Spectrum Sharing Initiatives in Unlicensed Bands: Advancements Towards 5G Networks

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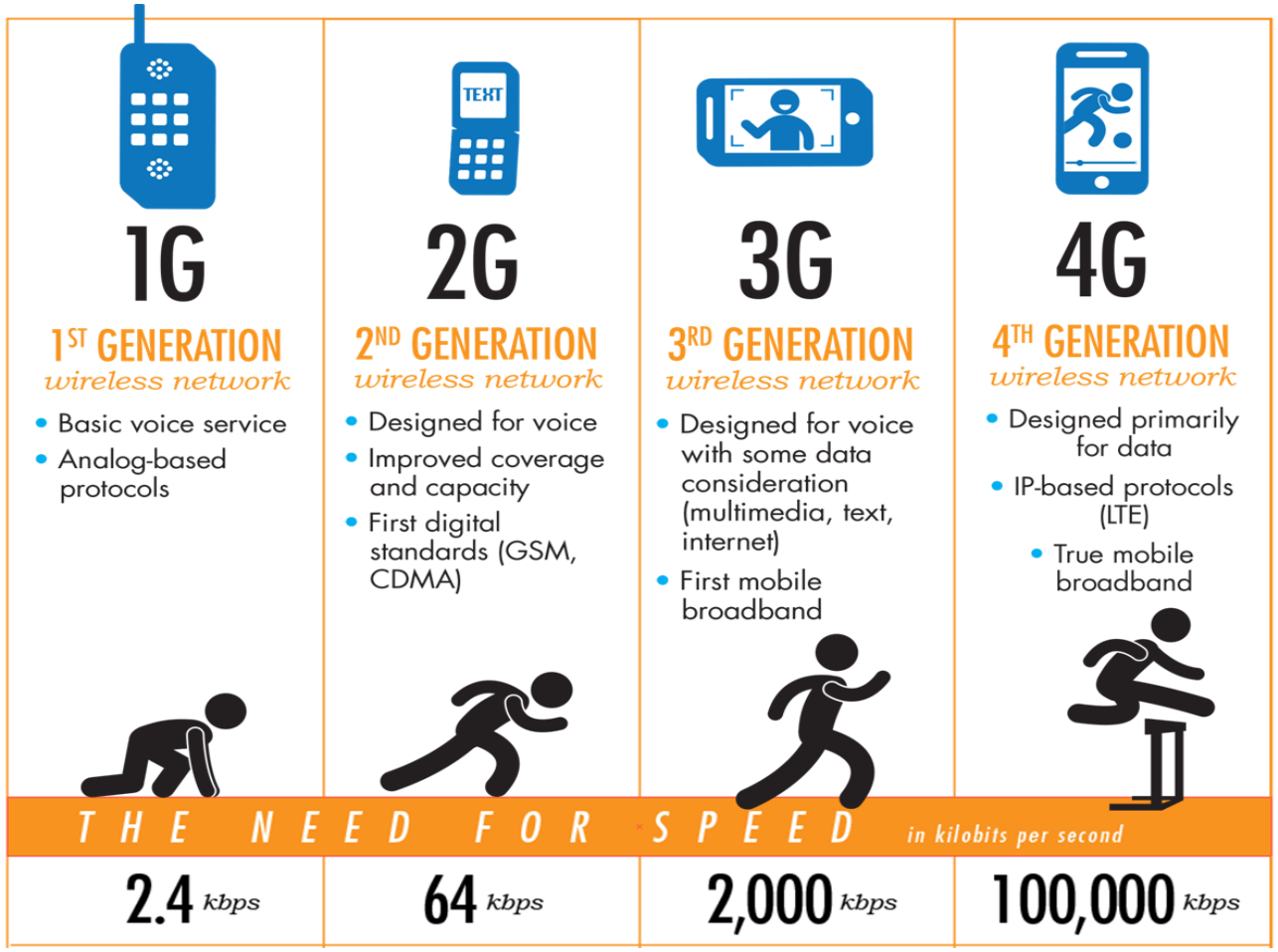
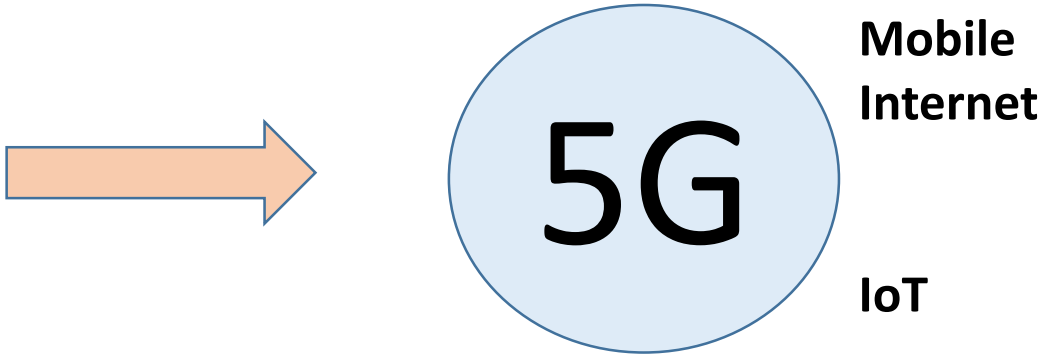
Talk Outline

