Technological Advisory Committee

Welcome to March 24, 2020 Meeting

Agenda

10am - 10:20am	Introduction and Opening Remarks
10:20am - 10:50am	Presentation on Record Retention Policy (Darice Gamble) Presentation on FACA Rules and Guidance (Paula Silberthau)
10:50am - 11:30am	Artificial Intelligence WG
11:30am - 12:10pm	Future of Unlicensed Operations WG
12:10pm - 1pm	Lunch Break
1pm - 1:40pm	5G RAN Technology WG
1:40pm - 2:20pm	5G IOT WG
2:20pm - 2:40pm	Closing Remarks
3pm	Adjourned

FCC TAC AI-WG
Artificial Intelligence

Chairs: Lisa Guess, Cradlepoint
Adam Drobot, OpenTechWorks, Inc.

FCC Liaisons: Michael Ha, Mark Bykowsky, Monisha Ghosh, Martin Doczkat, Robert Pavlak

Date: March 24, 2020

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2020 Work Group Team Members

- Shahid Ahmed, Independent
- Nomi Bergman, Advance
- Brian Daly, ATT
- Adam Drobot, OpenTechWorks
- Jeffrey Foerster, Intel
- Dale Hatfield, Univ of Colorado
- Lisa Guess, Cradlepoint
- Russ Gyurek, Cisco
- Stephen Hayes, Ericsson
- Mark Hess, Comcast
- Nageen Himayat, Intel
- Steve Lanning, Viasat
- Kevin Leddy, Charter
- Brian Markwalter, CTA
- Lynn Merrill, NTCA
- Michael Nawrocki, ATIS
- Nimish Radia, Ericsson
- Dennis Roberson, entigenlogic
- Marvin Sirbu, SGE
- Kevin Sparks, Nokia Bell Labs
- David Tennenhouse, VMware
- Jack Nasielski, Qualcomm

Artificial Intelligence WG - 2020 Charter

The Artificial Intelligence (AI) and Computing working group will continue its work on analyzing the ability of AI to improve the performance of telecommunications networks and the services enabled by these networks.

To that end, the working group will focus on the following questions as outlined in the subsequent slides:

Objective 1

- How can the results from recent programs in AI for spectrum and networking, such as the DARPA Spectrum Collaboration Challenge (SC2) and the NSF/Intel joint solicitation on Machine Learning for Wireless Networking Systems (MLWiNS), be leveraged for real-world systems and applications and for investigating new applications?
  - Understand spectrum usage, techniques to automatically identify signals, detect and understand violations
    - Enforcement
    - Use and exploitation of results from federally funded research programs
    - Schedule top 3 winners from challenge as SME speakers – (lessons learned and formulation of use cases)

https://www.spectrumcollaborationchallenge.com/ - DARPA Spectrum Challenge
https://www.nsf.gov/events/event_summ.jsp?cntn_id=299111&org=CISE - MLWiNS

Objective 2

- AI relies on curated and labeled data sets being available for algorithm development and testing: what should the parameters of such data sets be?
- What data sets are already available?
  - Use cases helpful to the FCC such as Broadband America
  - Datasets for congestion, provisioning, advertising, marketing are other examples
- How can new data sets be collected and made available to the community?
  - Where can data be used?
  - What is the purpose of the data?
  - How do you incent carriers to share information for mutual improvement?

Objective 3

- How can AI be used to extract meaningful information from data that is either already available (e.g. from the Measuring Broadband America (MBA) program) or may become available, to determine the following:
  - Coverage
  - Service parameters
  - Fraudulent activities such as unauthorized spectrum usage

Objective 4

- As legitimate applications of AI start proliferating, what risks should be evaluated and what AI tools exist or should be developed to identify and mitigate harms that might arise from the proliferation of AI? (How to promote safe use of AI? How to deter deleterious use of AI?)

  - Include concept of robustness

AI WG General Approach

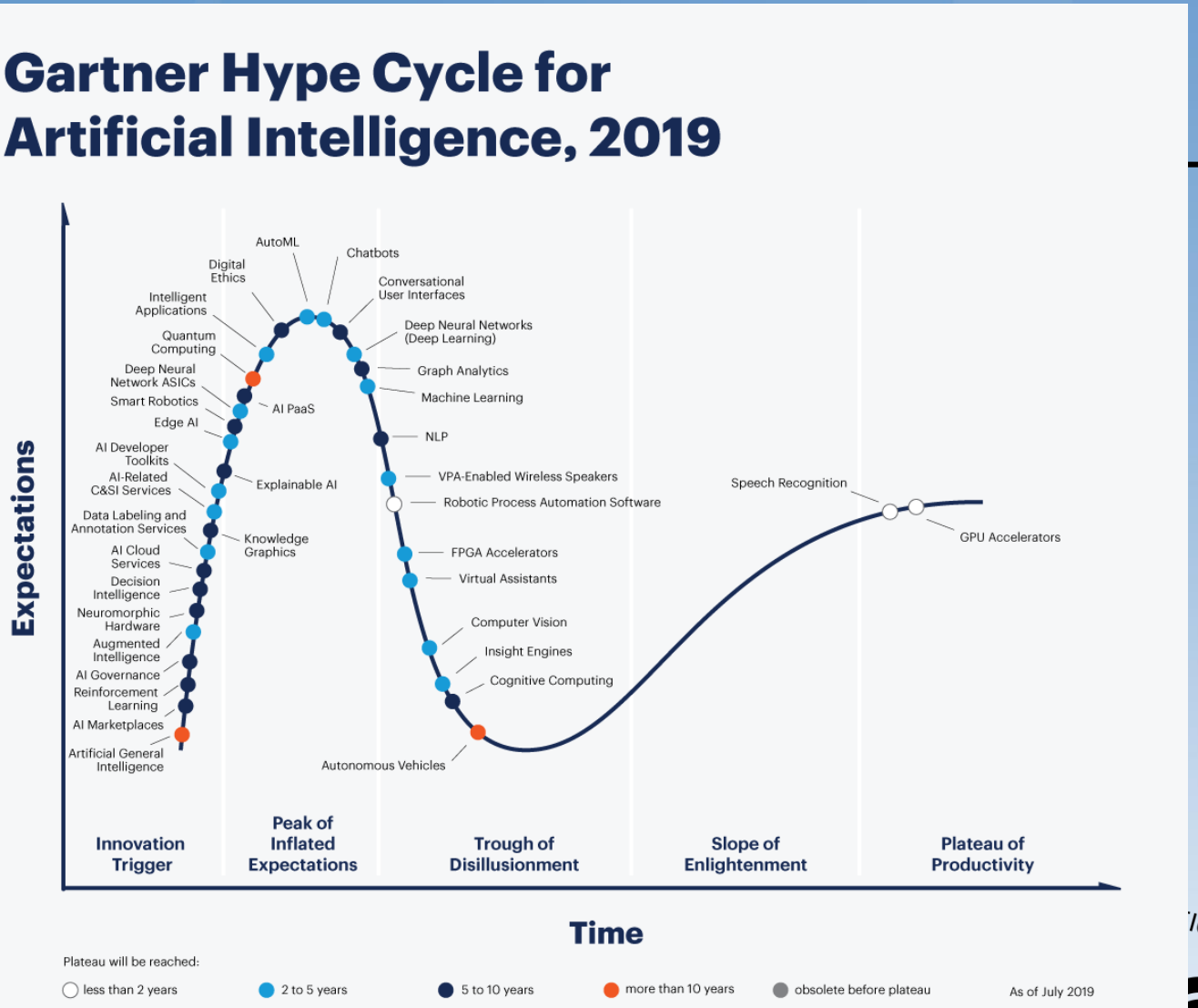
- Study use cases leveraging industry expert presenters
- Prioritize and categorize use cases and data
- Understand use cases in context of AI WG Charter
- Establish 2 sub-working groups to explore complex subtopics
  - Safe use of AI
  - Lessons learned and value from Federally funded research – e.g. NSF/DARPA and other programs.
- Work Product for AI WG in 2020
  - Actionable recommendations by Dec 2020
  - Whitepaper specific to AI in Telecomm. Sample topics below:
    - 3GPP
    - Input from Industry Analysts, ACUMOS, OpenRAN collaboration
    - Security considerations
    - Implementation Best Practices

Targeted Speakers:

- Eric Horvitz- Technical Fellow and CTO, Microsoft. Industry expert AI
- DARPA winning teams – GatorWings from Univ of Florida, MarmotE from Vanderbilt, Zylinium comprised of a team of independent researchers
  - Understand test bed, winning projects and use case application
- Spectrum Access Systems
  - Discuss AI and data sets sharing practices between owners of the SAS
- Rebecca Dorch, Senior Spectrum Policy Analyst at the Institute for Telecommunication Sciences
- Harry Serden, author of ”Machine Learning and Law”
  - Gain understanding of data rights, ethical use, other FCC–relevant legal considerations
- KC Claffy, UCSD: Center for Applied Internet Data Analysis (CAIDA) - mapping the internet and lessons learned
- “Rebooting AI” authors Gary Marcus and Ernest Davis
- Coverage, Option 3, and rural funds. Invite LEOs who are using AI to coordinate satellite/broadband coverage for rural areas
- AI Consultant to understand AI methodologies and approaches
- Jagan Shantigram, CTO DataMi, Crowdsourcing to collect data from handsets for network performance/control

Final thoughts:

There is a rich set of AI use cases, some are ready for prime time.

