EE : 451
MOBILE COMMUNICATION SYSTEMS

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School of Electrical Engineering and Computer Science
National University of Sciences and Technology

Course Information

- Lecture Timings:
  - Tuesday: 2 p.m- 3 p.m.
  - Thursday: 11a.m - 1p.m.

- Office Hours
  - Thursday 2-3 (Or by appointment)

- Text Book
  - Wireless Communications: Principles and Practice
    by Theodore S. Rappaport, Second Edition

Credits and Acknowledgements

- I gratefully acknowledge the following professors because most often I will be teaching the lectures/slides/notes from them
  - Prof. Mary Ann Ingram (Georgia Tech)
  - Prof. Gordon L. Stuber (Georgia Tech)
  - Prof. Geoffrey Ye Li (Georgia Tech/Imperial College UK)

- Throughout the course, I will borrow examples and explanations from the following book:
  - *Principles of Mobile Communications* by Prof. Gordon Stuber, 3rd Edition.

IPT: Information Processing and Transmission Lab.

Research Areas

- Wireless Communications
- Stochastic Modeling
- 5G/6G Networks

Director:
Prof. Syed Ali Hassan

Total Research Grants in Process:

- 100 Million Rs. (Approx.)

- Team Members
- MS Students: 14
- PhD Students: 8
- UG Students: 12
- PG Supervised: 60+
- PhD Supervised: 7

Publications:

- Journals: 100+
- Conferences: 120+

Collaborations

- Georgia Tech, USA
- Cisco Systems Inc. USA

Adept Tech Solutions (Pvt) Ltd

- CTO at ATS
- Offices in
  - Silicon Valley (US)
  - TechOne (NUST)

RIPPLETS

In disaster situations, the utmost priority is planning rescue operatior directly impacted by devastation.

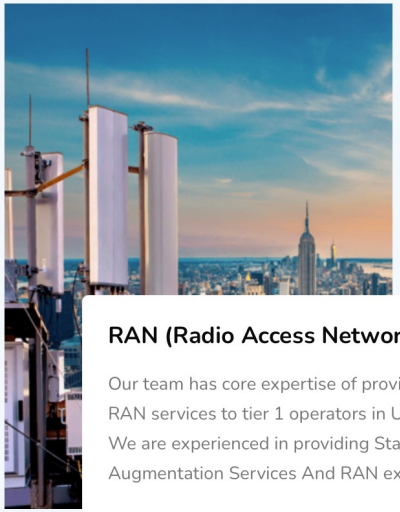
Through optimized planning, resources can be better utilized in areas concentration of affected persons. This is only possible if valuable int impacted individuals is immediately available to first responders.

To address this, Adept Tech Solutions has developed a Device-to-de connectionless communication mechanism to identify trapped victim traditional communication infrastructure ceases to exist.

One of the key benefits of our solution is that it facilitates the search process for first responders by providing guidance and live support ir as allowing the voluntary engagement of the general public in rescu

Download Brochure

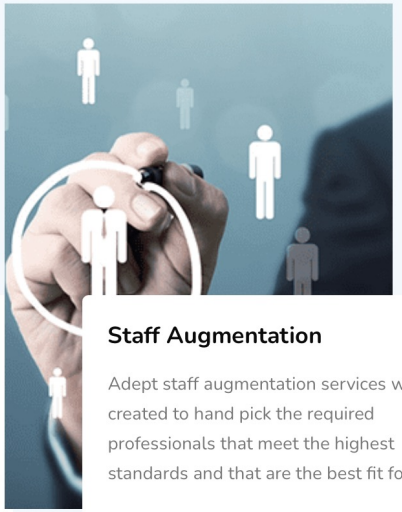
OUR SERVICES



RAN (Radio Access Network)

Our team has core expertise of providing RAN services to tier 1 operators in USA. We are experienced in providing Staff Augmentation Services And RAN experts...

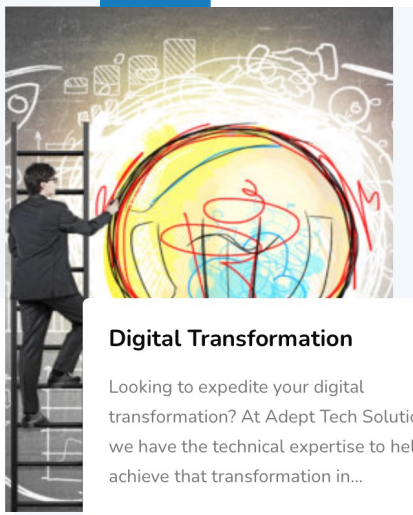
Explore More >



Staff Augmentation

Adept staff augmentation services were created to hand pick the required professionals that meet the highest standards and that are the best fit for...

Explore More >



Digital Transformation

Looking to expedite your digital transformation? At Adept Tech Solutions, we have the technical expertise to help y achieve that transformation in...

Explore More >

ASCEND

- De-identification: Completely anonymizes entries of the data without knowing who is
- Signature extraction: The tool allows the u DNA of the underlying original data by eva statistical properties and preserving them format.
- Secure login: The tool provides signature e capabilities to the administrator account, w non-admin account can generate data from file only, allowing working with the datase simultaneously.

Topical Outline

- Overview of Digital/Mobile Communications
  - History and Standards
- Cellular Digital Systems
- Wireless Propagation
  - Path Loss
  - Shadowing
  - Fading
- Digital Modulations
- Access Techniques
- MIMO and Multi-Antenna Systems
- Modern Trends in Wireless/Digital Communications

About Class

- Focus on “Principles of Mobile Communications”
- Everything Open - - - Grind the concepts

This does not mean to open and study the book ON/DURING the Exam

- End Semester Project
- Attendance Policy
- Travel

Today's Outline

- History and evolution of mobile radio
  - Brief history of cellular wireless telephony
  - Generations of Wireless Technology

HISTORY OF WIRELESS TECHNOLOGY

The beginning…

- Most credit Guglielmo Marconi, “the father of radio”, with the initiation of wireless technology
- **1894** Marconi experimented with Hertzian Waves (radio waves) to produce and detect waves over long distances
- **1896** Marconi established the Wireless Telegraph & Signal Company, the first radio factory
- **1901** St John’s, New Foundland, Marconi received the first trans-Atlantic wireless signal from Poldhu, England

US Military jumps into Wireless

- During World War II the US Military used wireless signals with encryption to send battle plans and instructions
- US Military started the shift to radio data transmission technology

Wireless Networking: Birth of the Wireless Network

- **1971** network technologies met radio technologies when the first wireless Local Area Network (LAN) was established at the University of Hawaii during the experiment, ‘ALOHANET’

- ALOHANET used a bidirectional star topology consisting of (7) computers over (4) islands

Wireless Networking: Cellular

- **1973** Dr Martin Cooper, Motorola Labs, invented the first personal mobile cellular telephone (weighed 2.5 lbs, 30 individual circuit boards, no display screen, 9”x5”x1.75”, 10 hours to charge for 35 minutes of use)

- **1983** marked American entry into the commercial cellular service market

- **1987** FCC allows and encourages cellular service providers to use alternate technologies in the 800Mhz radio spectrum to prompt use of digital transmission

Wireless Networking: IEEE

- **1990** IEEE 802 Executive Committee established the 802.11 Working Group to create a wireless LAN standard.
- **1997** working group approved IEEE 802.11 as the world's first wireless LAN standard
- New standards are continuously being developed by the Institute of Electrical and Electronics Engineers

First Generation

- Advanced Mobile Phone Service (AMPS)
  - US trials 1978; deployed in Japan (’79) & US (’83)
  - 800 MHz band — two 20 MHz bands
  - Duopoly within each market
- Nordic Mobile Telephony (NMT)
  - Sweden, Norway, Demark & Finland
  - Launched 1981; now largely retired
  - 450 MHz; later at 900 MHz (NMT900)
- Total Access Communications System (TACS)
  - British design; similar to AMPS; deployed 1985

Second Generation — 2G

- Digital systems
- Leverage technology to increase capacity
  - Speech compression; digital signal processing
- Utilize/extend “Intelligent Network” concepts
- Improve fraud prevention
- Add new services
- There are a wide diversity of 2G systems
  - IS-54/ IS-136 North American TDMA; PDC (Japan)
  - iDEN
  - DECT and PHS
  - IS-95 CDMA (cdmaOne)
  - GSM

North American CDMA (cdmaOne)

