

5G Standardization

Mobile World Congress 2015

5G Standardization Roadmap

1G (1980s)
Analog Voice

2G (1990s)
Digital Voice

3G (2000s)
Broadband Data

4G (2010s)
Widespread Broadband

5G “The Living Network” (2020s)
Ultra Broadband Era and IoT Era

5G Services

M2M, V2X, Explosion of Video, Proximity and Context Awareness, Tactile Internet, Public Safety, ...

5G Network Architecture

Device-centric and D2D, Dense and Layered Architecture, NFV and Cloud RAN, SON, ...

5G Air Interface

Massive MIMO, Advanced Waveforms, NOMA, Full Duplex, ...

5G Spectrum

Flexible and Dynamic Spectrum Sharing, New Spectrum for Access and Backhaul, mmWave, ...



5G Standards Incubation

Numerous industry forums and research projects working today to feed 5G standardization tomorrow

Next Generation Mobile Networks (NGMN) Alliance

- Developing end to end operator requirements to satisfy the needs of customers and markets in 2020+

Small Cell Forum

- Study Groups exploring Wi-Fi Integration, Virtualization, SON and more for dense small cell deployments

ETSI Industry Specification Groups (ISGs)

- Organized around a set of ETSI work items each addressing a specific technology area (e.g. millimeter Wave Transmission (mWT), Mobile-Edge Computing (MEC) and Network Function Virtualization (NFV))

Open Network Foundation (ONF)

- Technical communities analyzing Software-Defined-Networking (SDN) requirements, evolving the OpenFlow Standard to address the needs of commercial deployments, and researching new standards to expand SDN benefits

Open Daylight

- Collaborative open source project looking to accelerate the adoption of software-defined networking (SDN) and create a solid foundation for Network Functions Virtualization (NFV)

Large Scale Industry-Academic Research Projects

- METIS-2020, 5GPPP, 5G Forum, and many more...



ITU Regulation: Setting the Stage for 5G

Identifying Additional Spectrum for 5G

WRC 2015

- Additional spectrum expected to be identified for IMT at World Radiocommunication Conference (WRC) in 2015
- More than 500 MHz of additional spectrum could be identified for IMT below 6 GHz
 - Low band (<1 GHz) for macro coverage
 - Mid-to-high band (1-3 GHz) for macro/micro coverage
 - High band (3-6 GHz) for micro/pico/hotspots

WRC 2019

Spectrum outlook for 2020 and beyond:

- Potential Agenda Item for spectrum above 6 GHz to be considered at WRC 2019
- Additional Spectrum below 6 GHz could also be considered

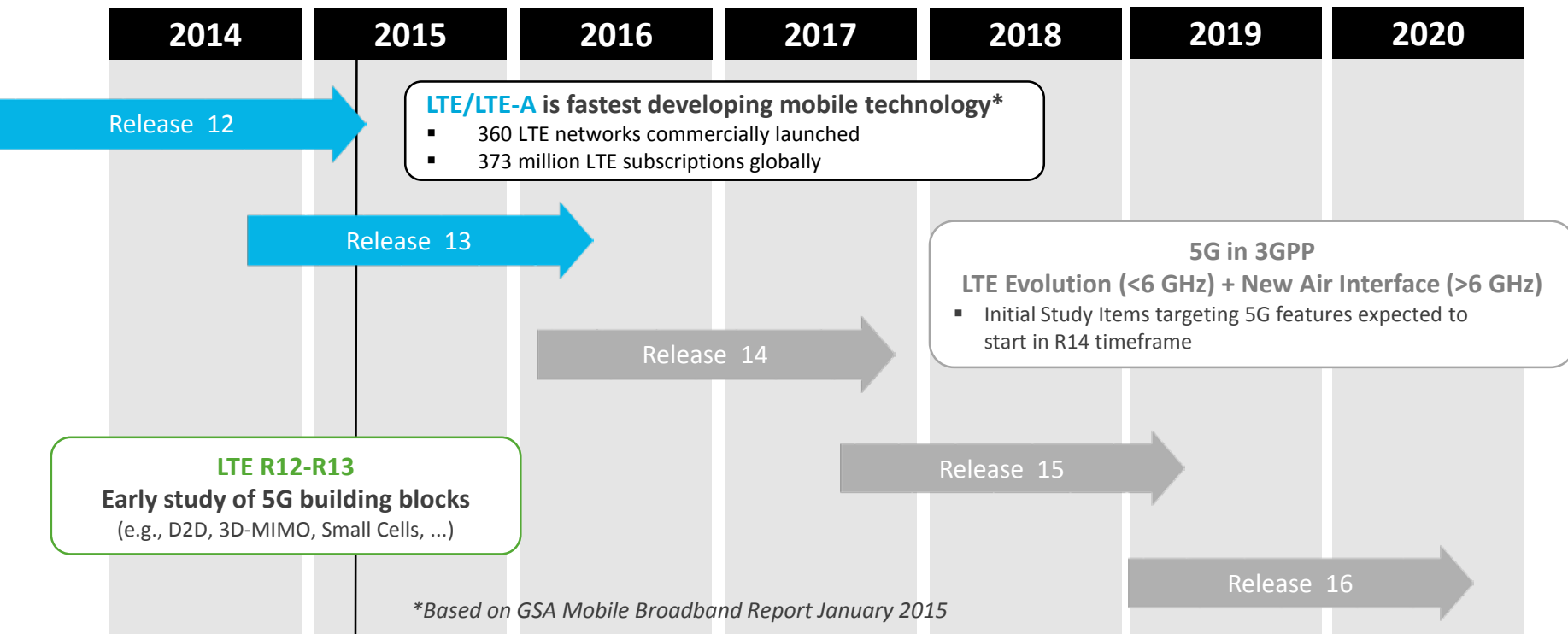
Identifying Capabilities for 5G

- The mobile community is working towards defining objectives for IMT-2020
- Key capabilities **have been identified and** may continue to evolve in the future

