Innovative Technologies for 6G Networks

A PHY Layer Perspective

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Outline

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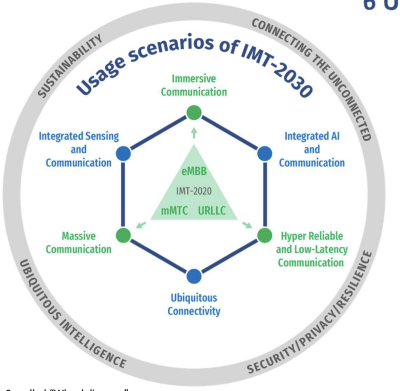
IMT-2030 Usage Scenarios



So called "Wheel diagram"

6 Usage scenarios

Extension from IMT-2020 (5G)

- eMBB ➡ Immersive Communication
- mMTC ➡ Massive Communication
- URLLC ➡ HRLLC (Hyper Reliable & Low-Latency Communication)

New

- Ubiquitous Connectivity
- Integrated AI and Communication
- Integrated Sensing and Communication

4 Overarching aspects:

act as design principles commonly applicable to all usage scenarios

Sustainability, Connecting the unconnected,
Ubiquitous intelligence, Security/privacy/resilience

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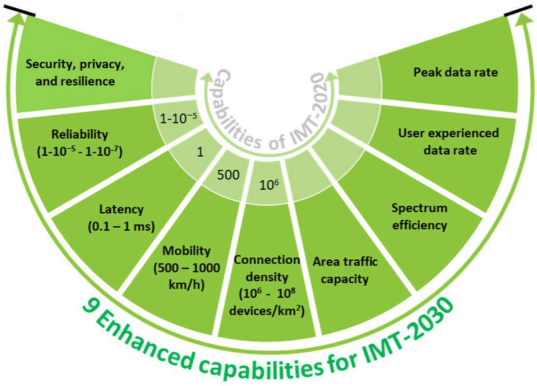
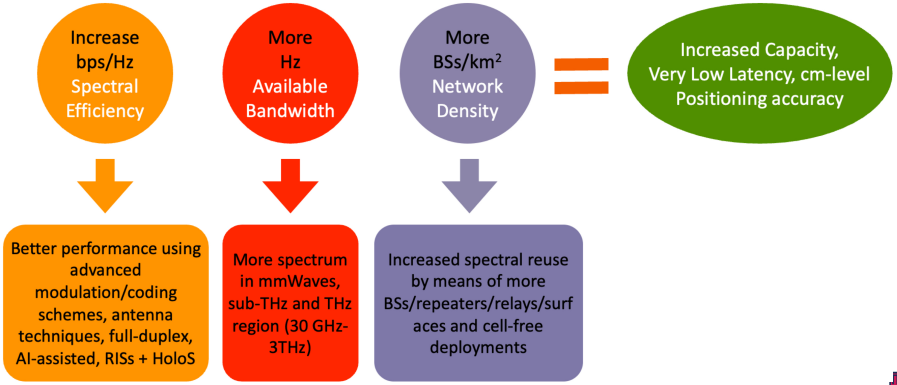
IMT-2030 Capabilities



So called "Palette diagram"

Technologies to enhance the radio interface



Advanced modulation, coding, and multiple access schemes

1. Advanced modulation schemes (to support 1 Tbps with low PAPR and phase-noise)
2. Advanced coding techniques (extreme performance and diverse use cases)
3. Advanced waveforms (sensitivity to frequency dispersion and high PAPR)
4. Advanced multiple access (massive connectivity, higher spectral efficiency, low latency and lower implementation complexity, and to provide differentiated service capabilities.)

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Advanced antenna technologies

1. Extreme MIMO (E-MIMO) with new type of antenna arrays (e.g., holographic MIMO)
2. E-MIMO with distributed mechanism (cell-free architecture)
3. E-MIMO with AI assistance (ML-based techniques for beam-pairing/assignment, compress CSI feedback, etc.)

In-band full-duplex communications

1. Self-Interference (mainly at BS)
2. Cross-Link Interference (among UEs and among BSs)
3. Research on Successive Interference Cancellation (SIC) is needed

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THz communications

1. Pencil-beam THz radio to cope with the high molecular absorption loss.
2. THz transceiver technologies
3. Spectrum aspects for THz (channel models at sub-THz bands)

Technologies for Ultra-high positioning

1. Target: centimetre-level positioning accuracy within a few tens of millisecond latency (where GNSS is available)
2. Other design factors: power consumption, scalability/capacity, network deployment complexity, availability and security/privacy
3. Promising Technologies: mmWave and THz, Carrier Phase Positioning (CPP), and AI/ML

Multiple physical dimension transmission

1. Reconfigurable intelligent surface (RIS)
2. Holographic radio (HoloS)
3. Orbital Angular Momentum (OAM)

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Huygen's Metasurfaces

1. Metasurfaces have the ability to manipulate electromagnetic wavefronts in ways beyond those observed in natural materials or interfaces.

