Spectrum Technology Evolution for Future Cellular Systems

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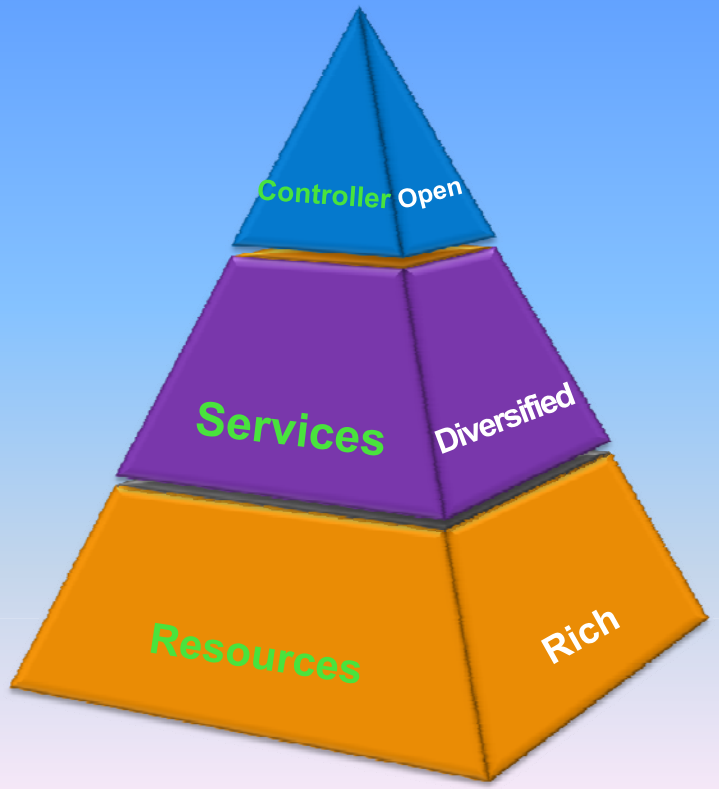
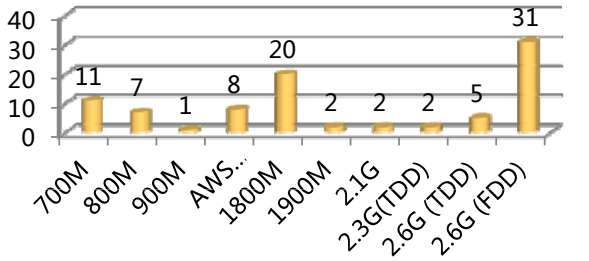
Outline

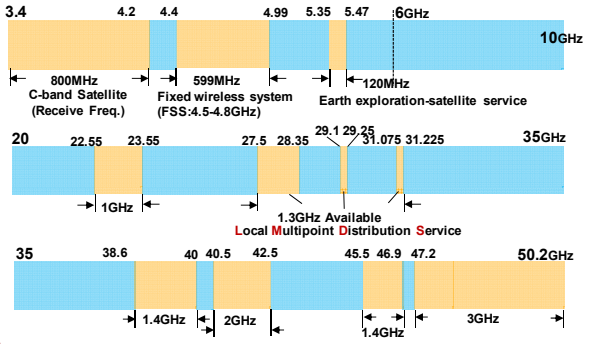


- Challenges
- Flexible/Wide Pipe: Open Carrier
- Wide Pipe: mm Wave Communications
- Wide Pipe: LTE over Unlicensed
- Wide/Flexible Pipe: ASA/LSA
- Conclusive Remarks

