Mobile and WLAN technologies

Lecturer: Prof Xiaodong Chen

- Introduction to Mobile/WLAN Technologies
- Overview of module organisation

Age of Mobile Internet

iPhone 11

iPhone 1 1 Specs:

2G & 2.5G:
GSM/EDGE (850, 900, 1800, 1900 MHz)
3G & 3.5G:
TD-SCDMA 1900 (F), 2000 (A)
CDMA EV-DO Rev. A (800, 1900, 2100 MHz)
UMTS/HSPA+/DC-HSDPA (850, 900, 1700/2100, 1900, 2100 MHz)
4G:
FDD-LTE (Bands 1, 2, 3, 4, 5, 7, 8, 12, 13, 14, 17, 18, 19, 20, 25, 26, 29, 30, 66, 71)
TD-LTE (Bands 34, 38, 39, 40, 41, 42, 46, 48)
Gigabit-class LTE with 4x4 MIMO and LAA4

802.11ax Wi-Fi 6 with 2x2 MIMO

Bluetooth 5.0 wireless technology

Ultra Wideband chip for spatial awareness5
NFC with reader mode
Express Cards with power reserve

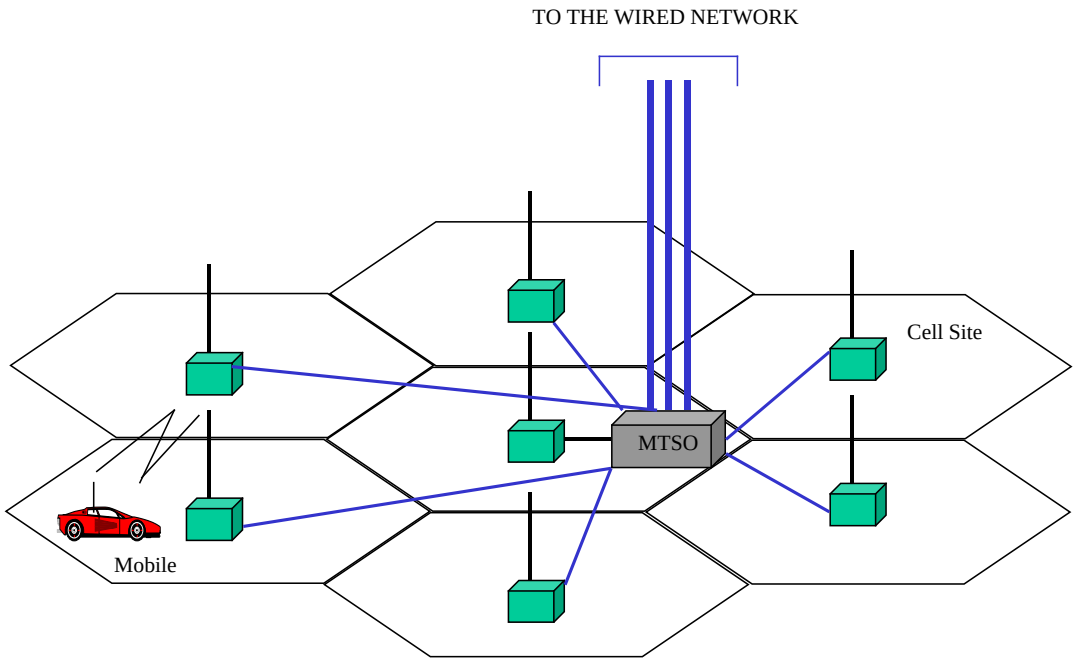
Installed all the technologies covered in this module!

History of Mobile Phones

Evolution of Mobile Networks

1st Generation: analog – voice

AMPS(Advanced Mobile Phone Service) – FDMA



Martin Cooper

•Inventor of cell phone

Drawbacks:

- **poor voice quality**
- **limited capacity**
- **manual roaming**
- **no security**
- **poor battery life**

Evolution of Wireless Networks

2nd generation: digital – voice, text

- Cellular & PCS with seamless roaming and integrated paging
- IS-95 – narrowband CDMA
- IS-136, GSM -TDMA

- Low data rate!
- …

3rd Generation

- Wide-area mobile: voice/data – smart phone
  - 2.5G: GPRS, EDGE (64-144 kbps)
  - 3G standards: (144kbps – 2mbps)

  UMTS/IMT2000, Wideband CDMA, CDMA2000, TD-SCDMA

  – High bandwidth requirement.

4th Generation – LTE/LTE-A

- **High speed data access (100Mbps – 1Gbps)**
  - **Advanced antennas: MIMO**
  - **Signalling: OFDM**
  - **Features: MAGIC**
    - » **Mobile Multimedia**
    - » **Anywhere Anytime**
    - » **Global Mobility Support**
    - » **Integrated Wireless Solutions**
    - » **Customised Personal Services**
  - **Mobile Internet**

Impact of Mobile Internet

What is your personal experience?

5th Generation Mobile Network

1G (~1980)

Analogue

2G (1990)

GSM

3G (2003)

UMTS

4G

(2010)

