

# *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.*

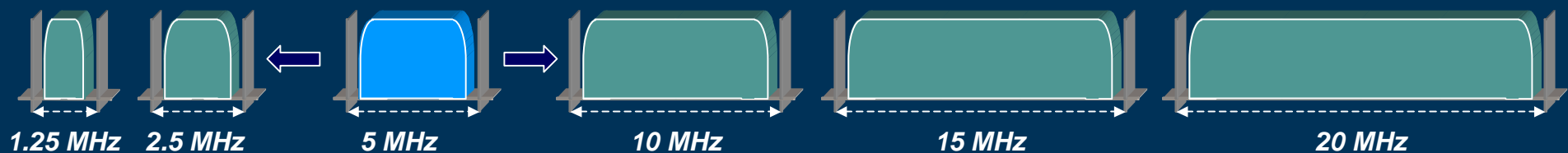
# Evolved UTRA – Some Targets

- 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 (5<sup>th</sup> 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 (5<sup>th</sup> 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.***

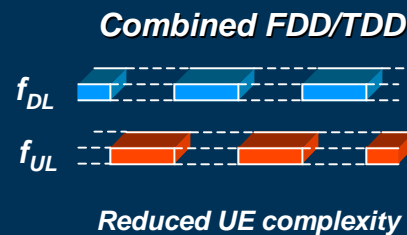
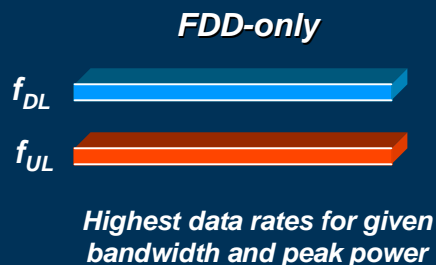
# Evolved UTRA – Spectrum Flexibility

- 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.