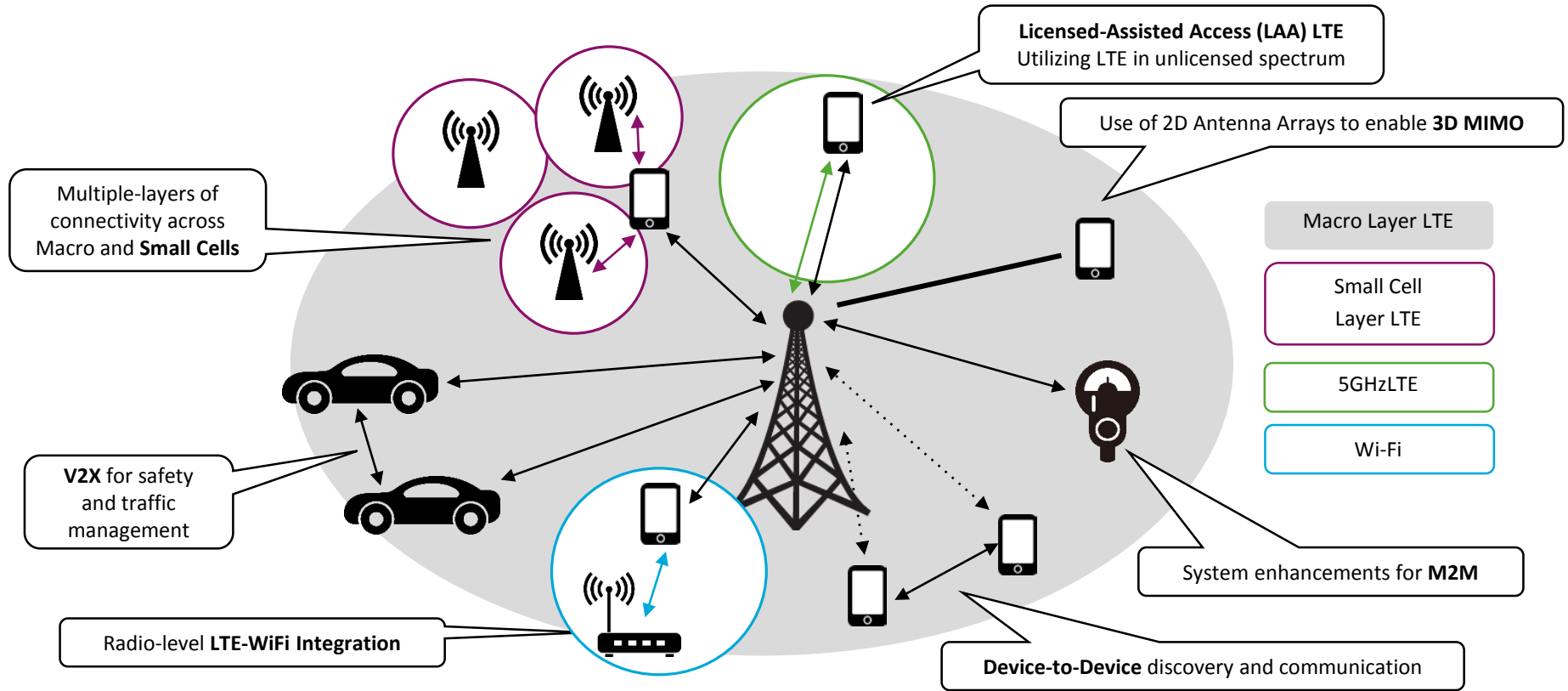
User experienced data rate	Peak data rate	Mobility	Latency	Connection density	Energy efficiency	Spectrum efficiency	Are Traffic Capacity
[100 Mbit/s – 1 Gbit/s]	[20 Gbit/s]	500km/h	1ms (radio interface)	10 ⁶ per km ²	100 times IMT-Advanced	[2,3,5 times IMT-Advanced]	10 Mbps/m ²

3GPP: Standardization Timeline

Well positioned to drive the definition of next generation wireless communication standards



