

IEEE Future Networks Webinar - 1 June 2022 - 11:00 am ET

The Road to 6G: INGR Mapping Future Networks into 2032

Register
today:

bit.ly/INGRWebinarRoadto6G



Francesco Carobolante, IoTissimo
Harish Kumar Sahoo, VSSUT
Narendra Mangra, GlobeNet LLC
David Witkowski, Oku Solutions

International Network Generations Roadmap (INGR)

Future network technologies (5G, 6G, etc.) are expected to enable fundamentally new applications that will transform the way humanity lives, works, and engages with its environment. Be a part of this transformation today!

- The INGR is a semi-annual technical document highlighting network technology evolutions over 3-, 5- and 10-year horizons.
- Created by a group of 100+ international IEEE experts from industry, academia and prominent research labs, organized across 15 distinct working groups.
- Every 12-18 months, INGR will release a new multi-chapter document highlighting development needs, the challenges/roadblocks to achieving those needs, and potential solutions to those challenges.
- At least twice a year, INGR leadership will do outreach to industry and hold presentations highlighting the most crucial future technical roadblocks, to engage industry to solve or avoid those risks and roadblocks.
- **FREE with Future Networks membership – Join today!**



Contact us to
get involved!
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IEEE INGR Structure and Working Groups

CATEGORY	DESCRIPTION	INGR WORKING GROUP CHAPTERS
Access	Describes how the users are able to reach the network	<ul style="list-style-type: none"> • Massive MIMO • mmWave and Signal Processing • Hardware • Energy Efficiency
Networks	Describes how the networks are interconnected	<ul style="list-style-type: none"> • Edge Automation Platform • Satellites • Optics
System and Standards	Describes system standards and testability	<ul style="list-style-type: none"> • Standardization Building Blocks • Testbed • Systems Optimization
Enablers and Users	Represents all the elements that enable deployment, assure functionality and security and address impact on society and environment	<ul style="list-style-type: none"> • Deployment • Applications and Services • Security and Privacy • Artificial Intelligence and Machine Learning (AI/ML) • Connecting the Unconnected (CTU)

Accessing INGR 2022 Chapters

1. Visit FutureNetworks.ieee.org/roadmap
 2. Sign in as an FNI member (IEEE account)
 3. Download all chapters
- Not a member of Future Networks?
 - Add it to your IEEE account
 - Membership is free for IEEE Society members
 - USD \$5 - \$15 annually for others
 - URL to join: bit.ly/fni-join



IEEE FNI INGR Webinar

The Road to 6G: A Transdisciplinary Framework for Future Networks Transformation

01 June 2022

Narendra Mangra, GlobeNet LLC

IEEE FNI International Networks Generation Roadmap Co-Chair,
IEEE SA P1950.1 Smart Cities Architecture Chair,
IEEE SA Telehealth Industry Connections Co-Chair
IEEE Transdisciplinary Framework Industry Connections Co-Chair

