



Wireless Communications and Technology

Trevor Miller

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This book is compiled in such a manner that it will provide in-depth knowledge about the theory and practice of wireless communications and technology. It describes in detail the various concepts and technologies used in this subject. Wireless communication allows transfer of data in the form of text, voice and image between two points which are not connected via wires. Wireless communication technology is used in mobile and portable applications, wireless networks, and personal digital assistants (PDAs), etc. Most of the topics introduced in this text cover new techniques and applications of the subject. Different approaches, evaluations and methodologies on the subject have been included in it. For all those who are interested in wireless communications and technology, this textbook can prove to be an essential guide.

Trevor Miller pursued his Msc in Wireless Communications and Signal Processing from the University of Bristol, United Kingdom. He is actively engaged in the researches focused on two-way radios, mobile satellite communications and wireless sensor networks. Miller has written numerous articles and books on wireless energy transfer and wireless networking. He has traveled and lectured extensively throughout Europe and the United States; primarily for undergraduate education.

Miller Wireless Communications Technology

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Edited by
Trevor Miller

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Preface

This book is compiled in such a manner that it will provide in-depth knowledge about the theory and practice of wireless communications and technology. It describes in detail the various concepts and technologies used in this subject. Wireless communication allows transfer of data in the form of text, voice and image between two points which are not connected via wires. Wireless communication technology is used in mobile and portable applications, wireless networks, and personal digital assistants (PDAs), etc. Most of the topics introduced in this text cover new techniques and applications of the subject. Different approaches, evaluations and methodologies on the subject have been included in it. For all those who are interested in wireless communications and technology, this textbook can prove to be an essential guide.

A foreword of all Chapters of the book is provided below:

Chapter 1 - Wireless communication is the information that has been transferred from one point to another without the use of an electrical conductor. Radio is the most common technology that is used in contemporary times. The chapter will provide an integrated understanding of wireless communication; **Chapter 2** - The networks mentioned in this chapter are wireless network, wireless mesh network, personal area network, space network, comparison of wireless data standard and multipath propagation. Wireless networks use wireless connections; they are mostly used in radio communications. The most common examples of wireless networks include cell phone networks, wireless sensor networks and satellite communication networks. This text elucidates the networks related to wireless communication; **Chapter 3** - This section is an overview of the subject matter incorporating all the major aspects of a radio. Some of the topics discussed in this text are radio propagation, radio frequency, skywave and radio broadcasting. The pattern in which radio waves travel is known as radio propagation whereas radio frequency is the frequency that is used for communication and lies in between 3 kHz to 300 GHz. The topics discussed herein are of great importance to broaden the existing knowledge on radio; **Chapter 4** - To understand radio frequency identification, it is very important to understand real-time locating system, microchip implant and transponder timing. Real-time locating systems are used in tracking objects and people in real-time. This section elucidates the crucial aspects of radio frequency identification; **Chapter 5** - Radio navigation is an application that is used to trace an object on Earth whereas radars are used to determine the position and range of an object. Countries use radars to detect unknown aircrafts, ships, spacecrafts and guided missiles. The other wireless technologies and applications explained in this chapter are Wi-Fi, hotspot and Li-Fi; **Chapter 6** - Light is used to carry information from a distance and this form of communication is known as optical communication. One of the forms of optical communication is optical wireless communications. The aspects elucidated in this section are of vital importance, and provide a better understanding of optical wireless communications; **Chapter 7** - Wireless security is very important in today's times. It prevents unapproved access to computers that use wireless networks. A brief explanation of intrusion detection system, RADIUS and Wi-Fi protected access is also provided, which provides a better understanding of wireless security.

I would like to thank the entire editorial team who made sincere efforts for this book and my family who supported me in my efforts of working on this book. I take this opportunity to thank all those who have been a guiding force throughout my life.

Editor

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Introduction to Wireless Communication

Wireless communication is the information that has been transferred from one point to another without the use of an electrical conductor. Radio is the most common technology that is used in contemporary times. The chapter will provide an integrated understanding of wireless communication.

