Federal Communications Commission Technological Advisory Council Meeting

August 29, 2024

FCC Technological Advisory Council Agenda – August 29, 2024

10:00am – 10:10am	Opening Remarks
10:10am – 10:55am	Advanced Spectrum Sharing WG Presentation
10:55am – 11:40am	AI/ML WG Presentation
11:40am – 12:25pm	6G WG Presentation
12:25pm – 12:30pm	Closing Remarks
12:30pm	Adjourned

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FCC TAC
Advanced Spectrum Sharing WG
Status Update

Chairs: Andrew Clegg (Wireless Innovation Forum)
Monisha Ghosh (Wireless Institute, Univ. of Notre Dame)

Date: August 29th, 2024

Rob	Alderfer	Charter Communications, Inc.
Mark	Bayliss	Visual Link Internet
Donna	Bethea-Murphy	Viasat
Dean	Brenner	TAC Chair
Michael	Cataletto	Scientel Solutions, LLC
Ranveer	Chandra	Microsoft Corporation
Lynn	Claudy	NAB
Andrew	Clegg	Wireless Innovation Forum
Carlos	Cordeiro	Intel
Brian	Daly	AT&T
Aleksandar	Damnjanovic	Qualcomm Incorporated
Jay	Desai	Amazon
Skyler	Ditchfield	GeoLinks
Adam	Drobot	Stealth Software Technologies, Inc.
Monisha	Ghosh	Wireless Institute, Notre Dame
Iain	Gillott	Wireless Infrastructure Association
Manu	Gosain	Northeastern University
Dick	Green	Liberty Global Corporation
Lisa	Guess	Ericsson
David	Gurney	Motorola Solutions Inc.
Dale	Hatfield	University of Colorado at Boulder

Jason	Jackson	Kyndryl
David	Kaufman	Amazon (Alternate Member)
Humberto	La Roche	Cisco Systems, Inc.
Greg	Lapin	ARRL
Mike	Laskowsky	Rural Wireless Association
Jason	Livingood	Comcast
Dan	Mansergh	Apple Inc.
Brian	Markwalter	Consumer Technology Association
Lynn	Merrill	NTCA - The Rural Broadband Association
Amit	Mukhopadhyay	Nokia
Jack	Nasielski	Qualcomm Incorporated
Bridget	Neville	Sirius XM Radio Inc.
Roger	Nichols	Keysight Technologies, Inc.
Timothy	O'Shea	DeepSig Inc.
Jon	Peha	Metro 21, Smart Cities Institute
Tom	Sawanobori	CTIA
Henning	Schulzrinne	SGE (Columbia University)
Ardavan	Tehrani	Samsung
Rikin	Thakker	NCTA - The Internet & Television Association
Michelle	Thompson	Open Research Institute, Inc.
David	Young	ATIS

Advanced Spectrum Sharing WG Attendees

Presentations to the Spectrum Sharing

- Mike Marcus, Marcus Spectrum Solutions (7/2/24)
  - Title: “Coexistence and Spectrum Sharing Above 100 GHz: Opportunities, Challenges and Solutions”
  - Related charter items: [1, 4, 5, 6, 9, 10]
- David Willis & Steve Leach, Ofcom (7/16/24)
  - Title: “Cellular/Wi-Fi hybrid sharing in upper 6 GHz - UK update”
  - Related charter items: [1, 2, 3, 4, 5, 6, 8, 10]
- Dinesh Bharadia, UCSD (7/25/24)
  - Topic: Impact of network topology on energy efficiency
  - Related charter items: [9]
- Billy Kozma (ITS) and Mark Walker (Cablelabs) (8/27/24)
  - Topic: The role of clutter on propagation loss
  - Related charter items: [1, 2, 3, 6]
- William Blackwell, MIT Lincoln Labs (9/10/24) (scheduled)
  - Topic: mmW sensors
  - Related charter items: [4, 5, 6, 7]
- Doug Hyslop, CTIA (10/15/24) (scheduled)
  - 3.7 GHz and radio altimeters
- TBD (NSF and others)
  - Topic: Advanced technologies and their role in spectrum sharing
  - Related charter items: [1, 4, 5, 7, 8]

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Possible Disposition of Each Item

1. Final recommendation* by Dec 2024
2. Preliminary recommendation* by Dec 2024, final recommendation* by August 2025.
   - Preliminary means consensus, but possible additional recommendations to come.
3. Have no preliminary or final recommendation* by Dec 2024, have a final recommendation* by August 2025
   - Some recommendation(s) for an item by December 2024, final recommendation by Aug 2025

*In some cases, the result of work may be an "advisement" or summary of state-of-the-art, rather than a recommendation

Advanced Spectrum Sharing Charter Item 1

- **What will advanced sharing frameworks and architectures look like in the future?**
- Lead: Amit Mukhopadhyay (Nokia)
- Current status: Preliminary recommendations in draft
- Related to charter items: [2, 3, 5, 6, 7, 8, 10]
- Goal: Preliminary recommendations by Dec 2024, final recommendations by August 2025.

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Advanced Spectrum Sharing Charter Item 2

- **How will spectrum sharing models adapt and evolve to meet the growing demand for spectrum access among various services to support multiple purposes? How can the interplay between terrestrial and satellite services be complemented in sharing models to promote more efficient spectrum use?**
- Lead: Amit Mukhopadhyay (Nokia)
- Status: Preliminary Recommendations in Draft
- Related to charter items: [1, 3, 6, 10]
- (Stretch) Goal: Final recommendations by Dec 2024

Advanced Spectrum Sharing Charter Item 3

- **To what extent can the FCC optimize its propagation models to reflect less conservative, more realistic assumptions and support more intensive sharing while still protecting against harmful interference? Are there specific bands where improved propagation models offer a pathway to liberalize performance capabilities beyond what the FCC permits today?**
- Lead: Dave Gurney (Motorola)
- Status: Document in Draft
- Related to charter items: [1, 2, 10]
- Goal: Preliminary recommendations by Dec 2024, final recommendations by August 2025.

Advanced Spectrum Sharing Charter Item 4

- **What steps can be taken to better facilitate spectrum repurposing efforts? How can potential intra-band and inter-band issues be identified and addressed early in the process? How can incumbent services be better informed about the nature of adjacent or nearby spectrum environments and how can users be encouraged to take steps needed to accommodate new spectrum uses in those environments? What steps and processes should be used regarding adjacent band spectrum users' wide receiver bandwidths (i.e., the passband extends into adjacent bands)?**
- Leads: Tom Sawanobori (CTIA), Roger Nichols (Keysight)
- Status: Document in Draft
- Related to charter items: [5, 6, 7, 10]
- Goal: Preliminary recommendations by Dec 2024, final recommendations by August 2025.

Advanced Spectrum Sharing Charter Item 5

- **What is the current state of the art in receiver technology? What state of the art active antenna array and filter technologies can be utilized to mitigate potential harmful interference? How can advanced antenna systems help reduce both inter-system and intra-system interference and enhance intra-system performance (e.g., beam vs. null steering)? What are the cost benefit tradeoffs on utilizing the current filter technologies or advanced antenna systems? Are there specific bands where improved receiver technologies offer significantly improved coexistence beyond what is permitted today?**
- Leads: Monisha Ghosh (UND) & Dale Hatfield (Silicon Flatirons)
- Status: Initial discussions with SMEs and relevant projects like DARPA's COFFEE
- Related to charter items: [1, 4, 7, 8]
- Goal: Final recommendations by August 2025.

Advanced Spectrum Sharing Charter Item 6

- **What are the candidate bands or services that can co-exist with low-power, indoor-only operation such as factory automation?**
- **What are the sharing mechanisms to consider?**
- Lead: Jason Jackson (Kyndryl)
- Status: Draft Work Artifact being progressed for review by WG. Will share with WG Sept 6th, complete by Sept 13 and review with the TAC after Sept 17th.
- Related to charter items: [6, 8]
- Goal: Final Recommendations by Dec 2024
- Note: Consider combining 6.1, 6.2 and 8

Advanced Spectrum Sharing Charter Item 7

- **What are the sharing mechanisms to consider among various services above 95 GHz, including passive services?**
- Lead: Jason Jackson (Kyndryl)
- Status: Deferred
- Related to charter items: N/A
- Goal: Final disposition proposed; will be discussed further

Advanced Spectrum Sharing Charter Item 8

- **What role should sensors play in informing spectrum use and in supplementing spectrum sharing databases?**
- Lead: Jason Jackson (Kyndryl)
- Status: Draft Work Artifact being progressed for review by WG. Will share with WG Sept 6th, complete by Sept 13 and review with the TAC after Sept 17th.
- Related to charter items: [6, 8]
- Goal: Final Recommendation by Dec 2024
- Note: Consider combining 6.1, 6.2 and 8

Advanced Spectrum Sharing Charter Item 9

- **What are the trade-offs between efficient spectrum use and environmental considerations, including sustainability and energy efficiency?**
- Lead: Rob Alderfer (Charter)
- Status: Discussions with SME (Dinesh Bharadia, UCSD); more discussions planned
  - SME input summary:
    - Wireless signal dispersion creates losses that manifest as energy consumption in base stations and user devices
    - Minimizing losses by reducing transmission distance (as in small cell architectures) can enhance energy efficiency of mobile networks and extending battery life of UEs (phones)
    - Localized traffic demand growth complements the opportunity to drive greater energy efficiency into mobile networks
- Related to charter items: [7, 10]
- Goal: Preliminary recommendations by Dec 2024, final recommendations by August 2025.

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Advanced Spectrum Sharing Charter Item 10

- **What methods can support the Commission in identifying spectrum bands that have the most potential and flexibility for sharing and repurposing? What are the candidate bands and which bands should be prioritized? How should those bands be combined or separated for federal and/or non-federal uses? What are the optimal coordination processes between stakeholders to better support implementation and consideration of these methods?**
- Leads: Michael Cataletto (Scientel), Andrew Clegg (WInnForum)
- Status: Document in Draft - Coordinating with the 6.1 / 6.2 team.
- Related to charter items: [1, 2, 3, 4, 6, 7, 9]
- Goal: Preliminary recommendations by Dec 2024, final recommendations by August 2025.

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Related Charter Items

		Future SS frameworks	Evol. of SS models; terrestrial/satellite	Prop models	Spectrum repurposing; inter/intra-band coex	Advanced technologies	Indoor	>95 GHz	Sensors	Energy efficiency	Candidate bands
Future SS frameworks	**1**		X	X		X	X	X	X		X
Evol. of SS models; terrestrial/satellite	**2**	X		X		X	X				X
Prop models	**3**	X	X			X	X				
Spectrum repurposing; inter/intra-band coex	**4**					X	X	X			X
Advanced technologies	**5**	X	X	X	X		X	X	X	X	X
Indoor	**6**	X	X	X	X	X		X			X
>95 GHz	**7**	X			X	X	X			X	X
Sensors	**8**	X				X					
Energy efficiency	**9**					X		X			X
Candidate bands	**10**	X	X		X	X	X	X		X	

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12:30pm	Adjourned

FCC TAC

Artificial Intelligence, Machine Learning Working Group - AIWG

AIWG WG Chairs: Lisa Guess, Ericsson
Adam Drobot, Stealth Software Technologies, Inc.
AIWG SWG Chairs: Ardavan Tehrani, Samsung
(Softwarization) Richard Kessler, Marvell

FCC Liaisons: Bahaman Badipour**,** Chrysanthos Chrysanthou, Rajat Mathur, Patrick Sun, Martin Doczkat – DFO, and Sean Yun – Alternate DFO

FCC Observers: Robert Acacio, Damian Ariza, Etemad, Kamran, Jonathan Lu, Mathew Miller,, Joseph Prebble, and Aniqa Tahsin

Date: August 29th, 2024

Agenda August 29, 2024

- Artificial Intelligence and Machine Learning Working Group
- AIWG Charter
- Organization and Timelines for 2024 and 2025
- Background, Trends, and Developments in AI and ML
- Progress Report
  - Bucket 1 - AI/ML for Spectrum Sharing
  - Bucket 2 - Network Safety, Security, Assurance, and Performance
  - Bucket 3 - Testing
  - Bucket 4 - Softwarization
- Summary
- Appendices

Artificial Intelligence and Machine Learning Working Group Members

Name	Organization	Name	Organization
Bayliss, Mark	Visual Link Internet	Lapin, Gregory	ARRL
Brenner, Dean (1)	SGE	Markwalter, Brian	Consumer Technology Association (CTA)
Clegg, Andrew (2)	Wireless Innovation Forum	Merrill, Lynn	NTCA
Daly, Brian K. (3)	AT&T	Mukhopadhyay, Amit	Nokia
Drobot, Adam T.	Stealth Software Technologies	Nasielski, Jack	Qualcomm
Ghosh, Monisha (2)	University of Notre Dame	O’Shea, Tim	Deepsig.Ai
Gosain, Abhimanyu (3)	Northeastern University	Pankajakshan, Bejoy	Mavenir
Guess, Lisa	Ericsson	Peha, Jon M.	Carnegie Mellon University
Gupta, Sachin	NRECA	Sirbu, Marvin	SGE
Hatfield, Dale H.	University of Colorado	Sung, LiChing	NTIA Office of Spectrum Management
Kessler, Richard	Marvell	Tehrani, Ardavan M.	Samsung
Lan, Tian	SGE		

(1) TAC Chair, (2) SSWG Chairs (3) 6GWG Chairs

Artificial Intelligence and Machine Learning Working Group FCC Liaisons and Observers

Name	Organization	Name	Organization
Acacio, Robert	EMCD - Observer	Miller, Matthew	PRD - Observer
Ariza, Damian	PRD - Observer	Prebble, Joseph	PRD - Observer
Badipour, Bahman	PRD - Liaison	Sun, Patrick	OEA - Liaison
Chrysanthou, Chrys	EMCD - Liaison	Tahsin, Aniqa	PRD - Observer
Etemad, Kamran	WTB – Observer		
Lu, Jonathan	EMCD - Observer		
Mathur, Rajat	EMCD - Liaison		
Doczkat, Martin	FCC EMCD – FCC DFO		
Yun, Sean	FCC EMCD – FCC ADFO		

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Artificial Intelligence and Machine Learning Working Group Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter.

Bucket 1: AI and ML for Spectrum Sharing and Management

1.1 Explore the use of AI/ML methods to improve the utilization and administration of spectrum (licensed, unlicensed, and shared) based on the fundamental characteristics of propagation, interference, signal processing, and protocols. How could the scalability aspect of AI/ML algorithms support such methods by use of techniques such as parallelization, dimensionality reduction, sampling, and approximation?

1.2 How can AI/ML be leveraged to help better understand real-time spectrum usage, either at the front end (e.g., improved sensing) or the back end (e.g., improved analytics)?

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Artificial Intelligence and Machine Learning Working Group Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 2: Network Safety, Security, Assurance, and Performance

2.1 Evaluate the use of AI/ML methods and techniques applied to assuring the safety, security, and performance of network equipment, network control, and network operations in a network environment that increasingly relies on automation, is seeing a rapid growth of new network connections, and is increasingly digitized and softwareized.

2.2 Explore and evaluate AI-enabled networks in optimizing long convergence time, memory complexity, and complex behavior of machine learning algorithms under uncertainty as well as how the highly dynamic channel, traffic, and mobility conditions of the network contribute to the challenges of AI networks.

2.3 How can AI/ML techniques be used to address the challenges of data quality, availability, privacy, and security in wired and wireless networks, such as data cleansing, data fusion, data anonymization, and data protection?

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Artificial Intelligence and Machine Learning Working Group Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 3: Testing Regimes for AI/ML in Telecommunications

3.1 What approaches should be taken, if any, on testing and certification of AI/ML softwarization of network components, capabilities, and equipment?

Artificial Intelligence and Machine Learning Working Group Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 4: Softwarization of Telecommunications

4.1 What are the opportunities, for the Commission, to use AI/ML to improve its analysis of data presently collected and housed in databases like ULS?

4.2 What are the implications and complications of using AI/ML in optimizing wireless and wired networks performance by analyzing network traffic patterns, network failures, proactive corrective actions, network routing, and predicting network congestion?

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Artificial Intelligence and Machine Learning Working Group Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 4: Softwarization of Telecommunications

4.3 How can AI/ML techniques be used to support the integration and interoperability of wired and wireless networks, such as heterogeneous access networks, multi-domain networks, and adaptive network slicing?

4.4 How can AI/ML techniques be used to design and implement novel network architectures and protocols for wired and wireless networks, such as software-defined networking (SDN), network function virtualization (NFV), and information-centric networking (ICN)?

Organization and Timelines for 2024 and 2025

The AIWG has taken the ten items in the Charter and organized them as four Buckets.

