
Modern Wireless Networks

Introduction



UNIVERSITY
AT ALBANY
State University of New York

IECE 574– Spring 2021

Prof. Dola Saha

Introductions

➤ Instructor

- Prof. Dola Saha, PhD University of Colorado Boulder
- <http://www.albany.edu/faculty/dsaha/>
- <https://www.albany.edu/wwwres/facultyresearch/mesalabs/>
- dsaha@albany.edu

➤ Students

Information

➤ Course Website:

- https://www.albany.edu/faculty/dsaha/teach/2021Spring_ECE574/2021Spring_ECE574.html

➤ Blackboard:

- <https://blackboard.albany.edu/>

Course Website	Blackboard
Lecture Slides	Project Assignment & Submission
Class Calendar / Schedule	Lecture Videos
Other Information	Announcements
	Grades

Office Hours

Instructor

Zoom

Wednesday & Friday – 9:30-10:30am

By appointment

Pre-Requisite

- ICEN 472 Advanced Digital Communications
- ICEN 416 Computer Communication Networks
- The students are expected to be comfortable in
 - MATLAB

Textbooks

➤ Required:

- None

➤ Highly Recommended:

- Erik Dahlman, Stefan Parkvall and Johan Skold, "5G NR: The Next Generation Wireless Access Technology", First Edition, Elsevier, ISBN: 978-0-128-14323-0, 2018.
- Eldad Perahia and Robert Stacey, "Next Generation Wireless LANs: 802.11n and 802.11ac", Second Edition, Cambridge University Press, ISBN: 9781107016767, 2013.

➤ Reference:

- 3GPP Documents
- IEEE Standards for Wireless LANs

Slides in this course will be taken from these books.

Software Defined Radio

- Follow the link and setup the Pluto SDR
 - <https://www.mathworks.com/help/supportpkg/plutoradio/ug/guided-host-radio-hardware-setup.html>
 - <https://www.mathworks.com/help/comm/supported-hardware-software-defined-radio.html>



Use loopback cable
for transmission

Assignments & Grading

➤ Assignments

- 4 Short Projects (Wireless Fundamentals, Wi-Fi, LTE, Bluetooth)

➤ Grading

- Each Short Project - 25%

Grading Scale

- A: 100-95 points A-: 94-90 points
- B+: 89-87 points B: 86-84 points B-: 83-80 points
- C+: 79-77 points C: 76-73 points C-: 72-70 points
- D+: 69-67 points D: 66-63 points D-: 62-60 points
- E: 59 points and below

Academic Integrity

- Undergraduate Academic Regulations
 - http://www.albany.edu/undergraduate_bulletin/regulations.html
- Academic Dishonesty
 - Plagiarism, Cheating on examinations, unauthorized collaboration, etc.
- Practicing Academic Integrity
 - Citation
- Penalties for Violation
 - Zero in the assignment, lowering grade, failing grade, VAIR will be submitted

What is Plagiarism?

- Getting help from the Internet and not cite it
- Asking someone else to write the code for you
- Copying your friend's code – both the students are involved in plagiarism

In Class Decorum

- **Required** to keep your video turned on
- No use of phones
- No use of Computers / laptops
- **DO NOT** browse random things in class
- No crosstalk
- No Food/Drink
- Raise hand to ask questions

Why this course?



Why this course?

- Prepare you for the industry



What will be covered?

➤ Fundamentals of Wireless Communication

		Wireless Physical Layer
1	Feb 2	Signal, Modulation
	Feb 4	Coding, Channel Capacity
2	Feb 9	Doppler, Coherence Time
	Feb 11	Signal Propagation, Pathloss, Shadowing
3	Feb 16	Multipath, Channel Models
	Feb 18	OFDM, Channel Estimation and Equalization
4	Feb 23	MIMO Precoding, Transmit Diversity
	Feb 25	Spatial Multiplexing

What will be covered?

- Wireless LANs – Dissect Signals from 802.11 devices using SDRs

		Wireless LANs
5	Mar 2	PHY, MAC, PCF, DCF, IFS, Carrier Sense, Backoff
	Mar 4	Synchronization, Association, 802.11a/b/g/n/ac
6	Mar 9	Enhanced DCF, Frame Aggregation, STBC
	Mar 11	Channel Bonding, HT/VHT Frame, Preambles
7	Mar 16	MU-MIMO, Grouping
	Mar 18	Tx Beamforming

What will be covered?

➤ 3GPP World

		Cellular Systems
8	Mar 23	1G/2G/3G Systems, Cell, GSM, CDMA, Handoff
	Mar 25	LTE - Architecture, Frame, Synchronization, RACH
9	Mar 30	OFDM, SC-FDMA, Space Time Coding
	Apr 1	Packet Core – S-GW, P-GW
10	Apr 6	No classes
	Apr 8	PDCP, RLC, RRC, Control and Data Channel
11	Apr 13	Bearer Management, Hybrid ARQ
	Apr 15	MU-MIMO, Precoding
12	Apr 20	Carrier Aggregation, CoMP, D2D
	Apr 22	5G (5G NR, LTE for Massive MTC)

What will be covered?