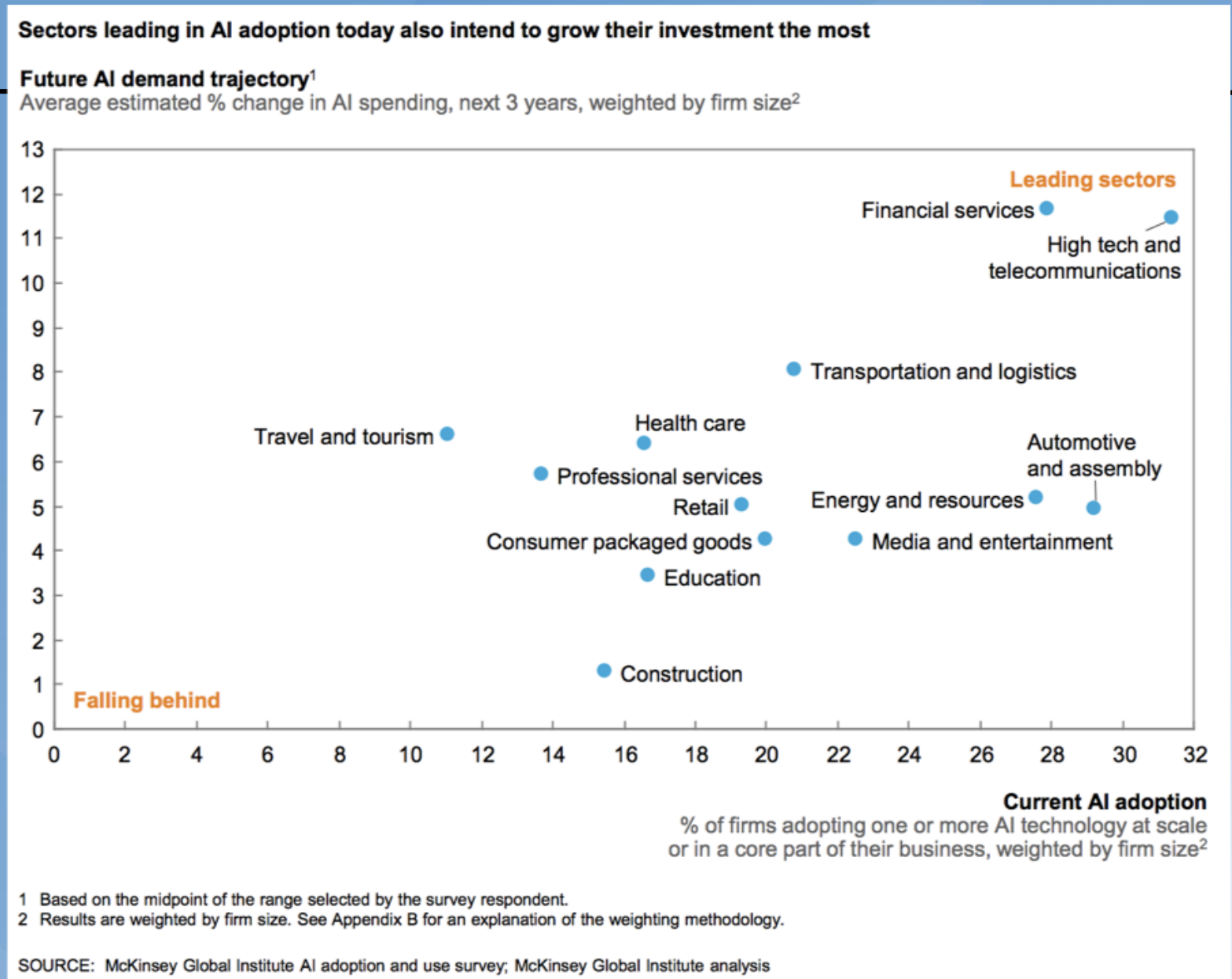


Final Thoughts:

Telecommunications is a leading sector for AI adoption.

-*Source: McKinsey Global Institute AI adoption and use survey, November 2019*

https://www.mckinsey.com/featured-insights/artificial-intelligence/global-ai-survey-ai-proves-its-worth-but-few-scale-impact



Thank you

Future of Unlicensed Operations

WG Chairs: Kevin Leddy, Charter & Brian Markwalter, CTA

Date: March 24th, 2020
Meeting: Virtual

2020 Working Group Team Members

FCC Liaisons: Michael Ha, Nick Oros, Bahman Badipour, Monisha Ghosh, Mark Bykowski

Working Group Members

Brian Daly, AT&T
Jeff Foerster, Intel
Russ Gyurek, Cisco
Jack Nasielski, Qualcomm
Steve Lanning, ViaSat
Chris Richards, Ericsson
Lynn Merrill, NTCA
Mark Hess, Comcast
Peter Ecclesine, Cisco

Future of Unlicensed Operations Meeting Agenda

- Recap of Working Group Charter
- Summary of Scope
- Walkthrough of Topics

FCC Charter for Unlicensed Spectrum Operations Working Group

Unlicensed operations play a vital role in the 5G ecosystem and continue to provide opportunities for innovation.

It is critically important for the Commission to understand both the potential pathways for continued evolution of unlicensed operations as well as potential modifications of current operations that are necessary to support new services and applications.

To that end, this working group will focus on a number of key topics for future unlicensed operations:

- (1) How do unlicensed operations continue to complement or compete with licensed services?
- (2) How can unlicensed operations improve the user experience and potentially become more competitive?
- (3) What are the new services and novel applications of unlicensed (i.e. Wi-Fi 6 and 7, low power IOT, personal radar, unlicensed LTE/5G NR, UWB etc.)? Are there new protocols that may improve the spectrum sharing among various services and applications? Should the Commission reevaluate certain regulations to promote such novel applications?
- (4) How can we enhance the use of unlicensed operations while sharing with radars (i.e. DFS in 5GHz) and what are the enabling technologies that may allow more unlicensed operations in more bands?

Future of Unlicensed Operations: Outline of Scope

The following topic areas are proposed to address the FCC's goals for this working group:

- **Topic #1: History and Current State of Unlicensed Spectrum**
  - Define the landscape of unlicensed spectrum policy – history and current state
  - Evaluate the "as-is" model for unlicensed operations
- **Topic #2: Use Cases for Unlicensed Spectrum and Complementarity with Licensed Technologies**
  - Assess new services and novel applications of unlicensed spectrum (i.e. low power IOT, personal radar, Wi-Fi 6, Wi-Fi 7, unlicensed LTE/5G NR, UWB etc.), and their potential impact on current spectrum models
  - Evaluate interactions between licensed and unlicensed technologies, particularly in unlicensed spectrum bands
- **Topic #3: Opportunities to Enable Unlicensed Access and Facilitate New Use Cases**
  - Investigate opportunities to meet growing demand for existing unlicensed spectrum and to facilitate new unlicensed technologies
- **Topic #4: Technical Improvements**
  - Evaluate how to enhance the use of unlicensed operations while sharing with incumbent users
  - Understand how emerging technologies have made unlicensed spectrum more efficient or usable

Topic #1: History and Current State of Unlicensed Spectrum

Purpose: To provide historical context and an account of current activities related to unlicensed spectrum. Summarize current use cases and architectural models

- What is the history of unlicensed spectrum in the US?
- What is the portfolio of unlicensed spectrum as it relates to the objectives of this working group, and how is it regulated?
- Are there good or bad examples of unlicensed spectrum policy outside of the US?
- What is the current pipeline of unlicensed spectrum?
- What are the as-is technical/operational and deployment models for unlicensed spectrum?
- What is the current user experience (products and services) with unlicensed spectrum?
- How has the TAC previously evaluated unlicensed spectrum?

Topic #2: Use Cases for Unlicensed Spectrum and Complementarity with Licensed Technologies

Purpose: Topic #2 is focused on understanding the use cases for unlicensed spectrum, including the relationship between licensed and unlicensed operations, and how consumers benefit / will benefit

- Assess new services and novel applications of unlicensed spectrum (i.e. Wi-Fi 6 and 7, low power IOT, personal radar, Wi-Fi 6, Wi-Fi 7, unlicensed LTE/5G NR, UWB etc.), and their potential impact on current spectrum models
- Evaluate interactions between licensed and unlicensed technologies, particularly in unlicensed spectrum bands
  - What impacts to unlicensed technology and deployments could result from changes in unlicensed spectrum policy (increase in portfolio, changes in rules)?
  - How do unlicensed and licensed technologies currently work together across the spectrum and in particular in unlicensed spectrum bands?
  - How can the FCC's evaluation of coexistence facilitate more efficient and intensive use of shared licensed/unlicensed bands?

Topic #3: Opportunities to Enable Unlicensed Access and Facilitate New Use Cases

Purpose: Topic #3 will identify opportunities to facilitate the development and deployment of new unlicensed technologies

- For the emerging use cases identified in Topic 2 that require access and use of unlicensed spectrum:
  - What are the technical requirements for these use cases?
  - Define which are long-tail technologies vs near term
- Is the current portfolio of unlicensed spectrum capable of satisfying new use cases?
- Are there candidate unlicensed bands for future consideration by the FCC?
  - Low and mid-band opportunities
  - Opportunities between 6 – 60 GHz
  - 70-300 GHz unlicensed
- How should technical rules and interference analysis change to promote better sharing of spectrum for broader unlicensed / lightly licensed use?
  - What are the different methods for granting unlicensed access to spectrum?
  - How can the FCC best apply a spectrum sharing model in different bands?
  - Are there opportunities for technical rule changes to expand the use of existing spectrum?
- How can the commission best promote the advancement of novel applications?

