

Long-Term 3G Evolution – Radio Access

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Note: The slides reflect the status as of November, 2005 and are subject to change as a function of future work in 3GPP and elsewhere.

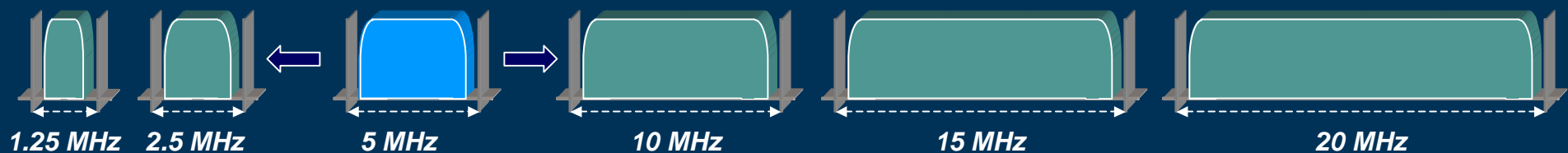
Evolved UTRA – Some Targets

- Packet-switched domain only – no circuit-switched domain.
- Reduced delay
 - User-plane latency: < 5 ms (UE to RAN-edge, one way)
 - Control-plane latency: < 100 ms (camped-to-active), < 50 ms (dormant-to-active)
- **Downlink**
 - Peak data rate 100 Mbps
 - 20 MHz, two Tx antennas
→ 2x2 MIMO
 - User throughput
 - 3-4 times HSDPA (average)
 - 2-3 times HSDPA (5th percentile)
 - Spectral efficiency
 - 3-4 times HSDPA
 - Assumes two Rx antennas for both E-UTRA and HSDPA (RAKE only)
- **Uplink**
 - Peak data rate 50 Mbps
 - 20 MHz, one Tx antenna
→ *without* MIMO
 - User throughput
 - 2-3 times HSUPA (average)
 - 2-3 times HSUPA (5th percentile)
 - Spectral efficiency
 - 2-3 times HSUPA
 - Assumes two Rx antennas for both E-UTRA and HSUPA

Should be achieved for at least 5 km cell range.

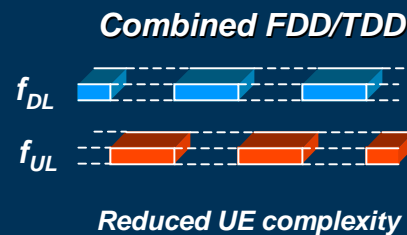
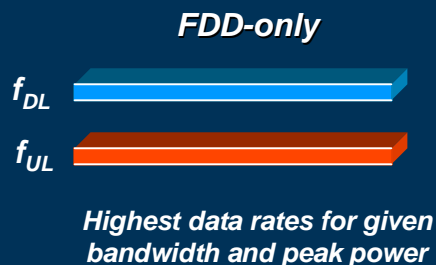
Evolved UTRA – Spectrum Flexibility

- Up to 20 MHz to enable high data rates
- Less than 5 MHz for spectrum flexibility
 - *Spectrum allocation*, not transmission bandwidth
 - Current 3GPP assumption 1.25 MHz
 - Other values may be more relevant – revisit for a potential work item



Evolved UTRA – Spectrum Flexibility

- Operation in paired and unpaired spectrum required
➔ Support for FDD and TDD operation
- Maximum commonality between FDD and TDD
 - ...but need to consider TDD-specific characteristics and coexistence with existing UTRA deployments.