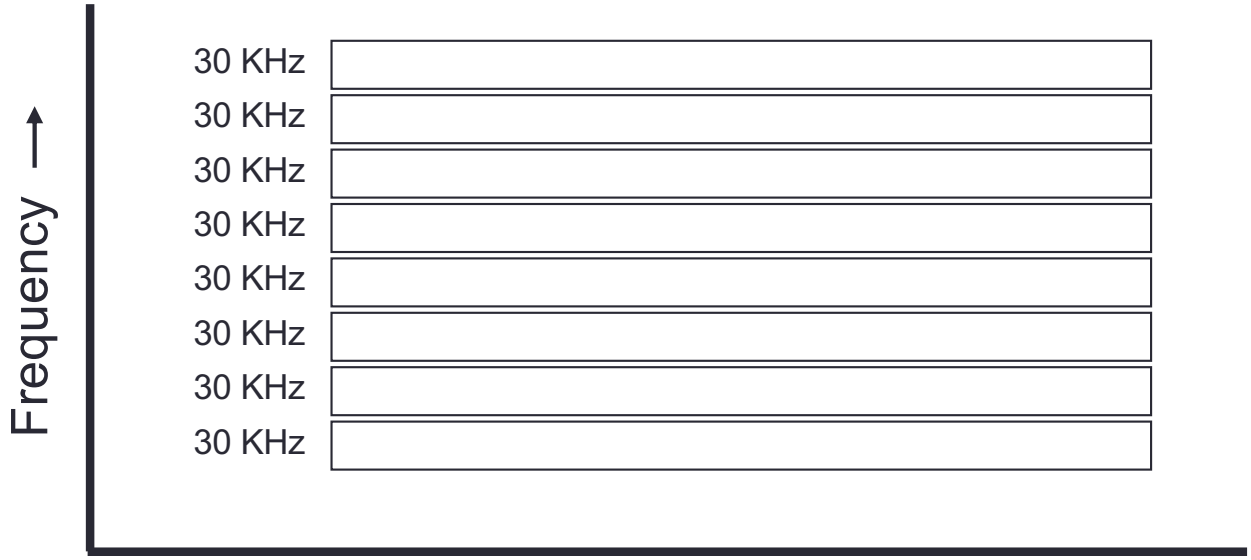
- Code Division Multiple Access
  - All users share same frequency band
  - Discussed in detail later as CDMA is basis for 3G
- Qualcomm demo in 1989
  - Claimed improved capacity & simplified planning
- First deployment in Hong Kong late 1994
- Major success in Korea (1M subs by 1996)
- Used by Verizon and Sprint in US
- Simplest 3G migration story today

GSM

- « Groupe Special Mobile », latter changed to « Global System for Mobile »
  - Joint European effort beginning in 1982
  - Focus on seamless roaming across Europe
- Services launched 1991
  - Time division multiple access (8 users per 200KHz)
  - 900 MHz band; later extended to 1800MHz
  - Added 1900 MHz (US PCS bands)
- GSM is dominant world standard
  - Well defined interfaces; many competitors
  - Tri/Quad-band GSM phone can roam the world today