- **Evolution of 5th Generation (5G) Networks**
- **Spectrum Sharing in Unlicensed Bands**
- **Recent Initiatives in Unlicensed Bands**
  - ✓ **Cellular Technologies**
  - ✓ **IoT Technologies**
- **Research Challenges and Directions**
- **Conclusions**

Evolution of Telecom Networks

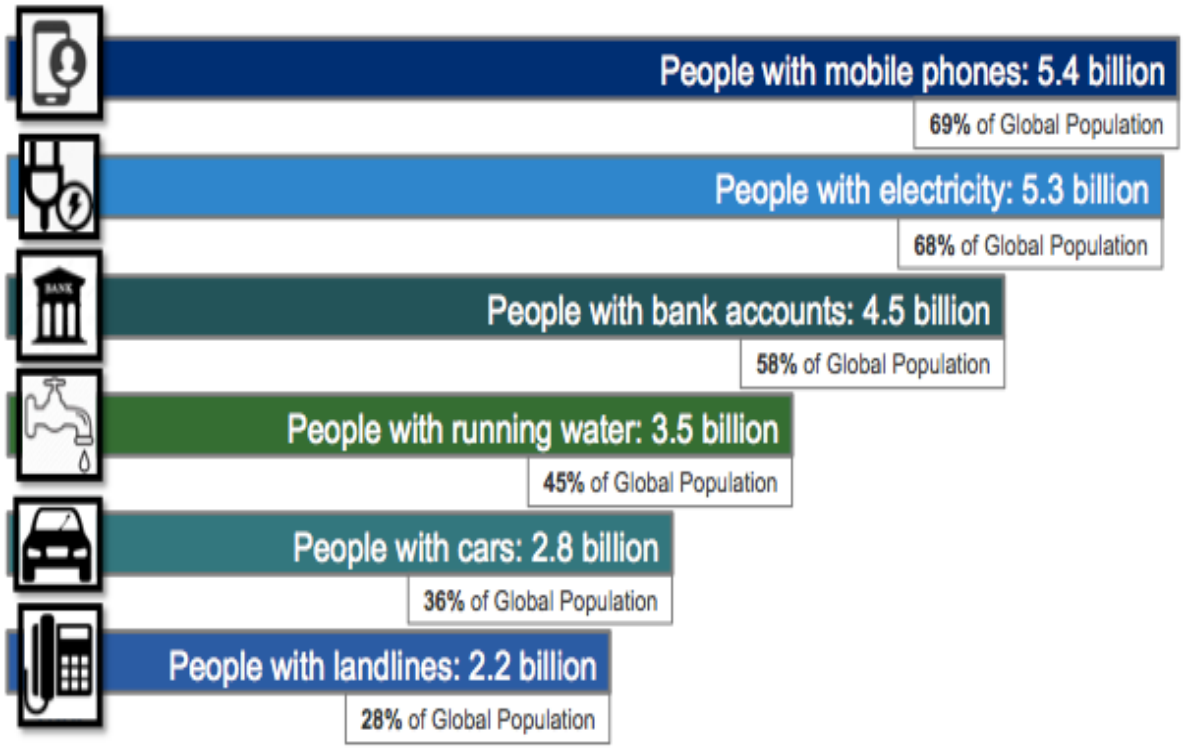




- ✓ High speed in tens of Gbps
- ✓ Huge number of connected devices (50 billion)
- ✓ Significant growth in mobile traffic (366.8 Exabytes per annum)
- ✓ Ubiquitous coverage
- ✓ Heterogeneous connectivity
- ✓ Scalable and new service experience any time and any where
- ✓ Ultra-rich Quality of Experience

Global Mobile Data Traffic Growth

	2015	2020
More Mobile Users	4.8 Billion	5.5 Billion
More Mobile Connections	7.9 Billion	11.6 Billion
Faster Mobile Speeds	2.0 Mbps	6.5 Mbps
More Mobile Video	55% of Traffic	75% of Traffic

