Senior and Master Air Cadet

Satellite and Data Communications

Module (Learning Outcome) 4:

Know the type and roles of mobile communications

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Learning Outcomes

- Know the **types and roles of mobile communications**, including:
  - Mobile communications.
  - Wi-Fi.
  - Bluetooth.

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Lessons in Module 4

1. Principles of Mobile Communications.
2. Principles of Wi-Fi.
3. Principles of Bluetooth.

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Satellite & Data Communications

Lesson 1:

Principles of Mobile Data Communications

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Mobile Communications

- In this lesson you will learn about the basic principles and technical concepts of mobile data communication, including:
  - Mobile computing.
  - Cellular mobile data networks.
    - UK mobile data network evolution.
    - Mobile network elements.
    - System access, radio coverage and handoff management.
    - Mobile data devices, services and applications.

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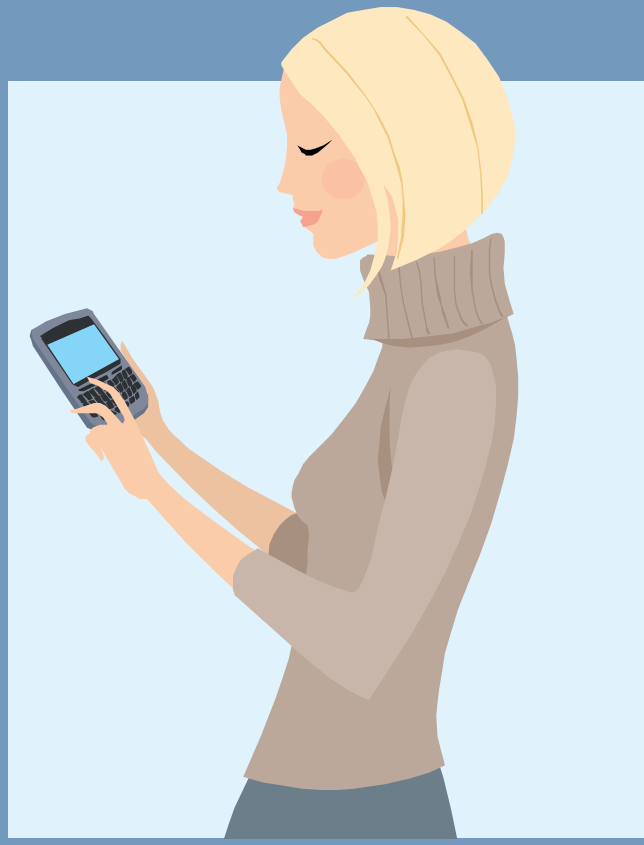
Wireless and Mobile Data Networking

- As networked computing applications became more widely deployed, network access became important, not only through fixed access at home or at work, but also while travelling.
- For example, mobile workers need easy remote access to their organisation's intranet.
- There are two means of providing wireless data connectivity for users on the move:
  - Mobile computing.
  - Nomadic access.

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Mobile Computing

- *Mobile computing* provides network access whilst a user is “on-the-go”:
  - When walking or in a vehicle.
  - Using portable devices.
- It evolved from voice based *cellular* mobile telecommunications technology.
- A mobile network uses *mobility management* to maintain a continuous session as the user moves around, by seamless handover of the session between one radio base station and the next.



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Cellular Mobile Data Networks

- Since the start of the first public mobile telephone networks in the UK in 1985, data communications technology has evolved rapidly through a series of generations.
- Each generation data networking capabilities have increased to meet demand.
  - **1G** systems were analogue and designed only to make telephone calls
  - **2G** Global System for Mobiles (GSM) system were digital and supported mobile data communications at low bit rates.
  - **3G** systems allowed greater mobile data rates and simultaneous voice and data.
  - **4G** systems began to address the demand for access for high-speed broadband mobile data.
  - **5G** system implementation is underway supporting broadband on the move providing data rates comparable to wired connections.
- There are many different standards of competing technologies that support data traffic in different ways and at different speeds.
- These technologies are loosely categorised by generation.