IEEE FNI INGR Applications and Services Chapter – 2022 Edition

Applications and Services Chapter 2022 Edition

Transdisciplinary Framework

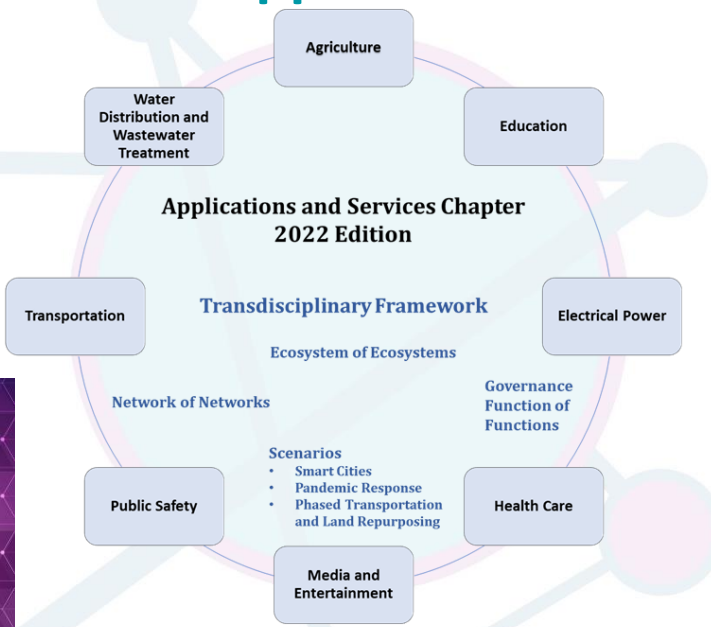
Ecosystem of Ecosystems

Governance
Function of
Functions

Network of Networks

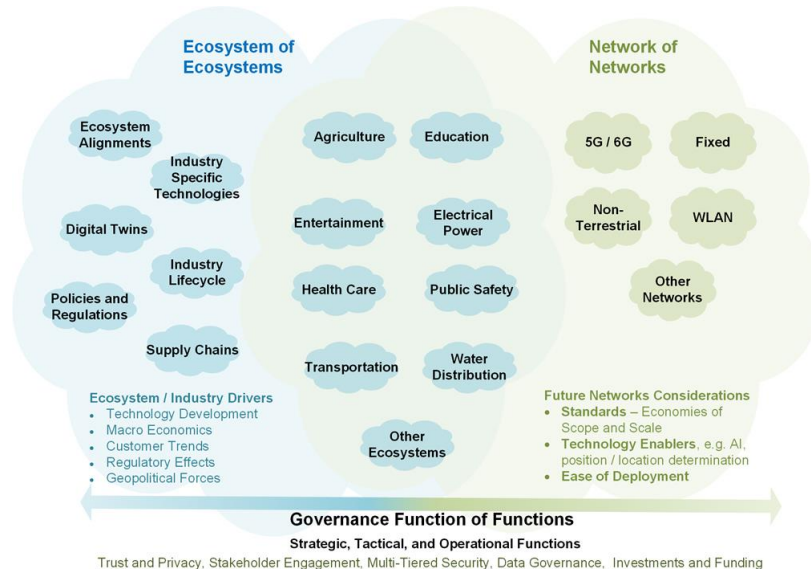
Scenarios

- Smart Cities
- Pandemic Response
- Phased Transportation and Land Repurposing



IEEE INGR Applications and Services 2022 Edition

- <https://futurenetworks.ieee.org/roadmap>



Wednesday, 19 January 2022 - 11am ET

Transdisciplinary Framework for 5G-Enabled Apps and Services in the New Reality

Presented by Narendra Mangra, GlobeNet LLC

WHAT'S NEXT

5G AND BEYOND: A ROADMAP APPROACH
An IEEE Future Networks Webinar Series

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Recording available at IEEE TV -

<https://ieeetv.ieee.org/2021-webinar-applications-services>



5G-Advanced and the Road Towards 6G

5G-Advanced

Mobile Broadband Evolution
Immediate Commercial Needs
Device Evolution

Further Vertical Expansion
Long Term Vision
Network Evolution

- ❖ Critical Communications
- ❖ Service Frameworks
- ❖ Vertical Enablers

5G Use Case Categories

Device Drivers

- Form Factors
- Technologies
- Bands of Operation
- Device Capabilities
- Battery Life

eMBB

RedCap

URLLC

mMTC

Deployment Drivers

- High Data Rate
- Low Latency
- Connection & Traffic Density
- Reliability
- Position Accuracy
- Mobility

Transdisciplinary Framework and Related Initiatives

IEEE SA IC21-005-001 Transdisciplinary Framework Industry Connections

Transdisciplinary Framework for 5G, Future Networks Applications, and Services

Developing framework that is flexible, adaptable, and scalable

<https://standards.ieee.org/industry-connections/transdisciplinary-framework-5g/>