Topic #4: Technical Improvements

Purpose: Topic #4 focuses on the technical opportunities for unlicensed spectrum, including enhancements to sharing, efficiency, and use of a wider range of bands

- What are the current technical capabilities of technologies relying on unlicensed spectrum?
- How is unlicensed spectrum currently used, what are the pain points/bottlenecks, and what is needed for further innovation?
- What issues arise within today's bands and rules with regard to new use cases that may impair current unlicensed models (interference, over-crowding, channel size, emission masks, etc.)?
- What are all the methods for sharing spectrum with incumbent users and with other unlicensed users?
  - Are there new sharing technologies being developed?
  - What incumbent licensed technologies or new unlicensed technologies need to mature to enable innovation in spectrum sharing?
  - Are there new protocols that may improve the spectrum sharing among various services and applications?
- What best practices can advocates and FCC engineers employ in evaluating coexistence between potential new unlicensed entrants and incumbent or existing unlicensed technologies?
  - How can the FCC best implement prior TAC recommendations related to risk-informed interference assessment?

Thank You!

Technological Advisory Committee

March 24, 2020 Meeting

- Lunch Break -

5G RAN Technology Working Group Readout

WG Chairs: Tom Sawanobori, CTIA & Kevin Sparks, Nokia

Date: March 24, 2020
Meeting: FCC TAC virtual meeting

WG Progress To-Date

- Kickoff 3/10 - with large, diverse & talented set of members enrolled (high interest!)
- High level ‘plan of attack’ agreed, aimed at main intents of charter
- Topic areas brainstormed, and preliminary speaker list being developed
- One SME talk presented, laying out high level view of E2E RAN components

2020 5G RAN Technology Working Group Team Members

- Shahid Ahmed, Imagine Wireless
- Ahmad Armand*, T-Mobile
- Kumar Balachandran*, Ericsson
- Mark Bayliss, Visualink
- Lynn Claudy, NAB
- Brian Daly, AT&T
- Satish Dhanasekaran, Keysight
- Russ Gyurek, Cisco
- Dale Hatfield, Univ of Colorado
- Stephen Hayes, Ericsson
- Frank Korinek*, Motorola Solutions
- Karri Kuoppamaki, T-Mobile
- Greg Lapin, ARRL
- Brian Markwalter, CTA
- Lynn Merrill, NTCA
- Khurram Muhammad*, Samsung
- Jack Nasielski, Qualcomm
- Madeleine Noland, ATSC
- Brian Olsen*, T-Mobile
- Jesse Russell, incNetworks
- Travis Russell, Oracle
- Paul Steinberg, Motorola Solutions
- David Tennenhouse, VMWare
- David Young, Verizon
- Charlie Zhang, Samsung

*SME participant

- Dennis Roberson, entigenlogic
- Michael Ha, FCC

FCC Liaisons: Bahman Badipour, Reza Biazaran, Bob Pavlak, Ken Baker, Kamran Etemad, Sean Yun, Sean Spivey, Charles Mathias

5G RAN Technology WG: 2020 Charter (parsed)

Broad Areas:
RF vRAN/BBU Fronthaul Spectrum Mgmt./Interference

Explore advanced technologies that may be used in 5G/6G radios, both at base stations and client devices.

1. What is the roadmap of RAN architecture evolution in 5G/6G radios and how does it compare to the previous generations?
2. How does the potentially disruptive network virtualization proposed by O-RAN affect the development of RF front-end and fronthaul technologies?
3. What are the broader implications of the convergence of the use of advanced RF/RAN system components and spectrum management policies?
   - RF front end: advanced multi-band antennas, filtering technology, feed networks, amplifier efficiency, A/D converters, etc.
   - Baseband Processing: vRAN technology & architectures
   - RAN systems: self-optimization & configurability of advanced components, fronthaul technologies, eMBB/URLLC/mMTC performance optimization
4. Does incorporation of these advanced technologies and capabilities into radio equipment warrant a reexamination by the Commission of its policies and procedures pertaining to spectrum management?
5. How can the Commission best characterize the use of advanced RF system components in the analysis of in-band and out-of-band emissions to optimize efficient use of spectrum?
6. How can propagation modeling tools be better utilized to predict interference between systems?
7. How might equipment authorization procedures need to be modified to better address these advanced features, especially as the worst-case configuration used during testing continues to deviate from expected performance under normal operations?
8. What is the potential for interference risks as more dynamic components and features are introduced into advanced wireless systems, which could result in widely varying interference potential over time, particularly across broad geographic areas.

Initial Information Collection & Analysis (plan of attack)

	Client (UE)	RF Front End	Fronthaul	Baseband Processing	E2E RAN System
Performance/ Capability	2	1	2	1	2
Configurability/ Dynamics	2	1	2	1	2
Implications/ Impacts	3	3	3	3	3
Interference Risks	3	3	-	3	3