LTE-A

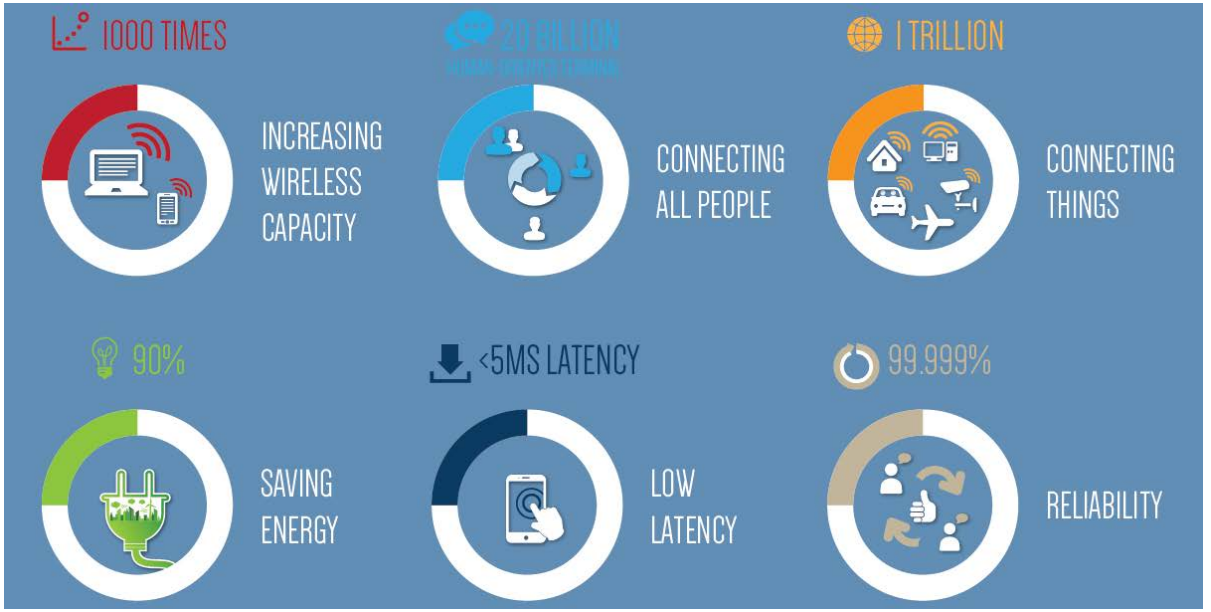
5G

(2020)

5G Initial Requirements

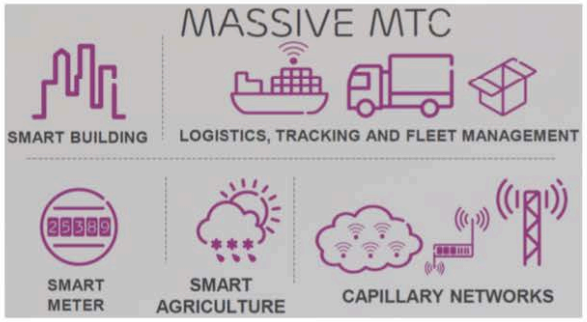
– Focus on "User Experience"

- Intelligent Terminal

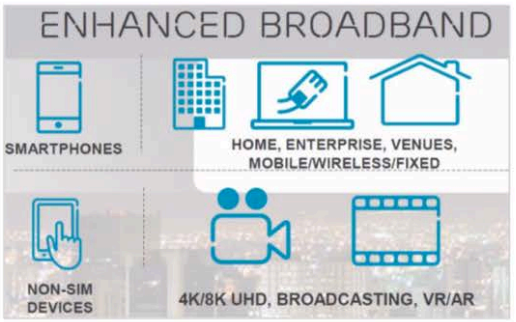


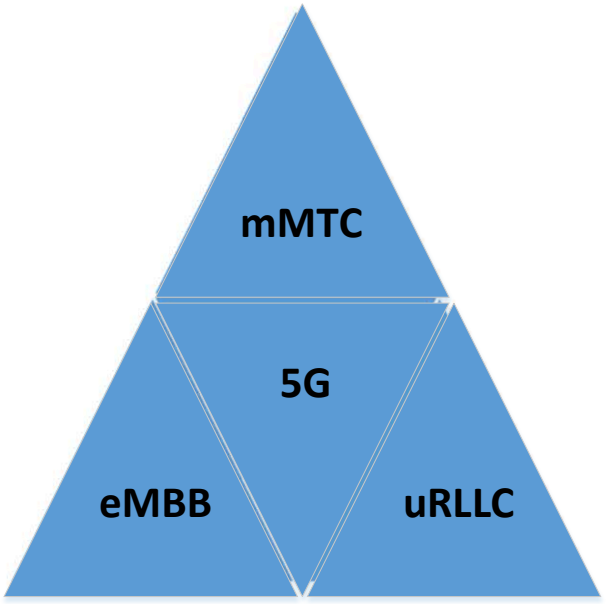
5G Application Scenarios

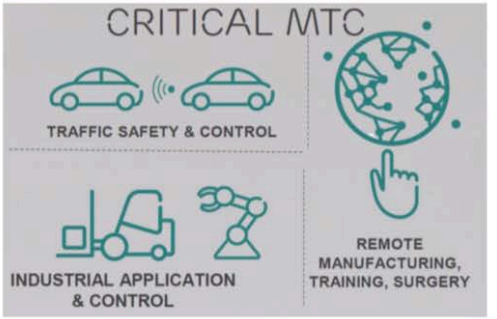
Low Cost
Low Energy
Low Data Volume
Large Numbers