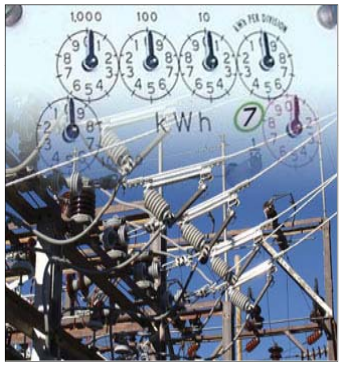
Challenges of the Future Network

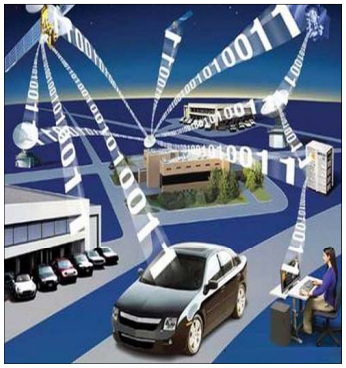
Diversified Spectrum for Big Data

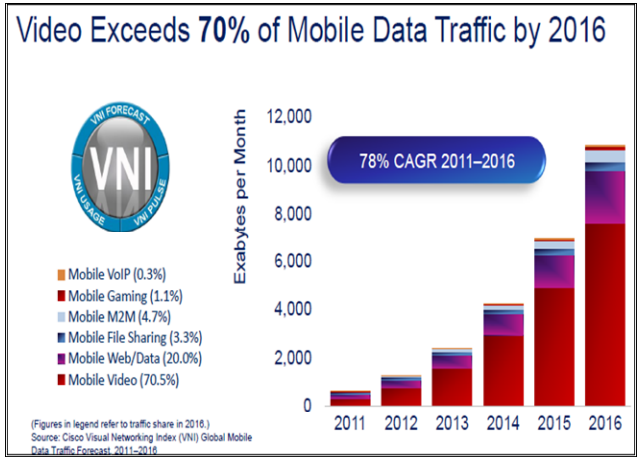




Diversified Service for Big Data

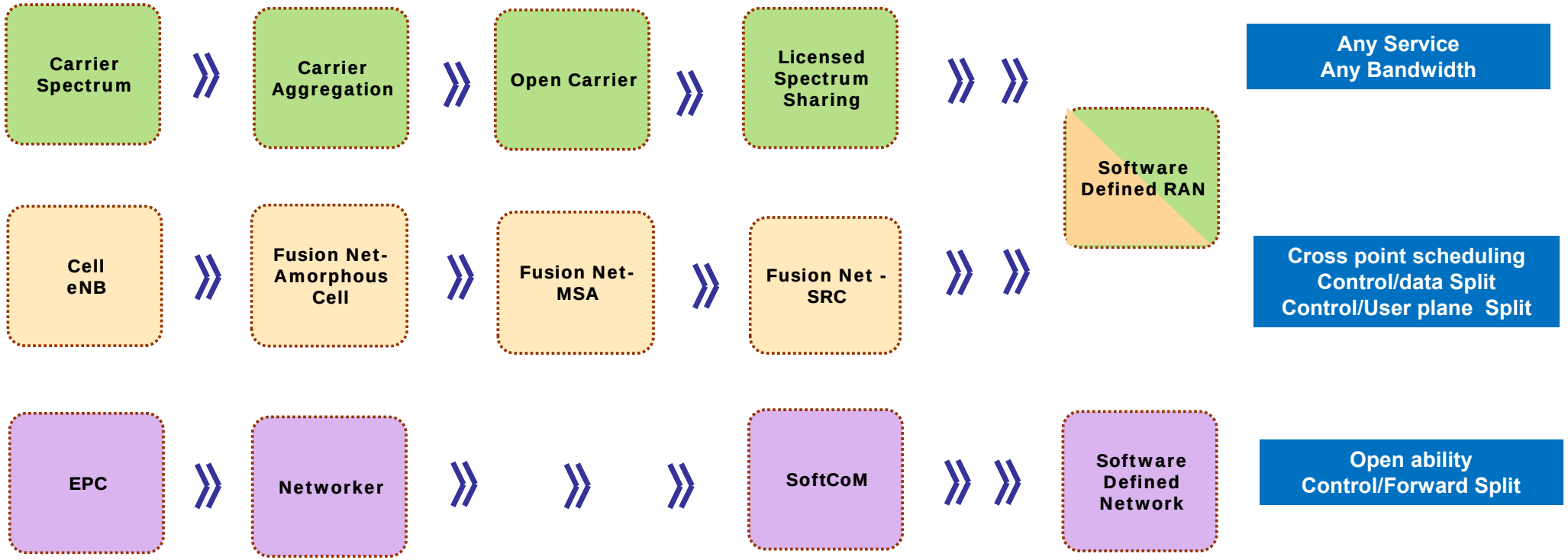




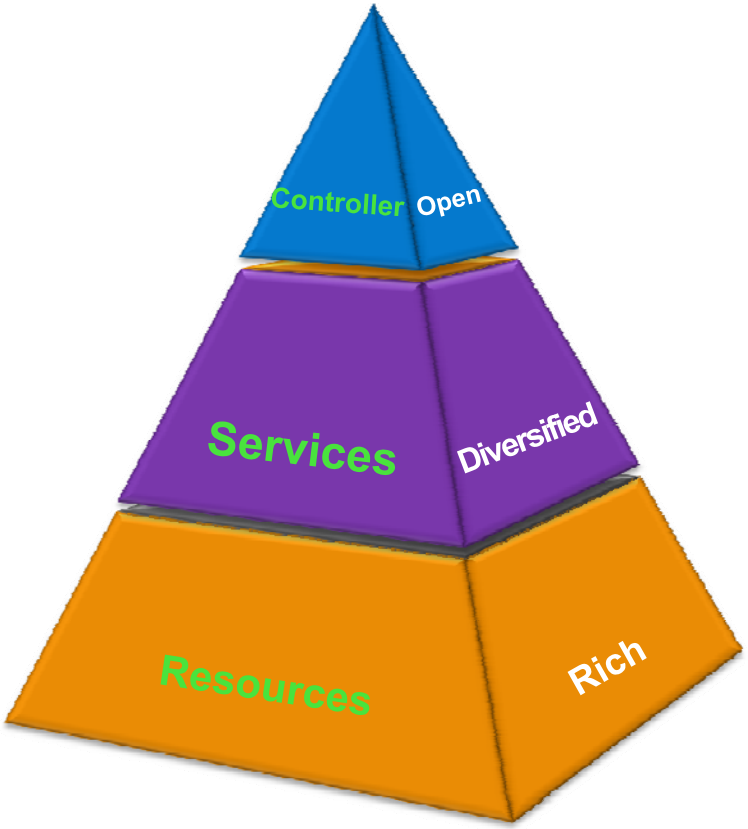


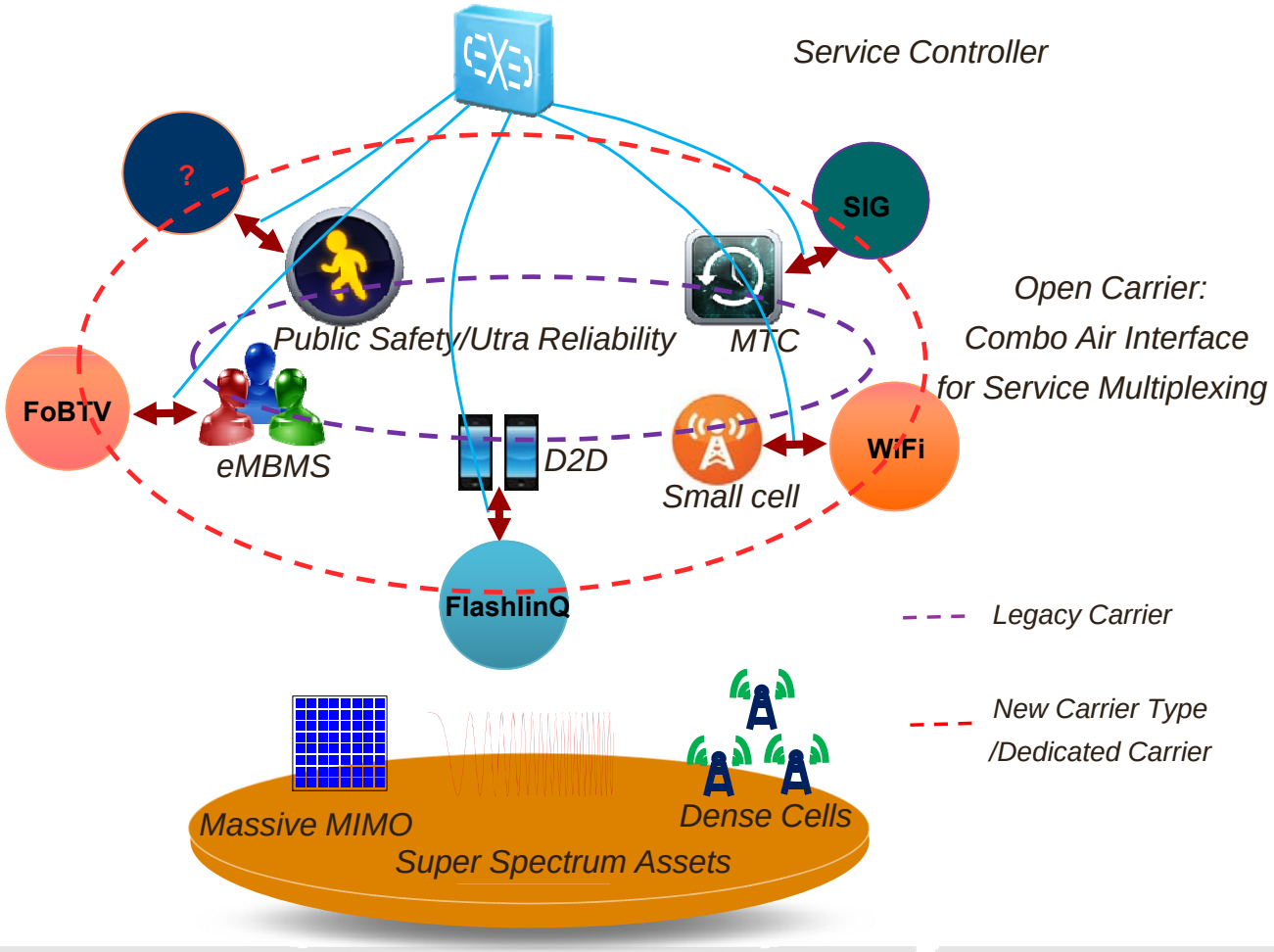
Diversified UE Capabilities for Big data