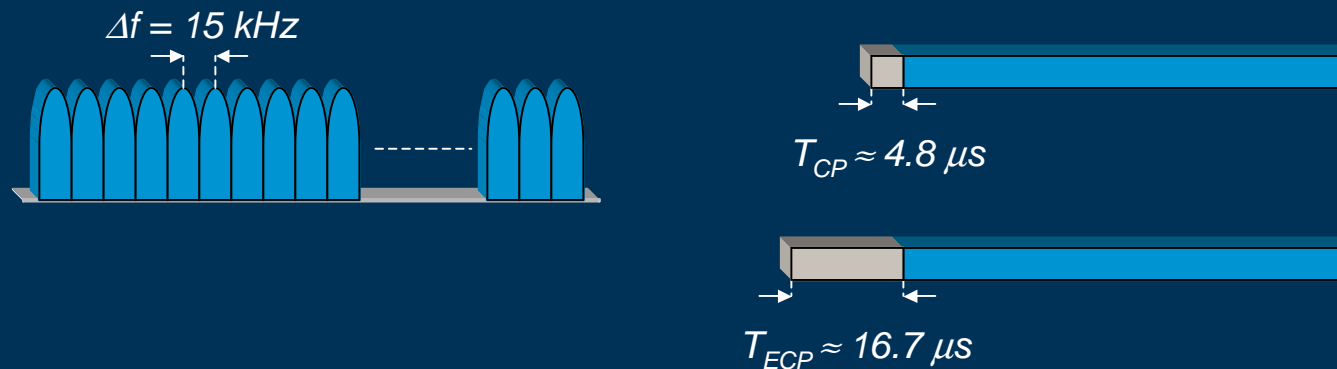


Evolved UTRA

Downlink transmission scheme

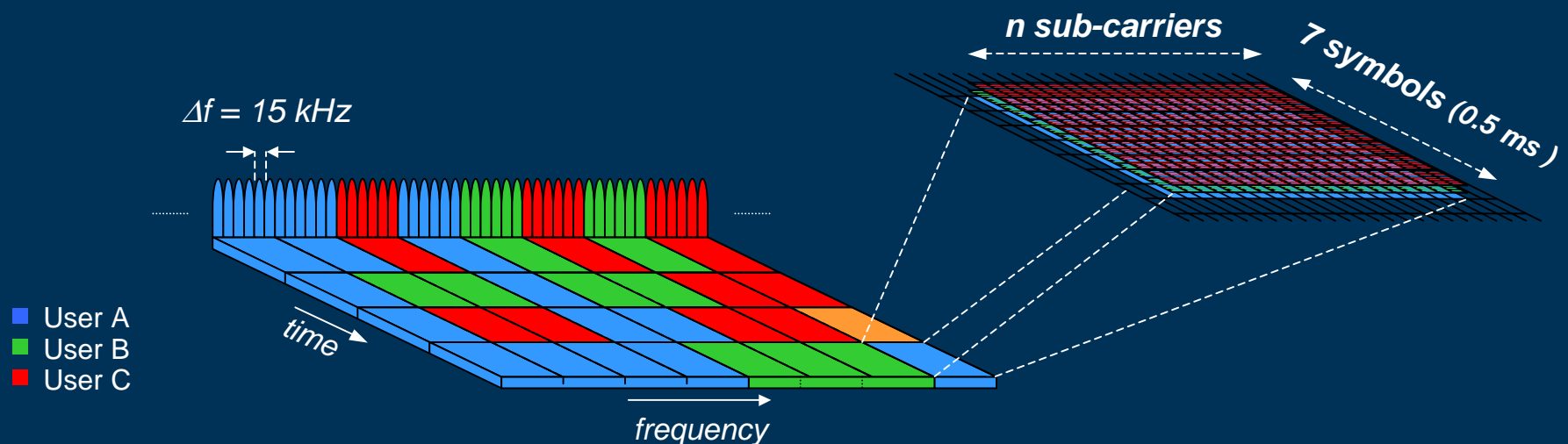
Downlink Transmission Scheme

- Conventional OFDM with cyclic prefix
 - Carrier spacing $\Delta f = 15$ kHz
 - $T_{CP} \approx 4.8 \mu s$
 - Extended cyclic prefix needed for broadcast/multicast and environments with extreme delay spread
 - $T_{ECP} \approx 16.7 \mu s$