Upfront info collection sessions

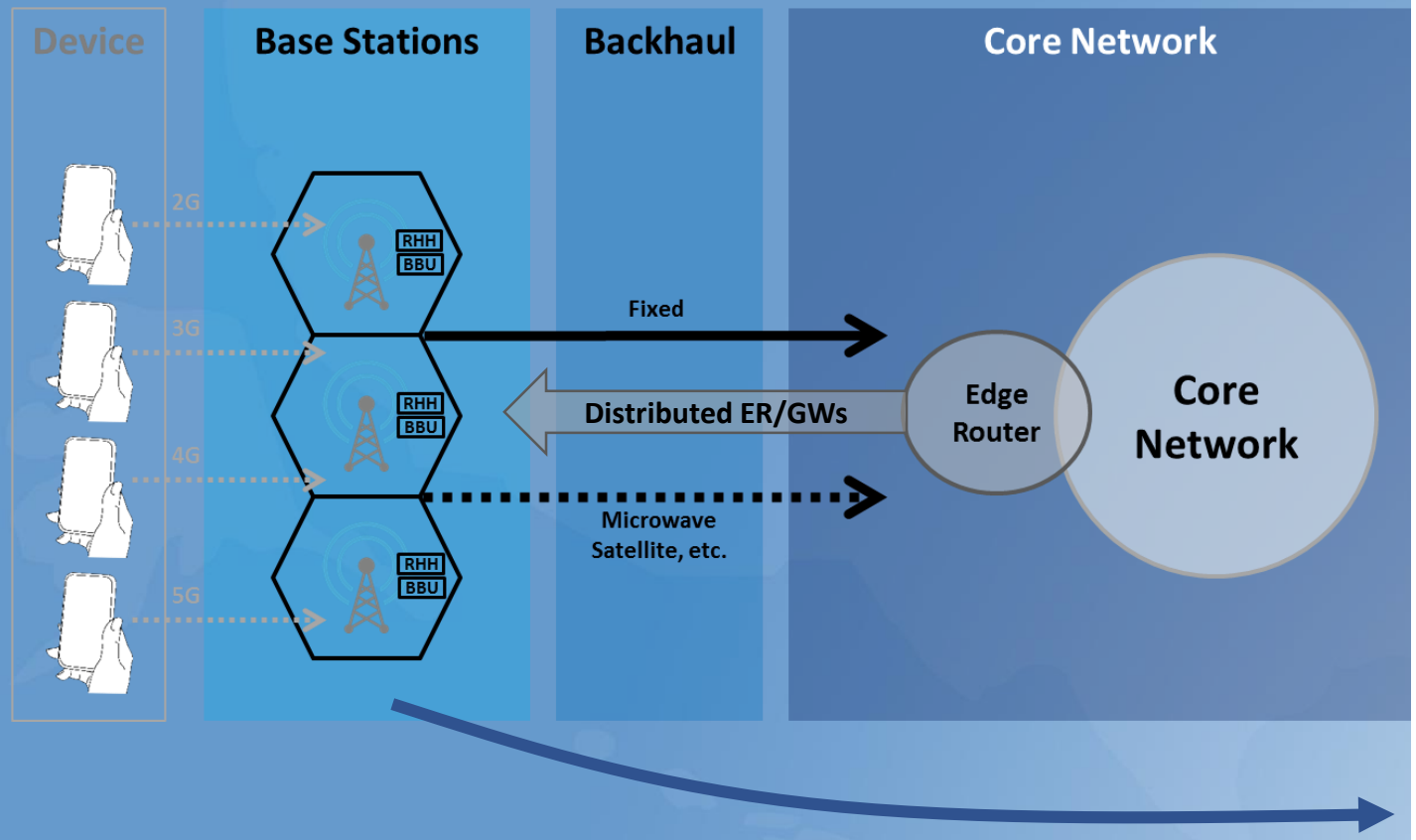
Downstream discussion/analysis

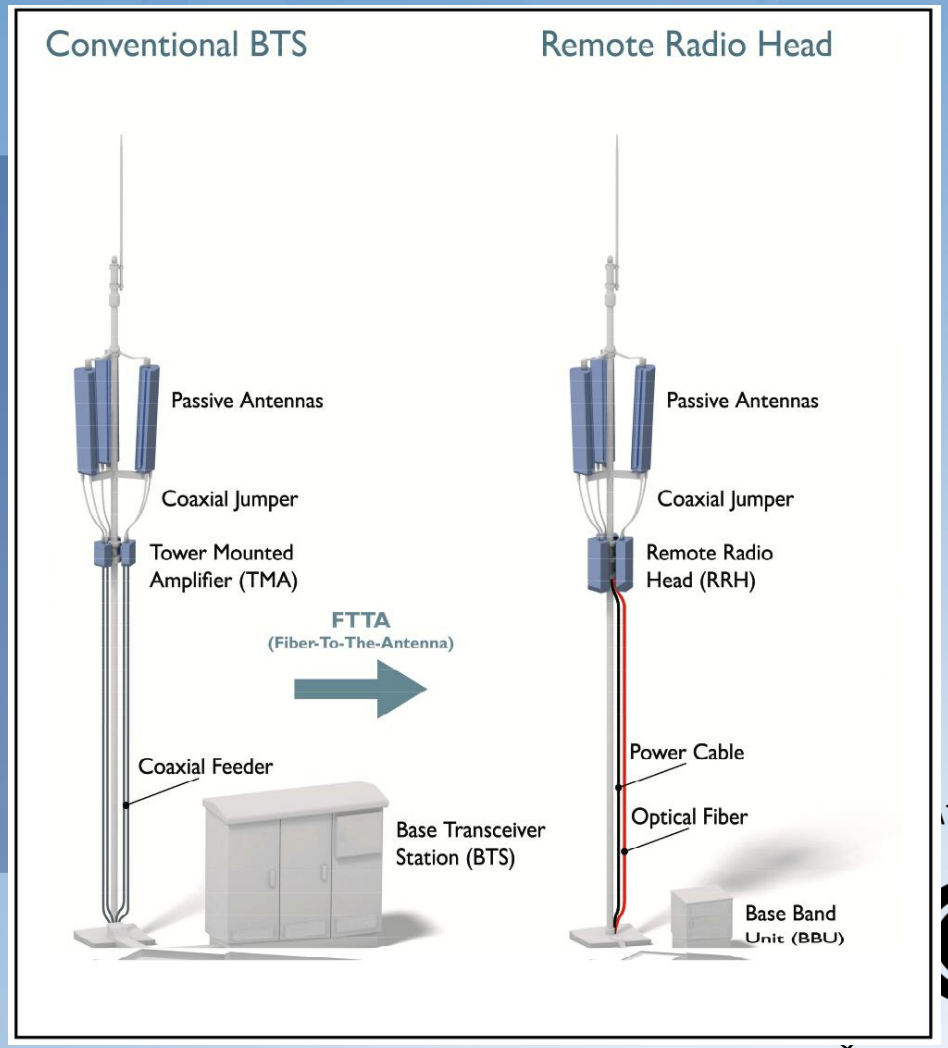
Numbers = rough ordering/priority
Small font = expected lesser effort

Educational outputs: Summary of above

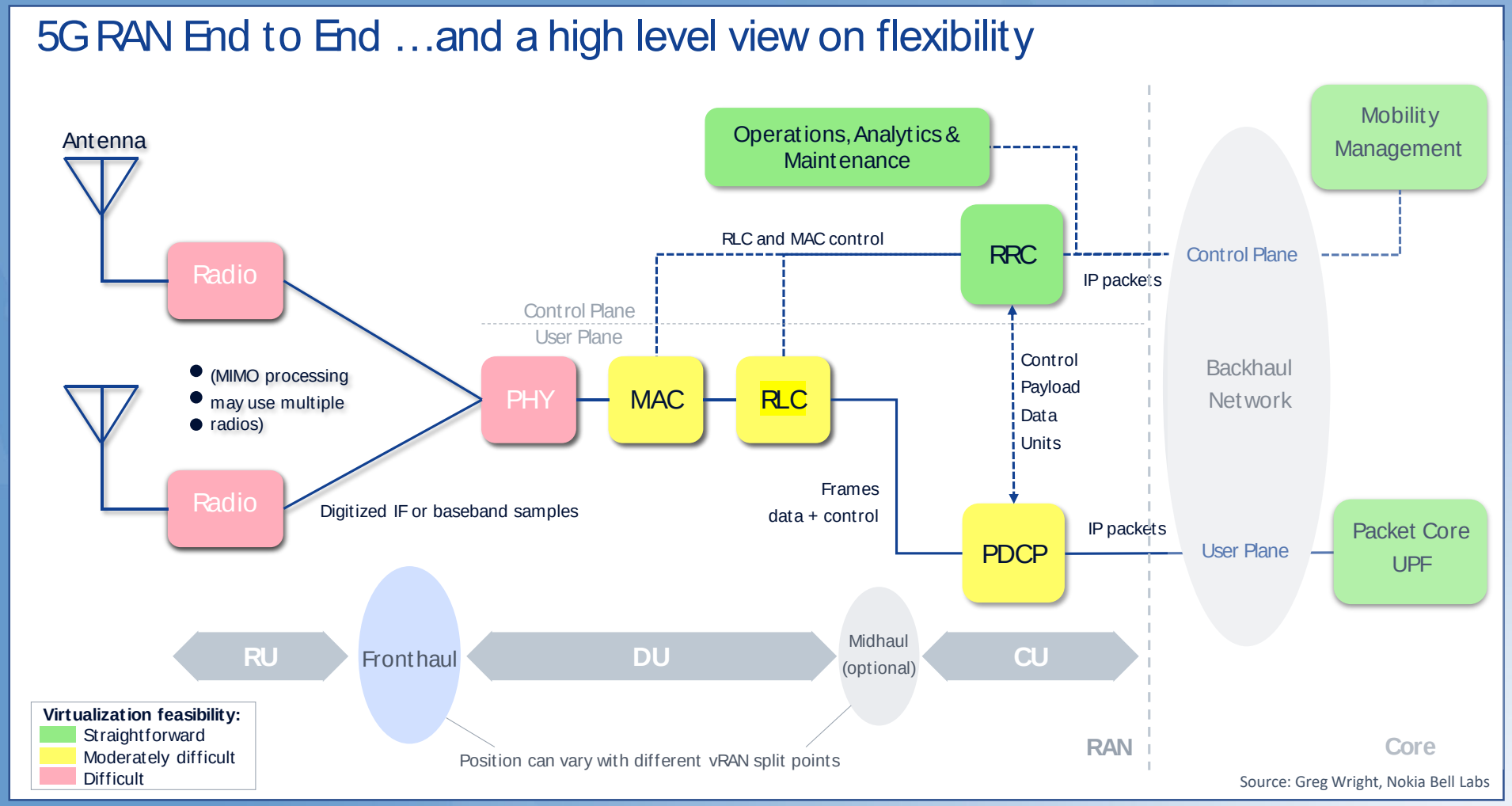
Actionable analysis: Interference, Spectrum Management & Equipment Authorization

High Level Architecture (Classic RAN shown)

