



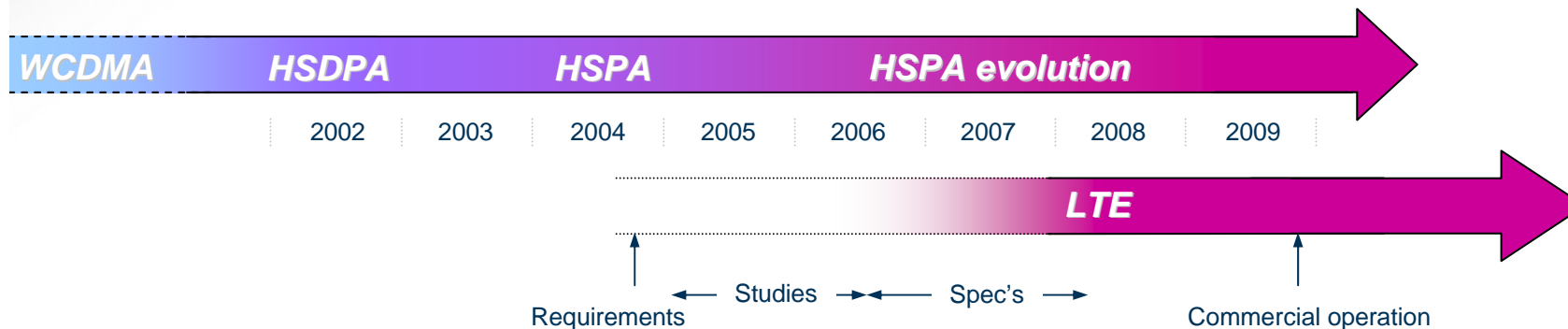
LTE – The Global Standard for Mobile Broadband

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Ericsson Research*

Mobile Broadband

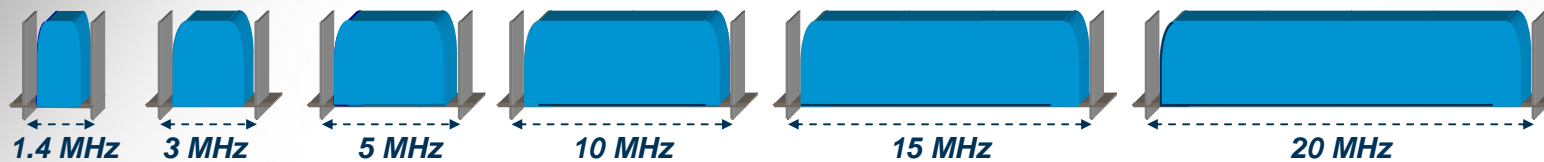
HSPA and LTE

- HSPA ("Turbo-3G")
 - Packet data in current 3G networks
- LTE
 - Significantly higher performance in a wide range of spectrum allocations
 - Downlink up to 300 Mbit/s
 - Uplink up to 75 Mbit/s
 - Reduced latency 10 ms RTT
 - Packet-switched services only