Subject	Area Covered	Responsibility
Bucket 1	**AI and ML for Spectrum Sharing and Management** 1.1 – 1.2	AI/ML Working Group **Functionality and Performance**
Bucket 2	**Network Safety, Security, Assurance, and Performance** 2.1 – 2.3	AI/ML Working Group **Functionality and Performance**
Bucket 3	**Testing Regimes for AI/ML in Telecommunications** 3.1	AI/ML Sub-Working Group **Softwarization**
Bucket 4	**Softwarization of Telecommunications** 4.1 – 4.4	AI/ML Sub-Working Group **Softwarization**

Organization and Timelines for 2024 and 2025

Deliverables

Bucket	Output	Format	
WG-Bucket1	1. Recommendations	Short Presentation	
(1.1-1.2)	2. Summary Brief	In Depth Presentation	
	3. White Paper	Summary Findings and Rationale	2025
WG-Bucket 2	1. Recommendations	Short Presentation	
(2.1-2.3)	2. Summary Brief	In Depth Presentation	
SWG-Bucket 3	1. Recommendations	Short Presentation	
(3.1)	2. Summary Brief	In Depth Presentation	
	3. White Paper	Summary Findings and Rationale	2025
SWG-Bucket 4	1. Recommendations	Short Presentation	
(4.1-4.4)	2. Summary Brief	In Depth Presentation	

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Background, Trends, and Developments in AI and ML

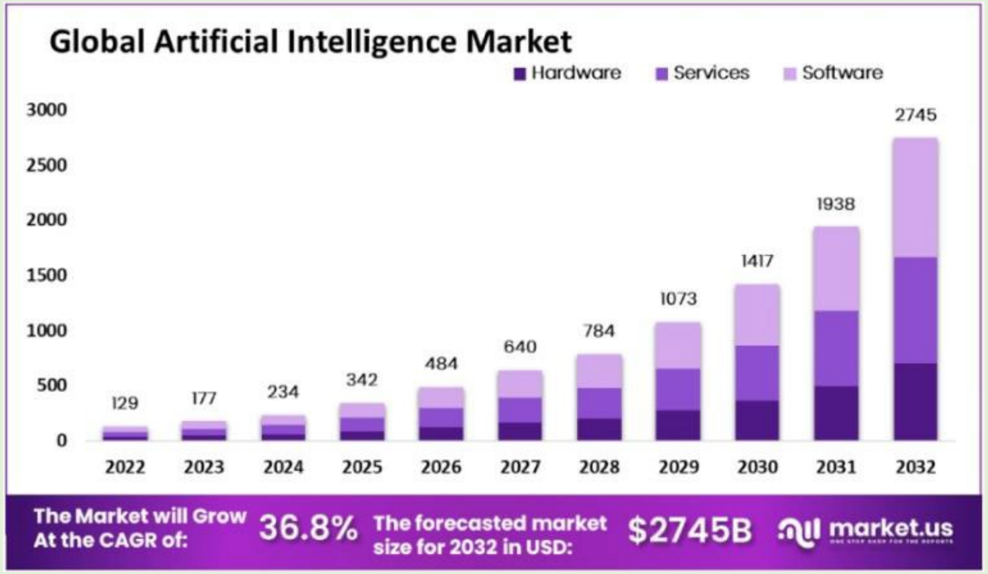
Topic 1: High Level of Investment and Growth in AI and Softwarization

Topic 2: Shifting Demand for 5G: From Consumer to Industry

Topic 3: Leveraging AI to Maximize Telecommunications Efficiency

Topic 4: Key Issues and Responses in AI Integration in Telecommunications

Topic 1: High Level of Investment and Growth in AI and Softwarization



- **Rapid sustained growth will occur in the global AI market**
  - In 2022, the **software segment** held a dominant position in the AI market, accounting for over **39.3%** of the market share. AI software is crucial for various applications, such as natural language processing, machine learning, and neural networks, making it integral to AI systems.
  - North America leads in the AI market, capturing over 51% of the global market share
  - AI is expected to cause a **~21%** net increase in the United States GDP by 2030.
  - Globally, AI will contribute about **~$15.7 trillion** to the economy by 2030.
  - AI's development might result in the loss of **~85 million** jobs but will also create **~97 million** new ones, netting a gain of **~12 million** jobs worldwide.
  - Source: "Global Artificial Intelligence Market By Solution (Hardware, Software, and Services), By Technology (Deep Learning, Machine Learning, NLP), By End-Use (Manufacturing, Healthcare, Law, BFSI, Advertising & Media, Retail, Agriculture, Automotive & Transportation, Other End-Uses), By Region and Key Companies - Industry Segment Outlook, Market Assessment, Competition Scenario, Trends and Forecast 2023-2032" https://market.us/report/artificial-intelligence-market/

- Summary: AI leveraged by and enabled by telecommunications contributes to competitiveness, growth of the economy, and jobs

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Topic 2: Shifting Demand for 5G: From Consumer to Industry

The demand for 5G is increasingly shifting from consumer-focused applications to industrial and enterprise use cases. This transition reflects the maturity of the technology and its potential to drive innovation across various sectors. Here are some key points outlining this shift:

1. Consumer Market Saturation:

- **Slower Uptake:** While 5G has been marketed heavily to consumers for faster and better experiences, the actual uptake has been slower than expected. Many consumers are still content with 4G, and the benefits of 5G for everyday activities (like streaming or browsing) are not always immediately apparent.
- **Device Penetration:** Most modern smartphones are now 5G-enabled, but the novelty of 5G alone is no longer a strong selling point leading to market saturation.

2. Industrial and Enterprise Adoption:

- **Industry 4.0:** 5G enables automation, IoT, and real-time data processing for smart factories and connected machinery.
- **Private 5G Networks:** Interest is growing for private 5G networks within industries such as manufacturing, logistics, and energy, offer more control, security, and reliability allowing businesses to optimize their operations with tailored solutions.
- **Smart Cities and Infrastructure:** Governments leveraging 5G for smart city initiatives like traffic management and public safety. Connecting thousands of devices in a small area with minimal latency is particularly valuable in these settings.

3. Emerging Use Cases:

- **Healthcare:** 5G is enabling advanced telemedicine, remote surgeries, and real-time health monitoring. The pandemic accelerated the adoption of these technologies, highlighting the critical role of reliable and fast connectivity in healthcare.
- **Agriculture:** Precision farming powered by 5G allows for real-time monitoring of crops, livestock, and environmental conditions. This connectivity supports data-driven decision-making, improving yield and sustainability.
- **Transportation and Autonomous Vehicles:** 5G is critical for the development of autonomous vehicles, supporting vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. This is essential for safety, navigation, and efficiency in transportation networks.

Topic 2: Shifting Demand for 5G: From Consumer to Industry

4. Economic Impact:

- **Cost Efficiency:** As industries adopt 5G, they benefit from increased efficiency, reduced downtime, and enhanced productivity. This economic impact is driving more sectors to explore and invest in 5G technologies.
- **New Business Models:** Industrial 5G adoption drives new business models, particularly in the fields of automation, IoT services, and data analytics. Enterprises will monetize these capabilities, leading to innovation in products and services.

5. Challenges and Considerations:

- **Security:** As 5G networks become more integral to industrial operations, concerns about cybersecurity are growing. Ensuring the security of these networks is paramount, especially in critical infrastructure and sensitive industries.
- **Infrastructure Investment:** The shift towards industrial 5G requires significant investment in infrastructure, including the deployment of new base stations, small cells, and edge computing resources. Industries and governments are collaborating to address these challenges.

Sources: "Private 5G Network Market - By Component (Hardware, Software, Services), By Spectrum (Licensed Spectrum, Unlicensed Spectrum), By Industry Vertical (Manufacturing, Healthcare, Transportation & Logistics, Energy & Utilities, Retail, Oil & Gas), & Forecast 2024 – 2032" https://www.gminsights.com/industry-analysis/private-5g-network-market
"5G private networks enhance industry productivity" https://www.ericsson.com/en/reports-and-papers/mobility-report/articles/5g-private-networks-enhance-industry-productivity
"Will 5G Make 2024 the Industrial Economy's Most Connected Year Yet?" https://www.pymnts.com/connectedeconomy/2023/will-5g-make-2024-the-industrial-economys-most-connected-year-yet/
"Private 5G and the Future of Corporate Telecommunications" https://www.bradley.com/insights/publications/2024/02/private-5g-and-the-future-of-corporate-telecommunications
"Explore the Top 10 5G Trends in 2024" https://www.startus-insights.com/innovators-guide/5g-trends/

Summary: The move from consumer to industrial demand for 5G reflects the technology's critical role in enabling the next wave of digital transformation across industries. As 5G continues to mature, its impact on industrial sectors is expected to grow even further, driving innovation and efficiency on a global scale.

Topic 3: AI Maximizes Telecommunications Efficiency – Current

- **Fiber Network Optimization**
  - **Traffic Prediction:** Manages peak loads, avoids congestion.
  - **Predictive Maintenance:** Reduces downtime with real-time monitoring.
  - **Network Planning:** Optimizes routes, minimizes costs.
  - **Dynamic Bandwidth Allocation:** Ensures efficient use of resources.
    - Current Example: "How is AI Transforming Predictive Maintenance in Telecom Networks" https://teletimesinternational.com/2024/ai-transforming-predictive-maintenance-telecoms/
- **Enhanced Service Delivery**
  - **QoS Optimization:** Continuously improves service quality.
  - **Automation:** Reduces manual intervention with self-optimizing networks.
    - Current Example: "Artificial Intelligence based QoS optimization for multimedia communication in IoV systems" https://www.sciencedirect.com/science/article/abs/pii/S0167739X18320314
- **Security Enhancements**
  - **Anomaly Detection:** Quickly identifies potential security threats.
  - **Threat Mitigation:** Responds to cyber threats like DDoS.
    - Current Example: "AI in Cybersecurity: Exploring the Top 6 Use Cases" https://www.techmagic.co/blog/ai-in-cybersecurity/#:~:text=By%20detecting%20patterns%20and%20anomalies,across%20multiple%20systems%20and%20applications.
- **Energy Efficiency**
  - **Energy Management:** AI-driven optimization of power consumption.
    - Current Example: "The growing imperative of energy optimization for telco networks" https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-growing-imperative-of-energy-optimization-for-telco-networks

Summary: Although these areas are more mature in the AI adoption curve, AI will be critical to enable continuous improvement of efficiency, reliability, and security in telecom, enabling providers to meet the growing demand for ubiquitous high-speed connectivity.

Topic 3: AI Maximizes Telecommunications Efficiency – Evolving

Key Developments in AI for Spectrum Management:

•**Dynamic Spectrum Allocation:**
- **AI Capabilities:** AI will enable real-time analysis and adjustment of spectrum resources based on demand and conditions.
- **Efficiency Gains:** Optimize spectrum use, reduce congestion, and ensure more equitable distribution across users.

•**Interference Mitigation:**
- **AI Capabilities:** Advanced AI algorithms mitigate interference between users or services sharing the same spectrum.
- **Efficiency Gains:** Cleaner signal transmission and reduced disruptions will enhance overall network performance.

•**Cognitive Radio Networks:**
- **AI Capabilities:** AI-powered cognitive radios will autonomously detect available spectrum and switch to the best frequencies.
- **Efficiency Gains:** This will maximize spectrum utilization, reduce manual oversight, and increase network resilience.

•**Spectrum Sharing Optimization:**
- **AI Capabilities:** AI will facilitate better spectrum sharing among various entities, such as commercial and government services.
- **Efficiency Gains:** Predictive models allocate resources more effectively, improving the overall efficiency of spectrum use.

Sources:

- "Cognitive Radio and AI-Enabled Networks" https://globecom2024.ieee-globecom.org/sites/globecom2024.ieee-globecom.org/files/GC%202024%20Track%20CFP-CRAEN.pdf
- "Why AI holds major promise for spectrum sharing at scale" https://www.rcrwireless.com/20240402/ai-ml/why-ai-holds-major-promise-for-spectrum-sharing-at-scale-reader-forum
- "How Generative AI Could Impact Network Planning, RAN Configuration, and Spectrum Management" https://www.5gamericas.org/how-generative-ai-could-impact-network-planning-ran-configuration-and-spectrum-management/

Summary: AI is set to revolutionize spectrum management by enabling more efficient use of resources, reducing interference, and automating processes. The integration of AI will be crucial in optimizing spectrum allocation in the era of 5G and beyond.

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Topic 4: Key Issues and Responses in AI Integration in Telecommunications

- **Data Privacy and Security**
  - **Issue**: AI systems require large amounts of data, raising concerns about data privacy and potential breaches.
  - **Responses**: Standards bodies are developing frameworks to ensure compliance with data protection laws and secure handling of sensitive information.
- **Bias and Fairness**
  - **Issue**: AI systems can perpetuate biases, leading to unfair treatment of users or groups.
  - **Responses**: Industry groups like IEEE and ITU are creating guidelines to ensure fairness, transparency, and unbiased AI decision-making in telecom.
- **Interoperability**
  - **Issue**: Proprietary AI systems in telecom may not work well together, leading to inefficiencies.
  - **Responses**: Standards bodies such as 3GPP and ITU focus on creating interoperable frameworks for seamless integration of different AI systems and telecom technologies.
- **Ethical Use of AI**
  - **Issue**: AI deployment in telecom raises ethical concerns, including potential surveillance, job loss, and the need for human oversight.
  - **Responses**: Organizations like IEEE and ITU are developing ethical guidelines to ensure responsible AI use in telecommunications, respecting human rights.
- **Regulatory Compliance**
  - **Issue**: The fast pace of AI technology development challenges regulatory compliance, especially with varying regional laws.
  - **Responses**: Industry groups and standards bodies are collaborating with regulators to ensure AI systems in telecom meet local and international regulations, with a focus on transparency and accountability.

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Topic 4: Standards Bodies and Industry Groups Involved in AI Regulation in Telecommunications

- **International Telecommunication Union (ITU) -** United Nations specialized agency leading global standards for telecommunications.
  - **Key Activities**:
    - Focuses on future networks, including AI and machine learning.
    - Developed ITU-T Y.3172 recommendation for AI architecture in future networks, including 5G.
  - **Concerns Addressed**: Ensures global best practices, interoperability, fairness, and ethical use of AI.

- **3rd Generation Partnership Project (3GPP) -** Collaboration between telecom standards bodies to develop protocols for mobile telecommunications.
  - **Key Activities**:
    - Incorporates AI/ML into 5G network specifications.
    - Focuses on automating network management and enhancing 5G performance.
  - **Concerns Addressed**: Ensures security, efficiency, and seamless integration of AI in telecom networks.

- **Institute of Electrical and Electronics Engineers (IEEE) -** Major global standards organization, Develops standards for a wide range of technologies, including AI and telecommunications.
  - **Key Activities**:
    - Global Initiative on Ethics of Autonomous and Intelligent Systems.
    - Provides ethical guidelines and standards (e.g., IEEE P7000 series) relevant to telecom applications.
  - **Concerns Addressed**:
    - Ethical implications of AI.
    - Issues related to bias, transparency, and accountability in AI-driven telecom systems.

Topic 4: Standards Bodies and Industry Groups Involved in AI Regulation in Telecommunications (cont.)

- **European Telecommunications Standards Institute (ETSI) -** Produces globally applicable standards for ICT, including AI in telecom.
  - **Key Activities**:
    - Industry Specification Group on Experiential Network Intelligence (ENI).
    - Applies AI techniques to improve telecom network operations.
  - **Concerns Addressed**:
    - Technical challenges of AI implementation in telecom.
    - Ensures reliability, security, and data privacy.

- **Alliance for Telecommunications Industry Solutions (ATIS) -** U.S.-based organization developing standards and solutions for the telecommunications industry.
  - **Key Activities**:
    - Focuses on AI's role in network automation, cybersecurity, and enhancing user experience in telecom services.
  - **Concerns Addressed**:
    - Practical deployment of AI in telecom.
    - Emphasizes operational efficiency, security, and regulatory compliance.

Summary: While AI holds great promise for transforming telecommunications, these organizations and standards bodies are critical in addressing the technical, ethical, and regulatory challenges to ensure its safe and effective deployment.

Progress Report

Bucket 1 - AI/ML for Spectrum Sharing
Bucket 2 - Network Safety, Security, Assurance, and Performance
Bucket 3 - Testing
Bucket 4 - Softwarization

Progress Report - Bucket 1 - AI/ML for Spectrum Sharing

Bucket 1: AI and ML for Spectrum Sharing and Management

1.1 Explore the use of AI/ML methods to improve the utilization and administration of spectrum (licensed, unlicensed, and shared) based on the fundamental characteristics of propagation, interference, signal processing, and protocols. How could the scalability aspect of AI/ML algorithms support such methods by use of techniques such as parallelization, dimensionality reduction, sampling, and approximation?

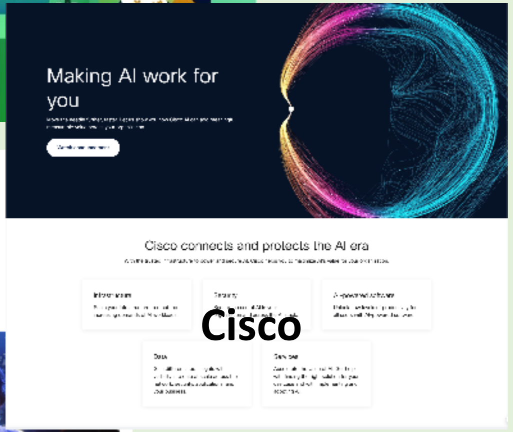
1.2 How can AI/ML be leveraged to help better understand real-time spectrum usage, either at the front end (e.g., improved sensing) or the back end (e.g., improved analytics)?

Bucket 1 - AI/ML for Spectrum Sharing

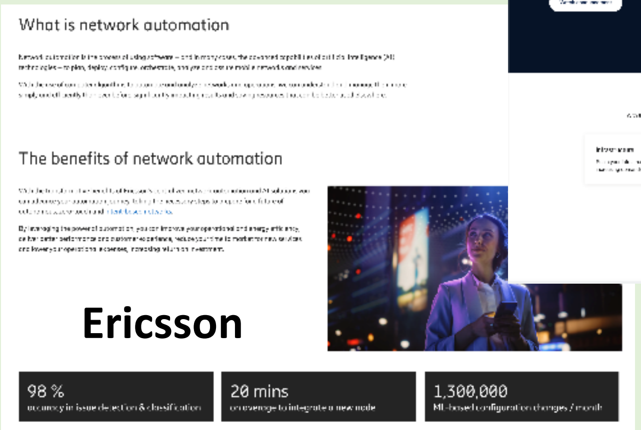
Propagation Models and AI for Spectrum Sharing (Part of Bucket 1)

Nokia

Cisco



Ericsson



Ericsson

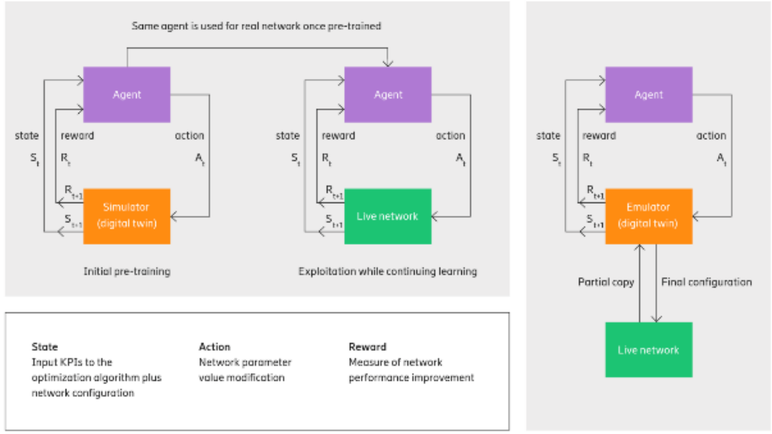


Figure 25: Live networks using simulators and emulators as digital twins

Digital twins enabling rewards from first implementation

Digital twins are a suitable solution to avoid the effects of erratic initial explorations on live mobile networks. Exploration is performed on an external entity that mimics the behavior of the live network. Once the agent has acquired all the necessary knowledge from the digital twin, the achieved policy can be safely applied to the live network. From that moment onwards, the agent will decide optimal actions on the live network, while continuing to learn from its feedback and also allowing a configurable degree of controlled exploration.

