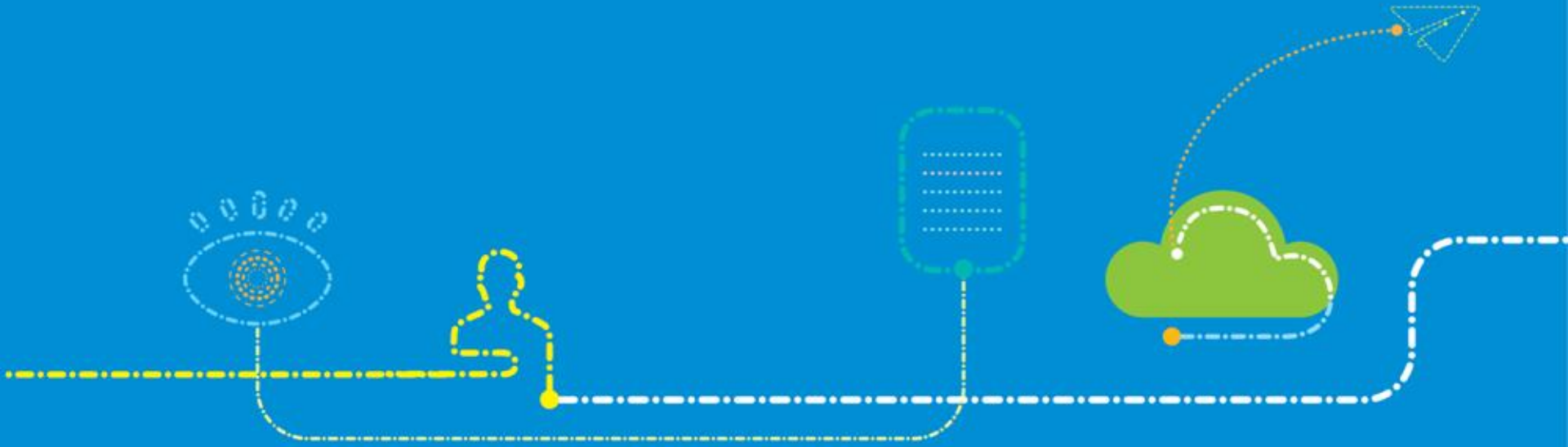
Considerations on 5G Key technologies & Standardization

Sept. 2015



Mobile – IT & CT Convergence (M-ICT) Era

Connecting Whenever & Wherever
with Everything & Everyone

User-Centric Device
Services & Applications

Digital Mapping
of the Physical World

Security & Privacy

Man-Man, Man-Machine, Machine-Machine, Mobile

Enabler @ M-ICT Helps Transformation of Operators,
Operation Efficiency of Gov. & Enterprises, and Consumers Quality of Life

User Demands Drive Innovation & Convergence of
Devices, Networks & Services

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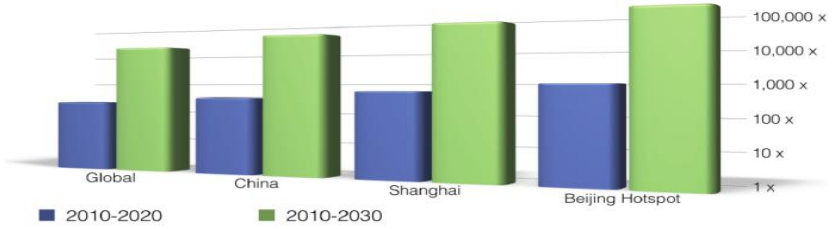
Main Drivers of 5G

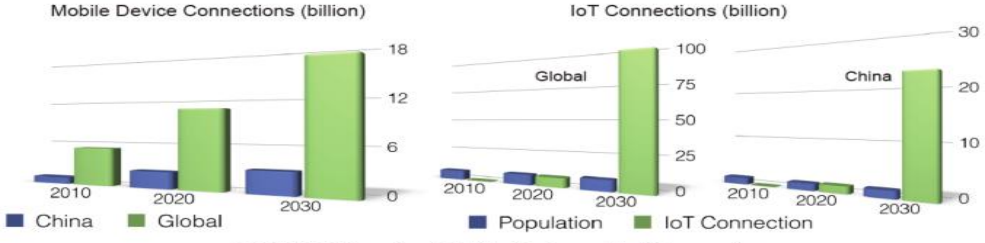
Enhanced Mobile Internet and Internet of Things (IoT)