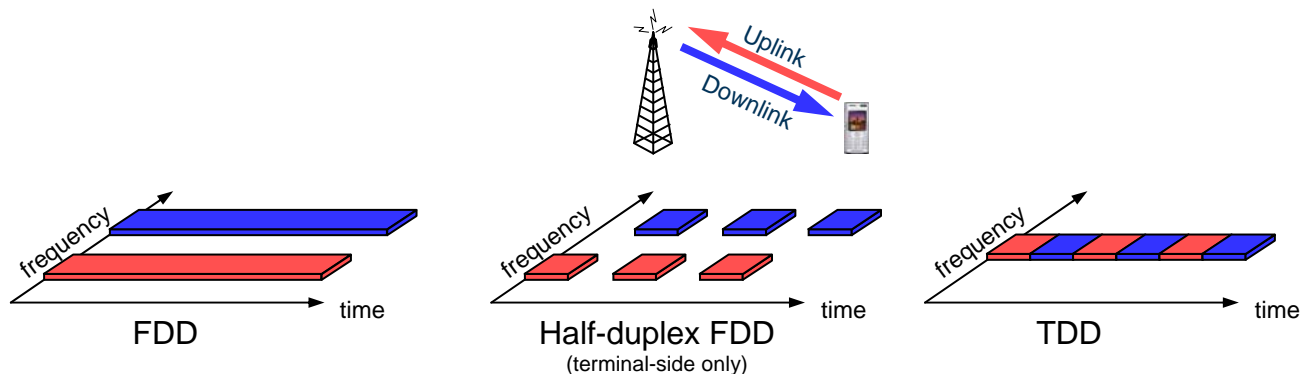


LTE – Spectrum Flexibility

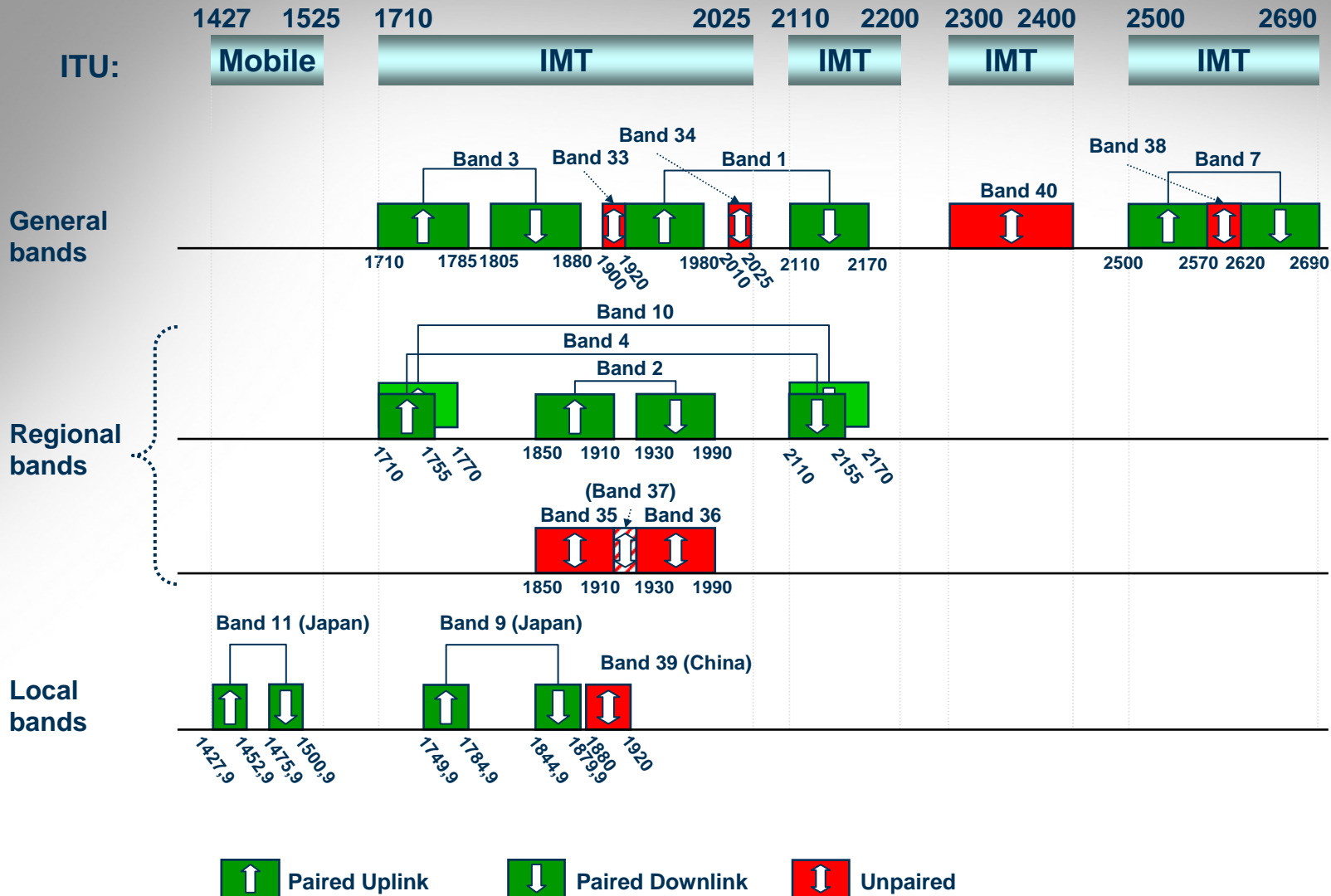
- Operation in differently-sized spectrum allocations
 - Baseband specifications support from 1.4 MHz to 20 MHz
 - Radio requirements set for a limited set of spectrum allocations