Typically, two types of digital twins can be considered for initial offline learning: emulators and simulators, as shown in Figure 25. An emulator contains a partial replica of the live network, providing accurate results but requiring big data techniques for efficient operations. A simulator is a software program that models the behavior of a network based on a set of hypothetical scenarios. In many cases, simulators are suitable to capture general trade-offs and trends.

Summary: Considerable activity and investment in AI for improving utilization and sharing of spectrum.

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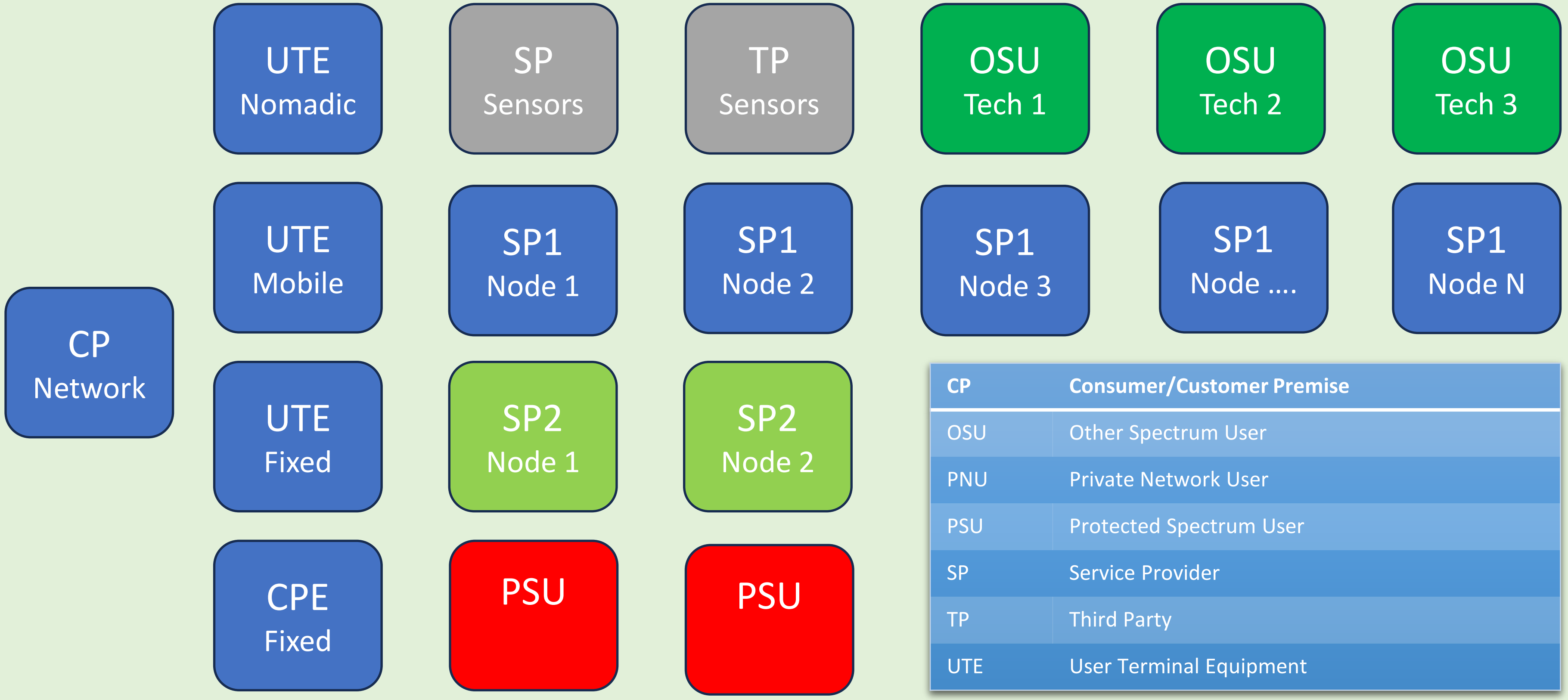
Bucket 1 - AI/ML for Spectrum Sharing

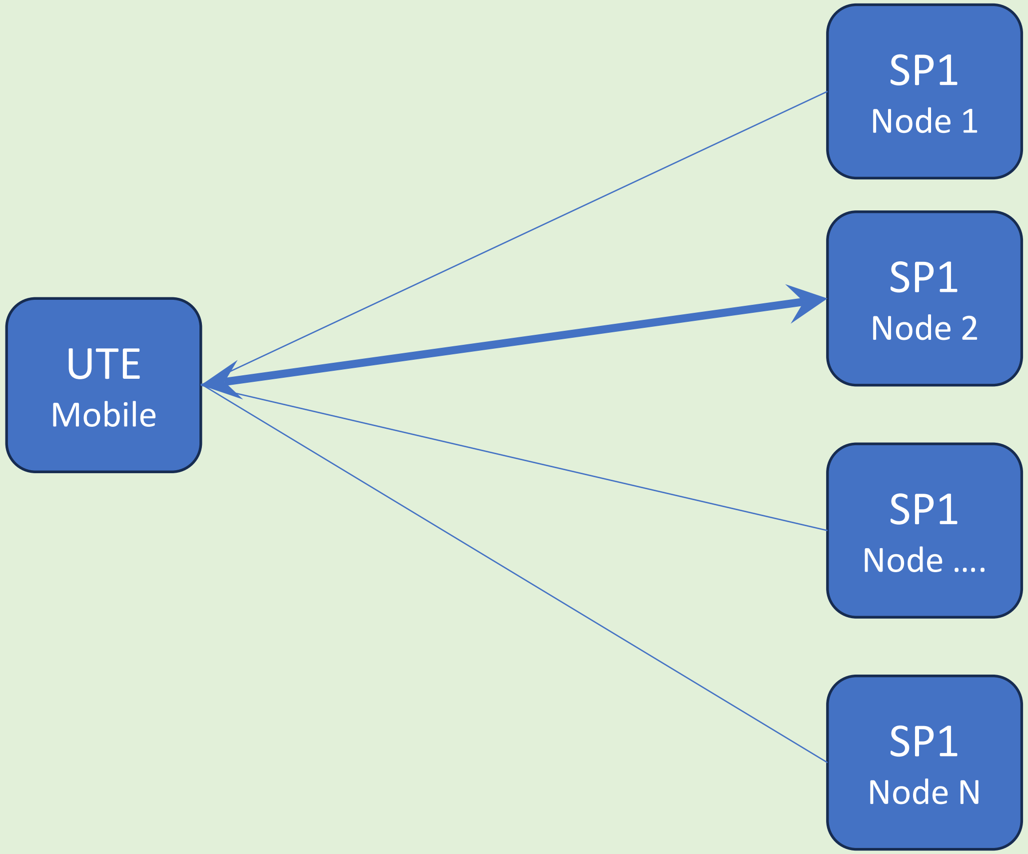
Propagation Models and AI for Spectrum Sharing (Part of Bucket 1)



CP	Consumer/Customer Premise
OSU	Other Spectrum User
PNU	Private Network User
PSU	Protected Spectrum User
SP	Service Provider
TP	Third Party
UTE	User Terminal Equipment

Bucket 1 - AI/ML for Spectrum Sharing

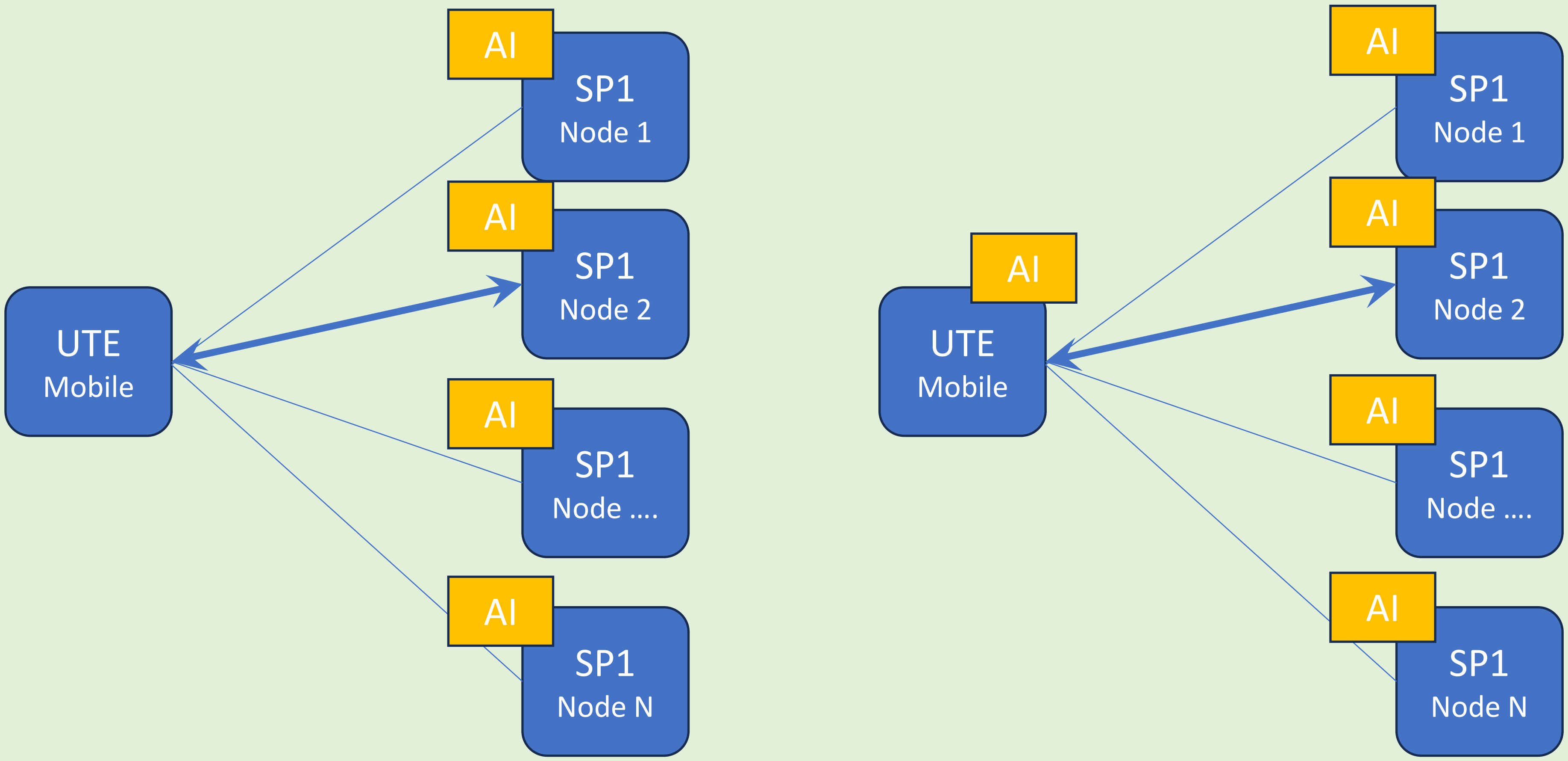
Propagation Models and AI for Spectrum Sharing (Part of Bucket 1)



1. Provide Best Service to UTE
2. Minimize
   - Signal Elsewhere
   - Power
   - Etc
3. Optimize Parameters for Local Conditions
4. Guarantee Protection for PSUs
5. Co-Exist with other spectrum users
6. Contribute to Maximize Available Spectrum

Bucket 1 - AI/ML for Spectrum Sharing

Propagation Models and AI for Spectrum Sharing (Part of Bucket 1)



Bucket 1 - AI/ML for Spectrum Sharing

Propagation Models and AI for Spectrum Sharing (Part of Bucket 1)

Parametrized Statistical Models a la 3GPP
Generative Channel Models (ML Models Conditioning on use cases – Proof points but not widely used.)
Fast Ray Tracing Models (Calibrated with local measurements)

Other Data Driven Models
Existing work on CBRS

Ultimate Goal: Using ML to Choose the model for each location and local conditions with a time dimension and real-time

Bucket 1 - AI/ML for Spectrum Sharing

Propagation Models and AI for Spectrum Sharing (Part of Bucket 1)

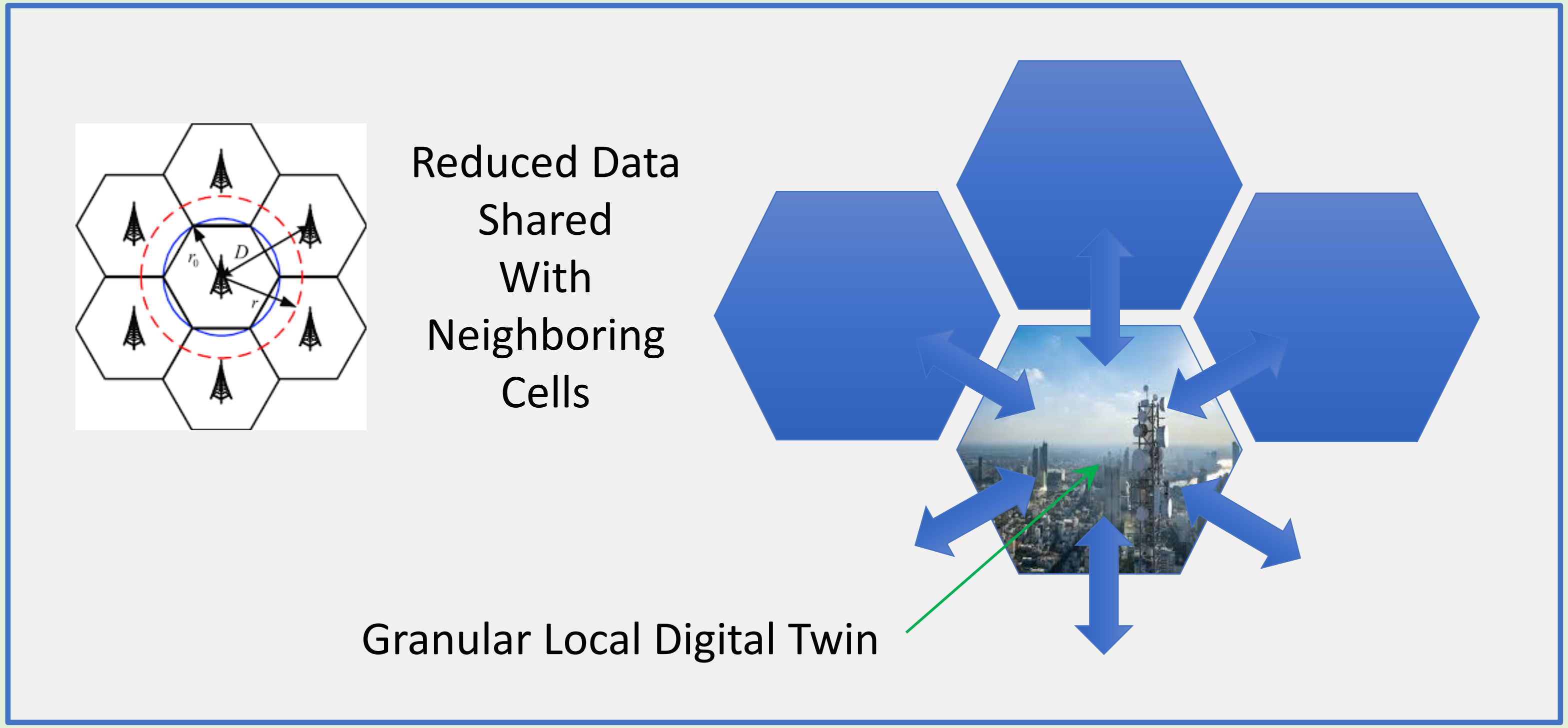
Study Group 3 ITU how to apply AI/ML to Propagation
- Reference Model to Use – balance with data driven approaches
- Minimize features and Data Needs

Need to develop metrics for quality of results (validation methods and measure vs data)

Use of Simulation and emulations (for modeling and understanding performance and as a source of synthetic data)

Bucket 1 - AI/ML for Spectrum Sharing

Digital Twins and Automation



Growing literature and experimentations.

Progress Report - Bucket 2 - Network Safety, Security, Assurance, and Performance

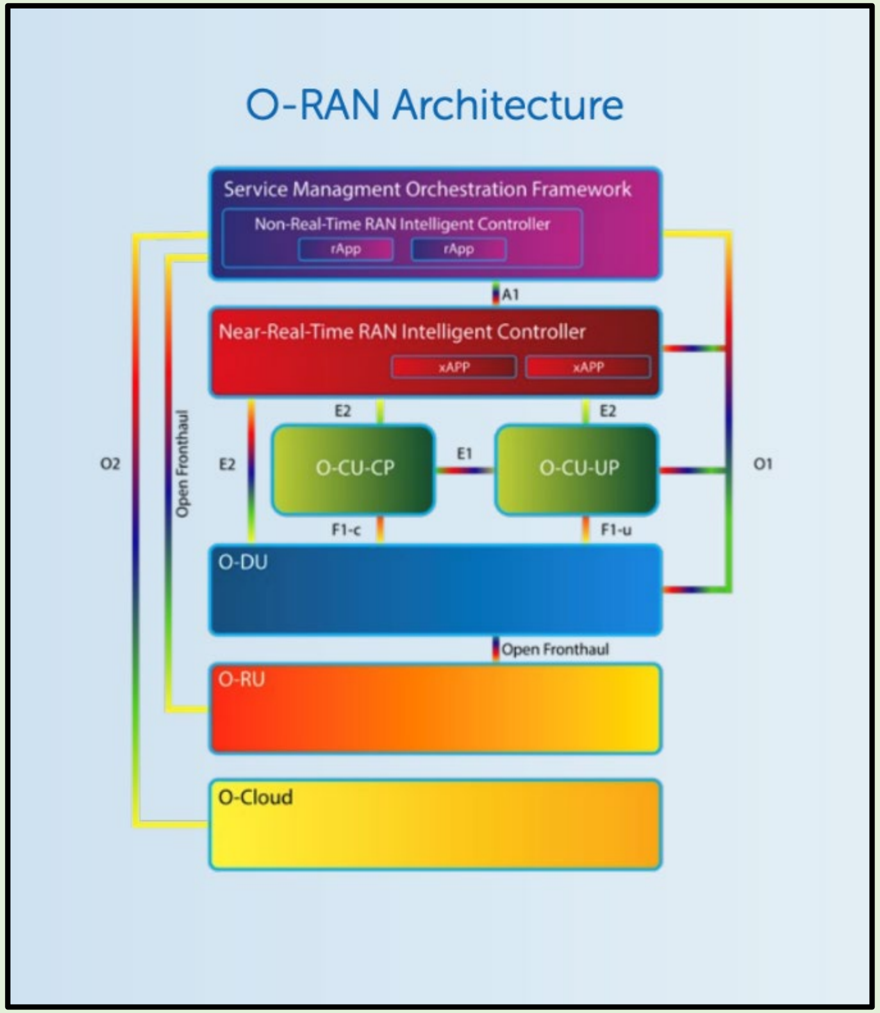
Bucket 2: Network Safety, Security, Assurance, and Performance

2.1 Evaluate the use of AI/ML methods and techniques applied to assuring the safety, security, and performance of network equipment, network control, and network operations in a network environment that increasingly relies on automation, is seeing a rapid growth of new network connections, and is increasingly digitized and softwareized.