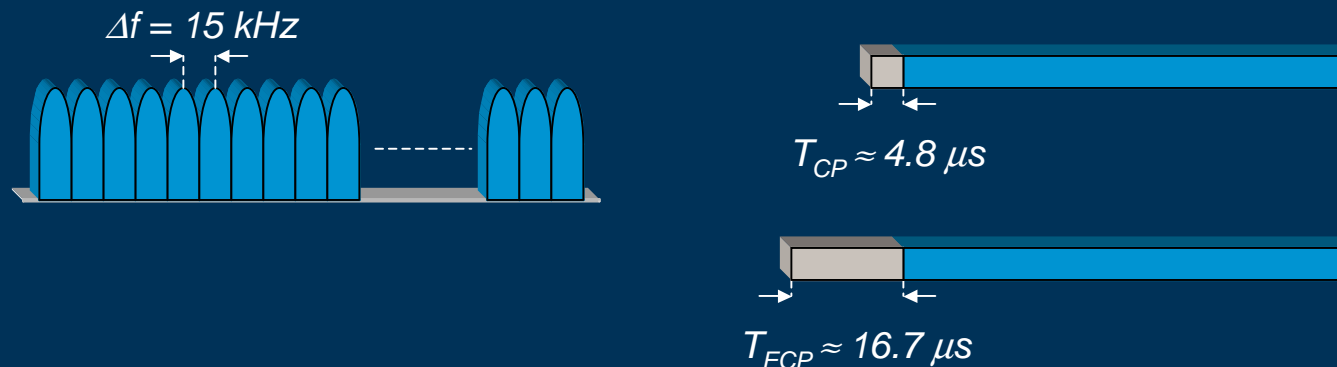


# Evolved UTRA

## *Downlink transmission scheme*

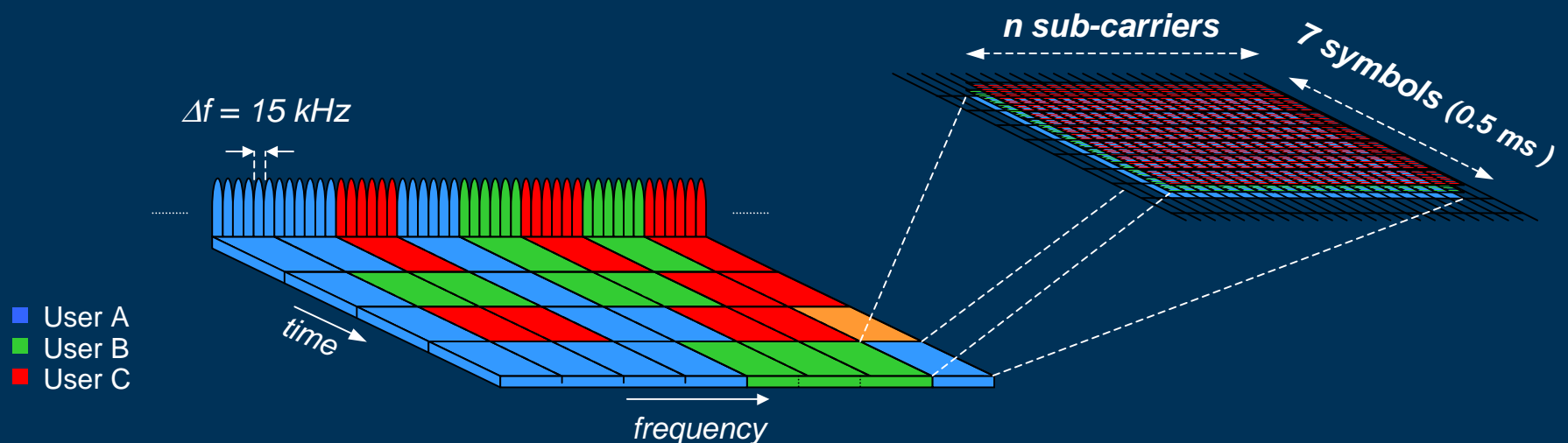
# Downlink Transmission Scheme

- 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*

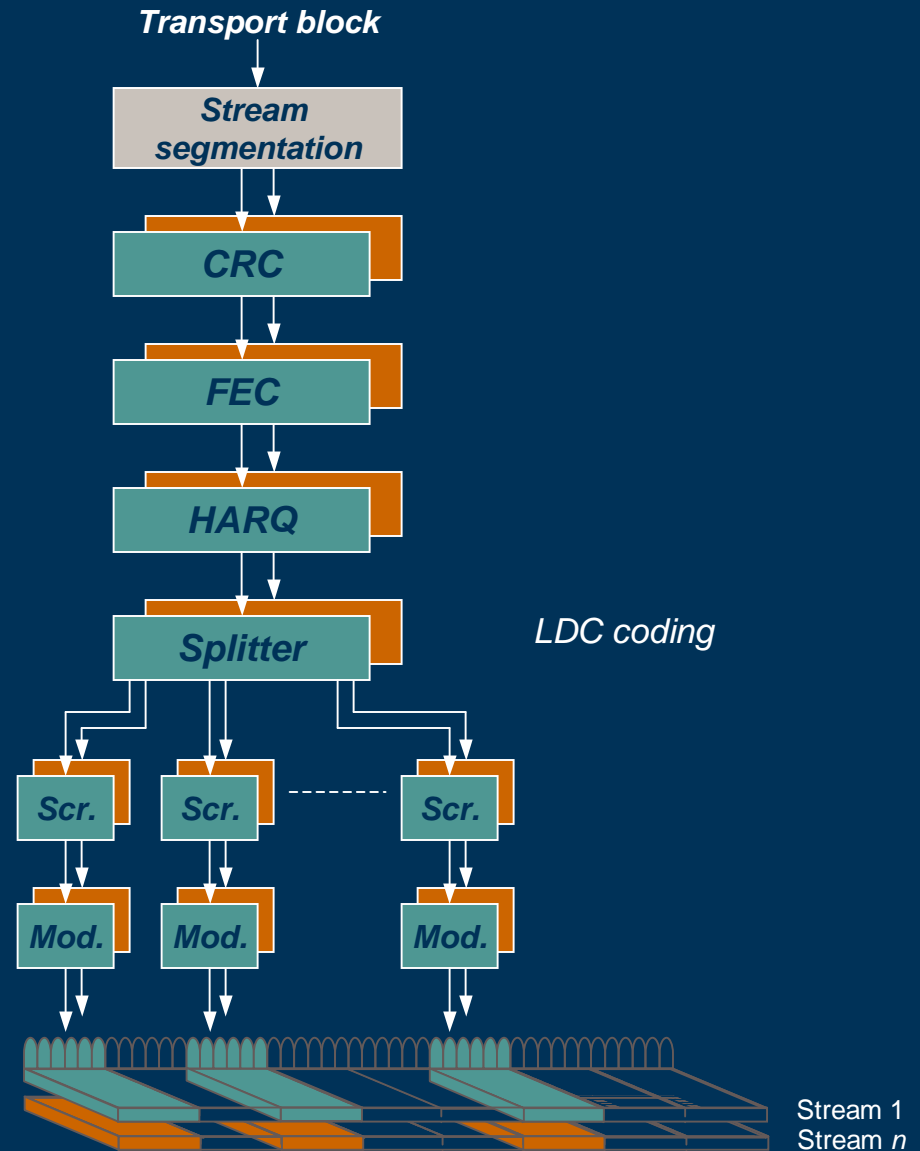
*Select sub-set of coded bits as determined by scheduler and HARQ status*