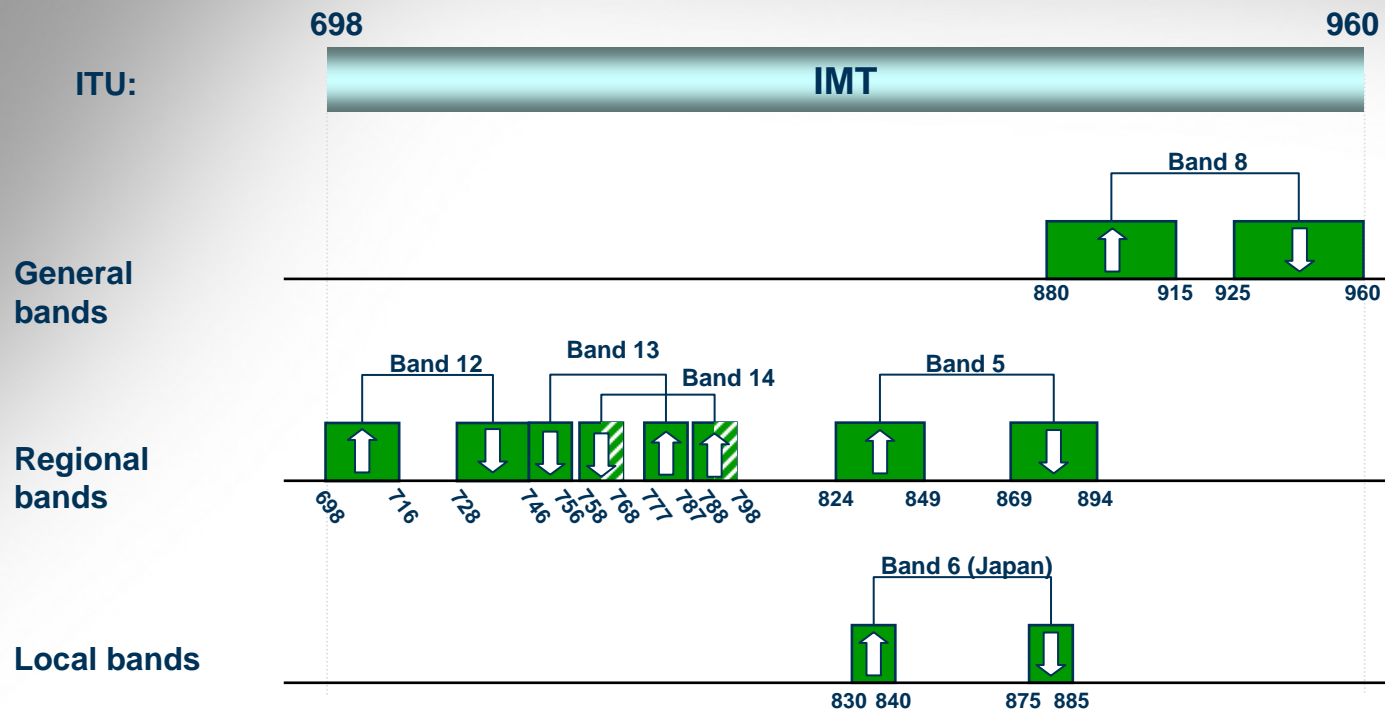
- Support for paired *and* unpaired spectrum allocations
 - FDD for paired spectrum
 - TDD for unpaired spectrum



LTE – Supported Frequency Bands



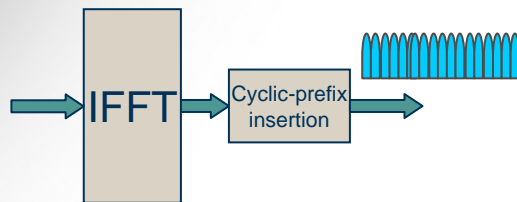
LTE – Supported Frequency Bands



LTE – Basic Transmission Scheme

Downlink – OFDM

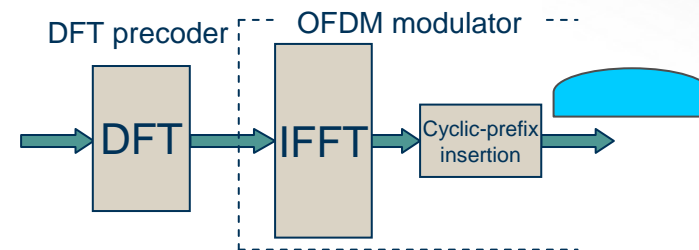
- Parallel transmission on large number of narrowband subcarriers