IEEE FNI INGR 2022 Edition – Applications and Services

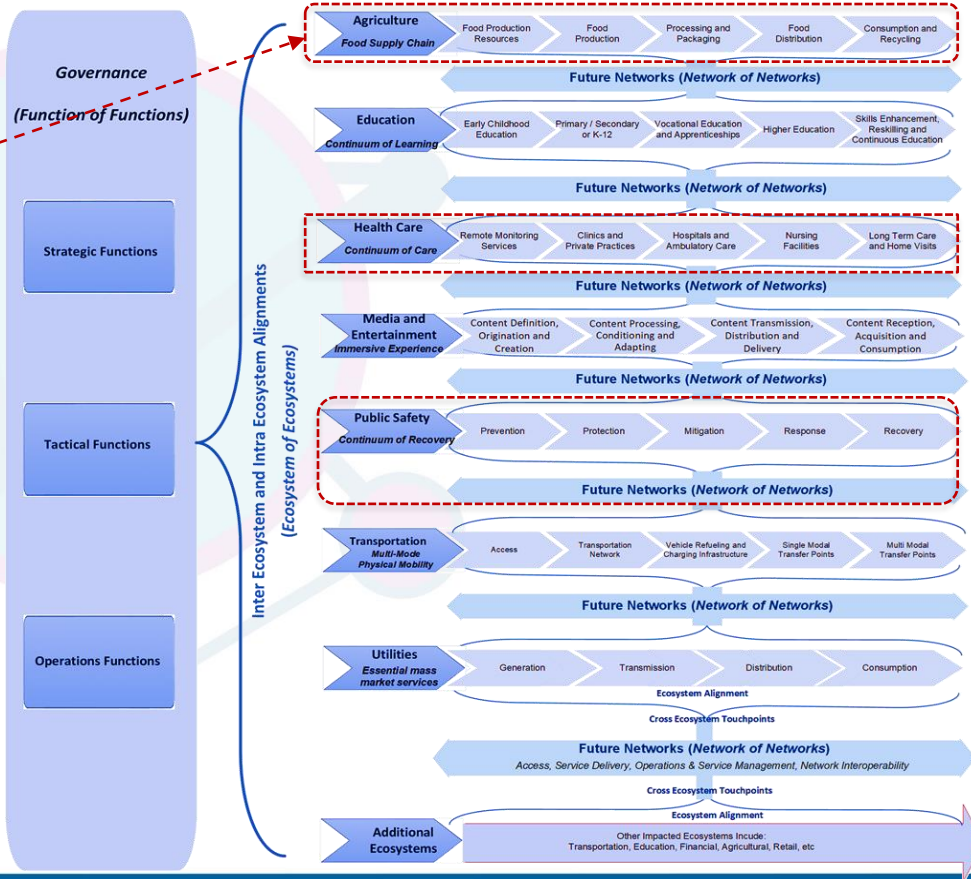


IEEE SA P1950.1 Standard Development

Report Action

P1950.1 - Standard for Communications Architectural Functional Framework for Smart Cities

<https://standards.ieee.org/ieee/1950.1/10176/>



Agriculture

- Food Supply Chain
- Rural Development
- Environmental Sustainability

IC20-018-01: Telehealth Industry Connections

Transforming the Telehealth Paradigm: Sustainable Connectivity, Accessibility, Privacy, and Security for All

Establish the foundation of security, connectivity, accessibility, and privacy for future technological innovation in telehealth delivery

<https://standards.ieee.org/industry-connections/transforming-telehealth/>



<https://publicsafety.ieee.org/>



The Road to 6G: Deployment

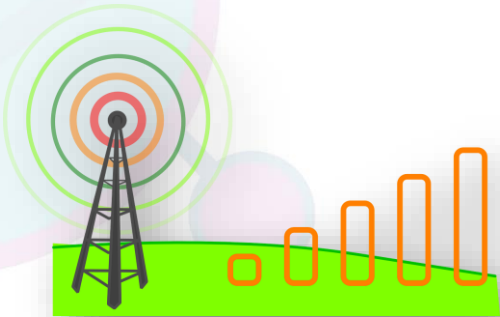
Prepared for IEEE Future Networks Webinar – June 2022

David Witkowski, CEO, Oku Solutions LLC

david@okusolutions.com

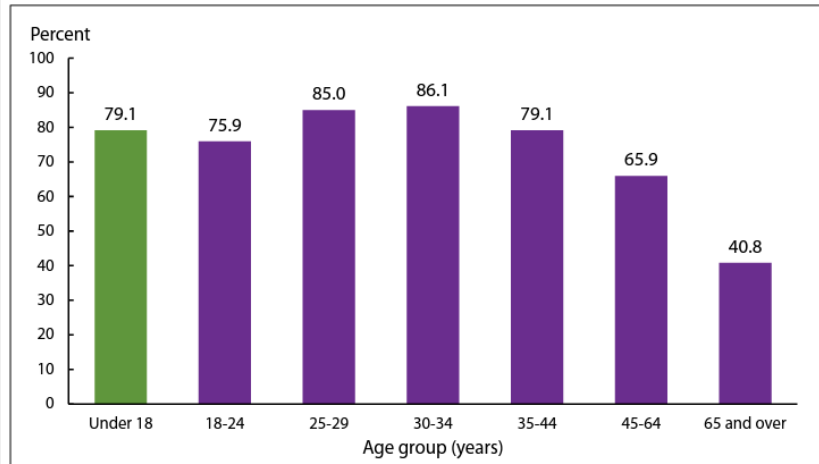
+1-408-889-9741

Basic Requirements of 21st Century Life



Wireless-Only

Figure. Percentages of wireless-only adults and of children living in households with only wireless telephone service, by age group: United States, January–June 2021



NOTES: Wireless-only adults are adults who live in households with only wireless telephone service and have their own wireless telephone. In 2021, data collection procedures for the National Health Interview Survey were modified because of the COVID-19 pandemic. Estimates from 2021 may have been impacted by these changes. See text in this report for more details.

SOURCE: National Center for Health Statistics, National Health Interview Survey.