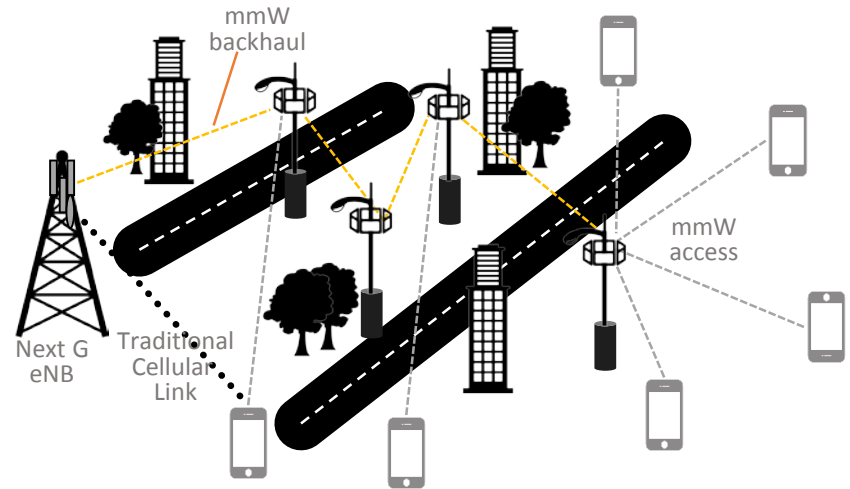
3GPP: 5G LTE Evolution (<6 GHz)



5G Emerging Technologies in the network subsystem

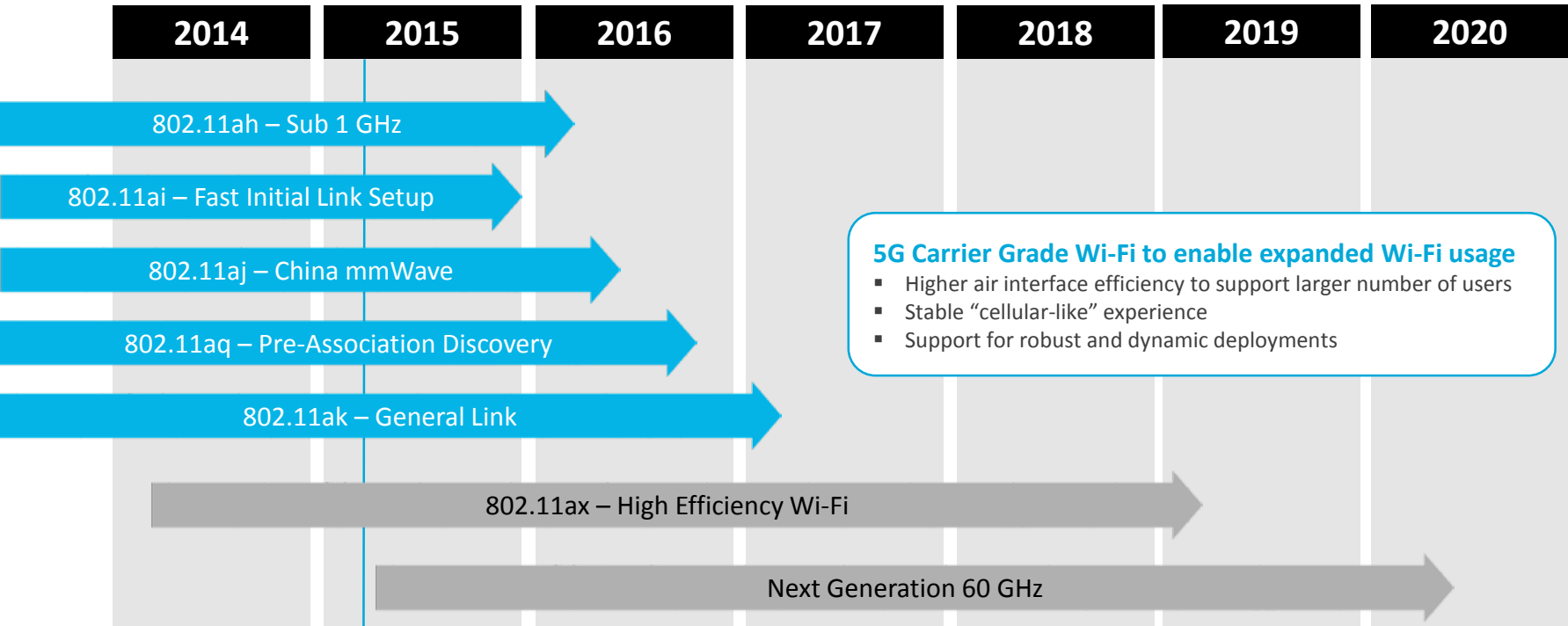
New air interface design above 6 GHz

- New non-backwards compatible air interface designs in **cmWave** and **mmWave** spectrum
- Tight integration of backhaul and access, along with LTE for macro-layer connectivity
- Potential Air Interface techniques
 - Spectrally agile Advanced Waveforms
 - Advanced spatial processing techniques, e.g. Massive MIMO, CoMP and more
 - Exploiting advanced receivers through Non-Orthogonal Multiple Access
 - Full duplex single channel communications to increase bandwidth efficiency
 - “Ultra-light” protocol design for latency reduction and “always-on” connectivity