Ultra Reliable,
Low Latency,
High availability







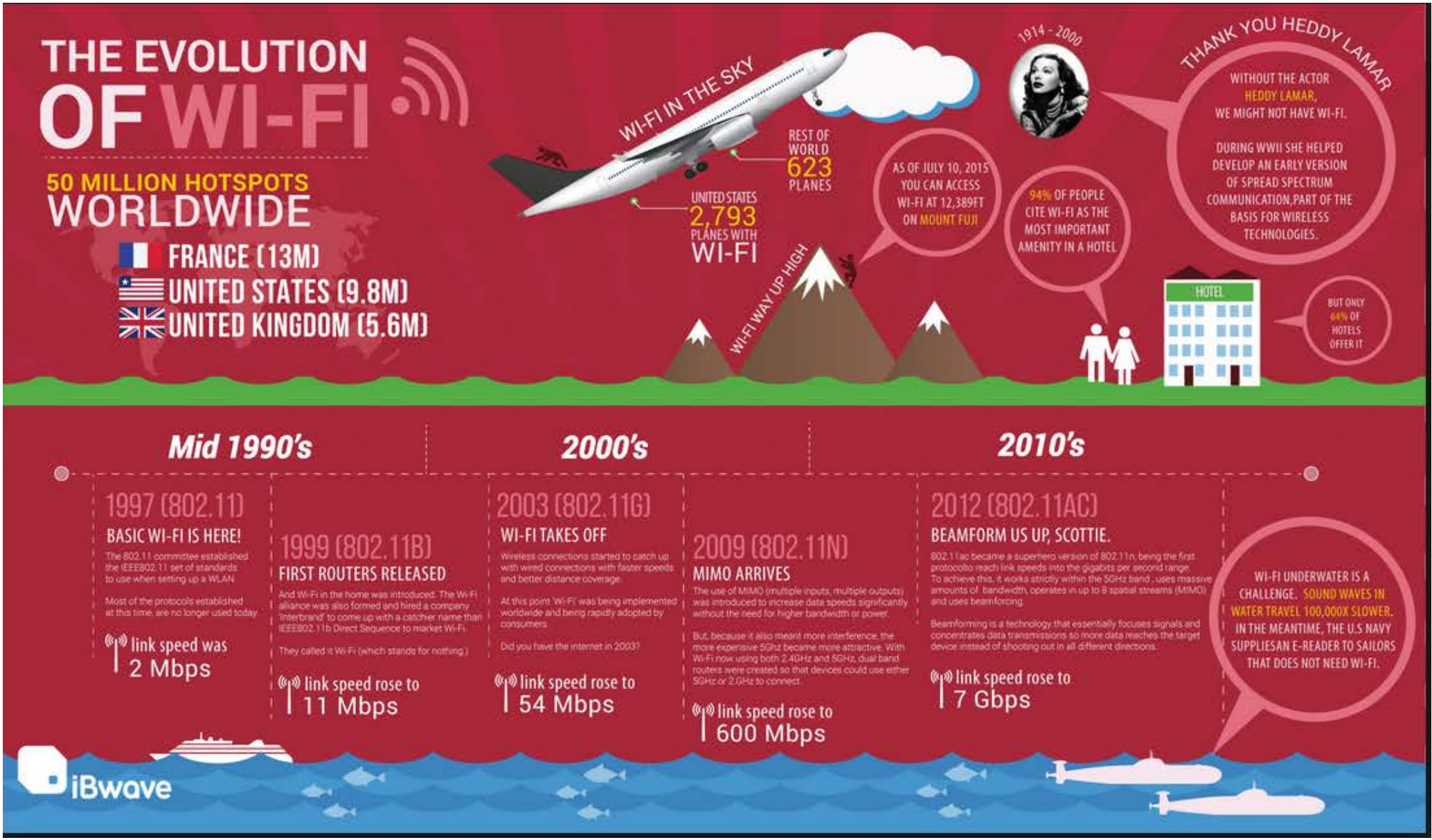
High Throughput
Low Latency

Intelligent Terminal

MTC – Machine Type of Communications

Figures from: H. Ji, et al. "Introduction to Ultra Reliable and Low Latency Communications in 5G", arXiv:1704.05565v1
O. Yilmaz, Ultra-Reliable and Low-Latency 5G Communication, EuCNC'16

Evolving of WLAN/Wi-Fi



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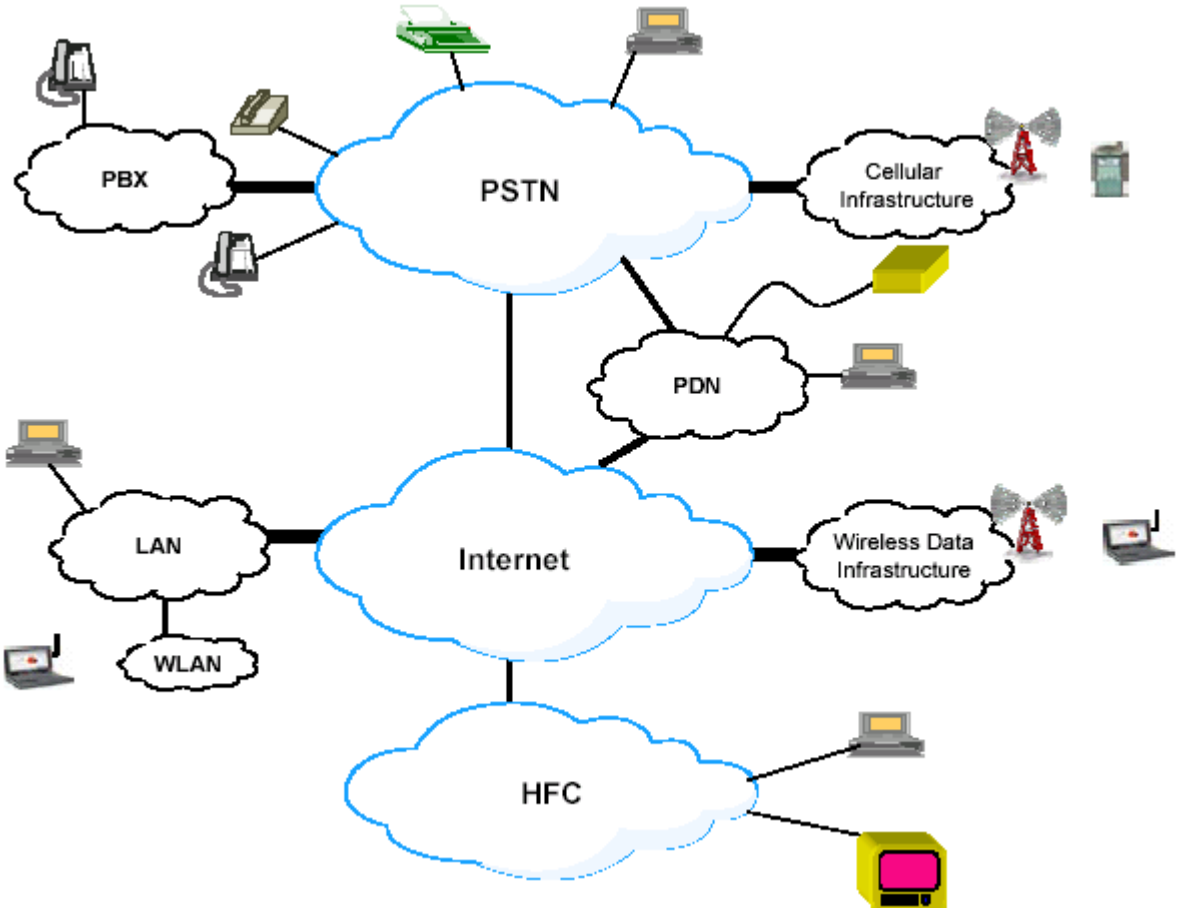
History of Internet



