Summary of Deliverable 2.3: Components of a new air interface - building blocks and performance

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Contributors

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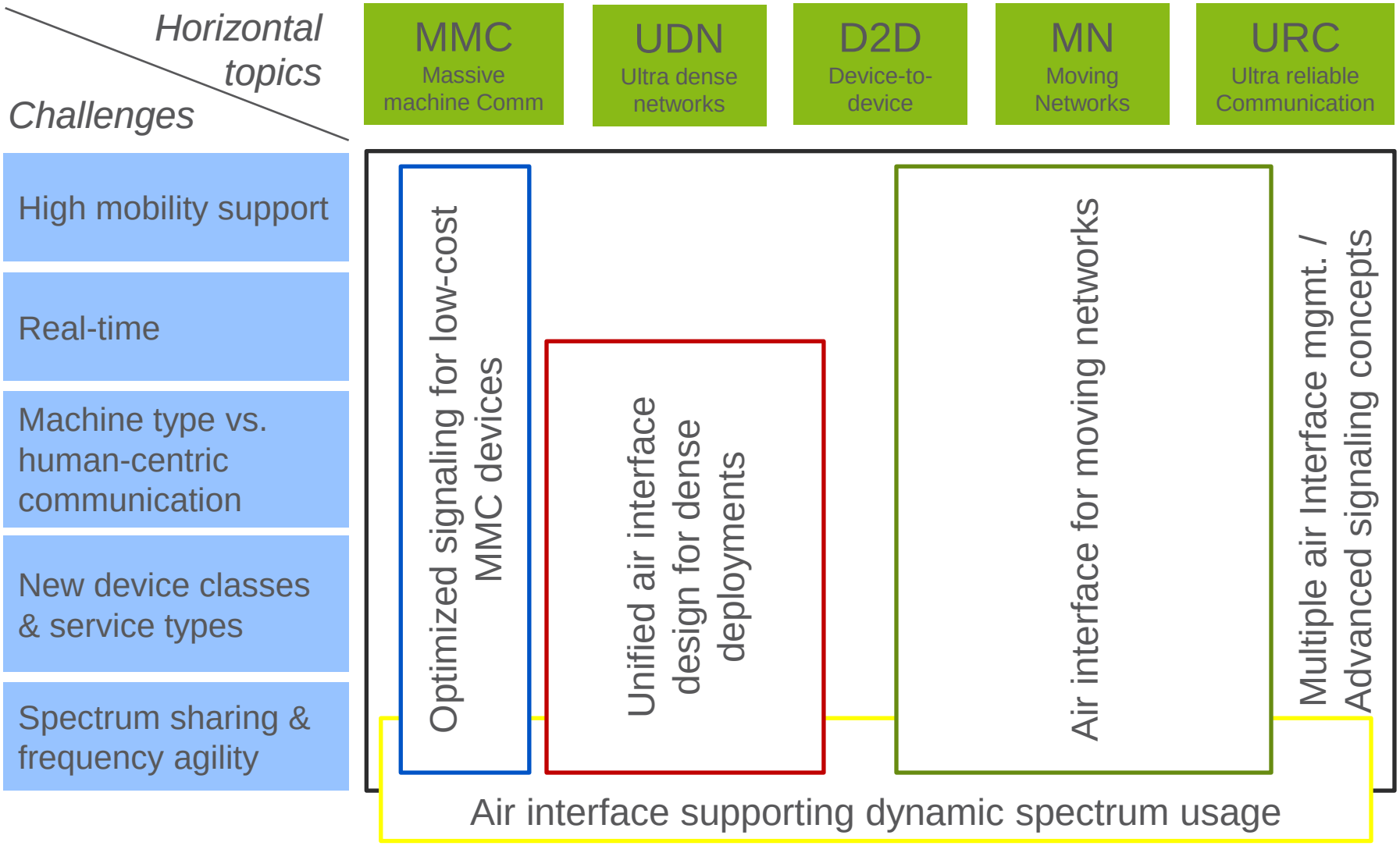
Summary