Downlink Transmission Scheme

- Scheduled downlink (similar principle as HSDPA)
 - No dedicated channels
- Channel-dependent scheduling in time *and* frequency domain
 - Minimum time \times frequency resource for scheduling and link adaptation
 - MIMO \rightarrow 3-dimensional resource blocks (*time \times frequency \times stream*)



Downlink Coding Chain

Segmentation for per-stream channel coding/decoding and error detection

Rel6 Turbo coding

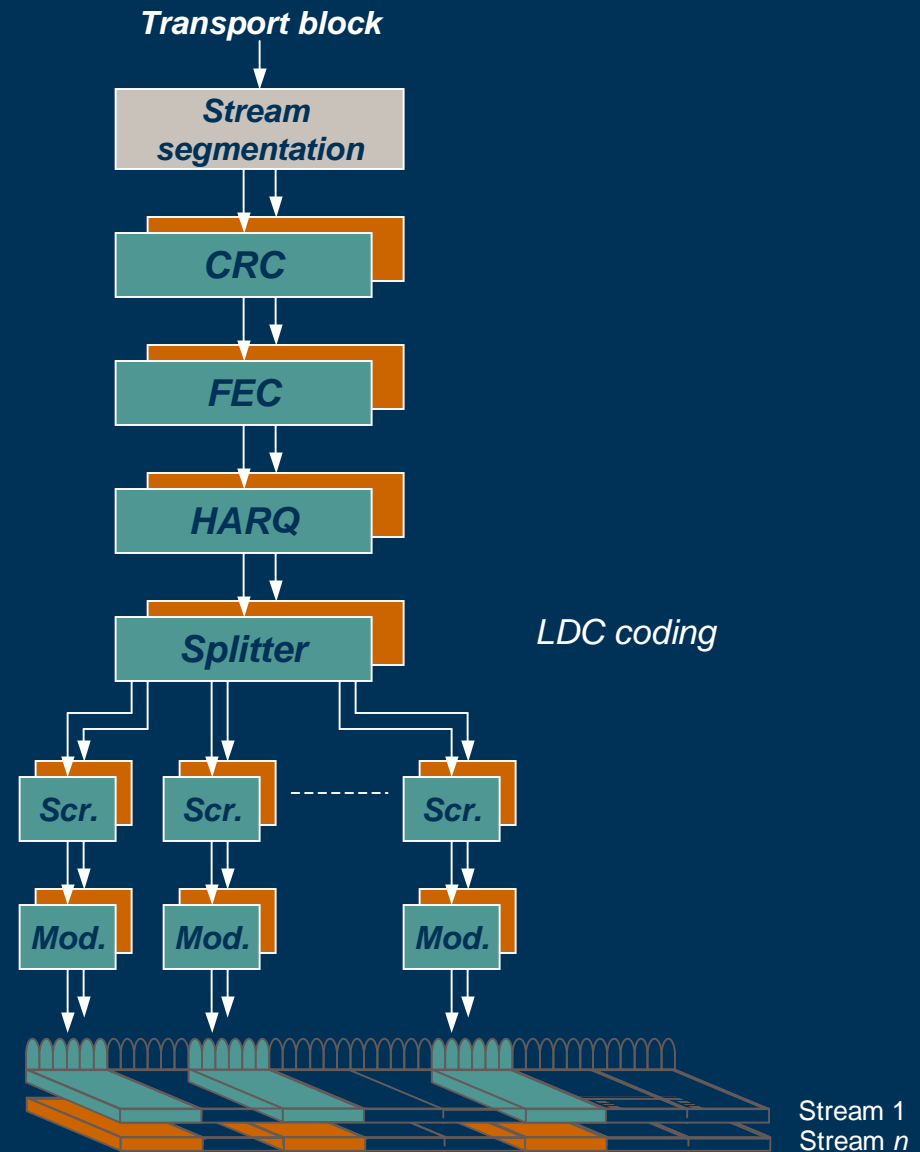
Select sub-set of coded bits as determined by scheduler and HARQ status

