



CARRIER AGGREGATION CONCEPTS FOR LTE REL-10

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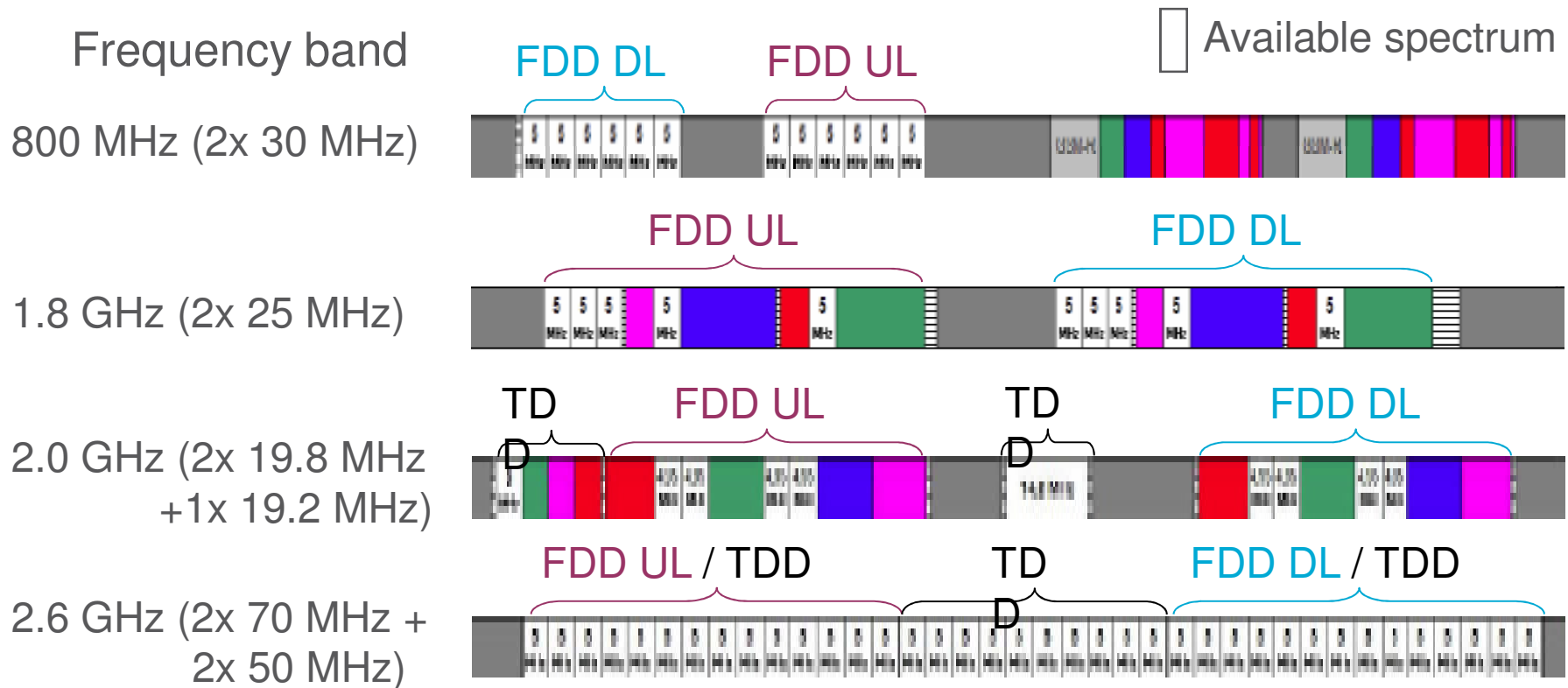
RADIO PROTOCOLS AND MULTIMEDIA
TECHNOLOGIES RESEARCH

OUTLINE

- › Motivation
- › Carrier Aggregation Modes in Frequency Domain
- › Component Carrier Types
- › Basic Component Carrier Concept
- › Control Signaling for Carrier Aggregation
- › Carrier Aggregation in Heterogeneous Networks

MOTIVATION

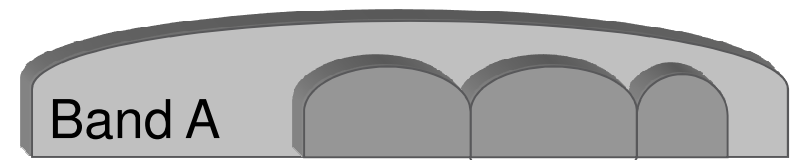
- › Frequency auction in Europe, esp. Germany
- › Independent LTE cells vs. carrier aggregation
 - LTE goal: 1 Gbit/s in downlink (up to 5 component carriers, up to 100 MHz)