- Benefits:
 - Avoid own-cell interference
 - Robust to time dispersion
- Main drawback
 - Power-amplifier efficiency

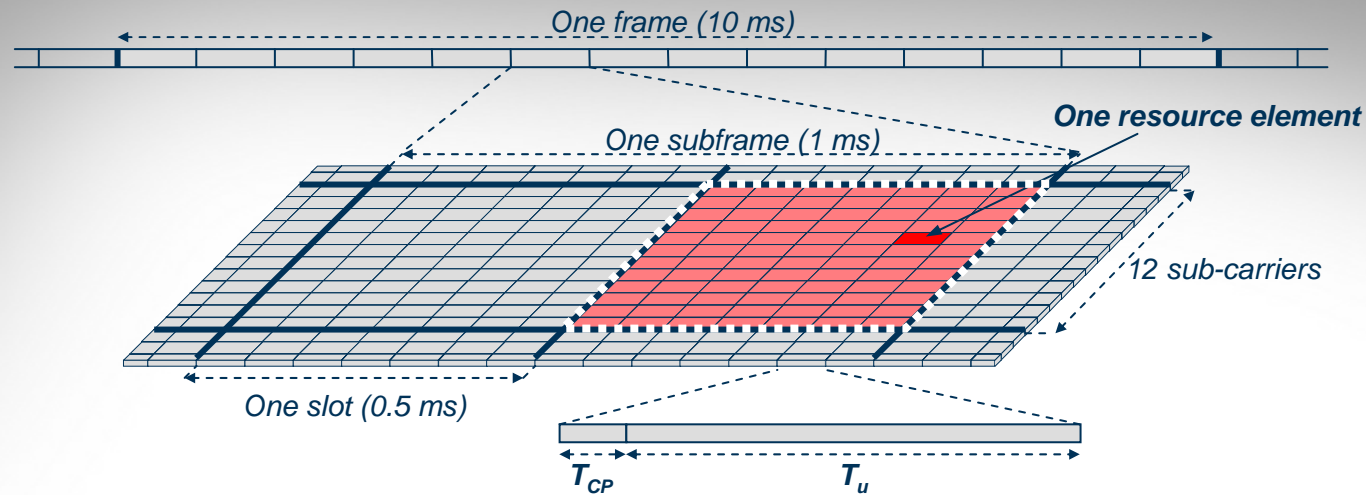
Uplink – DFTS-OFDM

- DFT-precoded OFDM



- Tx signal has single-carrier properties
 - ⇒ Improved power-amplifier efficiency
 - Improved battery life
 - Reduced PA cost
 - **Critical for uplink**
- Equalizer needed ⇒ Rx Complexity
 - **Not critical for uplink**