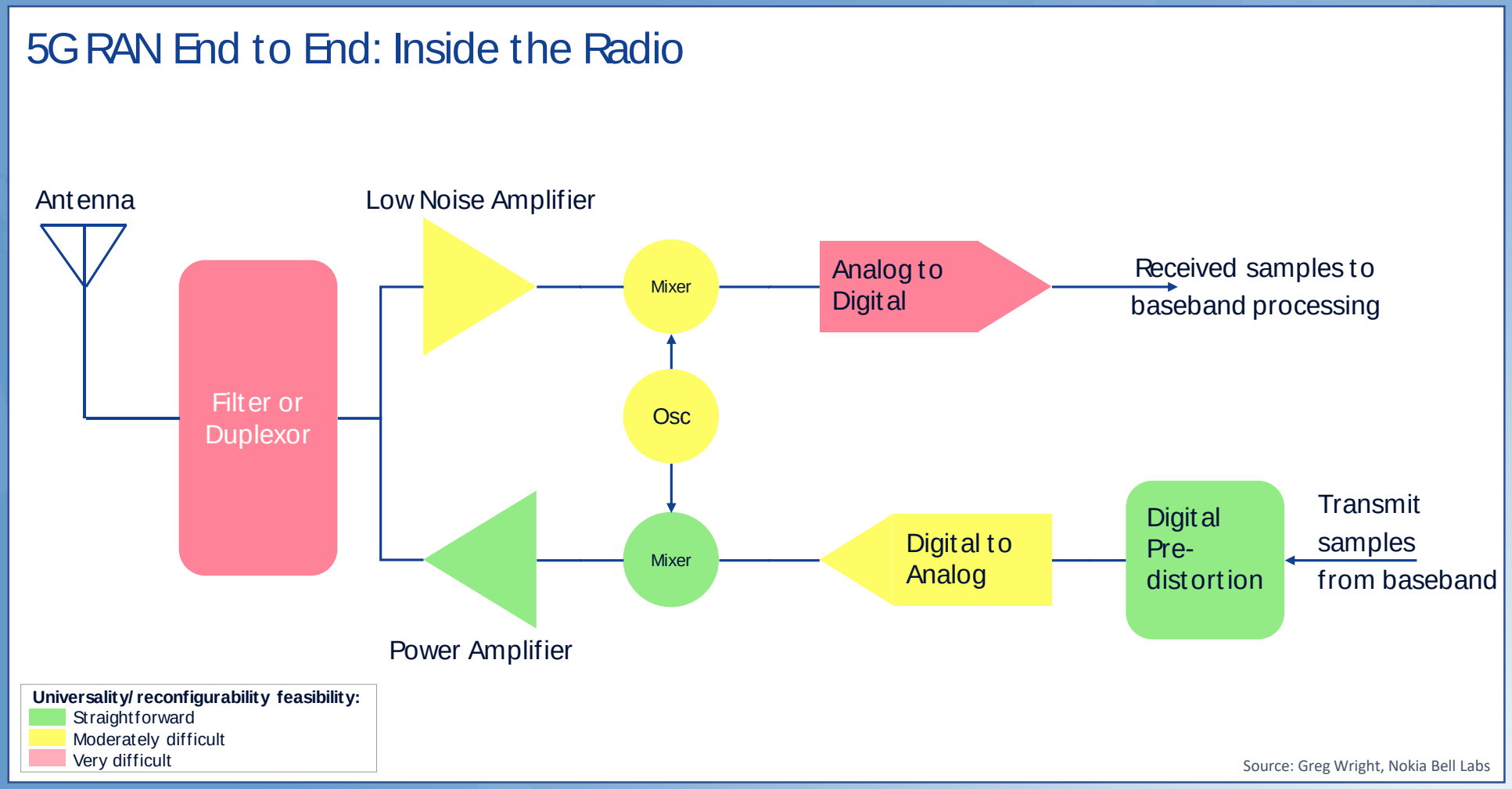




End-to-End RAN Architecture



Radio Components



Target Speaker List

Topic	Speaker	Entity	Date
Overview of E2E RAN components & flexibility	Greg Wright	Nokia Bell Labs	3/17/20 ✓
RF technology evolution*	(Kumar – suggested speaker for A/D converters)	(Ericsson)	
UE technology evolution*#	(Jack – looking for speaker)	(Qualcomm), Samsung?	
vRAN technology evolution	Rob Soni	Nokia Bell Labs	tbd, potential multi-speaker vRAN session, joint w/5G/IoT WG
vRAN technology evolution	(David T – looking for VMWare speaker	VMWare	
vRAN technology evolution	(Tom S. pursuing)	Intel	
mmWave & mMIMO	(Greg Lapin – looking for speaker)		
Fronthaul tech. evolution	(Kevin pursuing)		
Interference Management	(Ken Baker & Tom S. pursuing)	Verizon (*tentative*)	tbd

*or subset
or by vertical

WG Next Steps

- Finalize initial SME speaker list & schedule
- Seek diverse perspectives on technology evolution across RAN, UE & fronthaul areas, with initial focus especially on RF and baseband processing/vRAN
- Plan joint SME sessions with 5G/IoT WG for BBU/vRAN areas
- Consider proposal to develop a list of ‘ripe pre-competitive research areas’ as area of actionable recommendations (D. Tennenhouse)

Thank You!

5G/IoT/O-RAN Working Group 2020

WG Chairs: Russ Gyurek, Cisco & Brian Daly, AT&T

Date: March 19, 2020

2020 Working Group Team Members

- Ahmad Armand, T-Mobile
- Mark Bayliss, Visualink
- Marty Cooper, Dyna
- Adam Drobot, OpenTechWorks
- Jeffrey Foerster, Intel
- Dale Hatfield, Univ of Colorado
- Stephen Hayes (H. Akhtar), Ericsson
- Steve Lanning, Viasat
- Greg Lapin, ARRL
- Brian Markwalter, CTA
- Lynn Merrill, NTCA
- Robert Miller, inc Networks
- Jack Nasielski, Qualcomm
- Mike Nawrocki, ATIS
- Charlie Zhang, Samsung
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- Scott Robohn, Juniper
- Jesse Russell, incNetworks
- Travis Russell, Oracle
- Kevin Sparks, Nokia Bell Labs
- Marvin Sirbu, Spec. Gov. Emp.
- Tom Sawanobori, CTIA
- David Young, Verizon
- David Tennenhouse, VMware

FCC Liaisons: Michael Ha, Padma Krishnaswamy, Charles Mathias, Ken Baker, Sean Spivey, Nicholas Oros, Monisha Ghosh

2020 Charter from FCC

5G in low/mid/high frequency bands - critically important to the communications industry, our economy, and U.S. international competitiveness

5G systems are now being deployed, and **6G is being discussed**

- Provide information on the **development and deployment** of this technology, make recommendations, and provide technical insights on new developments that have arisen

Recent industry developments in the **virtualized radio access network (RAN)** space, such as those undertaken by the O-RAN Alliance, have the potential to disrupt conventional cellular network design and deployment

- How scalable are such approaches and what time frames should be anticipated before scalability is achieved?
- How can v-RAN help large and small companies to become more efficient or competitive?
- What are the key challenges of disaggregating the network among multiple vendors?
- How can such disruptive technologies be tested and deployed in realistic environments?
- How will they evolve to keep pace with the ever increasing bandwidth requirements of cellular systems?

Other topics for this Working Group include:

- How can 5G services over mmWave bands be made **more robust**?
- **How will 5G coexist** with Wi-Fi in bands with existing and new unlicensed devices?
- What is the status of the deployment of **service by verticals** such as transportation, energy, health care, etc. and is any Commission action needed to encourage this deployment?
- Is **dedicated or shared spectrum** needed to support industrial IoT applications, what spectrum would be suitable for this purpose, and what are the enabling technologies to consider? Are there any other communication technology trends about which the Commission should be aware to prepare for the future beyond 5G?

5G/IoT/O-RAN: Work Distillation

5G Development & deployment updates to FCC. Advise on tech insight, new dev

Beyond 5G

How will 5G co-exist with un-licensed bands and services?

O-RAN Focus for WG:

1. Tech review related to potential to disrupt conventional cellular network design/deploy.
2. How scalable is O-RAN, time-frame (RAN WG?)
3. How will O-RAN help drive efficiency, competitiveness of RAN companies?
4. What are challenges in dis-aggregating/multi-vendor approach
5. Testing and deployment
6. O-RAN evolution

What is the status of deployment of 5G by vertical: Transportation, Energy, HC, Industrial, Enterprise, etc. What can FCC do to accelerate?

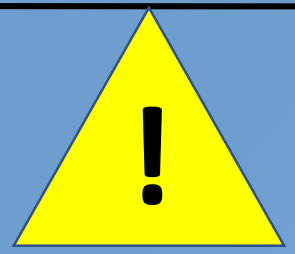
What are the needs for dedicated/shared spectrum related to Industrial? What spectrum is suitable? What other technologies are needed

5G/IoT/O-RAN Work Plan

- **O-RAN**
  - O-RAN Framing
    - Collaborate with the RAN WG
    - O-RAN alliance review
    - ATIS work review
    - 3GPP related work review
  - adoption, market impact/timing
  - pact related to WW competiveness
  - Key challenges/tech uncertainties
  - Produce recommendations

- **5G Development and deployment**
  - Advise the FCC on standards progress, impacting events
  - WW deployments, Issues, hurdles
- **Technology awareness: new developments and beyond 5G**
  - Technologies beyond 5G
  - 6G planning updates
  - Non-terrestrial networks (Satellite +), Wi-Fi6
  - What are the key emerging technology enablers
  - Network architecture changes and evolution (ITU network 2030 work)-
- **5G verticals and related impacts & needs**
  - Industrial, HC, Transportation, Energy/critical infrastructure, Agriculture, other
- **Spectrum related to verticals**
  - Are there vertical specific needs?
  - Emerging spectrum policies (Germany and China)
  - Shared spectrum opportunity and assessment (CBRS, NTIA report/DoD)
  - Dedication spectrum exploration: eg. Germany
  - Related technology needs to be successful
  - USA Competitive impacts (with/without)
  - Provide recommendations
- **5G impact related to unlicensed bands and services**
  - Interference
  - Co-existence
  - Provide recommendations

Standards Update



- Standards vs. ***Coronavirus***
- 3GPP, ATIS, IETF, etc. face to face meeting cancellations *at least* through May have disrupted the global standards process
  - All groups attempting to progress using virtual electronic meetings and e-mail
  - Some groups better prepared, others difficult due to size of the groups and number of contributions
- The next couple of months will determine the impacts to 3GPP Release 16 and 17 timelines
  - Will attempt to "hold" the timelines, however significant "exceptions"
  - R17 timeline is already slipping → delay it by 3 months as a start
- ITU-R IMT-2020 process
  - ITU-R Working Party 5D met in late February 2020 and concluded Step 4 of the IMT-2020 process as planned
    - Evaluation by independent evaluation groups of the previously submitted (under Step 3) candidate RITs or SRITs
    - Further steps dependent on COVID-19 impacts to June meeting
- All regional and global standards and industry associations affected
  - 5GAA, 5G ACIA