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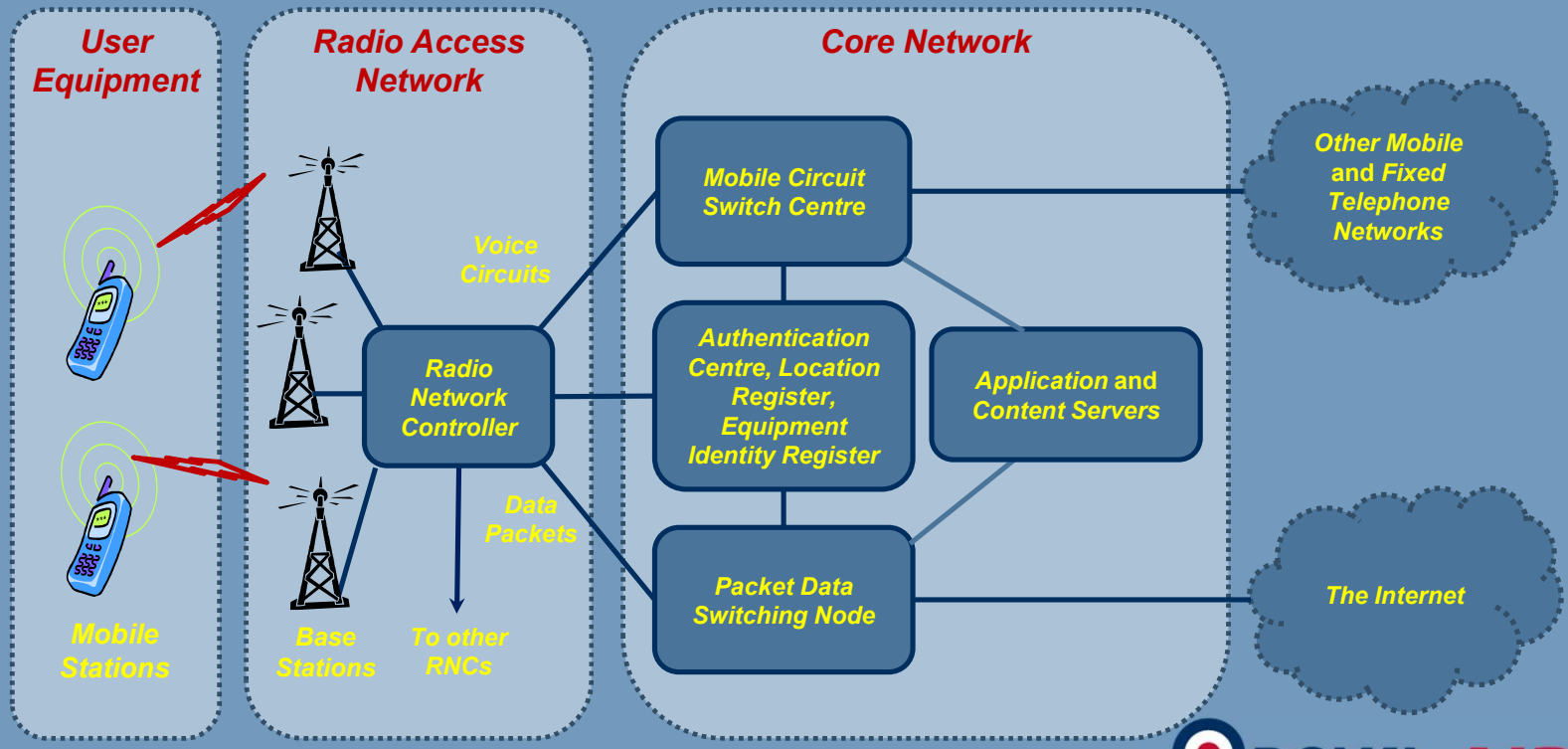
UK Mobile Data Network Evolution

Generation	2G				3G		4G
Network Standard	Global System for Mobiles (GSM)				Universal Mobile Telecoms System (UMTS)		Long Term Evolution (LTE)
UK Launch Date	1990's	2002	2000	2006	2003	2006	2012
Data Service Type	CSD	HSCSD	GPRS	EDGE	WCDMA	HSPA	LTE
	Circuit Switched Data	*High Speed Circuit Switched Data*	*General Packet Radio Service*	*Enhanced Data Rates for GSM*	*Wideband Code Division Multiple Access*	*High Speed Packet Access*	
Max Data Rate	10 kbps	10's of kbps	~100 kbps	~300 kbps	~300 kbps to 2 Mbps	~5 to 15 Mbps	~1 to 20 Mbps

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Mobile Network Elements

- A typical 3G mobile network is built around three major elements (shown in red):



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User Equipment

- *User Equipment (UE)* are devices used to access the mobile network.
- The User Equipment contain all the hardware and software needed to:
  - Connect to mobile networks through a device's internal radio modem.
  - Provide the interface to the user.
- Every User Equipment is allocated a unique *International Mobile Equipment Identity (IMEI)* used by a network to:
  - Identify devices.
  - Stop unauthorised or stolen phones from accessing a network if necessary.
- Different types of devices are used for mobile data services:
  - Mobile computing equipment.
  - Smartphones.
  - Dedicated data terminals.