Mobile Data Traffic: Thousands of times growth



2010-2030 Growth of Mobile Data Traffic

Mobile Device & IoT Connections: Up to 100 billion



2010-2030 Growth of Mobile Device and IoT Connection

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5G Components in a Nutshell

	Spectrum below 6G	Spectrum above 6G
LTE evolution	Yes	No
New RAT	Yes	

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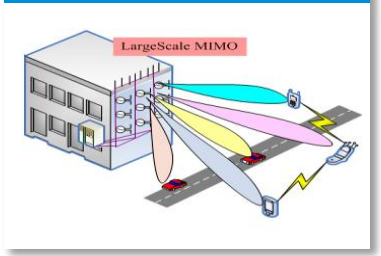
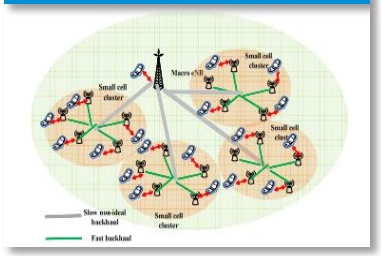
Key Technologies

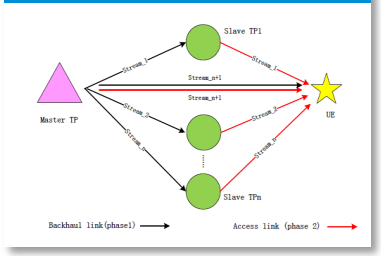
Massive MIMO



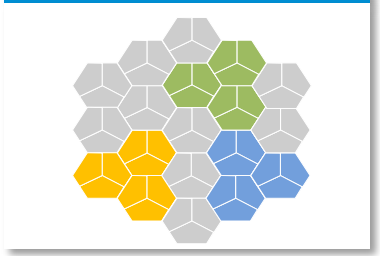
Intercell Interference Coordination



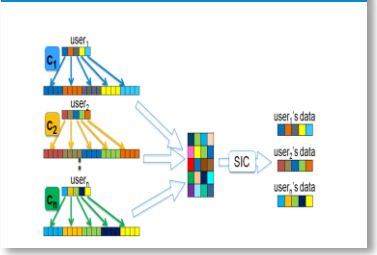
Joint Access & Backhaul



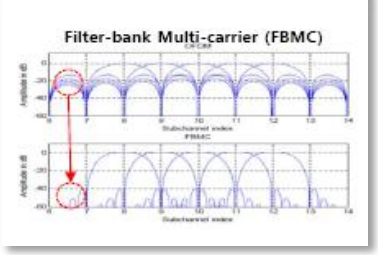
Smooth Virtual Cell



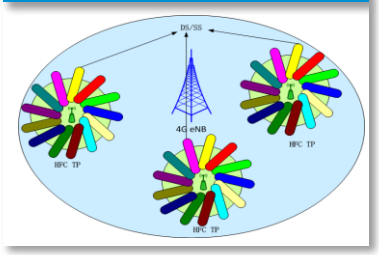
New Multiple Access



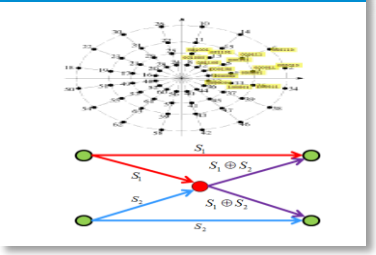
New Waveform



Hi-Frequency



New Coding & Modulation



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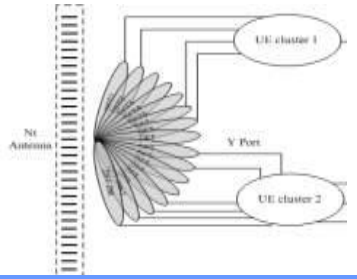
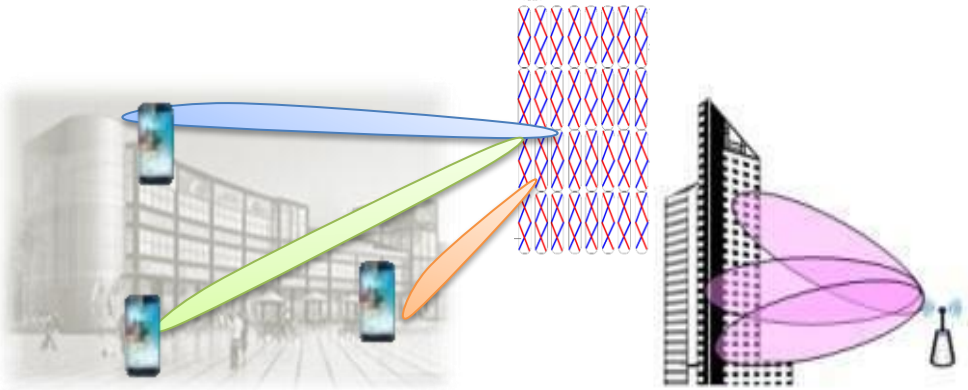
Massive MIMO

