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Wireless Networks: Types, Implementations, and Applications

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I. INTRODUCTION

Wireless networks allow users to send and receive information without having to rely on wires. Because of the lack of a tether, a device can freely move within a specific range, while retaining its network connection. Ranges can span from a few feet to a broader scope, such as an entire city. A wireless network enables access to the internet from nearly any location in the world.

Wireless networks are communication systems that foster connections between computer devices. These gadgets include various laptops, desktop computers, servers, and smartphones. Some devices may require adaptors or specific software to establish a connection. However, with the progress of technology and the onset of the Internet of Things (IoT), nearly any electronic device can be connected to a network.

The data being sent through wireless networks has increased within the last decade. Emails, chat messages, web pages, voice calls, and even video streams have no problems being transmitted without wires. There may be decreases in quality or speed compared to a wired network, but the ability to move without being disconnected provides a considerable advantage to the wireless connectivity.

Wireless network types are classified depending on the range they cover. Each type works differently and is suited to different kinds of applications. The wireless network type must take into consideration the requirements and goals of a network.

Wireless Personal Area Network

One type of wireless network is the Wireless Personal Area Network (WPAN). The typical operating range of a WPAN is 1 to 10 meters (Kraemer & Katz, 2009), which gives the user enough mobility to walk around a small room. A WPAN makes use of both Infrared and Bluetooth technology to network the connected devices.

Infrared

Infrared networks use diffused infrared technology, which utilizes a 2 Mbps bandwidth and a 9-meter transmission range. While it may not cost a lot to produce, infrared technology is not commercially popular because of the signal's susceptibility to strong light (Management Association, Information Resources, 2010). Initially, digital data was transmitted between devices that had infrared sensors. These sensors, often installed in rear and side ports of a device, used a technology similar to remote control units for televisions and air conditioners. While several techniques tried to extend the capabilities of infrared networks, it remained a one-on-one type of connectivity primarily. This restriction significantly limited its use for other network applications. Additionally, infrared connections required a direct line of sight between devices, so any physical obstructions, such as walls and other objects, also blocks the infrared communication.

Bluetooth

The Bluetooth technology makes use of radio waves, enabling electronic devices to connect and communicate wirelessly via short-range connections (Haartsen&Mattisson, 2000). Its WPAN, commonly referred to as a piconet, is composed of a master device and several slave devices. The first device in the network often acts as the master of the piconet. Bluetooth networks use frequency-hopping spread spectrum within the 2.4 GHz frequency range (Michael & Borland, 2006) and consist of several mobile access points. With the frequency-hopping technique, devices use randomly chosen frequencies changing about 1,600 times every second. Once the piconet has been established, the devices change frequencies together to maintain the connection with each other while avoiding any other existing Bluetooth connections within the area.

Wireless Local Area Network

Another type of wireless network is the Wireless Local Area Network (WLAN). A WLAN covers up to 100 meters (Kraemer and Katz, 2009), giving its users access to the network within more extensive areas, such as homes, libraries, coffee shops, and airports.

Infrastructure WLAN

Wireless LANs can be configured into different architectures to fit the requirements of a system. The first type of WLAN is an infrastructure architecture. This type is what most users implement, as a means to augment a wired network. An infrastructure type of WLAN interfaces user devices to a wired distribution system and extends its coverage through access points (Fig. 1). Each access point forms a Basic Service Set, allowing users within that radio cell to connect to the access point (Geier, 2010). Through the access point, users of the same network may communicate with each other, with the servers, and other network applications allowed through the distribution system. The access points also serve to broadcast beacon frames, identifying the presence of the WLAN. A variation of the infrastructure type uses controllers to handle data from the access point to the distribution system and vice versa.