- Introduction of TeC clusters
  - TeC clusters (TeCC) group TeCs with similar research context and objectives
  - Compared to the research topics (RTs) introduced in D2.1, they allow for a more detailed structuring. RTs are now substituted by the TeCCs.
  - To ensure consistency with the RTs, the RT numbering is kept and a sub-categorization is introduced.
    - e.g. TeC cluster #12.1 is the 1st TeC cluster defined for RT 12.
- Preliminary research results for each TeC cluster
  - Compact description in the main body: 0.5 - 1 page per TeC
  - Details in the Annex & referenced papers (submitted)
- Conclusion: Brief summary of the TeCs investigated and their potential

Overview on WP2 deliverables

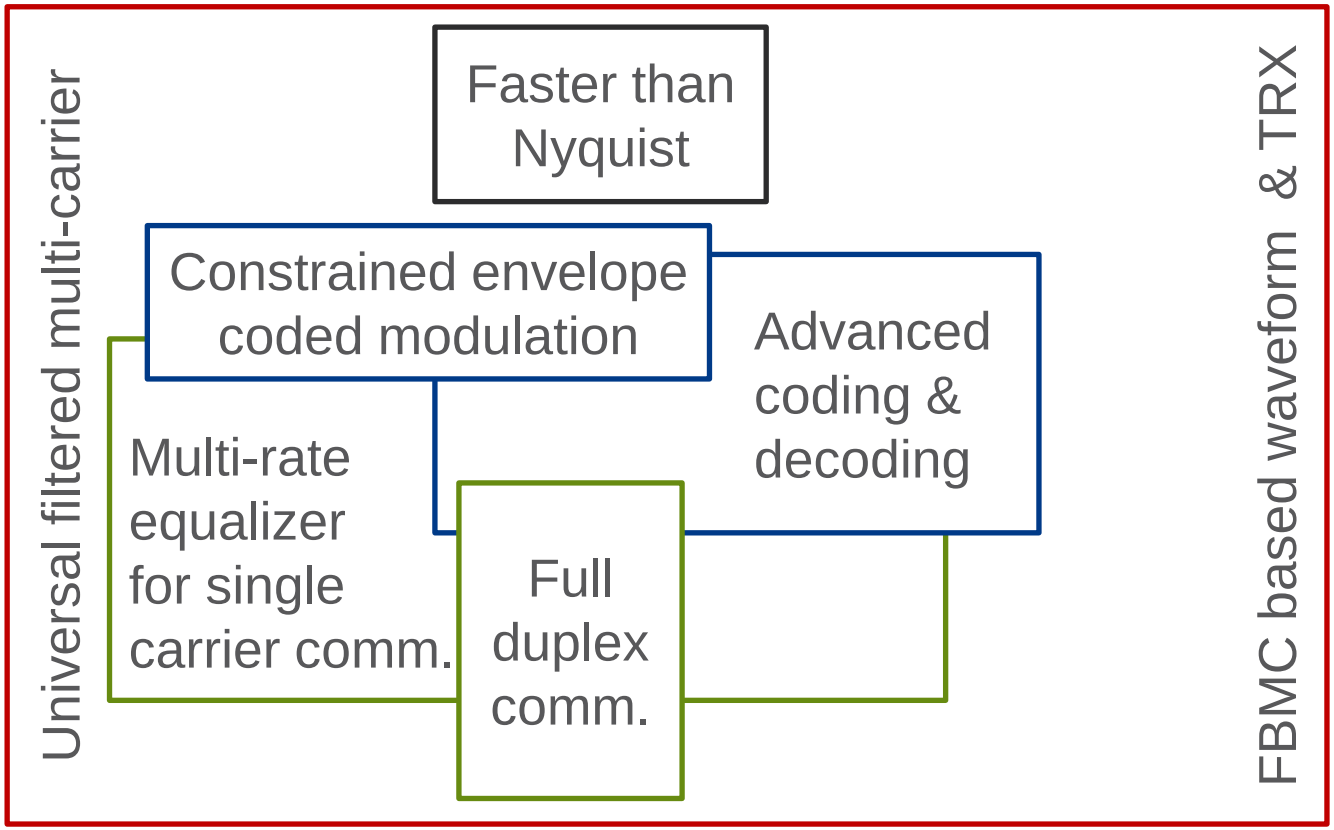
- D2.1 „Requirement analysis and design approaches for 5G air interface“:
  - Short descriptions of the 14 research topics and requirements addressed by each of them. Introducing framework of „general requirement metrics“.
- D2.2: „Novel radio link concepts and state of the art analysis”
  - State of the art analysis and detailed description of the planned research per research topic
- D2.3: „Components of a new air interface - building blocks and performance”
  - Preliminary research results for each TeC cluster (formerly „research topic“)