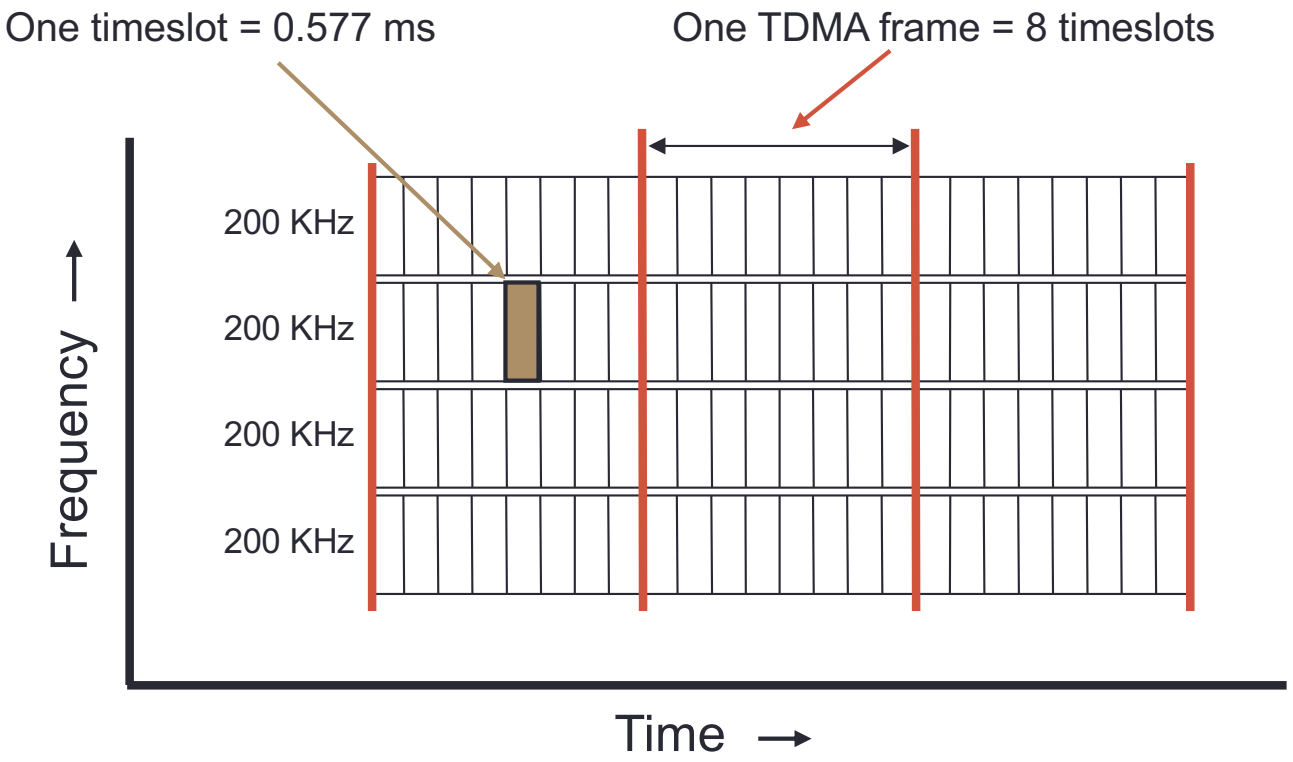
1G — Separate Frequencies

FDMA — Frequency Division Multiple Access

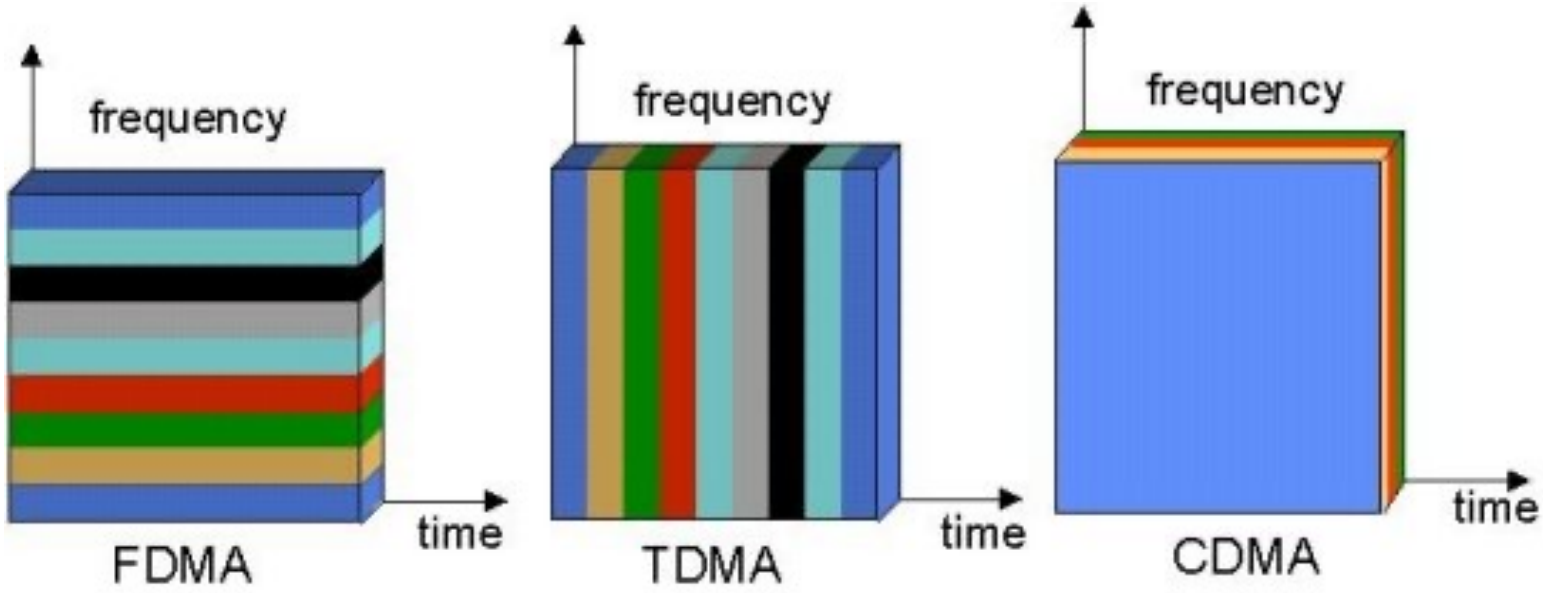


2G — TDMA

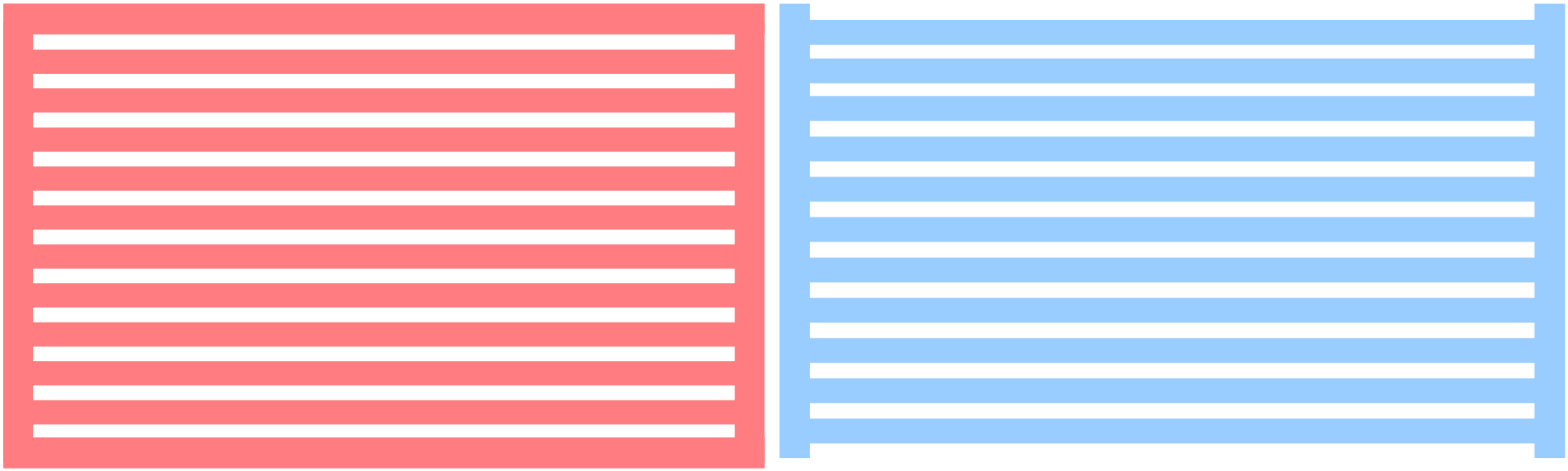
Time Division Multiple Access



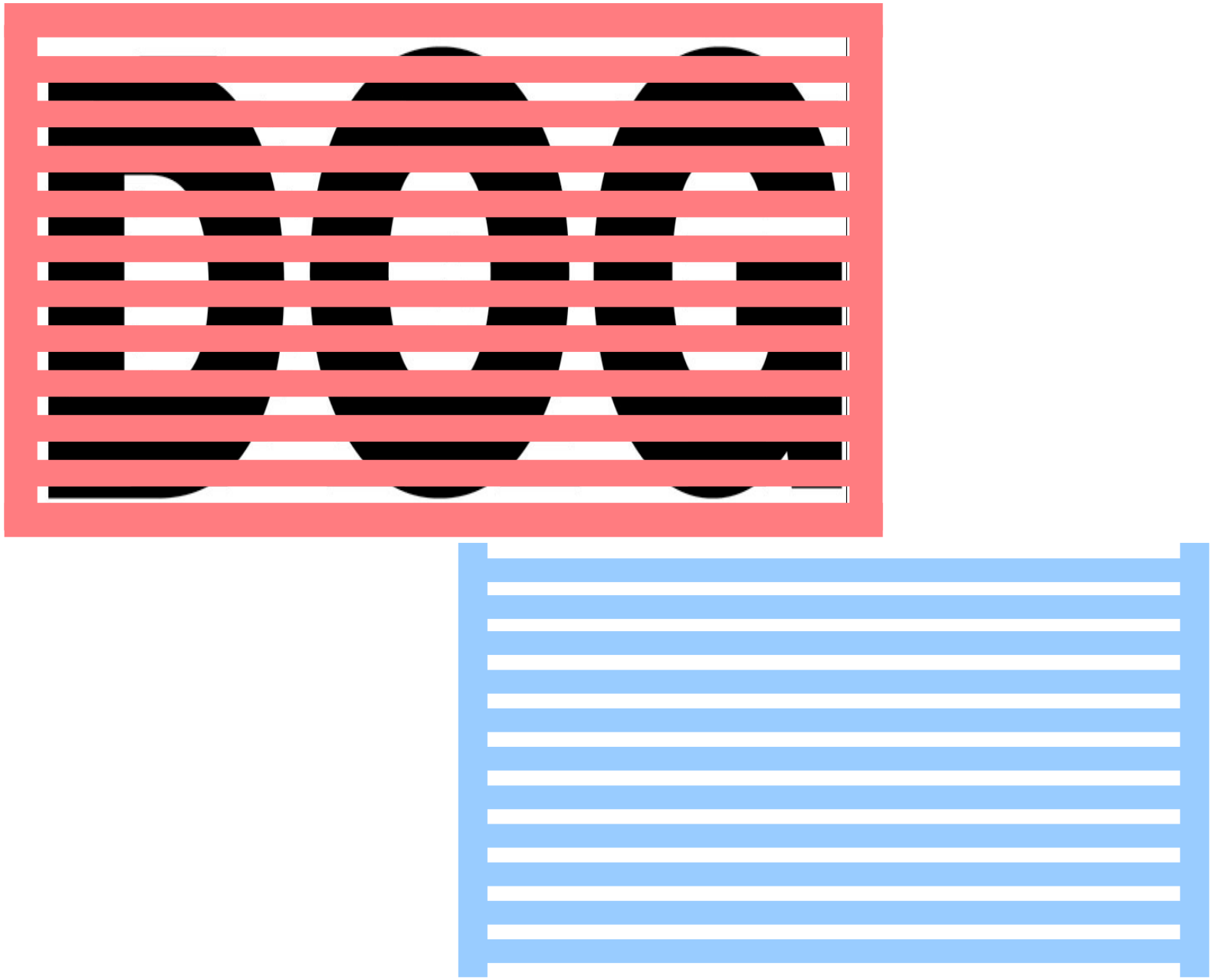