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Mobile Data Devices

- Mobile phones were first used primarily for making and receiving telephone calls.
- Subsequently, suitably equipped laptop computers or notebooks obtained Internet access through the mobile network using an external *radio modem* module or ‘dongle’.
- However mobile network operators focused on handheld devices for mobile internet access.
- Initially there were dedicated mobile data devices without voice capabilities, such as *Personal Digital Assistants (PDA) and feature phones.*
- These have since evolved into more complex *Smartphones* which entered the market later.
- Dedicated data devices also exist which are used for many different specialised business applications.





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Smartphones

- Smartphones are small multimedia computers that also function as phones.
- A key feature of a smartphone is the ability to install and run applications.
- They use special mobile software operating systems such as:
  - (Apple) iOS.
  - (Google) Android.
  - (RIM) Blackberry
- Many different types of mobile data services provided by the network operators, can be accessed using smartphones depending on device features and software.



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Subscriber Identity Module

- User Equipment houses a removable smartcard chip called *a Subscriber Identity Module (SIM)*.
- The card is usually swappable between User Equipment.
- It is uniquely identified by its *Integrated Circuit Card Identifier* (ICCID).
- The SIM can store:
  - Information required to connect to the network.
  - Passwords.
  - Additional user information such as contact lists and text messages.



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Radio Access Network

- User Equipment communicate with a network of *Base Stations,* called *Node B,* consisting of:
  - Radio transmitters.
  - Radio receivers.
  - Antennas.
- *Radio Network Controllers (RNC)* connect to, co-ordinate and control groups of base stations.
- The function of the RNC is to:
  - Allocate radio channels used by user equipment communicating with base stations.
  - Determine how the radio channel is used.
  - Manage transfer of calls between base stations.



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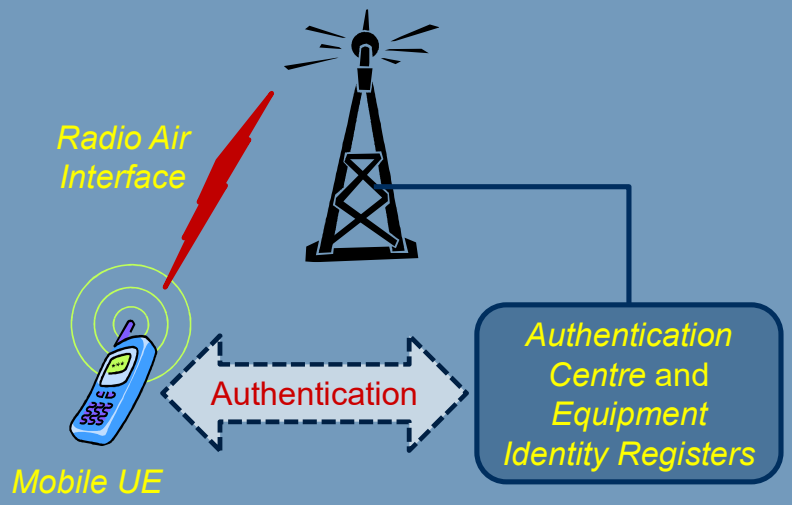
Core Network

- A 3G *Core Network* contains the fixed infrastructure to operate the entire network comprising.
- Two types of switches are used to route voice and data traffic:
  - *Mobile Circuit Switch Centre:*
    - Routes voice traffic around the network.
    - Routes voice traffic to other external mobile and telephone networks.
  - *Packet Data Switching Node:*
    - Routes voice traffic around the network.
    - Routes voice traffic to the Internet.
- There are a number of additional supporting database systems:
  - The *Authentication Centre, Equipment Register and Location Register* control user access to network; track mobile locations; route calls and data; and calculate billing.
  - The *Application Servers* and *Content Servers* deliver additional network services.