*Map to selected resource blocks as determined by scheduler*

*Scrambling for inter-cell randomization*

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

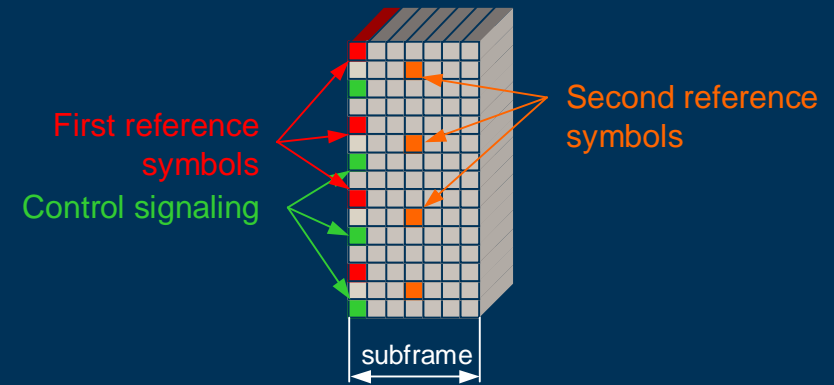
*Mapping to selected resource blocks as determined by scheduler*





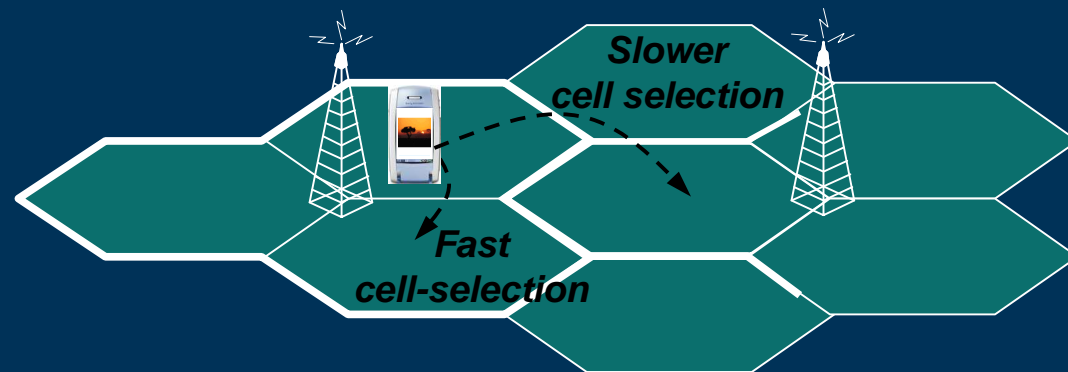
# Downlink Reference Signals

- 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



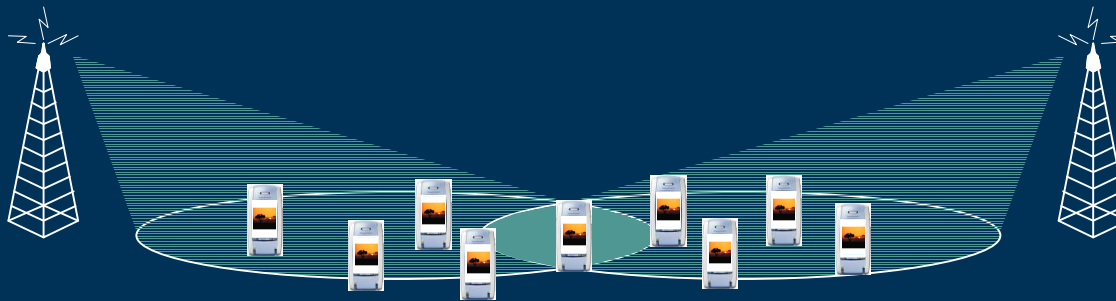
# Downlink Macro Diversity – Unicast

- 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

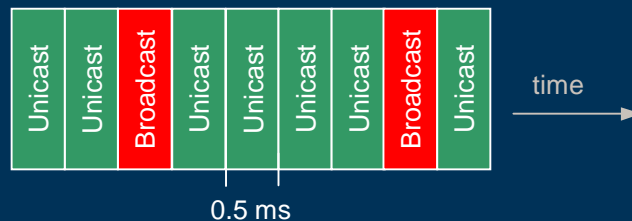


# Downlink Macro Diversity – Broadcast

- 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

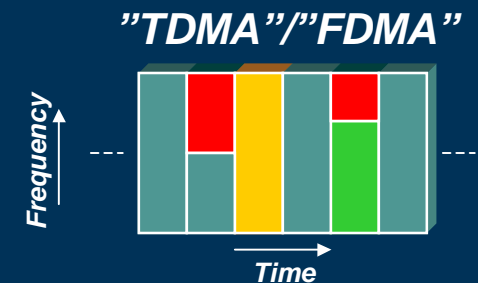
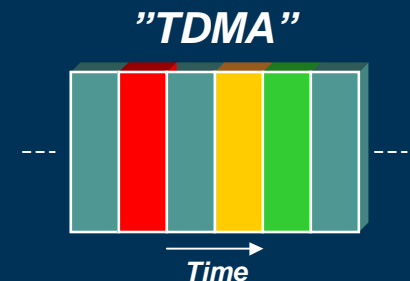
## *Uplink transmission scheme*