Multi-Access Radio Techniques



Courtesy of Petri Possi, UMTS World



Courtesy of Suresh Goyal & Rich Howard



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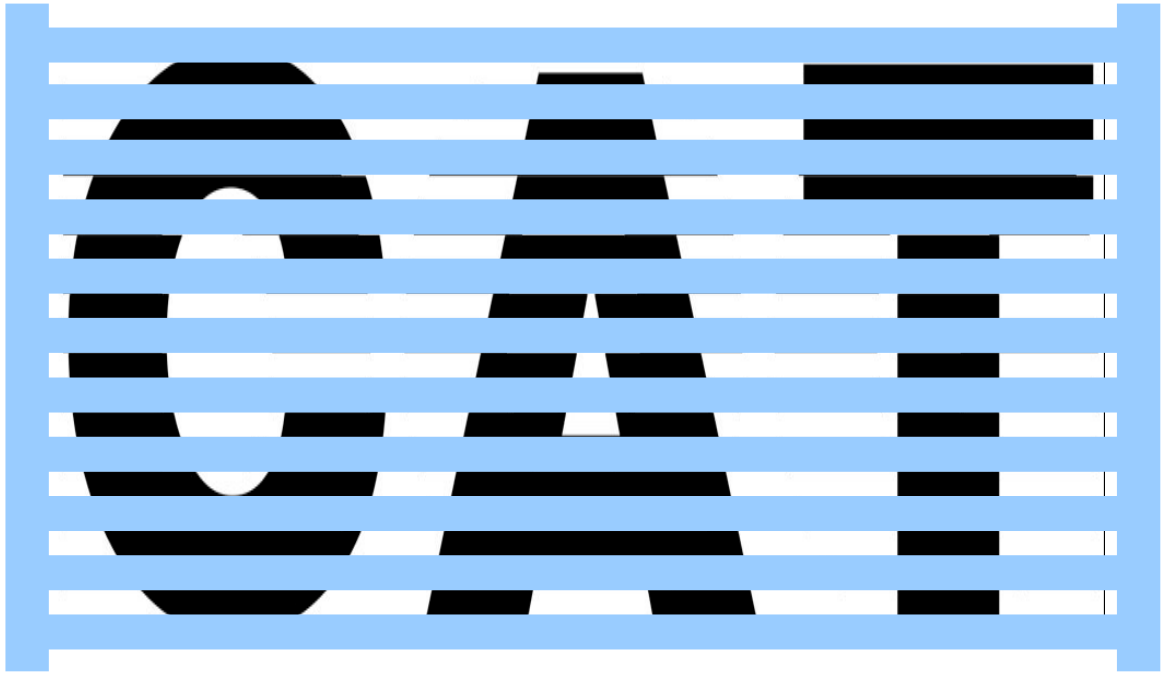
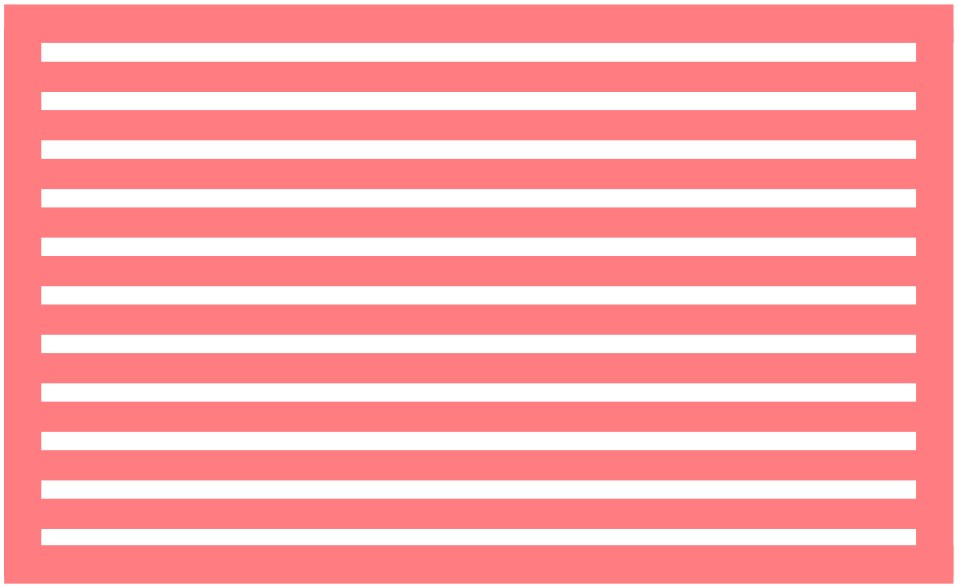
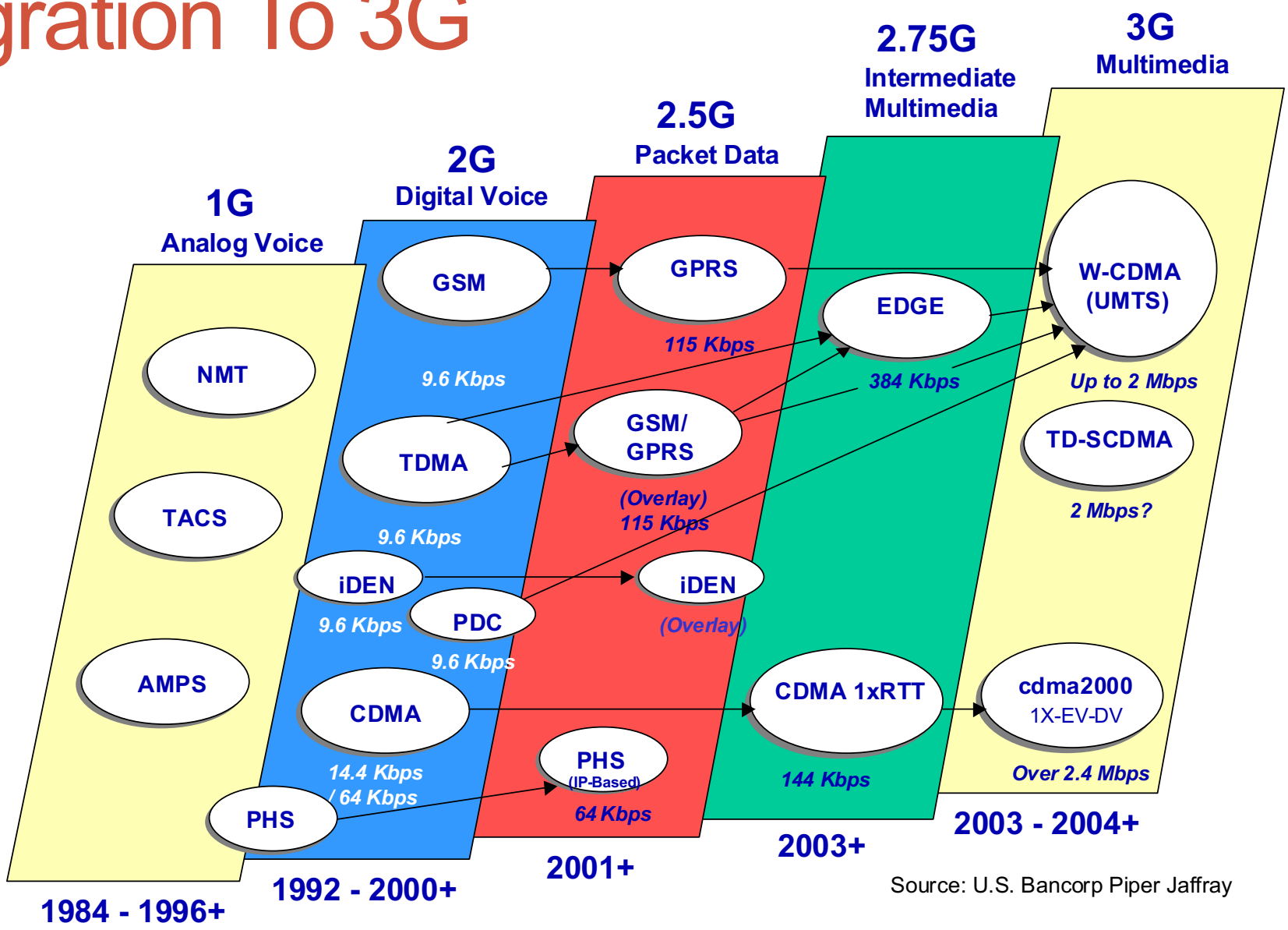