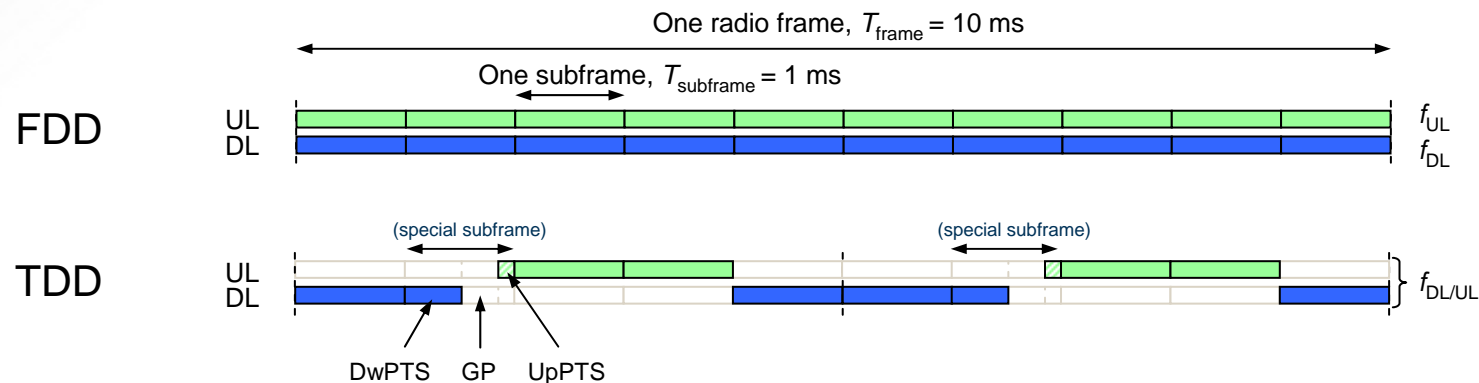
Physical Resources



- Time domain structure:
 - 10 ms frame consisting of 10 subframes of length 1 ms
 - Each subframe consists of 2 slots of length 0.5 ms
 - Each slot consists of 7 OFDM symbols (6 symbols in case of extended CP)
- Resource element (RE)
 - One subcarrier during one OFDM symbol
- Resource block (RB)
 - 12 subcarriers during one slot (180 kHz × 0.5 ms)

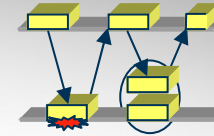
LTE – FDD and TDD

- Single radio-access technology supporting FDD and TDD
 - Two duplex schemes part of the same specification
 - Same level of maturity for FDD and TDD (TD-LTE)
- Baseband, higher layers, etc common for FDD and TDD
- Same hardware for FDD and TDD ➔ economy of scale
 - TDD can leverage on FDD volumes
 - Same degree of economy of scale for TDD as for FDD

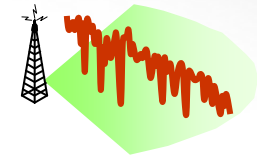
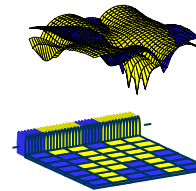


LTE – *Basic Principles*

- Hybrid-ARQ with soft combining
 - *Rapid retransmissions of erroneous packets*



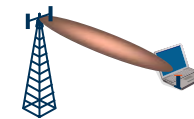
- Channel-dependent scheduling
 - *In time and frequency*
 - *Packet-switched, no CS support*



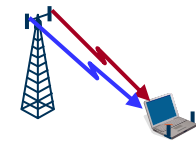
- Multi-antenna support
 - *Exploit spatial channel properties*



Transmit diversity

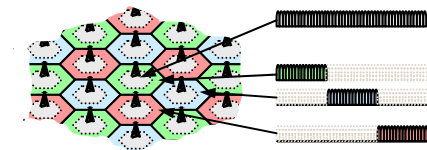


Beam-forming



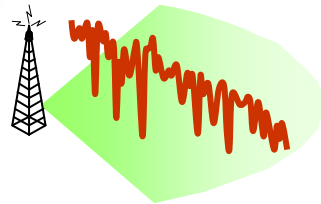
MIMO

- ICIC
 - *Inter-Cell Interference Coordination*
 - *To improve cell-edge performance*



Scheduling

- 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!