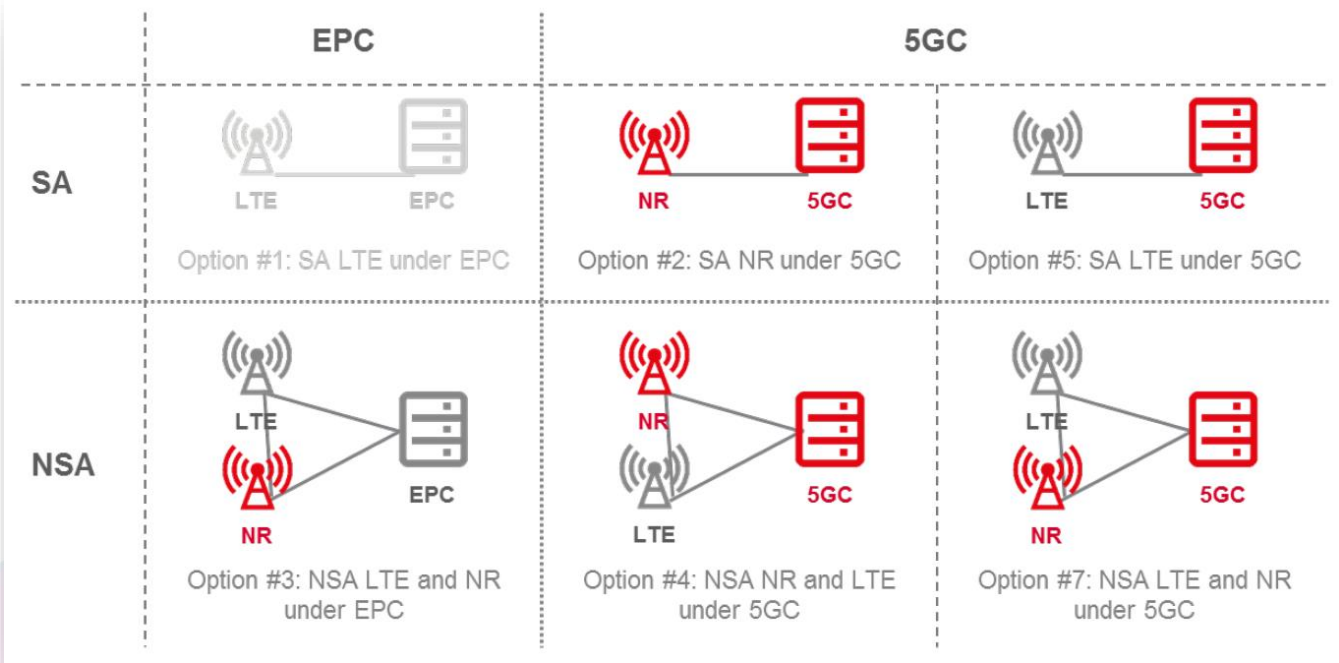
- CDC Wireless Substitution (Bi-annual, June 2021)
- Wireless-only (U.S. wide)
 - 57 million children (79.1%) live in wireless-only households.
 - Renters: 81.9%
 - Poverty: 68.3%
 - Hispanic: 77.4%
 - Ages 25-29: 85.0%
 - Ages 30-34: 86.1%
 - Ages >44: 65.9%
- **Key Point: >80% of calls to 9-1-1 come from wireless phones**