T2.1 TeCCs: Flexible air interface design

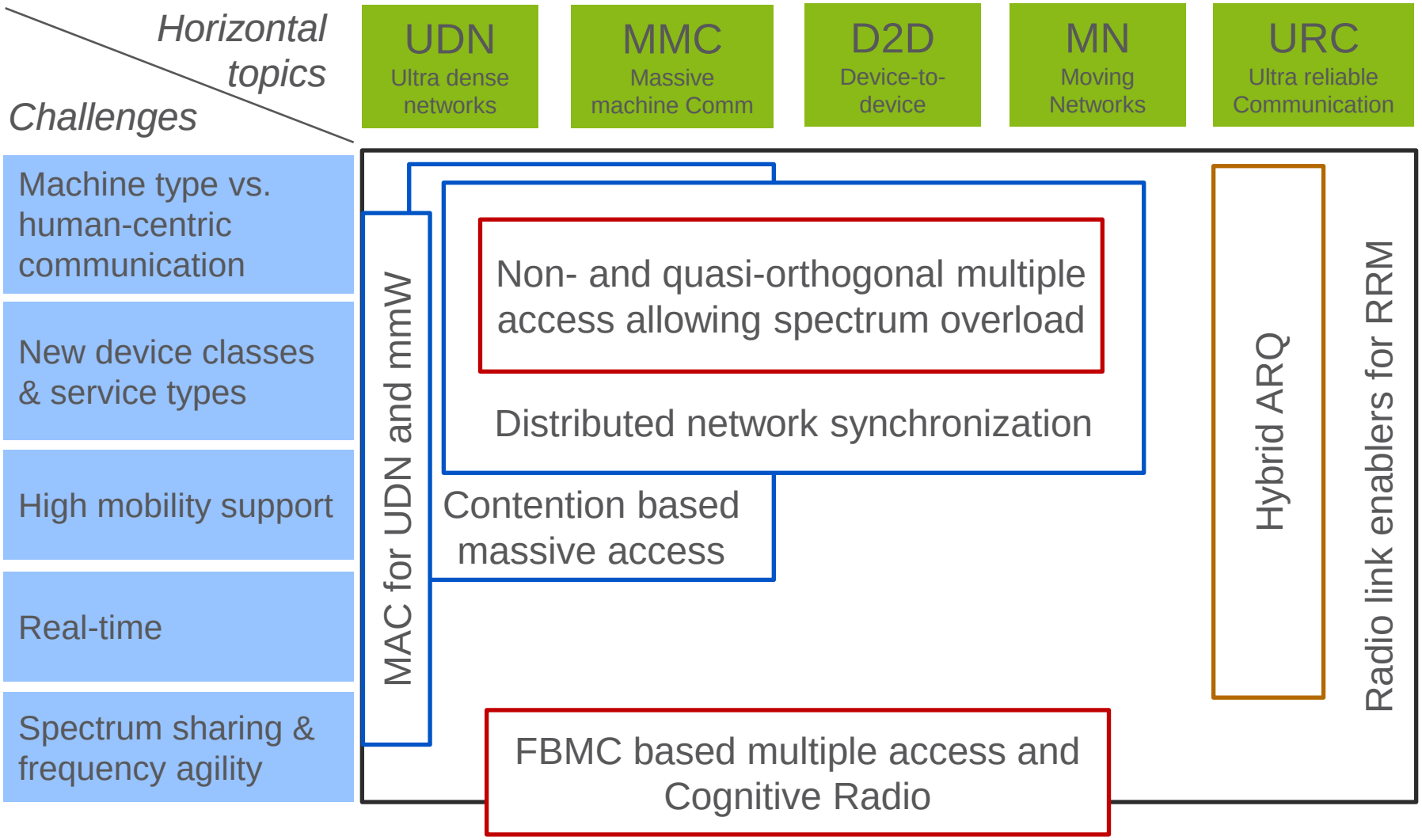


T2.2 TeCCs: Waveforms, Mod/Cod & TRX Design

Challenges \ Horizontal topics	MMC Massive machine Comm	UDN Ultra dense networks	D2D Device-to-device	MN Moving Networks	URC Ultra reliable Communication
Machine type vs. human-centric communication					
New device classes & service types					
High mobility support					
Real-time					
Spectrum sharing & frequency agility					



T2.3 TeCCs: Multiple Access, MAC & RRM



TeCs in the Clusters

TeCC#1: Unified air interface design for dense deployments
- UDN TDD frame numerology
- METIS UDN optimized frame structure
- Flexible TTI for eff. energy saving and high-speed transfer

TeCC#2: Optimized signaling for low-cost MMC devices
- MMC-type D2D links
- Hybrid access scheme for reduced signaling overhead

TeCC#3: Air interface supporting dynamic spectrum usage
- RF architectures for multi-band operation

TeCC#4: Multiple air interface management
- Multi-RAT PHY layer design & multi-band processing
- Software configurable air interface

TeCC#5 Advanced signaling concepts
- Signaling for non-orthog. multiple access

TeCC#6: Air interface for moving networks
- Framework for URC
- URC framework for modelling and predicting link reliability
- Channel estimation for V2V links
- Channel predicition for the backhaul link

TeCC#7: Faster than Nyquist

TeCC#8: Filtered and filterbank based multi-carrier

TeCC#8.1: FBMC based waveform & transceiver design

TeCC#8.2: Universal filtered multi-carrier (UFMC)

TeCC#9: Modulation & coding and new channel coding concepts