Wi-Fi: Standardization Timeline

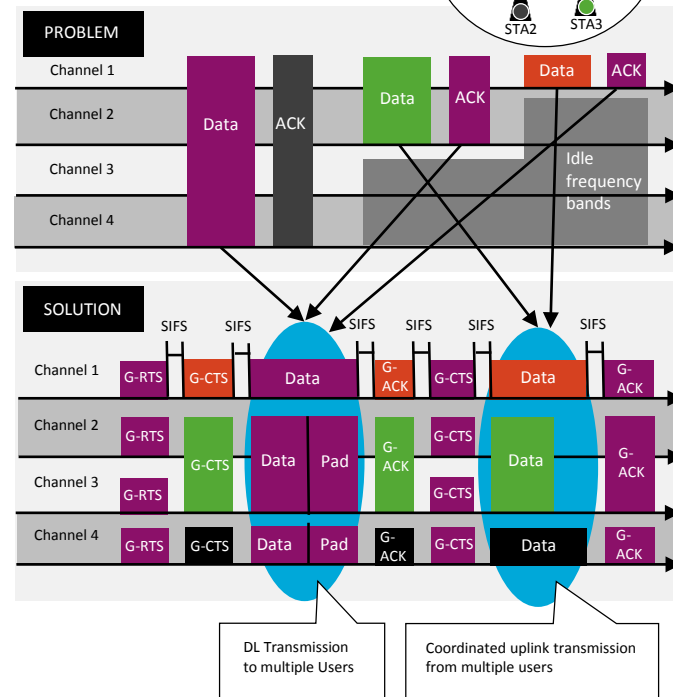
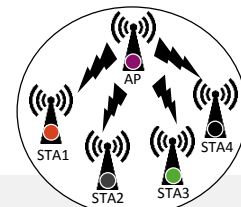
Expecting Wi-Fi to continue evolving as a key radio technology within 5G networks



Wi-Fi: 5G Feature Highlights (1/2)

802.11ax – High Efficiency WLAN

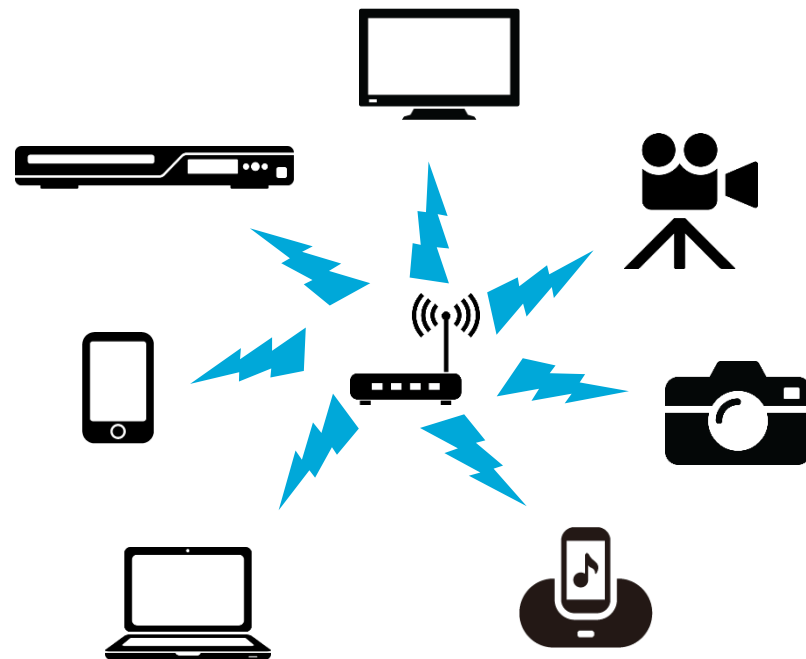
- Successor to 802.11ac targeting **at least four times improvement in the average throughput per station in dense deployment scenarios**
 - Significant improvement of spectral efficiency with a high density of STAs
 - Focusing on frequency bands between 1 GHz and 6 GHz
- Potential enhancements include:
 - Introduction of OFDMA to 802.11
 - MIMO extensions to OFDMA
 - Introduction of access control to 802.11
 - UL multi-user MIMO
 - Fractional CSMA and Enhanced Power Control
 - Backward compatibility and coexistence



Wi-Fi: 5G Feature Highlights (2/2)