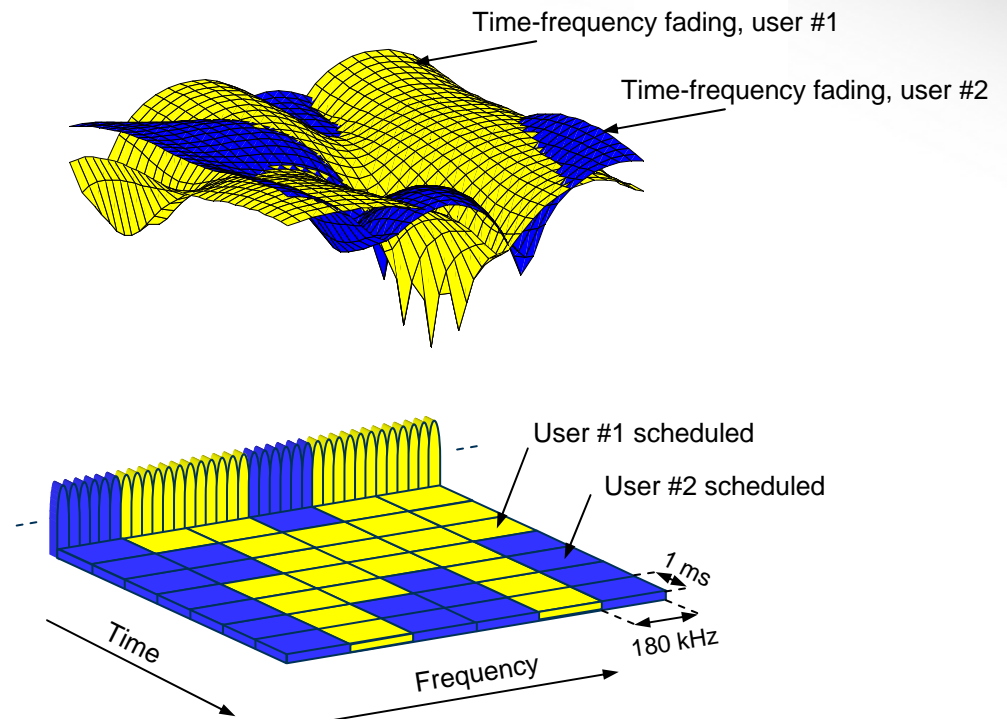
Channel-dependent Scheduling

- Scheduling determines at each time instant...

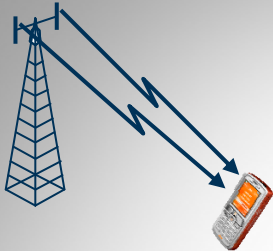
- ...to whom to assign the shared channel
- ...which data rate to use

- Basic idea:
transmit at fading peaks

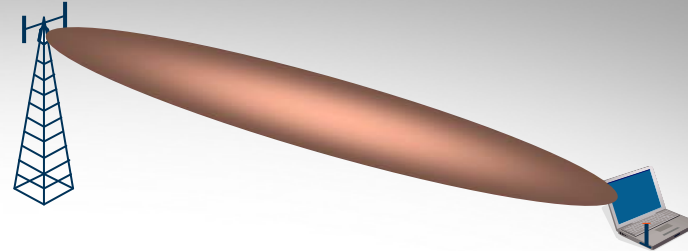
- Tradeoff:
fairness vs. cell throughput



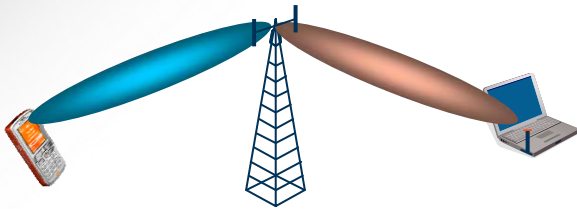
LTE – Multi-Antenna Transmission



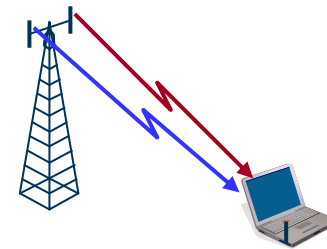
Diversity for improved system performance



Beam-forming for improved coverage (less cells to cover a given area)



SDMA ("MU-MIMO") for improved capacity (more users per cell)