TeCC#9.1: Constrained envelope coded modulation

TeCC#9.2: Advanced coding and decoding
- Adaptive complexity flexible baseband
- Practical lattice codes

TeCC#10: Advanced transceiver design

TeCC#10.1: Full duplex TRX

TeCC#10.2: Multi-rate equalizers for single carrier comm.

TeCC#11: Multiple access (MA)

TeCC#11.1: Non- & quasi-orthog. MA allowing spectrum overload
- Non-orthogonal multipe access (NOMA)
- UL SCMA random access

TeCC#11.2: FBMC based multiple access and Cognitive Radio
- MA with Cognitive Radio
- Precoding & RX processing for MA MIMO FBMC

TeCC#12: Medium access control

TeCC#12.1: Contention based massive access
- Coded random access
- Coded access reservation
- Adv. PHY processing for enhanced MAC

TeCC#12.2: Distributed network synchronization

TeCC#12.3: MAC for UDN and mmW

TeCC#13: Hybrid automatic repeat request (HARQ)
- Incremental Redundancy with backtrack retransmission
- Mult-level ACK/NACK for reliabilty based HARQ

TeCC#14: Radio Link Enablers for RRM

Which of the METIS major goals have been addressed?

T2.1 Flexible air interface	
■	1000x data volume
■	10-100x user data rate
■	10-100x number of devices
■	10x longer battery life
■	5x reduced E2E latency
■	Energy efficiency and cost

T2.2 Waveform, mod/cod & TRX	
▨	1000x data volume
■	10-100x user data rate
■	10-100x number of devices
■	10x longer battery life
▨	5x reduced E2E latency
■	Energy efficiency and cost

T2.3 MA, MAC and RRM	
■	1000x data volume
■	10-100x user data rate
■	10-100x number of devices
■	10x longer battery life
■	5x reduced E2E latency
■	Energy efficiency and cost

