CHAPTER 1:
Introduction
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Overview of Wireless Systems

- **Mobility**: Outdoor (Vehicle, Walk, Fixed) | Indoor (Walk, Fixed/ Desktop)
- **Coverage**: Wide Area Network (WAN) | Personal Area Networks (PAN) | Low Power Systems
- **Modern Cellular Systems (WAN)**: UMTS (3G), GPRS, EDGE, HSPA, WiMAX, LTE, LTE Advanced (4G), UMTS (3G)
- **Modern Cellular Systems (WAN)**: UMTS (3G), GPRS, EDGE, HSPA, WiMAX, LTE, LTE Advanced (4G)
- **Wide Area Network (WAN)**: Coverage, Low Power Systems, UMTS (3G), WiFi, 802.11a/b, 802.11n, 802.11 ac, LTE, LTE Advanced (4G)
- **Local Area Network (LAN)**: Hot Spots, Bluetooth, WiFi, 802.11a/b, 802.11n, 802.11 ac, UWB
- **Vehicular Networks (high mobility)**: Sensor Networks, Bluetooth, WiFi, 802.11a/b, 802.11n, 802.11 ac, UWB
- **Sensor Networks**: Local Area Network (LAN), Hot Spots, Bluetooth, WiFi, 802.11a/b, 802.11n, 802.11 ac, UWB
- **UWB**: Vehicular Networks (high mobility), Sensor Networks, Bluetooth, WiFi, 802.11a/b, 802.11n, 802.11 ac, UWB
- **UWB**: Vehicular Networks (high mobility), Sensor Networks, Bluetooth, WiFi, 802.11a/b, 802.11n, 802.11 ac, UWB
Evolution of Cellular Systems

1G
- AMPS
- TACS
- NMT
- 1980s

2G
- 2.0G GSM
- 2.5G cdmaOne
- 2.75G GPRS
- 1990s

3G
- 3.0G UMTS
- 3.5G HSPA
- 3.9G HSPA+
- 2000s

4G
- LTE-A
- LTE-B
- LTE-C
- 2010s

5G
- 2020s
- 2030s

Analog
- Different for each country
- 2.8 kbps – 56 kbps

Digital
- TDMA-based
- First data services
- 15 kbps - 400 kbps
- (Narrowband)

CDMA-based
- (LTE: OFDMA-based)
- * Introduction of MIMO
- * Mobile Internet – Application Explosion
- * Range of Mbps
- (Broadband)

All OFDMA-based
- Novel enabling technologies
- Range of Gbps
- (Mobile Broadband)
- xDSL like experience

New Waveforms
- mm-Wave access & backhaul
- Ultra-dense small cells
- Range of tens of Gbps
- (Ubiquitous Connectivity)
- Fiber like experience
EVOLUTION OF MOBILE TRAFFIC

Exabytes per month

3GPP Subscriptions (millions)
EVOLUTION OF WIRELESS SYSTEMS


1 Exabyte = $10^{18}$ Bytes

Pictures taken at St. Peter’s Square for papal inauguration ceremonies of Pope Benedict (2005) and Pope Francis (2013)
Requirements

Many New Services and Applications

Explosion of Users’ Demand for Mobile Data

Ubiquitous Wireless Broadband Access to a Very Large Cloud Platform