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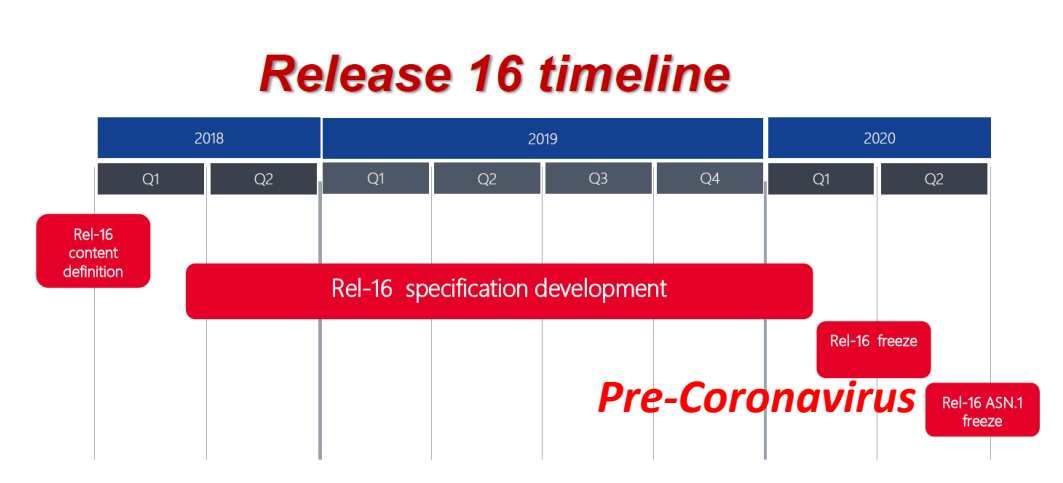
Standards Update – Release 16

- Release 16
  - Was targeted to be complete in March, but … (ASN.1 in June)
  - Three distinct pillars that Release 16 focused on:
    - Automotive,
    - Industrial IoT and
    - Operation in unlicensed bands
  - Release 16 → IMT-2020 submission initial full 3GPP 5G system to completion

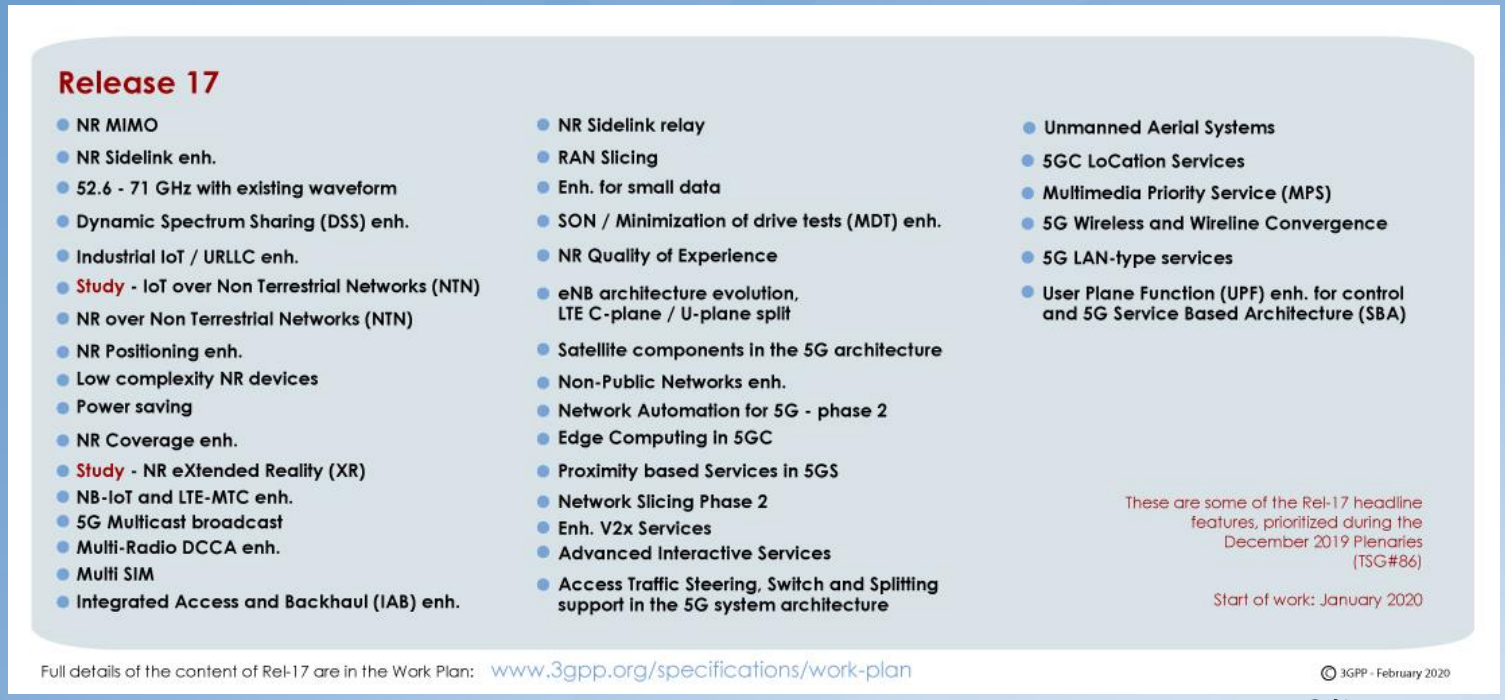


Release 16

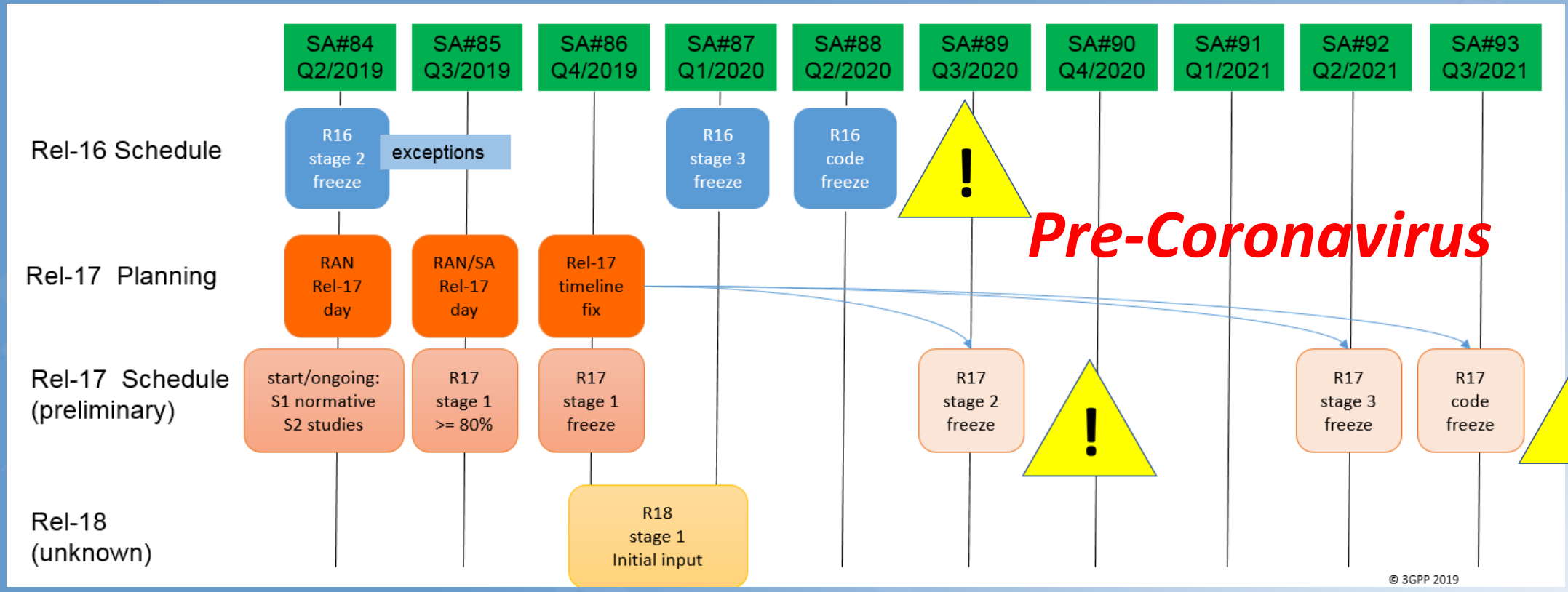
- **The 5G System – Phase 2**
- **V2x Phase 3:** Platooning, extended sensors, automated driving, remote driving
- **Industrial IoT**
- **Ultra-Reliable and Low Latency Communication (URLLC) enhancements**
- **NR-based access to unlicensed spectrum**
- **5G Efficiency:** Interference Mitigation, SON, eMIMO, Location and positioning, Power Consumption, eDual Connectivity, Device capabilities exchange, Mobility enhancements
- **Enhancements for Common API Framework for 3GPP Northbound APIs (eCAPIF)**
- **FRMCS Phase 2**

