


 Marmara University, 2021

# Wireless and Mobile Networks


**Subject 1**  
Introduction to Wireless Communication

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Associate Professor


 Contents


- Introduction
- Applications of Wireless Communication
- Evolution of Wireless Technologies
- Frequency Bands

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 INTRODUCTION


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 Wireless Communication




No physical medium

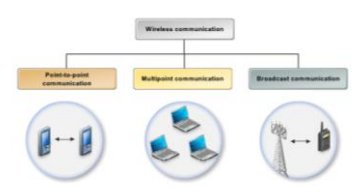
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 Wireless Communication



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 Wireless Communication



```

graph TD
    WC[Wireless communication] --> P2P[Point-to-point communication]
    WC --> MC[Multicast communication]
    WC --> BC[Broadcast communication]
    P2P --> P2P_Icon(( ))
    MC --> MC_Icon(( ))
    BC --> BC_Icon(( ))
  
```

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## Evolution of Wireless Communication



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## Evolution of Wireless Communication



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## Evolution of Wireless Communication



In 1914, the first ever voice over radio transmission took place



this technology became more popular with the interconnection of mobile users and telephone lines

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## Evolution of Wireless Communication



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## Wireless Communication Mediums



Electromagnetic waves are used depending on the range of transmission

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## Wireless Communication Mediums



Infrared waves

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## Wireless Communication Mediums



Operates within 15-30 feet

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## Wireless Communication Mediums



Microwave and radio wave technologies

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## Wireless Communication Mediums



**Radio networks are ideal for installations where:**

- Large areas need to be covered
- Obstacles exist in the transmission path

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## Wireless Communication Mediums



**Microwave networks are ideal for installations where:**

- Large areas need to be covered
- No obstacles exist in the transmission path

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## APPLICATIONS OF WIRELESS COMMUNICATION



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## Wireless Communication Applications



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## Wireless Communication Applications



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## Wireless Communication Applications



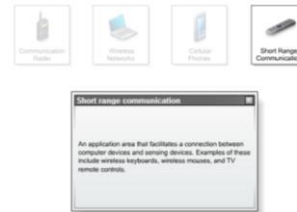
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## Wireless Communication Applications



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## Wireless Communication Applications



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## Advantages and Disadvantages of Wireless Communication



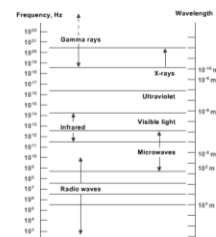
### The quality of wireless network depends on :

- Physical obstructions
- Climatic conditions
- Interference from other wireless devices



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## Challenges in Wireless Communications



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## Challenges in Wireless Communications



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## Challenges in Wireless Communications



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## Challenges in Wireless Communications



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## Challenges in Wireless Communications



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## Challenges in Wireless Communications



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## Challenges in Wireless Communications



the quality of wireless networks depends heavily on external factors

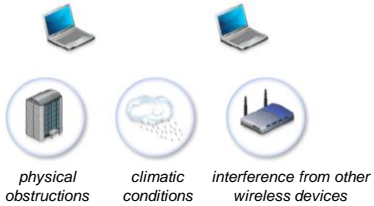


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## Challenges in Wireless Communications

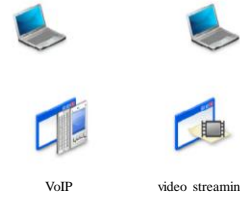


*the quality of wireless networks depends heavily on external factors*



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## Challenges in Wireless Communications



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## Challenges in Wireless Communications



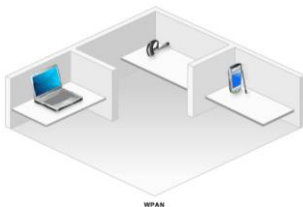
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## EVOLUTION OF WIRELESS TECHNOLOGIES



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## Evolution of WPAN Technologies



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## Evolution of WPAN Technologies



*Infrared systems had a very low data rate and operating range*

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## Evolution of WPAN Technologies



Bluetooth

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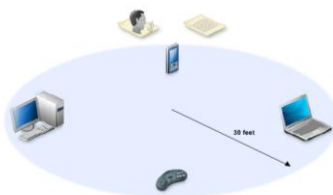
## Evolution of WPAN Technologies



2.4 GHz

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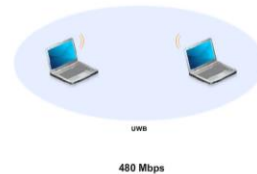
## Evolution of WPAN Technologies



**Bluetooth 4.2** has been released on December 2, 2014  
**Bluetooth 5** has been released on June 16, 2016

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## Evolution of WPAN Technologies