Trend of Software Defined Telecommunication

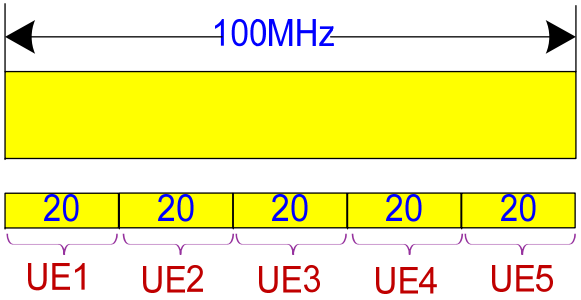


Open Carrier: Any Service Multiplexing

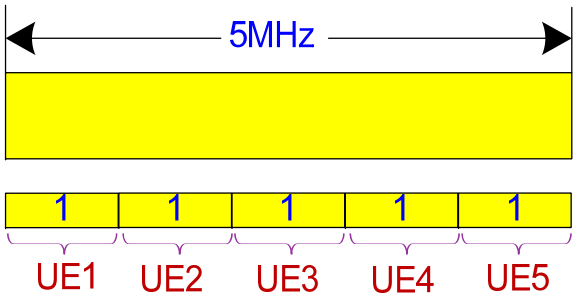




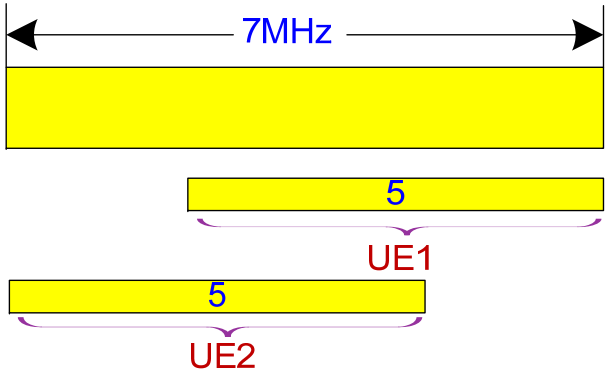
Open Carrier: Any Bandwidth



(a)Larger BW at eNB, ≤20MHz at UE

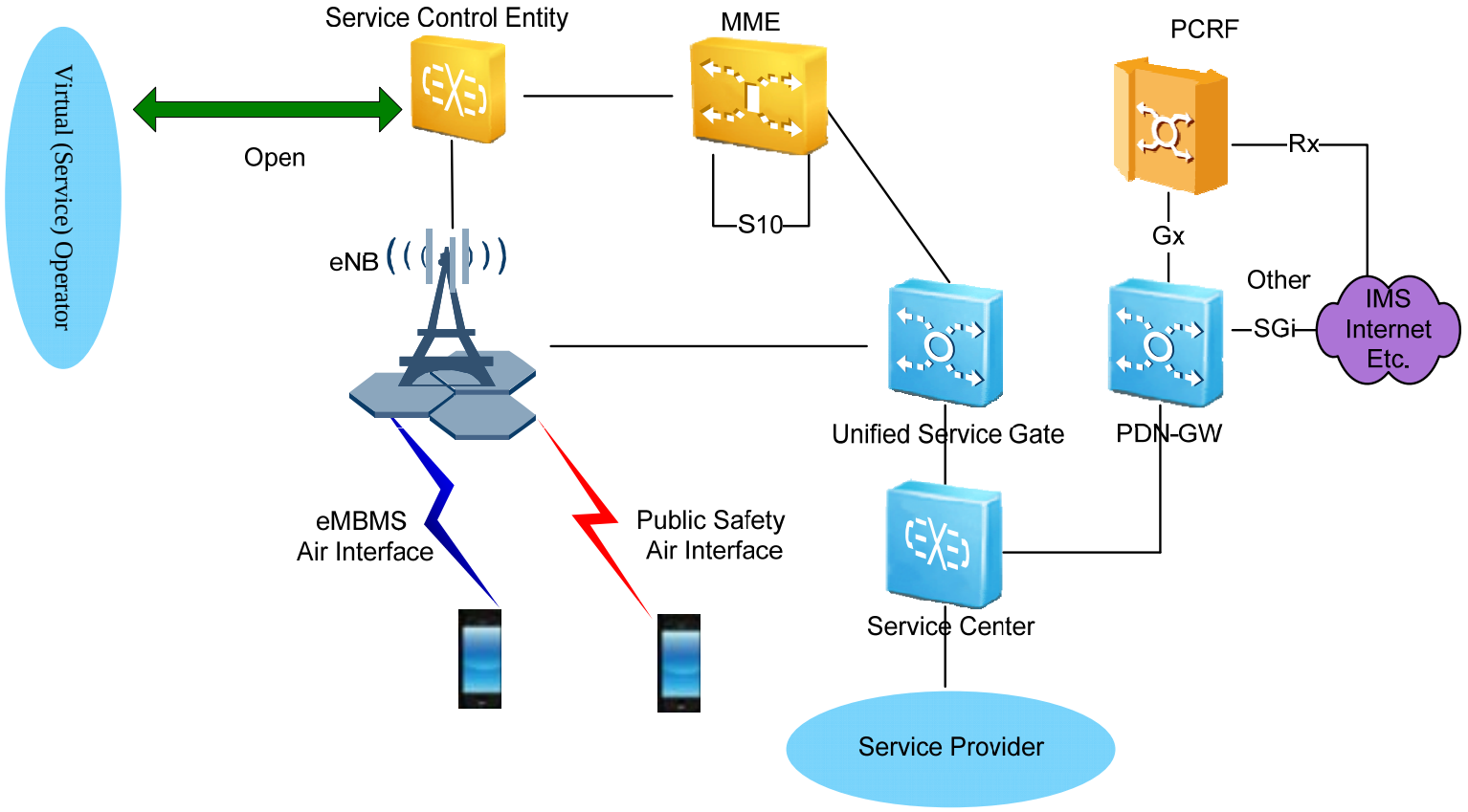


(b)Smaller BW at UE(e.g. Low Cost MTC)