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System Access

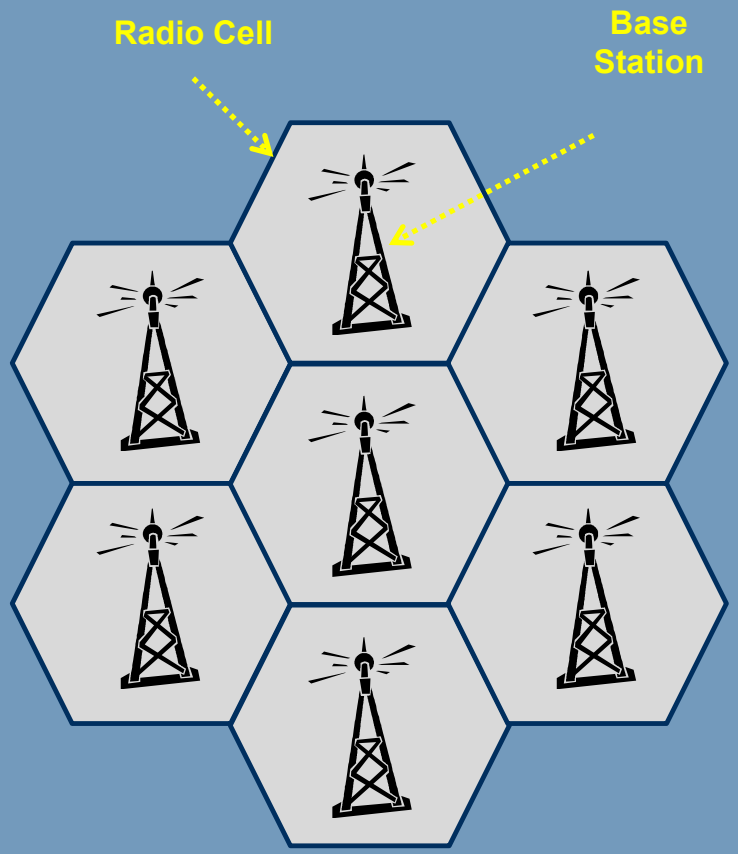
- When a mobile device is first switched on, it registers with the network through the nearest base station.
- *Authentication* takes place to prove that the UE is genuine and allowed to access the network.
- A protocol called the *Radio Air Interface* is used by mobile devices and base stations to:
  - Communicate using *microwave frequencies* allocated exclusively to a specific network operator.
  - Share the radio channel between many mobile devices simultaneously.



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Radio Coverage

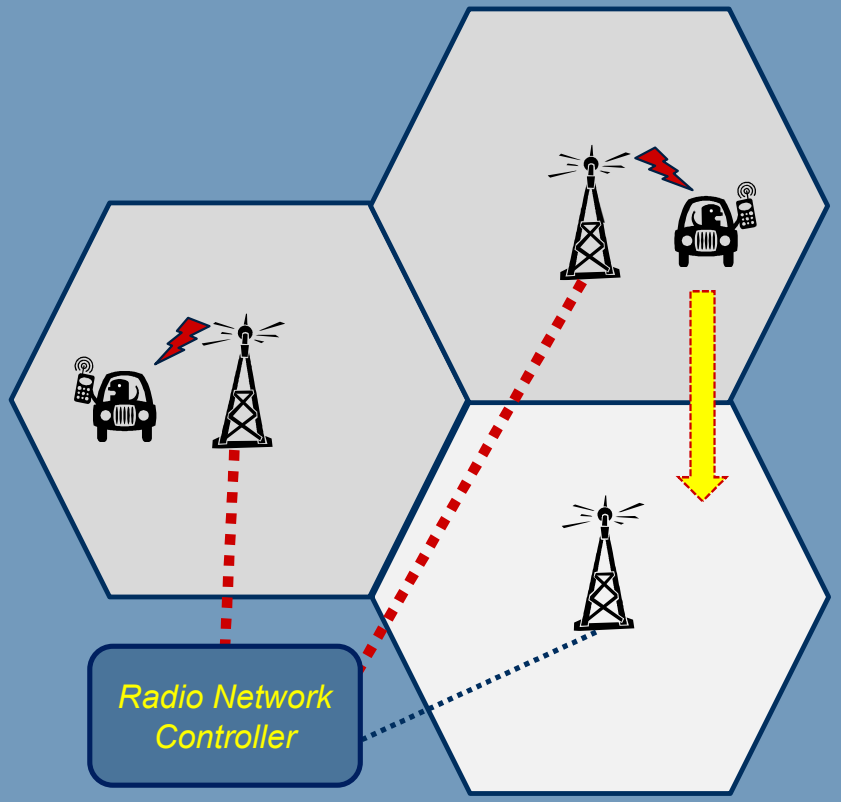
- Uninterrupted radio coverage is achieved by dividing the network's geographical area into a collection of adjacent *cells.*
- A cell is the defined geographical radio coverage area of a single base station.
- In a national mobile network thousands of cells are deployed across the country.
- Mobile devices move around a network and access services via the base station belonging to whichever cell the mobile is located within.