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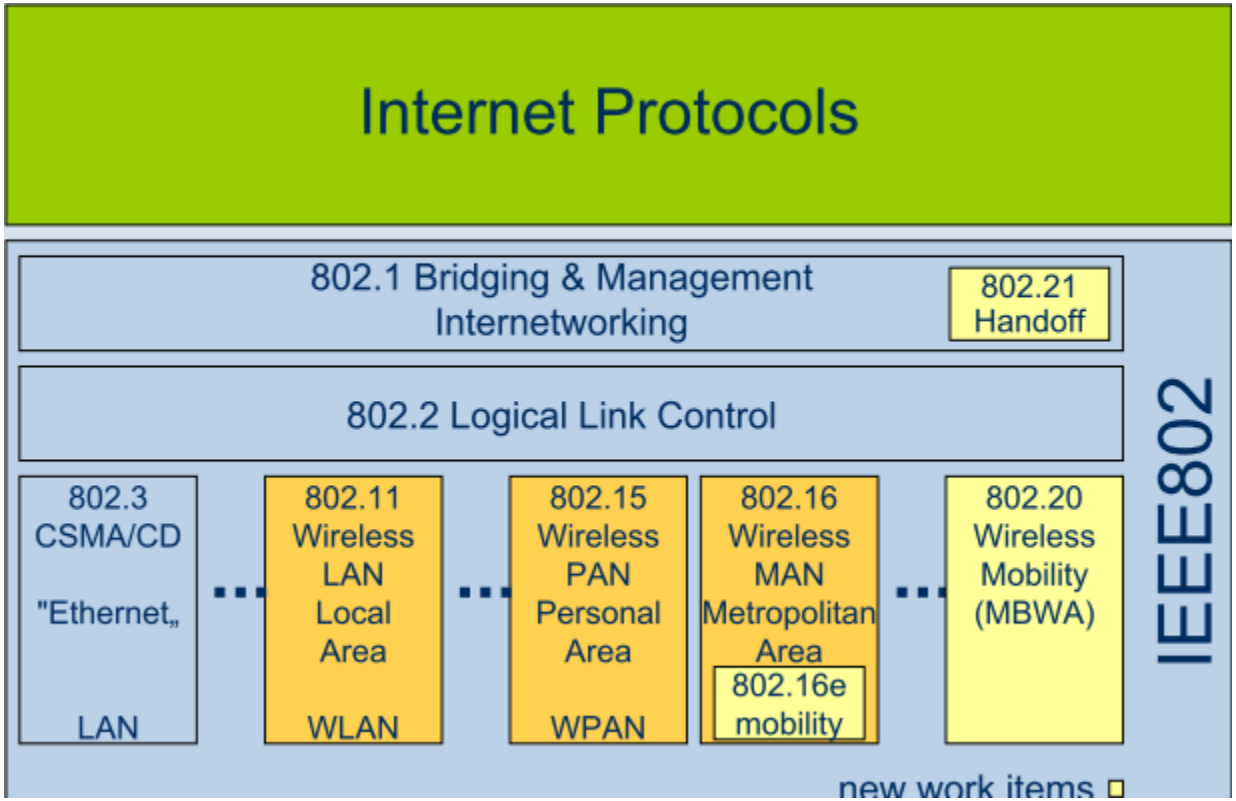
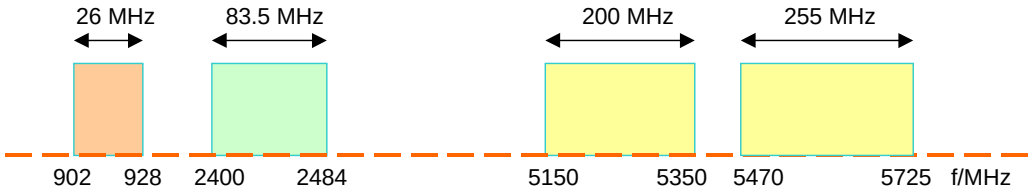
IEEE 802 Standards

- **IEEE 802.11x:**
  - **Wireless LAN, also known as WiFi**
- **IEEE802.15 covering:**
  - **Bluetooth (802.15.1) and WiMedia (802.15.3) - Wireless PAN**