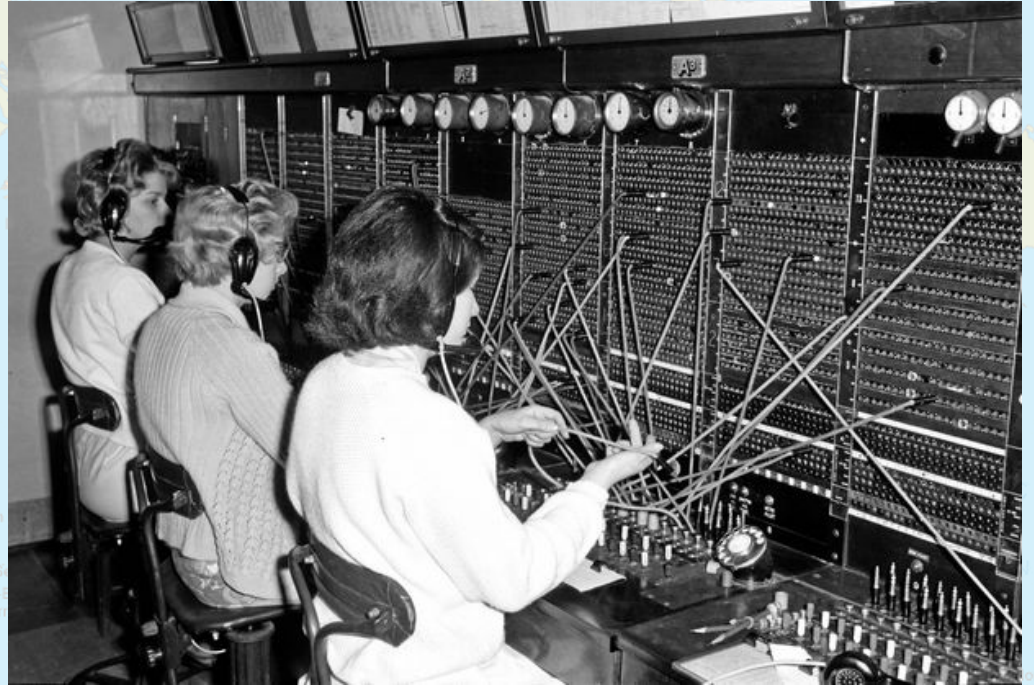
➤ mmWave, Vehicular & IoT Comm

		Communication for Internet of Things
13	Apr 27	Bluetooth, BLE and iBeacon – PHY and MAC
	Apr 29	802.15.4, Zigbee, Cluster Tree Network, UWB, Spread Spectrum
14	May 4	LoRA
	May 6	SigFox
		60GHz mmWave
15	May 11	mmWave propagation and fading, 802.11ad standard

