Software Defined Air Interface

- Air interface Design Paradigm Shift for 5G

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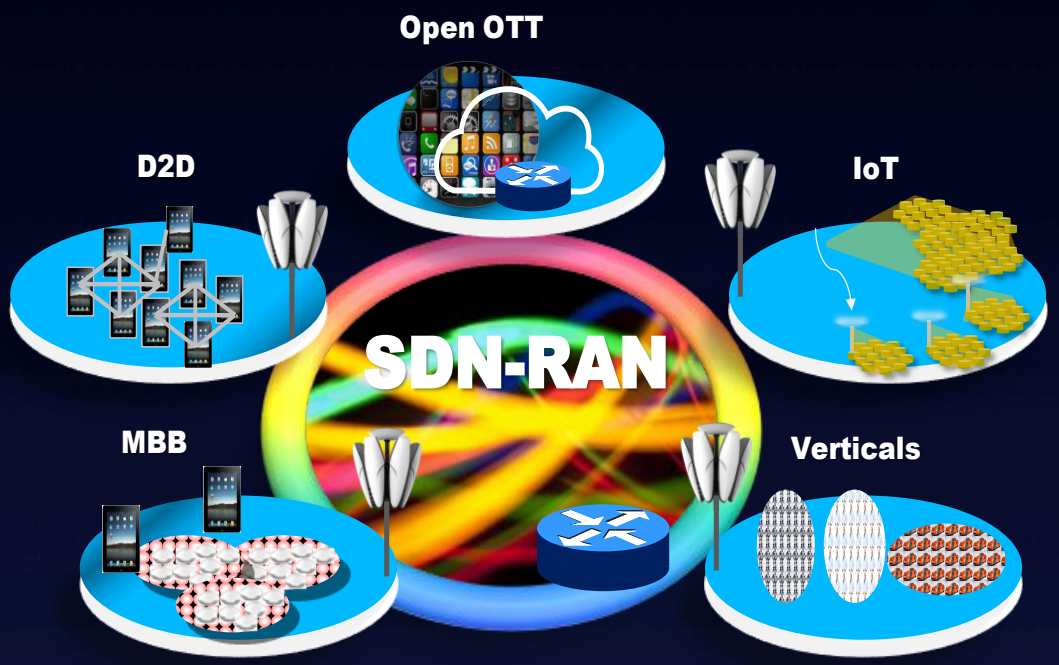
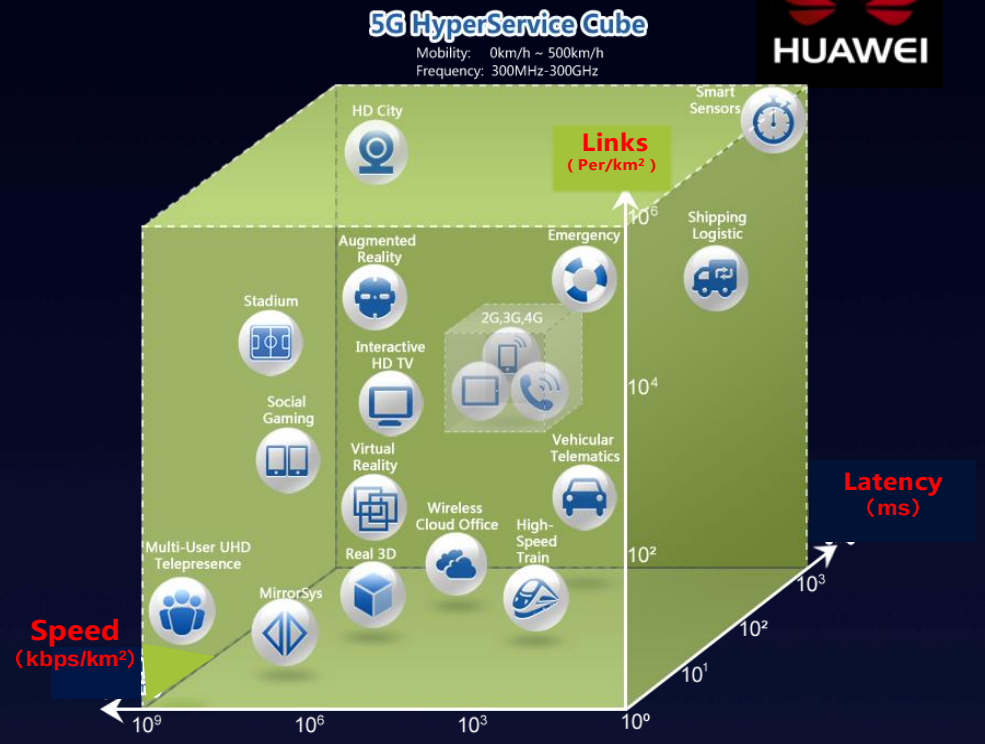
Dec. 8th, 2014

Challenges to 5G Air Interface





Diverse QoE requirements (data rate; latency; reliability; packet size)