Wireless

Wireless communication is the transfer of information or power between two or more points that are not connected by an electrical conductor. The most common wireless technologies use radio. With radio waves distances can be short, such as a few meters for television or as far as thousands or even millions of kilometers for deep-space radio communications. It encompasses various types of fixed, mobile, and portable applications, including two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other examples of applications of radio *wireless technology* include GPS units, garage door openers, wireless computer mice, keyboards and headsets, headphones, radio receivers, satellite television, broadcast television and cordless telephones.

Somewhat less common methods of achieving wireless communications include the use of other electromagnetic wireless technologies, such as light, magnetic, or electric fields or the use of sound. The term *wireless* has been used twice in communications history, with slightly different meaning. It was initially used from about 1890 for the first radio transmitting and receiving technology, as in *wireless telegraphy*, until the new word *radio* replaced it around 1920. The term was revived in the 1980s and 1990s mainly to distinguish digital devices that communicate without wires, such as the examples listed in the previous paragraph, from those that require wires or cables. This is its primary usage in the 2000s. LTE, LTE-Advanced, Wi-Fi and Bluetooth are common modern wireless technologies used in the 2000s.

Wireless operations permit services, such as long-range communications, that are impossible or impractical to implement with the use of wires. The term is commonly used in the telecommunications industry to refer to telecommunications systems (e.g. radio transmitters and receivers, remote controls, etc.) which use some form of energy (e.g. radio waves, acoustic energy,) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances.

Photophone

The world's first wireless telephone conversation occurred in 1880, when Alexander Graham Bell and Charles Sumner Tainter invented and patented the photophone, a telephone that conducted

audio conversations wirelessly over modulated light beams (which are narrow projections of electromagnetic waves). In that distant era, when utilities did not yet exist to provide electricity and lasers had not even been imagined in science fiction, there were no practical applications for their invention, which was highly limited by the availability of both sunlight and good weather. Similar to free-space optical communication, the photophone also required a clear line of sight between its transmitter and its receiver. It would be several decades before the photophone's principles found their first practical applications in military communications and later in fiber-optic communications.



Bell and Tainter's photophone, of 1880.

Early Usage

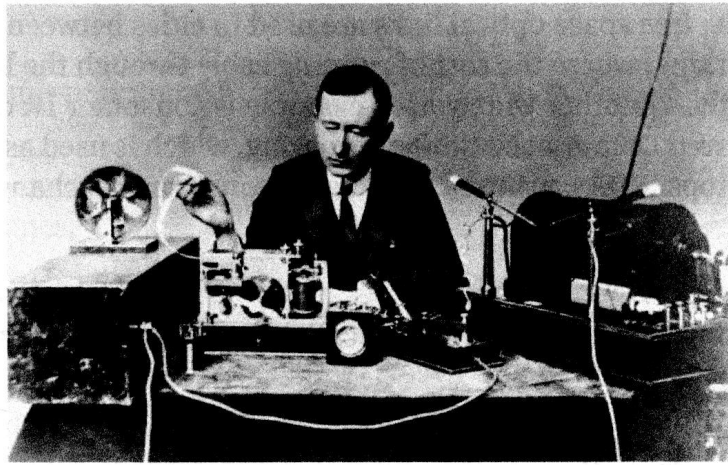
David E. Hughes transmitted radio signals over a few hundred yards using a clockwork keyed transmitter in 1878. As this was before Maxwell's work was understood, Hughes' contemporaries dismissed his achievement as mere "Induction." In 1885, Thomas Edison used a vibrator magnet for induction transmission. In 1888, Edison deployed a system of signaling on the Lehigh Valley Railroad. In 1891, Edison obtained the wireless patent for this method using inductance (U.S. Patent 465,971).