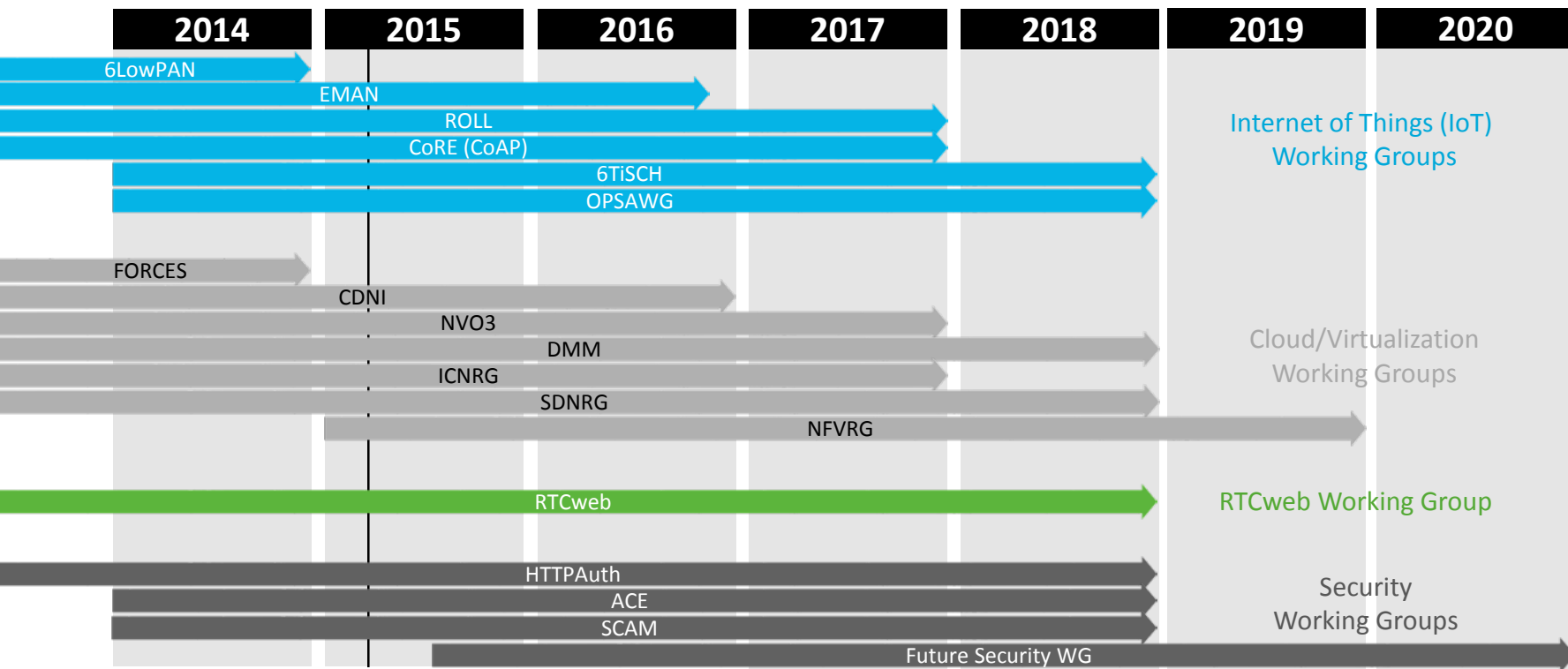
Next Generation mmWave WLAN (NG60)

- Evolving existing 802.11ad interface towards **30+ Gbps**
- Target use cases:
 - Wireless “Cable” replacement
 - Connector-free platform extension
 - Multi-Gigabit cloud
 - HD video
 - D2D collaboration
 - Mobile traffic offload
 - Wireless Backhaul
 - High-speed data download
- Potential enhancements:
 - SU/MIMO (2x2): Closed and Open loop
 - Channel Bonding
 - New Modulations formats (e.g. 64 QAM)



IETF: Standardization Timeline

Multiple IETF Working Groups defining building blocks for future 5G networks



IETF: 5G Feature Highlights

Numerous industry forums and research projects working today to feed 5G standardization tomorrow

Internet of Things (IoT)

- Multiple WGs covering L2/L3 framing, IP routing, applications protocols (CoAP, 6tisch), network and energy management (e.g. OPSAWG, EMAN)

Cloud/Virtualization

- Need for standardization broadly recognized within IETF in spite of numerous proprietary deployments today
- Current IETF activities include Internet Data Center virtualization (NVO3) and SDN (FORCES, DMM)
- Smarter content management and localization protocols will allow higher amounts of information and reduced network latency to access them (e.g. ICN, CDNI)