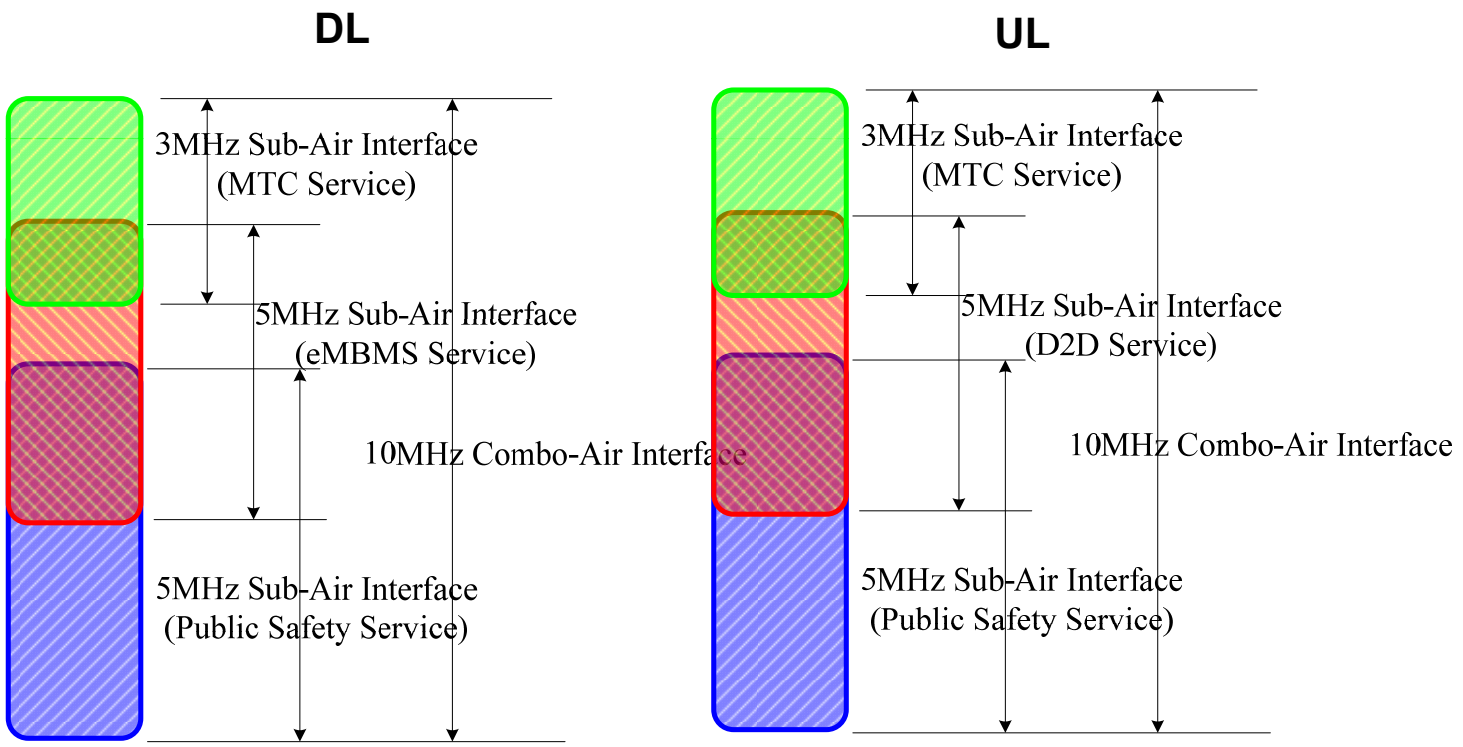
(c)Non-standard BW

Technology Enabler: Service Controller



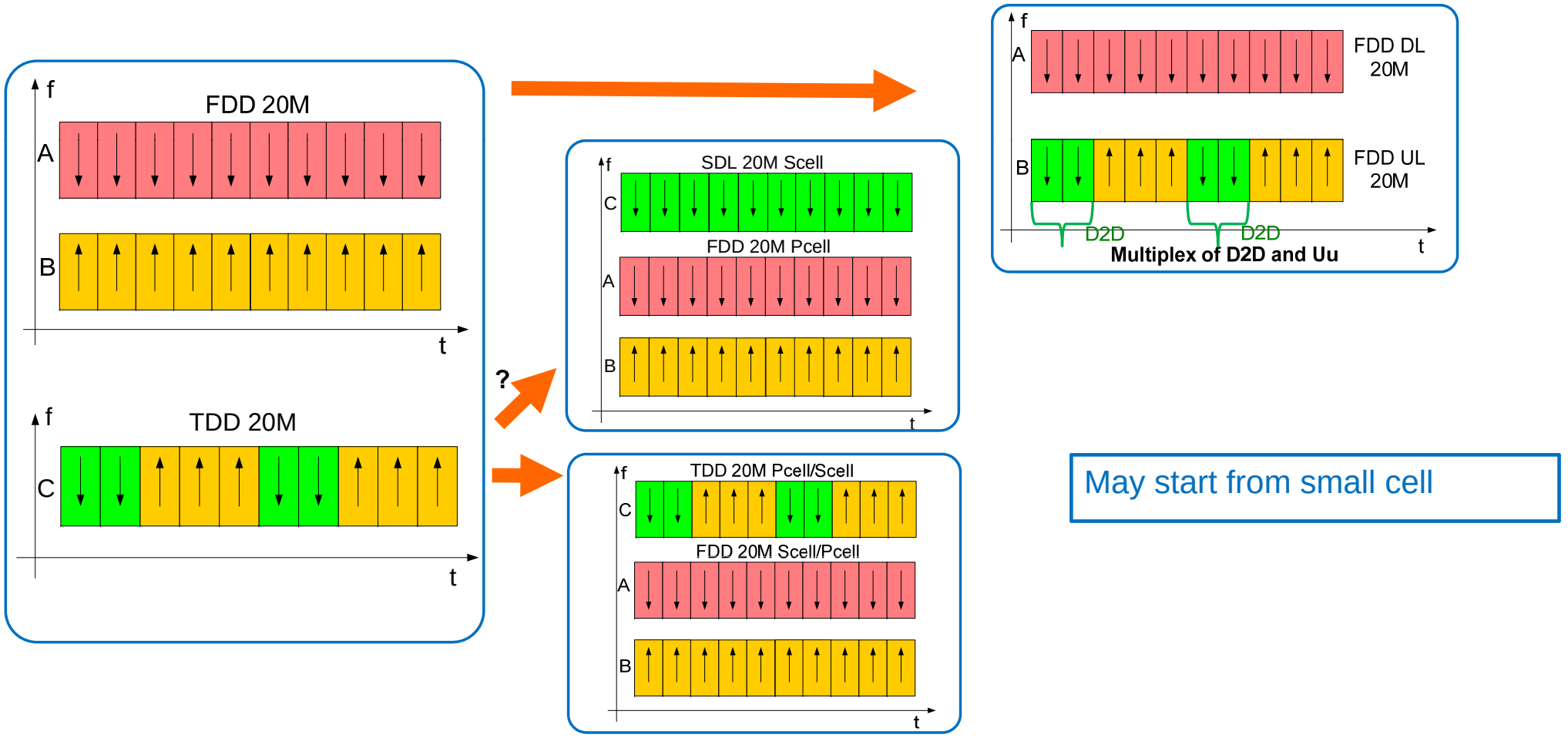
Technology Enabler: Combo Air Interface

- Coexistence of Sub-systems
- Initial Access (DL & UL)
- System Information Change & Adaptation
- Virtual DC



One example of Open Carrier

Open Carrier helps FDD/TDD Spectrum Convergence

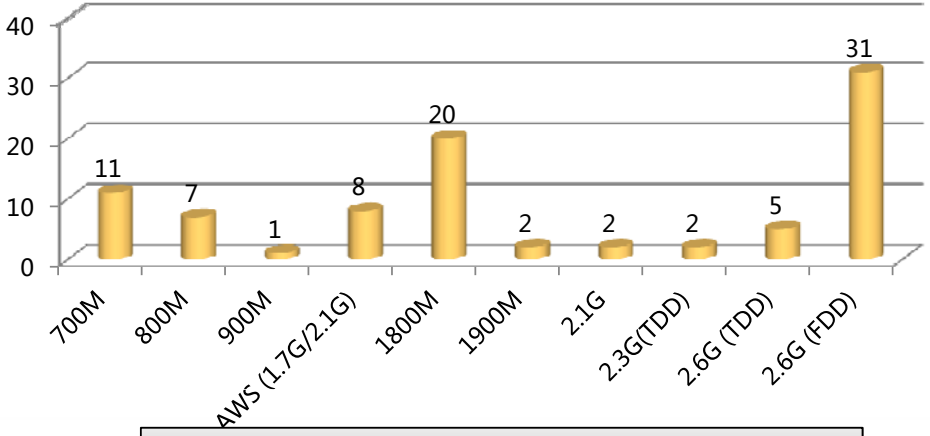


May start from small cell

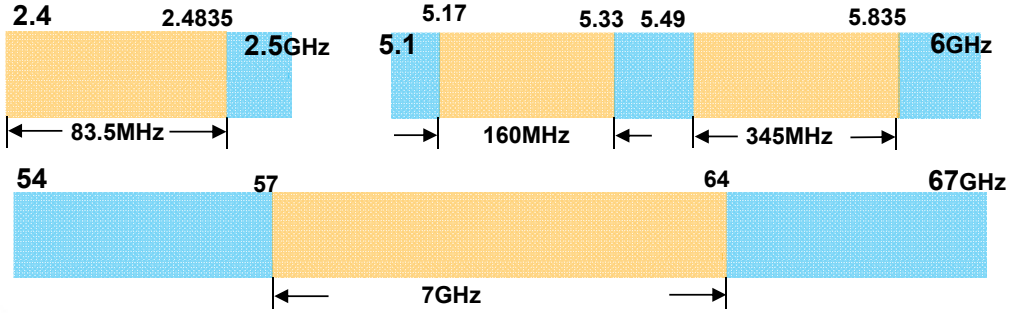
Super Spectrum Assets

Licensed Spectrum (Commercialized)