Trunk Call or Long Distance Calling

➤ 8:00AM – Call local exchange to setup a call to India

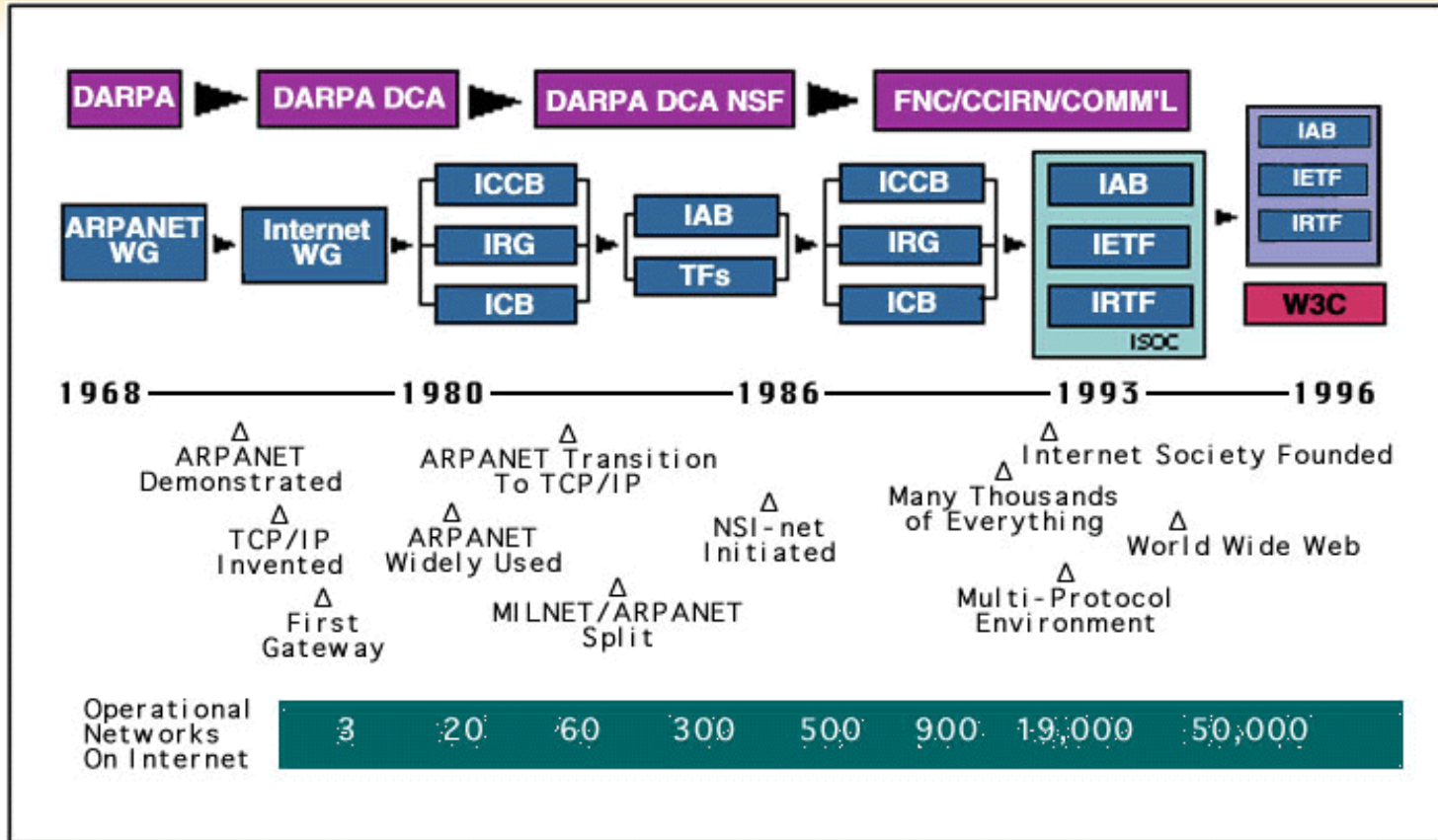
➤ 8:00PM – Transatlantic link setup



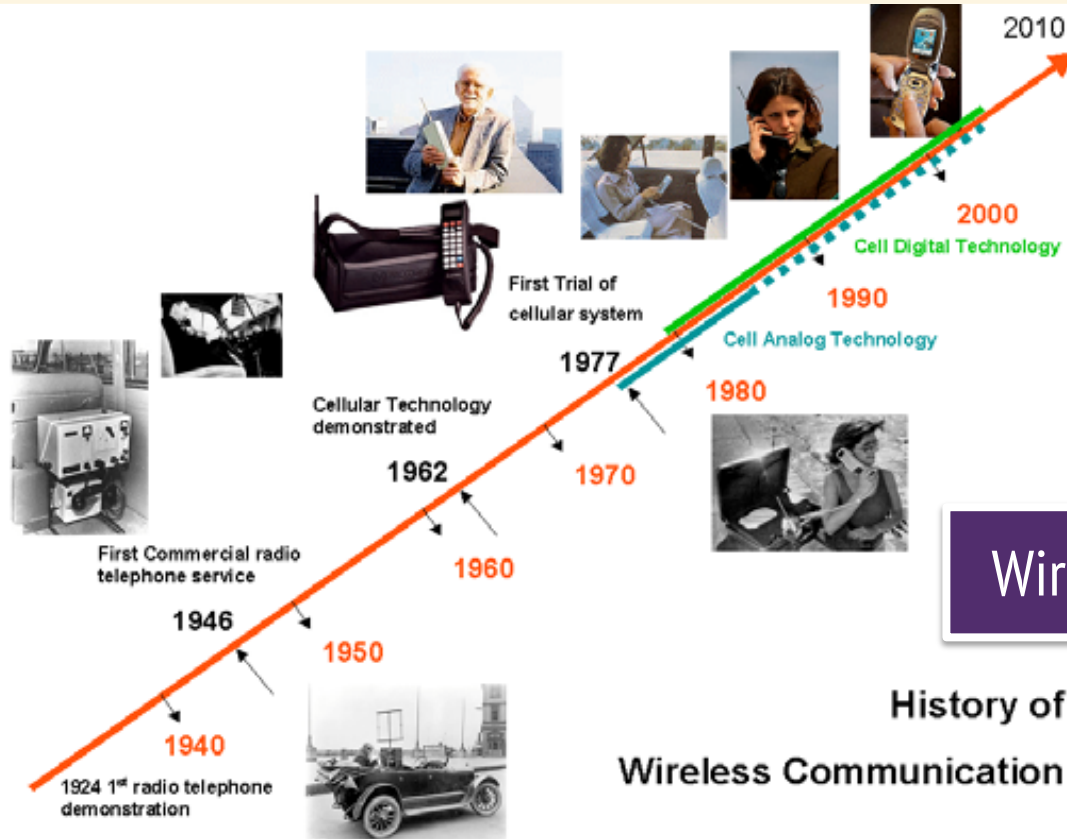
Circuit Switching



A Brief History of the Internet