4G Limitations

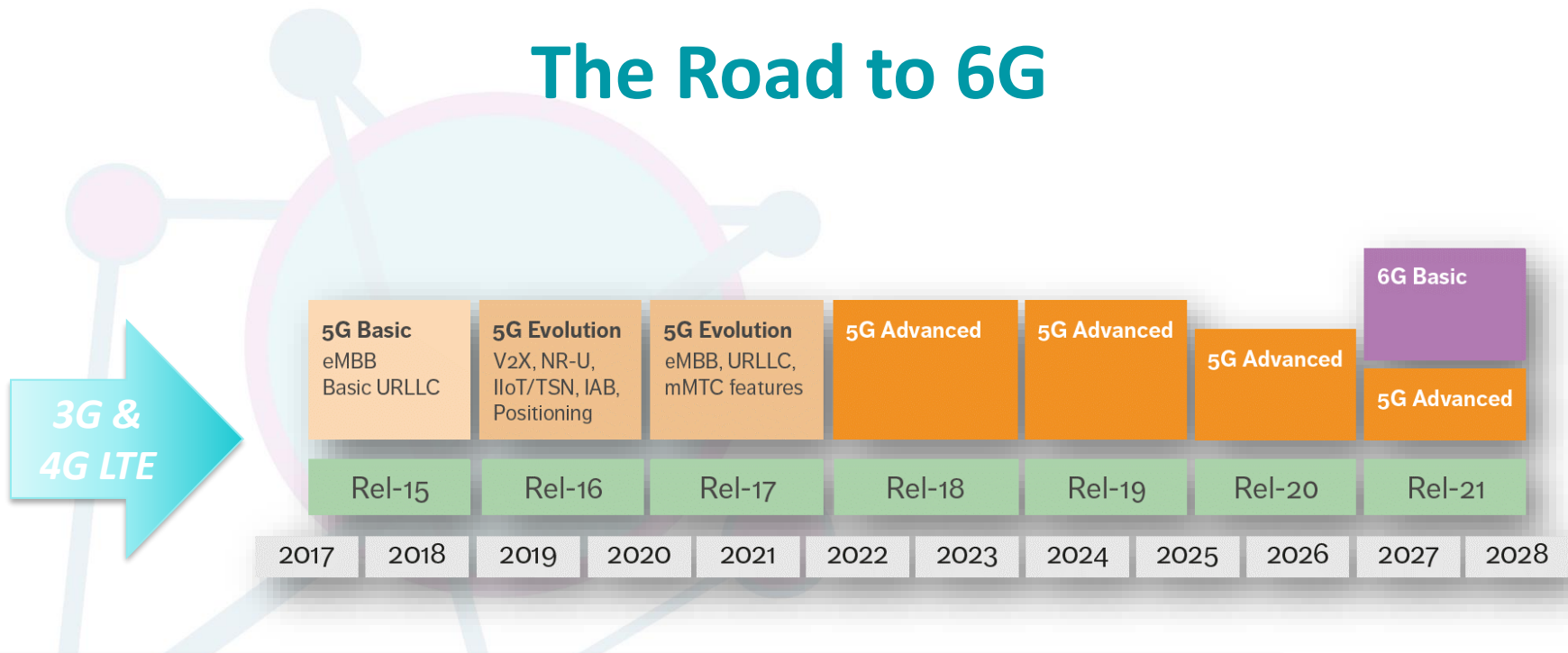


- Designed for personal devices (phones, tablets, hotspots).
- Not optimized for the Internet of Things.
- Not optimized for fixed broadband.
- LTE is capacity limited (~200 per radio-sector)
- ***Key point: Even without new features, the carriers and operators need 5G to support exponential usage.***

5G Evolution



The Road to 6G



- 5G is *revolutionary*, but the road to 5G/6G is *evolutionary*
- The 3GPP roadmap is incremental, designed to both *sustain* existing technologies and *realize* new technologies

Massive MIMO: Technology For 5G and Beyond



Harish Kumar Sahoo

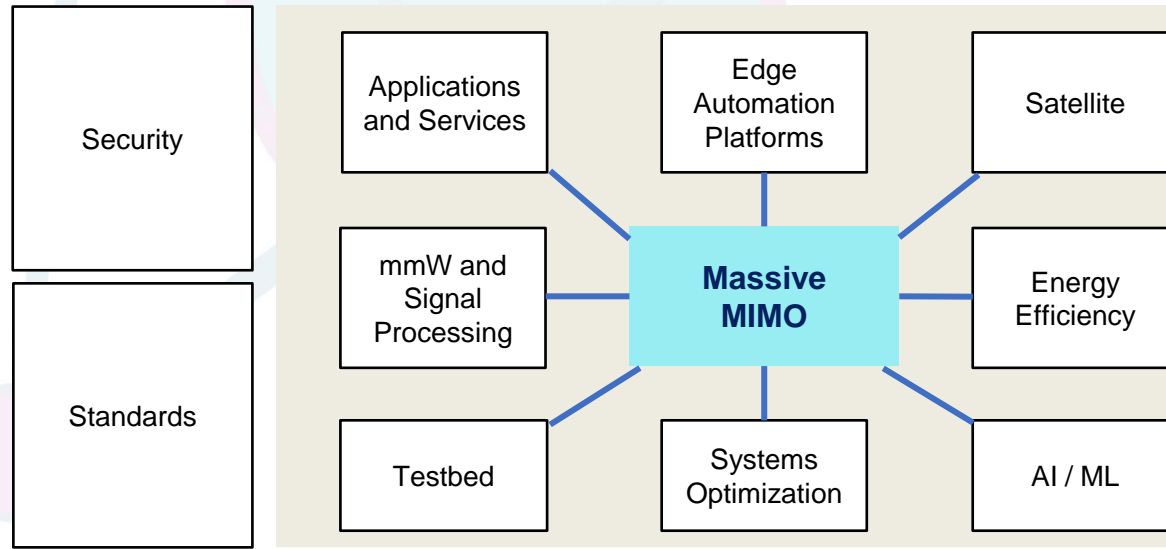
Professor, Department of Electronics and TC Engg. ,
Veer Surendra Sai University of Technology, India