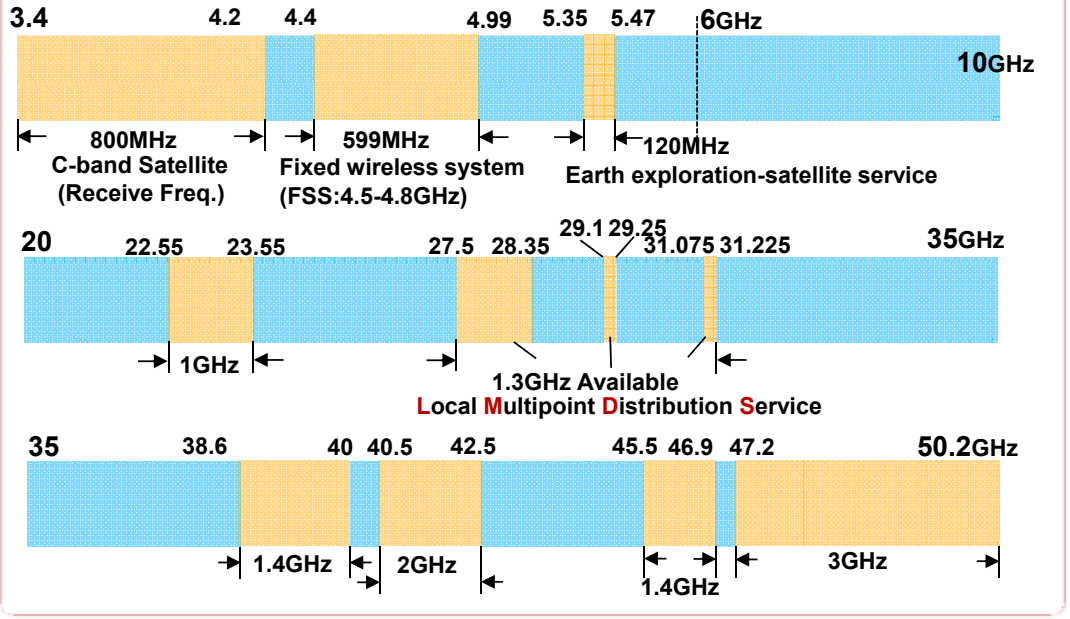
Band distribution of 72 LTE Commercial Networks until May 8, 2012 (Source: GSA)



Unlicensed Spectrum



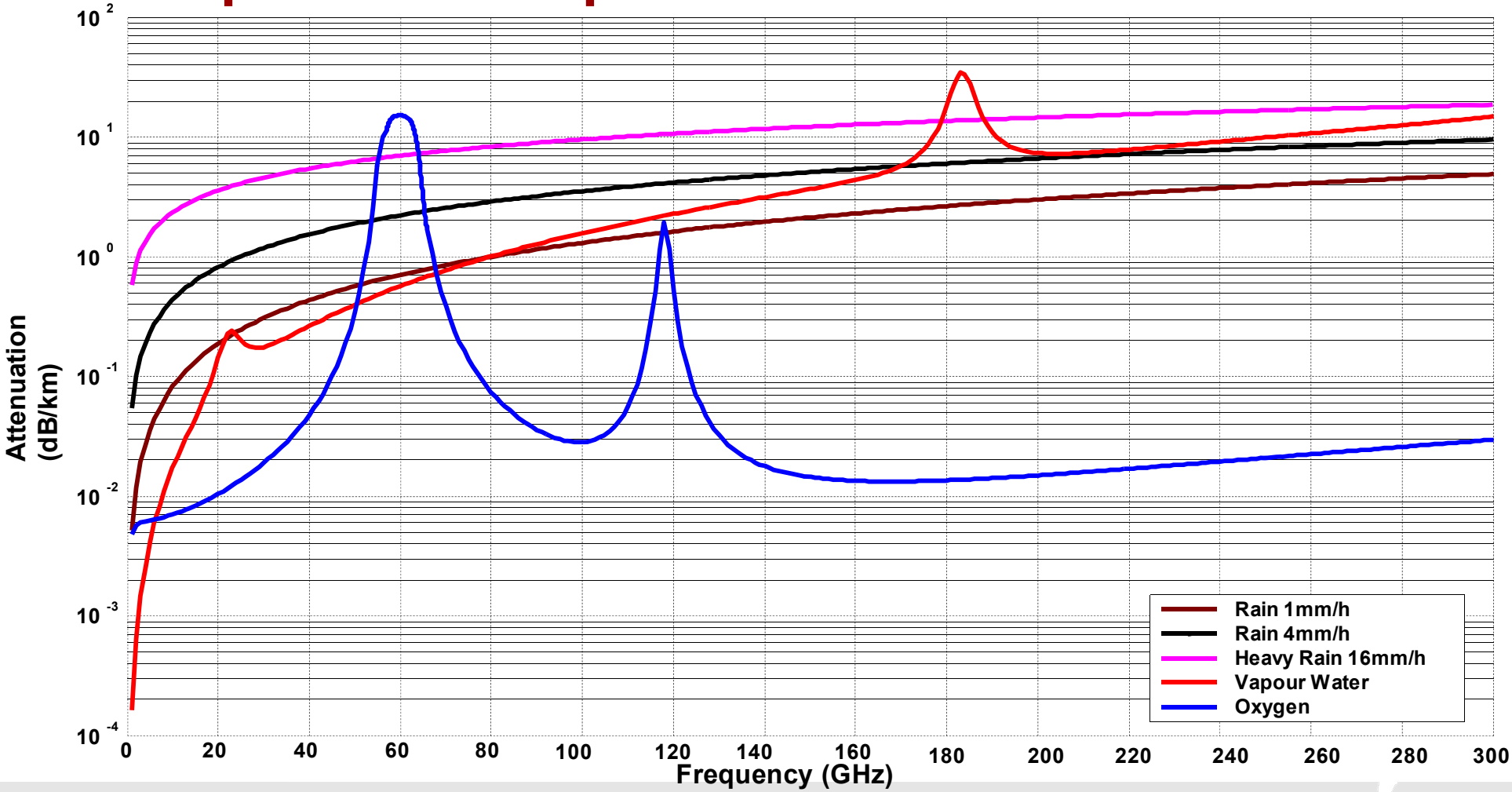
Licensed or ASA/LSA Spectrum (Potential)



Spectrum requirements for IMT in year 2020 (WP 5D)

	Total spectrum requirements for RATG 1	Total spectrum requirements for RATG 2	Total spectrum requirements RATGs 1 and 2
Lower user density settings	440 MHz	900 MHz	1 340 MHz
Higher user density settings	540 MHz	1 420 MHz	1 960 MHz

Atmospheric Absorption Effects of mm Wave



Technical Challenges/Solutions of mm Wave Communications

Challenges

Propagation Channel:

- Large-Scale Fading → path loss & shadowing.
- Small-Scale

Antenna Array and Beamforming Design:

- Efficient beamforming algorithm and protocol
- Small-size, low lost, low-cost & efficient antenna arrays.

Integrated Circuit and DSP:

- Large bandwidth requires fast ADC & high-speed sampling rates DSP
- Challenging to design small size, low-cost & low-power IC.