Benefits

- Capacity enhancement via Space Division Multiplex
- Lower Interference, Easy Network Planning
- Lower Energy Consumption, Green Site





Challenge

High Overhead of Pilot & Feedback

Solutions

- Beamformed Pilot for UE Cluster
  - compressive sensing based pilot
  - pilot coordination between cells
- CSI Feedback
  - Adaptive Codebook for 3D massive MIMO
  - Enhanced CSI feedback based on partial channel reciprocity

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Network Densification

Area Traffic Capacity: **DL: 10T bps/km^2** **UL: 2T bps/km^2**

To fulfill challenging requirements at reasonable costs

Dense deployments result in severe interference

Interference control enhancement

Indoor/outdoor

Virtual cell eliminates interference and handovers

Unplanned or semi-planned deployment

Deployment costs are minimal

Self-backhaul, with non-ideal backhaul

Flexible deployment, lower costs

Transmission points (TPs): large number / maybe from different vendors

Interference control enhancement

General solutions to common issues across different scenarios

The study on UDN focuses on

1. Interference management and suppression
2. Joint access and backhaul
3. Cell virtualization

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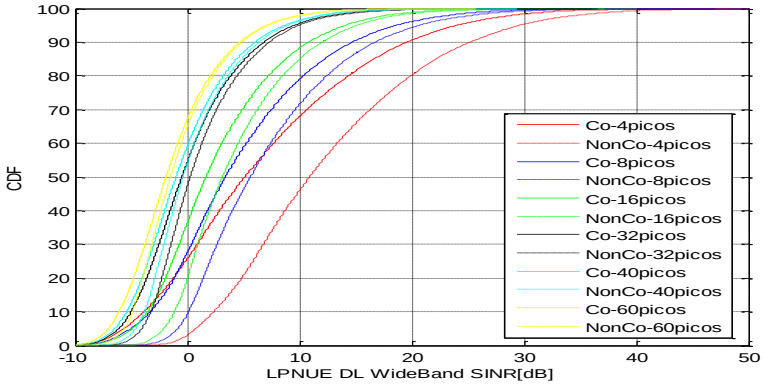
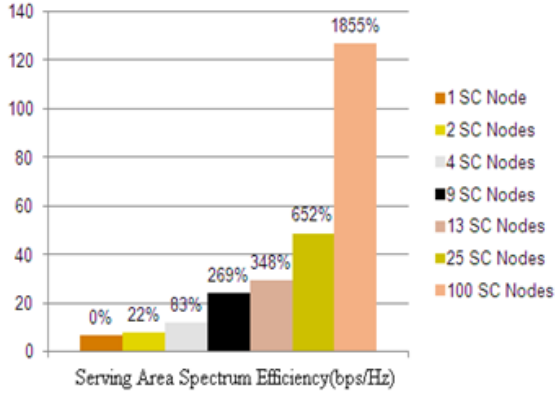
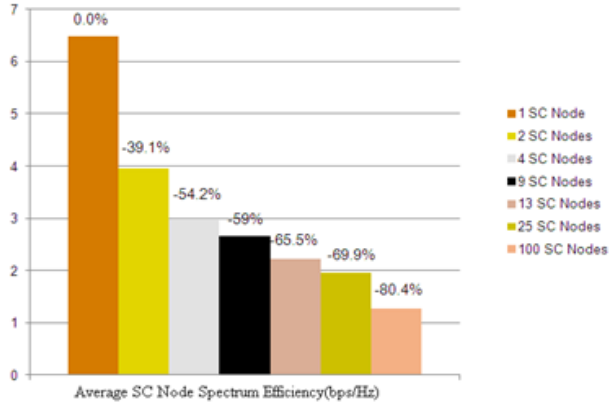
Interference Issue



Significant degradation in SINR when the density of small nodes > 8 per macro cell