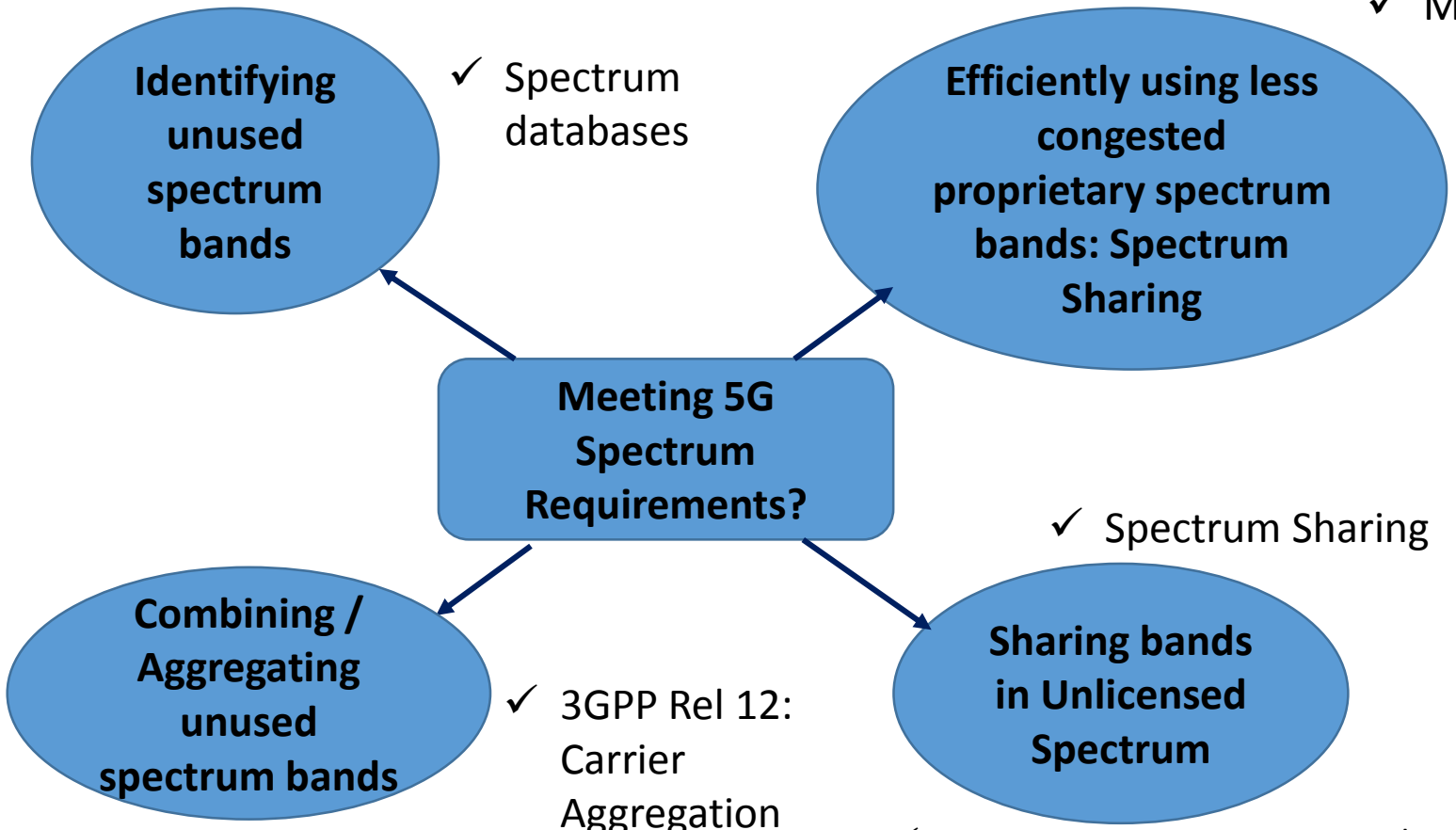


- ✓ By 2020: Growth of mobile users → two times faster than global population
- ✓ By 2020: More people with mobile phones than electricity at home

Source: Cisco VNI Global Mobile Data Traffic Forecast, 2015-2020

Need for More Spectrum in 5G

More Spectrum – From where and how??



