Software Defined Air Interface
- Air interface Design Paradigm Shift for 5G

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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

Traffic type, transmitting & receiving condition

Air Interface Configuration (SoftAI)

Optimized air Interface

Waveforms
- SCMA
- f-OFDM
- FBMC
- OFDM

Frame Structure
- Flexible TTI
- Flexible duplex

Multiple Access Scheme
- Scheduled
- Grant-free
- LBT

Coding Modulation
- Polar
- Turbo
- Network coding

Protocols
- Adaptive HARQ

Candidate technologies for AI building blocks

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

- Spectrum Range
- Vertical Applications
- Tx and Rx Capability
- Support Legacy RAT

Static Air Interface Configurations

- Spectrum dependent WF, TTI
- Pre-defined customized AI
- Subset AI for low cost node / device
- Subset AI for legacy UE

Data

Traffic/QoE classification

QoE/traffic characteristics provisioning from network

Selected AI options

WF, MA, TTI, Protocol selector

data transmitted with option 1
data transmitted with option 2
data transmitted with option N

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
A new frequency domain non-orthogonal waveform
SCMA codewords are carried by f-OFDMA tones
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

Non-active tone
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 TTls

• 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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