RTCweb

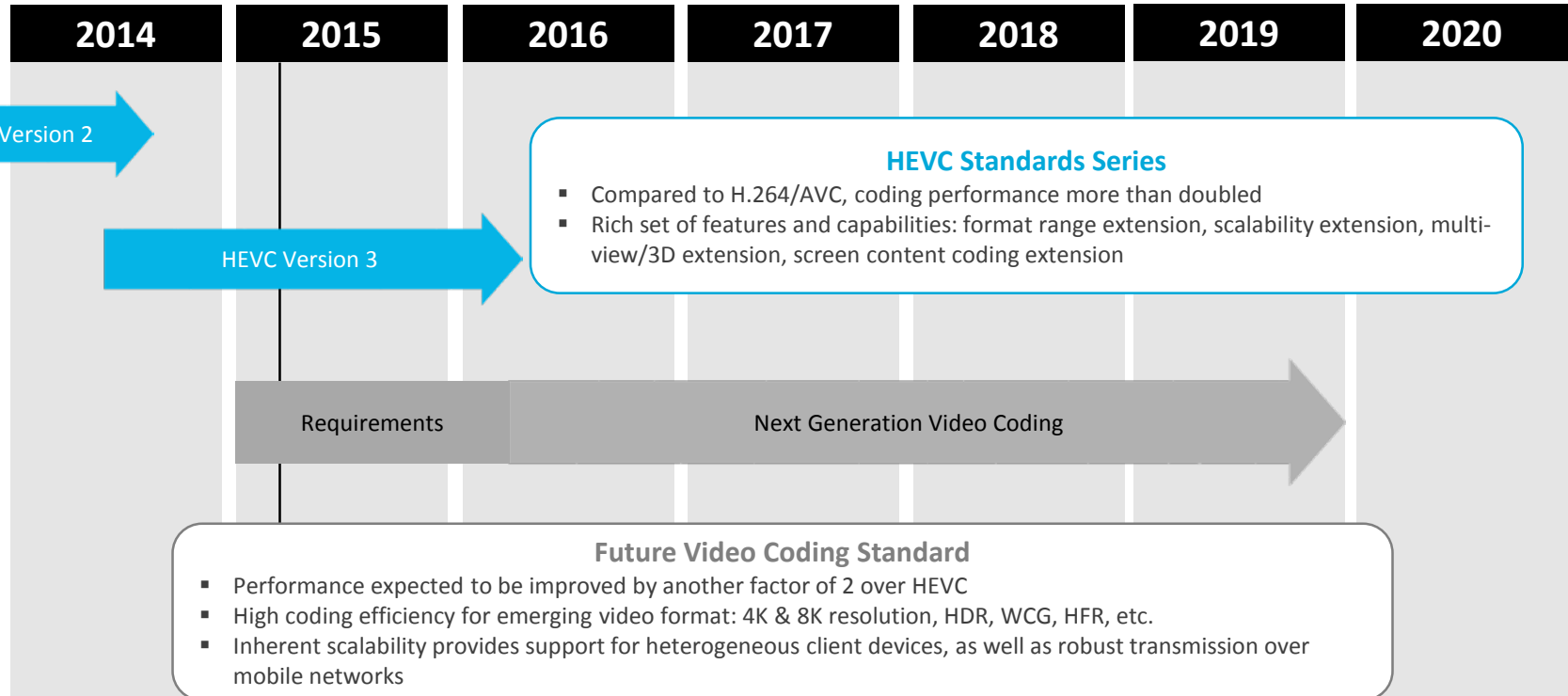
- Browser to browser interactive rich communication using audio, video, collaboration, games, etc. between web browsers of two or more peers
- Real-time communications in web browsers (RTCweb)
- Additional parallel application API standardization work underway in W3C

Security

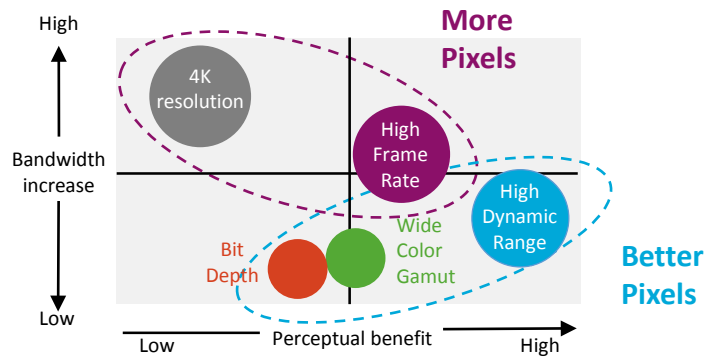
- Strongly motivated by reporting of widespread (pervasive) surveillance on the Internet
- Previous IETF security solutions were more local and or point-to-point
- Work recently started with more still to come (HTTPAuth, ACE, SACM)

Video: Standardization Timeline

Video traffic volume continues to explode along with the need for enhanced visual quality

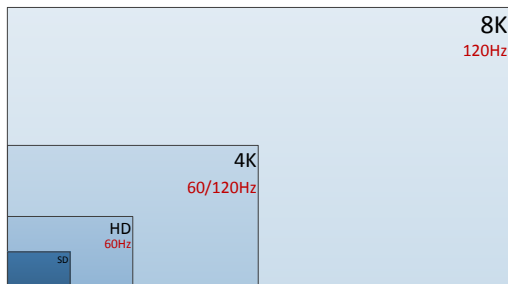


Video: 5G Feature Highlights (1/2)



Video 2020

- 2x compression efficiency, esp. for the emerging formats
- User generated content, video streaming, video sharing, surveillance, etc.
- Desirable features: scalability, low power consumption, etc.



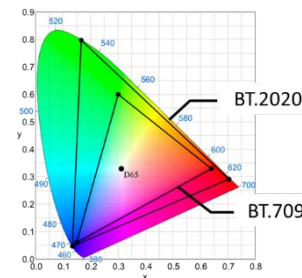
Increased spatial resolution and temporal frame rate are continuing trend of “more pixels”