2.2 Explore and evaluate AI-enabled networks in optimizing long convergence time, memory complexity, and complex behavior of machine learning algorithms under uncertainty as well as how the highly dynamic channel, traffic, and mobility conditions of the network contribute to the challenges of AI networks.

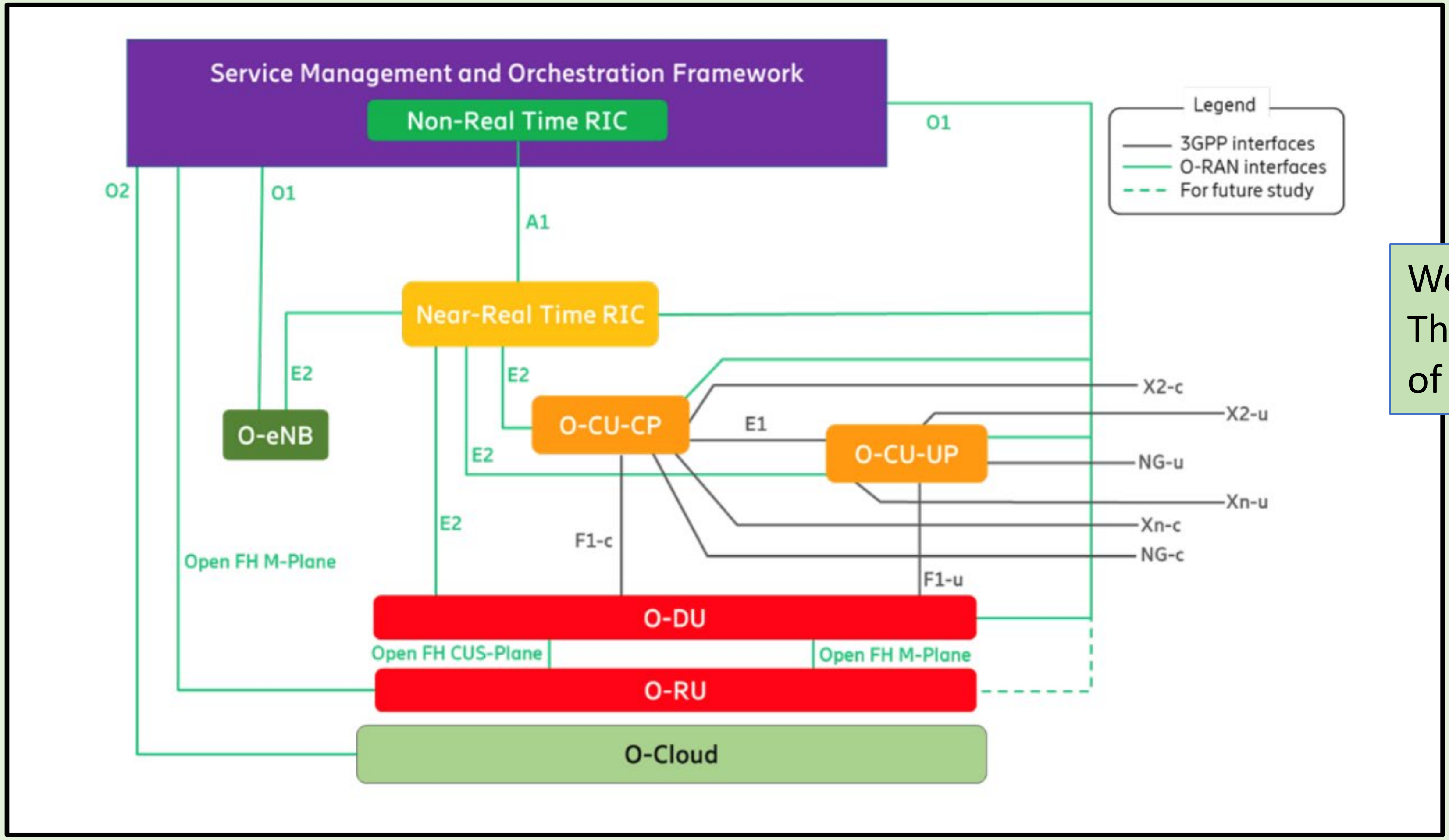
2.3 How can AI/ML techniques be used to address the challenges of data quality, availability, privacy, and security in wired and wireless networks, such as data cleansing, data fusion, data anonymization, and data protection?

Bucket 2 - Network Safety, Security, Assurance, and Performance



A priority use case for Application of AI/ML

Bucket 2 - Network Safety, Security, Assurance, and Performance



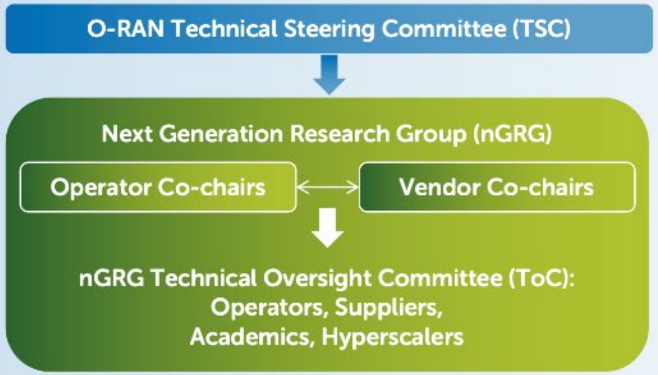
Well identified interfaces! The challenge is the number of parameters involved.

Bucket 2 - Network Safety, Security, Assurance, and Performance

O-RAN Next Generation Research Group (nGRG) Structure and Research Streams

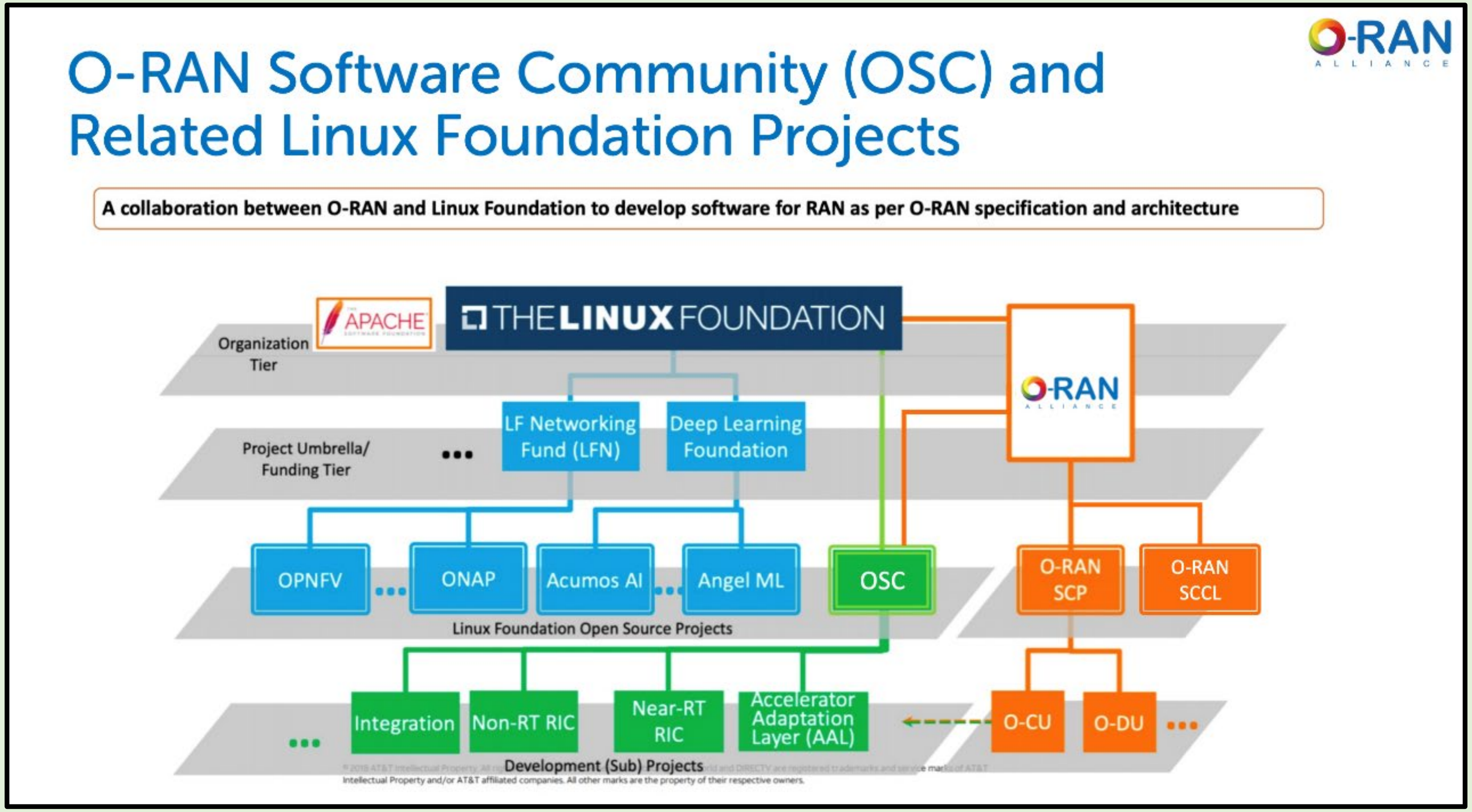
O-RAN ALLIANCE

The nGRG focuses on research of open and intelligent RAN principles in 6G and future network standards



	Research Streams
RS01	6G use cases and standard gap analysis
RS02	Architecture towards 6G O-RAN
RS03	Native AI and cross domain AI
RS04	Native security
RS08	nG Research Platform

Bucket 2 - Network Safety, Security, Assurance, and Performance



Progress Report – AIWG Softwarization SWG
Bucket 3 Testing Charter

Bucket 3: Testing Regimes for AI/ML in Telecommunications

3.1 What approaches should be taken, if any, on testing and certification of AI/ML softwarization of network components, capabilities, and equipment?

3.1.1 Testing and Certifying Systems that have AI/ML Inside

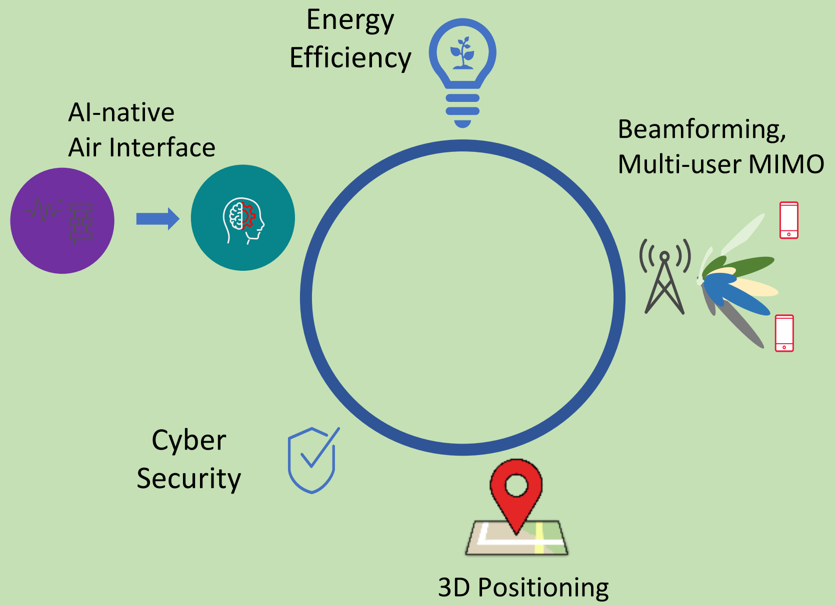
3.1.2 AI/ML for Testing and Certifying Components and Systems

Industry Trends, Testing & Certification: Testing Systems With AI Inside

Bucket 3.1.1

- Communication systems are trending toward more AI inside, some examples:
  - There has been significant ramp up of AI/ML in 5G networks
  - O-RAN RAN Intelligent Controller (RIC) architecture
    - Open interfaces to telecom modules to extract data, apply AI models
  - 3GPP has been working on AI use cases for a few years
    - These include beam management, positioning and channel state compression
  - The IMT-2030 vision (which will be the basis for 6G standards) prominently calls out ubiquitous AI.

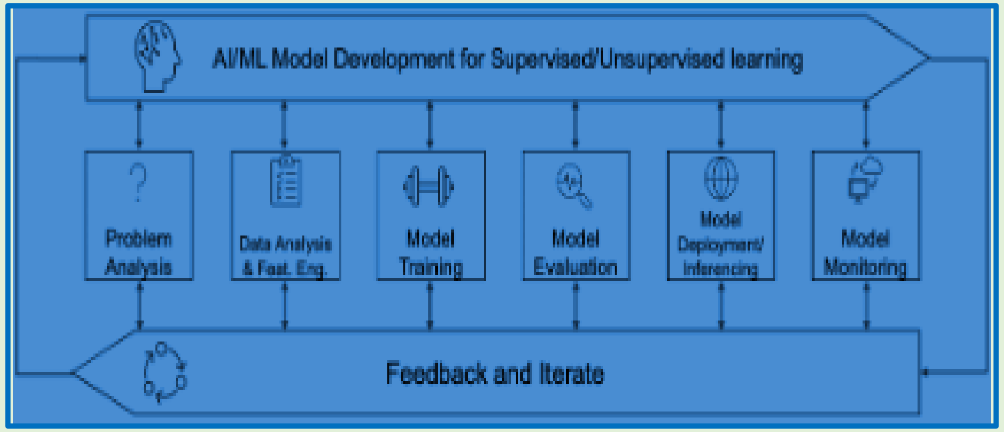
Communication Use Cases for AI



Industry Trends, Testing & Certification: Testing Systems With AI Inside (Continued)

Bucket 3.1.1

- Diverse communication use cases, some examples:
  - Physical layer improvements:
    - AI Receiver or "1-sided" ML – self-contained, proprietary
    - AI Transceiver or "2-sided ML" – may require standardization
  - MIMO beam selection & management
  - Network level planning and performance optimization
  - Energy Optimization

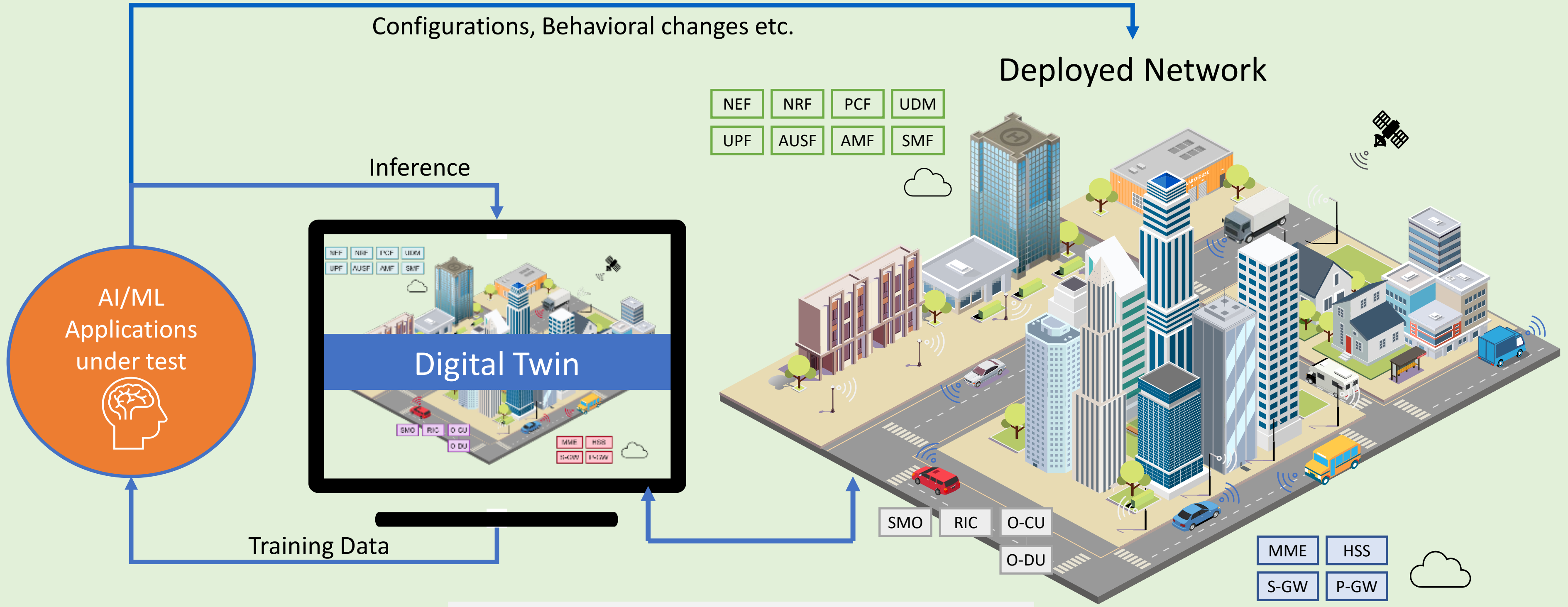


- End to end AI Lifecycle Management approach, adapted to Telecommunications, is needed
  - Data governance, data security should be key parts of this framework

Digital Twins for Training and Testing/Evaluation of AI/ML performance

Bucket 3.1.1

Integrated modeling of network, environment and users at scale (aka Digital Twin)
Enables validation of AI/ML solutions to complex RAN optimization problems