Per node capacity decreases although per area capacity increases





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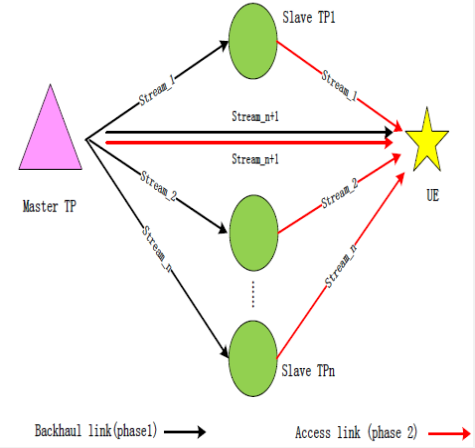
Joint Access and Backhaul

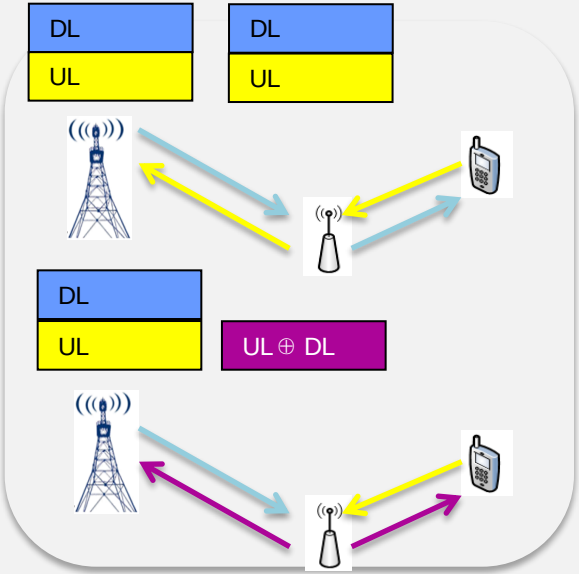


Backhaul Link

- Of broadcast nature
- Works during Phase1
- Independent streams transmitted in different spatial sub-channels

Access Link

- Of multiple access nature
- Works during Phase2
- Independent streams transmitted in different spatial sub-channels



- Wireless backhaul takes advantage of broadcast nature, consequently UE achieves higher data rate
- By collaboration of multiple relays, the capacity of wireless backhaul can be boosted up by Virtual MIMO.
- Network coding reduces the resources needed for relay node, improves resource (e.g. spectrum) utilization

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Smooth Virtual Cell

- User is dynamically served by one or more coordinated TPs
- User is always located at the center of its virtual cell, always achieves best performance
- Effective way to deal with mobility and interference issues in network densification

QoE

User Centric Service provision

Unplanned Deployment

Dynamic Forming/ Reforming

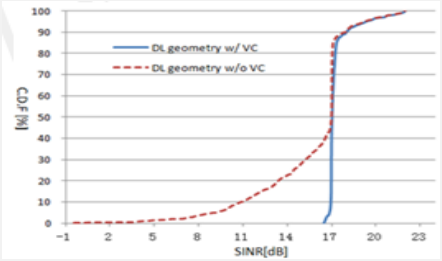
Hybrid control (Master + Slave)

Data synchronization

Self-backhaul

Benefits

Uniformed User Experience



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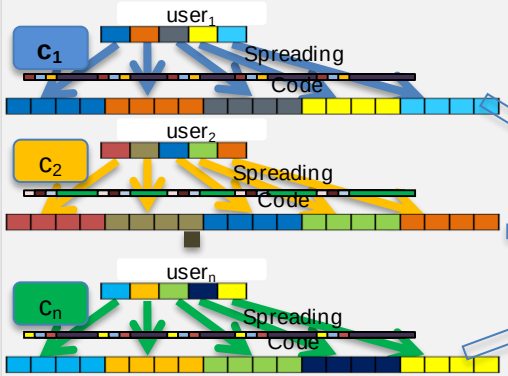
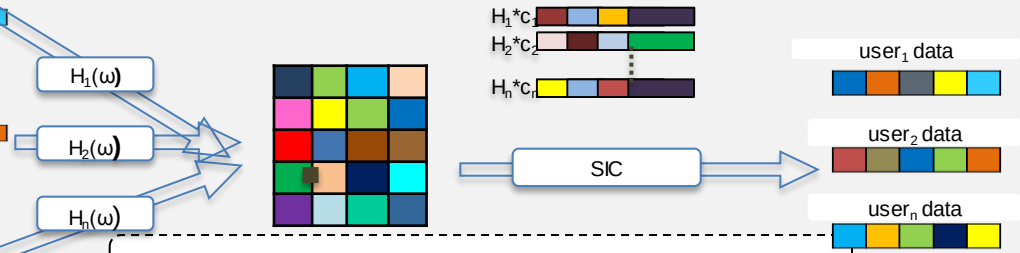
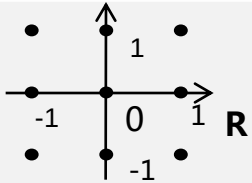
New Multiple Access e.g. MUSA (Multi User Shared Access)