Map to selected resource blocks as determined by scheduler

Scrambling for inter-cell randomization

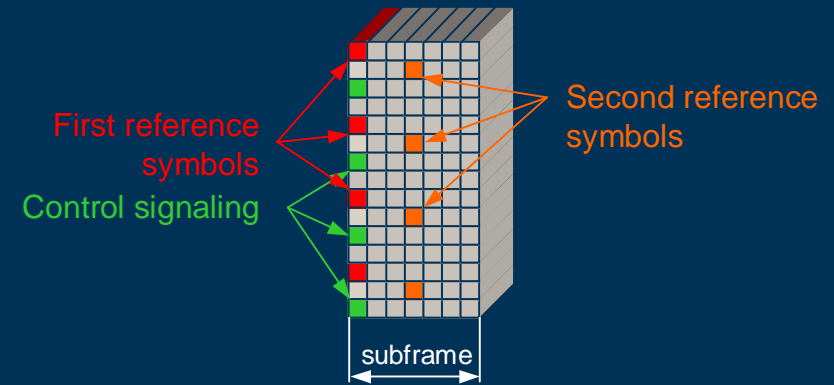
Per-chunk modulation as determined by scheduler (QPSK, 16QAM, 64QAM)

Mapping to selected resource blocks as determined by scheduler



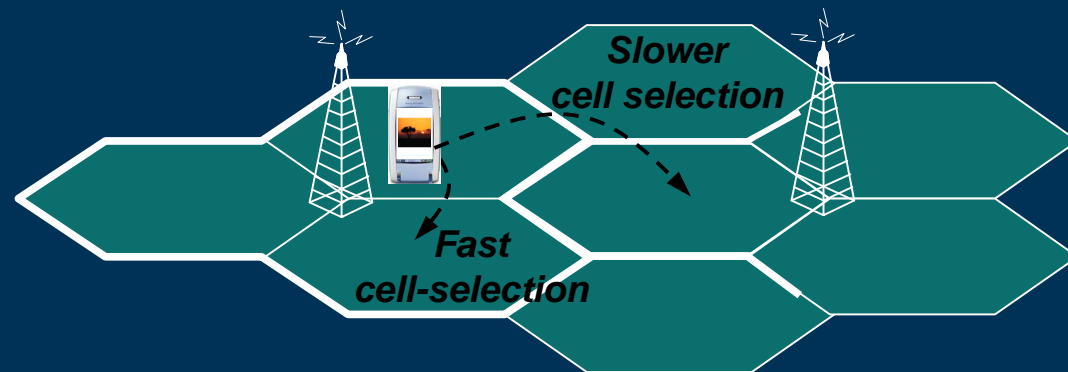
Downlink Reference Signals

- First reference symbols
 - Transmitted at beginning of subframe
 - Sufficient for demodulation of control information
- Second reference symbols
 - Transmitted at an additional time instant in the subframe
 - May not always be present
- Control signaling
 - UL and DL scheduling
 - At beginning of subframe to minimize latency



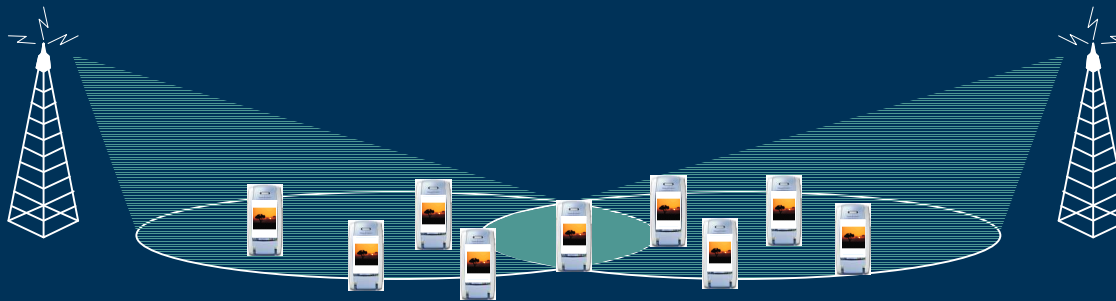
Downlink Macro Diversity – Unicast

- Fast intra-Node B cell selection *for unicast*
 - Intra-Node B soft combining (“softer handover”) possible – transmission from multiple cells seen as beam-forming by the UE
- Slower inter-Node B cell selection