Standards Update – Release 17

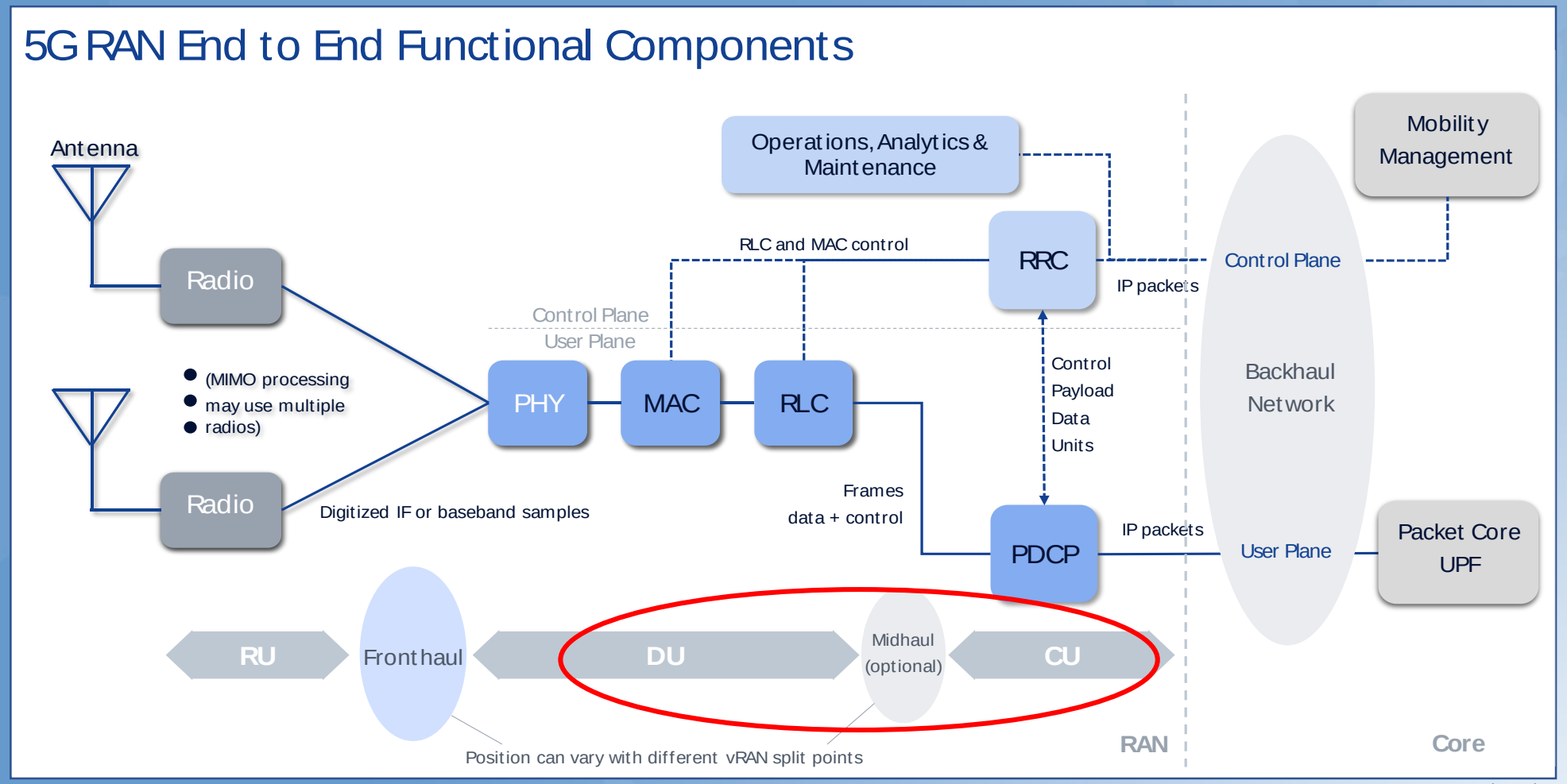
- Release 17
  - More than 30 Study and Work Items (SI and WI) for Rel 17
  - At the December 2019 RAN plenary almost all WI/SI objectives were significantly reduced
  - Shorter (15 month) release cycle has placed constraints on the Release 17 content
    - Expectation is yet further down-scoping due to the short release cycle
  - Impact of RAN agreed content on R-17 SA/CT work is not yet known



Standards Update – Projected Industry Release Timelines



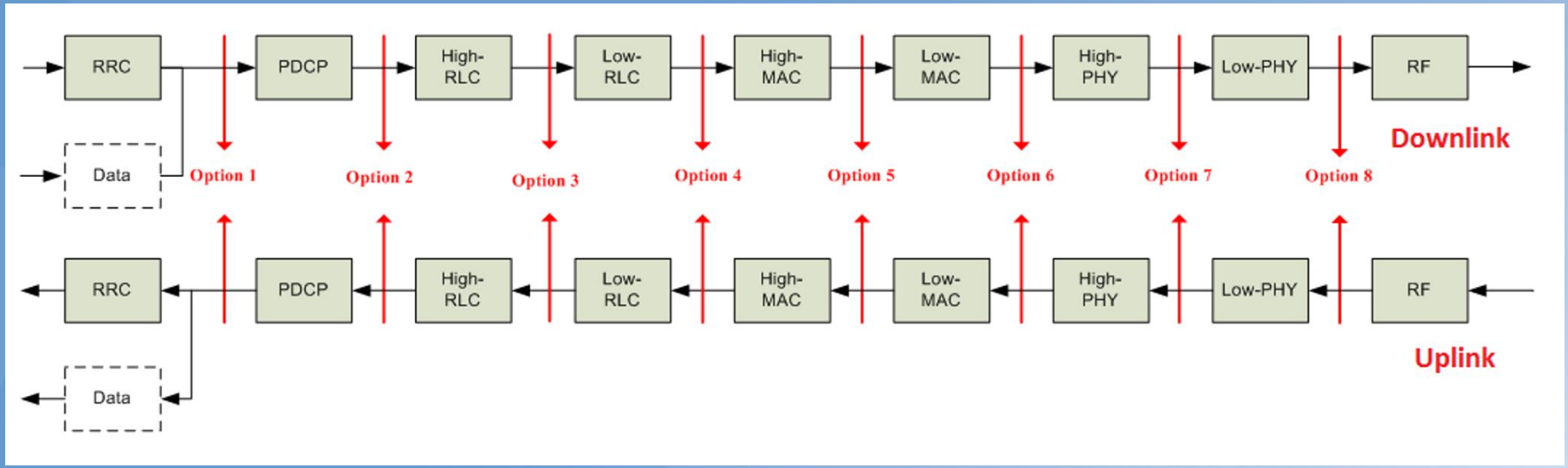
End-to-End RAN Architecture *(Thank you to 5G RAN Tech WG: Kevin/Tom)*



Source: Greg Wright, Nokia Bell Labs

3GPP

- 3GPP defines the overall standards for 4G and 5G.
- 3GPP RAN3 studied CU/DU splits below, then decided NOT to standardize any lower layer splits.



- O-RAN is specifying split option 7-2x (Open Fronthaul interface), and referring to split options 2 (F1 interface), 6 (nFAPI), and 8 (CPRI)
- 3GPP plugs into O-RAN architecture at E1/X2/F1/Xn interfaces. 3GPP and O-RAN also engage on management interfaces.

Open RAN Update

- O-RAN Alliance:
  - All WG's have a deliverable in the 1st half of 2020
  - Operator driven alliance
  - Vendors are participating cautiously
  - How to open up complex system & Maintain KPI levels
    - Opening interfaces to O-CU, O-DU and Near-RT (Real Time) RIC (RAN Intelligent Controller) are challenging
    - E2 interface: lower elements communication is key area, but very complex (radio resource management)
  - Security: security across O-RAN, process and procedures to secure

- **WG1: Use Cases and Overall Architecture Workgroup.** It has overall responsibility for the O-RAN Architecture and Use Cases. Work Group 1 identifies tasks to be completed within the scope of the Architecture and Use Cases and assigns task group leads to drive these tasks to completion while working across other O-RAN work groups
- **WG2: The Non-real-time RAN Intelligent Controller and A1 Interface Workgroup.** The primary goal of Non-RT RIC is to support non-real-time intelligent radio resource management, higher layer procedure optimization, policy optimization in RAN, and providing AI/ML models to near-RT RIC.
- **WG3: The Near-real-time RIC and E2 Interface Workgroup.** The focus of this workgroup is to define an architecture based on Near-Real-Time Radio Intelligent Controller (RIC), which enables near-real-time control and optimization of RAN elements and resources via fine-grained data collection and actions over E2 interface.
- **WG4: The Open Fronthaul Interfaces Workgroup.** The objective of this work is to deliver truly open fronthaul interfaces, in which multi-vendor DU-RRU interoperability can be realized.
- **WG5: The Open F1/W1/E1/X2/Xn Interface Workgroup.** The objective of this work is to provide fully operable multi-vendor profile specifications (which shall be compliant with 3GPP specification) for F1/W1/E1/X2/Xn interfaces and in some cases will propose 3GPP specification enhancements.
- **WG6: The Cloudification and Orchestration Workgroup.** The cloudification and orchestration workgroup seeks to drive the decoupling of RAN software from the underlying hardware platforms and to produce technology and reference designs that would allow commodity hardware platforms to be leveraged for all parts of a RAN deployment including the CU and the DU.
- **WG7: The White-box Hardware Workgroup.** The promotion of white box hardware is a potential way to reduce the cost of 5G deployment that will benefit both the operators and vendors. The objective of this working group is to specify and release a complete reference design to foster a decoupled software and hardware platform.
- **WG8: Stack Reference Design Workgroup.** The aim of this workgroup is to develop the software architecture, design, and release plan for the O-RAN Central Unit (O-CU) and O-RAN Distributed Unit (O-DU) based on O-RAN and 3GPP specifications for the NR protocol stack.
- **WG9: Open X-haul Transport Work Group.** This workgroup focuses on the transport domain, consisting of transport equipment, physical media and control/management protocols associated with the transport network.