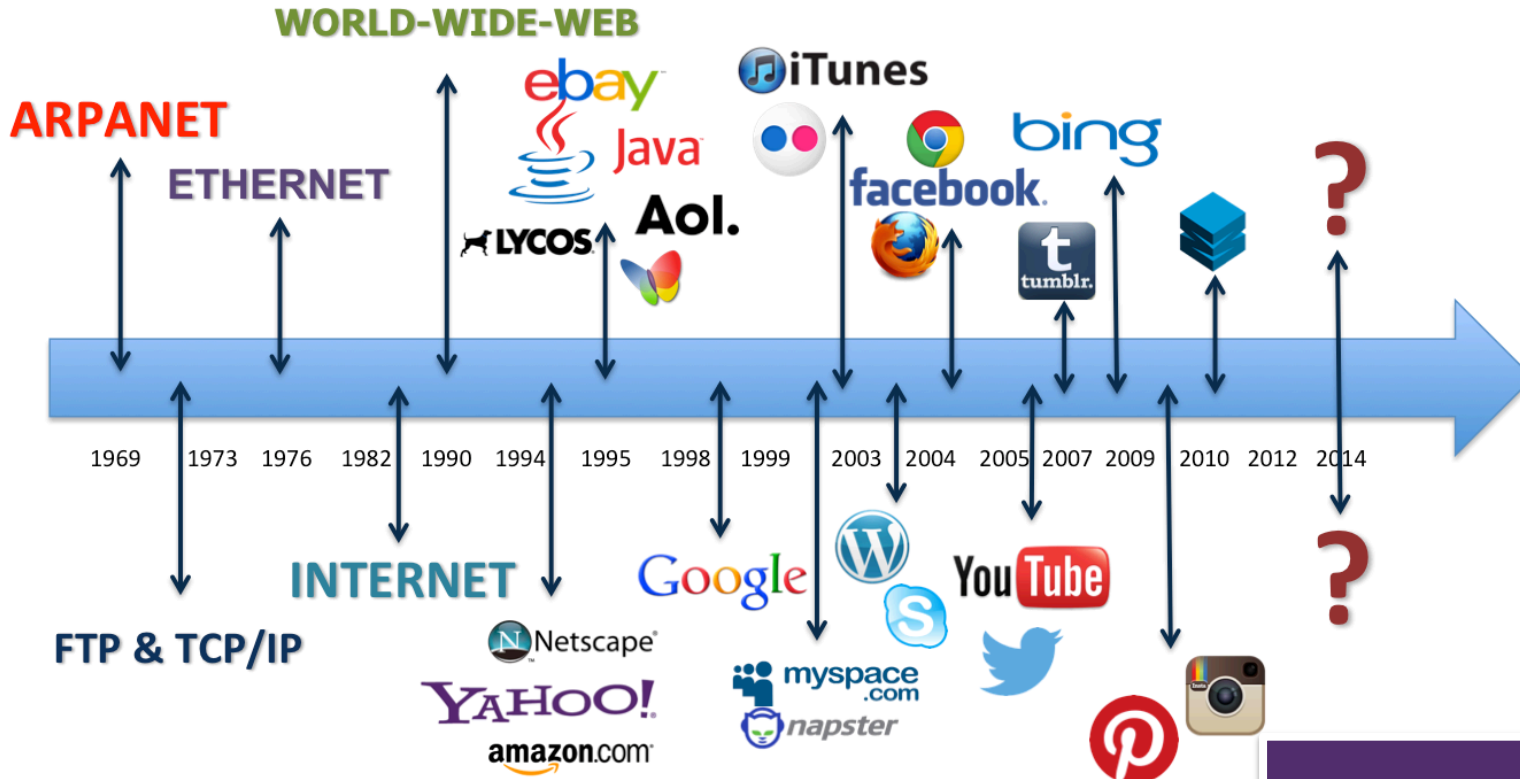
A Brief History of Wireless Comms



Wireless Communication

History of
Wireless Communication

Growth of the Internet



Networks

Advent of Smartphone



Wireless Networks
Computer Architecture
Embedded Systems

Impact on our lives (1)