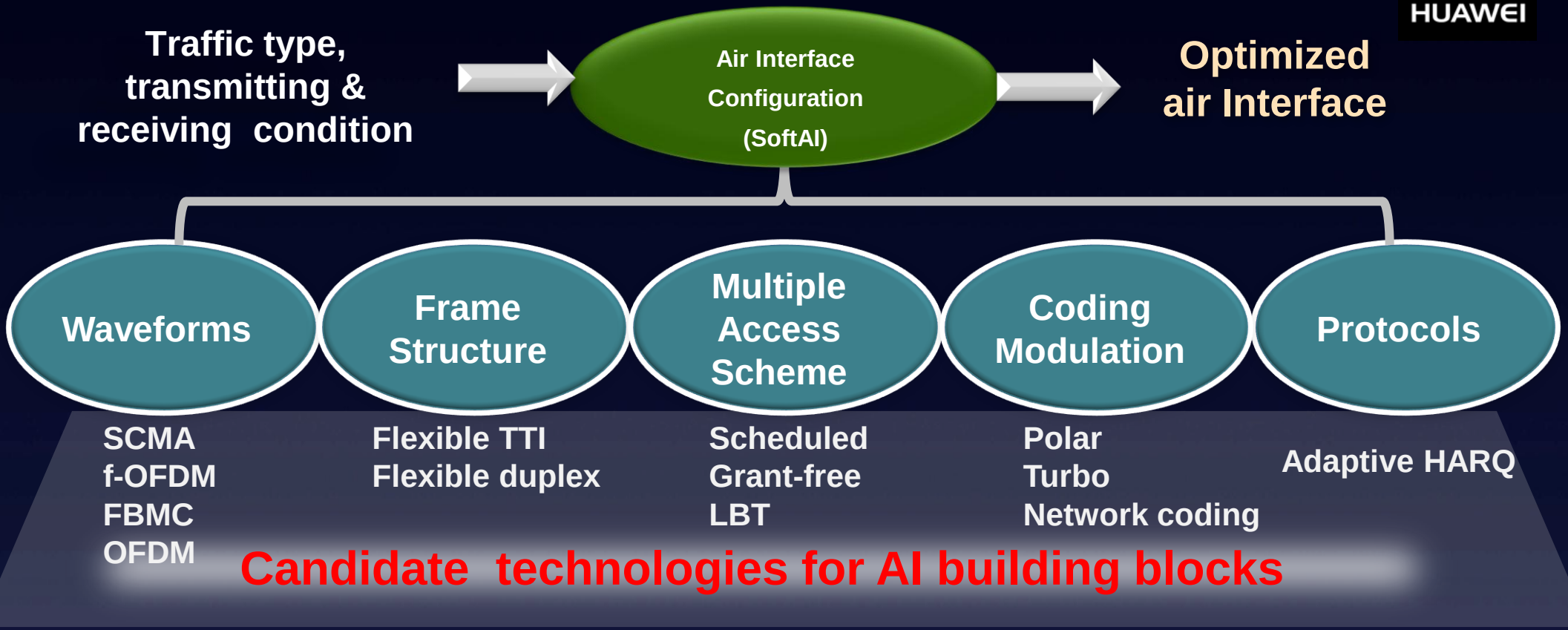
Diverse capabilities for both network transmit nodes and terminals

Diverse deployment environments & spectrum range

Single & unified air-interface for all spectrum and all use cases

Software Defined Air Interface

A Flexible AI

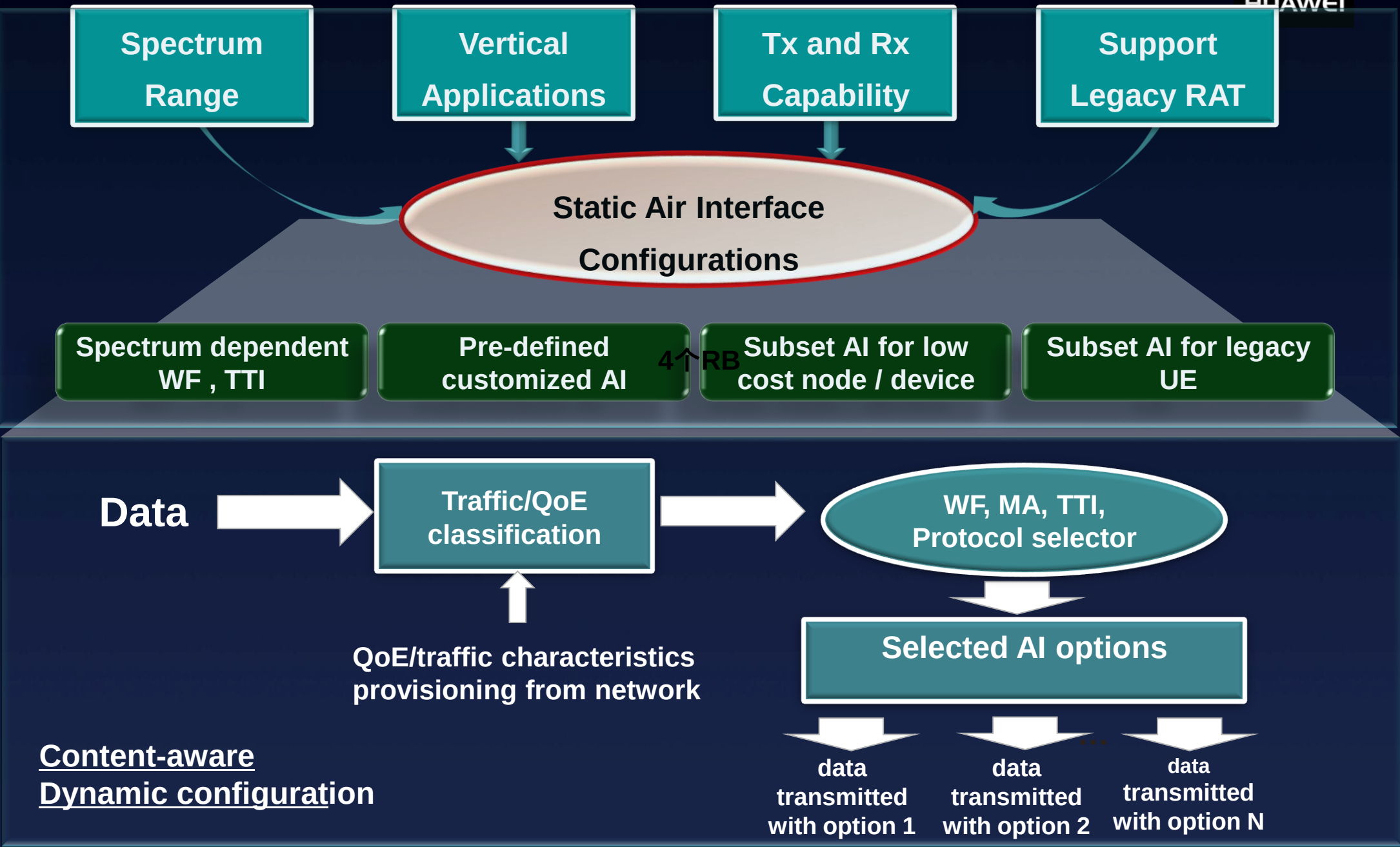


One size fits all -> AI Adaptation

- Optimized RAT for each application/use case
- Dynamic or semi-static or static configurable
- Across frequency carriers or within the same frequency carrier
- Forward compatible : easy to add unforeseeable new service/use case
- Backward compatible