- ✓ Spectrum databases
- ✓ Military / defense bands
- ✓ TV bands
- ✓ Spectrum Sharing
- ✓ 3GPP Rel 12: Carrier Aggregation
- ✓ Economic value in US → $49.78 billion of the annual GDP

Spectrum Sharing:

- Two or more technologies utilize the same range of spectrum bands
- Chunks of unutilized or little utilized spectrum frequencies can be shared in a cooperative way
- Effective utilization of spectrum

Spectrum Sharing in Unlicensed Bands

Licensed Spectrum

- ✓ Operator-controlled
- ✓ Sole ownership
- ✓ Customizable Deployment
- ✓ Little / No Interference
- X Hugely Expensive
- X Hardly available

Operators Looking for

Unlicensed Spectrum

- ✓ Available
- ✓ Not Overtly Congested
- ✓ Free to Use
- X Interference
- X Unplanned Deployment
- X Unregulated

Classification of Unlicensed Spectrum Bands

Higher Spectrum (> 6 GHz);

- ✓ More Frequency Reuse & Less Interference
- ✓ Energy Efficient & Higher data rates
- X Less Penetration abilities
- X Complex Hardware; Costly

Medium Spectrum (3.5 - 6 GHz):

- ✓ Less Interference
- ✓ More Spectrum Reuse
- X Limited Coverage
- X Needs More Small Cells
- X Coexistence Problem

Lower Spectrum (< 3.5 GHz):

- ✓ Less Spectrally Demanding
- ✓ Wide Area & Low Power
- X More Interference

5 GHz; < 1 GHz; 60 GHz (mmWave)

Recent Initiatives in 5 GHz Unlicensed Spectrum

- ✓ **LTE-Unlicensed (LTE-U)**: LTE in the Unlicensed Spectrum (5 GHz band; 5150-5925 MHz)
  - By Qualcomm in 2013; Pre-standard proprietary version backed by LTE-U Forum

- ✓ **Licensed Assisted Access (LAA)**: 3GPP standardization version (5 GHz band)
  - Part of ongoing Release 13 (Down Link); Completion: 2016

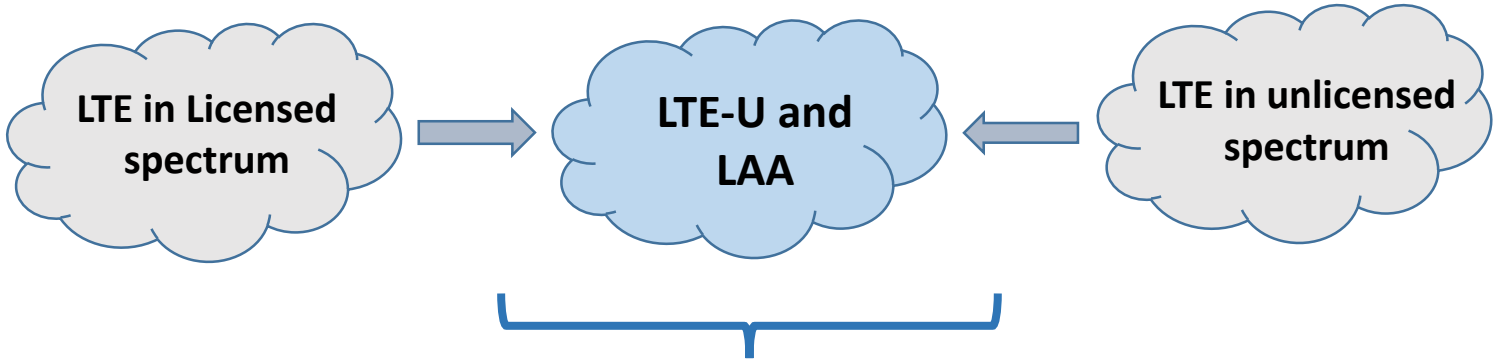
- ✓ **Enhanced LAA (eLAA)**: 3GPP standardization version
  - Part of future Release 14 (Down Link and Up Link); Expected Completion: 2017

- ✓ **LTE-WLAN Aggregation (LWA)**: 3GPP standardization version
  - Part of ongoing Release 13; Completion: 2016

- ✓ **MultiPath (TCP) Aggregation (MPTCP):** Standardized by IETF (Commercialization underway)

- ✓ **MulteFire**: Will be standardized by MulteFire Alliance (based on 3GPP standards)
  - Expected completion of technical specifications: End of 2016