In 1888, Heinrich Hertz demonstrated the existence of electromagnetic waves, the underlying basis of most wireless technology. The theory of electromagnetic waves was predicted from the research of James Clerk Maxwell and Michael Faraday. Hertz demonstrated that electromagnetic waves traveled through space in straight lines, could be transmitted, and could be received by an experimental apparatus. Hertz did not follow up on the experiments. Jagadish Chandra Bose around this time developed an early wireless detection device and helped increase the knowledge of millimeter-length electromagnetic waves. Later inventors implemented practical applications of wireless radio communication and radio remote control technology.

Radio

The term "wireless" came into public use to refer to a radio receiver or transceiver (a dual purpose receiver and transmitter device), establishing its use in the field of wireless telegraphy early on; now the term is used to describe modern wireless connections such as in cellular networks and wireless broadband Internet. It is also used in a general sense to refer to any operation that

is implemented without the use of wires, such as “wireless remote control” or “wireless energy transfer”, regardless of the specific technology (e.g. radio, infrared, ultrasonic) used. Guglielmo Marconi and Karl Ferdinand Braun were awarded the 1909 Nobel Prize for Physics for their contribution to wireless telegraphy.



Marconi transmitting the first radio signal across the Atlantic.

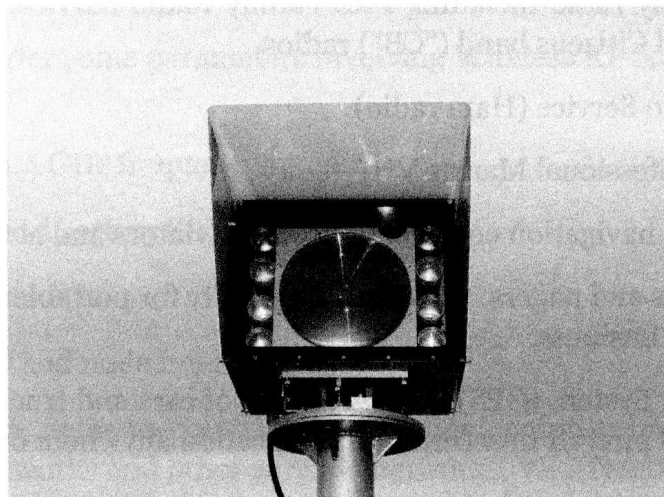
Modes

Wireless communications can be via:

Radio

radio communication, microwave communication, for example long-range line-of-sight via highly directional antennas, or short-range communication.

Free-space Optical



An 8-beam free space optics laser link, rated for 1 Gbit/s at a distance of approximately 2 km. The receptor is the large disc in the middle, the transmitters the smaller ones. To the top and right corner a monocular for assisting the alignment of the two heads.

Free-space optical communication (FSO) is an optical communication technology that uses light propagating in free space to transmit wirelessly data for telecommunications or computer net-

working. “Free space” means the light beams travel through the open air or outer space. This contrasts with other communication technologies that use light beams traveling through transmission lines such as optical fiber or dielectric “light pipes”.

The technology is useful where physical connections are impractical due to high costs or other considerations. For example, free space optical links are used in cities between office buildings which are not wired for networking, where the cost of running cable through the building and under the street would be prohibitive. Another widely used example is consumer IR devices such as remote controls and IrDA (Infrared Data Association) networking, which is used as an alternative to WiFi networking to allow laptops, PDAs, printers, and digital cameras to exchange data.

Sonic

Sonic, especially ultrasonic short range communication involves the transmission and reception of sound.

Electromagnetic Induction

Electromagnetic induction short range communication and power. This has been used in biomedical situations such as pacemakers, as well as for short-range Rfid tags.

Services

Common examples of wireless equipment include:

- Infrared and ultrasonic remote control devices
- Professional LMR (Land Mobile Radio) and SMR (Specialized Mobile Radio) typically used by business, industrial and Public Safety entities.
- Consumer Two-way radio including FRS Family Radio Service, GMRS (General Mobile Radio Service) and Citizens band (“CB”) radios.
- The Amateur Radio Service (Ham radio).
- Consumer and professional Marine VHF radios.
- Airband and radio navigation equipment used by aviators and air traffic control
- Cellular telephones and pagers: provide connectivity for portable and mobile applications, both personal and business.
- Global Positioning System (GPS): allows drivers of cars and trucks, captains of boats and ships, and pilots of aircraft to ascertain their location anywhere on earth.
- Cordless computer peripherals: the cordless mouse is a common example; wireless headphones, keyboards, and printers can also be linked to a computer via wireless using technology such as Wireless USB or Bluetooth
- Cordless telephone sets: these are limited-range devices.