# 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



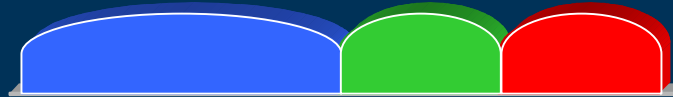
- Additional support for frequency-domain separation
  - Frequency-domain scheduling, FDMA
  - Flexible bandwidth allocation *in baseband processing*



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

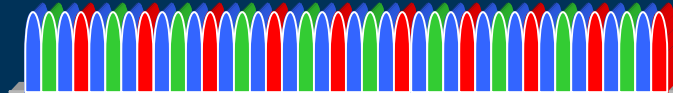
# FDMA – Localized vs. Distributed

## **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*

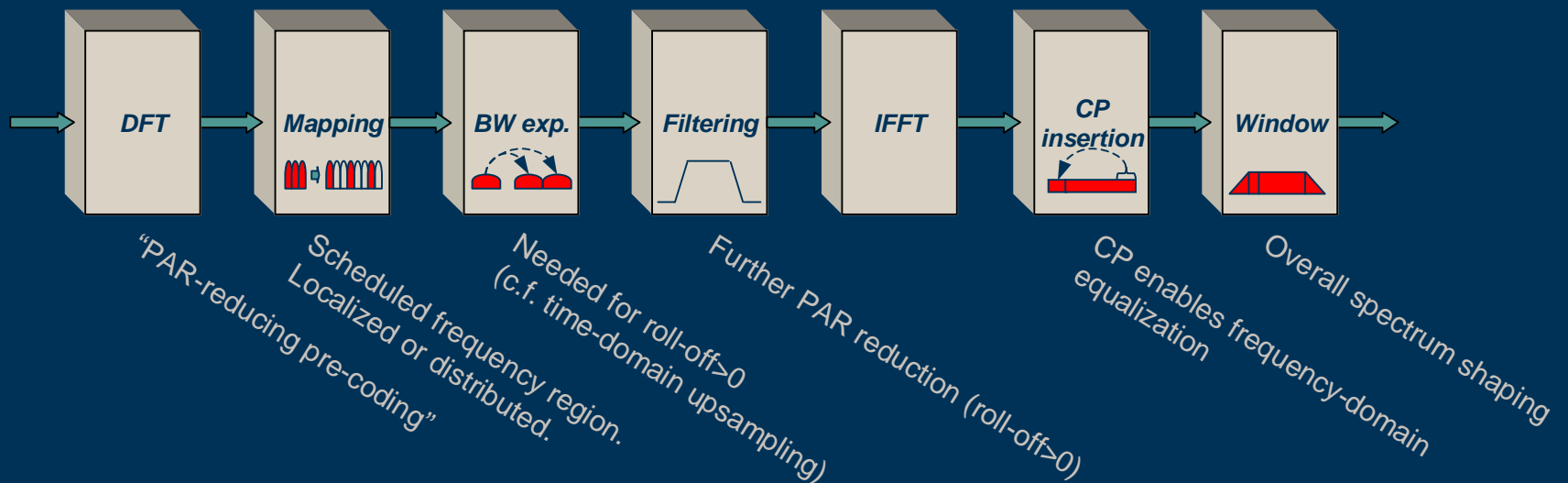
# SC-FDMA Transmission Scheme

- SC-FDMA subframe structure (0.5 ms case)



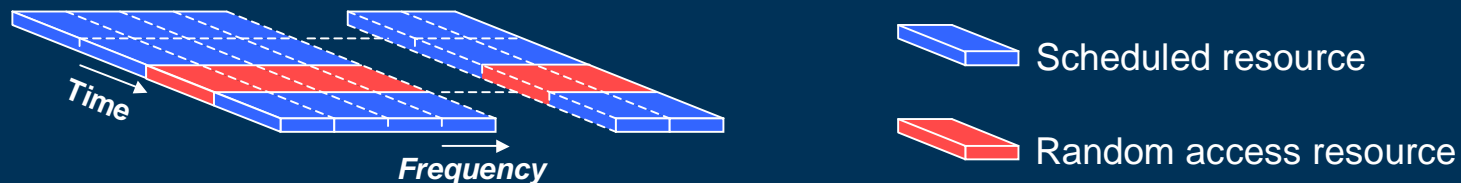
■ Short block (reference signal)     
 ■ Long block (data)     
 ■ Cyclic prefix (4.04  $\mu$ s)

- 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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