UWB  
480 Mbps

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## Evolution of WPAN Technologies



ZigBee

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## Evolution of WLAN Standards



WLAN Standard	Description
802.11	
802.11a	
802.11b	
802.11g	
802.11n	

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## Evolution of WLAN Standards



WLAN Standard	Description
802.11	802.11 is the original IEEE wireless working group and standard. It specifies wireless data transfer rates of up to 2 megabits per second (Mbps) in the 2.4 gigahertz (GHz) frequency band.
802.11a	
802.11b	
802.11g	
802.11n	

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## Evolution of WLAN Standards



WLAN Standard	Description
802.11	802.11a is an approved specification for a fast and secure wireless protocol. 802.11a supports speeds up to 54 Mbps in the 5 GHz frequency band. Unfortunately, that speed has a limited range of only 60 feet, which, depending on how you arrange your access points, could severely limit user mobility.
802.11a	
802.11b	
802.11g	
802.11n	

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## Evolution of WLAN Standards



WLAN Standard	Description
802.11	802.11b is probably the most common and certainly the least expensive WLAN protocol. 802.11b provides an 11 Mbps transfer rate in the 2.4 GHz frequency.
802.11a	802.11b has a range up to 1,000 feet in an open area, and a range of 200 to 400 feet in an enclosed space (where walls might hamper the signal). It is backward compatible with 802.11, but it is not interoperable with 802.11a.
802.11b	
802.11g	
802.11n	

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## Evolution of WLAN Standards



WLAN Standard	Description
802.11	802.11g is a specification for wireless data throughput at a rate of up to 54 Mbps in the 2.4 GHz band. It is compatible with 802.11b, which may be replaced by 802.11g or 802.11n due to faster speeds.
802.11a	
802.11b	
802.11g	
802.11n	

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## Evolution of WLAN Standards



WLAN Standard	Description
802.11	802.11n is the latest specification in the 802.11 family. It enables increased data rates of about 600 Mbps in both the 2.4 GHz and 5 MHz band. 802.11n provides a range of about 450 feet compared to the 300 feet range provided by the 802.11g standard. It also offers more reliable coverage.
802.11a	
802.11b	
802.11g	
802.11n	

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## Evolution of Cellular Technologies



Cellular Generation	Description
1G	
2G	
2.5G	
3G	
4G	

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## Evolution of Cellular Technologies



Cellular Generation	Description
1G	The very first mobile phones that came into existence in the 1980s are known as the first generation mobile phones. The technology primarily used in these phones is analog. First generation systems are voice-oriented systems, in which voice is transmitted between two mobile phones in the form of analog waves. The Advanced Mobile Phone Service (AMPS), Total Access Communication System (TACS), and Nordic Mobile Telephones (NMT) are some of the first-generation wireless communications systems. The first generation mobile phones were very bulky and were initially designed for installation in vehicles only.
2G	
2.5G	
3G	
4G	

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## Evolution of Cellular Technologies



Cellular Generation	Description
1G	Second generation systems are more sophisticated than the 1G ones and were introduced in the 1990s. They are voice-oriented systems based on digital signaling. 2G systems use digitized circuit-switched networks. The Global System for Mobile (GSM), US Time Division Multiple Access (US-TDMA), and Code Division Multiple Access (CDMA) are considered second-generation systems. Some advantages of 2G technology were the implementation of SMS and the reduced size of mobile phones, which were an instant hit in the cellular markets.
2G	
2.5G	
3G	
4G	

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## Evolution of Cellular Technologies



Cellular Generation	Description
1G	The technologies identified between second and third generations of wireless technology are referred to as 2.5G. They utilize the existing 2G infrastructure, but provide enhanced infrastructure efficiency and better service delivery features, as seen in 3G. This technology is based on both packet switching and circuit switching. GPRS is considered as 2.5G.
2G	
2.5G	
3G	
4G	

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## Evolution of Cellular Technologies



Cellular Generation	Description
1G	Third generation systems are high-speed voice-oriented systems integrated with data services. As the number of cell phone users increased, so did the need for high-speed data transmission. 3G networks offer more security compared to the other networks. Technologies such as CDMA EV-DO and HSPA are considered 3G systems.
2G	
2.5G	
3G	
4G	

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## Evolution of Cellular Technologies



Cellular Generation	Description
1G	Fourth generation systems are systems that will be based on an all-IP network. All devices that are part of the network will have an IP address, and the devices will communicate with each other based on their IP addresses. 4G systems are expected to supersede 3G systems with higher data rates, higher speeds, better QoS, and an enhanced user experience.
2G	
2.5G	
3G	
4G	

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## Evolution of Wireless Broadband Technologies



Wireless Broadband	Description
802.11b	
802.11a	

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## Evolution of Wireless Broadband Technologies