Courtesy of Suresh Goyal & Rich Howard

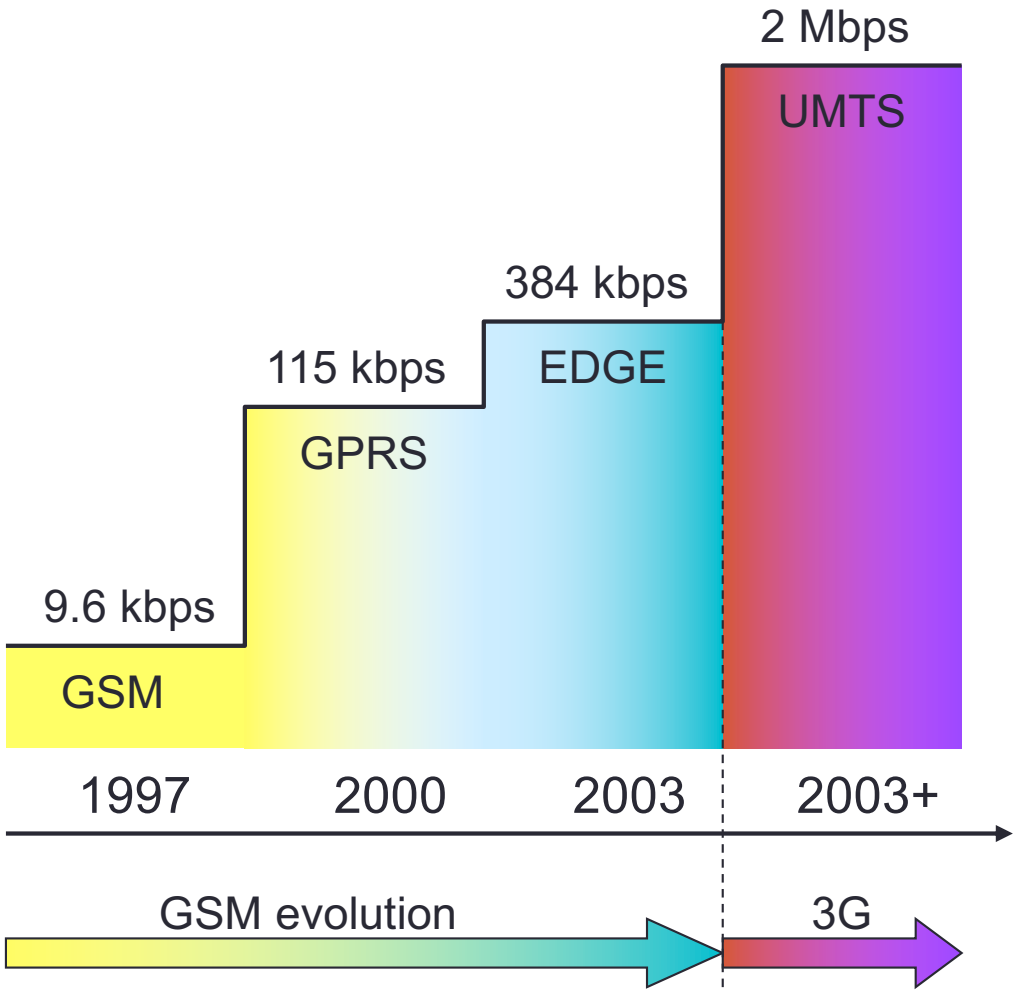
Courtesy of Suresh Goyal & Rich Howard

Migration To 3G



Source: U.S. Bancorp Piper Jaffray

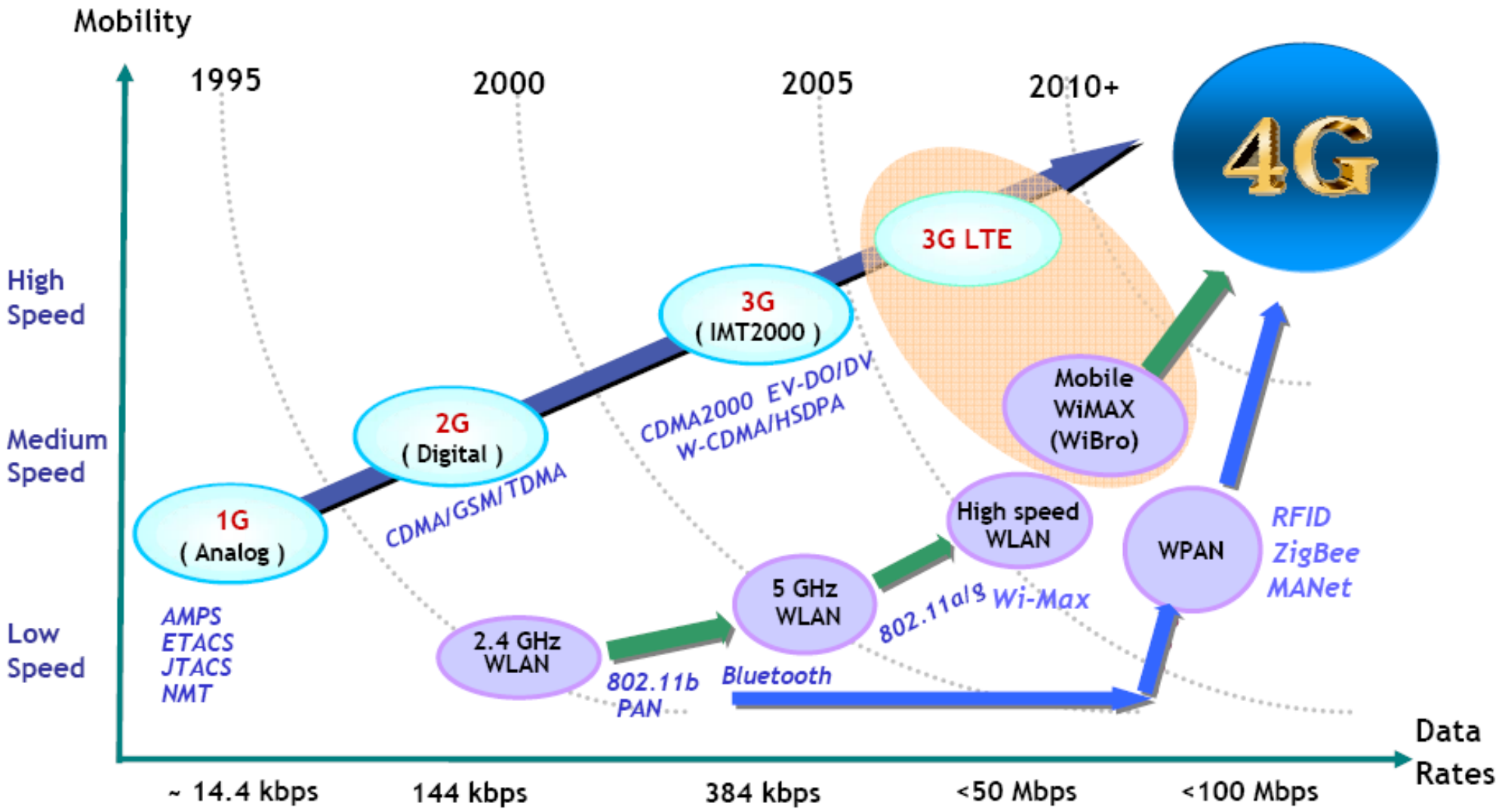
GSM Evolution for Data Access



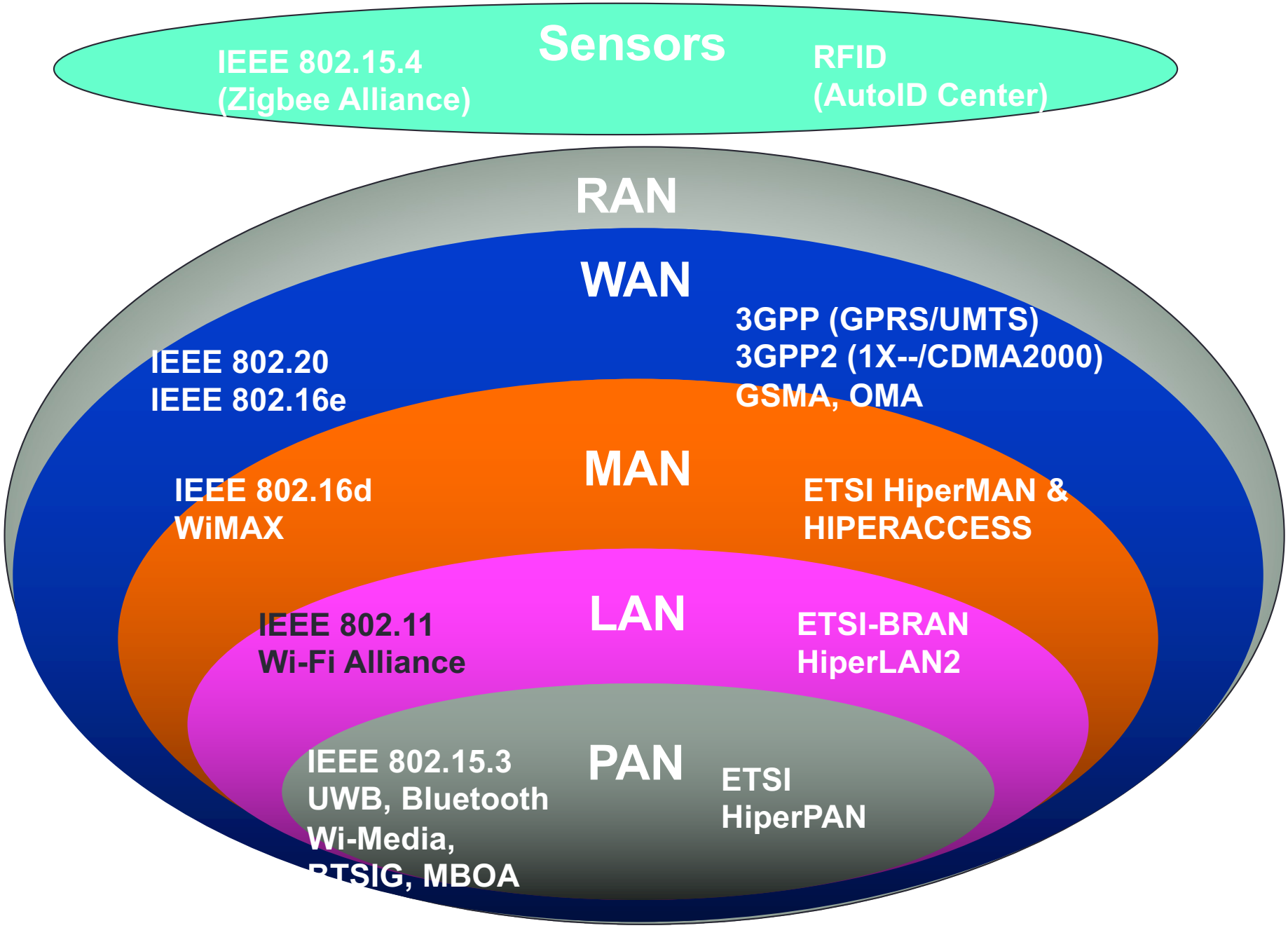
Why 4G ?