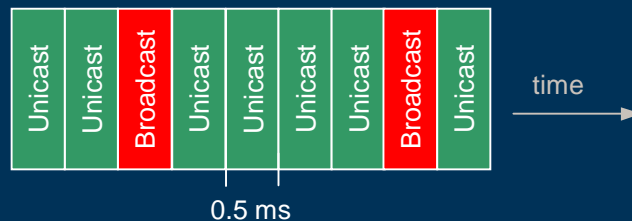


Downlink Macro Diversity – Broadcast

- Synchronized transmission from multiple cells
 - Appears as multipath propagation at the terminal
 - ➔ diversity gains exploited ‘for free’ by OFDM
- Same coding chain as for unicast – scheduler coordination among cells



- TDM of unicast (with short CP) and broadcast sub-frames



Evolved UTRA

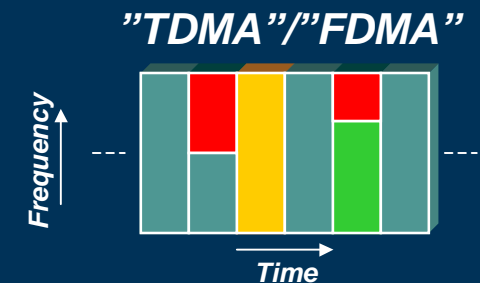
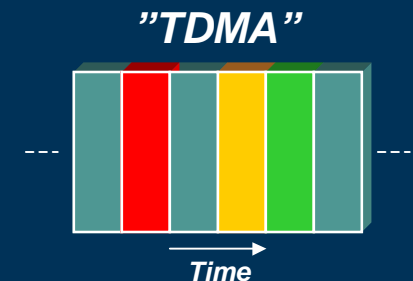
Uplink transmission scheme

Uplink Transmission Scheme

- Time-domain separation
 - Time-domain scheduling, TDMA
- Issue: *Potentially inefficient bandwidth utilization*
 - Limited payload and/or power-limited UE → Bandwidth not fully utilized



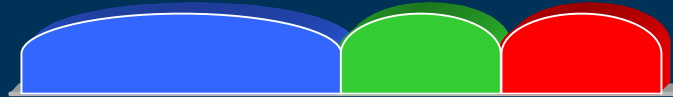
- Additional support for frequency-domain separation
 - Frequency-domain scheduling, FDMA
 - Flexible bandwidth allocation *in baseband processing*



Coverage, cost → high PA efficiency → single-carrier transmission

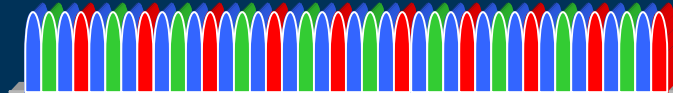
FDMA – Localized vs. Distributed

Localized FDMA



- *Each user transmission localized in the frequency domain*
- *Suitable for frequency-domain adaptation (see pilot discussion)*
- *Reduced requirements on synchronization and frequency accuracy*

Distributed FDMA



- *Each user transmission spread over the entire frequency band*
- *Frequency diversity*
- *Sensitive to frequency errors*