RLM/RRM

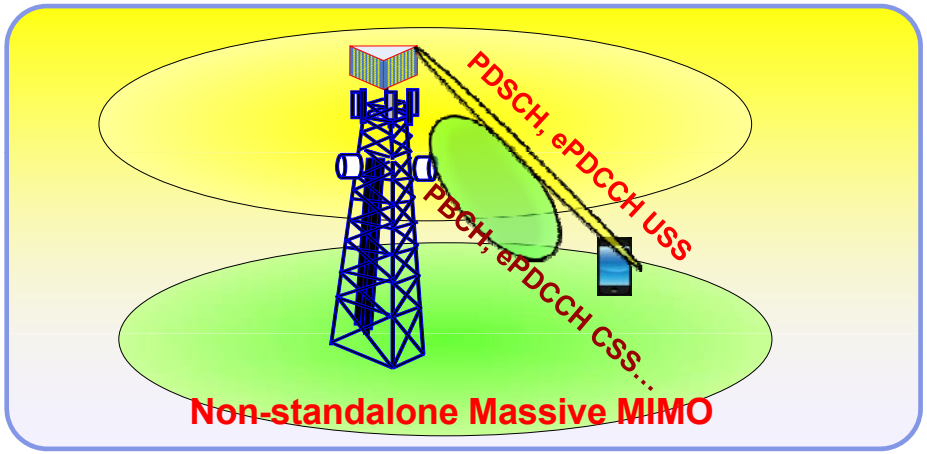
Potential Solutions

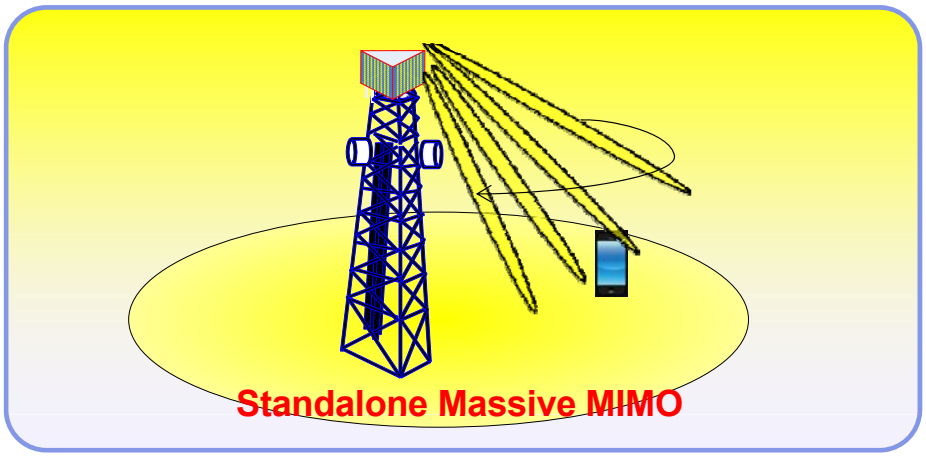
Non-standalone Massive MIMO

- Where a low frequency applies

Standalone Massive MIMO

- Beam Switching
- T/F Repetition





Authorized/Licensed Shared Access (ASA/LSA): Motivations and Opportunities

Motivations

- Accelerate harmonization and potential re-farming
  - Access underutilized spectrum, which may always have incumbent spectrum holders.

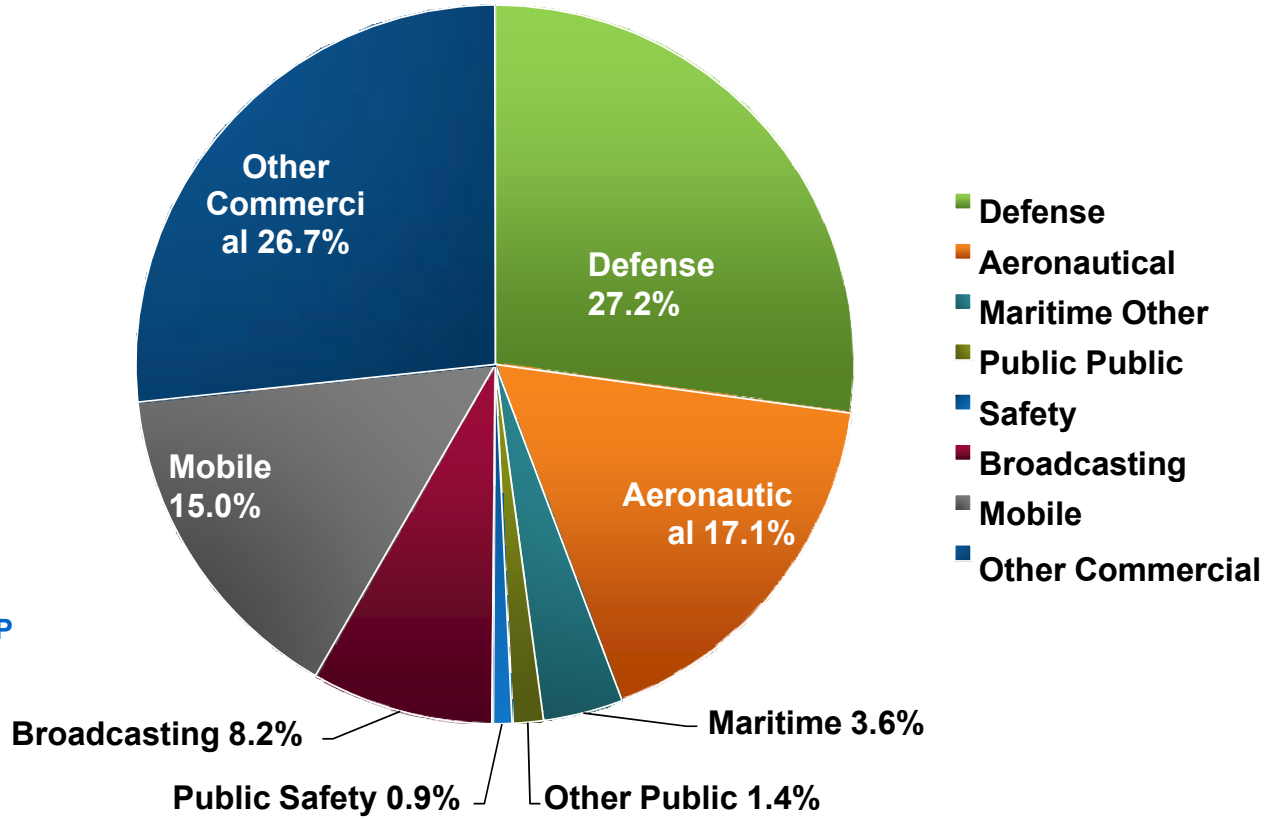
Opportunities

In USA:

- 1.7GHz: Sharing at 1700 MHz being worked in Commerce Spectrum Management Advisory Committee (CSMAC) / National Telecommunications & Information Administration (NTIA) . Spectrum currently used by Military and satellite weather.
- 3.5GHz: Federal Spectrum at 3600 MHz currently in use by high power navy radar & satellite systems. Aligns with 3GPP TDD bands 42& 43. Excellent for cellular small cells & international alignment.

In EU:

- European Union LSA efforts focused on 2300MHz-2400MHz



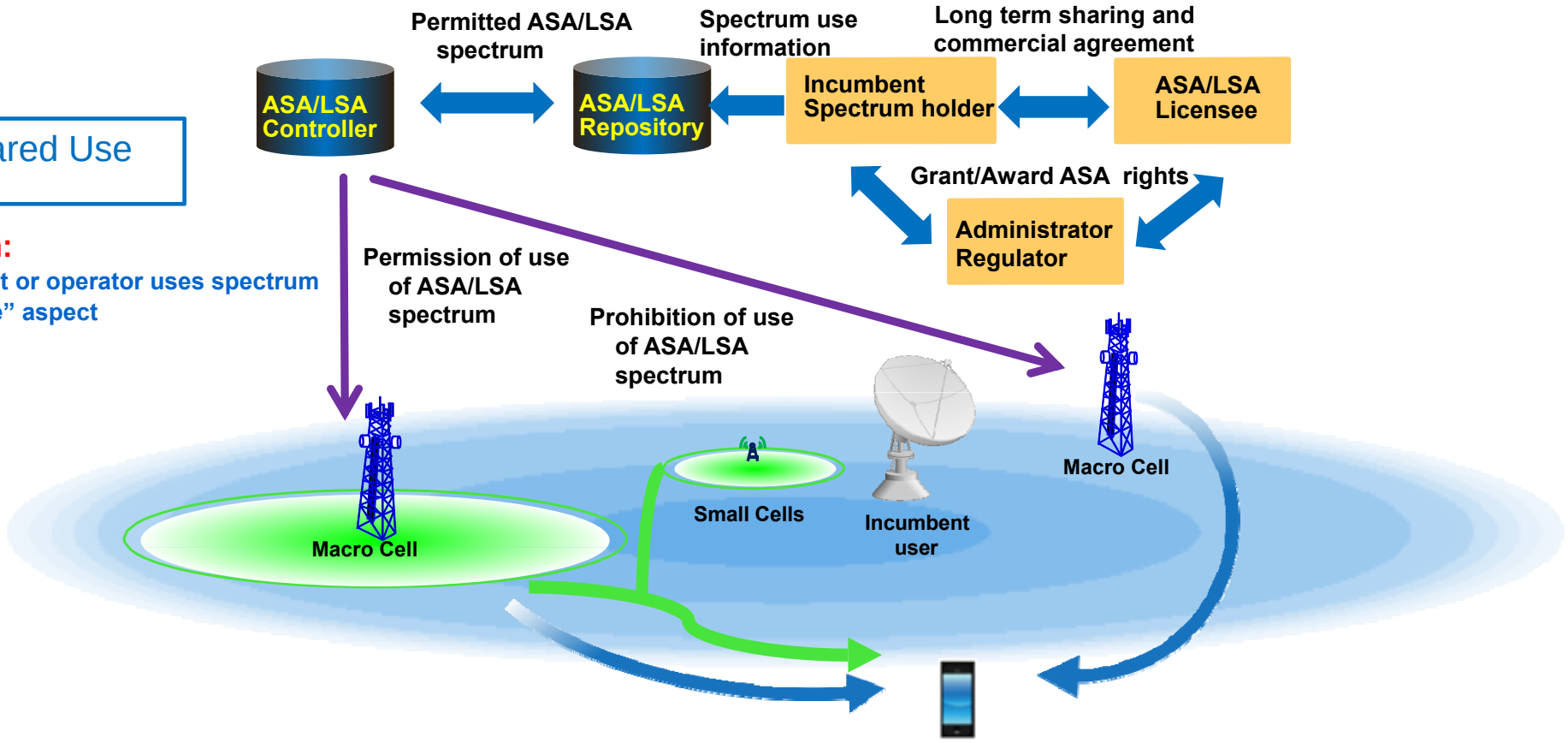
Spectrum Allocation within in a typical EU country (108 MHz – 6 GHz)