Current	4G
Voice communication	VoIP, high quality video conferencing
SMS, MMS	Video messaging
Internet browsing	Super-fast internet
Downloadable games	Online gaming with mobility
Downloadable video	High quality audio & video streaming
No TV service	Broadcast TV on-demand
Peer-to-peer messaging	Wide-scale distribution of video clips
	Mobile payment
	File transfer
	Many other innovative ideas

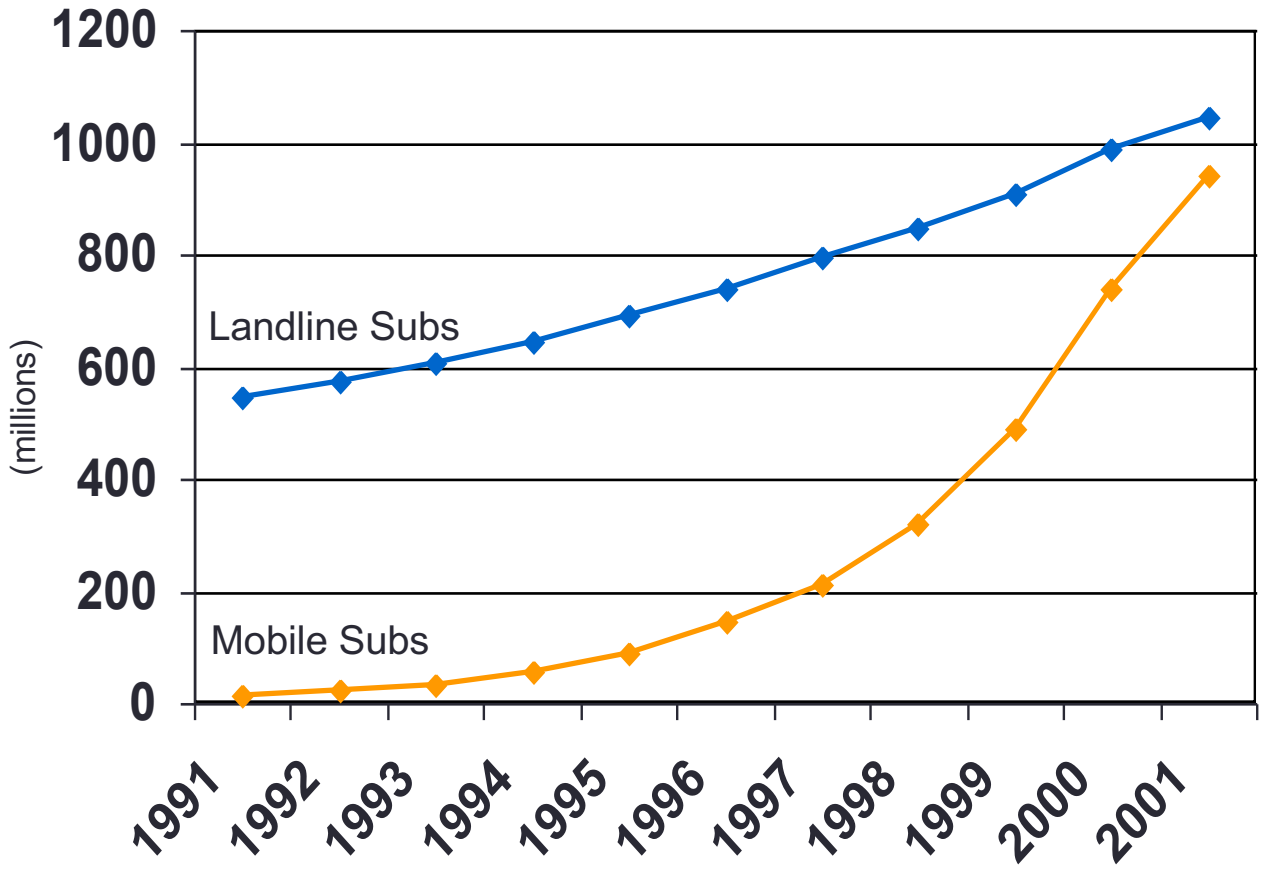
Technology Moving Towards 4G



Wireless Standards

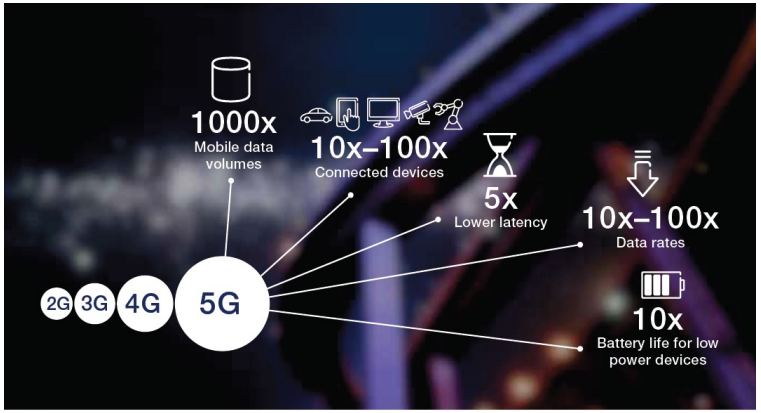


World Telecom Statistics



Crossover
has happened
May 2002 !