AI Adaptation Example

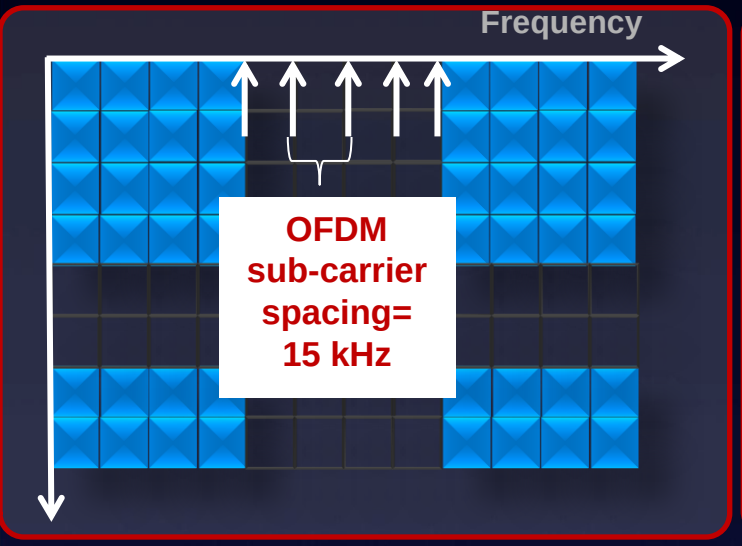
Co-existence of Multiple AI configurations