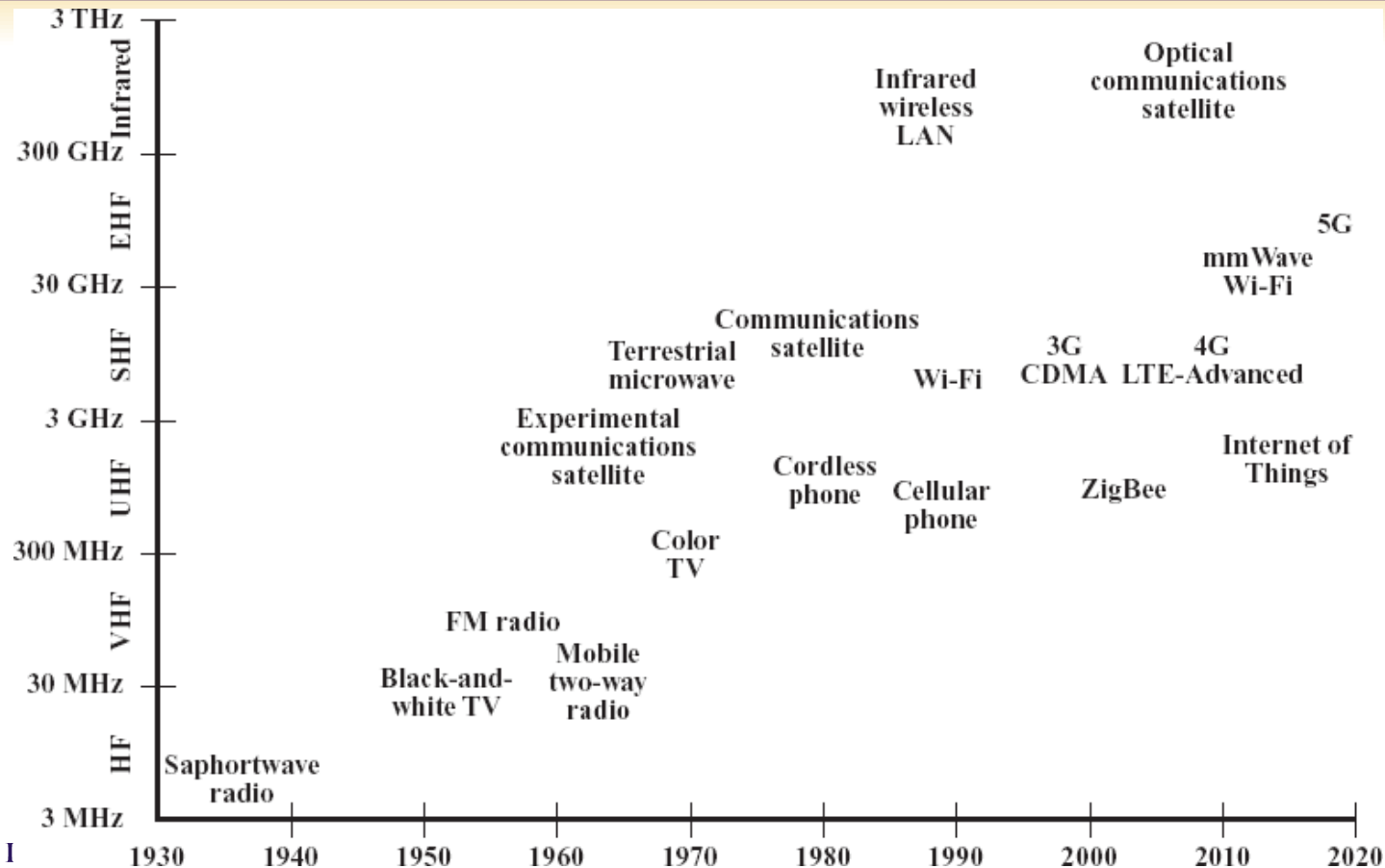


Impact on our lives (2)