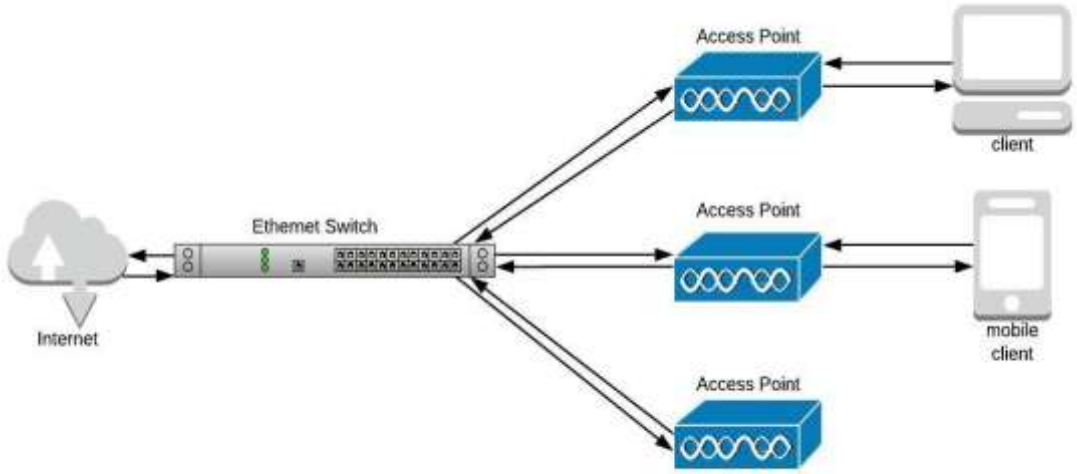

Fig. 1 Data flow through an infrastructure wireless LAN

WiFi, the most common WLAN technology, makes use of a computer's wireless adapter and an access point router. The device sends out data through a radio signal, transmitting it with an often built-in antenna, to communicate between the device user and the internet. The wireless router receives the message, decodes the data, and transmits it to the internet through a wired connection. When the internet sends back a response, the router receives the data through the wired connection, codes it into a radio signal, and transmits it to the device's wireless adapter.

Ad Hoc WLAN

The second type of Wireless LAN is the Ad Hoc WLAN, also known as peer-to-peer WLANs. Unlike infrastructure WLANs, ad hoc networks do not have access points or WLAN controllers. Instead, data is transmitted directly from the source device to the receiving device. Ad hoc networking allows the spontaneous creation of WLANs, with easy setup and takedown activities. Several devices may connect to an ad hoc WLAN, which often benefits groups in meetings or conferences.

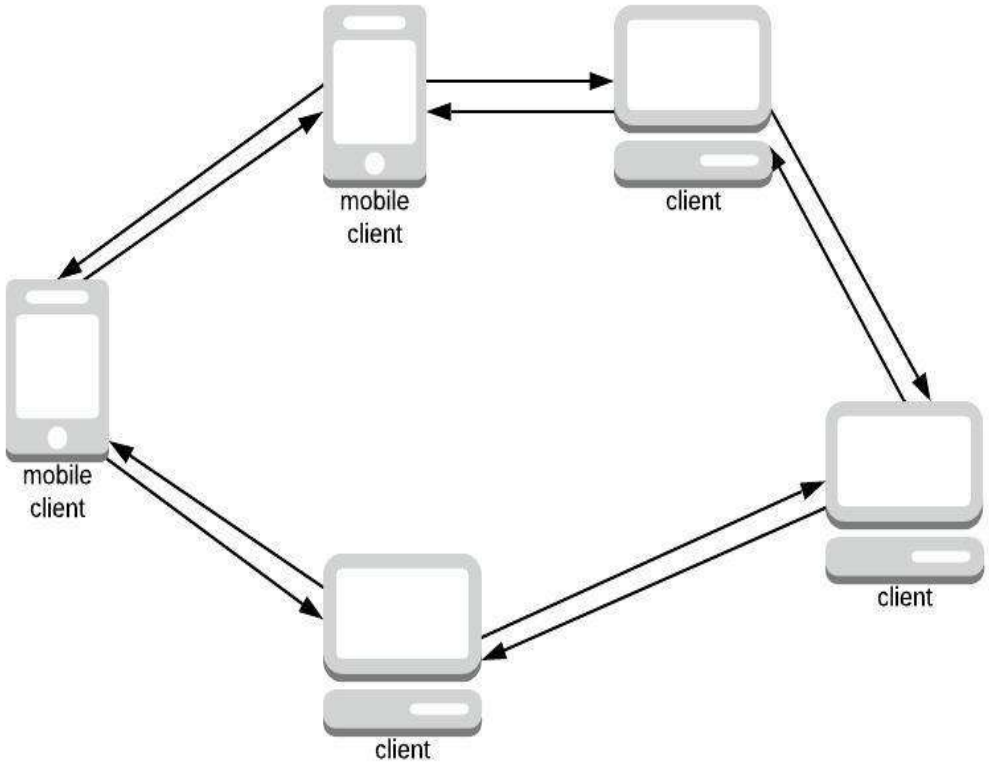

Fig. 2 Data flow through an ad hoc wireless LAN

Building an ad hoc network takes little configuration and requires no administration. It is crucial, however, that the client devices are within radio range of each other. Ad hoc networks are used in critical applications, such as search-and-rescue communications. Because there is no need to set up various infrastructures, teams connected through an ad hoc network may communicate without installation and cabling lead time.

Mesh WLAN

Geier (2010) also discusses the final type of wireless LAN, called the mesh wireless networks. It is similar to the infrastructure type of WLAN, but instead of access points connected via Ethernet, the mesh nodes in the network connect wirelessly. Mesh networks can be installed anywhere with available electrical or solar power. This type of WLAN is a good alternative for locations that cannot support cables such as parks, stadiums, construction sites, or any large and open areas. Mesh network latency can vary depending on its number of users, as well as the hops needed to move packets through the network.

Performance can be affected when roaming or routing delays happen across the WLAN. The setbacks for mesh networks include lack of electrical power, which may lead to higher installation costs and longer lead times. Solar power, a viable alternative, may not be able to provide the necessary energy to power the network. This option is also subject to several factors, such as the lack of sunlight during the night, fluctuating solar strength, and severe weather conditions.