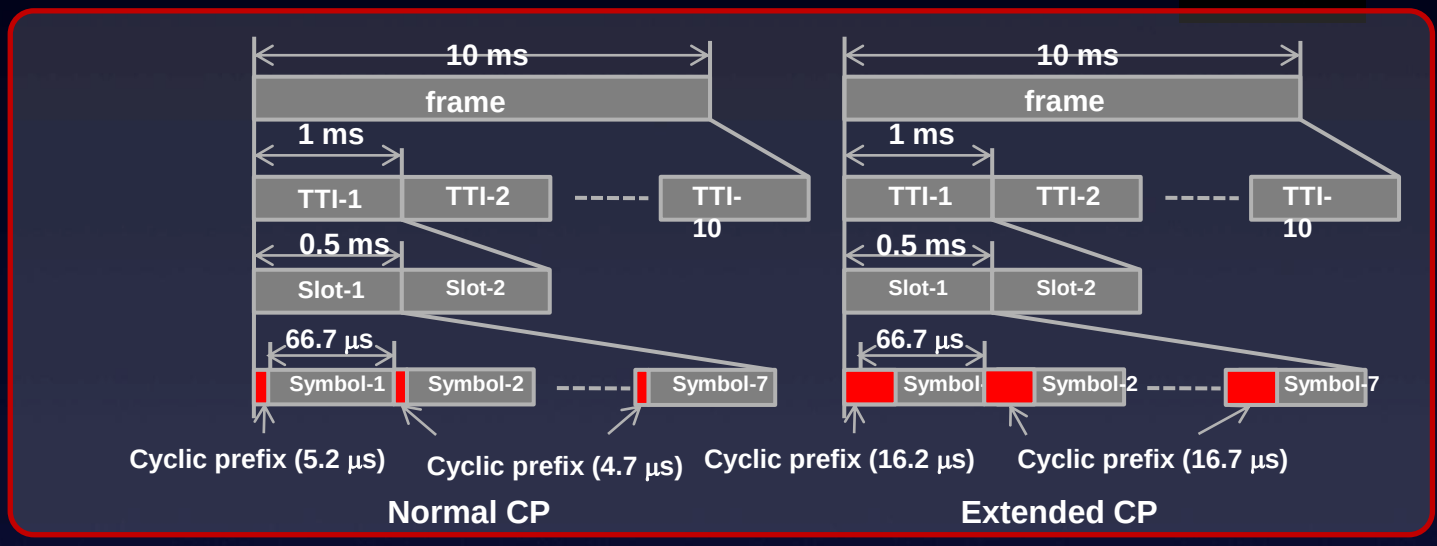


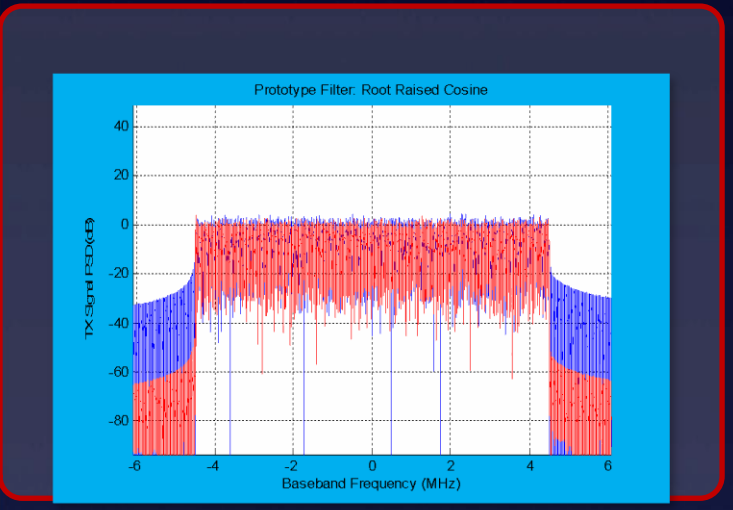
Content-aware Dynamic configuration

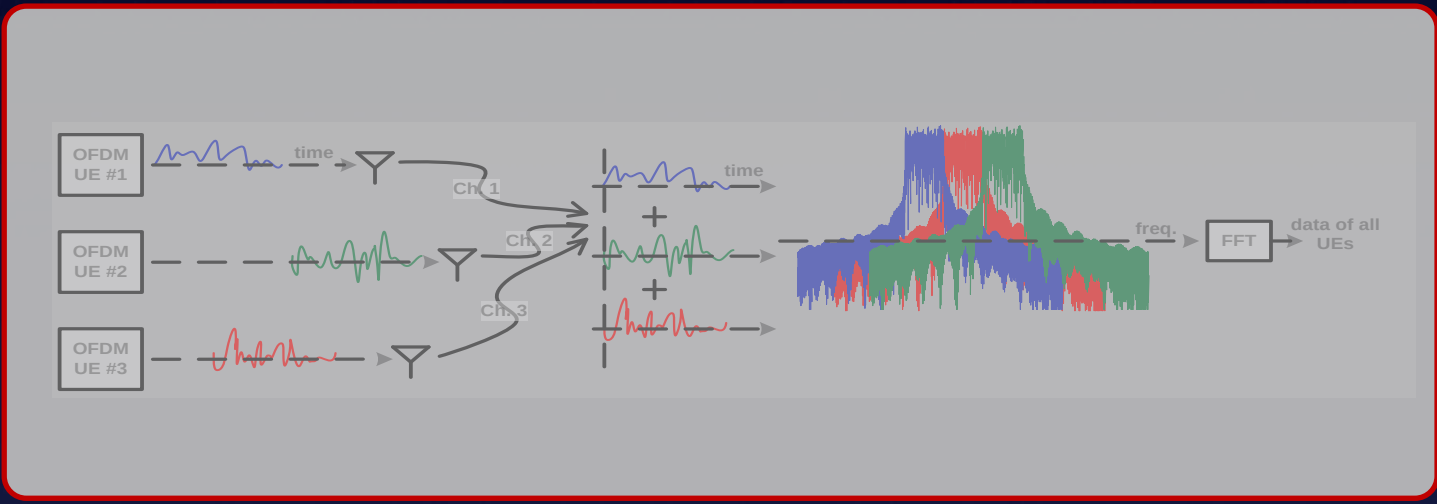
Flexible Waveform

Issues of Existing OFDM Waveform



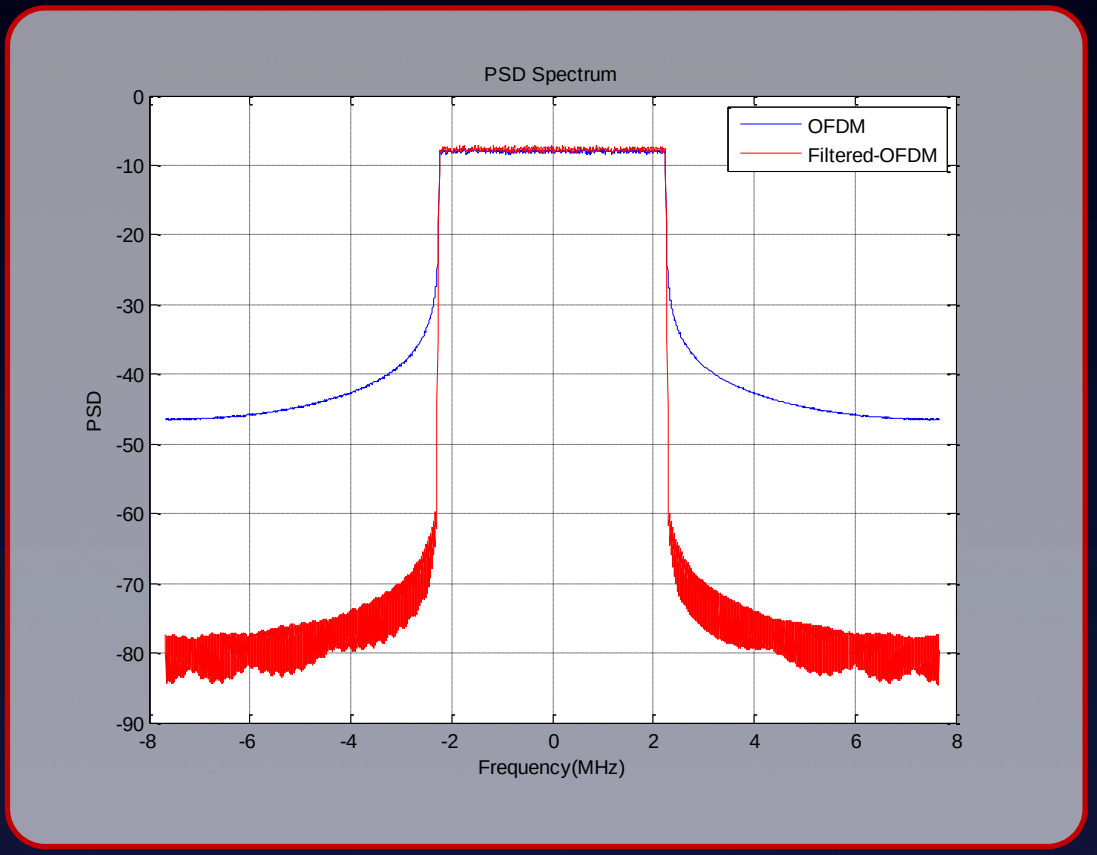






- OFDM waveform is not flexible
- OFDM waveform is not spectrum localized
- OFDM waveform cannot support asynchronous operation

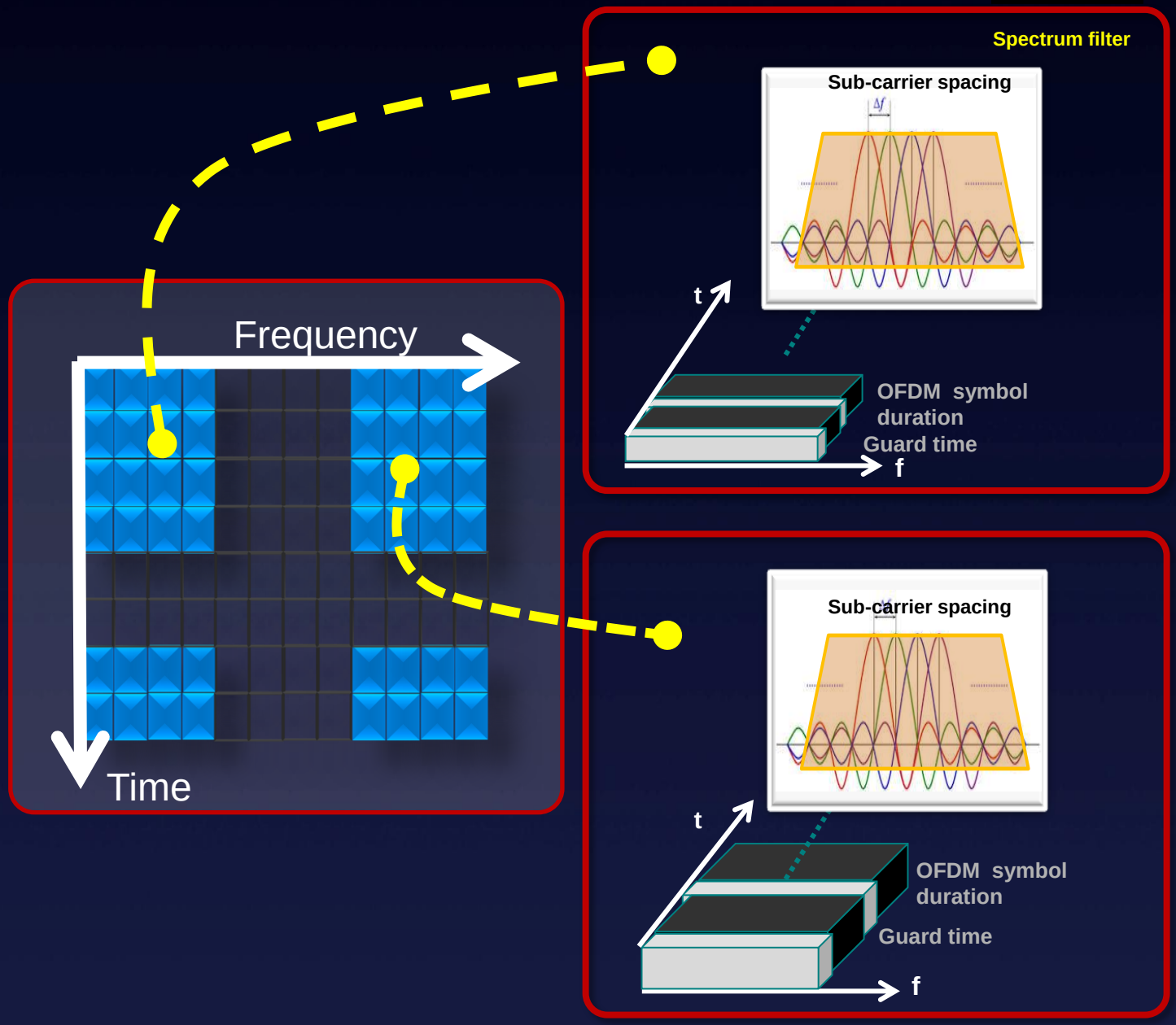
Frequency Localized Waveforms
Subband Filtered OFDM (f-OFDM)