Current Communication Protocols

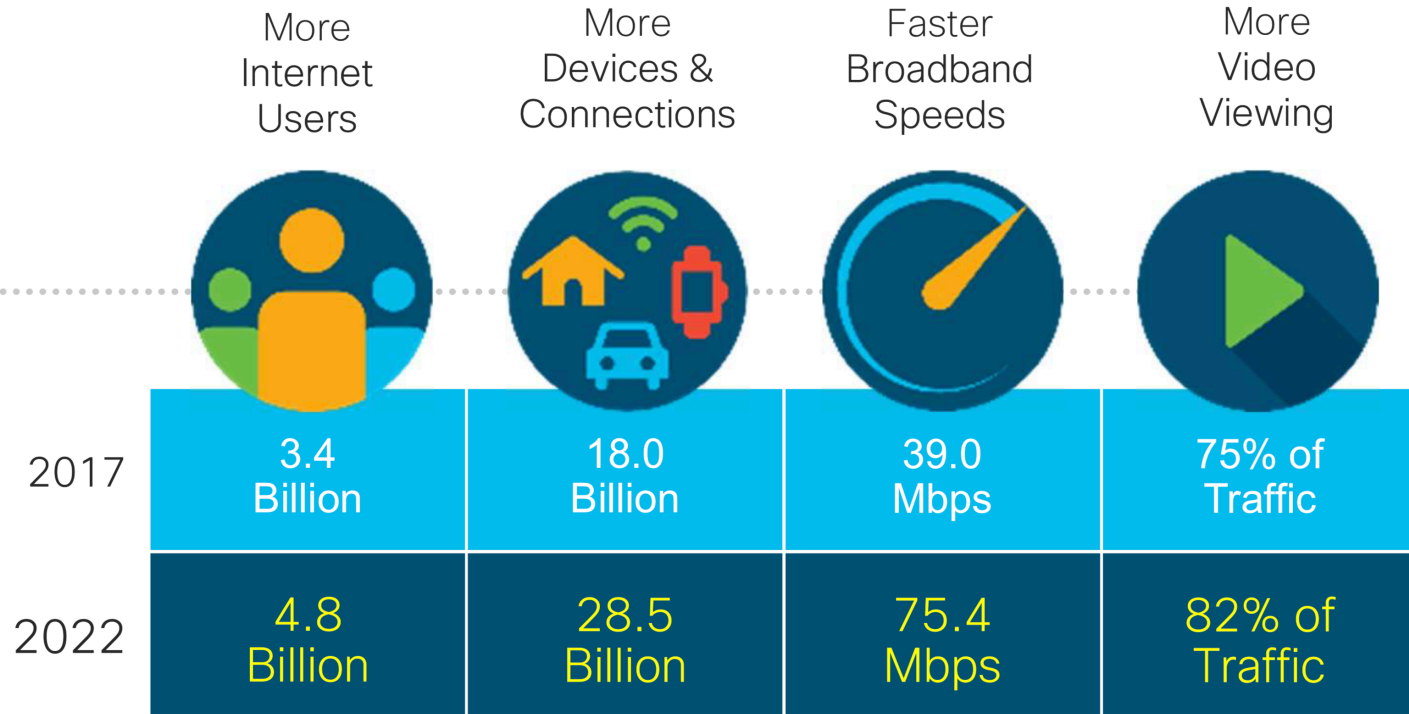
Milestones in Wireless Communication



How does the future look like?

Key Digital Transformers

By 2022



Source: Cisco Visual Networking Index, 2017

What's next? - Virtual Reality

➤ Examples

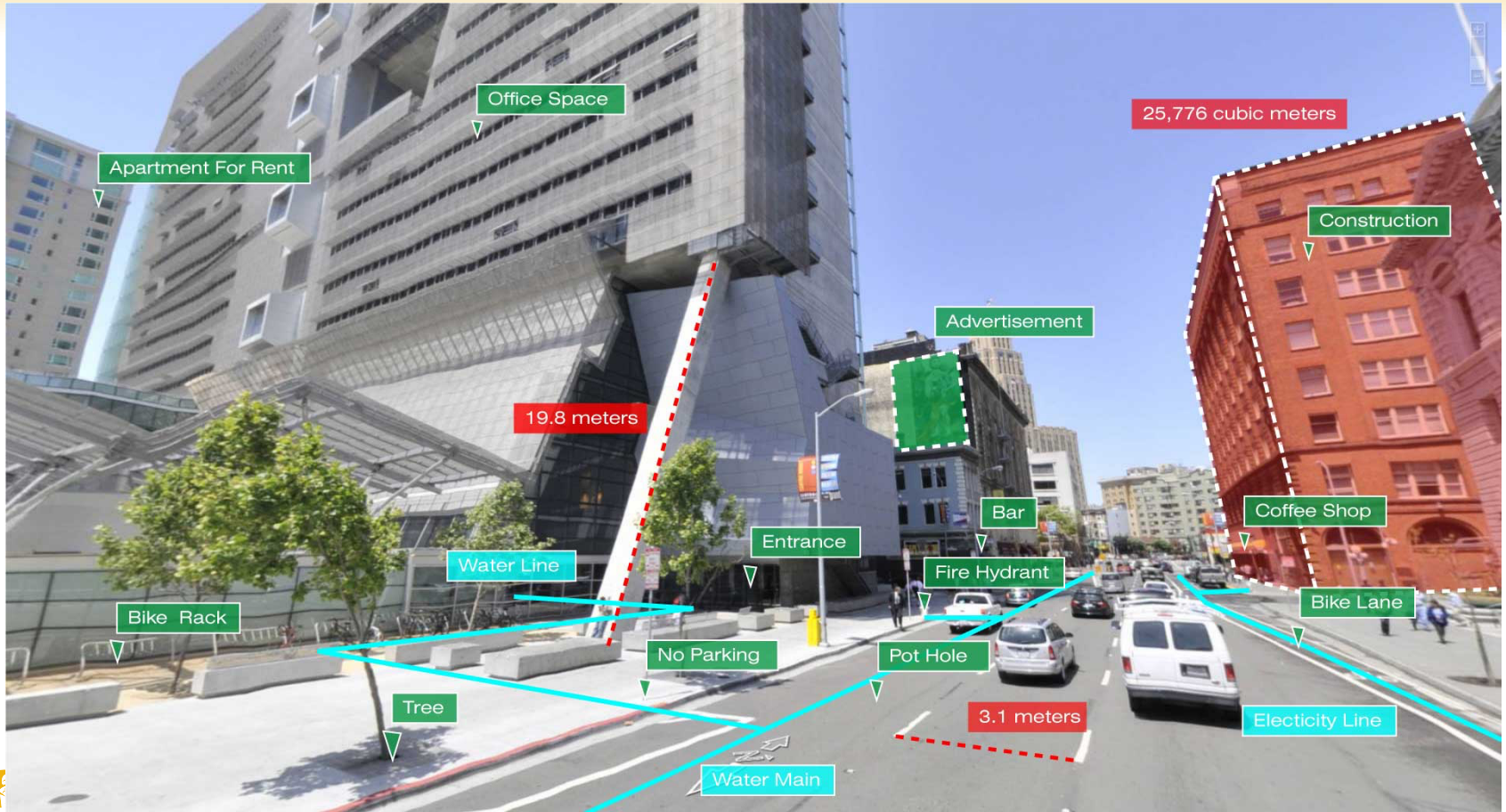
- Remote concert
- VR enabled learning in classroom
- Telesurgery