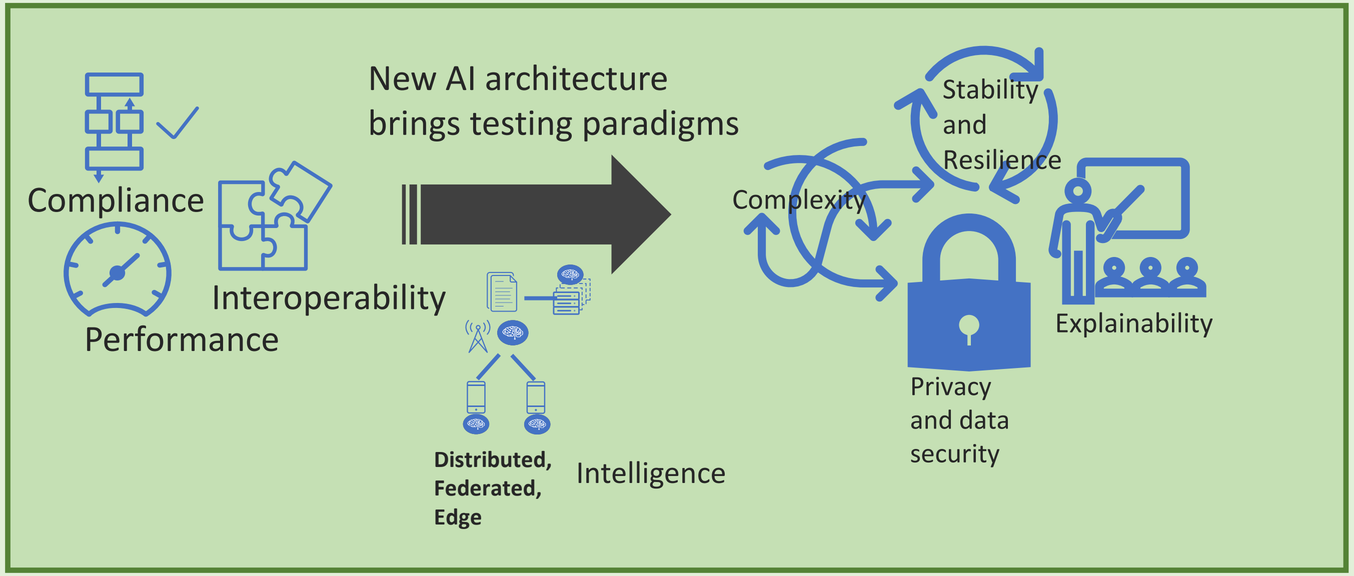


- Generation of synthetic training data for model training
- End to end performance evaluation & optimization
- Continuous monitoring of real network performance (+Retraining based on need)

Testing and Certification of systems with AI

Bucket 3.1.1

- Telecom-industry hasn't yet created robust testing and evaluation methodologies for AI models, but lot of discussion and debate is under way
  - **3GPP TR 38.843, v18.0.0, "Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface"** - https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3983 -
  - **O-RAN nGRG Research Report on Principles and Test Methodologies for AI/ML Testing in next generation networks** - https://www.o-ran.org/blog/first-research-reports-published-by-o-ran-ngrg-address-the-use-cases-ai-ml-and-security-aspects-of-6g-mobile-networks



Testing and Certification of systems with AI (Continued)

Bucket 3.1.1

- **Security considerations regarding use of AI will require special consideration in testing**

- **Regulations and guidelines/frameworks**:
  - **EU AI Act** - https://artificialintelligenceact.eu/the-act/
  - **NIST guidelines** - https://www.nist.gov/artificial-intelligence/ai-standards
  - **MLCommons** - https://mlcommons.org/
  - **MITRE framework** - https://www.mitre.org/focus-areas/artificial-intelligence
  - **SEI Carnegie Mellon** - https://www.sei.cmu.edu/about/divisions/artificial-intelligence-division/

- **FCC-driven test framework**
  Material & Human infrastructure maybe needed

Communications Testing Spectrum

Buckets
3.1.1 and 3.1.2

Trend: Complex, software-defined, continuous world

AI/ML may be crucial here

One-time test	Automated test	Continuous Monitoring/Testing
Static testing	Push-button lab testing	Always testing while live system is running AI behavior drift

Reference for automated test: Ericsson Blog - How automated testing can help address the Open RAN deployment challenges

Reference for continuous monitoring (for security): O-RAN Alliance Blog - continuous monitoring, logging, and alerting are on the journey to zero-trust security

Some Opportunities to use AI for Testing

Bucket 3.1.2

- Test configuration
  - Reduce complexity to use instrument / test platform
  - Save time via intelligent auto-configuration
- Test sequencing
  - Choose the best subset of test scenarios
  - Save time by schedule ordering
- Security testing
  - ‘Benign attacker” vulnerability probes
  - Threat pattern detection and learning
- Reliability testing
  - Generate outlier conditions to test
  - Detect / predict semiconductor process drift

Progress Report - Bucket 4 - Softwarization

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 4: Softwarization of Telecommunications

4.1 What are the opportunities for the Commission to use AI/ML to improve its analysis of data presently collected and housed in databases like ULS?

4.2 What are the implications and complications of using AI/ML in optimizing wireless and wired networks performance by analyzing network traffic patterns, network failures, proactive corrective actions, network routing, and predicting network congestion?

4.3 How can AI/ML techniques be used to support the integration and interoperability of wired and wireless networks, such as heterogeneous access networks, multi-domain networks, and adaptive network slicing?

4.4 How can AI/ML techniques be used to design and implement novel network architectures and protocols for wired and wireless networks, such as software-defined networking (SDN), network function virtualization (NFV), and information-centric networking (ICN)?

Eco-system

AI adoption is pervasive across all aspects of the Telecom eco-system

	Areas of Expertise/Strength		Goal
Regulators, Standard Orgs, Industry Alliances	Policy, Regulations, Standards	→ Through cooperation, securing technology completeness →	Interoperability Security National Priorities
Operators	Network/Traffic Data	→ Through cooperation, securing technology completeness →	New Services/ New products
Vendors	Communication Algorithm Knowledge	→ Through cooperation, securing technology completeness →	OpEx Efficiency Cost reduction
AI Companies	AI Knowledge / Training Infra	→ Through cooperation, securing technology completeness →	Planning/Development CapEx Reduction

Source: Please see References slide

Regulators, Standard Orgs, Industry Alliances

- **Regulators/Government**
  - FCC, NTIA, FTC, FCPA, NIST, ETSI, ECC, EU AI Office, ……..

- **Standard Organizations**
  - ITU: National spectrum allocations and spectrum governance
  - 3GPP(GSM): Operators and Vendors to create the specifications for Worldwide standards
  - User Equipment Suppliers who develop de facto standards (Android, Arm, Apple, …)

- **Industry Alliances**
  - GSMA, GSA, CTIA, ATIS, GTAA, AI-RAN Alliance, ………

Takeaway: AI in Telecom has a rich ecosystem, and many stakeholders – difficult environment for industry (especially smaller players)!

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Trends - Operators
AI as an Opportunity for Growth (New Services or Enabling Infrastructure)

- **Proactive cooperation with AI companies is being pursued**
  - Development and utilization of LLM, discovery of new AI consumer and enterprise services
  - Building an AI infrastructure using installations (Cloud Data Centers) and hardware (GPUs …..)

Operator(s)	Partner(s)	Contents
AT&T	Google	AT&T and Google Cloud Team Up (MEC for AI)
AT&T	Microsoft	AT&T creates ChatGPT-based tool for coders with help from Microsoft
NTT	NVIDIA	Enabling the World's First GPU-Accelerated 5G Open RAN for NTT DOCOMO with NVIDIA Aerial
SKT/DT		SK Telecom and Deutsche Telekom develop LLM for telcos
SKT	Small AI ventures	SKT Discusses 'K-AI Alliance' in Silicon Valley
SKT, DT, e&, Singtel		SK Telecom, Deutsche Telekom, e&, and Singtel Form Global Telco AI Alliance for Collaboration and Innovation in AI
SoftBank	NVIDIA	SoftBank Solves Key Mobile Edge Computing Challenges Using NVIDIA Maxine
Uplus	Google/Microsoft	LG U+ Develops Communication-Customized AI 'ixi-GEN'
Vodafone	Microsoft	Vodafone signs $1.5 billion Microsoft deal for AI, cloud and IoT

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Network Vendors

- Reducing Expenditure (OPEX, CAPEX) of increasingly complex components and networks, and use of AI-based network efficiency & performance improvement, as well as better planning and development techniques
- Moving towards virtualized architecture running software-defined functions on commodity equipment.

Automation / OPEX reduction

- Increase network efficiency
- Energy reduction
- Network Optimization
- Troubleshooting/recovery

Framework/Infra

Data/Model Infrastructure Structure

- AI/ML Data Management
- Life Cycle Management of AI/ML

Performance improvement

- Apply to various network components and funcational layers

H/W, S/W

H/W platform

- GPU-based cooperation with NVidia Omniverse
- Acceleration of CPU/DSP/AI chip in NE
- Edge and Cloud Data Centers

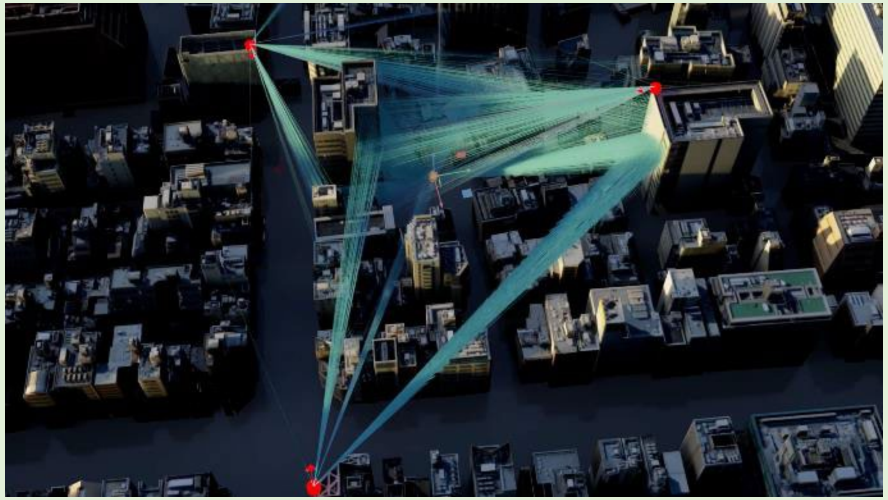
S/W platform

Related References

- Telecom AI (Ericsson)
- AI-Native Air-interface

AI companies

- **NVidia, Google, Microsoft, Apple, Amazon, …**
- **AI related companies are also expanding their shares in the telecommunications market by using their AI knowledge / training Infra**
- **Recently Nvidia has actively engaged with the telecom industry**
  - Claim GPU-based vRAN (virtualize RAN) can match CPU-based vRAN in price/performance
  - Championing “Multi-tenant” vRAN concept. Common HW for RAN and LLM. NTT/Softbank trials



Related References:

- [NVIDIA Unveils 6G Research Cloud Platform to Advance Wireless Communications With AI]

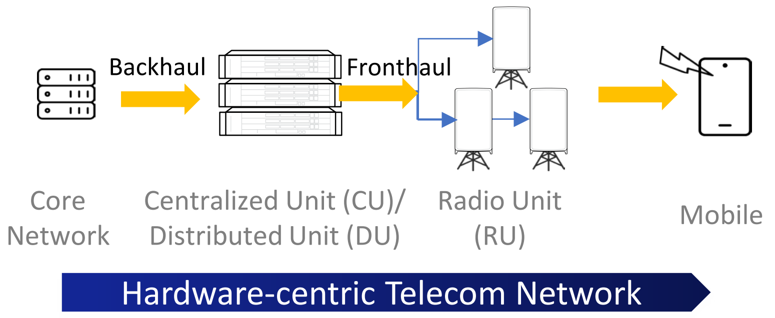
Trends
AI in Mobile Networks & 6G

Telecom Trend Beyond 5G and 6G

Softwarization, Virtualization, AI-Native

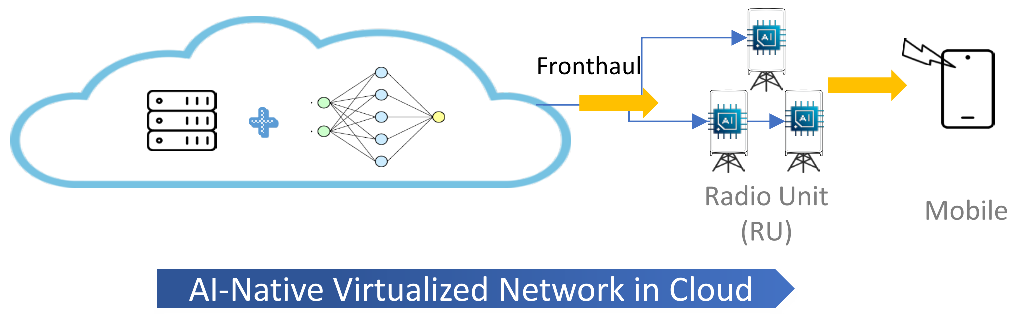
Today

- **Complex network with customized H/W**
- **High maintenance and upgrade costs**



Future

- **AI, Virtualization and Cloudification for scalability & flexibility**
- **Low maintenance costs and flexible upgrades**



Takeaway: AI dramatically lowering OPEX and CAPEX!

Related References:

- State of AI in Telecommunications: 2024 Trends
- Telecom Industry Trends: Shaping the Future in 2024

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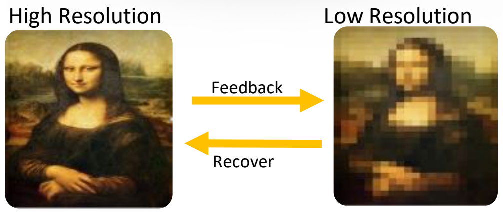
AI for Future Telecom

- **Wireless communication system could be automated end-to-end and optimally operated/managed using AI**

AI for L1/L2 Radio



AI Channel Estimation & Prediction

AI Precoding & Scheduler

AI for Network Automation

Network Analytics

Network Parameter Optimization

Telco LLM

Intent-based Optimization

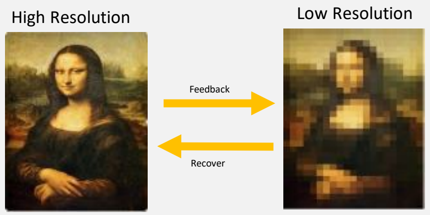
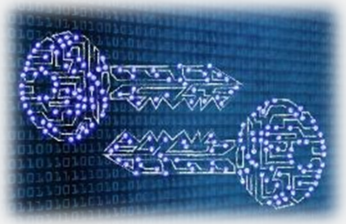
Multi-tenancy LLM

Related References:

- AI-Native Air-interface
- Network Automation and AI
- GTAA Launching a Multilingual Telco LLM

Takeaway: Automated network control and management – AI-Native Scalability/Reliability!

Attributes and Technologies for 6G

New attributes	**AI-Native**	**Sustainable Network**	**Ubiquitous Coverage**	**Quantum-Safe/ High Resilience**
				
Enabling Techs	AI channel Restoration/generation	NW/UE Power Saving w/ RF Innovations	FR1 Distributed MIMO & FR2 Joint Time & Phase Array	Post-Quantum Cryptography
	AI optimization	New mod./coding/waveform	FR3 Hybrid X-MIMO	Zero Trust Architecture
	AI network automation	Scalable vRAN	Multi-Connectivity Network (Ground & Satellite)	Reliable Cloud vRAN

Underlying attributes: Data Rate | Latency | Capacity | Spectrum Efficiency | Connection Density | Mobility

Related References:

- The Future of 6G Cellular Networks
- 6G: Future Telecom in AI Era - IEEE NOMS 2024 Keynote

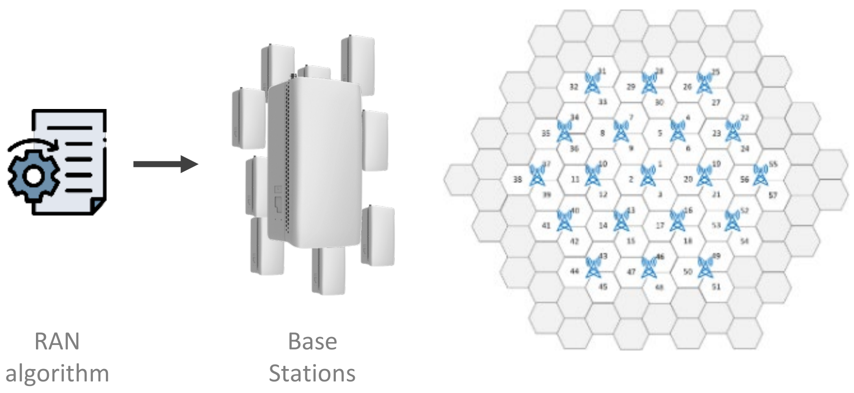
Takeaway: Pervasive impact on all attributes!