Advanced spreading

Each user's data is spread using low-correlation sequence, e.g., I/Q randomly taking {-1,0,1} values







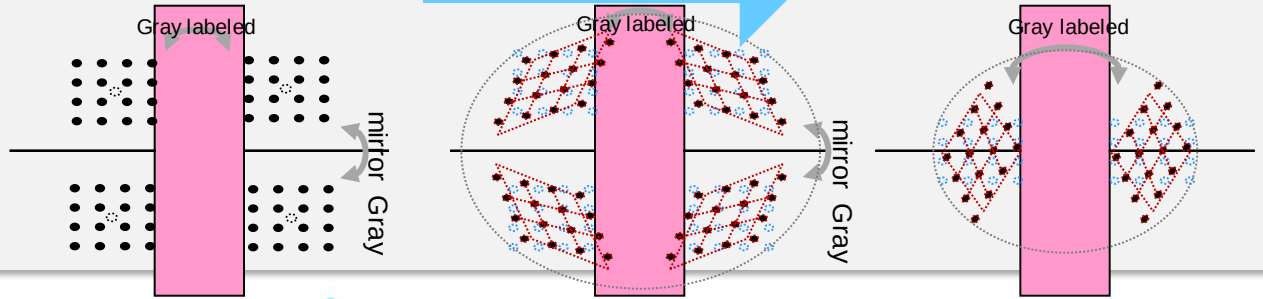
linear processing + bit level SIC, i.e., code blocks with high SINR cancelled first

Spread symbols transmitted in the same time-frequency resources

Constellation for superposition coding: Gray labeled

Shaping optimization

Improving the robustness of symbol-level SIC at UE



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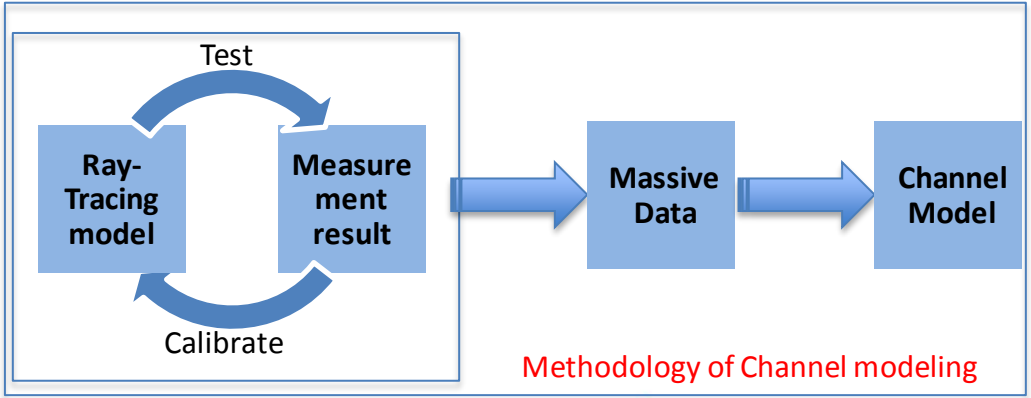
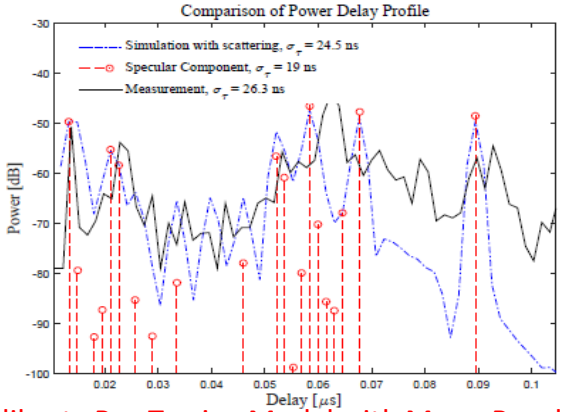
High Frequency - Channel Modeling