Wireless Broadband	Description
802.16d	This standard, also known as Fixed WiMAX, provides broadband access to users who are stationary. Generally, an antenna mounted on the rooftop acts as the receiver, which receives signals from the broadband service provider. Fixed WiMAX operates in the 2.5 GHz and 3.5 GHz frequency bands. They cover a range of about 10 miles and offer a speed of about 75 Mbps.
802.16e	

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## Evolution of Wireless Broadband Technologies



Wireless Broadband	Description
802.16d	This standard, also known as Mobile WiMAX, has evolved from the 802.16d standard. It provides broadband access to users who are stationary as well as mobile. The 802.16e standard incorporates various smart antenna technologies, such as MIMO, to increase the throughput and also provide better QoS. It also provides higher data rates and operates in the 2-6 GHz frequency range.
802.16e	

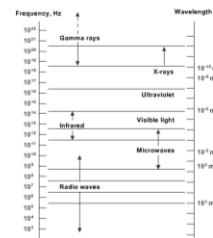
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## FREQUENCY BANDS



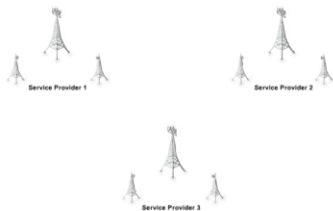
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## Need for Spectrum Allocation



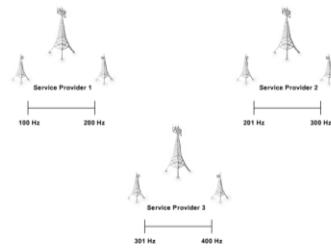
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## Need for Spectrum Allocation



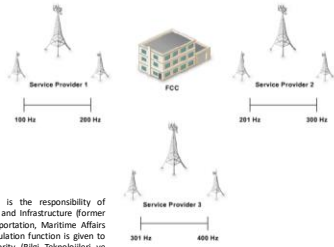
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## Need for Spectrum Allocation



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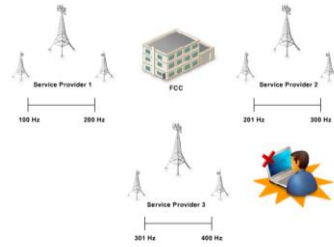
## Need for Spectrum Allocation



In Turkey, policy making is the responsibility of Ministry of Transportation and Infrastructure (former name is Ministry of Transportation, Maritime Affairs and Communications), regulation function is given to Telecommunications Authority (Bilgi Teknolojileri ve İletişim Kurumu)

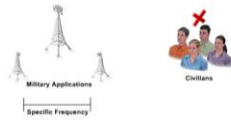
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## Need for Spectrum Allocation



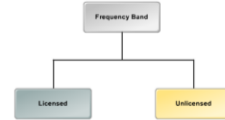
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## Need for Spectrum Allocation



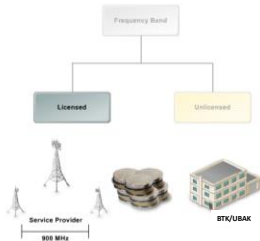
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## Types of Frequency Bands



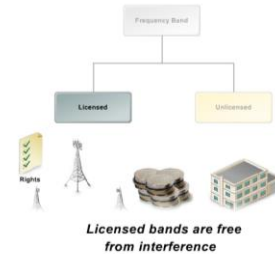
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## Types of Frequency Bands



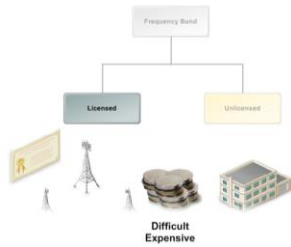
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## Types of Frequency Bands



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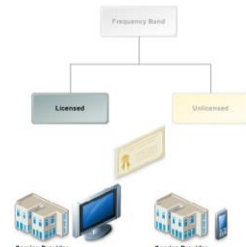
## Types of Frequency Bands



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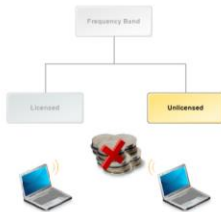
## Types of Frequency Bands



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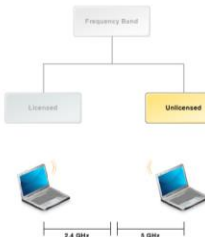
## Types of Frequency Bands



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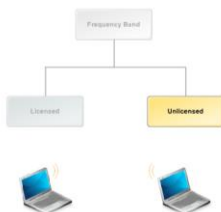
## Types of Frequency Bands