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Hand-Off Management

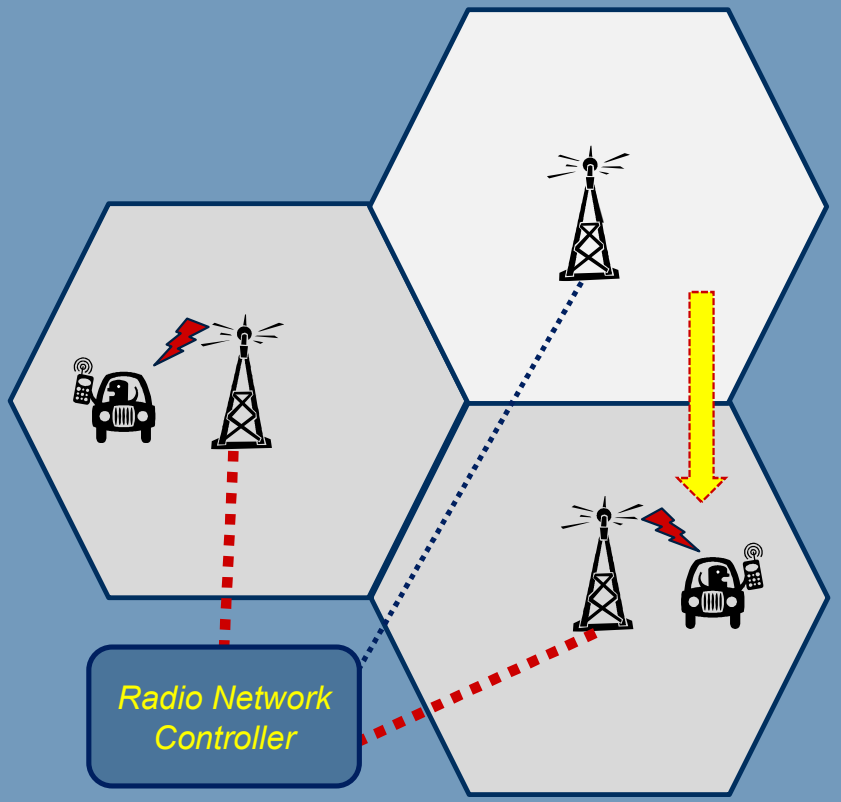
- As a mobile device moves between cells, there needs to be a way to transfer the call to the new cell.
- As the mobile device moves to the edge of the cell
  - the received signal gets weaker
  - then eventually reaches a point where it can no longer receive data reliably
- Meanwhile the surrounding cells have been monitoring the signal strength on all frequencies.



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Hand-Off Management

- When the signal from a surrounding cell becomes stronger than the signal from the current cell, the mobile device's frequency is switched to the channel of the adjacent cell.
- The flow of data is now re-routed seamlessly from the old to the new base station.
- The connection continues without a break in service with the user being unaware of any change.



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Mobile Data Services

- Mobile network operators offer several types of *mobile data services:*
  - *Short Messaging Service (SMS)* – allows 160 character text messages to be sent
  - *Multimedia Messaging Service (MMS)* - permits pictures, video clips and audio messages to be sent
  - *Streaming Service*
    - Presents audio-visual content for buffering and immediate replay.
    - Content is not stored permanently on the device.
    - Two types: Mobile TV and Content on Demand.
  - *Download Service* – allows content to be downloaded and replayed. Some providers limit plays or specify an expiry date.
  - *Internet Access Service*
    - Allows access to the Internet and World Wide Web.
    - Web servers can return a desktop or mobile version of web pages.