- **f-OFDM: Sub-band digital filter is applied to shape the spectrum of subband OFDM signal.**
  - **Good out-of-band leakage rejection**
  - **Maintain all the benefits of OFDM**
  - **M-MIMO friredly**
  - **Fragmental spectrum utilization**

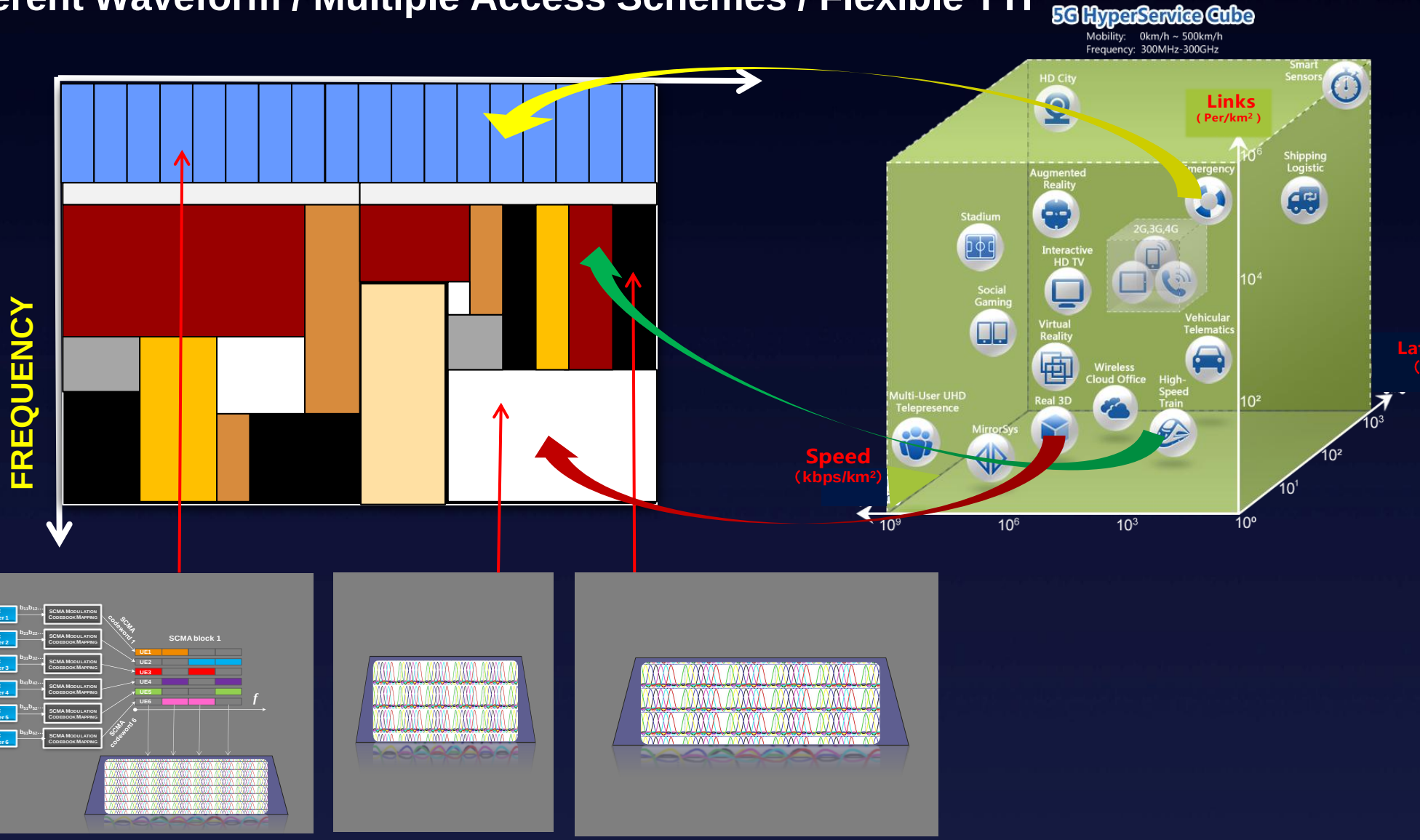
Flexible Time-frequency Lattice

- Co-existence of different time-frequency granularities
- Waveform optimized for different transmission condition and applications
- Regional broadcasting, high speed train, fixed devices,……
- Subband spectrum filter to control inter-block interference