Multi-layer transmission ("SU-MIMO") for higher data rates in a given bandwidth

Which technique to use depends on what to achieve

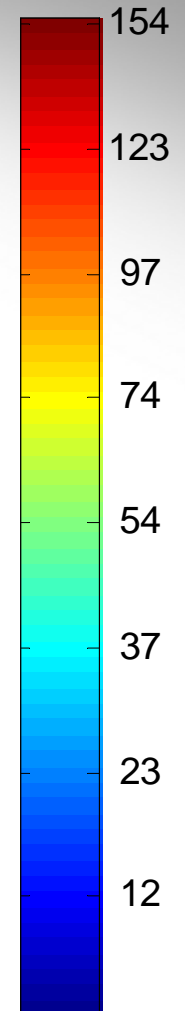
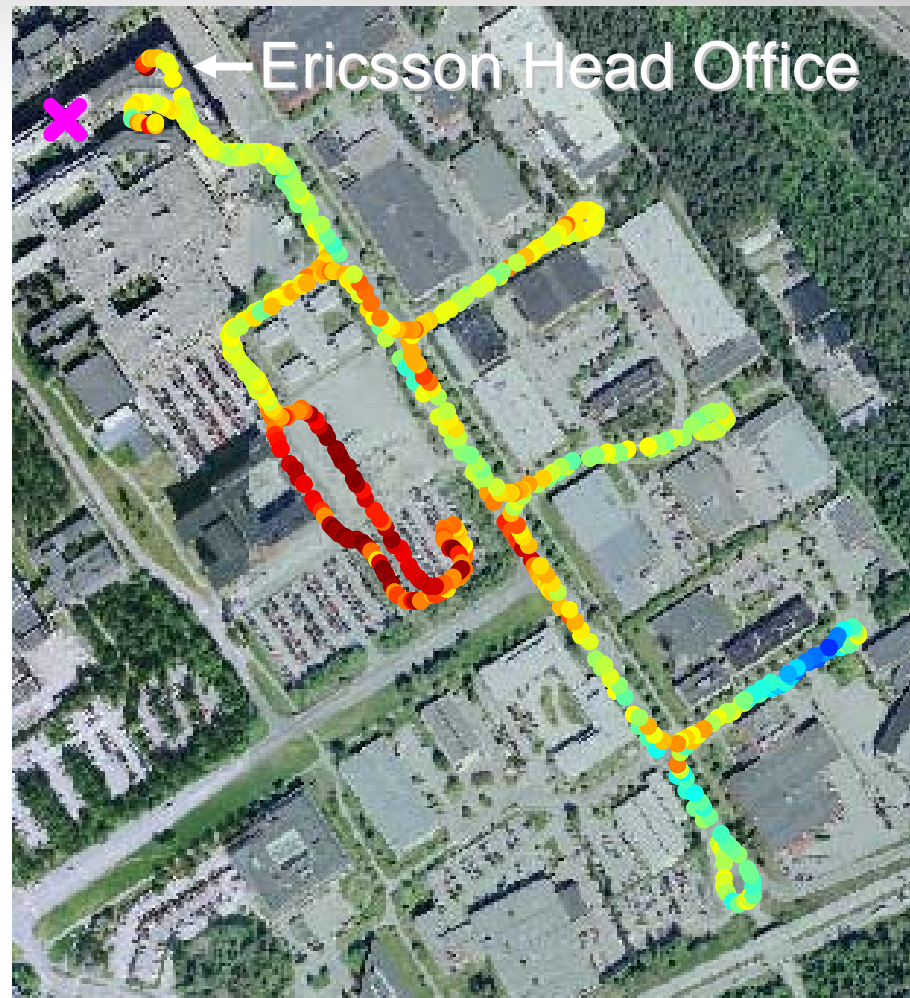
LTE – Example of Testbed Results

20 MHz, 2x2 MIMO

- Throughput
 - Max 154 Mbit/s
 - Mean 78 Mbit/s
 - Min 16 Mbit/s
- Terminal speed
 - Max 45 km/h
 - Mean 16 km/h
 - Min 0 km/h
- Distance
 - Max 710 m
 - Mean 360 m
 - Min 50 m



LTE Testbed
2007



LTE – 3GPP Standardization Status

- LTE Rel-8 radio-access specifications completed
 - Both for FDD and TDD operation

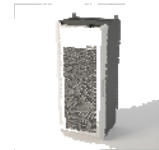
- Product development well under way
 - Prototypes and testbeds available
 - Initial commercial deployment 2010



LTE Testbed
2007



Prototype terminal,
Feb 2008, 144 Mbit/s



Commercial product
availability, 2009

- The main radio-access technology for future mobile broadband
 - Commitment not only from 3GPP operators but also from major operators currently relying on 3GPP2-based technologies
 - First technology approved by NGMN as complying with its recommendations on Next Generation Mobile Broadband Networks

NGMN – Next Generation Mobile Networks



- NGMN – operator-driven alliance
“...providing a coherent view of what the operator community is going to require...”
- NGMN decision, June 2008
“...based on intensive and detailed technology evaluations, 3GPP LTE/SAE is the first technology which broadly meets its recommendations and is approved by its Board...”

Members (19 operators)