CARRIER AGGREGATION MODES IN THE FREQUENCY DOMAIN

- > Contiguous carrier aggregation

- + Possibly only one FFT module and one radio frontend
- + Similar propagation characteristics



- > Non-contiguous carrier aggregation

- + Aggregation of fragmented spectrum

- > Intra- or single-band



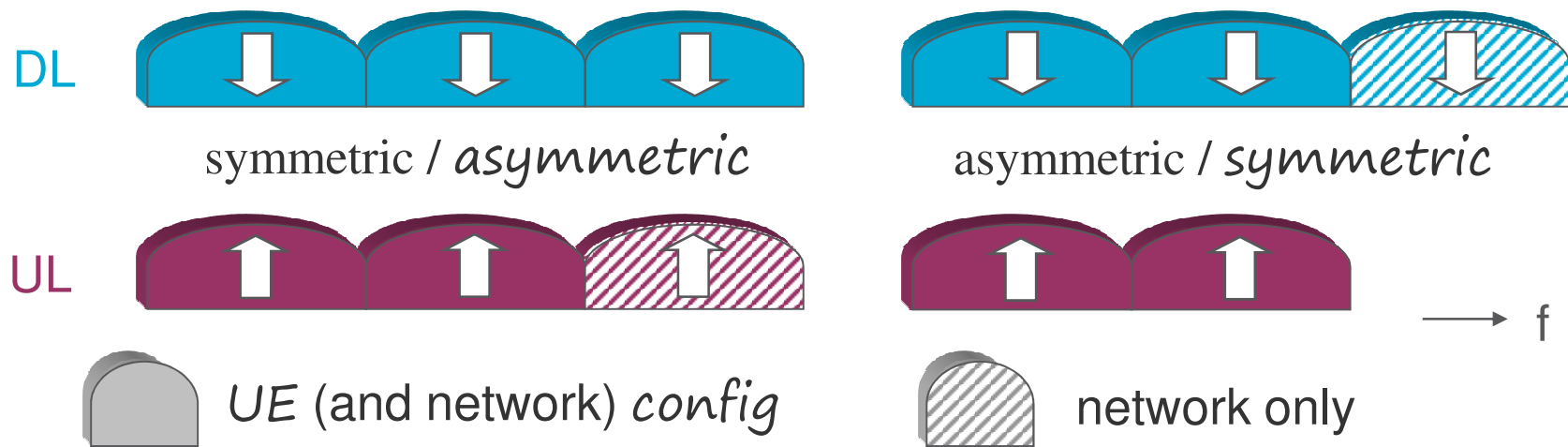
- > Inter- or multi-band



One CC

UPLINK-DOWNLINK SYMMETRY

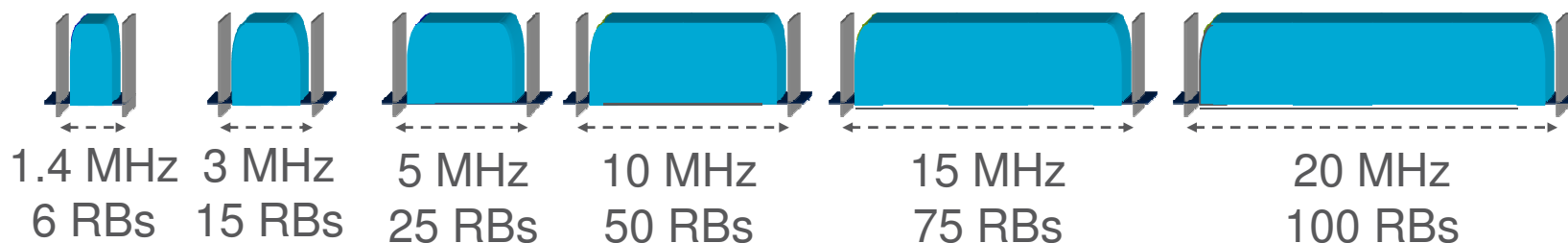
- › **Network** (a)symmetric carrier aggregation
 - Defined by number of DL and UL component carriers offered by network in a sector
- › **UE** (a)symmetric carrier aggregation
 - Defined by number of DL and UL component carriers configured for a UE
 - More UL than DL CCs not allowed
- › SIB2 specific linking between DL and UL