8-bit video

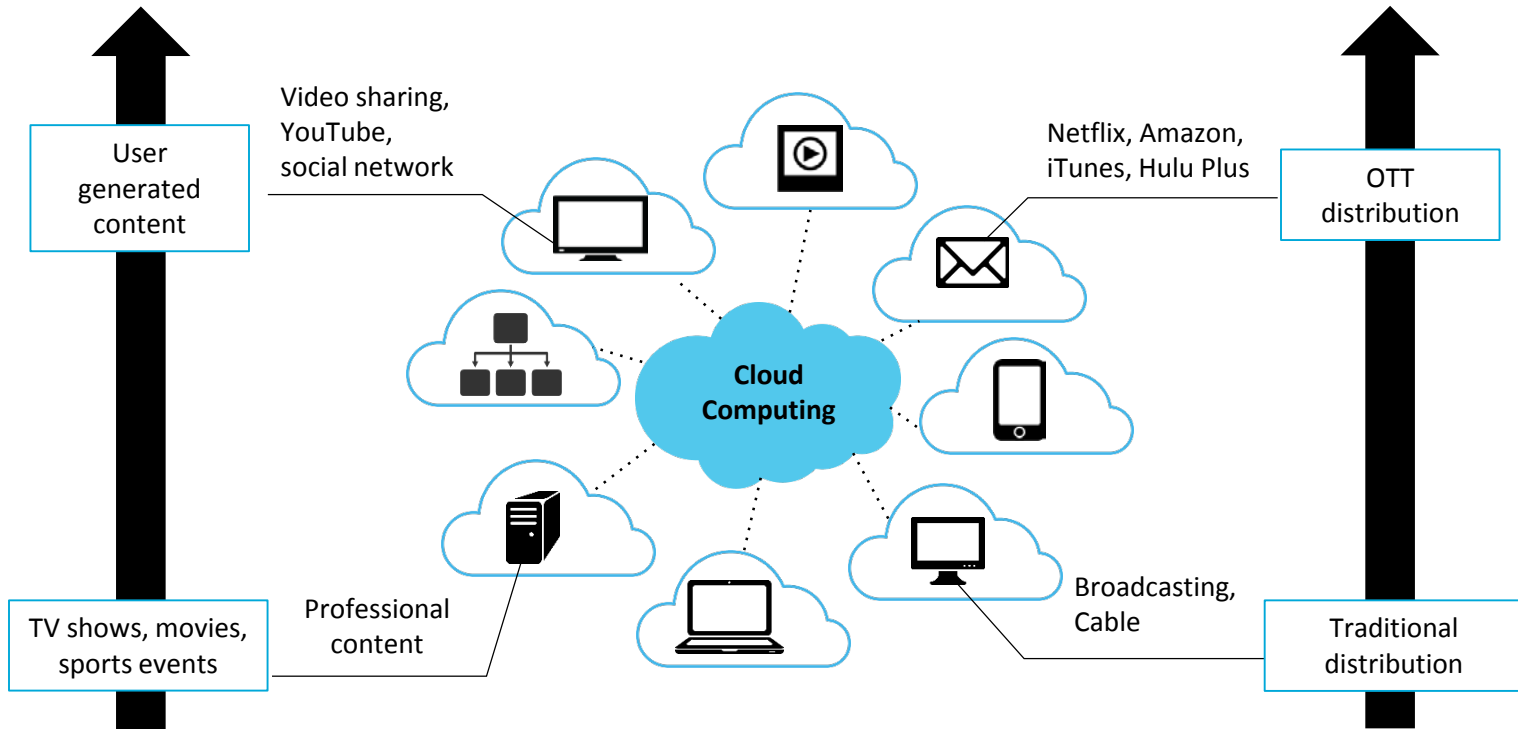


10-bit video



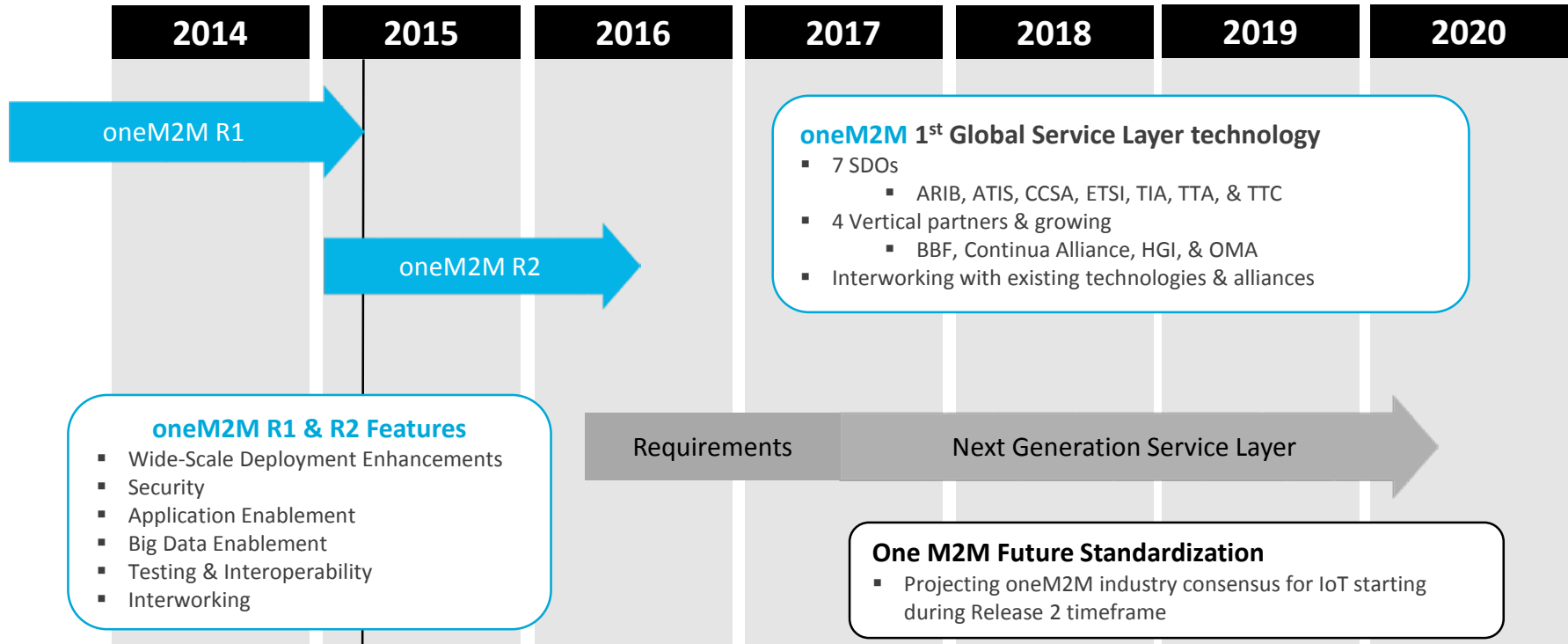
Higher bit depth, high dynamic range, and wider color gamut are domains for “better pixels”