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Mobile Applications

- Using these mobile data services, users can run applications on the WWW using a mobile data device in one of two ways:
  - A mobile content browser.
  - Dedicated mobile applications hosted on the user equipment.
- Applications are available to support many uses, the most popular being:
  - Email and Instant Messaging.
  - Web browsing and downloads.
  - Social networking.
  - Gaming and entertainment.
  - On-line commerce.
  - Navigation and location-based services.

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Cadet Learning Activity

- Cadets should discuss the mobile devices you use for wireless mobile data communications in your everyday life, then compare and contrast the different applications.
- Identify the mobile data services you have access to on your mobile device and discuss what you use them for with your device.
- Using these devices, access the settings menu and discover as much information about the device's wireless networking:
  - The device type and operating system.
  - The user equipment SIM card IMEI (if accessible) and ICCID
  - The network service provider.
  - The network type and generation.
  - Signal strength.
- Identify base stations near to your squadron.

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Satellite & Data Communications

Lesson 2:

Principles of Wi-Fi

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WiFi

- In this lesson you will learn about Wi-Fi and the concepts:
  - Nomadic access.
  - Wi-Fi technology.
    - Infrastructure networks.
    - Access Points.
    - Range.
  - Internet hotspots.
  - Voice over IP (VoIP).

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Nomadic Access

- *Nomadic access* provides data network access whilst a user is semi-portable when:
  - Travelling but operating from a fixed stationary location
  - Using portable devices such as laptops.
- It uses wireless networking which has evolved from wired LAN technology.
- A user can log-on whenever they are within radio range of an accessible *Wireless Local Area Network (WLAN)* station.
- If the user subsequently moves on to the coverage area of a different WLAN station, the session is terminated and the user has to log on again.



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Wi-Fi Technology

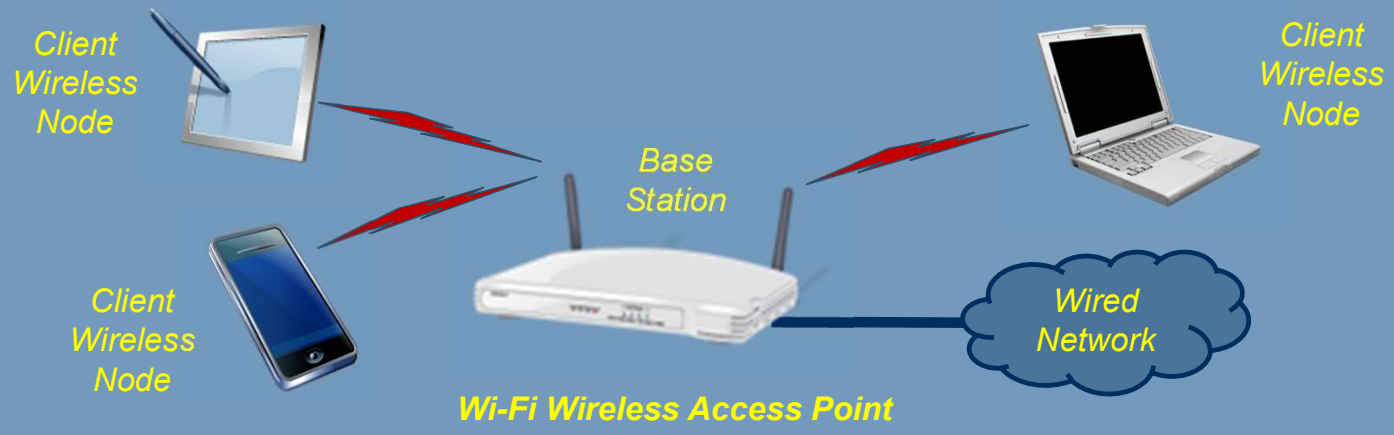
- *Wi-Fi,* meaning '*Wireless Fidelity',* is a wireless LAN networking technology which provides a user with *nomadic access*.
- Wi-Fi networks are accessed by a wide range of devices incorporating *radio modems.*
- The modems operate in the unlicensed Industrial, Scientific and Medical bands at frequencies of 2.4 GHz and 5 GHZ.
- Certified products conforming to the IEEE 802.11 technical standard produced by Wi-Fi Alliance are guaranteed to be interoperable.
- Various versions of the standard exist and new ones are evolving over time.
- Versions IEEE 802.11a and IEEE 802.11g provide theoretical data transfer rates of 54 Mbps.



