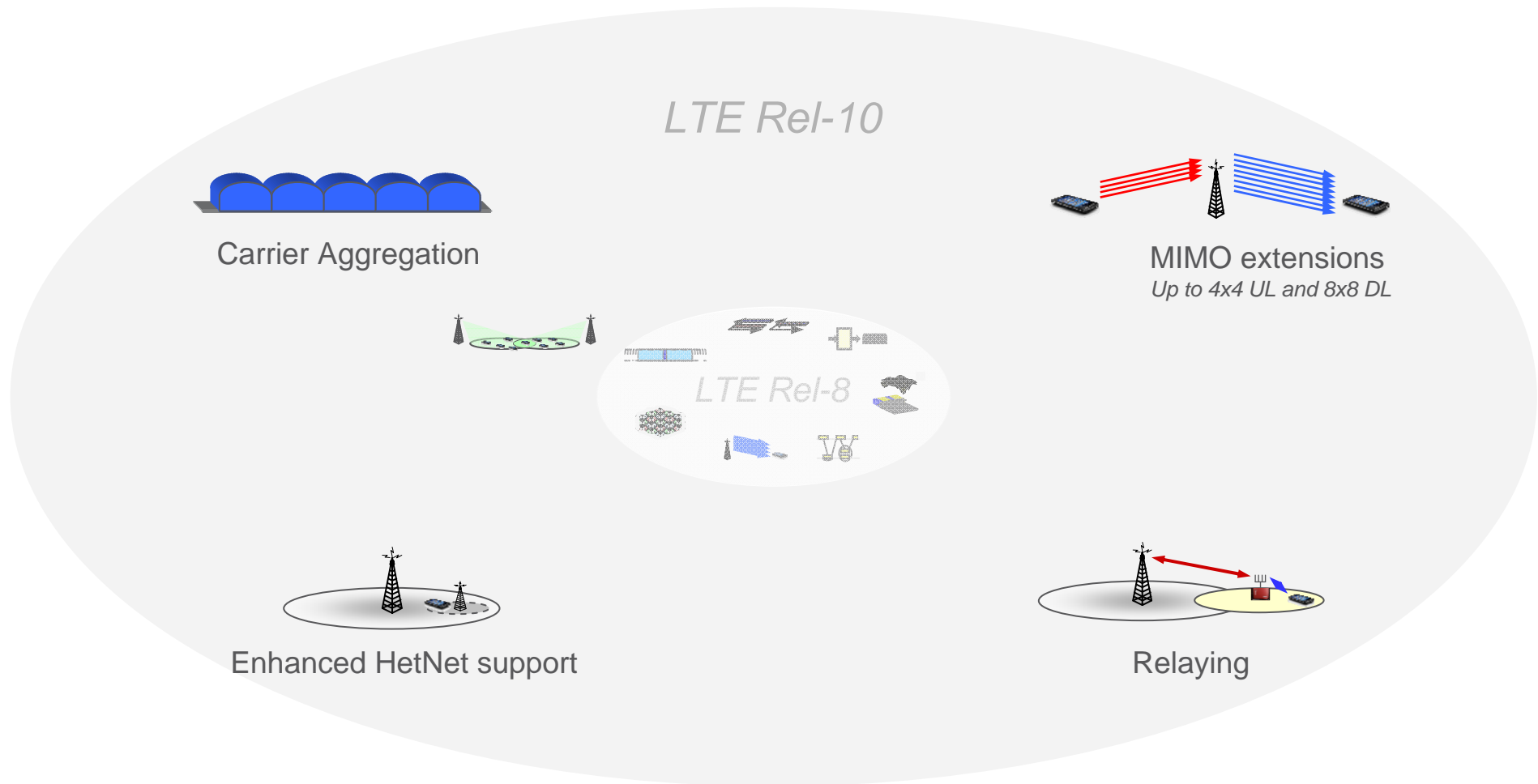
SUMMARY – LTE



SUMMARY – LTE



SUMMARY – LTE



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...

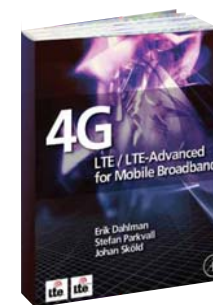


Open the 3GPP specifications...



...or read The Book!

Available in English, Chinese, Korean and Japanese.





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