Concept of ASA/LSA

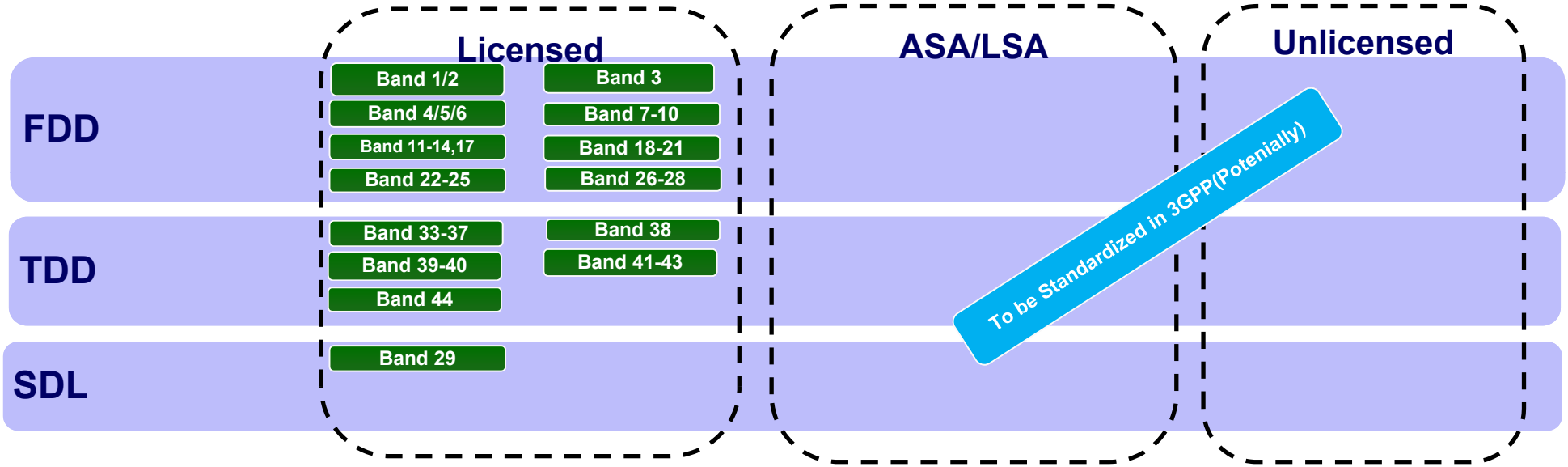
Exclusive Shared Use

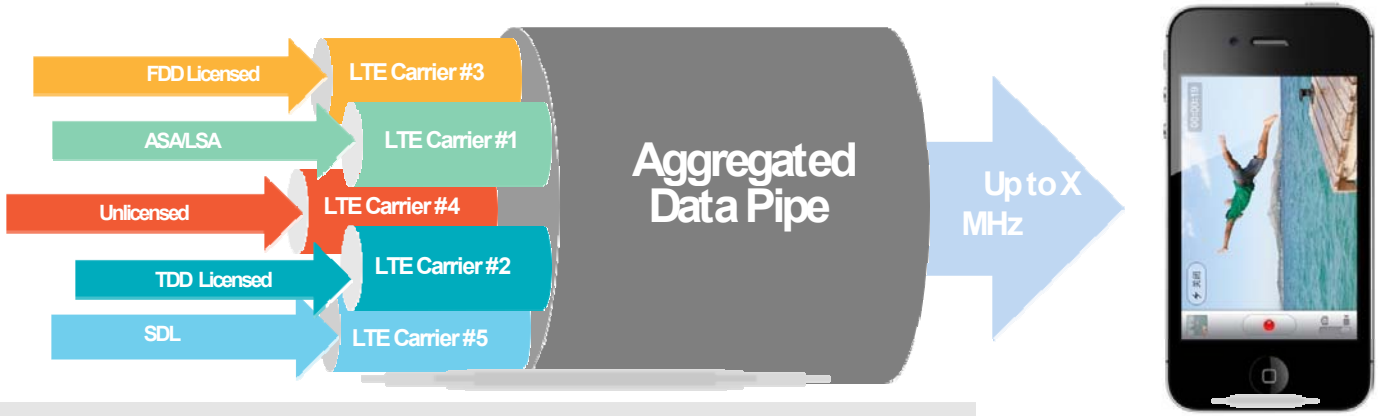
Binary Approach:

- Either incumbent or operator uses spectrum
- Introduces “time” aspect



Diversified Spectrum Assets and Heterogeneous Aggregation





A Popular technology on unlicensed spectrum: WiFi vs. LTE

Coverage comparison

- TD-LTE 5.9GHz 20dBm(38m)
- WIFI 5.9GHz 20dBm(28m)

Low

Peak rate comparison

- TD-LTE capacity is 1.09Gbps@80MHz,4X4MIMO
- WiFi capacity is 0.75Gbps@80MHz,4X4MIMO

Low

Low Efficiency than LTE

Protocol design

LTE Pros. :

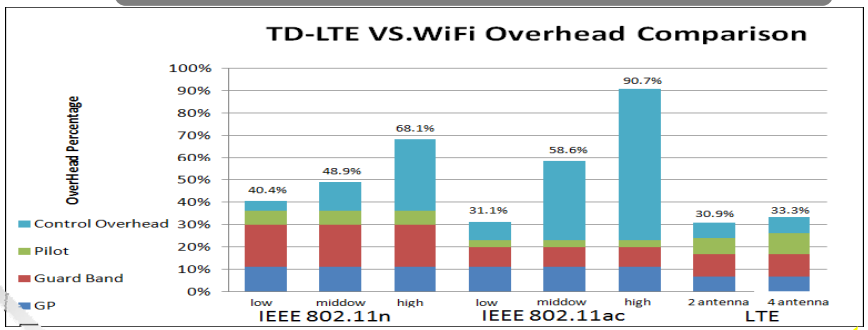
- Higher efficient scheduling mechanism
- Better QoS insurance
- Uniform OAM& SON
- Better Security
- Mobility and service continuity
- Better power saving

