

EEE 6109 Wireless Communication.

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Course Content

1. Wireless propagation
2. The wireless channel
3. Multiple access schemes
4. Multiple input multiple output systems
5. Diversity

Course website:

www.ciirawamaina.com/wireless-communication.html

Today's Lecture

1. Introduction to wireless communications
2. Technical challenges in wireless communications

Wireless communications

- ▶ We are surrounded by wireless devices
- ▶ Mobile telephony and associated services such as mobile money are having a huge impact on society
- ▶ Wireless sensor networks are also gaining ground with the proliferation of the internet of things (IoT)
- ▶ Over a trillion devices could be connected by 2035 ¹

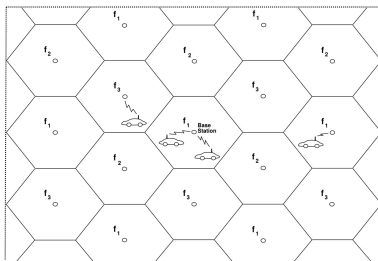
¹Sparks, P. (2017). The route to a trillion devices. White Paper, ARM.

History

- ▶ Maxwell and Hertz laid the foundation for wireless communications with their study of electromagnetism
- ▶ Tesla demonstrated the transmission of information via electromagnetic waves
- ▶ However Marconi was credited with the invention of wireless communications
- ▶ Initial commercial applications in radio and TV
- ▶ In these systems, information transmission is unidirectional

First Generation Systems

- ▶ Need for bidirectional mobile communication emerged
- ▶ Early systems suffered from spectrum limitations limiting the number of users
- ▶ The cellular principle invented by researchers at AT&T's Bell Labs allowed an increase in number of users
- ▶ The geographical area is divided into cells and different cells may use the same frequency



Source: Goldsmith, A. (2005). Wireless communications. Cambridge university press.

1G

- ▶ Deployed in the 70's and 80's
- ▶ Used analog FM modulation
- ▶ Examples include
 - ▶ Advanced Mobile Phone System (USA)
 - ▶ Nippon Telephone and Telegraph (NTT) - 1979
 - ▶ Nordic Mobile Telephone (NMT)



2G

- ▶ Analog systems had low spectral efficiency
- ▶ The European Telecommunications Standard Institute (ETSI) started the development of a digital cellular standard - Global System for Mobile Communications (GSM)
- ▶ Digital voice
- ▶ Simple data services such as SMS

3G

- ▶ Need for greater data rates
- ▶ Advances in Code Division Multiple Access and other spread spectrum techniques
- ▶ Systems allow streaming of audio and video

4G

- ▶ 4G networks have gained traction recently
- ▶ In Kenya, 4G is available in major centres
- ▶ Based on MIMO-OFDM

5G

- ▶ Operating at above 6GHz (millimeter waves)
- ▶ Using LDPC for channel coding
- ▶ massive MIMO

Wireless Communication Services

- ▶ Broadcast
- ▶ Cellular telephony
- ▶ Wireless Local Area Networks - IEEE 802.11 standard
- ▶ Wireless sensor networks - IoT
- ▶ Satellite communication

Requirements - Data Rates

- ▶ Sensor networks - a few bits per second to a few kilobits per second
- ▶ Speech communication - 5 to 64 kbits/second
- ▶ WLANS - up to 100 Mbits/s

Requirements - Number of Users

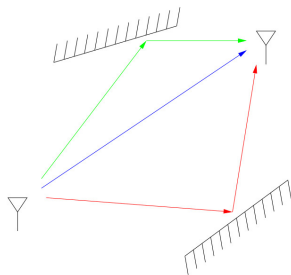
- ▶ Cellular systems - 50 active users
- ▶ WLANS - around 10

Other Requirements

- ▶ Mobility
- ▶ Energy consumption
- ▶ Use of spectrum - exclusive or shared
- ▶ Quality of service

Technical Challenges

- ▶ Multipath propagation
 - ▶ Line of sight between the TX and RX
 - ▶ Reflection or diffraction from Interacting Objects (IOs) in the environment
- ▶ Signals from different paths have different amplitude, delay, direction of departure from TX, Direction of Arrival at RX, phase shift
- ▶ The change in total signal amplitude due to interference from multiple multipath components is known as small scale fading.



Technical Challenges

- ▶ Shadowing - this is the reduction in signal strength due to presence of an obstacle.
- ▶ Shadowing gives rise to large scale fading

Technical Challenges - Intersymbol Interference (ISI)

- ▶ The impulse response is not a single delta but a sequence of pulses
- ▶ Signals carrying information from different symbols interfere with each other

Other Technical Challenges

- ▶ Spectrum limitations
- ▶ Energy limitations
- ▶ User mobility

Readings

- ▶ Molisch - Chapter 1 - 3