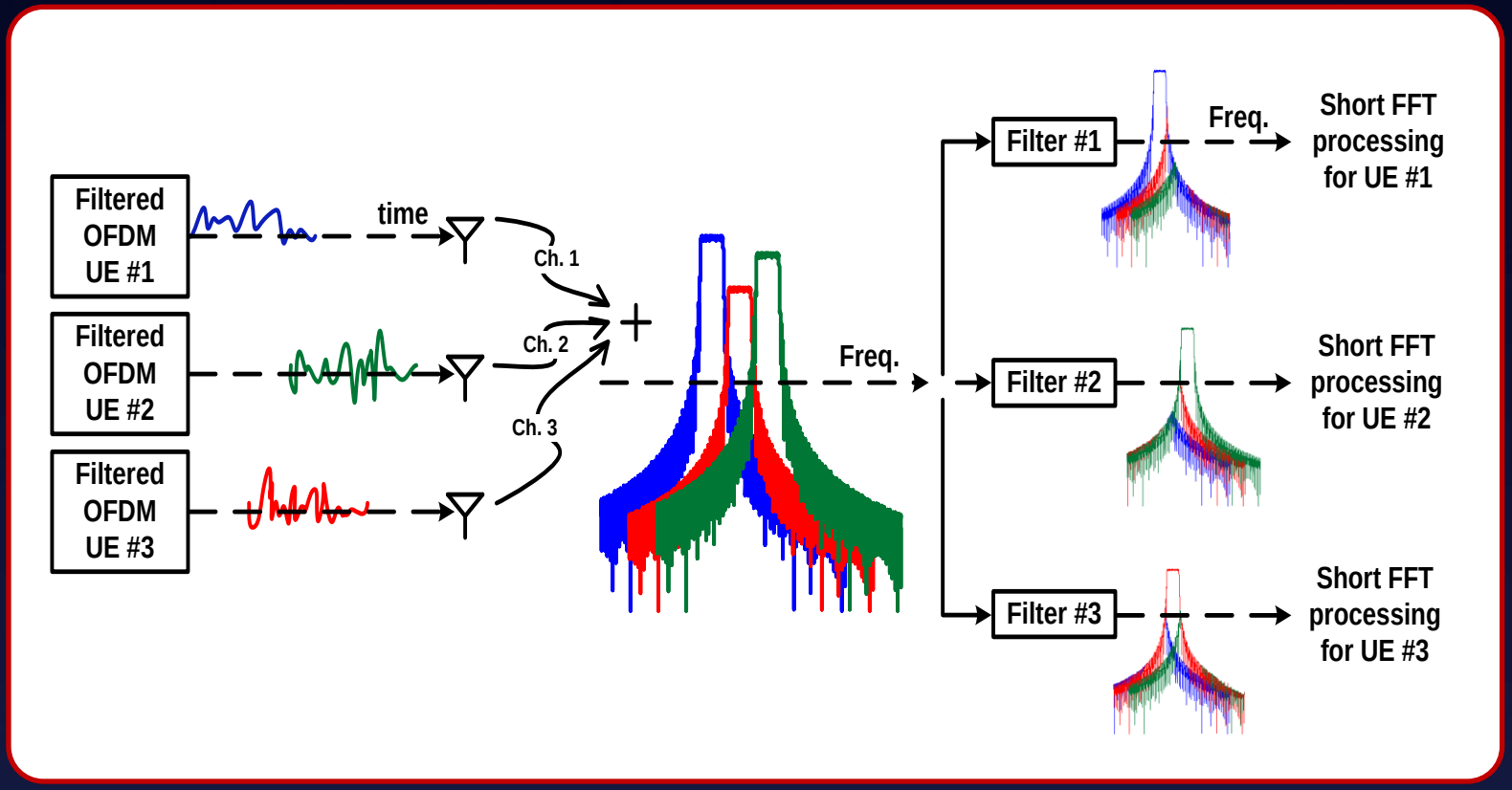
Enable Single Waveform for All Applications

Unified Air Interface to Support
Different Waveform / Multiple Access Schemes / Flexible TTI

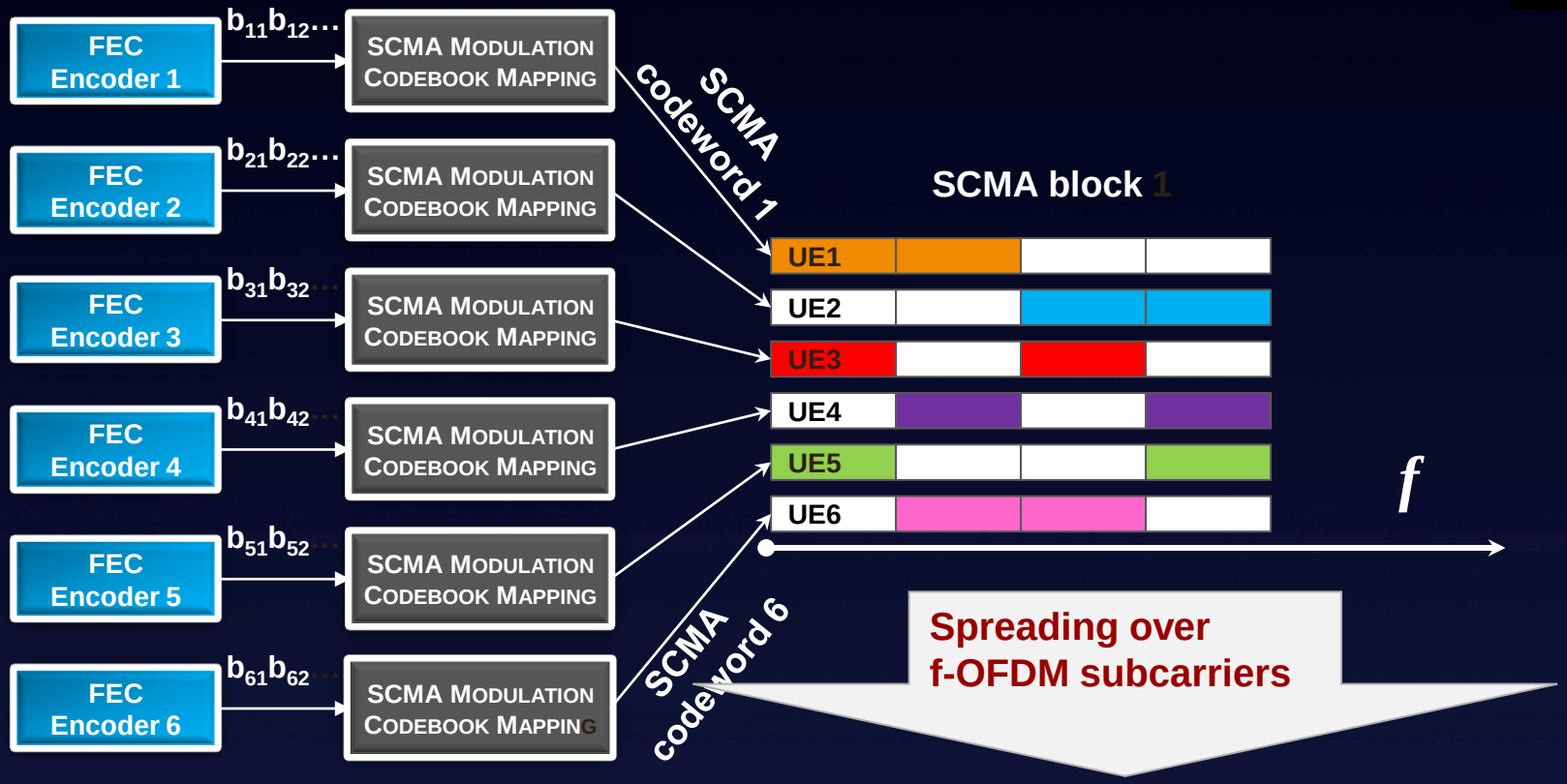


f-OFDM Supports Asynchronous OFDMA

- Support asynchronous OFDMA/SC-FDMA transmission
- Robust to frequency and timing mismatching
- No timing advance signal needed