2. They consist of subwavelength resonant elements (unit cells) arranged in an electromagnetically thin sheet.

3. By engineering the scattering elements inside individual unit cells, a spatially varying response can be obtained with regard to the amplitude, phase, and polarization of the transmitted and reflected fields.

ETSI GR on RIS Definition

1. It is a surface, i.e. it is not a volumetric material, in order to reduce the implementation complexity, the losses, etc. while still being able to fully control the electromagnetic waves.

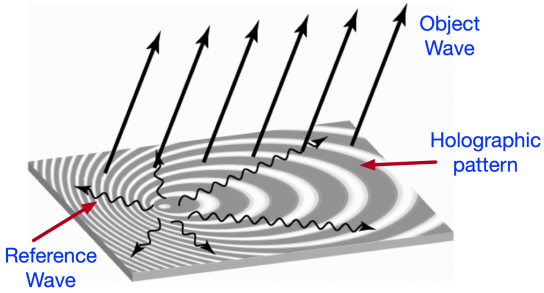
2. It is an engineered (or intelligent) surface, i.e. it can realize functions that a non-engineered surface (i.e. a metal plate) cannot realize.

3. It is reconfigurable, i.e. its response can be adapted over time based on the network conditions. The reconfigurability encompasses multiple functions including controlled reflection, refraction, scattering, modulation, etc.

Reconfigurable intelligent surface (RIS)

1. Reflective Static (to cover shadowed areas)
2. Reflective Reconfigurable
3. Reconfigurable Active (Amplify & Forward)
4. Reconfigurable Decode & Forward (regenarative relay with baseband processing)

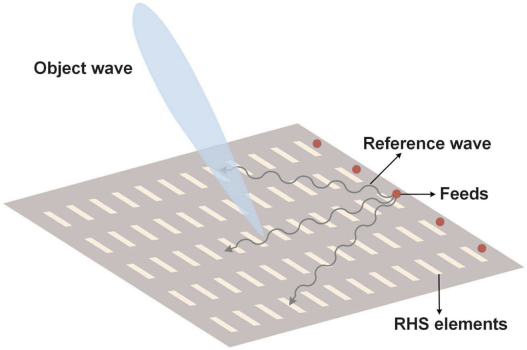
Holographic Surfaces



A leaky-wave antenna

- Utilizes the method of series feeding: radiation elements are located progressively farther away from the feed point. The reference wave propagates on the surface exciting the elements one by one.
- The pattern records the interference between the reference wave and the object wave.
- Two steps: holographic training and holographic communication

Holographic Surfaces



1. An intelligent surface as a continuous array of an infinite number of infinitesimal metamaterial elements.
2. By controlling the EM response of the metamaterial, the holographic pattern and the corresponding desired beam directions can be reconfigured (reconfigurable holographic surface).
3. Exploiting an uncountable infinite number of antennas in a finite space defines *hologrpahic MIMO*

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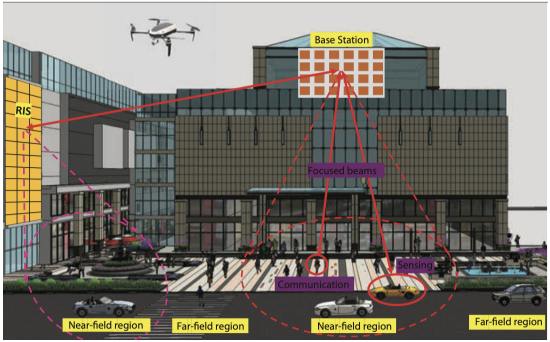
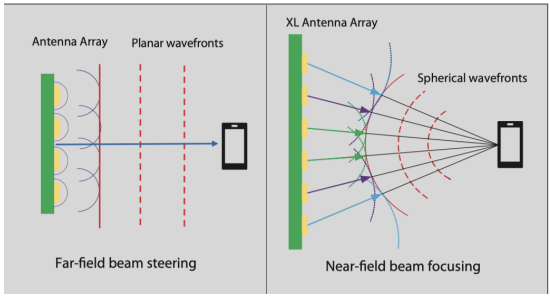
Large Surfaces and Near Field Communications





Thank You

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