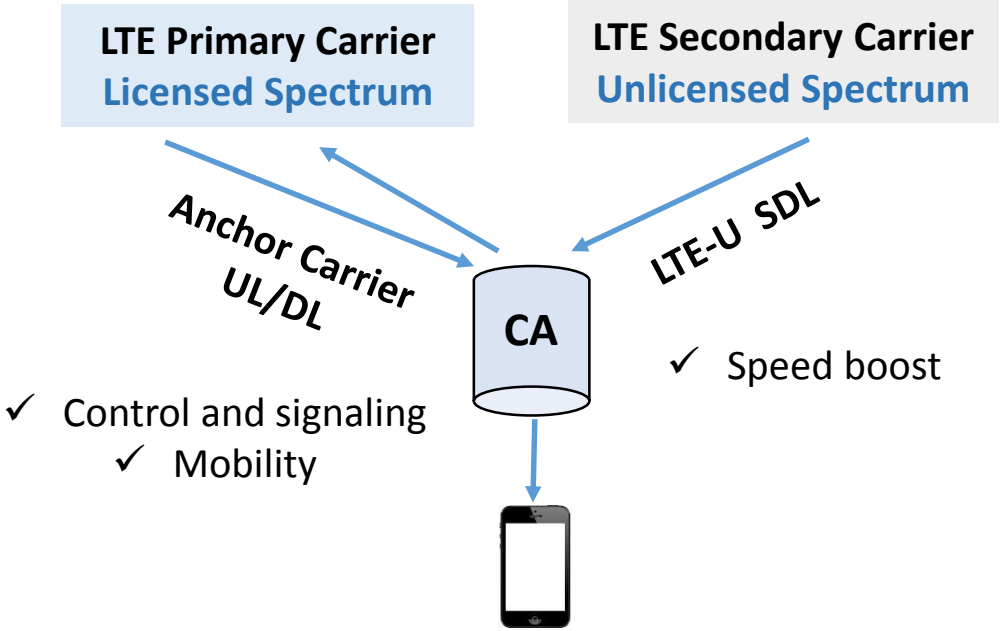
LTE-Unlicensed and Licensed Assisted Access



Aggregation of LTE transmission in licensed and unlicensed bands using **Carrier Aggregation** (CA)

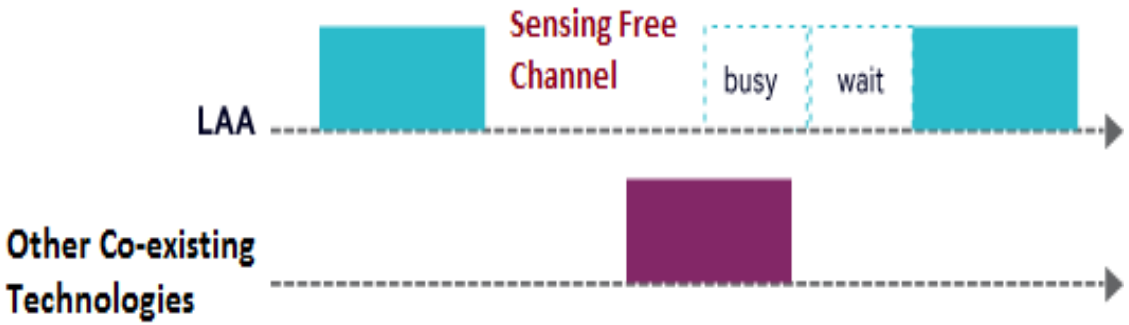
- **Advantages:**
  - ✓ Greater data capacity
  - ✓ Faster download speeds → as simultaneous data transmission over both licensed and unlicensed spectrum
  - ✓ Easy bundling of LTE-U with existing LTE carriers in licensed spectrum

LTE transmission in licensed band would expand into the unlicensed bands to increase size of available DL channel



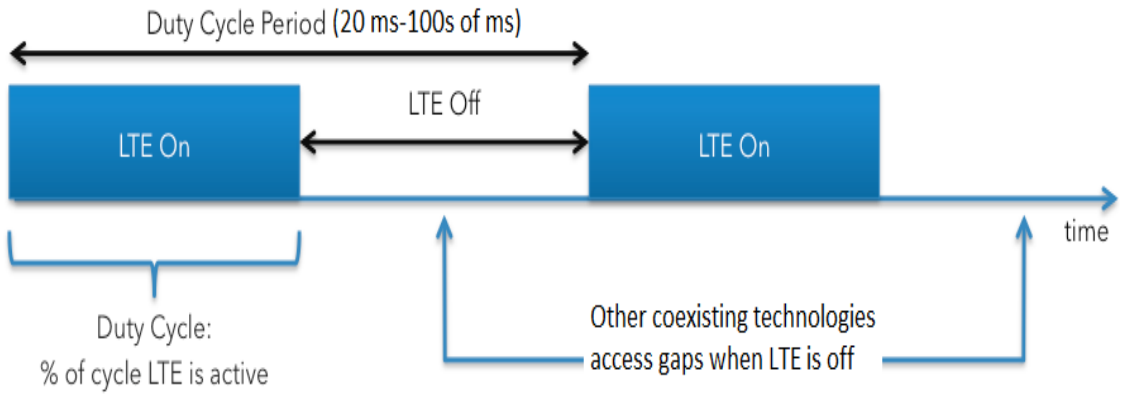
LTE-Unlicensed and Licensed Assisted Access