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## Types of Frequency Bands

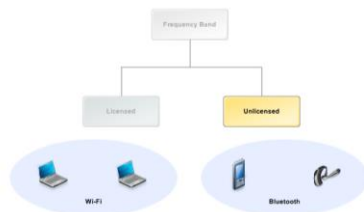


Unlicensed frequency bands  
are prone to interference

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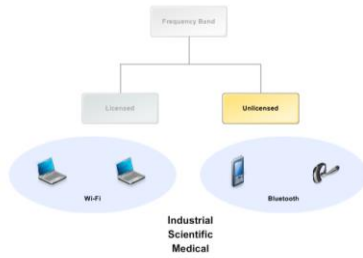
## Types of Frequency Bands



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## Types of Frequency Bands



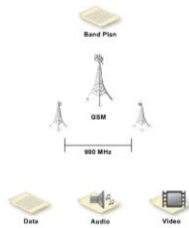
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## Band Plan



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## Band Plan



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## Band Plan



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## WLAN and WPAN Frequency Bands

Frequency Band	Description
902 MHz-928 MHz	
2.4 GHz-2.5 GHz	
3.65 GHz-3.7 GHz	
4.9 GHz-5 GHz	
5.15 GHz-5.825 GHz	

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## WLAN and WPAN Frequency Bands

Frequency Band	Description
902 MHz-928 MHz	Early proprietary implementations in the US used this frequency band.
2.4 GHz-2.5 GHz	
3.65 GHz-3.7 GHz	
4.9 GHz-5 GHz	
5.15 GHz-5.825 GHz	

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## WLAN and WPAN Frequency Bands



Frequency Band	Description
902 MHz-928 MHz	Unlicensed band used primarily for WLAN and WPAN implementations. The standards 802.11b, 802.11g, and 802.11n operate in this frequency range.
2.4 GHz-2.5 GHz	
3.65 GHz-3.7 GHz	
4.9 GHz-5 GHz	
5.15 GHz-5.825 GHz	

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## WLAN and WPAN Frequency Bands



Frequency Band	Description
902 MHz-928 MHz	A potential band in the US. The standard 802.11y will operate in this frequency range.
2.4 GHz-2.5 GHz	
3.65 GHz-3.7 GHz	
4.9 GHz-5 GHz	
5.15 GHz-5.825 GHz	

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## WLAN and WPAN Frequency Bands



Frequency Band	Description
902 MHz-928 MHz	This band is used only in Japan. The standard 802.11j operates in this frequency range.
2.4 GHz-2.5 GHz	
3.65 GHz-3.7 GHz	
4.9 GHz-5 GHz	
5.15 GHz-5.825 GHz	

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## WLAN and WPAN Frequency Bands

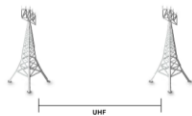


Frequency Band	Description
902 MHz-928 MHz	Unlicensed band used for WLAN implementations. The standards 802.11a and 802.11n operate in this frequency range.
2.4 GHz-2.5 GHz	
3.65 GHz-3.7 GHz	
4.9 GHz-5 GHz	
5.15 GHz-5.825 GHz	

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## Cellular Frequency Band

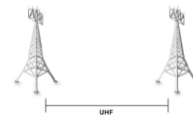


Ultra High Frequency

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## Cellular Frequency Band

US  
Europe  
Asia

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## Cellular Frequency Band



Cellular Technology	Frequency
AMPS	
NMT	
TACS	
GSM	
CDMA	
3G	
4G	

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## Cellular Frequency Band



Cellular Technology	Frequency
AMPS	800 MHz
NMT	
TACS	
GSM	
CDMA	
3G	
4G	

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## Cellular Frequency Band



Cellular Technology	Frequency
AMPS	450 MHz
NMT	
TACS	
GSM	
CDMA	
3G	
4G	

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## Cellular Frequency Band



Cellular Technology	Frequency
AMPS	900 MHz
NMT	
TACS	
GSM	
CDMA	
3G	
4G	

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## Cellular Frequency Band



Cellular Technology	Frequency
AMPS	900 MHz, 1800 MHz, and 1900 MHz
NMT	
TACS	
GSM	
CDMA	
3G	
4G	

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## Cellular Frequency Band



Cellular Technology	Frequency
AMPS	1850-1910 MHz and 1930-1990 MHz
NMT	
TACS	
GSM	
CDMA	
3G	
4G	

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## Cellular Frequency Band



Cellular Technology	Frequency
AMPS	900 MHz and 2 GHz
NMT	
TACS	
GSM	
CDMA	
3G	
4G	

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## Cellular Frequency Band



Cellular Technology	Frequency
AMPS	700 MHz and 2.5 GHz
NMT	
TACS	
GSM	
CDMA	
3G	
4G	

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