- **Unified channel propagation model @6GHz – 100GHz**
- **High Frequency Channel model candidates**
  - Hybrid deterministic and stochastic model based on ray-tracing techniques related to typical scenarios
  - Enhanced Stochastic model with High-Frequency channel key characteristics
- **Methodology of Channel modeling**
  - Ray tracing simulations based on calibrated 3-D model on the basis of measurement results
  - Calibrated measurement results



Methodology of Channel modeling



Calibrate Ray Tracing Model with Meas. Results

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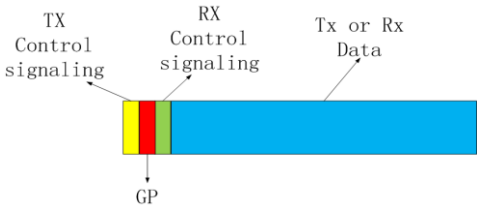
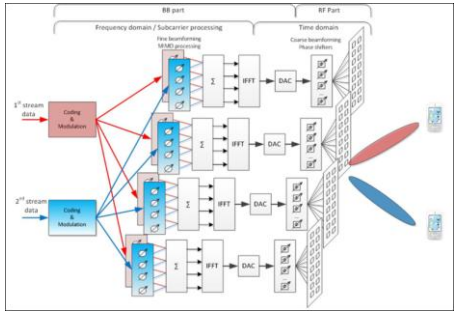
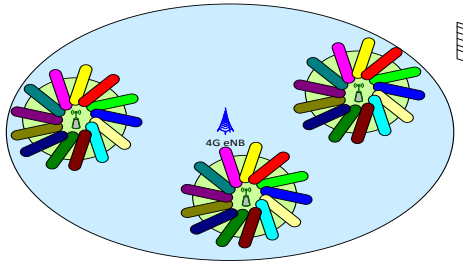
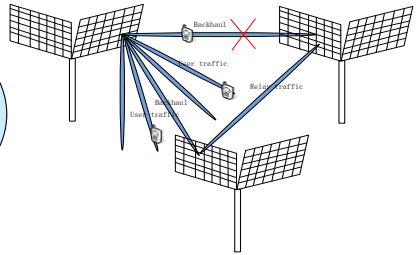
High Frequency - Potential Issues

- Numerology and frame structure including waveform selection
- Access procedures including discovery, synchronization, beam-tracing (beam switch), fast link recovery, etc.
- Special signaling and channel design to support above procedures
- Integration design for access and backhaul
- MAC layer including beam management, coordination and scheduling, etc.









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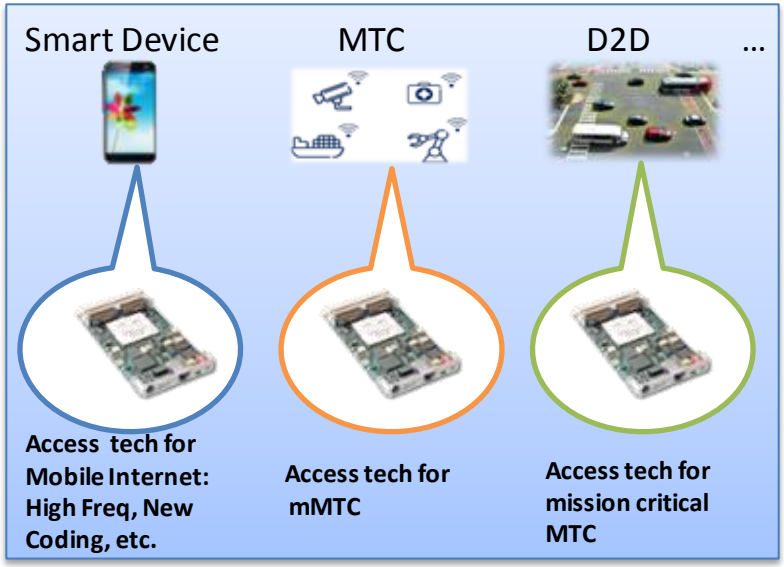
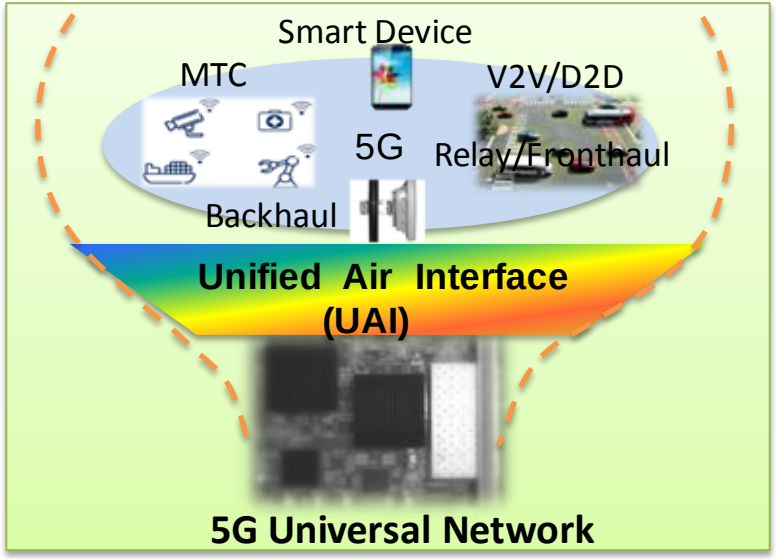
Unified Air Interface For 5G (1/2)