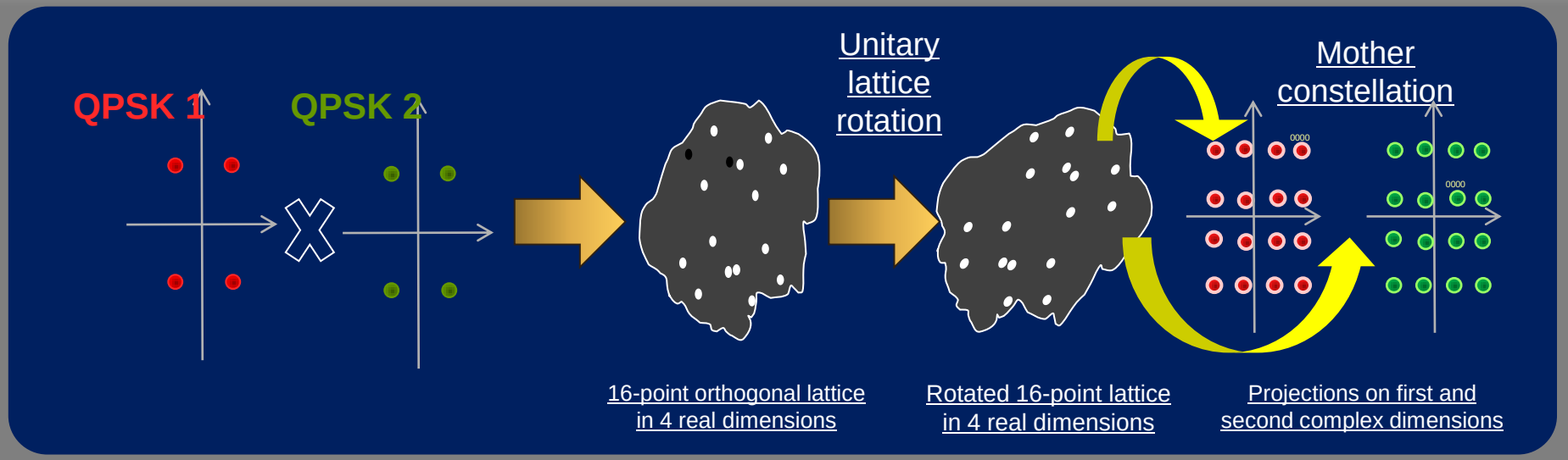
f-OFDM based SCMA (Sparse Code Multiple Access)

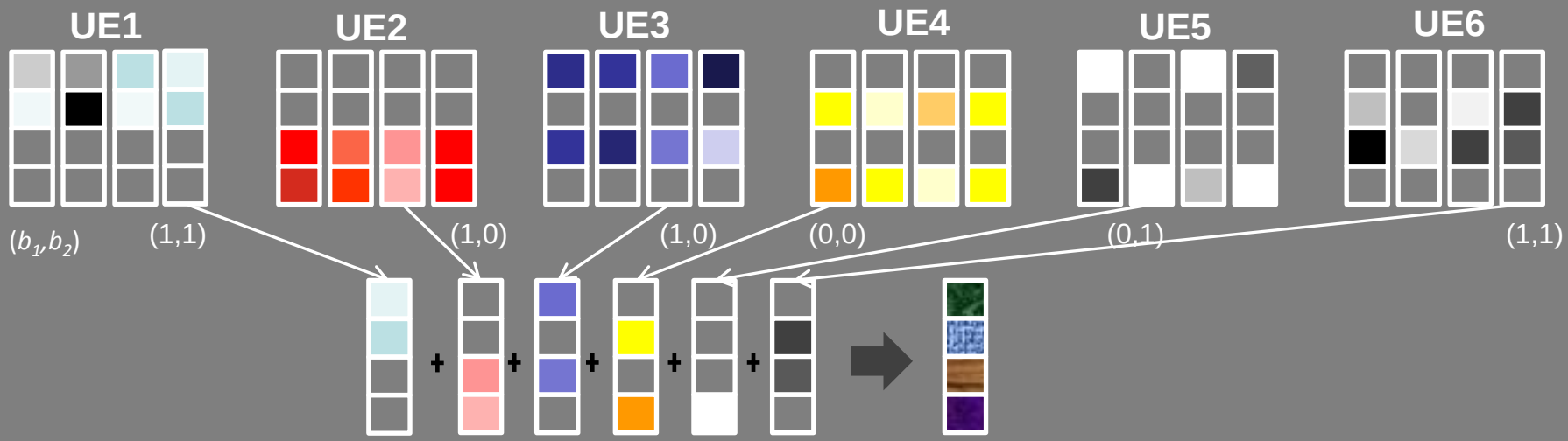


A new frequency domain non-orthogonal waveform

SCMA codewords are carried by f-OFDMA tones

SCMA Code Book





- SCMA codebook based on Multi-dimensional Lattice Constellation to exploit shaping gain and coding gain
- Each UE/layer stores a unique codebook
- Binary input data is mapped to a codeword of the corresponding codebook
- Low PAPR and low projection codebooks possible

SCMA Benefits/Applications

Massive Connectivity, Spectrum Efficiency Enhancement, Ultra Low Latency; Energy Saving

Orthogonal multi-user multiplexing

- Scheduling required to maintain the orthogonality
- ~100 ms delay due to state transition and request-grant procedure (UL)
- Signaling overhead for small packet transmission