Simple but limited

DL resource efficiency

- WiFi： **52.4% to 4.8%**
- TD-LTE： **61.2% to 38.1%**

Overhead



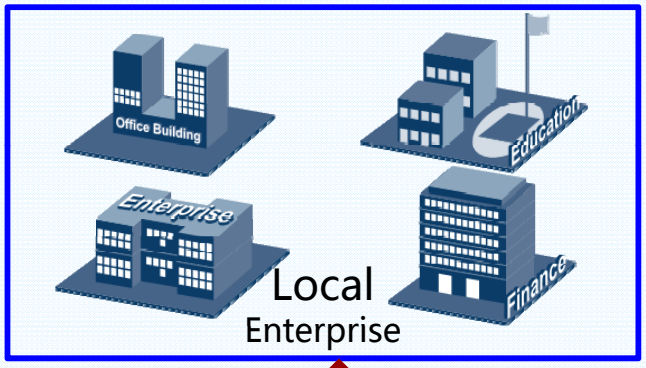
- WiFi： **40.4%, 68.1%**
- TD-LTE： **30.9%, 33.3%.**

High

Low Efficiency → Unlicensed Spectrum is not fully used & Deployment is limited

Focuses on the Prioritized scenarios: Operator and Enterprise

Main Application Scenarios for Unlicensed Spectrum



Solutions to be applied:

IEEE WiFi Wireless Broadband Alliance

- WiFi self-evolution
- Carrier WiFi @unlicensed

LTE

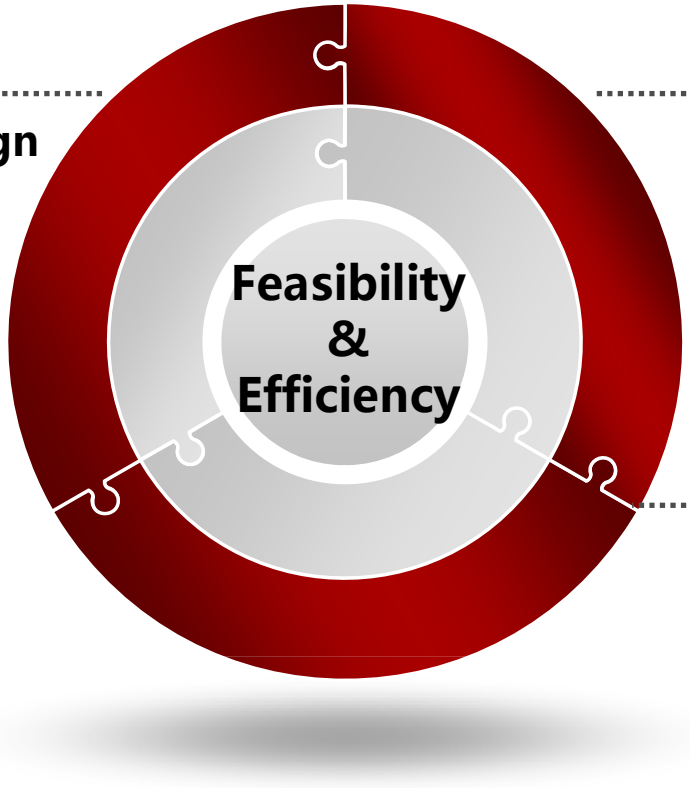
- **LTE-Hi @unlicensed**
- **As secondary CR system**

As an **integrated part of LTE licensed network,**
U-LTE is used in scenarios deployed by operators and enterprises.

U-LTE: An integrated part of LTE licensed network

1. Secondary Carrier design

- **Option 1:** DL only unlicensed carrier (FDD Pcell or TDD Pcell)
- **Option 2:** DL+UL unlicensed carrier (FDD Pcell or TDD Pcell



2. Co-existence

- **2.1 Inter-operator interference**
- **2.2 Inter-RAT system: Mainly WiFi**

Better Experience

- **Implement the LTE valuable features (Mobility, QoS, security, …) through Pcell**
- **Explore the wide band resources on unlicensed spectrum**
- **It is beneficial to be compatible with the design of residential scenarios**

Note: Pcell is Primary Cell

Summary of LTE on unlicensed Spectrum (U-LTE)

Scenarios

- Scenarios deployed by operators and enterprises are prioritized
- It is beneficial to be compatible with the design of residential scenarios

Technologies

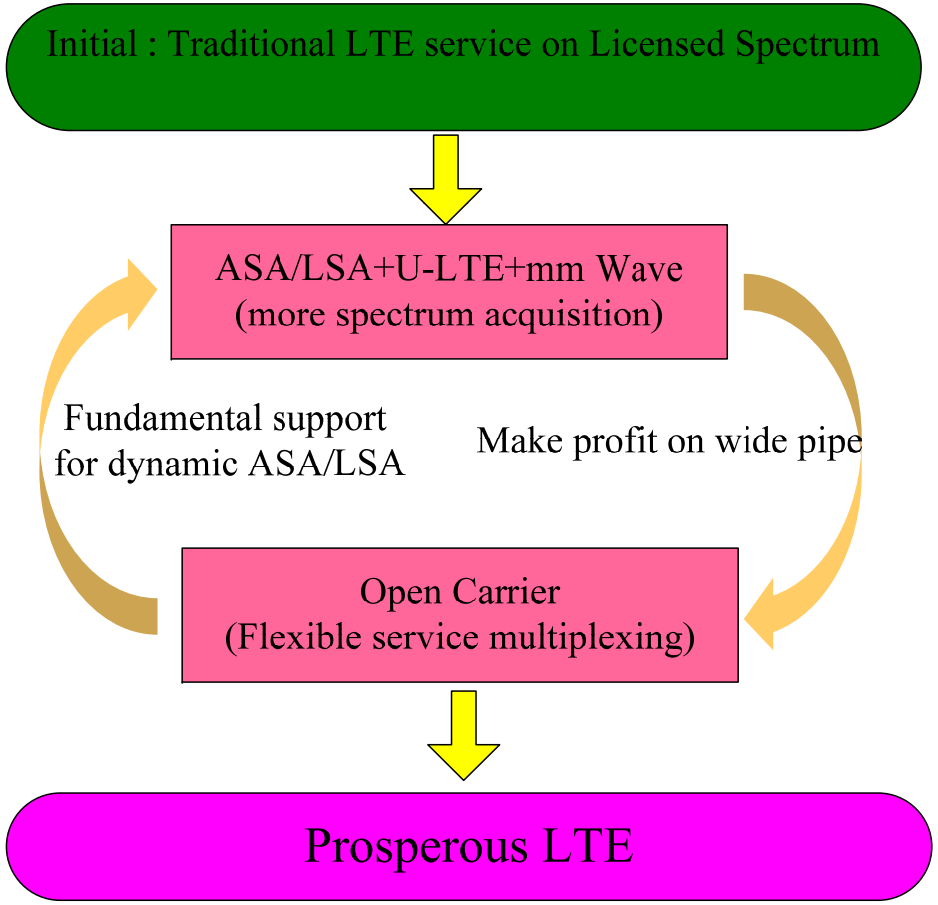
- Aggregating unlicensed spectrum as the secondary component carriers with the licensed carriers
- Both Self-Protection and Fairness should be guaranteed
- LTE can provide configurable different level of fairness
- Inter operator coexistence should be handled
- Explore the wide band resources on unlicensed spectrum

Industry

- Make an available business model with operators
- Standardization on RAN and RF technologies in 3GPP
- Drive a mature industry with operators, infrastructure, chipset, terminal vendors etc.

Conclusive Remarks

- 2 spectrum technology evolution directions
  - More spectrum acquisition
  - Flexible spectrum utilization
- The 2 directions are highly correlated
- Iterative effect



Iterative effect of spectrum technologies


Thank you
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