- Dedicated Hardware for Different Apps
- Various Air Interface Architectures



- Scenario-awareness Air Interface
- Universal AI Architecture

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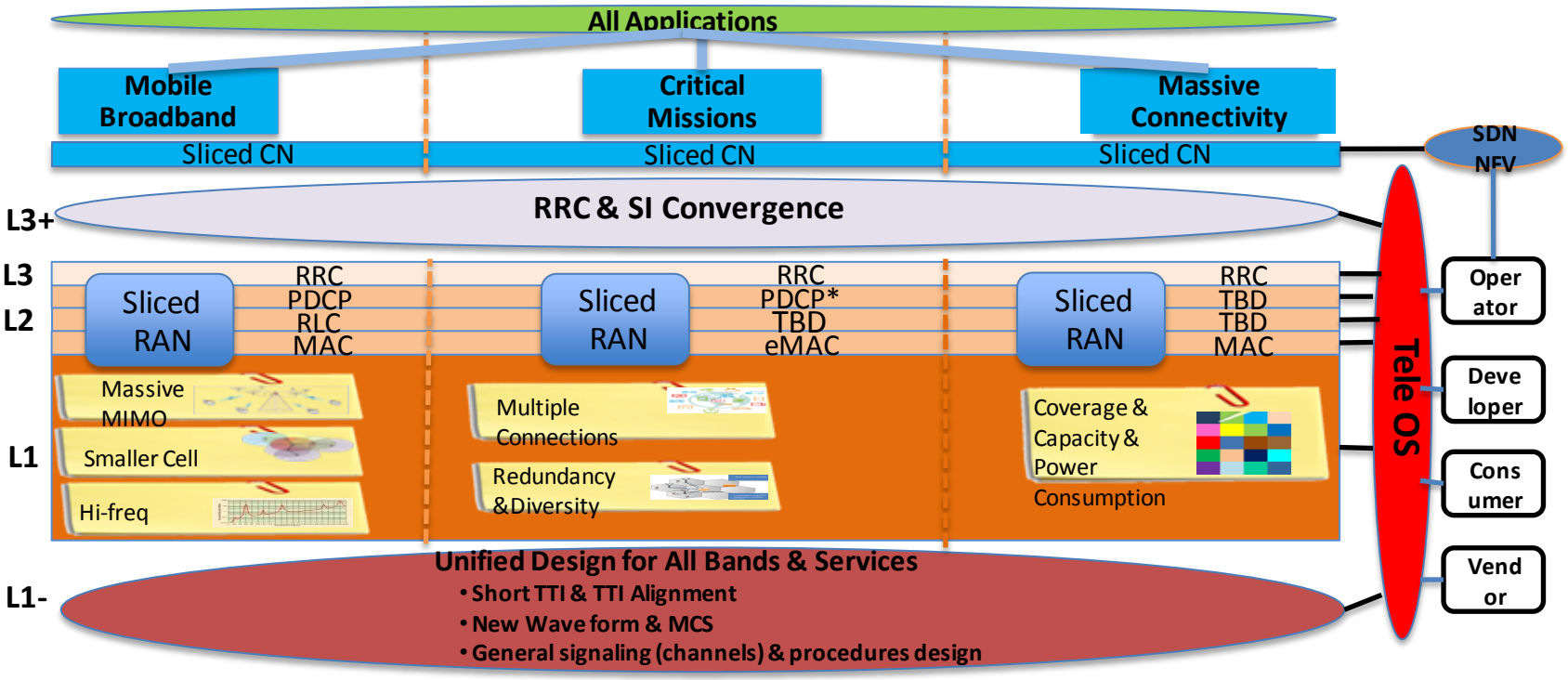
Unified Air Interface For 5G (2/2)