IEEE802 Spectrum

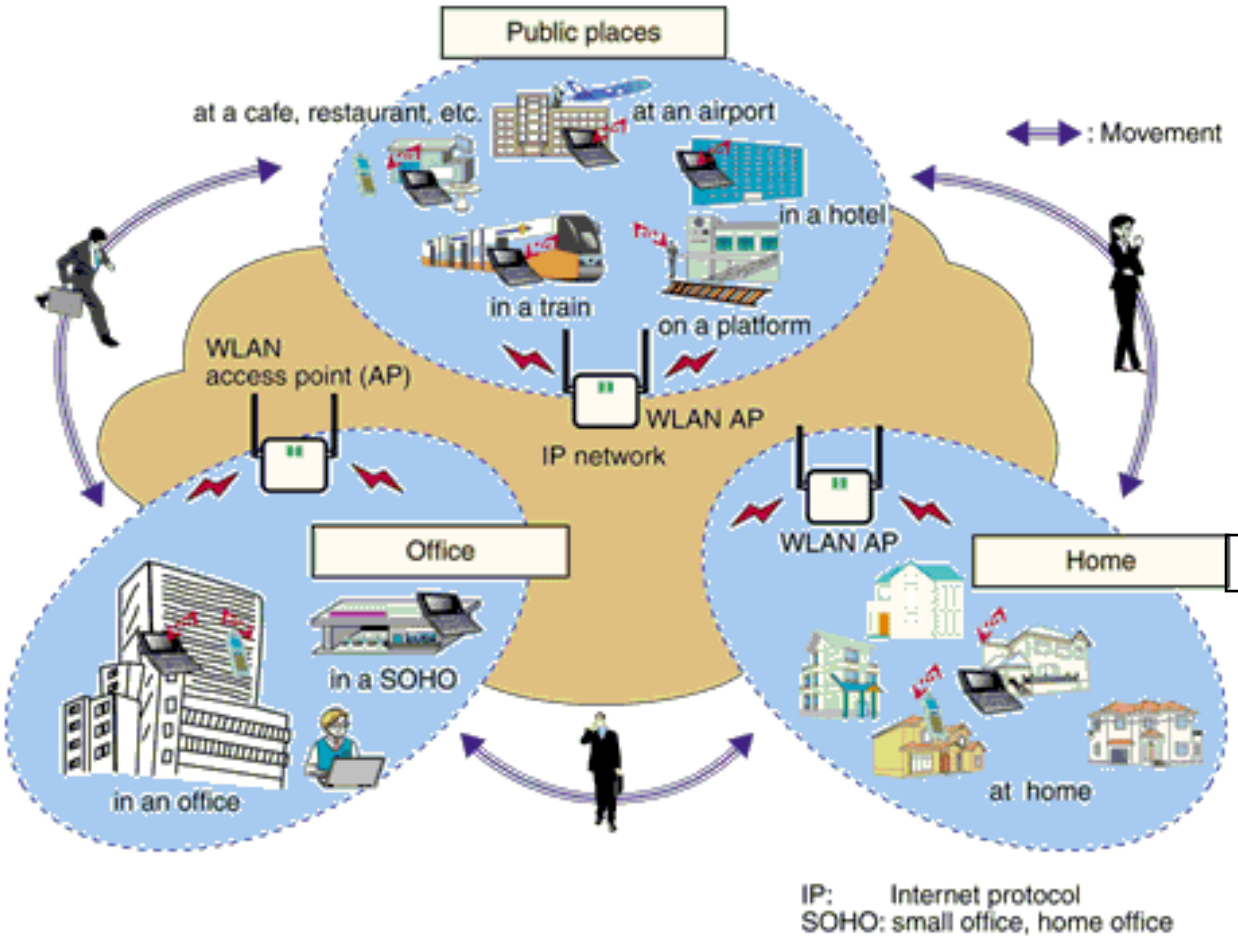
- **WLAN (IEEE802.11)**
  - **ISM bands: 2.4 GHz and 5 GHz**