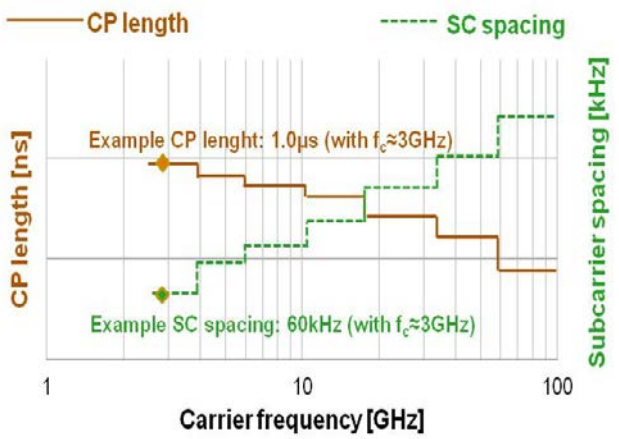
Some technical highlights in D2.3

- General air interface aspects revisited improving SoTA (e.g. LTE/LTE-A)
  - Use case specific air interface design (UDN, MN)
  - Novel waveform approaches increasing flexibility
  - Analysis of contention based acess schemes for complementing scheduled access
  - New multiple access schemes
    (NOMA: power domain, SCMA: sparse code domain)
  - HARQ with reliability based multi-level ACK/NACK

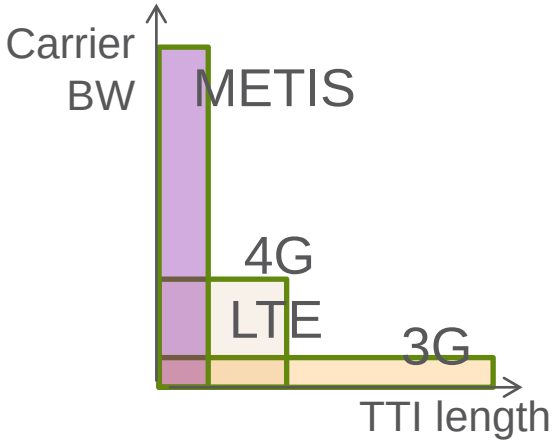
T2.1 Promising TeC clusters

› TeC cluster #1: Unified air interface design for dense deployments

Given that a broad range of frequencies may be used in UDN, a scalable frame structure allows to adapt framing times and symbol durations, which facilitates a common base band design meeting low cost constraints. Research covers dynamic partitioning of UL/DL periods in TDD mode to account for the highly asymmetric traffic expected in UDN.



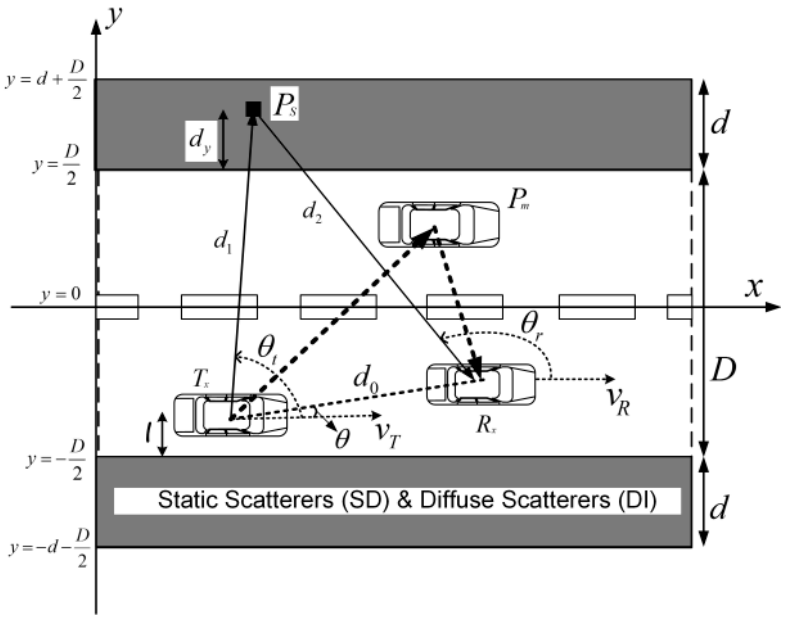
METIS goals addressed	
	1000x data volume
10-100x (via wider BW, short distance, short latency, etc.)	10-100x user data rate
> 50x discovery capacity	10-100x number of devices
~7-40x (w.r.t. LTE-A)	10x longer battery life
PHY RTT ~1ms, TTI ~0.25ms	5x reduced E2E latency
	Energy efficiency and cost