Massive MIMO Working Group Overview

Vision

100 - 1000 controllable antenna elements per person in the next 10-20 years

1kMIMO2040

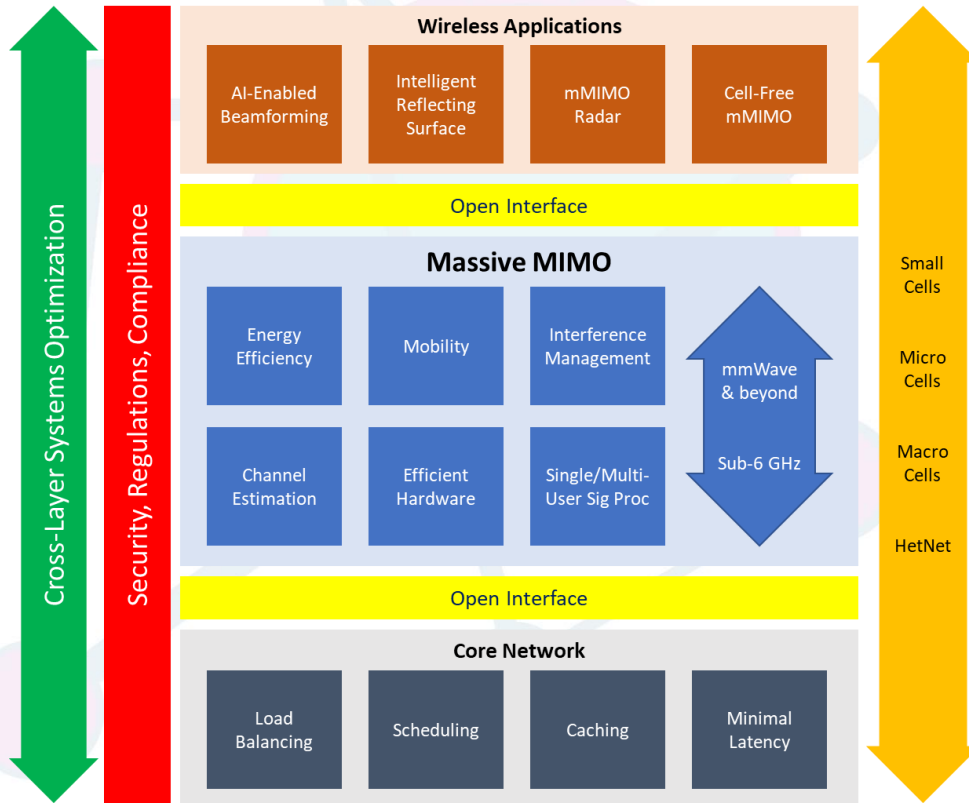


Connecting the Unconnected

Massive MIMO Long-Term Vision

- **100-1000** controllable antenna elements per person in the next 10-20 years
 - Enables **intelligent control** of the wireless physical layer
 - Evolves wireless from an interference-limited medium to a **multiuser** communication fabric
- Transforming ubiquitous person-to-person communications to pervasive **device-to-device** communications
 - Emphasis on **networking-like** scheduling, routing and optimization techniques
 - Enables the next-generation of **distributed** signal processing and machine learning algorithms

Massive MIMO Emerging Ecosystem



<https://futurenetworks.ieee.org/roadmap>

Some of the Research Problems

- Accurate reconstruction of data in presence of fading effect and user mobility.
- To meet the high data rate due to growing traffic.
- To address the complexity in the modeling when there is substantial increase in the number of antenna.
- To exploit channel sparsity in MIMO and Massive MIMO communication environment.
- To design efficient hybrid precoder for millimeterwave Massive MIMO

FDD and TDD Massive MIMO Systems

- In FDD, UL and DL use different frequency bands and hence the CSI corresponding to the UL and DL will be different.
- Based on the assumption of channel reciprocity, only CSI for the UL needs to be estimated in TDD Based System.
- As the number of BS antennas, N , grows large in massive MIMO systems, the traditional FDD channel estimation for the DL is quite difficult and challenging.



Thank You

The Road to 6G

Addressing the Energy Challenge

Francesco Carobolante, IoTissimo®

IEEE Future Networks Webinar – 1 June 2022

The Exponential Energy Challenge of 5G

Exponentially growing energy

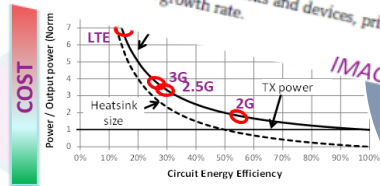
Fig. 2.1 The global ICT footprint*
GtCO_{2,e}



6G Summit 2020

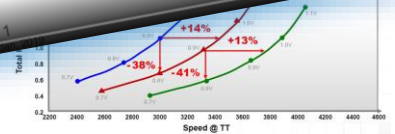
There Is Not Enough Electricity to Run 5G - Finding the Road to 6G