COMPONENT CARRIER (CC) TYPES

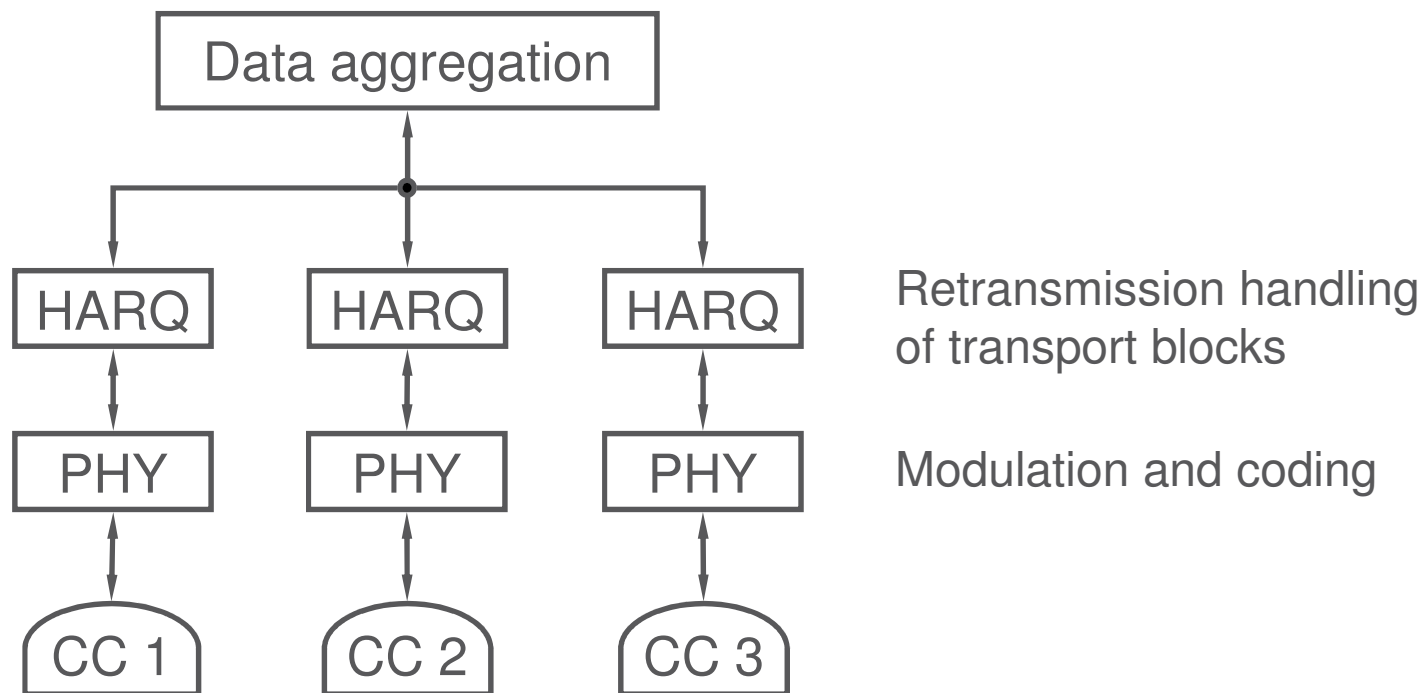
BACKWARDS COMPATIBLE CARRIERS

- › Chosen for Rel-10
- › Maximum reuse → limited complexity
- › Each CC appears as a Rel-8 serving cell to Rel-8 UEs
 - Synchronization and reference signals
 - System Information
 - Backwards compatible bandwidths
- › Signaling extensions for Rel-10 transparent to Rel-8 UEs
- › LTE Rel-8 carrier bandwidths / Rel-10 CC bandwidths:



DATA AGGREGATION IN REL-10

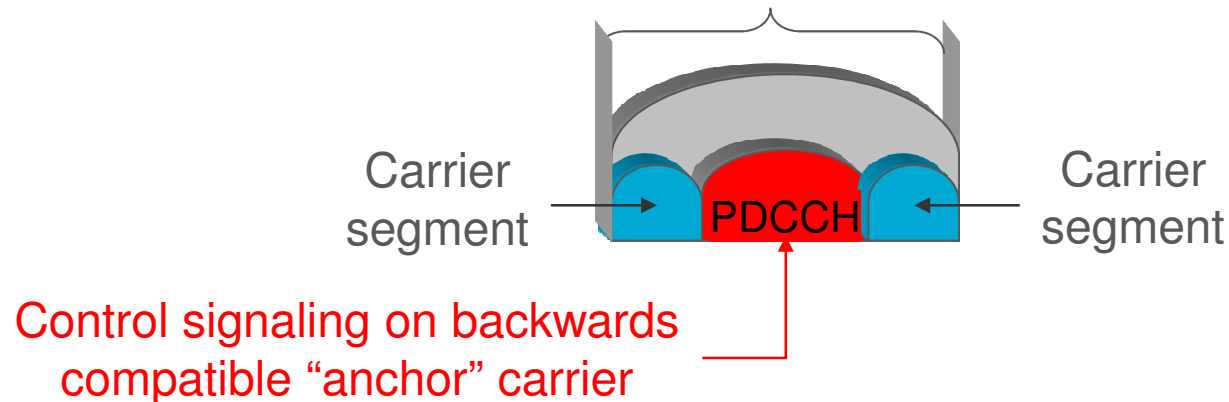
- > Data aggregation in MAC layer
- > Separate HARQ processes and feedback
- > Individual transmission modes (modulation and coding)