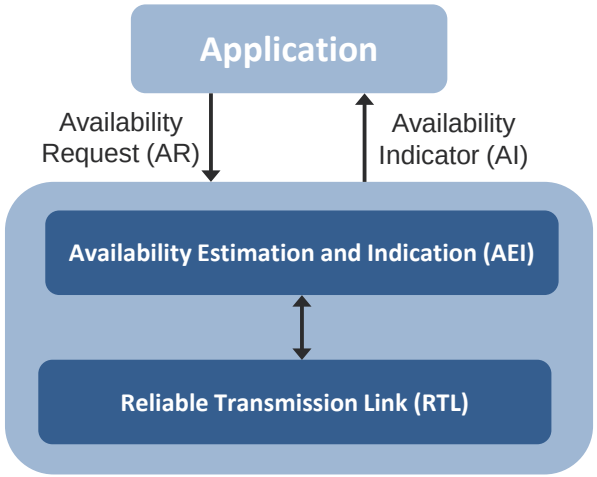
T2.1 Promising TeC clusters

› TeC cluster #6: Air interface for moving networks

Air interface design takes into account the requirements for V2x communications. The objective is to improve the robustness of mobile communication links and enable services with strict reliability requirements such road traffic applications. The research embraces novel channel estimation and channel prediction techniques for highly time variant channels, as well as novel metrics for URC.



METIS goals addressed	
	1000x data volume
10x	10-100x user data rate
	10-100x number of devices
	10x longer battery life
5x-10x for V2V	5x reduced E2E latency
	Energy efficiency and cost