Example - Self-learning 5G/6G network with AI

AI enables customized design for each cell with site-specific optimization

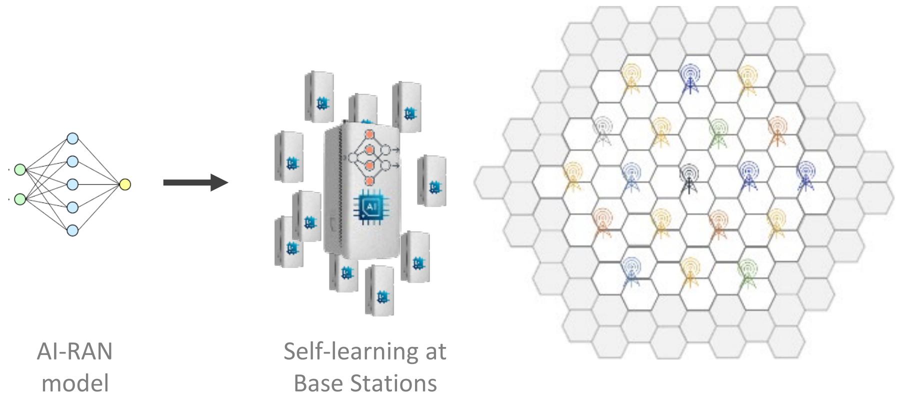
Today

One solution for millions of base stations



Future

A million solutions for a million base stations

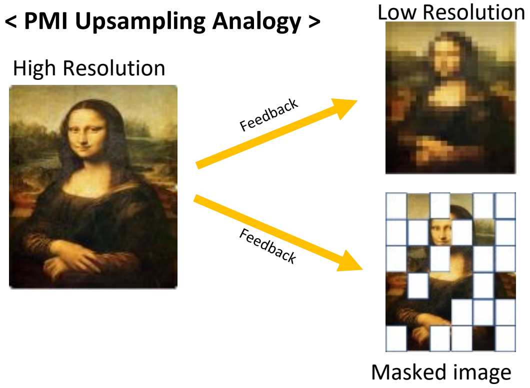


Related References:

- [Self-Learning and Adaptive Networking Protocols and Algorithms for 6G Edge Nodes]
- [Self-Evolving Wireless Communications: A Novel Intelligence Trend for 6G and Beyond]

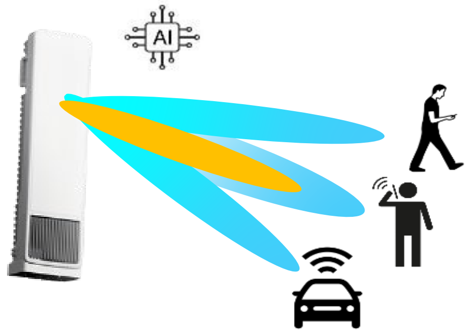
Example - AI-Native Intelligent Radio: Promising Areas

AI to Fill Missing Info



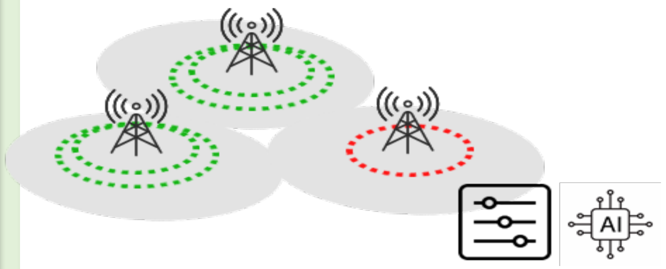
- Channel upsampling
- SCell prediction
- Digital-twins for channel model

AI for Optimization



- PHY: Channel estimation/prediction.
- MAC: MU scheduling, link adaptation, MIMO mode switch
- Power saving

AI for Automation
(ORAN rApp)



- Network analytics
- Network parameter optimization

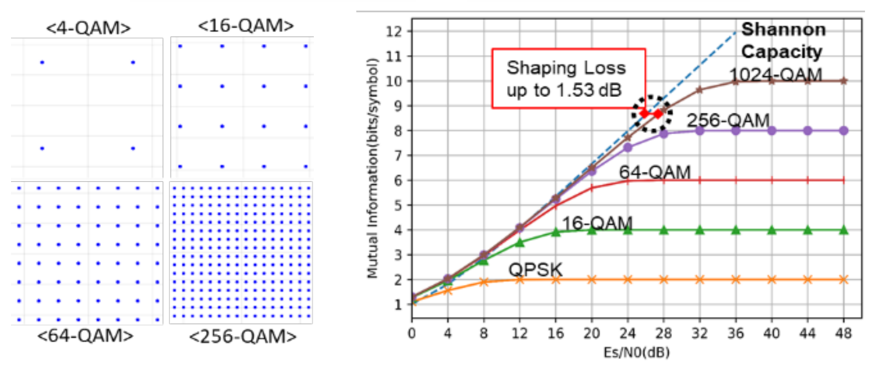
Related References:

- Researchers Propose Digital Twinning of 6G Networks
- Advancing 6G Network Performance: AI/ML Framework for Proactive Management and Dynamic Optimal Routing
- Distributing Intelligence for 6G Network Automation

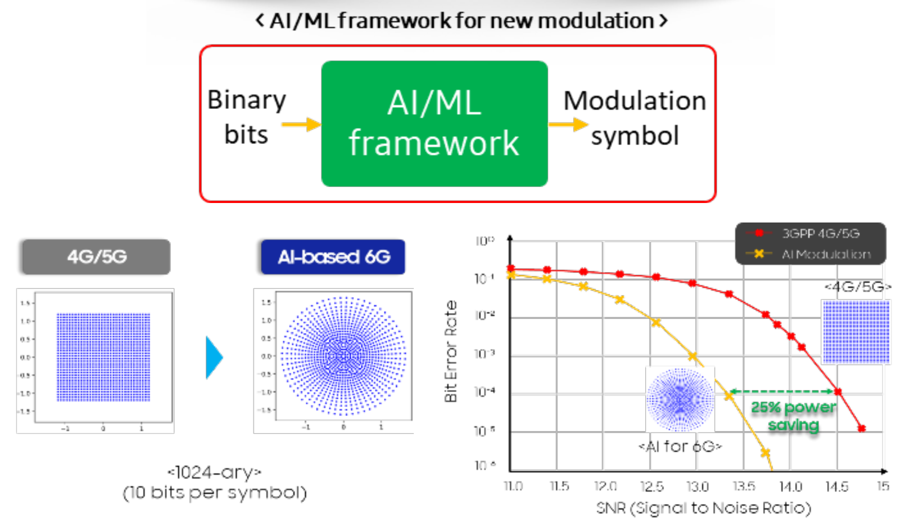
Example - Energy Efficient Modulation with AI

- Square QAMs have been employed in 3G/4G/5G and Wi-Fi standards for decades
- They have up to 1.53 dB gap (42% more power required) to an ideal performance
- AI/ML-based modulations outperforms 256-QAM and 1024-QAM by 0.7 dB and 1.2 dB, respectively

Conventional Modulation



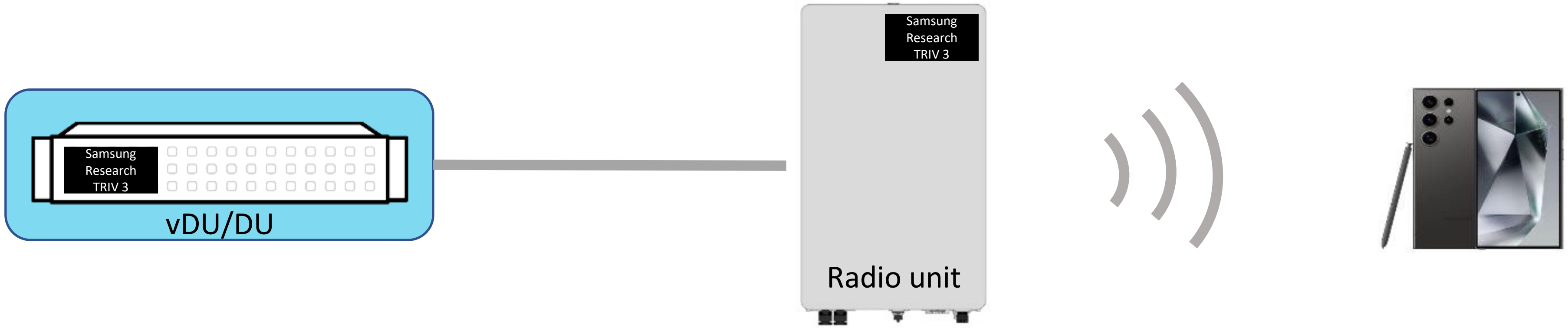
AI/ML-based New High-order Modulation



Related References:

- [6G: Future Telecom in AI Era - IEEE NOMS 2024 Keynote]

Example - AI Modem Vision (Robustness & Resiliency)



- High capacity (>5Gbps) all-SW vDU (w/ SW LDPC)
- **1.5X** downlink and uplink Tput
- **2X** supported cells

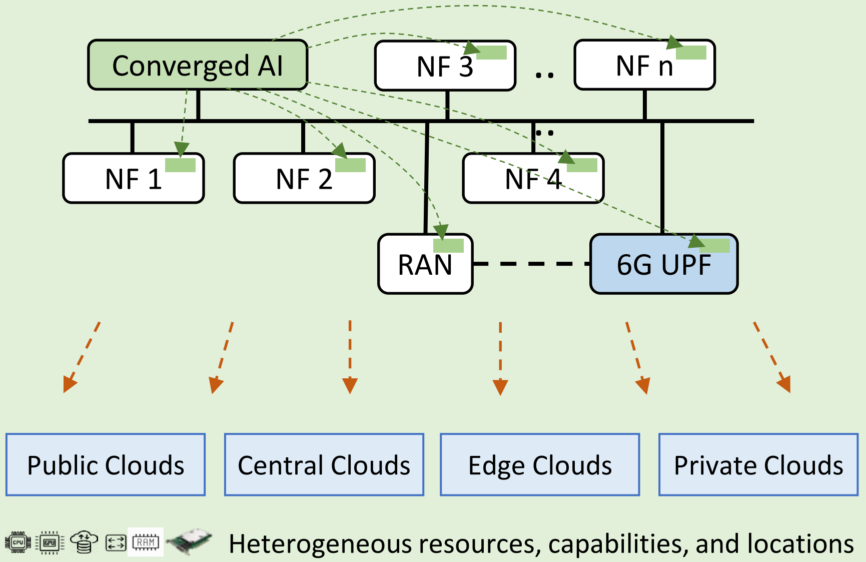
- **1.5X** downlink and uplink Tput
- **2X** uplink coverage
- **2X** carriers/bandwidth

Significantly improved user experience
- **30-50% less** call drop rate
- **20-30%** power saving

Source: Samsung Research America (SRA)

Implications - Cloud-native 6G System Architecture

- System architecture enhancement to fully utilize the flexibility over the heterogeneous clouds with the extended SBA, RAN-CN convergence, etc.



Potential approaches under consideration

- **Extended service-based architecture**
  - ✓ Applying SBI extended across RAN and CN
  - ✓ Flexible NF deployment in heterogeneous cloud
- **Optimization across RAN and CN**
  - ✓ Utilizing common cloud platform for both RAN and CN
  - ✓ Redefining NFs in a more efficient way by reducing dependency and redundancy among NFs
- **Data/AI management architecture**
  - ✓ Unified data/AI framework for RAN and CN

Related References:

- 6G Cloud-Native System

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Summary

- We see introduction of AI in existing networks and pervasive plans in all future generation network developments.
- The AI Ecosystem is very large and complex. The use of spectrum, agreement on standards, and ingestion of end user technologies, mandates a significant learning curve. This requires close attention and mechanisms for collaboration to share learnings across the community/stakeholders could have significant positive impacts.
- AI is likely to drive three outcomes:
  - Considerable amount of experimentation, pilot deployments, and investment in the learning curve to overcome the challenges and issues for maturing AI Technologies.
  - Creation of new and unanticipated services and products.
  - A change in the economics of both OpEx and CapEx of telecom networks and operations (Ranging from the nature of Business Models to the Operation of Telecommunication Assets)

References (Continued)

- **Telecom AI (Ericsson)** - https://www.ericsson.com/en/ai
- **AI-Native Air-interface** - https://www.bell-labs.com/research-innovation/what-is-6g/6g-technologies/ai-native-air-interface#gref
- **NVIDIA Unveils 6G Research Cloud Platform to Advance Wireless Communications With AI** - https://nvidianews.nvidia.com/news/nvidia-unveils-6g-research-cloud-platform-to-advance-wireless-communications-with-ai
- **State of AI in Telecommunications: 2024 Trends** - https://resources.nvidia.com/en-us-ai-in-telco/state-of-ai-in-telco-2024-report
- **Telecom Industry Trends: Shaping the Future in 2024** - https://www.ilink-digital.com/insights/blog/telecom-industry-tech-trends-shaping-the-future-in-2024/
- **Network Automation and AI** - https://www.ericsson.com/en/network-automation/network-automation-and-ai
- **GTAA Launching a Multilingual Telco LLM** - https://www.telekom.com/en/media/media-information/archive/agreement-jv-for-telco-specific-llm-1068392

References (Continued)

- **The Future of 6G Cellular Networks** - https://www.6gworld.com/blog/6g-cellular-networks/
- **6G: Future Telecom in AI Era - IEEE NOMS 2024 Keynote** - https://noms2024.ieee-noms.org/program/keynotes
- **Self-Learning and Adaptive Networking Protocols and Algorithms for 6G Edge Nodes** - https://ieeexplore.ieee.org/document/10179645
- **Self-Evolving Wireless Communications: A Novel Intelligence Trend for 6G and Beyond** - https://arxiv.org/abs/2404.04844
- **Researchers Propose Digital Twinning of 6G Networks** - https://www.6gworld.com/exclusives/researchers-propose-digital-twinning-of-6g-networks/
- **Advancing 6G Network Performance: AI/ML Framework for Proactive Management and Dynamic Optimal Routing** - https://www.computer.org/csdl/journal/oj/2024/01/10522874/1WMgpeh8IoM
- **Distributing Intelligence for 6G Network Automation** - https://ieeexplore.ieee.org/document/10279655
- **6G Vision, Key Enablers and Timeline – IEEE IMS 2024, Future G Summit** - https://2024.ims-ieee.org/

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Summary

Since the last TAC Meeting the AIWG has concentrated on identifying

- Industry Trends
- Technology Maturity
- Likely Areas of Impact

The AIWG has also heard from a number of SMEs about progress and prospective uses of AI for priority Use Cases.

Recommendations – Short Presentation Format

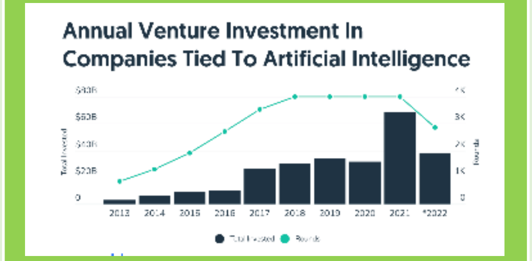
Issues Addressed

1. Spectrum Sharing and Management
2. Safety, Security, Assurance, and Performance
3. Testing Regimes for Telecommunications
4. Softwarization of Telecommunications

Strategic Priorities

1. "100 Percent Broadband"
2. Empower Consumers
3. Advance US Global Competitiveness
4. Public Safety and National Security
5. Foster Operational Excellence
6. Diversity and Inclusion

Industry & Federal Trends



Considerations

1. The FCC's Strategic Priorities
2. Industry Trends
3. Technology Maturity
4. Timeliness
5. Impact

The FCC
Service Providers
Consumers
Industry
The Public Sector

Inputs

1. AIWG SME Discussions
2. External Presentations
3. Supporting Documents
4. FCC Liaisons

Nature of Recommendations

In Process

Deliverables

Appendix

Speakers

Speaker	Talk Title	Date		
Andy Clegg	Propagation Challenges	May 1st		
Parul Kapur	AI and ML Status of Legislation and Regulations	May 22nd		
Aniket Bera Purdue	Details of AI Model Building - LLMs	June 5th	Tim, Tian George Mason	
Etienne Chaponniere	Regulations and Legislation (EU, US, etc)	June 12th	Jack Nasielski Qualcomm	
Tim O'Shea Deepsig.AI	AI and ML – Understanding what's in the Spectrum	June 19th		
Rajesh Gadiyar Nvidia	AI/ML Digital Twins for Telcos	June 26th	Bejoy Mavenir	

Speakers

Speaker	Talk Title	Date		
Michele Polese Northeastern	AI/ML in Radio Access Networks	August 7th		
Alex Jinsung Choi O-RAN Alliance and DT	O-RAN Alliance AI/ML WG Plans and Progress	August 21st		
Nageen Himayat	Progress on use of AI/ML In Wireless Networks	September		
Rodney Brooks MIT - CSAIL	The Promises and Limitations of AI	October		

Andrew M. Clegg

CTO, Wireless Innovation Forum, and Spectrum Engineering Lead at Google

Background: Andrew Clegg is Spectrum Engineering Lead for Google, where he was one of the principal architects of the CBRS band. He also serves as the Chief Technical Officer for the Wireless Innovation Forum (WInnForum). He represents WInnForum on the FCC Technological Advisory Council where he Co-Chairs the Spectrum Sharing Working Group - SSWG.

Talk Title: What could we learn using AI/ML if we had access to (obfuscated) CBRS deployment data?

Abstract: This talk will describe the CBRS deployment data that are shared among Spectrum Access Systems each evening, from which aggregate interference calculations and other tasks are performed. The interchange specification is in Wireless Innovation Forum Technical Standard TS-0096. FCC rules prohibit the release of data about specific CBSDs (96.55(a)(3)), and permission from the SASs would need to be obtained to access even obfuscated data. A manner will be proposed to obfuscate the data (and additional proposals would be welcome), and then the question will be asked to the group if there is something to be learned by applying AI/ML techniques to the resulting dataset, if such a dataset were available.

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Parul (Paula) Kapur

Founder Kap Ocean LLC

Background: Parul (Paula) Kapur is a Founder of Kap Ocean LLC, an Artificial Intelligence and Innovation consulting firm. Her focus is on Artificial Intelligence, Innovation and Partnership initiatives. Paula has expertise in Strategy, Policy, Ethics, Responsibility, Risk and much more. She focuses on Telecommunications, Medical, and Software technologies. Paula is also an Intellectual Property and Patent Attorney. She has a JD, a MS in Electrical Engineering and a BS in Biomedical Engineering. Moreover, Paula has been a Speaker and Panelist in various Artificial Intelligence, Innovation and Patents activities.

Talk Title: "Legislation, Regulations and Policies Related to Artificial Intelligence and Telecommunications."

Abstract: The presentation will focus on the current status of Legislation, Regulations and Policies related to the use of Artificial Intelligence and Machine Learning, generally applied to Telecommunications. In particular, discussion areas will include Executive Order No. 14410; National Telecommunications and Information Administration; Federal Communications Commission; Federal Trade Commission; European Union Artificial Intelligence Act; Intellectual Property & Artificial Intelligence; and State Legislation & Regulation. Moreover, topics such as robocalls, robotexts and deepfakes will be included in the presentation.

https://www.linkedin.com/in/parulkapur/
https://kapocean.com/index.html

Aniket Bera

Purdue University

Background: Dr. Aniket Bera is an Associate Professor at the Department of Computer Science at Purdue University. He directs the interdisciplinary research lab IDEAS (Intelligent Design for Empathetic and Augmented Systems) at Purdue, working on modeling the "human" and "social" aspects using AI in Robotics, Graphics, and Vision. He is also an Adjunct Associate Professor at the University of Maryland at College Park. He received his Ph.D. in 2017 from the University of North Carolina at Chapel Hill. He is also the founder of Project Dost. He is currently serving as the Senior Editor for IEEE Robotics and Automation Letters (RA-L) in the area of "Planning and Simulation" and the Conference Chair for the ACM SIGGRAPH Conference on Motion, Interaction and Games (MIG 2022). His core research interests are in using Machine Learning models for understanding human behaviors using multi-modalities, Augmented Intelligence, Multi-Agent Simulation, Social Robotics, Autonomous Agents, Cognitive modeling, and planning for intelligent characters.