COMPONENT CARRIER (CC) TYPES

NON-BACKWARDS COMPATIBLE CARRIERS

- > Candidates for Rel-11
- > Reduced overhead at higher complexity
- > Only configurable with backwards compatible CC
- > Extension carriers
 - Separate HARQ processes with independent transport formats
- > Carrier segments
 - Adjacency criterion, single HARQ entity for combined bandwidth
 - Combined bandwidth restricted to 110 resource blocks (20 MHz)



COMPONENT CARRIER CONCEPT

ENERGY EFFICIENCY



- › Configuration, activation and deactivation of CCs (or DL of serving cells, respectively) **for UE**
 - UE obtains relevant system info for serving cells corresponding to configured CCs
 - For deactivated serving cells
 - › No PDCCH (control) / PDSCH (data) reception
 - additional UE complexity to receive scheduling information only for activated serving cells
 - › No channel quality measurements and reporting of CQI (channel quality indicator)
 - › Potentially mobility measurements
 - UL transmission on any configured UL CC on UL grant reception
- › CCs can be switched off **by network** if not configured for any UE

COMPONENT CARRIER CONCEPT

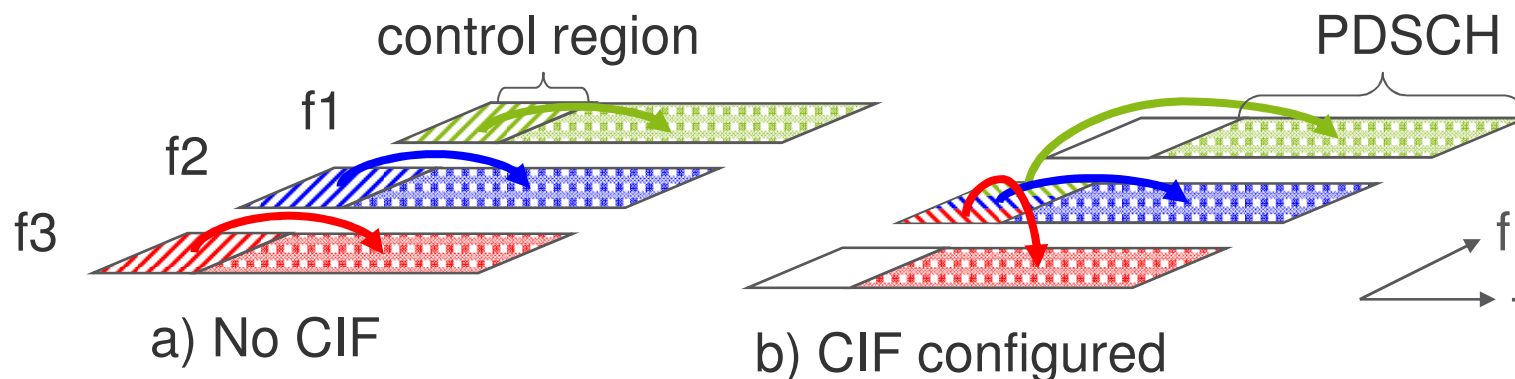
PRIMARY AND SECONDARY CARRIERS/CELLS

- › Carrier aggregation irrelevant for idle mode UEs
- › Only one RRC connection to the network
- › Security input and NAS mobility info only from one serving cell, the primary serving cell (**PCell**), all other serving cells are called secondary serving cells (**SCells**)
- › UL/DL carrier corresponding to PCell is primary CC (**PCC**) and to SCell is secondary CC (**SCC**)
- › Main **PCell** characteristics
 - System information monitoring as in Rel-8
 - cannot be deactivated
 - RACH only allowed in PCell
- › Relevant system information of configured **SCells** obtained via dedicated signaling