➤ Requirements

- Very high throughput
- Very low latency (<10ms)



What's next? - Augmented Reality

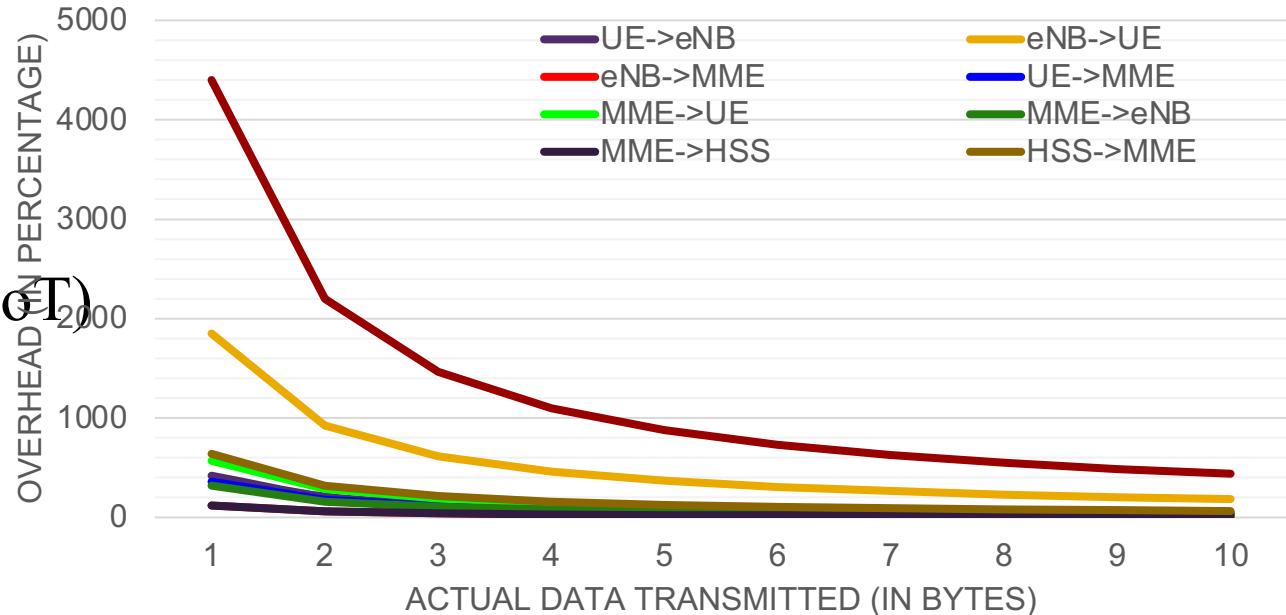


Internet of Things

➤ What is different?