Non-orthogonal multi-user multiplexing

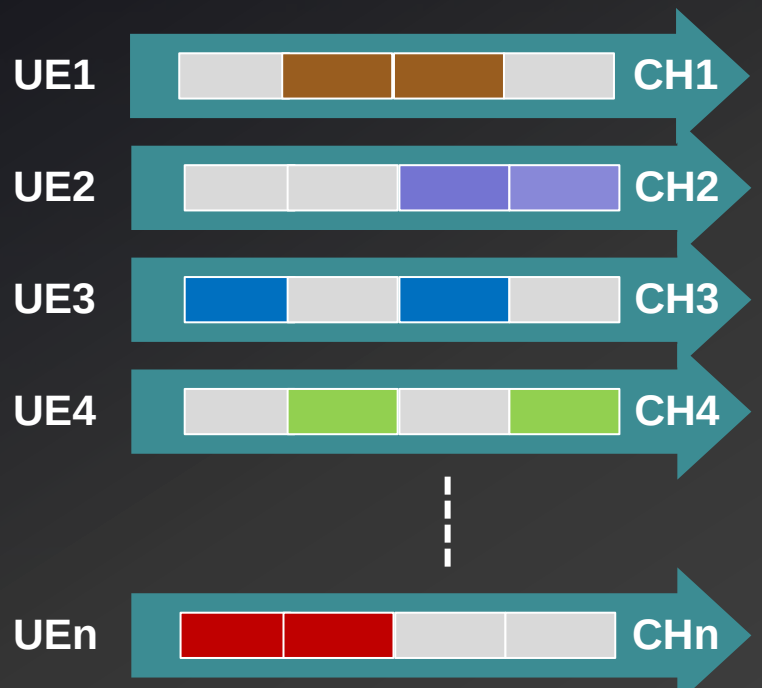
- Support signal superposition
- Better coverage
- High multi-user detection complexity
- Limited number of concurrent Users

Overloaded multi-user multiplexing

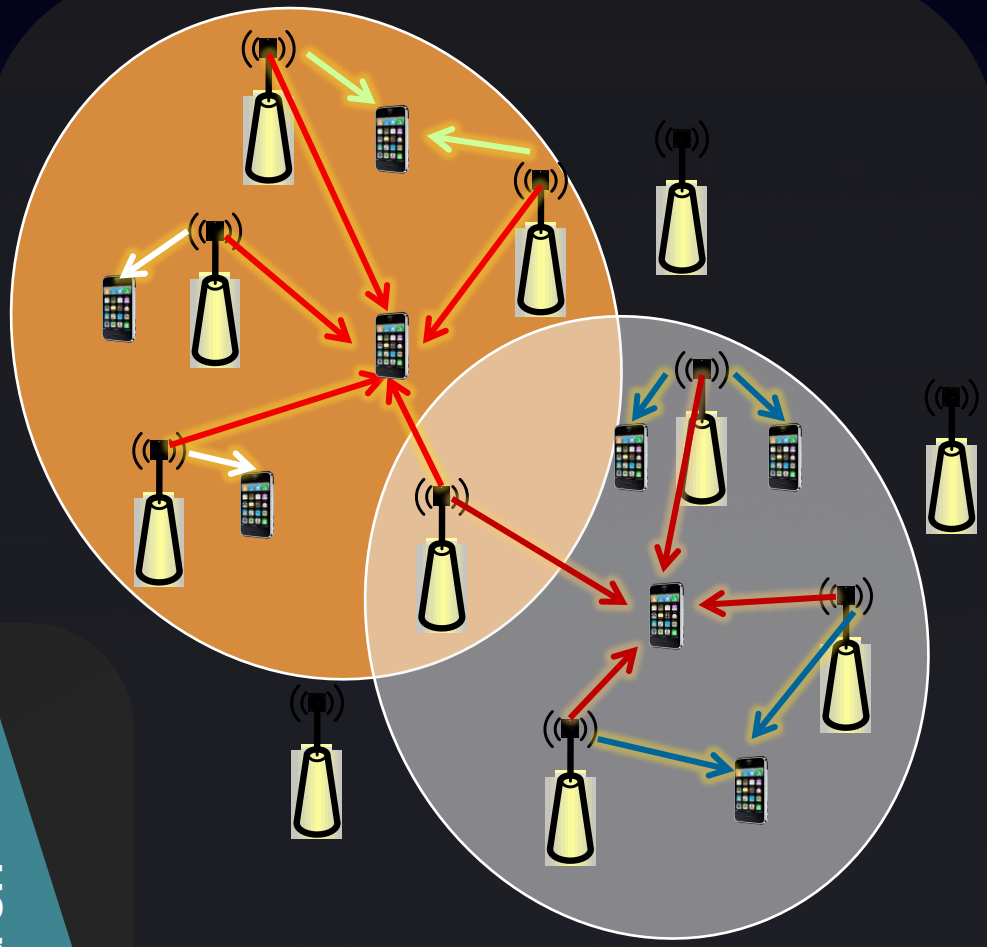
- Less collision even with overloaded concurrent Users
- Low multi-user detection complexity
- Low latency (<1 ms) due to grant free access
- 0 dB PAPR for MTC
- Long battery life
- Better coverage with scalable SCMA codebook design

SCMA Benefits/Applications

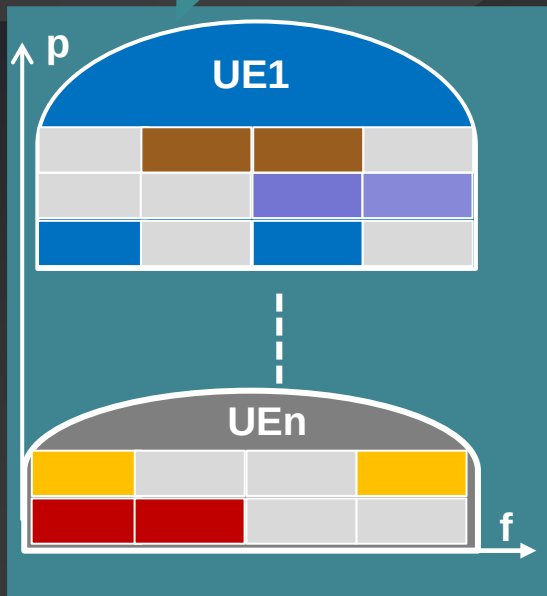
SCMA OL MU Transmission & CoMP



UL MU MA
(SCMA codeword division multiple access)
with blind detection



OL CoMP
(Multi-TP SCMA layer & power based coordination)



DL Open- Loop MU MA
(SCMA layer & power allocation)

Conclusion

- Software configurable air interface
  - Flexible air interface to meet 5G requirements
    - Co-existence of different air interface configurations
    - Optimized for different services and different applications
  - Backward compatible & Forward compatible
- f-OFDM enables flexible waveform
  - Basic waveform for 5G
  - Co-existence of different waveforms, multiple access schemes and different TTIs
- SCMA is a basic non-orthogonal multiple access scheme for 5G
  - Massive connectivity
  - Flexible multi-transmitter resource sharing to enable UE centric access

THANK YOU

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