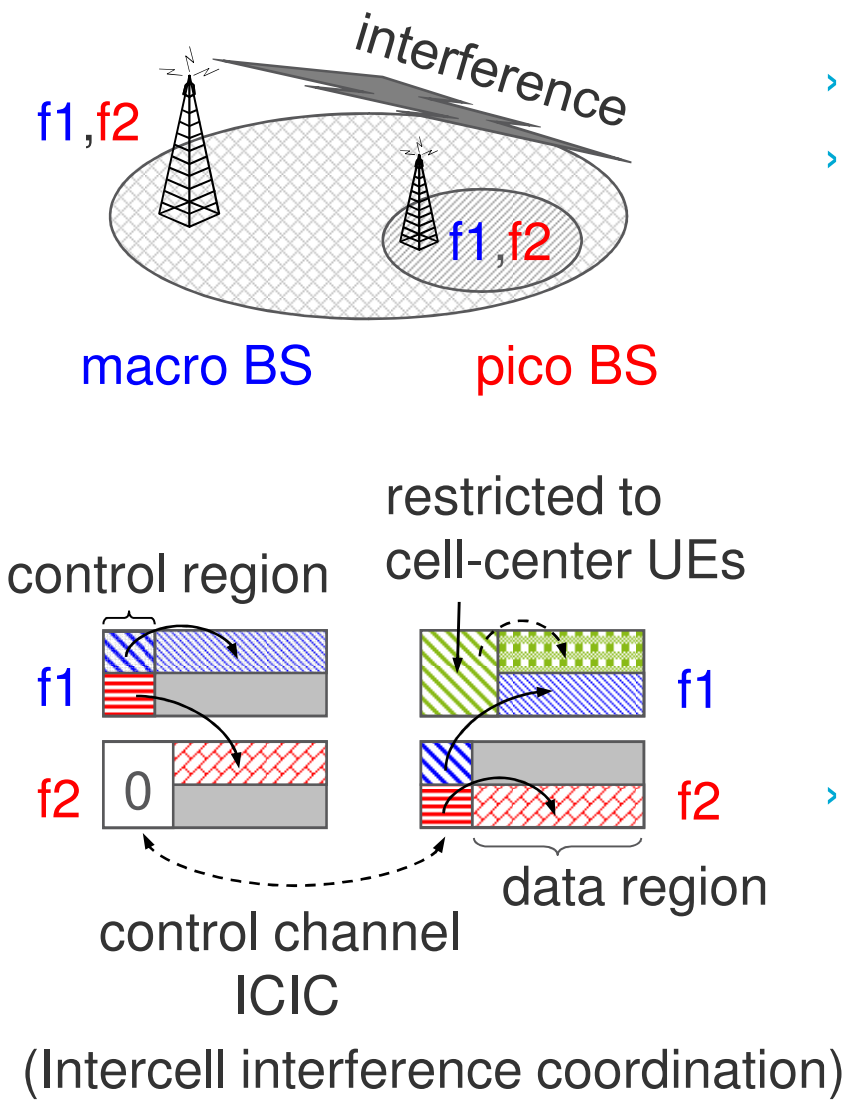
COMPONENT CARRIER CONCEPT

CONTROL SIGNALING: SCHEDULING (PDCCH)

- > Reuse of Rel-8 PDCCH structure
 - Each DL or UL shared channel transmission has its own PDCCH containing DL assignment or UL grant
- > In Rel-10 configurable 3-bit Carrier Indication Field (CIF)
 - Enables cross-carrier scheduling
 - Semi-static configuration indicates presence/absence of CIF
 - CIF only possible in UE specific search space (scheduling of data, but paging, random access, system information not supported)



CARRIER AGGREGATION IN HETEROGENEOUS NETWORKS



- > In Rel-8 ICIC for data but not control
- > Cross-carrier scheduling allows ICIC even for control channels
 - **Pico BS** uses CCs on $f1$ and $f2$ and transmits its **control in cell $f2$**
 - **Macro BS** uses CCs $f1$ and $f2$ and transmits its **control in cell $f1$**
 - > If cell $f2$ is used at least the control channels (L1/L2, sync, PBCH) with reduced (potentially zero) power
- > PCFICH on cross-scheduled CC:
 - for pico BS large control region on $f1$ due to robustness
 - for macro BS large control region on $f2$ to avoid interference to pico BSs

SUMMARY

- › Good progress in 3GPP to complete WI this year

- › Beneficial if spectrum available
 - Aggregation of “narrow” CCs to obtain larger overall bandwidth
 - 1 Gbit/s in DL only possible with carrier aggregation
 - Flexible bandwidth combination allowing new LTE bandwidths even up to 100 MHz
 - Backwards compatibility
 - Efficient interference management for control channels specifically in heterogeneous networks
 - Costs: minimum additional UE complexity
 - › Additional scheduling complexity only if SCells are activated
 - › Simple solution for system information reception in SCells



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