- **Bluetooth (IEEE802.15.1)**
  - **ISM band: 2.4 GHz**

- **WiMedia (IEEE802.15.3)**
  - **UWB bands: 3.1 – 10.6GHz in USA.**

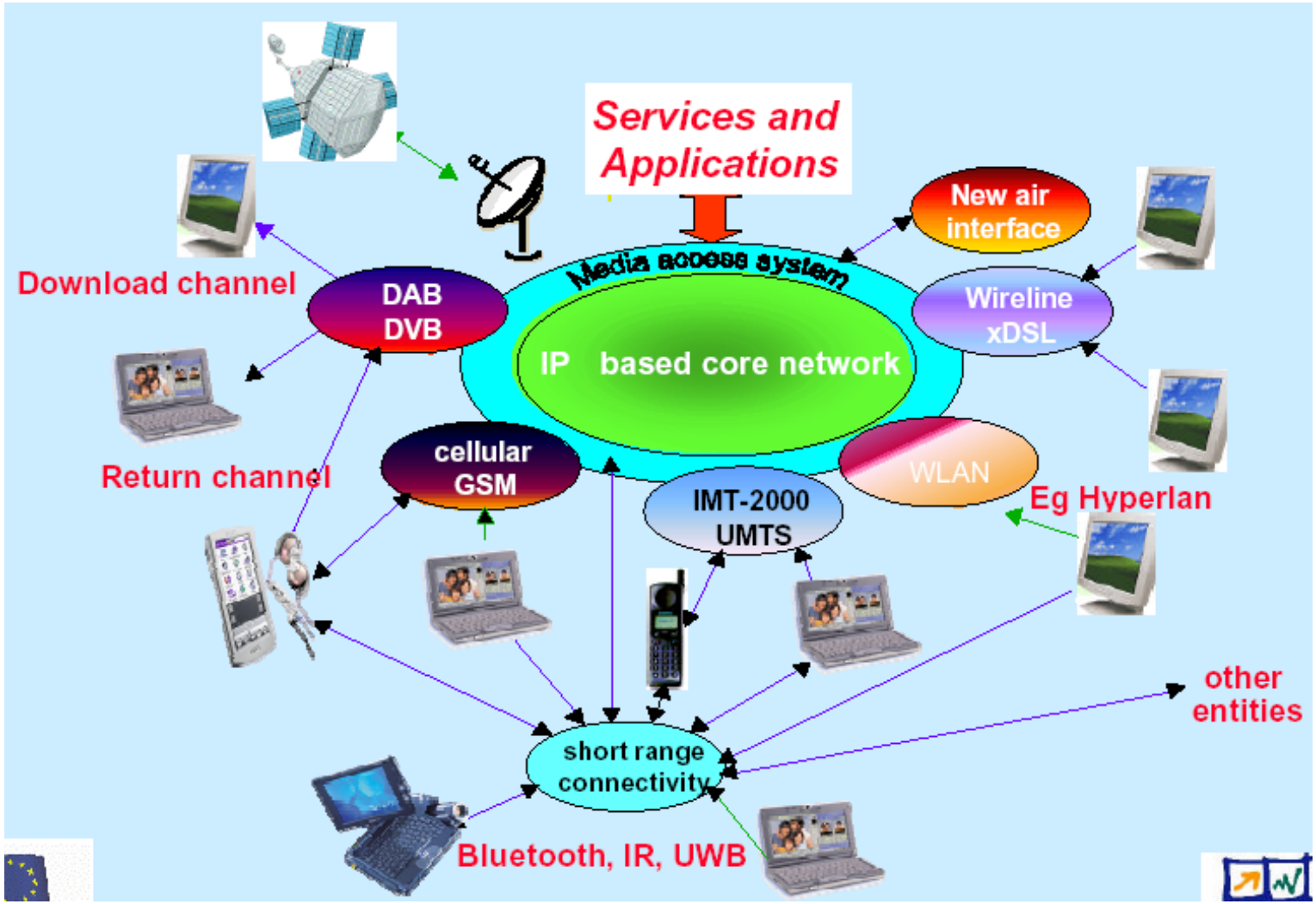
Wide IEEE802 Applications



Gigabit WLAN/WPAN

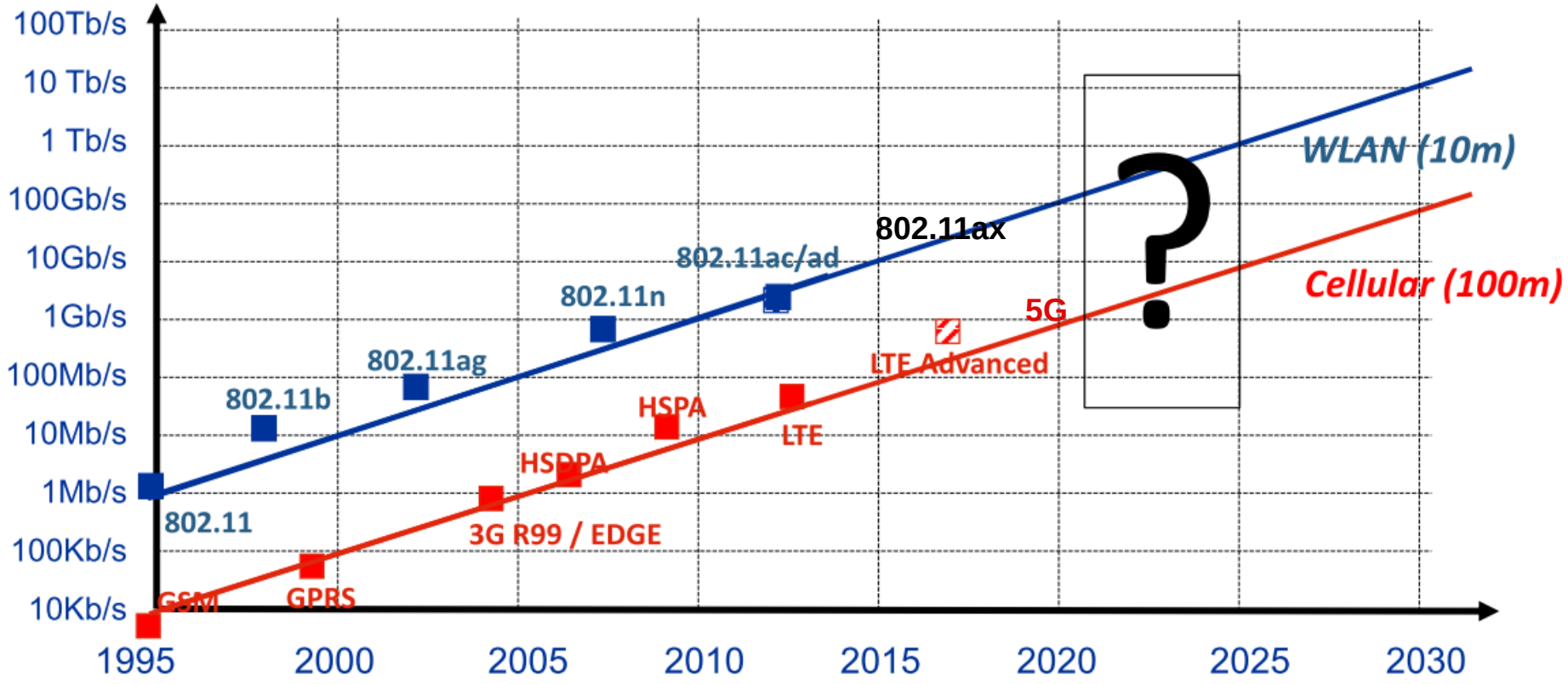
- **New Applications are fueling the need of high data rate WLAN/WPAN!**

Evolving Communication Networks



Core and Access Networks

Evolution of Wireless Networks



Question: 5G or 6G?

Generic Challenges in Wireless Access

- Wireless Access  Mobility and Portability

(Anywhere and any time)

Three fundamental issues:

1. Wireless channel impairment solutions
2. Channel access (Multiple access)
3. Mobility management (handoff/handover)

Other issues:

- Data Rate and network capacity
- QoS for voice, data, multimedia traffics
- Power control (smooth operation and battery life)
- Privacy/security (encryption)