- Scale
- Dense
- Overhead
- Spurious
- Low latency (IIoT)

Percentage Overhead to setup a connection



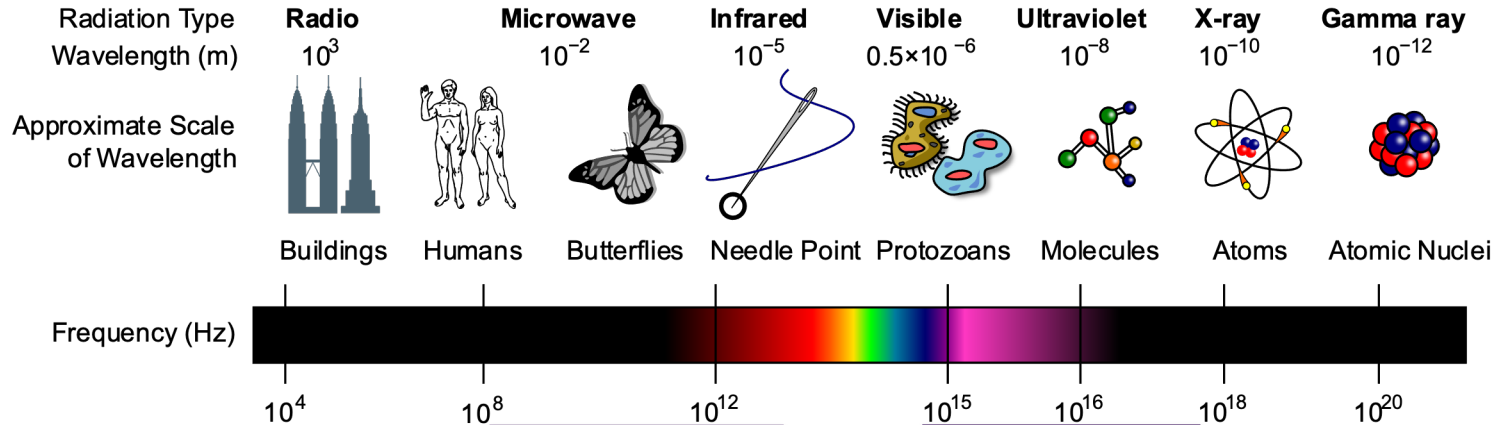
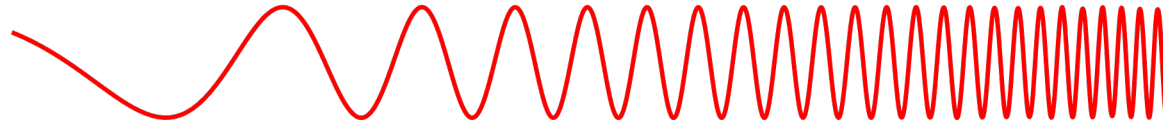
Challenges

- Speed of light = 299,792,458m/sec
- Transatlantic Links
 - 15,428 km → 5.1msec
 - 14,000 km → 5msec
 - 24,000 km → 8msec
- VR Requirement is end-to-end delay
 - <10ms
- We are limited by Physics!



Future Wireless Frequencies

Penetrates Earth's Atmosphere?



Millimeter waves
30-300GHz

Terahertz waves
300GHz-3THz

mmWave Comm
57-64GHz unlicensed, others

THz Comm
0.1-10THz

Visible Light Comm
430-700THz

Different in New Spectrum

- Pathloss / Penetration
- Smaller Antenna Size
- Massive MIMO – higher capacity
- Directional beam – spatial reuse
- Beamforming and Beam tracking
- Handover
- Localization

Introduction to Standards

- The 3rd Generation Partnership Project (3GPP) unites [Seven] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as “Organizational Partners” and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies.
- The original scope of 3GPP (1998) was to produce Technical Specifications and Technical Reports for a 3G Mobile System based on evolved GSM core networks and the radio access technologies that they support (i.e., Universal Terrestrial Radio Access (UTRA) both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) modes).

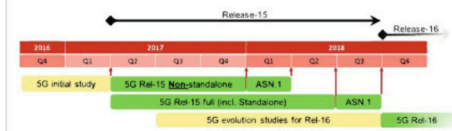


A GLOBAL INITIATIVE

June 2018, for 5G World Summit



Early progress on 5G Specifications
Page 2



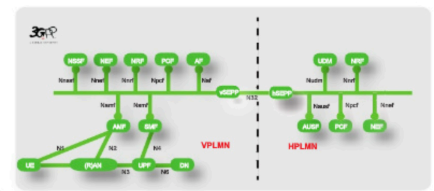
IMT-2020 Status
Page 4



Mission Critical Services in 3GPP
Page 10



5G System Architecture
Page 5



About 3GPP
Page 12

- 1 Specifications
- 2 Change Requests
- 3 Release Freeze Dates
- 4 Three-Stage Methodology
- 5 Working Group Structure
- 6 Members and Officials

Introduction to Standards

➤ IEEE Standards Association

IEEE STANDARDS ASSOCIATION



IEEE Standard for Information technology—
Telecommunications and information exchange between systems
Local and metropolitan area networks—
Specific requirements

Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 802.11™-2016
(Revision of
IEEE Std 802.11-2012)