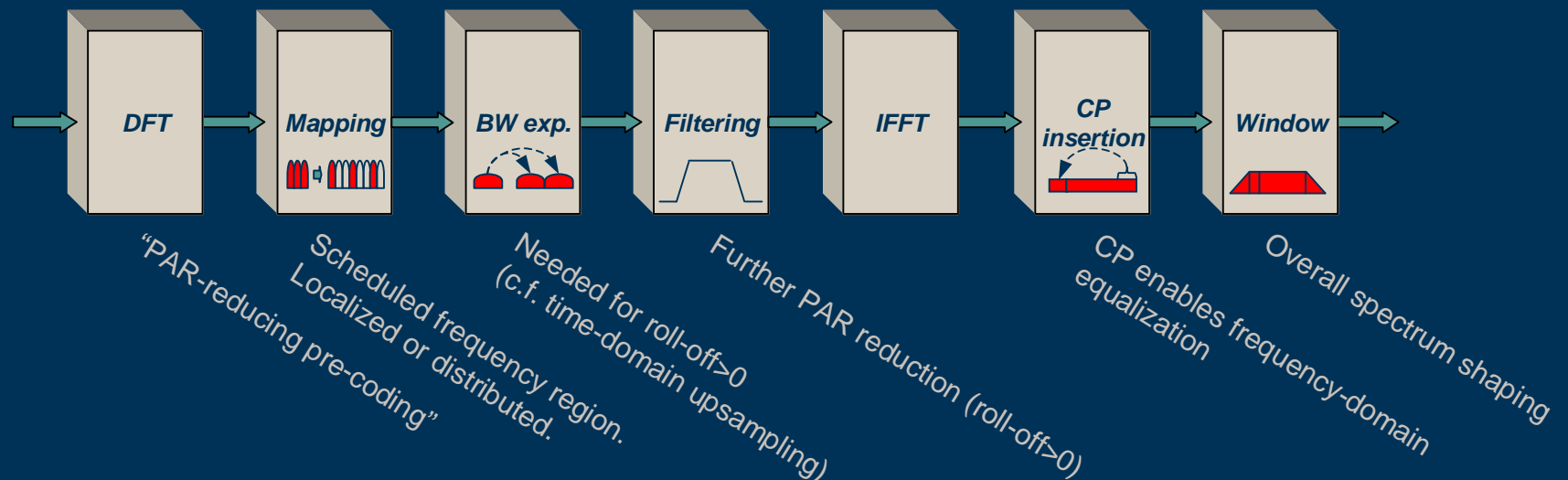
SC-FDMA Transmission Scheme

- SC-FDMA subframe structure (0.5 ms case)



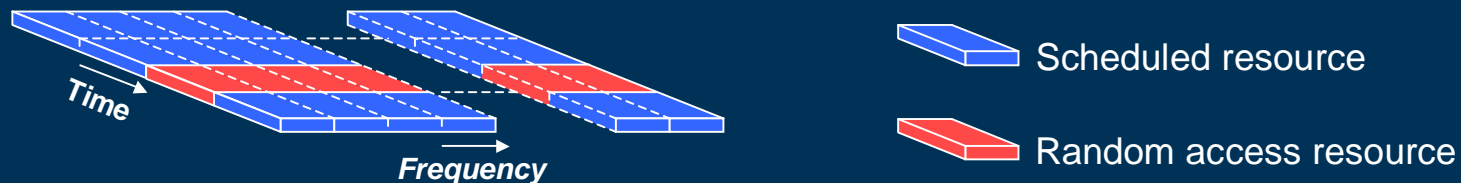
■ Short block (reference signal) ■ Long block (data) ■ Cyclic prefix (4.04 μ s)

- Frequency-domain generation of SC-FDMA (focus in 3GPP)
 - In principle, both time-domain and frequency-domain generation is possible
 - Same numerology as for downlink



Uplink Scheduling

- Scheduled uplink access should be main mode of operation
 - Orthogonal uplink design
 - UE requests resources – network responds with resource assignment
- Channel-dependent scheduling not straight-forward
 - No continuous reference signal from all UEs
 - May exploit uplink reference signals transmitted for other reasons
- Contention-based access required for (at least)
 - Random access
 - No uplink (time) synchronization ➔ special treatment
 - Scheduling request
 - Uplink time synchronization present ➔ part of control signaling



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