Challenges in 5G

Support Diverse Use Cases & Requirements

1

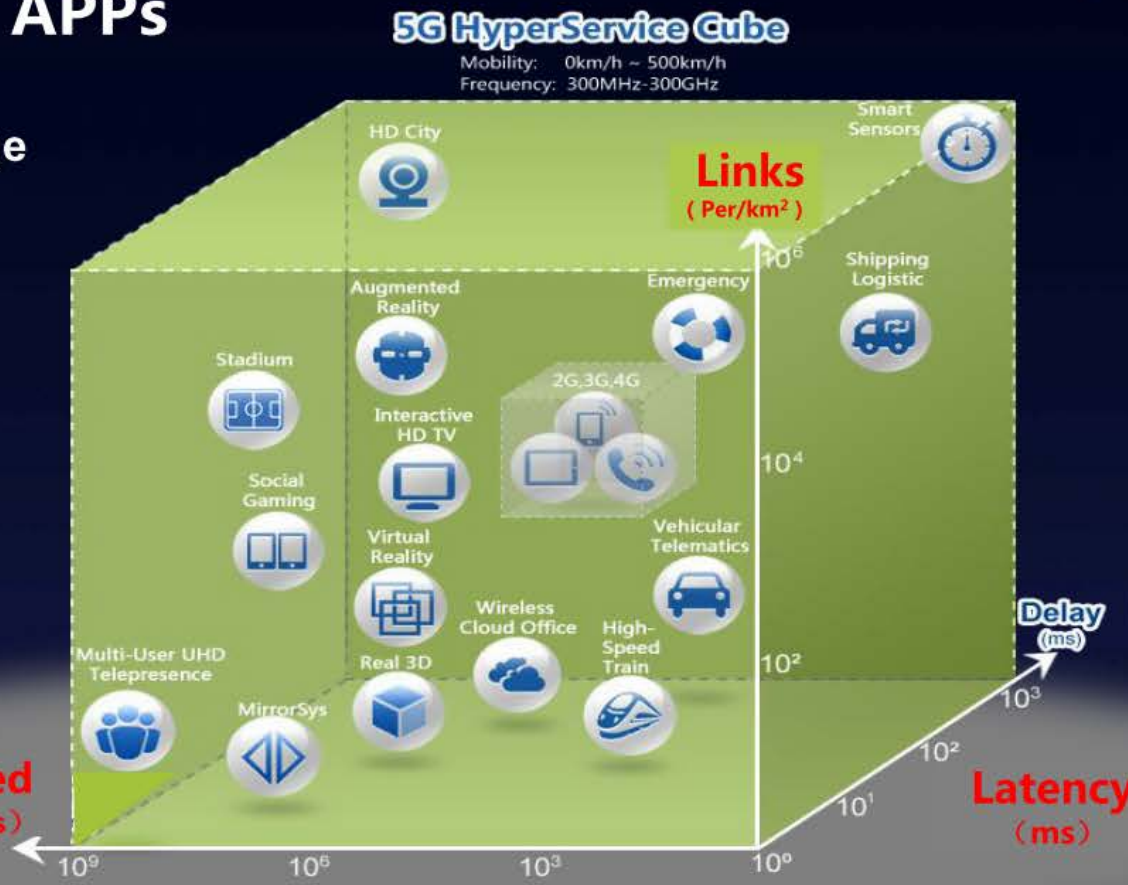
Beyond Internet Access and APPs

Unprecedented Performance Challenge

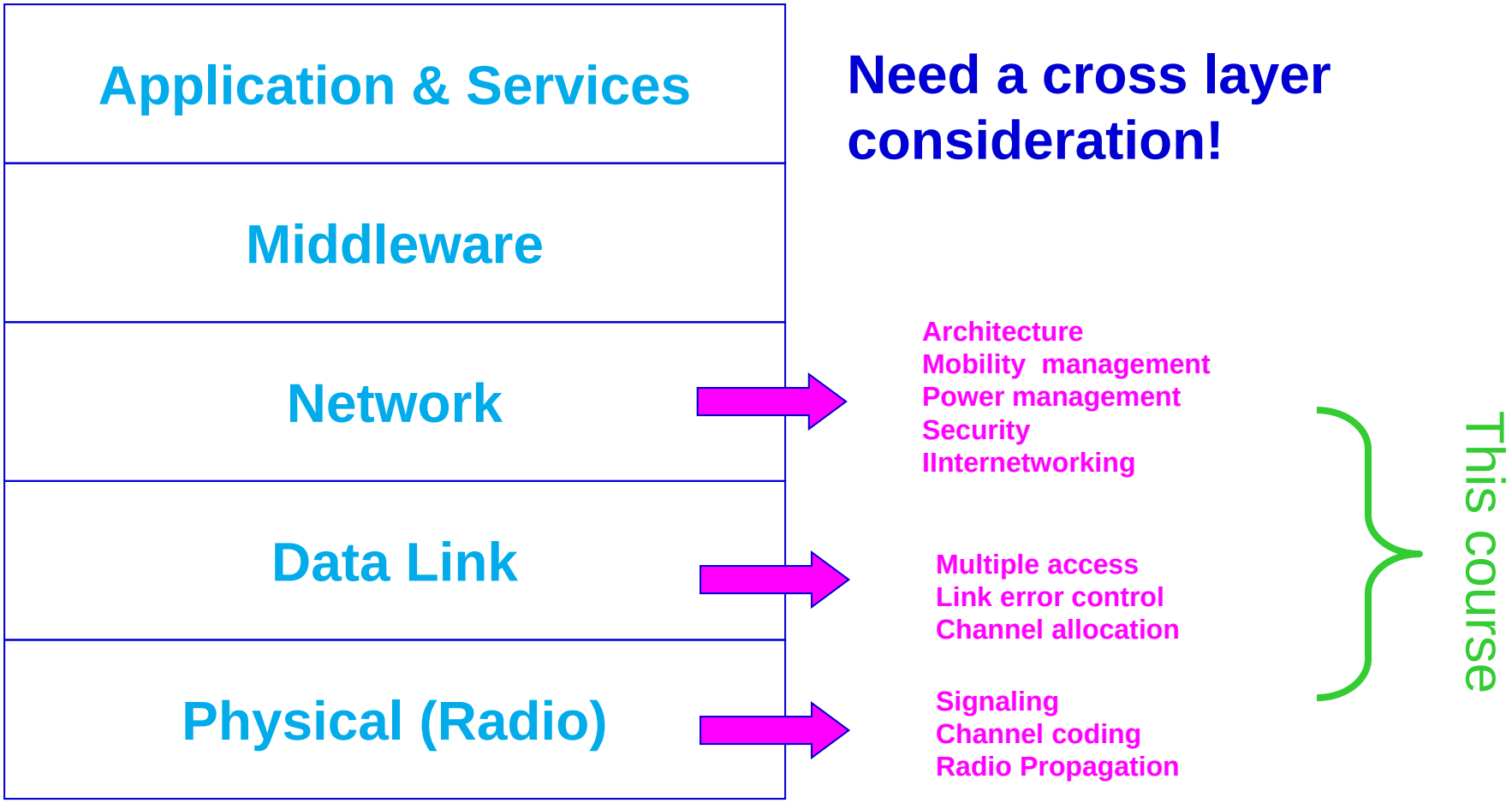
- Stretched in 3 Dimensions
  - Speed
  - Links
  - Response
- Spectrum Efficiency
- All Spectrum Access

Networks Re-Architect Challenge

- No-Cell Virtual RAN
- Software Defined &Simplicity
- Service Aware and Monetize