Talk Title: “Building the Future with Machine Learning and Foundation Models: A Practical Guide.”

Abstract Follows

https://www.linkedin.com/in/abera/
https://www.cs.purdue.edu/homes/ab/

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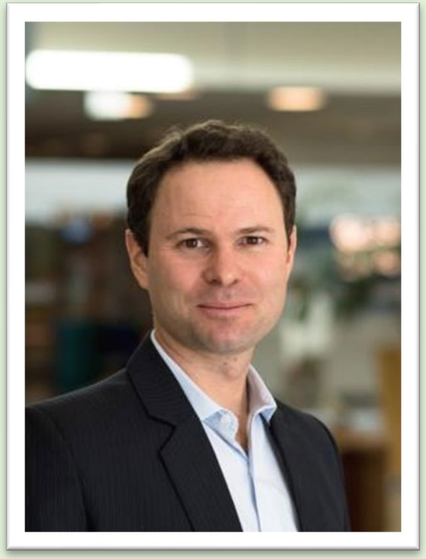
Aniket Bera

Purdue University

Continued

Abstract: Machine learning (ML) and foundation models are at the forefront of technological innovation, driving significant advancements across various industries. This talk offers an introductory guide to understanding these powerful tools. We will explore the essential principles of machine learning, including supervised, unsupervised, and reinforcement learning, providing a solid foundation for understanding how ML models are developed and optimized. The discussion will then shift to foundation models, highlighting their architecture, capabilities, and transformative potential in areas such as natural language processing, computer vision, and more.
Real-world examples and practical applications will be showcased to illustrate how ML and foundation models are being utilized in telecommunications, customer service, and content creation, among other fields. These examples will demonstrate the tangible benefits and challenges of integrating these technologies into existing systems. By the end of this session, attendees will have gained a deeper understanding of the foundational concepts of ML and foundation models, as well as practical insights into their application in modern industries. This talk aims to equip industry leaders with the knowledge and tools necessary to leverage these technologies effectively, fostering innovation and building the future.



Etienne Chaponniere
Vice President
Technical Standards

Qualcomm

Background: Telecommunication professional with 25 years' experience in the cellular industry in ASIC design, System Engineering in 3G & 4G, technical standardization leadership, technical standards group chairmanship and board representation; Etienne Chaponniere, VP of Technical Standards, currently leads Qualcomm's standardization efforts in Artificial Intelligence, Security and regional standards worldwide. Etienne holds a Masters in Télécommunication from the École Polytechnique Fédérale de Lausanne (Switzerland)

Talk Title: "Regulatory and Legislative Landscape for AI/ML in Telecommunications."

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Tim O'Shea
CTO at DeepSig

and

Research Assoc. Professor
Virginia Tech University

DeepSig

Background: Tim O'Shea is a Research Assistant Professor at Virginia Tech and the CTO and Co-Founder at DeepSig Inc in Arlington, VA. He is focused on leveraging machine learning and data-driven approaches within the wireless physical layer to help improve baseband processing spectral efficiency, energy efficiency, and environmental awareness and automation in 5G, 5G Advanced, and 6G. His research focuses also include AI/ML applications in cryptocurrency, cybersecurity, generative applications, and other interesting emerging verticals.

He has run numerous applied R&D efforts for DARPA, NSF, DOD, IARPA, EU HORIZON-2020, Industry, and others. Previously he worked with wireless startups Hawkeye 360 and Federated Wireless in seed stage and held engineering R&D positions with both the US DOD and with Cisco Systems. He is the author of over 100 academic works and patents in this area and is involved in IEEE ComSoc, IEEE MLC ETI, Next-G Alliance, and OpenRAN Alliance, OpenRAN Policy Institute, the GNU Radio project and other efforts to accelerate AI driven communications system technology and its adoption within next generation RAN systems.

Talk Title: "AI/ML for Understanding Spectrum Usage."

https://www.linkedin.com/in/osheatim/
https://nationalsecurity.vt.edu/personnel-directory/oshea-tim0.html

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Rajesh Gadiyar

VP of Engineering
for Telco and Edge

NVIDIA

Background: Rajesh Gadiyar is the VP of Engineering for Telco and Edge at Nvidia. He is building technologies for virtualized 5G Radio Access Network (RAN) in the cloud. A key area of focus for him is the intersection of Artificial Intelligence (AI), Cloud Technologies and 5G/6G Networks. He works with communications service providers (CoSPs) to modernize their networks. Before joining Nvidia in 2022, Rajesh was the Vice President and Chief Technology Officer (CTO) for the Network Platforms Group at Intel. He led the architecture and product development efforts to accelerate cloud native network applications in 5G infrastructure, edge clouds, video processing and AI in Networking and delivered many generations of network server platforms. Prior to joining Intel, he led various engineering teams at Trillium Digital Systems and Wipro Ltd. Rajesh brings several years of experience in networking products, architecture, standards, and software development for Voice over IP, cellular, broadband, mobile telephony, and data networks. Rajesh has a B.S. in Electronics and Telecommunications engineering from National Institute of Technology, Trichy, India, and an MBA from UCLA Anderson School of Management. He is a regular speaker at industry events and conferences

Talk Title: "Digital Twin for 6G Networks."

Abstract Follows

https://www.linkedin.com/in/osheatim/
https://nationalsecurity.vt.edu/personnel-directory/oshea-tim0.html

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Rajesh Gadiyar

VP of Engineering
for Telco and Edge

NVIDIA

Continued

Abstract: Digital Twins are becoming increasingly popular in many industry verticals. Digital twins offer up data and insights that can significantly improve the way their real-world versions operate. There is a real opportunity to create Digital Twins of next generation wireless networks that can foster research and rapid innovations in new algorithms to improve spectral efficiency, network capacity planning for operators, and rapidly debugging complex network issues. Nvidia has developed Aerial Omniverse Digital Twin – a site-specific, large-scale, and highly accurate platform for system level simulation of 5G, 5G adv and 6G radio networks. Our goal is to foster rapid innovations in 1) Tackling the design of the 6G air interface 2) Studying the effect of AI on the data and control plane of 5G/6G cellular networks and enabling cost-effective open RAN infrastructure. In this presentation, we will discuss the key goals and attributes of a network digital twin, present Aerial Omniverse Digital Twin as a possible solution, and discuss how the community can collaborate with Nvidia to drive innovations in this critical area.

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Alex Jinsung Choi

SVP Head of T-Labs
Deutsche Telekom

and

Chair of O-RAN Alliance

Background: Dr. Alex Jinsung Choi is SVP of Strategy and Technology Innovation (STI) of Deutsche Telekom with responsibility for the Network Differentiation strategy to transform Deutsche Telekom's infrastructure to an open, distributed and cloud-native architecture with an automated production model. Dr. Choi is also Chief Operating Officer of the O-RAN Alliance. Dr. Choi has more than 20 years of experience in the mobile telecommunication industry & consumer electronics and has been thought leader driving forward key strategic and research topic in TelCo and AI. Dr. Choi was the first Chairman of the Telecom Infra Project (TIP) and previously served as CTO for SK Telekom. With the introduction of "NUGU", the first AI-based virtual assistant in Korea, Dr. Choi was influential in the development of AI solutions.

Talk Title: "O-RAN and AI/ML for Telecommunications."

https://www.linkedin.com/in/jinsung-choi-48a8b61/
https://www.o-ran.org/blog/o-ran-alliance-announces-its-new-chairman-of-the-board-and-new-coo
https://www.telekom.com/en/blog/515926-515926

Michele Polese

Assistant Research Professor
Electrical and Computer Engineering

Northeastern University

Background: Michele Polese is a Principal Research Scientist at Northeastern University, Boston, since March 2020, working with [Tommaso Melodia]. He received his Ph.D. at the Department of Information Engineering of the University of Padova in 2020 under the supervision of with [Michele Zorzi]. He also was an adjunct professor and postdoctoral researcher in 2019/2020 at the University of Padova. During his Ph.D., he visited New York University (NYU), AT&T Labs in Bedminster, NJ, and Northeastern University, Boston, MA. He collaborated with several academic and industrial research partners, including Intel, InterDigital, NYU, AT&T Labs, University of Aalborg, King's College and NIST.
He was awarded with the Best Journal Paper Award of the IEEE ComSoc Technical Committee on Communications Systems Integration and Modeling (CSIM) 2019, the Outstanding Young Researcher Award 2019 from the IEEE ComSoc EMEA Region, the Best Paper Award at WNS3 2019 and 2020, and the IEEE MedComNet Mario Gerla Best Paper Award 2020. His research interests are in the analysis and development of protocols and architectures for future generations of cellular networks (5G and beyond), in particular for millimeter-wave communication, Open RAN, and in the performance evaluation of complex networks.

Talk Title: "AI/ML for Open Radio Access Networks."

https://www.linkedin.com/in/michelepolese/
https://coe.northeastern.edu/people/polese-michele/

FCC Technological Advisory Council Agenda – August 29, 2024

10:00am – 10:10am	Opening Remarks
10:10am – 10:55am	Advanced Spectrum Sharing WG Presentation
10:55am – 11:40am	AI/ML WG Presentation
11:40am – 12:25pm	6G WG Presentation
12:25pm – 12:30pm	Closing Remarks
12:30pm	Adjourned

FCC TAC
6G WG

Chairs: Brian Daly (AT&T)
Manu Gosain (Northeastern University)

FCC Liaison: Martin Doczkat

Date: Aug 29, 2024

2024 6G Working Group Team Members

Bayliss, Mark	Visual Link Internet	Young, David	ATIS
Bhatt, Tejas	Marvell		
Brenner, Dean	Special Government Employee	Daly, Brian	AT&T
Cataletto, Michael	Scientel Solutions	Gosain, Manu	Northeastern University
Chakraborty, Tusher	Microsoft		
Clegg, Andrew	Wireless Innovation Forum	Acacio, Robert	FCC
Ditchfield, Skyler	GeoLinks	Davis, Michael	FCC
Drobot, Adam	Stealth Software Technologies	Doczkat, Martin	FCC
Gammel, Peter	Ubilite	Etemad, Kamrad	FCC
Ghosh, Monisha	Notre Dame	Ha, Michael	FCC
Guess, Lisa	Ericsson North America	Lu, Jonathan	FCC
Gupta, Sachin	NRECA	Mathur, Rajat	FCC
Laskowsky, Mike	United Telecom	Pavon, Barbara	FCC
Lapin, Greg	ARRL	Repasi, Ronald	FCC
Mansergh, Dan	Apple	Young, Janet	FCC
Merrill, Lynn	NTCA	Yun, Sean	FCC
Mukhopadhyay, Amit	Nokia		
Nasielski, Jack	Qualcomm		
Nicols, Roger	Keysight Technologies		
Sung, LiChing	NTIA		
Tehrani, Ardavan	Samsung		
Thakker, Rikin	NCTA		
Thompson, Michelle	Open Research Institute		

6G WG Charter (1)

- Provide information on the development and deployment of 6G technology, make recommendations and provide insights on new developments and expectations from technological and regulatory perspectives that FCC should pay attention to.

- **How do openness and customization capabilities in 6G benefit supporting flexibility and agile services and its coexistence with 5G?**

- What are the infrastructure needs for 6G, and how can the FCC proactively address them?

- How is 6G progressing or expected to progress at standards and international fora? What are the key points of emerging consensus or disagreement?

- What are competing 6G visions and expectations on key technological points between operators to compare and contrast?

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6G WG Charter (2)

- What is the status of small satellite development, what frequency bands are under consideration for non-terrestrial network (NTN) use, and what services are envisioned?
- What are the opportunities for using mmW/terahertz bands for 6G systems?
- **How is 6G technology envisioned to enhance or be utilized in various verticals, including autonomous driving, augmented and virtual reality, edge computing, emergency alerting, and smart cities?**
- What advancements in localization and positioning will 6G need for network optimization of beam steering antennas and metasurfaces?

6G WG Charter (3)

- What are the potential privacy and security risks that 6G networks will need to address regarding massive data collection and processing, as well as the ethical and social impacts of emerging applications such as brain-computer interfaces and holographic communications?

- How does 6G ensure the security and privacy of users' data and identity in various scenarios, such as distributed ledger technologies, physical layer security, distributed AI/ML, visible light communication (VLC), THz bands, and quantum communication?

- **How will 5G/6G networks support massive volume of mobile and IoT and XR devices with low-latency and seamless connectivity for near- and non-real time, trending toward real-time applications?**

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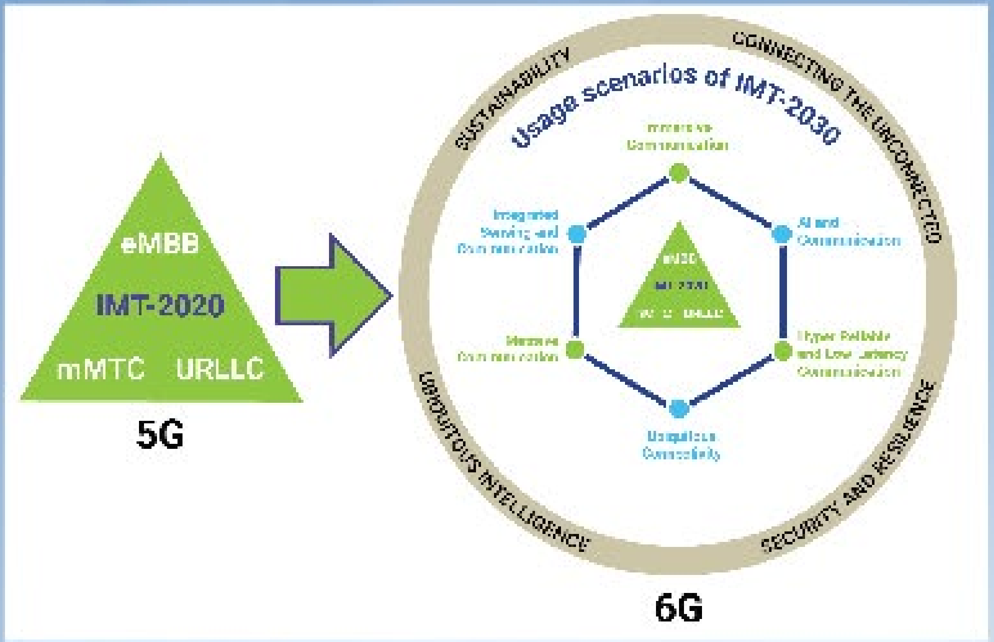
Recap from June 21 2024 Meeting

Look to drive down end to end cost to increase availability

- Business case for 6G to identify new revenue streams
- Operators have been more reluctant to deploy 5G standalone (SA) technology than vendors originally hoped
  - Struggled to find a business case to justify upgrading their networks to 5G SA
- Open architectures → reduce TCO
- Operators are not keen on a big RAN refresh, but most 6G R&D projects are focusing on new RAN technologies
- 6G networks must deliver growth opportunities for operators and their customers and help them both to drive out cost.
- “Although more than 20% of the initiatives identified focus on use cases, **so far there has been little analysis of what actual revenue or profit growth specific use cases could deliver for operators or for enterprises**. It is critical for the industry to understand whether enterprises would (not could) use 6G enhancements to drive innovation within their own businesses, and crucially whether they would pay for them, or opt for lower cost technology alternatives. Doing this analysis once the technology has been down a 10-year development path is too late.”

Analysis Mason, May 2024



Recap from June 21 2024 Meeting

Sustainability and energy consumption

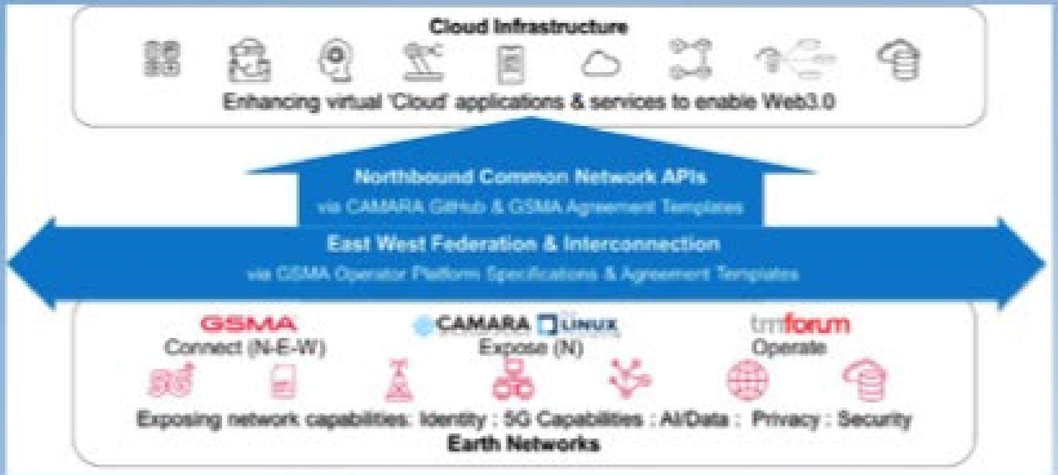
- The Information Communication Technology (ICT) ecosystem has developed a collaborative pathway to reach net zero emissions by 2050 at the latest
- Looking ahead to 6G, the principle of sustainability will be inherently pervasive throughout the entire framework
- Every 6G use case and facet must take the lifecycle analysis (LCA) of energy expenditure and efficiency into play, from the very first step of the design process all the way to the final commercialization and assessment step
- Energy consumption is a major consideration in the RAN, so improving energy savings and efficiency are pivotal for the 6G RAN
    - RAN's overall energy performance comprises two main areas: climate control and base station equipment
    - RAN's energy efficiency is also impacted by operational configurations such as network density, spectrum bands, and bandwidths, and the number of radio access technologies
    - In a RAN site, cooling accounts for about 40 percent of the power usage. Efficiently removing heat will help improve RAN power use efficiency (PUE).
- To further improve the energy efficiency of communication devices in the 6G era, various approaches could be explored, including:
    - Energy Optimization and Device Types
    - Low Power Wake Up Signal/Low Power Wake Up Radio
    - Energy Optimized Channel State Feedback
    - Joint Network and Device Energy optimization

Source: ATSI Next G Alliance

Recap from June 21 2024 Meeting

Role of API(s) to modularize architecture

- New 5G network capabilities exposed through data service APIs which are more readily available across global telecom networks and countries, making it seamless and easy to access within a controlled and federated market.
  - Using network application programming interfaces (APIs), operators expose network data and capabilities to software developers
  - Developers leverage the data and network capabilities to create new applications and services
  - Innovation, growth and profitability as the API economy flourishes
- GSMA Open Gateway
  - Framework of common network APIs designed to provide universal access to operator networks for developers.
  - Helps developers and cloud providers enhance and deploy services rapidly across operator networks via single points of access