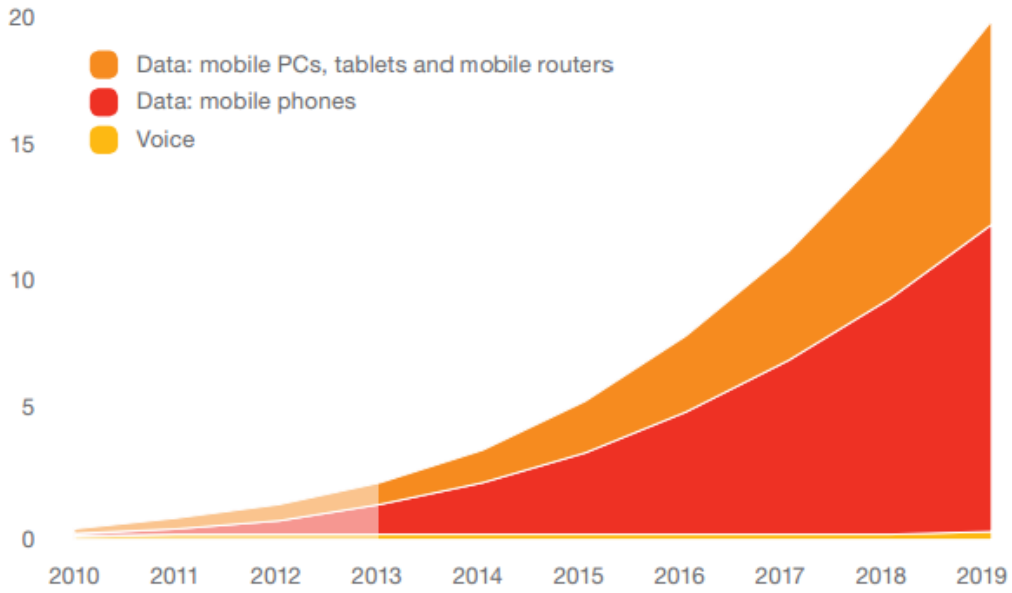
5G WIRELESS COMMUNICATION



Source: METIS

Why 5G

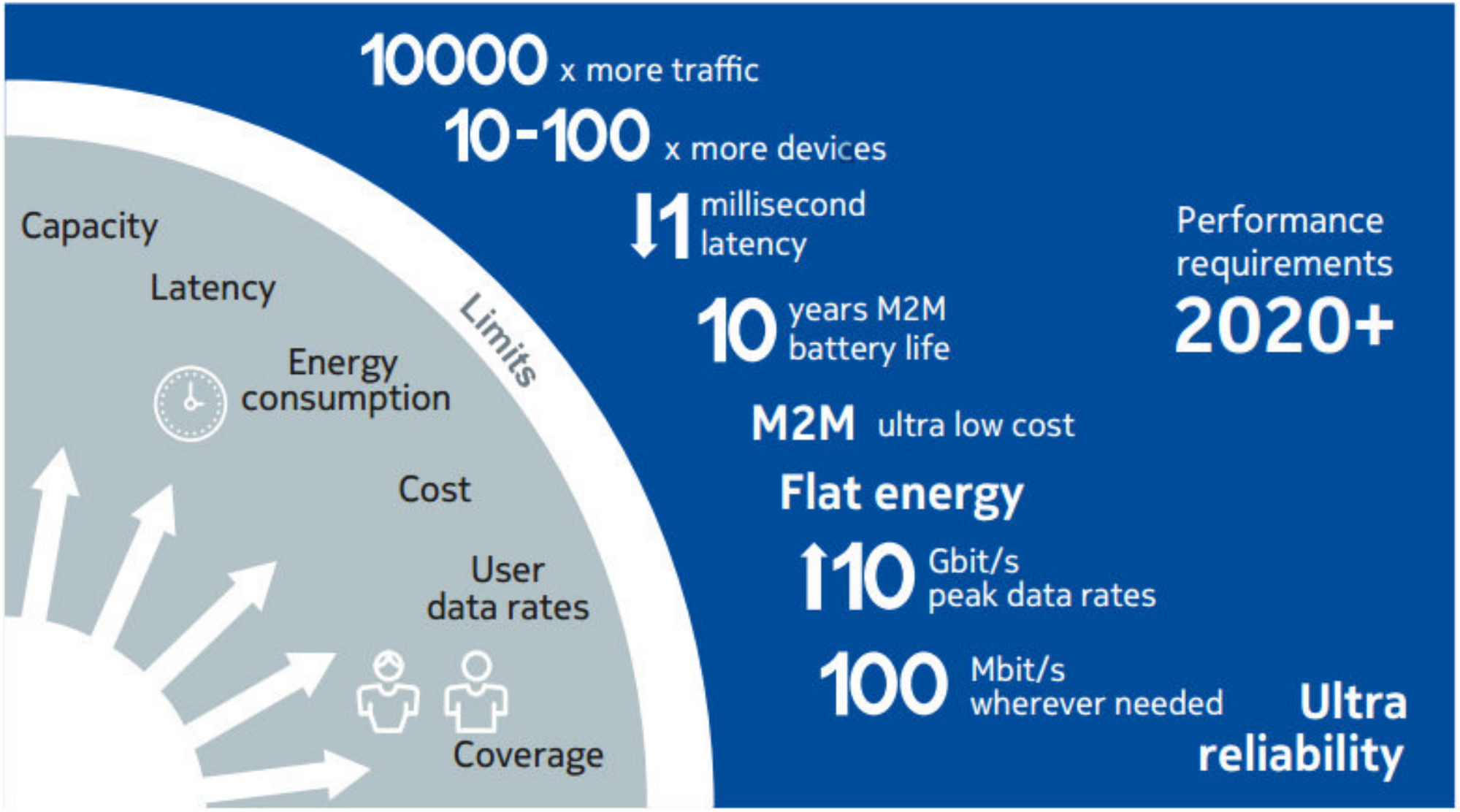
- Exponential increase of the population of wireless devices with ubiquitous Internet connectivity (expected to reach 50 billion by 2025)
- Internet of Things (IoT)



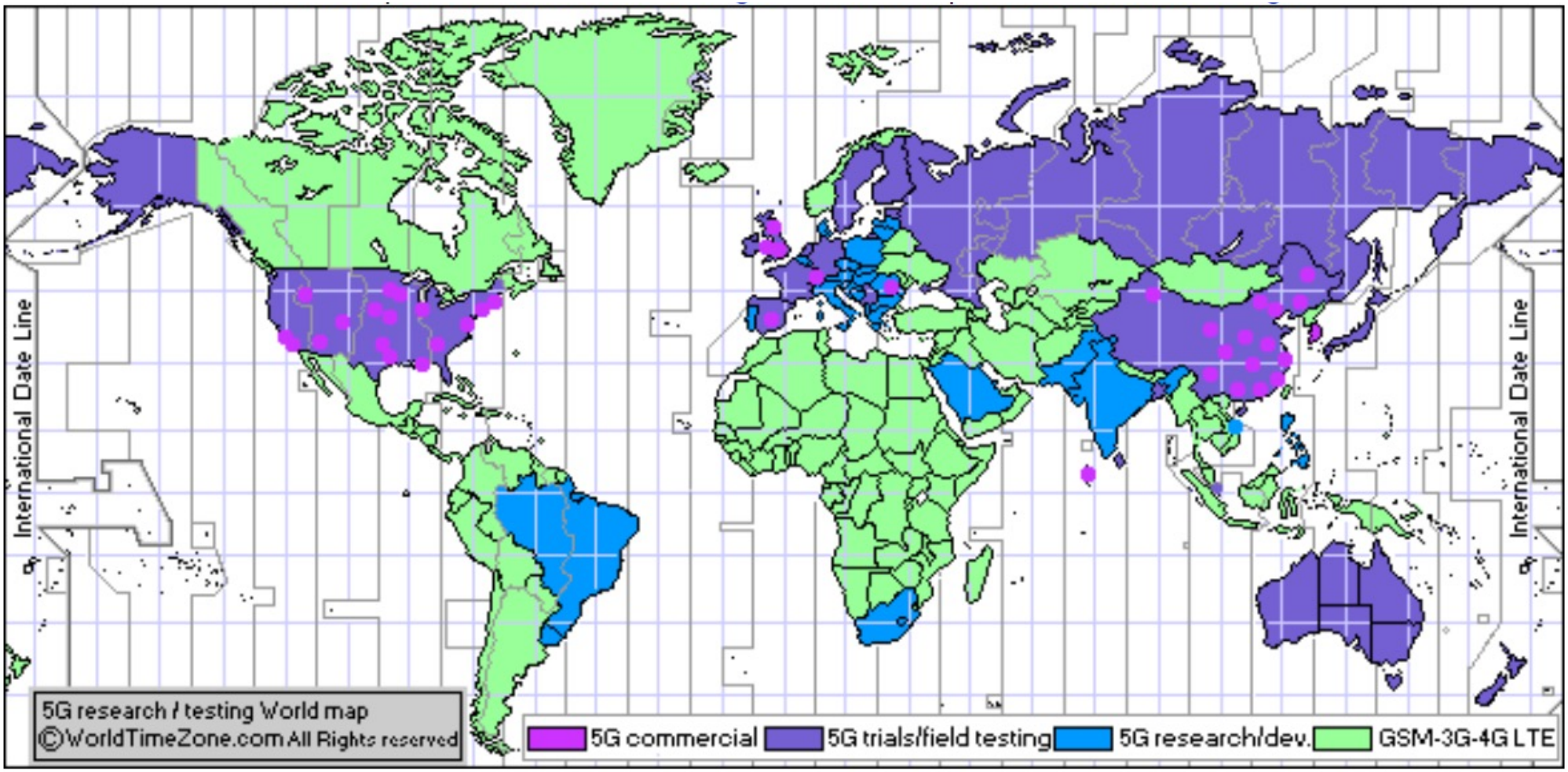
Source: Ericsson

Source: Ekram Hossein, *"Evolution Toward 5G Cellular Networks: A Radio Resource and Interference Management Perspective"*, IEEE ICC 2020

The 5G Networks



5G Rollout



5G Commercial Network Coverage Graph

[1] https://www.worldtimezone.com/5g.html

Limitations of 5G

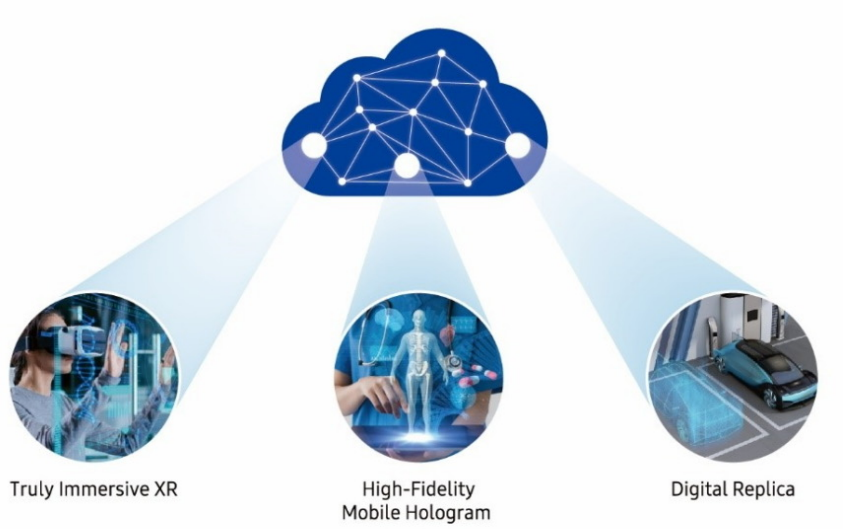
5G systems that are currently being marketed will readily support basic IoE and URLLC service.