Video: 5G Feature Highlights (2/2)



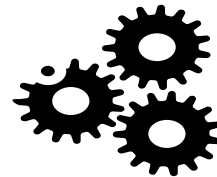
oneM2M: Standardization Timeline

Enabling IoT devices, applications, and services to utilize a common platform



oneM2M: 5G Feature Highlights (1/2)

- A common set of service layer capabilities
- Access independent view of end-to-end services
- Open/standard interfaces, APIs and protocols
- Security, privacy and charging aspects
- Reachability and discovery of applications
- Interoperability, including test and conformance specifications
- Identification and naming of devices and applications
- Management aspects (including remote management of entities)



**Based on oneM2M standards*

oneM2M: 5G Feature Highlights (2/2)

Future oneM2M features enabling IoT deployment in 5G networks

Interworking

- Enhance 3GPP interworking
- AllSeen
- OIC
- IIC

Application Enablement

- App APIs
- App development guide
- Service profiling

Testing and Interoperability

- Test specifications
- Certification (external)

Big Data Enablement

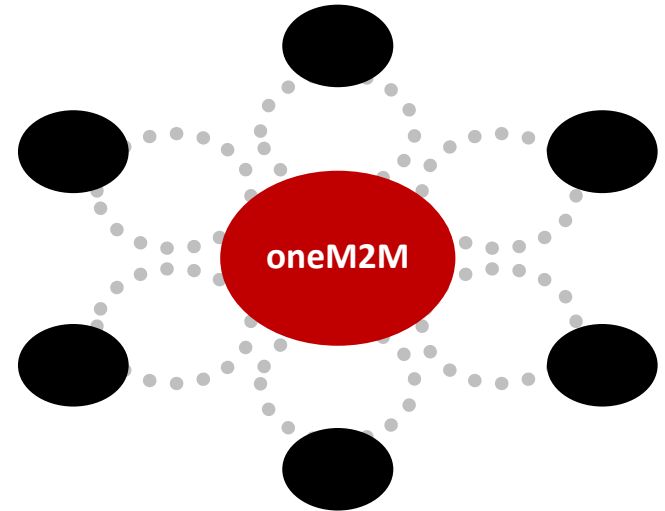
- Semantics support and use cases
- Analytics

Wide-Scale Deployment Enhancements

- Home Domain Enablement
- API versioning
- Plug and play scenarios
- Lessons learned from prototypes

Security

- E2E security
- Group authentication
- Role based security



**Based on oneM2M standards*

5G Standardization Challenges and Opportunities

New Challenges Ahead for 5G Standardization

- Complexity of emerging users and usage scenarios
- Evolving from single-purpose wireless system (mobile broadband) to a broader range of use cases and requirements (e.g. breadth IoT service and device types)
- Need for scalable service experience anytime and anywhere at a lower cost

Multiple Standards Organizations expected to define key building blocks for 5G

- Focus on coexistence, integration and harmonization across standards that complement each other to provide the ultimate 5G experience
- Leverage and enhance existing technologies toward 5G requirements (e.g. LTE evolution) to complement new technologies (e.g. new radio access technology)
- Different standards and/or technologies may be required to address different 5G use cases and requirements
 - ➔ Avoid “one standard fits all” approach

Involvement of key 5G verticals in standardization process

- New participants can play a key role in shaping 5G standards (e.g. emergence of Public Safety stakeholders in 3GPP)

InterDigital: Proven Standards Leadership

Well positioned for strong contributions to the design of 5G across multiple Standards Organizations

Proven InterDigital Standards Leadership Highlights

Current



3GPP RAN WG2 Vice
Chair (since 2013)

OMA Board of Directors/
Board Officer (since 2013)

ITU-R WP 5D - US
Spokesperson for
Technology (since 2013)

And
more...

Past



3GPP RAN WG3 Vice
Chair (2001-09)

Board of Directors Small
Cell Forum (2009-10)

802.21 WG
vice-chair (2010-12)

And
more...

Thousands of InterDigital contributions to various standards organizations over the years helping shape 3G, 4G and soon 5G

Development of standards-grade simulation platforms to validate 5G candidate technologies
Available for 3GPP, Wi-Fi, and many advanced concepts