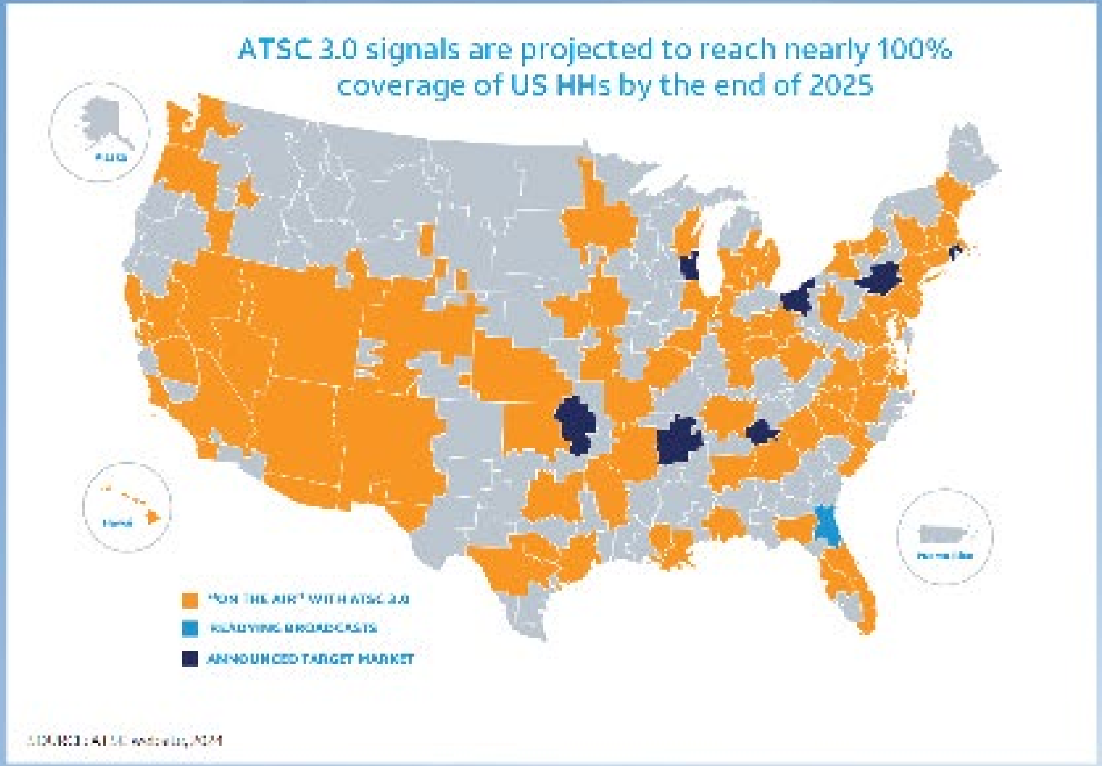
Charter Topic Updates

ATSC 3.0

ATSC 3.0 was adopted by the FCC in 2017 to enable a convergence with broadband streaming by providing for the transmission of video, audio, and data in a standard IP format

Datacasting on ATSC 3.0

- Enables a low-latency push of information to all devices in a metro area / region
- Allows for reliable, time-sensitive communications across regional areas and in congested environments
- Complementary to Cellular/Broadband



ATSC 3.0-enabled Datacasting Benefits: Complementary to Cellular

Additional Content Offload

- Ability to integrate with strained cellular and broadband networks to offload popular or surging content and improve network efficiency

Hyperlocal

- Targeted broadcasting transmissions enable myriad use cases
- Enhanced GPS, localized emergency alerts, personalized content and dynamic ad insertion

Increased Network Capacity

- Provides an alternative data route to end devices, decongesting the data pathways
- More content can be cached at edge and quickly delivered to consumers

Fast Download Speeds

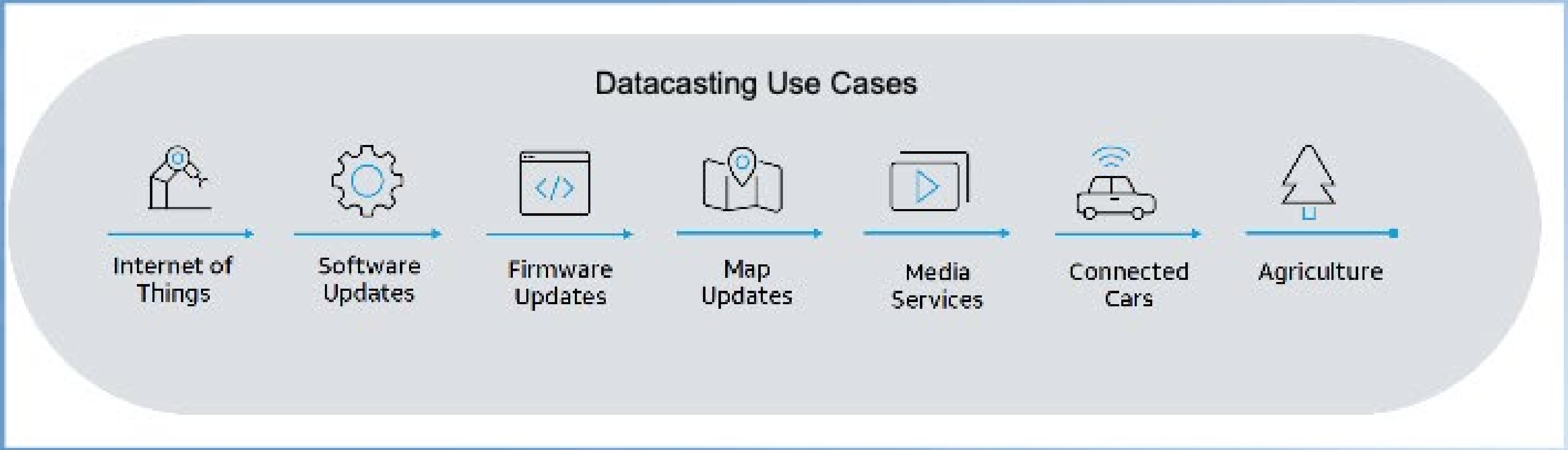
- A single 6 MHz broadcast channel can match or exceed traditional broadband download speeds: 50 Mbps+

Datacasting Use Cases

AT&T (and others) - dongle containing an ATSC receiver for datacasting services, connected via Bluetooth/WiFi to an external device

Use cases include:

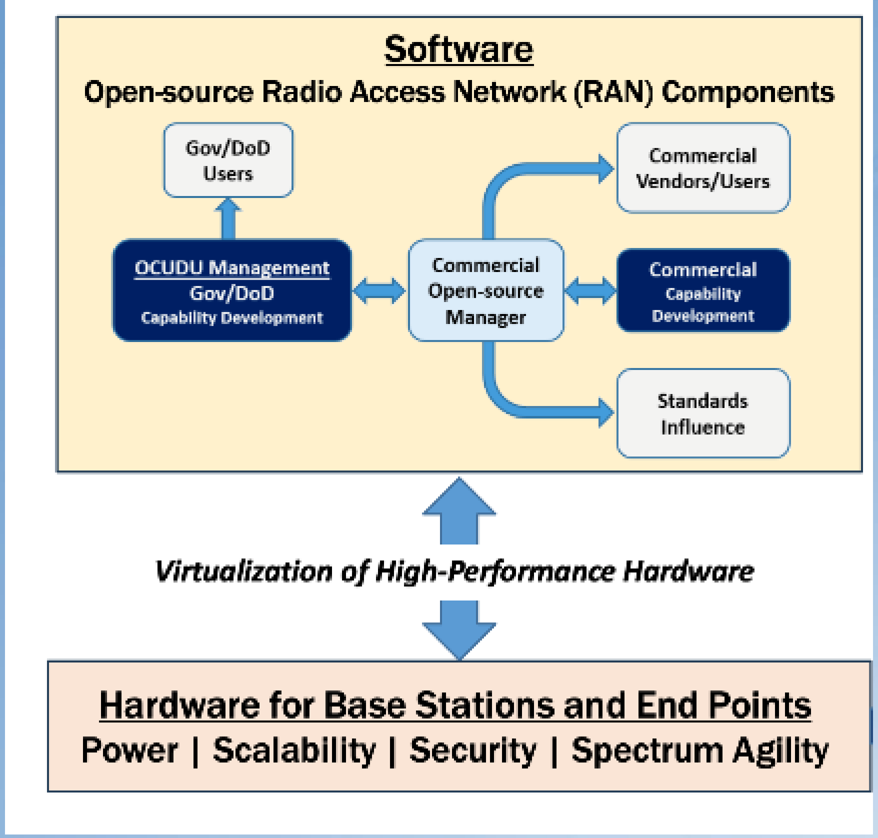
- Digital signage
- Firmware updates



Open Architectures for 6G

Key Benefits:

- Secure
- Customizable
- Interoperable
- Flexible
- Transparent
- Cost Effective
- Drives Innovation



Source: FutureG US DoD

Improve government capabilities with frameworks, algorithms, and architectures enabling more secure, resilient, real-time adaptable, flexible cellular networks that can serve dynamic deployments at the tactical edge.

Affecting 6G Standards through open source alternatives

Augmented and Virtual Reality: XR/VR/AR 6G Use Case Requirements

Defining XR:

- Persistent spatial internet with personalized digital experiences
- Spans both physical and virtual worlds
- Shared virtual space in VR/MR
- Digitally enhanced physical space with AR

Requirements

Motion to Render to Photon Latency = Edge Processing + 5G Round trip time + Device processing

100X Network Capacity

0.1-10 Gbps per User

Drivers

Physical, digital, virtual, immersive interactions will take human augmentation to next level via ubiquitous, low-power joint communication and sensing

Spatial compute enables immersive interaction with 3D digital content

Digital twins digitize the complex physical world in the metaverse

Augmented and Virtual Reality: XR/VR/AR 3GPP Enhancements

3GPP enhancements for XR

Low Power Modes Rel 15/16

Uplink Enhancements: Rel 16

XR Burst Handling Rel-17

Device latency and power efficiency in Release 18

Study Items

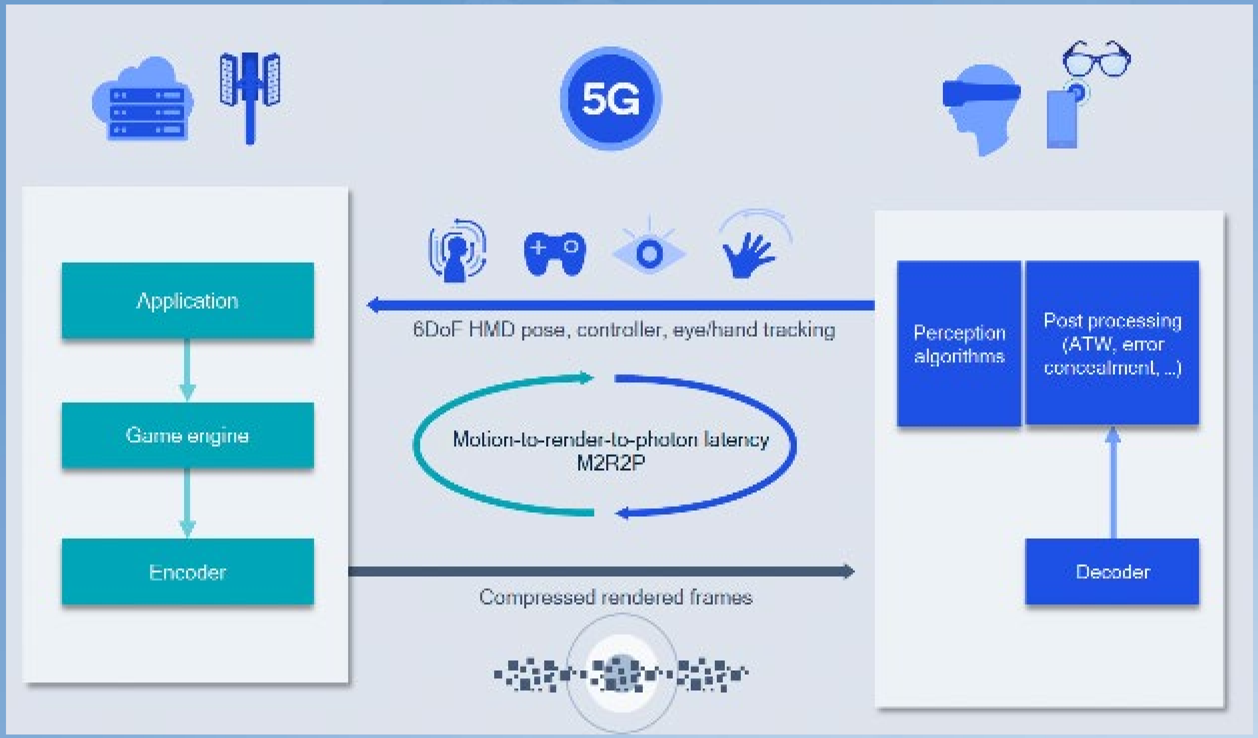
Align transmission to multimedia cadence

QoS based on multimedia payload

Staggering UE traffic arrivals at gNodeB

Sleep after low latency uplink transmission

Low Latency Mobility



Source: Qualcomm

Simultaneous in-band Transmit and Receive

Full Duplex : Key issue is Self-interference

Mitigation: Cancellation and suppression of self-interference

Issues: Analog cancellation scales with array size so ill-suited for large arrays in 5G

- Analog to Digital Converters do not follow Moore's law 1 bit/decade improvement
- Deployment within a brownfield environment and TDD configuration changes

Benefits: Increased Data rate for high data transfer applications in 6G

Utility in 6G Joint sensing and Communications

SME Speakers

Organization	Topic	Speaker	Summary
NEXTG ALLIANCE	NGA perspective on 3GPP SA-1 Use Case Workshop	Mr. David Young	• Sustainability native 6G: Privacy and Trust, Digital Equity and quality of Life Key value indicators (KVI) • Target shared investments in 6G Proof of Concepts and testbeds • Multi-sensory XR, Digital Twin, Connected vehicles, Cooperative Robots, Massive Sensors enabling new solutions • KPI's for positioning, reliability, sensing and sustainability
Hewlett Packard Enterprise	An update and roadmap for IEEE 802 Standards	Ms Dorothy Stanley	• Investigate WLAN support of Artificial Intelligence/ Machine Learning • IEEE 802.11 Working Group Standards development and Wi-Fi Alliance Interoperability Certification ecosystem enable a robust market ecosystem • Roadmap goals include: improve reliability of WLAN connectivity, reduce latencies, increase manageability, increase throughput including at different SNR levels, and reduce device level power consumption
Qualcomm	6G For Automotive	Dr Shailesh Patil	• Allow deployment of 6G without requiring hardware upgrade for already deployed 5G vehicles • Improved remote driving using reliable communication • Use transparent meta surfaces to replace RF cables for cost benefits • Remote Intervention for Automotive Safety Integrity Level (ASIL)

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SME Speakers

Organization	Topic	Speaker	Summary
Qualcomm	NGA perspective on 3GPP SA-1 Use Case Workshop	Mr Hemanth Sampath	• Sustainability native 6G: Privacy and Trust, Digital Equity and quality of Life Key value indicators (KVI) • Target shared investments in 6G Proof of Concepts and testbeds • Multi-sensory XR, Digital Twin, Connected vehicles, Cooperative Robots, Massive Sensors enabling new solutions • KPI's for positioning, reliability, sensing and sustainability
CEWI NETWORKS	Evolution of digital broadcasting technology, from ATSC1.0 to 3.0	Mr Colin Smith	• Investigate WLAN support of Artificial Intelligence/ Machine Learning • IEEE 802.11 Working Group Standards development and Wi-Fi Alliance Interoperability Certification ecosystem enable a robust market ecosystem • Roadmap goals include: improve reliability of WLAN connectivity, reduce latencies, increase manageability, increase throughput including at different SNR levels, and reduce device level power consumption
FutureG – Future Generation Wireless Technology Office, Department of Defense	6G For Automotive	Dr Martin Weiss	• Allow deployment of 6G without requiring hardware upgrade for already deployed 5G vehicles • Improved remote driving using reliable communication • Use transparent meta surfaces to replace RF cables for cost benefits • Remote Intervention for Automotive Safety Integrity Level (ASIL)

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SME Speakers

Organization	Topic	Speaker	Summary
RICE	Full Duplex Wireless	Dr Ashutosh Sabarwhal	• Sustainability native 6G: Privacy and Trust, Digital Equity and quality of Life Key value indicators (KVI) • Target shared investments in 6G Proof of Concepts and testbeds • Multi-sensory XR, Digital Twin, Connected vehicles, Cooperative Robots, Massive Sensors enabling new solutions • KPI's for positioning, reliability, sensing and sustainability
Organization	Topic	Speaker	Summary
	ATSC 3.0 Datacasting	Colin Smith	•AT&T is introducing a new protocol, which is to efficiently datacast a live, linear data stream. •Enables a low-latency push of information to all devices in a metro area / region •Allows for reliable, time sensitive communications across regional areas and in congested environments •Complementary to Broadband •Interoperability with cellular and broadband for back-channel

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6G WG Upcoming Charter Topics

- Additional SME presentations addressing the Charter items

- mmWave and THz
- Positioning and Timing
- Integrated Sensing and Communication

6G WG Next Steps, Meetings & Call for Participants

- Additional SME presentations addressing the Charter items

- Meeting schedule is Thursday’s from 4-5 PM Eastern (same as previous cycle)
  - Initial meeting cadence will be every other week

- Please send an email to brian.k.daly@att.com, agosain@coe.northeastern.edu , and tac@fcc.gov to be added to the list of participants in the 6G WG, added to the meeting invites, and subscription to the working group email list
  - Be sure to include all three email addresses on your request
  - We can only add those who have been vetted by the FCC for TAC membership

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Thank You

FCC Technological Advisory Council Agenda – August 29, 2024

10:00am – 10:10am	Opening Remarks
10:10am – 10:55am	Advanced Spectrum Sharing WG Presentation
10:55am – 11:40am	AI/ML WG Presentation
11:40am – 12:25pm	6G WG Presentation
12:25pm – 12:30pm	Closing Remarks
12:30pm	Adjourned