Wireless Metropolitan Area Network

A broader type of network is a Wireless Metropolitan Area Network (WMAN). WMAN solutions can address the need for connectivity over a large area. It uses fixed-access technologies and works by sending out radio frequency or infrared light from one point to another. Directive antennae are mounted at elevated locations to allow line of sight connectivity, with a range limited only by the Earth's curvature (Saha et al., 2003). As with other communications that require line of sight, wireless MANs are easily blocked by clouds, passing aircraft, or other obstructions (Shinder et al., 2003). Wireless MANs can use point-to-point, point-to-multipoint, or packet radio systems, depending on the needs and structure of the application to be serviced.

Point-to-point WMAN

With the use of radiofrequency or infrared signals, point-to-point solutions extend the network range across larger areas. Semi-directional or highly directional antennae are pointed towards each other to establish the connection. Point-to-point WMAN directly connects two nodes within the network. Applications for the point-to-point system includes health care institutions where data must be transmitted from primary hospitals to one of its remote branches. While there is not much flexibility in such solutions, point-to-point WMANs provide a low-cost alternative for connectivity.

Point-to-Multipoint WMAN

The Point-to-multipoint solution is comprised of a central antenna capable of omnidirectional broadcasts. A single transceiver connects users of the network, communicating with multiple remote stations. The point-to-multipoint system allows several nodes to position their antenna towards the central transceiver, which in turn receives and passes on the transmitted data.

This system adapts well when remote stations are added and removed frequently; new connections can be created without having to reconfigure the entire solution. When a large number of remote stations are needed, a point-to-multipoint system may be less costly than its point-to-point counterpart. A company with several warehouses within a city or a cluster of campus establishments surrounding its main building would benefit from the point-to-multipoint solution.

Packet Radio System

An alternative to antenna-based solutions is the Packet Radio System. Individual wireless routers are used by the system to transmit data from the source point to its intended receiver. An end-user has a packet radio Network Interface Card which forwards the data to the nearest wireless router. In turn, the router retransmits it to another, and the data continues to hop closer to its destination. The packets can be forwarded through several routers before it reaches its target.

An implementation of the packet radio system could be for applications that require support for an entire metropolitan area. Routers can be installed in strategic locations to allow seamless data transmissions. While the system may have a high initial cost, its wirelessness allows for quicker setup and replacements when necessary. The packet radio system can also survive despite having multiple points of failure; if a router becomes inaccessible, then the system protocol ensures that the router passes the data onto the next available router.

Wireless Wide Area Network

Another type of wireless network is the Wireless Wide Area Network (WWAN). WWANs use the network infrastructure of mobile communications to provide a wireless connection over a much wider area, such as an entire city, spanning over 100 kilometers (Mahmoud & Mohamad, 2016). This type of network gives users to connect with remote public or private networks (Šimek et al., 2007).

Unlike wireless local area networks, WWANs do not rely on the Ethernet for connectivity. Instead, WWANs rely on telecommunication networks, often with required encryption systems, to provide a means for data transmission.

A current issue with wireless wide area networks is caused by spectrum crunch, wherein the number of wireless spectrum frequencies has become very limited due to the continuously increasing consumer base. Telecommunications providers also use their network to deliver voice and data to their users, so congestion is expected within the system. WWAN administrators may have to reconfigure their connections to achieve connectivity without having to use systems that are nearly at maximum capacity.

Cellular Network

A different type of wireless network is the cellular network. Also called a mobile network, the cellular network is distributed over defined land areas. Each of these land areas is called a cell, with one or more assigned fixed-location transceivers. In practice, these cells have three transceiver stations, more commonly known as cell sites. Network coverage is provided by these stations, allowing voice, video, and other data transmissions. Adjoining cells use different sets of frequencies (Miao et al., 2016) to avoid interference. Quality is ensured through the use of this protocol.

Together, the cells provide network coverage over broad areas, allowing devices to move geographically without having to experience loss of data. Almost all locations have readily available cellular networks provided by telecommunications companies. Mobile devices such as smartphones and tablets can freely switch between cellular systems and other types of wireless networks. Additionally, less power is required from these devices since cell sites are often physically nearer to the user.

II. CONCLUSION

Wireless networks have proven to be an integral part of connectivity in today's highly digital world. Mobility while being connected to

the internet has been a critical component in the lives of people. Sending out emails while on the go, receiving business calls outside of the office, and working at remote locations are some of the examples where wireless networks play an essential role.

These days, more and more devices are being connected to the internet and with each other. Gadgets are being programmed to emulate thinking, and smart devices continue to dominate the markets. These items are already relying heavily on wireless networks for communication. To ensure that the appropriate type of wireless network is used, implementations must consider the desired range, expense budget, and expected usage of the system. Any application can develop and function properly with the right type of connectivity.

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