Earl McCune
IEEE Fellow
IEEE Standards; Energy Efficient Communication Hardware WG chair
Professor, TU Delft (Sustainable Wireless Systems)
CTO; Eridan Communications



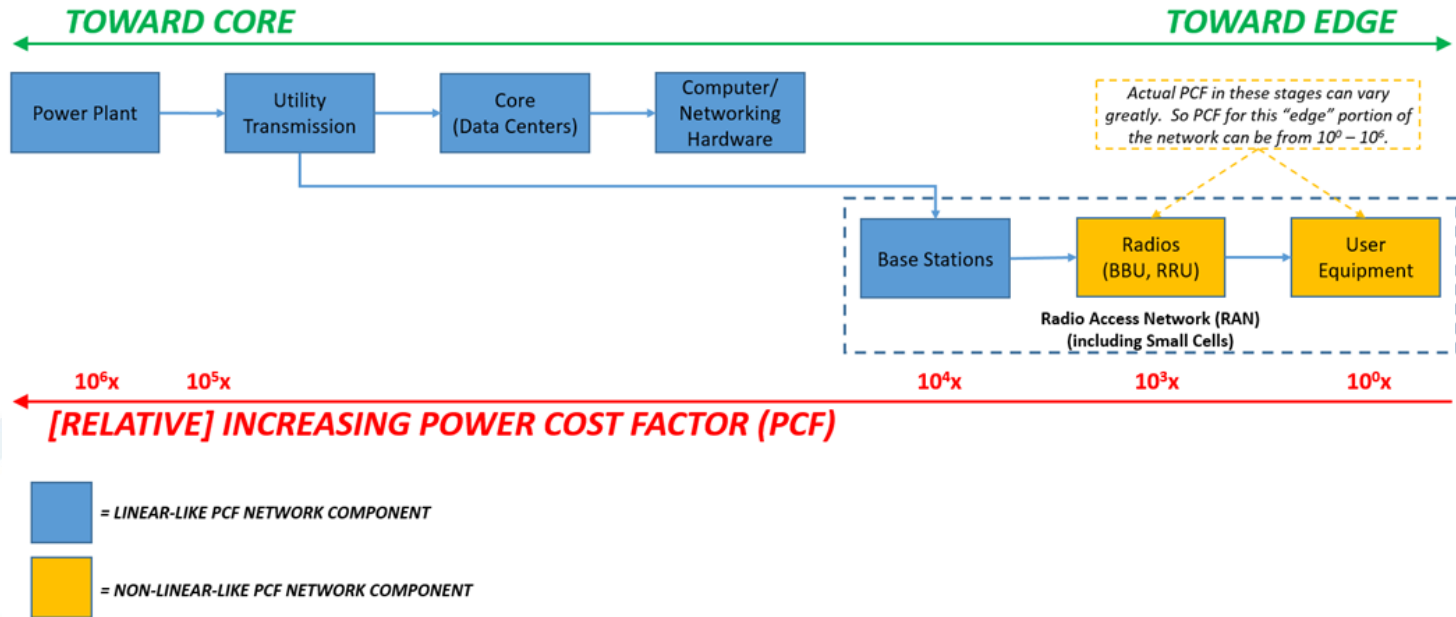
upstream!