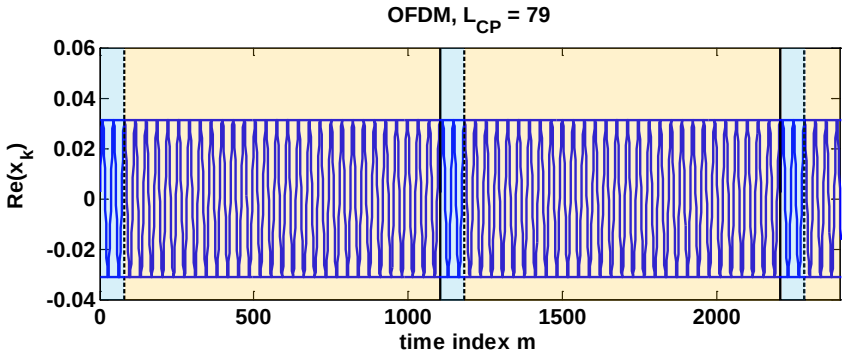


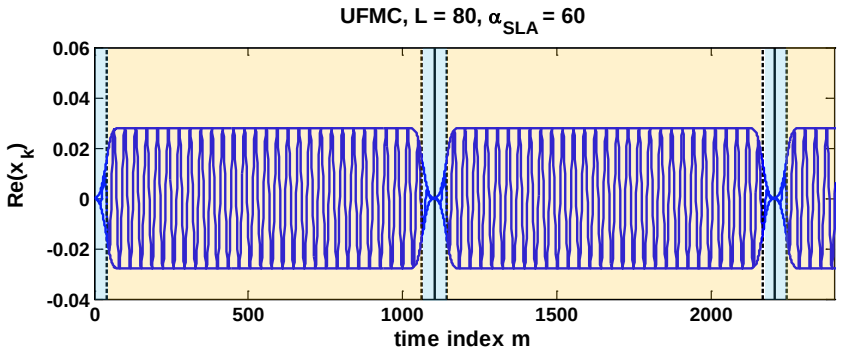
Framework for URC

T2.2 Promising TeC clusters

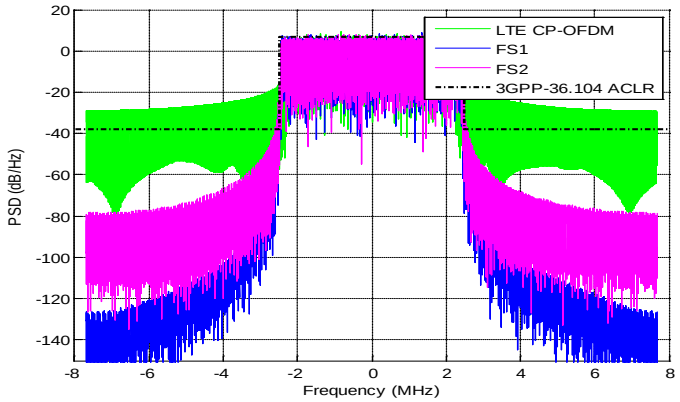
› TeC cluster #8:
Filtered and filter bank based multi-carrier

Use of pulse shapes with good energy localization in frequency domain enable partitioning the spectrum into independent bands with relaxed requirements for synchronization. Thus, these waveforms are promising enablers for efficient spectrum sharing, in particular for the access to fragmented bands. Enables high robustness against Doppler and sync. errors.





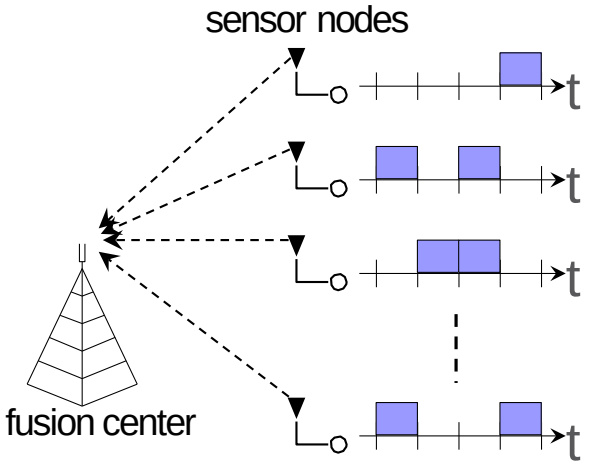
METIS goals addressed	
	1000x data volume
10-100x (case async. CoMP)	10-100x user data rate
10-100x (case MMC)	10-100x number of devices
Up to 10x (case UL relaxed sync.)	10x longer battery life
	5x reduced E2E latency
Reduced overhead (case CoMP, MMC)	Energy efficiency and cost

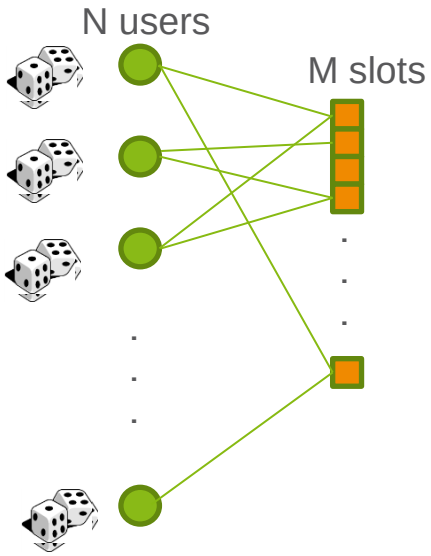


T2.3 Promising TeC clusters

› TeC cluster #12.1: Contention based massive access

MAC approaches for contention or reservation based access of a large number of devices with low overhead. Depending on the application requirements users may either transmit whenever they have data by using a random access channel or reserve resources with efficient access reservation. A promising technique in random access to resolve potential collision with low signalling is a combination of coded random access and compressive sensing multi-user detection, which exploits the sporadic access of MMC nodes.





METIS goals addressed	
	1000x data volume
	10-100x user data rate
10-100x	10-100x number of devices
Up to 10x	10x longer battery life
	5x reduced E2E latency
Reduced overhead & low device complexity	Energy efficiency and cost

What is evolution, and what is revolution?

- Evolution:
  - Multi-level ACK/NACK instead of 2-level ACK/NACK
- Revolution:
  - Fundamental change of basic signalling aspects (e.g. Waveform, frame design)
  - Contention based access complementing scheduled access
  - Novel multiple access schemes beyond TDMA/FDMA (power domain - NOMA, sparse codes domain - SCMA)