From 5G to FutureG: What Needs to Change, Why, and How?

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A 40+ year journey



Network evolution has historically been segmented into 10-year blocks, with each resulting in a new "generation"

5 years of 5G deployment

5G in numbers **5.9B** \$2,208.25B **20X** 57% Globally, connections are The global 5G services Smartphones connected to 57% of enterprises plan to expected to reach 1.9 billion market is estimated to 5G will reach download invest in 5G in the next one by end of 2023, rising to 5.9 to three years.³ reach \$2,208.25 billion by speeds of around 87.5 MB/s billion by end of 2027.1 2030.² - about 20x faster than 4G. ¹Omdia ²Grand View Research, Inc.

Operators are expected to spend more than \$1T between 2021–2026 on 5G networks

³Reimagining Industry Futures Study 2023, EY

"5G has become the <u>fastest adopted mobile technology in history</u>." -MWC 2025 (Mar 2025)



But when we look under the hood ...

5G networks (+ Add to myFT)

Telecoms operators face anxious wait for 5G to pay off

Consumers may be wowed by the next generation of mobile telephony — but they are taking their time



Way to go? 5G advertising at a metro station in Bangkok © Andre Malerba/Bloomberg

Source: Financial Times



Source: GSMA MWC '25

Beyond slightly faster connections, 5G smartphone customers struggle to notice any difference

Piecemeal 5G upgrades and unavailability of "real 5G" features to blame

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5G's most alluring promise remains digital transformation



Source: GSMA Intelligence



Source: Gartner survey of CIOs and execs regarding plans to invest in 5G. 2023.

Adoption by new enterprise verticals and digital transformation just beginning to happen.



From hurdles to horizons



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AFFORDABILITY



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Short-term price and long-term cost



Spectral efficiency + Cost efficiency + Energy efficiency



Mobile industry's insatiable spectrum demands

- Speed, reach and quality of FutureG will depend on spectrum availability
- Mid-band will still be the most desired band (good mixture of coverage and capacity)
- GSMA estimates that 2GHz of mid-band and 5GHz of mmWave spectrum will be needed to guarantee 5G requirements
- Even more spectrum will be needed to meet IMT 2030 requirements

Business | The \$90bn prize fight

Why American telecoms firms are splurging on 5G spectrum

An auction of mobile frequencies is turning a blockbuster



Source: The Economist



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"Use-it-or-share-it" model will prevail

- Spectrum is scarce in lower and mid bands, already occupied by federal and satellite incumbents <u>that cannot be relocated</u>
- Higher bands offer ample bandwidth, but <u>passive scientific users</u> operate there and need protection
- <u>Densification</u> can help but will significantly increase deployment costs and carbon footprint due to additional base stations



Source: Rhode & Schwartz

The only realistic way to meet spectrum demands is by sharing!



Leveraging FutureG's control, programmability, and agility, we can create solutions that allow federal and commercial systems to coexist seamlessly



The defining style of cellular generations: complexity





Source: Qualcomm

Source: telecomhall.com



Taming complexity by intelligent automation



E. Zeydan and Y. Turk, "Recent advances in intent-based networking: A survey," in Proc. IEEE 91st Veh. Technol. Conf. 2020

Intent-based Networking + Agentic AI can learn network and service behaviors, enabling the achievement of desired mission outcomes

Source: https://www.nucleoo.com/

Power-hungry culprits



Source: ITU-T Focus Group on Environmental Efficiency for Artificial Intelligence and other Emerging Technologies



Different ways to hit the snooze button



PA, transceiver modules, carrier and an entire cell can be shut down to save energy!



Application-aware networking: Impedance matching



A programmable network that dynamically adjusts to meet the needs of a specific AI workload, optimizing resource (energy) efficiency

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Truly converged networks



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Seamless operation of multi-domain networks



Source: https://www.eetasia.com/digital-twins-and-non-terrestrial-networks-applications-from-nasa-to-ukraine/

Spectrum management between (a) LEO mega constellations and terrestrial cellular networks (b) LEO networks and radio astronomy systems, and (c) LEO networks and GSO systems



Building a cohesive system by integrating multiple systems with different RATs



Integrability = Interoperability + Controllability

I. Chen, S. Abdallah, F. Xie and V. Ramaswamy, "Using 5G to Integrate Heterogeneous Networks with Improved Traffic Engineering," *MILCOM 2024 - 2024 IEEE Military Communications Conference (MILCOM)*, Washington, DC, USA, 2024, pp. 1192-1197, doi: 10.1109/MILCOM61039.2024.10773706.



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RAN disaggregation





Three Levels of Disaggregation + Control Platform = O-RAN Framework



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Resilience as Resistance & Recovery



Resist stress and **Recover** from faults



Pillars of resilience



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FutureG will be Al-native

AI/ML in current cellular networks



Mostly static network automation and optimization using SON (e.g., RACH optimization, mobility robustness, automatic neighbor relationships, etc.)

Net Mgmt

ML for user behavior predictions and to enable proactive actions. Common applications include traffic

classification, intrusion detection etc.

Element Mgmt

AI/ML application is limited to specific domains or network elements, resulting in 'islands of automation'

Basic Models

Supervised learning is the ML model that is commonly employed

26

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Atlas of AI/ML related standardization activities





Where will AI/ML be used in 6G?





Source: Boston Duck Tours

- Site-specific optimization adjusts the network to fit the environment and conditions
- Application-specific optimization customizes the network for particular applications

How will AI/ML be used in 6G?

Trend #1: Distributed and decentralized learning



Source: Rieke, N., Hancox, J., Li, W. et al. The future of digital health with federated learning. npj Digit. Med. 3, 119 (2020)

Resource constraints, delay limitations & privacy challenges leading to a "small data" paradigm

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Trend #2: Comprehensive AI



Cross-domain and cross-plane intelligence leading to "intelligence plane"



Trend #3: ML will increasingly be used for Optimization and Control

Experience-driven approach that can learn to configure and control a communication network from its own experience rather than an accurate mathematical model







From vision to action: Key takeaways

- Digitization in the industrial sector is key to improving efficiency, productivity, and driving innovation
- FutureG will drive digital transformation across industries by enabling faster, smarter, and more connected systems
- Focusing on AAAs (Affordability, Availability, Adoptability) is key
- The true potential of FutureG is in its programmable networking and core capabilities
- AI can be a game-changer, and its impact is maximized when combined with domain expertise

Backup



MEC App "Smart Migration"



Availability of up-to-date per UE radio network information at relevant granularity enabled by Open RAN architecture could improve response time by 50—100 ms

Connecting insights from different domains enables smooth, seamless and smart migration

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