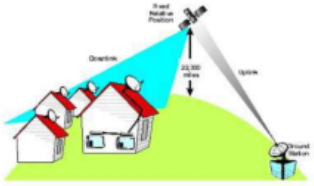
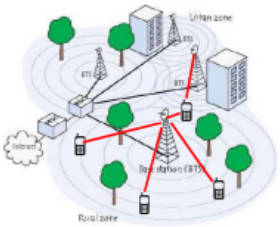
04 - Wireless infrastructure

04_Wireless_infrastructures.pdf

Introduction to wireless infrastructure

System overviews





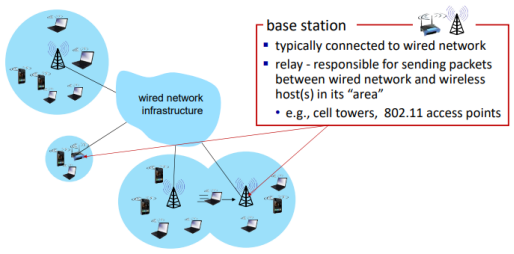
- **Satellite Systems**: Comprised of ground stations and satellites that relay signals. Satellites require "switching reference" as they move passively to maintain communication.
- **Cellular Networks**: Operate with terrestrial configurations, where base stations provide signals within cells, covering users in that area.
- **Wi-Fi**: Originally designed for local networks, later expanded to cover wider areas via IEEE standards.

Wireless technologies can be differentiated based on bitrate capacity and mobility support. For instance, 5G is designed to offer high data transmission rates, making it ideal for data-intensive applications. On the other hand, technologies like Bluetooth, Wi-Fi, and WLAN, while capable of supporting mobile users, were initially developed for fixed access and may not always provide optimal continuity for users on the move. Cellular networks, however, are specifically designed to support mobility, allowing smooth handoffs between cells and uninterrupted communication. In summary, the choice of wireless technology often depends on finding the right balance between bitrate capacity and mobility requirements, which are crucial factors for network performance and user experience.

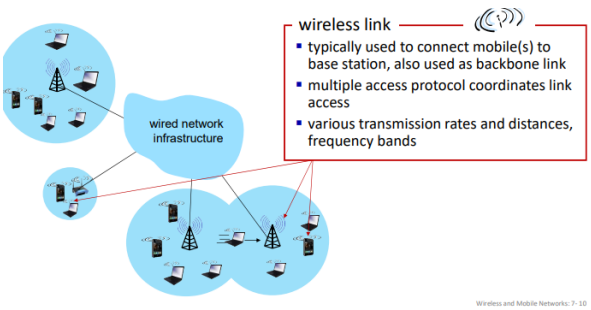
Wireless network

In a wireless network, the main elements include the base station and the wireless link, each with distinct characteristics and functions:

Base Station: This component is usually connected to a wired network, which can employ fiber optic cables for high-speed data transmission. Each base station covers a specific area, known as a cell, where it serves connected devices within that range.



Wireless Link: Unlike wired connections, wireless links (e.g., those used by smartphones) differ significantly in terms of bandwidth, interference, and multiple access protocols.

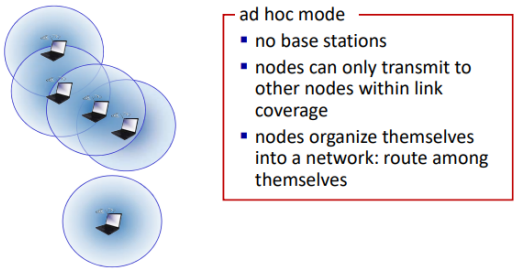


ADSL and VDSL are point-to-point connections, meaning each user has a dedicated fiber link, thus avoiding multiple access issues. However, with Passive

Optical Networks (PON), multiple users share the same link, which can lead to potential multiple access challenges.

This type of communication is known as infrastructure mode, where N users transmit their information through the network, always passing through a wireless network element. For example, if I send a message from my phone, it is first transmitted to the base station, which then forwards it to other users.

Ad hoc network



Ad hoc mode operates without any fixed infrastructure, allowing wireless links to be established directly between users. This approach offers advantages like reduced transmission time, bypassing the entire infrastructure, and the ability to form independent communities. However, it also has limitations, such as limited coverage area, inability to communicate with users outside the network, risk of network disconnection if a link fails, and security vulnerabilities.

In ad hoc mode, dynamic routing is required, so devices must handle functions like routing and addressing. A user may need to act as a relay node, maintaining the network, which adds complexity.

Ad hoc networks are commonly used in IoT applications, extreme environments, and vehicular ad hoc networks (between vehicles), enabling independent data exchange communities for security purposes. However, the complexity is higher because each device must support mobility, addressing, self-configuration, and routing within the network.

Wireless communication

Wireless communication differs significantly from wired communication in several key ways:

- **Decrease in Signal Strength**: Radio signals weaken as they travel through matter, a phenomenon known as path loss. The base station transmits at a certain power level, which decreases with distance as the signal reaches the receiver.
- **Interference from Other Sources**: Interference can be internal (occurring when multiple transmissions share the same frequency band at the same time) or external, caused by noise from surrounding environments. While internal interference can be managed, external interference often requires specific measures, such as using anechoic chambers to isolate signals.
- **Multipath Propagation**: Radio signals may reflect off objects, causing the receiver to receive the same signal at slightly different times. This effect can sometimes be harnessed to amplify the signal upon arrival.

At the receiving end, it's important to measure noise using the Signal-to-Noise Ratio (SNR), which serves as an indicator of transmission quality. Maintaining a known SNR level allows the network to monitor and control communication quality effectively.