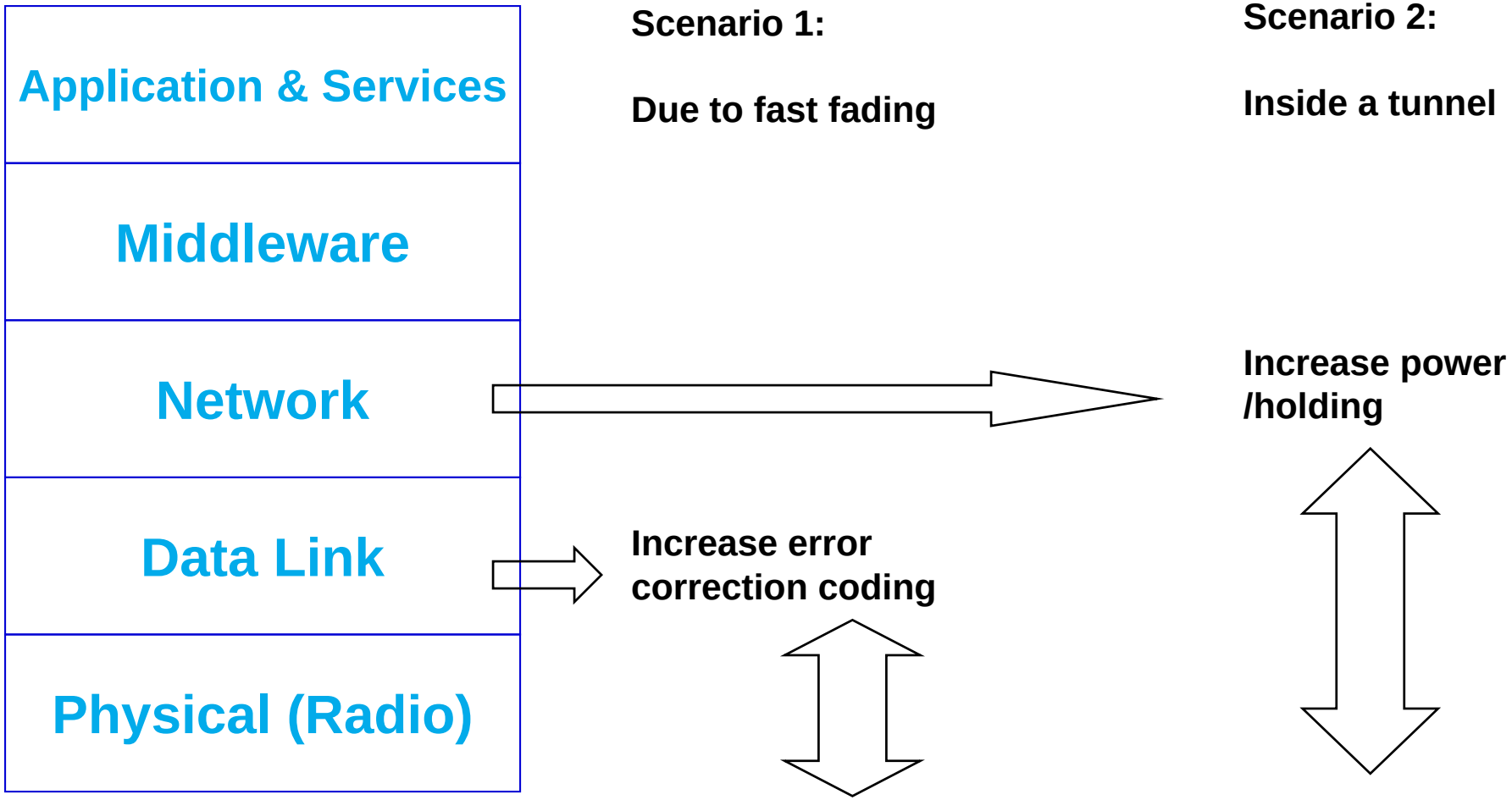


New Paradigm in Wireless System



A Standard Reference Protocol

A Case Study


Application & Services
Middleware
Network
Data Link
Physical (Radio)
Scenario 1:
Due to fast fading
Scenario 2:
Inside a tunnel
Increase power /holding
Increase error correction coding
The wireless link is getting weak

Module Content

- Introduction to/Review of wireless fundamentals (1 week)

- Fundamentals of cellular system – First Generation(AMPS) (2 weeks)
- Key mobile systems (4 weeks)
  - Second Generation (GSM, CDMAONE, GPRS)
  - Third Generation systems (UMTS, CDMA2000) / (HSPA)
  - Fourth Generation: LTE/LTE Advanced

- Wireless Local Area Networks (WLAN) (3 weeks)
  - Main standards of WLANs (IEEE 802.11a/b/g/i/n/ac/ad/ax)
- Wireless Personal Area Networks (WPAN) (1 week)
  - Bluetooth 1.0, 2.0, 4.0 and 5.0

The weekly lecture plan is on the course page!

2
3

Module Assessment

- Coursework (55%)
  - Assignment on Cellular Networks (15%) in Weeks 4-6
  - WLAN Lab Exercise (WLAN) (14%) in Weeks 8 - 10
  - Automated Multiple Choice Questions – MCQ (26%) in Week 12
    - Open Book MCQ test in 60 min, 26 Questions

- Final Exam (45%)
  - 4 Questions, open book and online, January, 2021.

- Class Quizzes (Formative Assessment)
  - There will be a number of quiz questions at the end of each lecture for you to check your learning.
  - The answers can be found in the lecture and the teacher will also go through these questions during the reviewing part of the following lecture.

Module References

- Main references
  - K. Pahlavan and P. Krishnamurthy, Principles of Wireless Networks: A Unified Approach, Prentice Hall, 2002 (new version coming)
  - William Stallings, Wireless Communications and Networks , Prentice Hall, 2002 (new version coming)
  - 802.11 Wireless Networks: The Definitive Guide by Matthew Gast; O'Reilly Media; 2nd edition , 2005

- Further readings:
  - Garg, Wireless Communications and Networks, Morgan Kaufmann 2007, ISBN 978-0-12-373580-5.
  - Mobile communications by Jochen Schiller; Second Edition; Addison-Wesley.
  - WCDMA for UMTS – HSPA evolution and LTE by Harri Holma and Antti Toskala, 4th Edition, Wiley, 2007.
  - HSDPA/HSUPA for UMTS: High Speed Radio Access for Mobile Communications by Harri Holma and Antti Toskala; Wiley, 2006.
  - Wireless Local-area Network Fundamentals by Pejman Roshan and Jonathan Leary; Cisco Press; 1 edition, 2009.
  - Cellular Communications Explained: From Basics to 3G by Ian Poole.
  - T.S. Rappaport, Wireless Communications: Principles and practice, Second Edition, Prentice Hall, 2002.