O-RAN Alliance - An industry approach to openness

- 5G network is very complex
- Key: Want to open up RAN to add more intelligence through open interfaces
- 9 working groups, > 150 members
- Create efficiencies for SP deployments
- Reduce capital and operating costs
- Common vendor implementation
- Move RAN to a SW based environment
- Output: Industry specification
- Challenge: how to open and keep KPI's

- Opening radio comms is very complex
- Open source SW model direction
- Challenge: cant deploy OS out of box
- This is a global issue
- How to implement OS SW on stack
- O-RAN must be scaled to match deployment
- Not to eliminate vendors, but want common interface across all vendor implementations
- Will provide framework for RAN evolution

Open RAN Update cont.

- O-RAN Software Community is a key part:
  - O-RAN Software Community (OSC) is a collaboration between the O-RAN Alliance and Linux Foundation (LF) with the mission to support the creation of software for the Radio Access Network (RAN)
  - Leverage other LF network projects, while addressing the challenges in performance, scale, and 3GPP alignment
  - First release of several SW packages
  - Initial set of software projects being discussed may include:
    - Near-Real-Time RAN Intelligent Controller (Near-RT RIC),
    - Non-Real-Time RAN Intelligent Controller (Non-RT RIC),
    - cloudification and virtualization platforms, Open Central Unit (O-CU),
    - Open Distributed Unit (O-DU), and
    - test and integration effort to provide a working reference implementation.
  - 1st release: Amber, Bronze in progress
  - 2 releases per year: June and December

Published O-RAN Specs (to-date)

WG1: Use Cases and Overall Architecture Workgroup

O-RAN Architecture Description v1.0 - February 2020 (O-RAN-WG1-O-RAN Architecture Description - v01.00.00)

O-RAN Operations and Maintenance Architecture Version 2.0 - December 2019 (O-RAN-WG1.OAM-Architecture-v02.00)
O-RAN Operations and Maintenance Architecture Version 1.0 - July 2019 (O-RAN-WG1.OAM Architecture -v01.00)

O-RAN Operations and Maintenance Interface Version 02.00 - December 2019 (O-RAN-WG1.O1-Interface-v02.00)
O-RAN Operations and Maintenance Interface Version 1.0 - July 2019 (O-RAN-WG1.OAM Interface Specification-v1.0)

WG2: The Non-real-time RAN Intelligent Controller and A1 Interface Workgroup

O-RAN AI/ML Workflow Description and Requirements Version 1.0 - December 2019 (ORAN-WG2.AIML.v01.00)

O-RAN A1 interface: General Aspects and Principles Version 1.0 - October 2019 (ORAN-WG2.A1.GA&P-v01.00)
O-RAN A1 interface: Transport Protocol Version 1.0 - October 2019 (ORAN-WG2.A1.TP-v01.00)
O-RAN A1 interface: Application Protocol Version 1.0 - October 2019 (ORAN-WG2.A1.AP-v01.00)

O-RAN Non-real-time RAN Intelligent Controller & A1 interface Use Case Requirements Version 1.0 - June 2019 (ORAN-WG2.Use Case Requirements v01.00)

WG4: The Open Fronthaul Interfaces Workgroup

O-RAN Fronthaul Interoperability Test (IOT) Version 1.0 - October 2019 (ORAN-WG4.IOT.0-v01.00)

O-RAN Fronthaul Control, User and Synchronization Plane Version 2.0 - July 2019 (ORAN-WG4.CUS.0-v02.00)
O-RAN Fronthaul Management Plane Version 2.0 - July 2019 (ORAN-WG4.MP .0-v02.00.00)
O-RAN Fronthaul Yang Models Version 2.0 - July 2019 (ORAN-WG4.MP-YANGs-v02.00)

O-RAN Fronthaul Control, User and Synchronization Plane Version 1.0 - March, 2019 (ORAN-WG4.CUS.0-v01.00)
O-RAN Fronthaul Management Plane Version 1.0 - March, 2019 (ORAN-WG4.MP .0-v01.00)
O-RAN Fronthaul Yang Models Version 1.0 - March, 2019 (ORAN-WG4.MP-YANGs-v01.00)

WG5: The Open F1/W1/E1/X2/Xn Interface Workgroup

O-RAN NR C-plane profile for EN-DC Version 2.0 - December 2019 (ORAN-WG5.C.1-v2.00)
O-RAN NR U-plane profile for EN-DC Version 2.0 - December 2019 (ORAN-WG5.U.0-v2.00)

O-RAN NR U-plane profile for EN-DC Version 1.0 - June, 2019 (ORAN-WG5.U.0-v1.00)
O-RAN NR C-plane profile for EN-DC Version 1.0- June, 2019 (ORAN-WG5.C.1-v1.00)
O-RAN EN-DC C-Plane Table Version 1.0 - June, 2019 (EN-DC C-Plane Tables v01.00)

WG6: The Cloudification and Orchestration Workgroup

O-RAN Cloud Architecture and Deployment Scenarios for O-RAN Virtualized RAN Version 1.0 - October 2019 (O-RAN-WG6.CAD-V01.00.00)

WG7: The White-box Hardware Workgroup

O-RAN Deployment Scenarios and Base Station Classes For White Box Hardware Version 1.0 - December 2019 (ORAN-WG7.DSC.0-v01.00)

WG8: Stack Reference Design Workgroup

O-RAN Base Station O-DU and O-CU Software Architecture and APIs Version 1.0 - July 2019 (ORAN-WG8.AAD-v01.0.0)

Refer to https://www.o-ran.org/specifications

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Security Concerns- 5G/RAN

- Wireless systems are inherently open and hence subject to jamming, spoofing, and sniffing/unauthorized interception attacks
  - Jamming
    - 4G and, increasingly 5G, jammers are available on the Internet for malicious, non-malicious and permitted uses
    - Smart (protocol aware) jamming can be particularly pernicious and is facilitated by low cost SDR techniques
  - Spoofing
    - Inducing a device (e.g., a UE) to connect to a rogue node (e.g., a stingray), thus facilitating 'man-in-the-middle' tpe attacks
  - Sniffing/Unauthorized Interception
    - Privacy issues: Allowing the collection of both meta-data and user information without detection

- 3GPP is demonstrating heightened focus on security in Rel.-15 and Rel.-16 (e.g., against cell site simulators)
  - Challenges associated w/ building out 5G while ntegrating older LTE without diminishing privacy & security
  - Potential over-emphasis on upper-layer attacks rather than RF or Layer 1 or Layer 2 vulnerabilities
  - Passive monitoring/sniffing/eavesdropping still allows for the collection and analysis of important system information because of the inherent openness of wireless networks

5G and the Future Marketplace

- ATIS published “Future Network Enabled Marketplace” report in February, 2020
- As 5G commercialization expands and standards evolve, it will become increasingly important to consider the surrounding marketplace and the technology, business and societal drivers
- A collective vision for the next 5-10 years allows the industry to focus on the collaborative opportunities
- Key pathways to the future include:
  - Cloudification of networks
  - Privacy and trust frameworks
  - Personalized customer experience
  - Enabling adjoining Industries
  - New business models
- Industry collaboration can position networks as the marketplace enabler

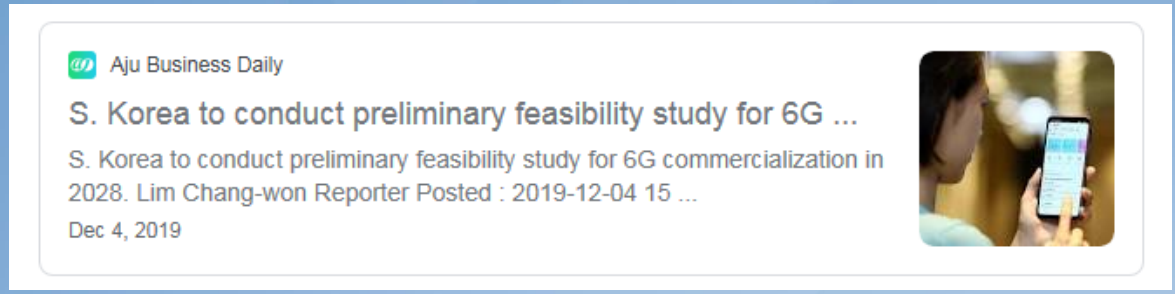
6G Research Update

- 6G Wireless Summit 2020 (moved to a virtual summit starting 3/17/2020)
  - Views that 6G will "unify the experience across physical, digital and biological worlds" and "integrate the physical and digital world"
  - "Internet of Senses" - enhanced brain-computer interaction and "in-body monitoring"
  - "Digital twins"
  - New spectrum – i.e. D-band (140-180 GHz) and above
  - New architectures – RAN/core convergence
  - ~2030 for commercialization

Source: 6G Wireless Summit 2020, ZTE Keynote

6G in 2028?

- Japan developing a 6G strategy and intends to dedicate 220 billion yen (€1.81 billion) to encourage private-sector research and development for 6G
- South Korean state-sponsored preliminary feasibility study will be carried out to develop core technologies for the commercialization of 6G in 2028 through cooperation with the private sector
  - "As a frontrunner in disseminating 5G mobile services, South Korea will conduct a preliminary feasibility study with a goal of achieving the world's first commercialization of 6G mobile telecommunication in 2028 ahead of China and other countries."
  - "South Korea announced earlier that it aims to allocate 976 billion won from 2021 through 2028 on 6G tech fields"



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Thank You!