- **LAA → Listen-Before-Talk or LBT** (regulatory requirement in unlicensed bands to check whether channel is free before talking; part of 3GPP Rel 13 standard)



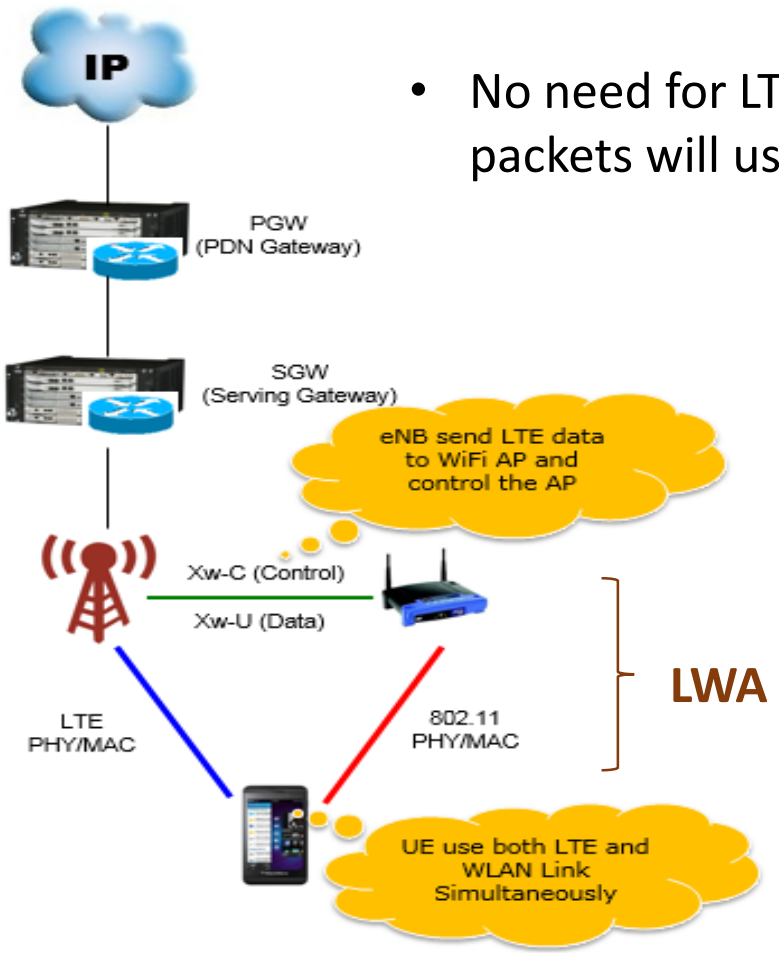
  - Sensing time → Clear Channel Assessment period
  - LBT is mandatory in Europe, Japan and others

- **LTE-U → Carrier Sensing Adaptive Transmission or CSAT** (non-regulatory and on-off duty-cycling based; part of 3GPP Rel 10-12 standards)



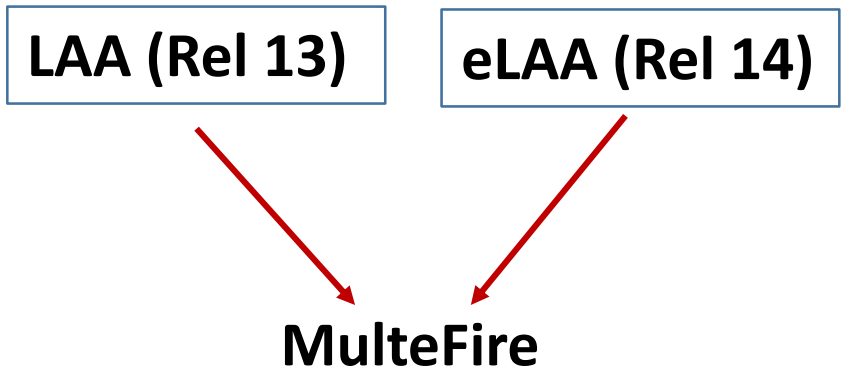
  - Sense channel utilization; random duty-cycling
  - Non-LBT markets, e.g., USA, China, India, Korea etc

LTE-WLAN Aggregation and MulteFire



- No need for LTE-U 5 GHz hardware as LTE packets will use WiFi APs

- LTE packets are transmitted using Wi-Fi Access Points in Unlicensed Spectrum



- Only LTE Unlicensed technology operating fully in the unlicensed spectrum (5 GHz globally; also 3.5 GHz in USA)

- Support for both LTE Up Link and Down Link in Unlicensed Spectrum (Listen-Before-Talk technology)

- No need of an anchor carrier in the Licensed spectrum

LTE and Wi-Fi: Coexistence in the Unlicensed Bands

Fair Sharing??