- **Satellite television:** Is broadcast from satellites in geostationary orbit. Typical services use direct broadcast satellite to provide multiple television channels to viewers.

Computers

- Wi-Fi
- Cordless computer peripherals:
 - mouse
 - headphones,
 - keyboards,
 - printers,
 - USB and,
 - Bluetooth
- Wireless networking
 - To span a distance beyond the capabilities of typical cabling,
 - To provide a backup communications link in case of normal network failure,
 - To link portable or temporary workstations,
 - To overcome situations where normal cabling is difficult or financially impractical, or
 - To remotely connect mobile users or networks.

Developers need to consider some parameters involving Wireless RF technology for better developing wireless networks:

- Sub-GHz versus 2.4 GHz frequency trends
- Operating range and battery life
- Sensitivity and data rate
- Network topology and node intelligence

Applications may involve point-to-point communication, point-to-multipoint communication, broadcasting, cellular networks and other wireless networks, Wi-Fi technology.

Cordless

The term “wireless” should not be confused with the term “cordless”, which is generally used to refer to powered electrical or electronic devices that are able to operate from a portable power source (e.g., a battery pack) without any cable or cord to limit the mobility of the cordless device

through a connection to the mains power supply. Some cordless devices, such as cordless telephones, are also wireless in the sense that information is transferred from the cordless telephone to the phone's base unit via some wireless communications link. This has caused some disparity in the usage of the term "cordless", for example in Digital Enhanced Cordless Telecommunications.

Electromagnetic Spectrum

Light, colors, AM and FM radio, and electronic devices make use of the electromagnetic spectrum. The frequencies of the radio spectrum that are available for use for communication are treated as a public resource and are regulated by national organizations such as the Federal Communications Commission in the USA, or Ofcom in the United Kingdom. This determines which frequency ranges can be used for what purpose and by whom. In the absence of such control or alternative arrangements such as a privatized electromagnetic spectrum, chaos might result if, for example, airlines did not have specific frequencies to work under and an amateur radio operator were interfering with the pilot's ability to land an aircraft. Wireless communication spans the spectrum from 9 kHz to 300 GHz.

Applications

Mobile Telephones

One of the best-known examples of wireless technology is the mobile phone, also known as a cellular phone, with more than 4.6 billion mobile cellular subscriptions worldwide as of the end of 2010. These wireless phones use radio waves from signal-transmission towers to enable their users to make phone calls from many locations worldwide. They can be used within range of the mobile telephone site used to house the equipment required to transmit and receive the radio signals from these instruments.

Data Communications

Wireless data communications are an essential component of mobile computing. The various available technologies differ in local availability, coverage range and performance, and in some circumstances, users must be able to employ multiple connection types and switch between them. To simplify the experience for the user, connection manager software can be used, or a mobile VPN deployed to handle the multiple connections as a secure, single virtual network. Supporting technologies include:

Wi-Fi is a wireless local area network that enables portable computing devices to connect easily to the Internet. Standardized as IEEE 802.11 a,b,g,n, Wi-Fi approaches speeds of some types of wired Ethernet. Wi-Fi has become the de facto standard for access in private homes, within offices, and at public hotspots. Some businesses charge customers a monthly fee for service, while others have begun offering it for free in an effort to increase the sales of their goods.

Cellular data service offers coverage within a range of 10-15 miles from the nearest cell site. Speeds have increased as technologies have evolved, from earlier technologies such as GSM, CDMA and GPRS, to 3G networks such as W-CDMA, EDGE or CDMA2000.