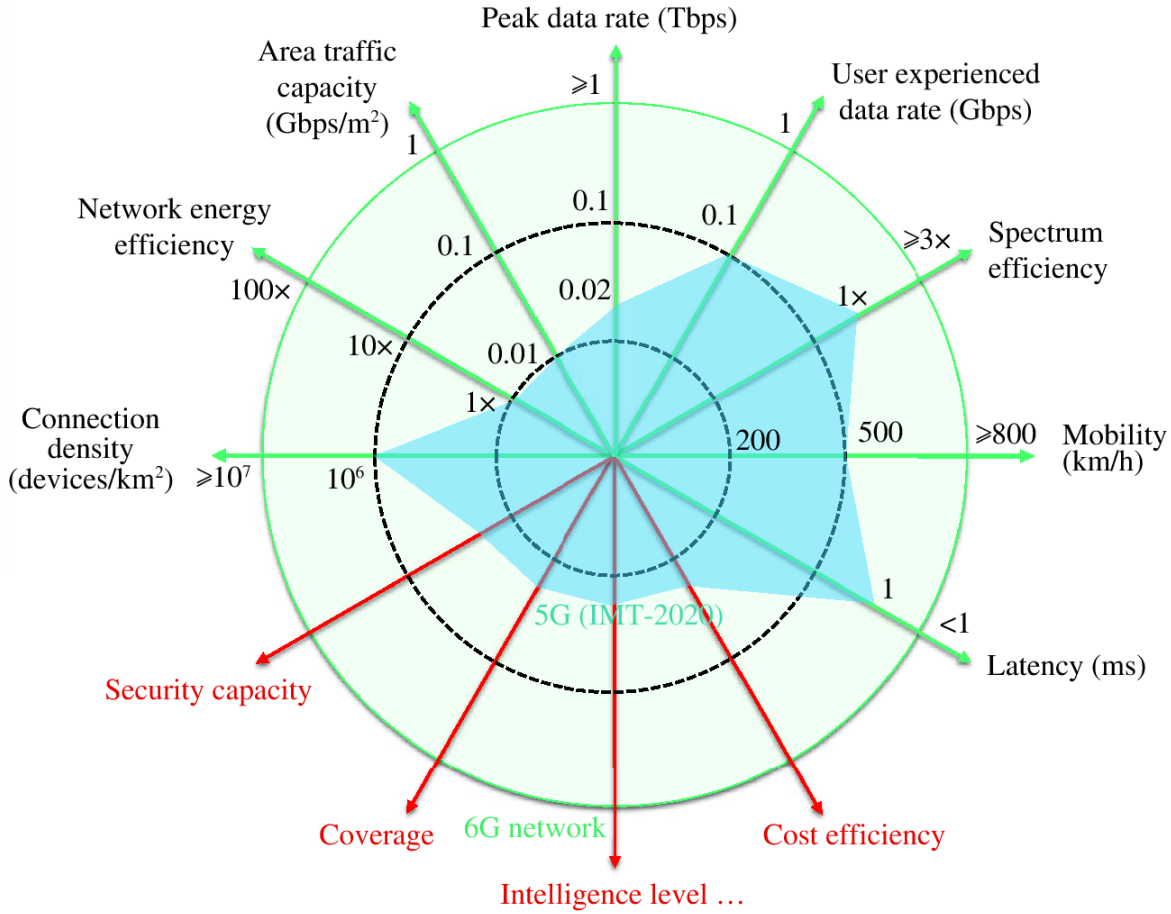
Whether they can deliver tomorrow's smart city applications?

WHAT'S THE NEXT G?


6G

The Vision of 6G

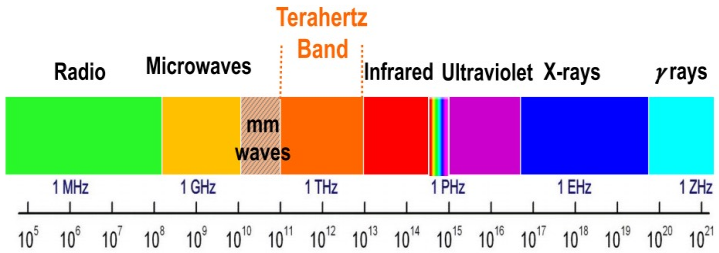




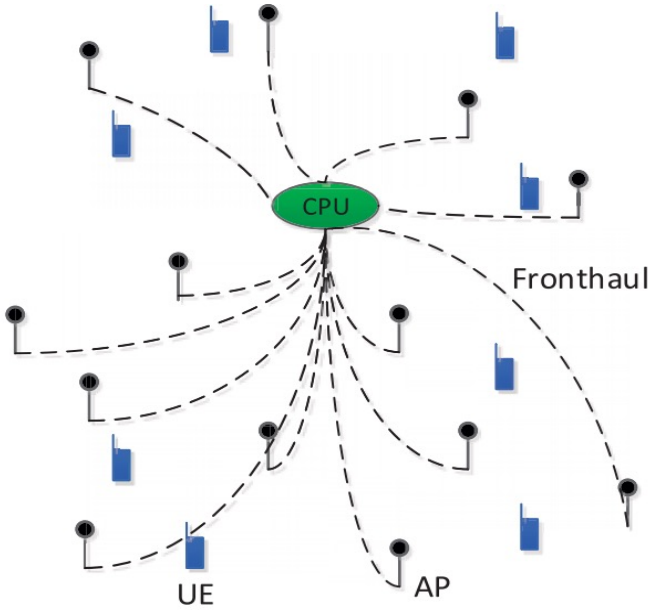
Key performance indicators for 6G.

''The Vision of 6G,'' Samsung Research, 14 July 2020. https://news.samsung.com/global/samsungs-6g-white-paper-lays-out-the-companys-vision-for-the-next-generation-of-communications-technology

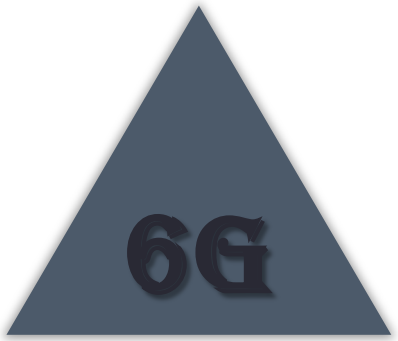
Key Physical Layer Enablers for 6G

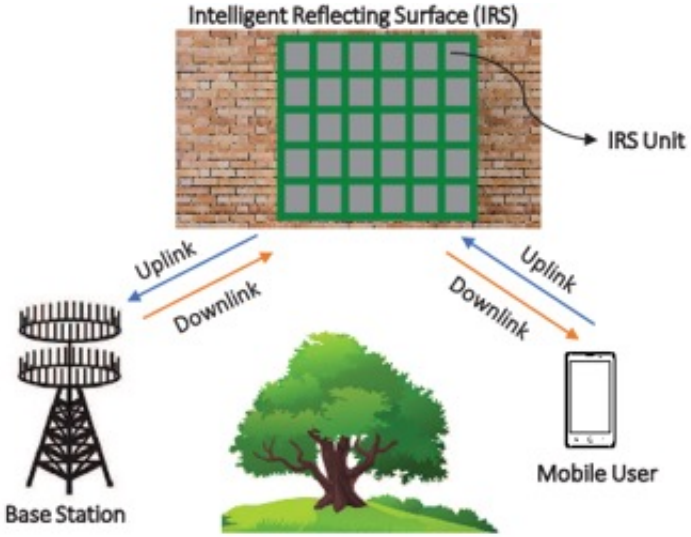


Terahertz Band Communication



Cell-free Massive MIMO





Smart Radio Environments

[1] M. Michail, et al. "The road to 6G: Ten physical layer challenges for communications engineers." *IEEE Communications Magazine* 59.1 (2021): 64-69.

THANK YOU

For more on our research, please visit:

www.ipt.seecs.nust.edu.pk