- WiFi operators not happy with the sharing and fear that WiFi performance will suffer
- LTU-U Forum (Ericsson, Qualcomm, Samsung, Verizon etc.):

Spectrum Sharing will not impact Wi-Fi services

- **Concerns?**
  - ✓ WiFi performance in presence of LTE
  - ✓ Interference will be significant
  - ✓ Cellular technology in unlicensed bands → "Unethical"

Challenges: Technical

- ‘Listen-before-Talk’ (LBT) requirements – how much will LTE-U implement? Novel coexistence mechanisms needs to be devised for ‘fair sharing’ of unlicensed bands.
- LTE-U’s duty-cycling may reduce Wi-Fi throughput and increase latency. How to solve this?
- Periodic beacons from Wi-Fi can be affected and it may increase power consumption of Wi-Fi clients. Also WiFi voice and video may suffer.
- How may LTE-U’s channel selection process interact with automatic channel selection algorithms in deployed Wi-Fi equipment? Smart selection of channels is very crucial to avoid interference.
- How to provide quality-of-service for LTE traffic on the unreliable unlicensed bands

Challenges: Non-Technical

- What policies are there to govern such “fair” sharing/use of spectrum?
- Unlicensed bands can be overused by operators → how may this be monitored and regulated?
- LTE-U may dominate over (even push out) Wi-Fi → How to monitor and regulate that “technology behaviour” in the unlicensed spectrum?
- Will the Governments in different countries encourage such sharing of unlicensed spectrum?

Effects of Unlicensed Spectrum Sharing on WiFi

- **Field Testing and Simulations results**:

✓ Wi-Fi performance is not degraded in presence of LTE-U

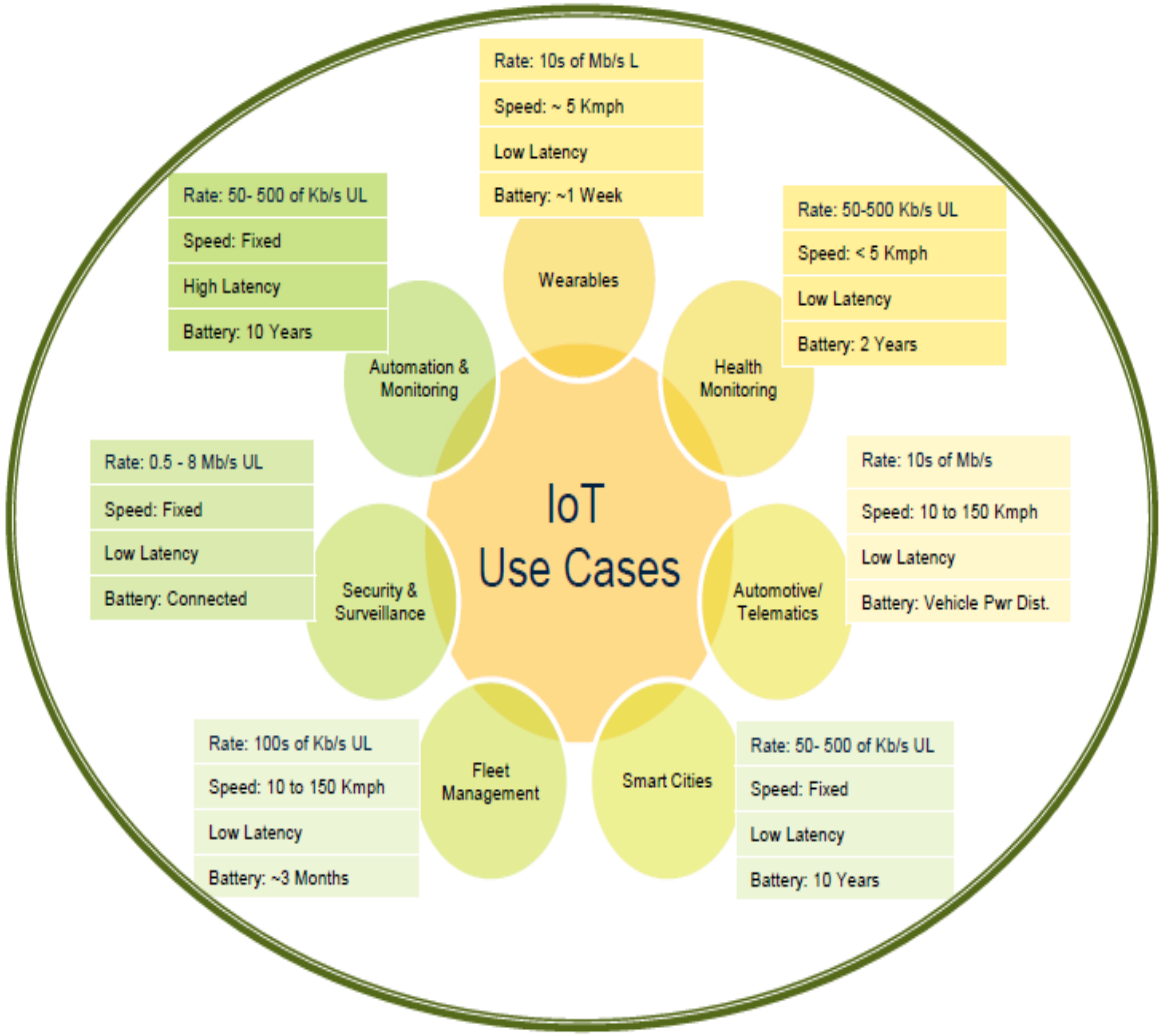
✓ Significant throughput gain can be achieved because of LTE licensed and unlicensed band aggregation