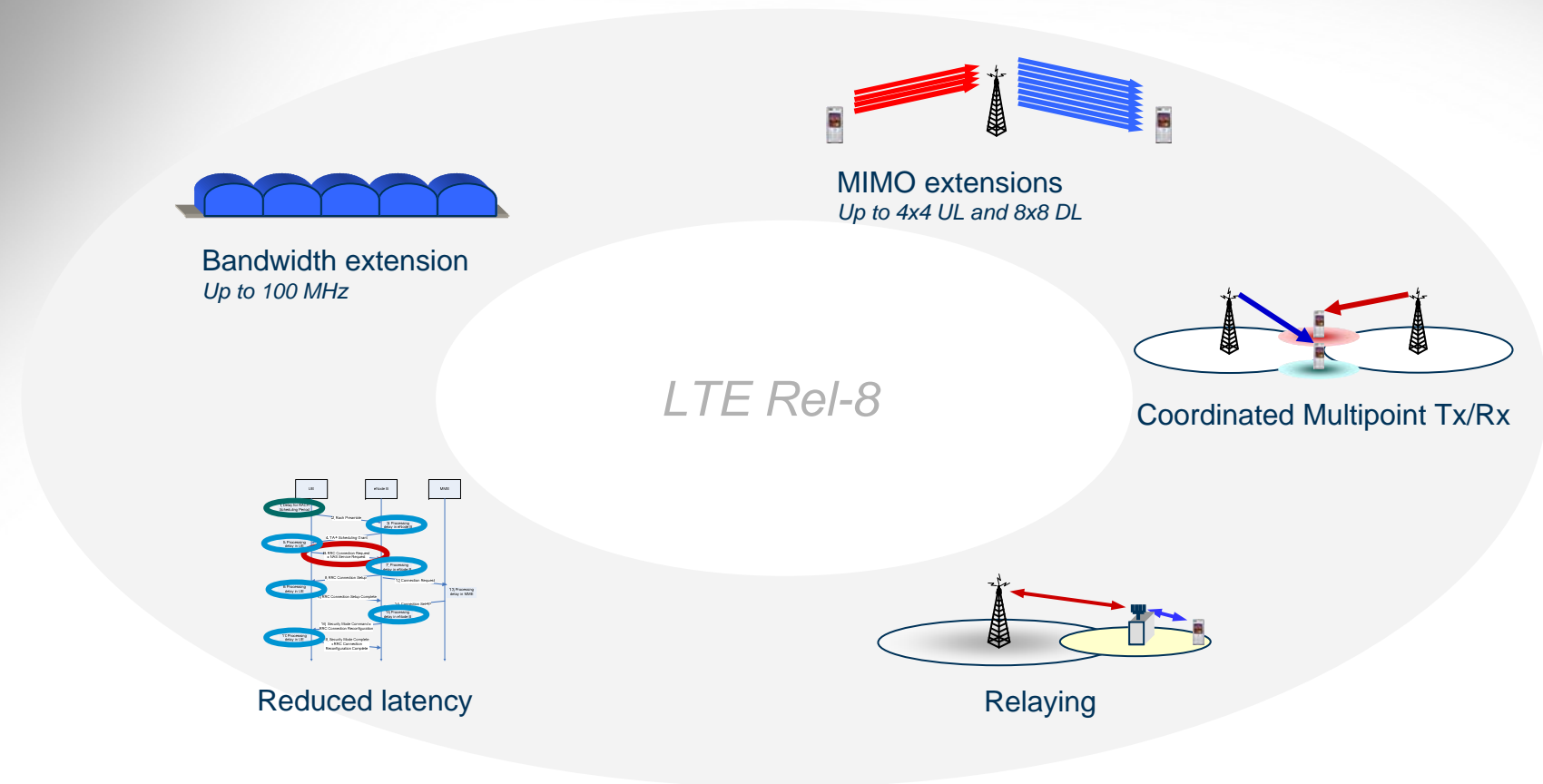


Sponsors (36 vendors)



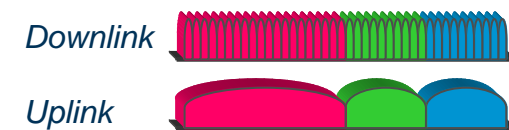
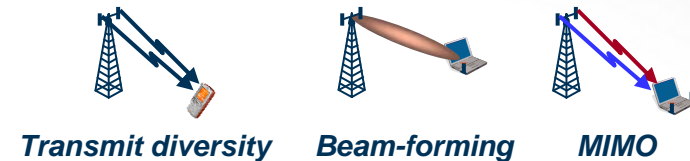
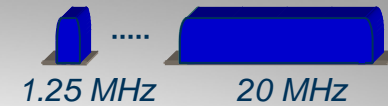
LTE – Additional Rel-10 Functionality

- LTE is evolving to meet and exceed IMT-Advanced requirements
 - *Already Rel-8 fulfills most of the requirements*



Summary – LTE

- Spectrum flexibility
 - 1.25 – 20 MHz
 - Paired **and** unpaired spectrum
- Integrated multi-antenna support
- New radio access
 - Downlink OFDM
 - Uplink DFTS-OFDM
- Strong operator commitment
 - First technology approved by NGMN as complying with its recommendations
 - Comittment also from operators using 3GPP2 technology



LTE – The Global standard for Next Generation (4G)

Thank You for the Attention!

For further details...