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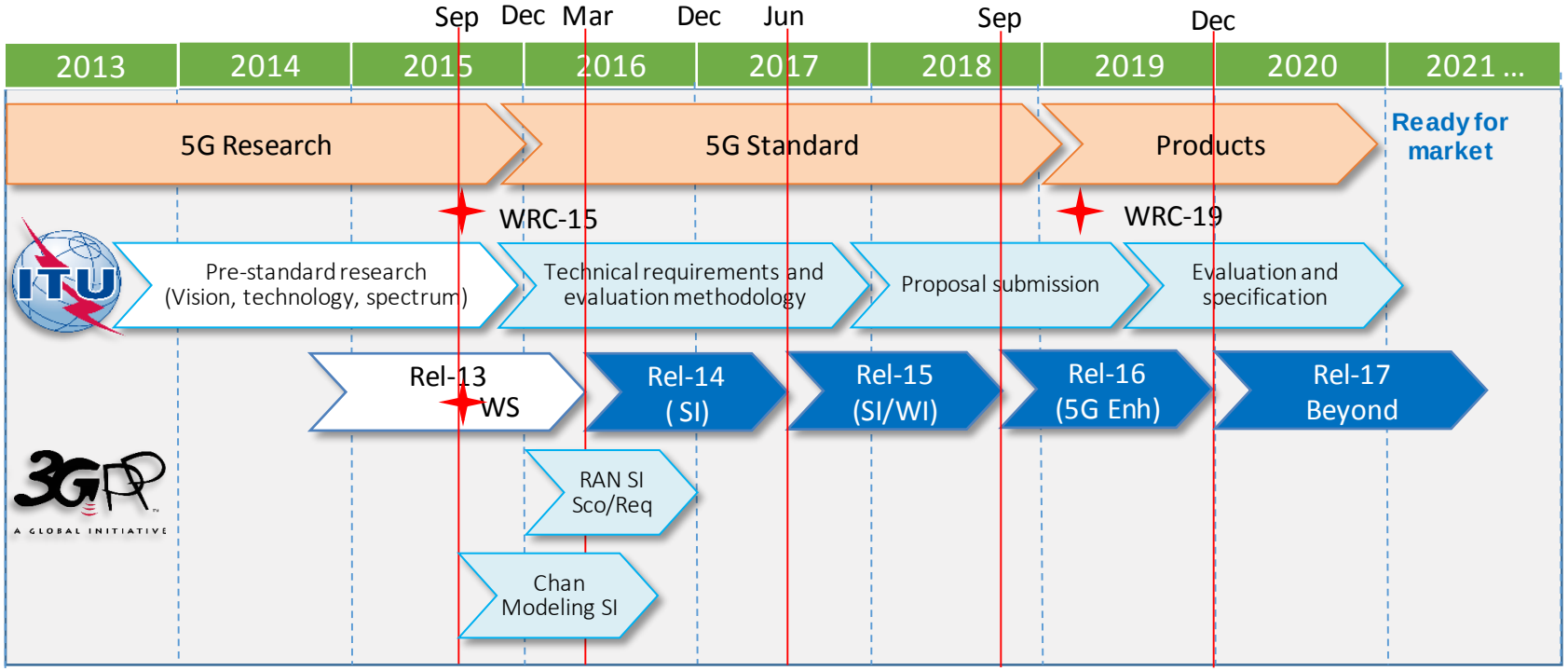

- Rel-14 should include Study Items for both LTE ev & New RAT
- Rel-15 should include WI for initial 5G features targeting commercial launch in 2020 focusing on eMBB
- Rel-16 should include WI for complementary 5G features targeting commercial launch beyond 2020 for further eMBB enhancements and IoT

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Summary

- 5G needs to meet diverse requirements of both eMBB & IoT
- 5G includes both LTE evolution and new RAT
- Phased approach is suitable for standardization of 5G
- 3GPP Rel-16 is expected to be ITU-R submission

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Thank you

Tomorrow never waits