✓ Interference effect on Wi-Fi from LTE-U is similar to that between Wi-Fi-Wi-Fi

✓ LAA network can reach higher capacity than a WiFi network

✓ LTE-U relies on LTE core network => changes in core network domain not needed while deploying

IoT Initiatives in Unlicensed Spectrum



Source: 4G Americas, "Cellular Technologies Enabling the IoT", Nov 2015

- By 2022: Expected more than 360 million IoT connections
- **Different applications have different service requirements**: excellent and ubiquitous coverage, ultra-low power operations, adequate bandwidth, secured and low-cost communication etc.
- Cellular technologies (e.g., LTE, WiMAX, HSPA etc.) cannot meet these requirements (high cost, low battery life etc.); WiFi, Zigbee, Bluetooth are short-ranged.
- Spectrum allocation needs to be application-specific and must satisfy service requirements → **A Huge Challenge to Meet!!**

IoT Initiatives in Unlicensed Spectrum

- **Requirements?**
  - ✓ Wide-area non-expensive machine communication network
  - ✓ Should be open global standard and not proprietary
  - ✓ Globally harmonized low-frequency spectrum
  - ✓ Spectrum should be of low cost and needs to be plentiful

Globally **harmonized low-frequency spectrum in unlicensed bands** can be made available for IoT → e.g., below 1 GHz like 870-876 MHz and 915-921 MHz; 700 MHz and TV White Spaces

- IoT **Low-Power Wide Area Network (LPWAN) technologies** in unlicensed spectrum:
  - ✓ **SigFox** → European company providing separate IoT network; 868 MHz in Europe, 900 MHz in USA
  - ✓ **LoRA (Long Range)** → European company; similar frequency bands
  - ✓ **Ingenu** → provides higher data throughout rates than LoRa and SigFox; operates in 2.4 GHz bands, so has shorter range

IoT Challenges in Unlicensed Spectrum

- Can we have worldwide default (preferably) unlicensed spectrum allocation for IoT connections? E.g., 915 – 928 MHz bands?

- Can IoT devices self-understand which country they are operating in and self-switch to allocated IoT spectrum bands there?

- An universally accepted LPWAN standard needed for M2M/IoT connections worldwide.
  - ✓ 3GPP is pursuing standardization of 3GG-based IoT technologies, but what about others?

- How will interference between different wide-ranged LPWAN technologies be handled?

IoT Challenges in Unlicensed Spectrum

- Multiple technologies use unlicensed spectrum in an uncoordinated manner. How transmission of data may be affected?

- Power-restrictions may reduce interference but will affect the wide-range of transmission. This is a trade-off!

- How can there be ‘fair sharing’ of the unlicensed spectrum between IoT technologies?

Conclusions

- Telecommunication and networking fraternity eagerly waiting to know what 5G will offer.
- 2020 vision → massive explosion of mobile traffic owing to huge number of connected devices, new services and use cases.
- More spectrum is required; spectrum sharing in unlicensed spectrum is the key.
- LTE plans to expand in 5 GHz unlicensed bands; coexistence with WiFi is an issue.
- Low power and wide-area IoT technologies are trying to use unlicensed spectrum.
- Cooperation, coexistence and fair sharing of unlicensed spectrum is important; worldwide harmonized and regulated unlicensed spectrum allocation approach is needed

Thank You..

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