5G Enabling Technologies
An Unified Adaptive Software Defined Air Interface

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Everything on Mobile

Everything Connected

Everything Virtualized
5G (Beyond Smartphone)

Transform the Industry Verticals

- 400MHz
- 100GHz
- 10GHz
- D2D
- Open OTT
- SDN-RAN
- IoT

**Verticals**

- MBB
- IoT
- SDN-RAN
- D2D

**Auto-drive**

**Medicare**

**Robots**

**Meters Sensors**

**Capacity**

1000X (Capacity/km²)

**Speed**

100X (10Gbps)

**Latency**

Less than 1ms

**Links**

100x

**Energy**

1000X Reduce
**5G (Beyond Internet Access and APPs)**

**Unprecedented Performance Challenge**

- Stretched in 3 Dimensions
  - Speed
  - Links
  - Response
- Spectrum Efficiency
- All Spectrum Access

**Networks Re-Architect Challenge**

- No-Cell Virtual RAN
- Software Defined & Simplicity
- Service Aware and Monetize
Single & Unified Air-Interface
for All Spectrum Access

Cellular Bands

Primary Band

Complementary Band

Visible Light

Unlicensed

Macro

1Gbps~4Gbps

0.5-2km

0.5GHz

Micro

3Gbps~10Gbps

50-100m

2.5GHz

Local

10Gbps~100Gbps

50m

40GHz

Primary Band

Complementary Band

unlicensed

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Foundational Technologies

Research Phase

5G Air Interface
Massive MIMO
5G mmWave
Full/Flexible Duplex
5G RAN&Core
5G UE
5G Vertical

Standardization Phase

Product Development Phase

(2014-2018)
Air Interface Characteristics

- Sparse Code Multiple Access (SCMA)
- F-OFDM
- Orthogonal-free & Synchronous free
- Spectral Localization
- Variable sub-Carrier Tailored to Applications
- Virtualized & Software Defined RAN Primitives
- Ultra-narrow Bands for Internet of Things Applications
- Ultra-wide-Bands for Virtual Reality Applications
- Ultra-low Latency for Vertical Applications
- Capacity X1000
- Spectrum Efficiency X30
- Latency X1/10
- Links X100
- Coverage 30dB
- Reliability x1000
- Mobility 500km/h
- Mobility 500km/h
**SCMA** (Sparse Code Multiple Access)

A new frequency domain non-orthogonal waveform

- Input bits are directly mapped to codewords and spread over multiple subcarriers
- Codewords can be assigned to the same UE (SU-SCMA) or different UEs (MU-SCMA)

- Non-orthogonal multiplexing of code layers
- Over-Dimension to increase overall rate and connectivity
- Sparsity to limit Rx complexity for detection
- Multi-dimensional codewords with shaping gain
- Spreading for robust link-adaptation, coverage

**LTE:** K (4) symbols mapped to K (4) sub-carriers

**SCMA:** N (6) symbols mapped to K (4) sub-carriers (N > K, overloading)
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
Flexible and scalable SCMA based access scheme which can compromise among spectral efficiency, coverage, detection complexity, connectivity, and link budget to adapt to different application scenarios.
Issues for OFDM Waveform

Spectrum not localized, need guard band

Not flexible to change sub-carrier spacing in Frequency

Synchronous Tx, large overhead for time alignment

Fixed symbol duration, not flexible to change CP
1. Sub-band digital filter is applied to shape the spectrum of subband OFDM signal.

2. Orthogonal subcarriers within each subband

3. Allow co-existence of waveforms with different OFDM Primitives
Spectrum Filtered OFDM (f-OFDM)

1. Sub-band digital filter is applied to shape the spectrum of subband OFDM signal.
2. Orthogonal subcarriers within each subband
3. Allow different cyclic prefix for each specific sub-band
F-OFDM Supports Asynchronous OFDMA

1. Support asynchronous OFDMA transmission
2. Non timing advance signal needed
Spectral Filtered OFDMA Characteristics

1. Good out-of-band leakage rejection
2. Similar spectrum localization performance compared to FBMC
3. Maintain all the benefits of OFDM
4. Easy for m-MIMO
Flexible Time-frequency Lattice

1. Co-existence of different time-frequency granularities
2. Waveform optimized for different transmission condition and applications
3. Regional broadcasting, high speed train, fixed devices,……
4. Subband spectrum filter to control inter-block interference
An Unified Adaptive Software Defined Air Interface to Meet Diverse Services Demand

- Unified air interface to support different waveform / multiple access schemes / flexible TTI
SCMA Prototype and Field Trial
5G Timeline

- 2010: WRC-12
- 2014: IMT New Spectrum, Vision
- 2016: Requirement
- 2018: Technology Eval
- 2020: WRC-18/19
- 2021: 5G

**3GPP**
- Rel 10
- Rel 11
- Rel 12
- Rel 13
- Rel 14
- Rel 15
- Rel 16

**ITU**
- LTE-Advanced
- LTE-B
- LTE-C
THANK YOU

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