IMAGE CREDIT: "SMART 2020," The Climate Group, GeSI

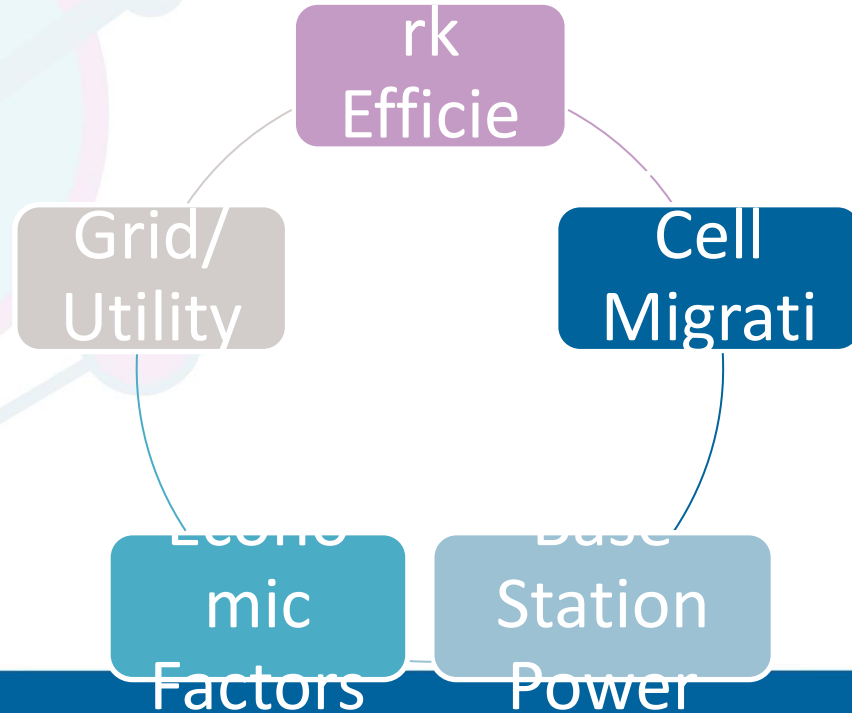
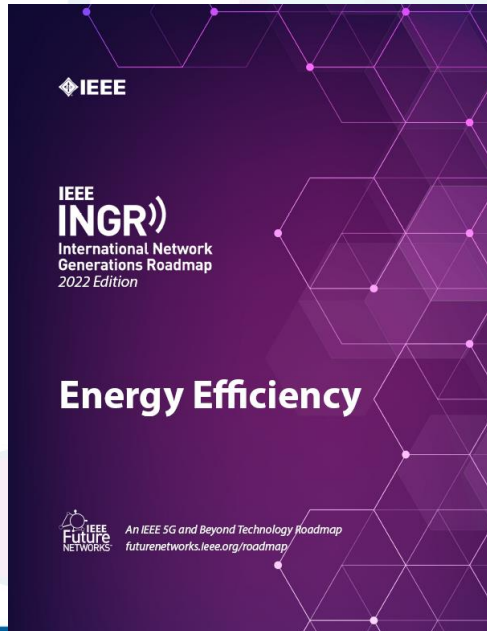


Connecting the Heterogeneous Subsystems

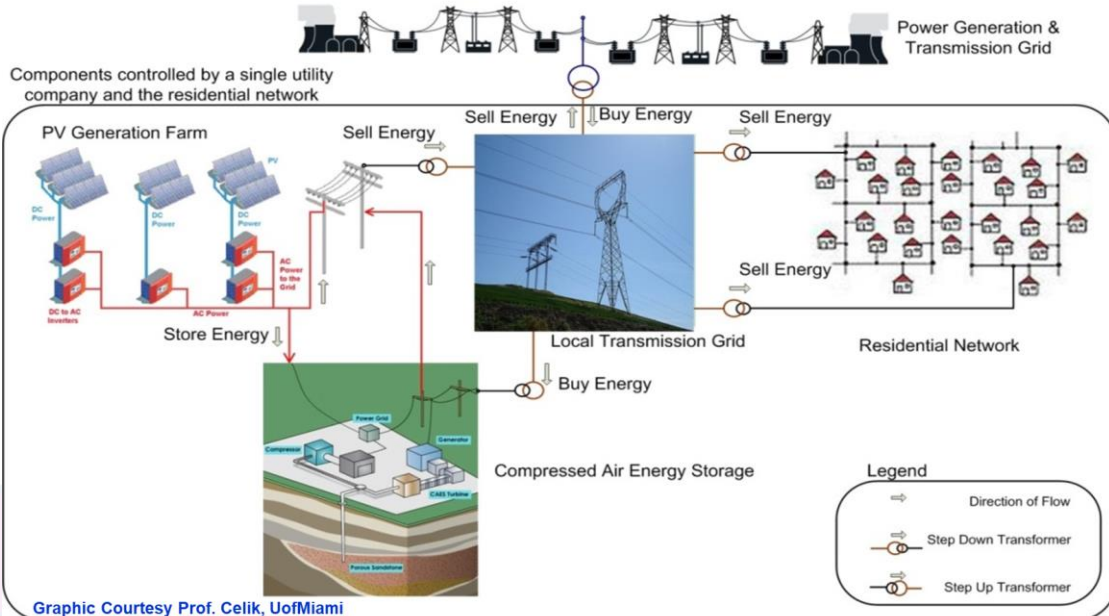
The 5G Power Value Chain



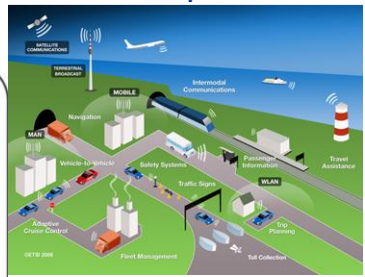
Addressing the Key Elements



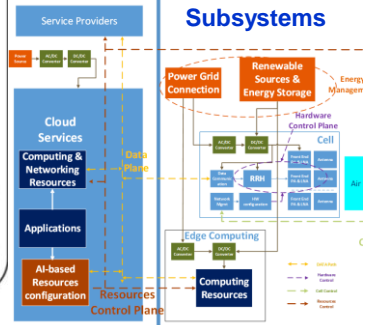
Developing a Systems of Systems Analysis



Associated Infrastructures Transportation



Subsystems



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