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Wi-Fi Infrastructure Network

- A Wi-Fi *Infrastructure Network* is used as an extension to wired networks.
- Stations connect wirelessly to an *Access Point, a* radio base station that controls station communications and connects to a router.
- The router in turn connects to a wired LAN or to a broadband connection linked to the Internet.
- Access Points are usually located on the wall or in the ceiling of a building or communal area.



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Access Point Connection

- When in range, a Wi-Fi enabled station learns through the radio channel the identity or *Service Set Identifier* (SSID) and capabilities of the Access Points.
- The station can send a request to *associate*, which the Access Point may accept or reject.
- If a network is open or unsecure, everyone is allowed to use it.
- Otherwise a security access password is needed to *authenticate* before data can be exchanged.
  - *WPA2* is the recommended security method
  - *WEP* was an earlier method but use is discouraged because of design flaws that make it easy to compromise

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Access Point Operation

- All stations in a WiFi network share the same channel.
- Only one station at a time can be allowed to send data.
- Wi-Fi standards do not define how many stations can join a network, but some equipment may have a limit.
- As the number of communicating stations increases, the channel capacity for each station decreases.
- A point will eventually be reached when the network becomes too congested to provide an adequate service.

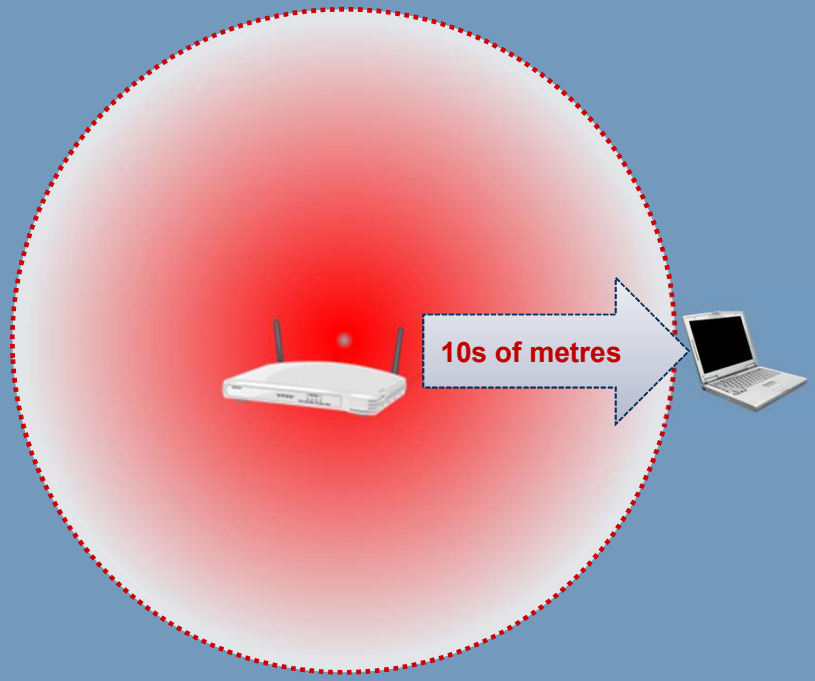


Wall mounted office Wi-Fi Access Point

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WiFi Range

- Any form of wireless communication is limited by how far the signals can travel.
- Typical Wi-Fi range is 10s of metres
- Physical barriers such as walls will reduce the data rate and distance further.
- WLANs in larger organisations may use several Access Points to cover a larger area.
- Access Points within range of each other must be set to use different frequencies or channels so that they do not interfere with each other.



Typical Range of a Wi-Fi Access point

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Internet Hotspots

- *Hotspots* are where WiFi internet access is open to the public.
- Some require you to register or pay for access.
- Others are free as a marketing ploy, as a public service or from an Internet user who opens up a connection.
- Hotspots have sprung up everywhere people go, resulting in a patchwork of coverage.
- The geographical area served by a Wi-Fi hotspot is typically only 10s of metres across and unlike mobile phone networks, coverage areas are generally not adjoining.
- For many users on the move, this level of mobility is an acceptable alternative to mobile phone networks.



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Voice Over IP

- *Voice Over Internet Protocol (VoIP)* allows wireless telephone calls to be made using WiFi through the Internet:
  - Either to other VoIP users of the system.
  - Or sometimes to conventional telephones.
- Typically you pay for calls to a landline or mobile phone, whereas calls to users of the same VoIP service are at no additional cost.
- Many VoIP software applications are available free from the Internet.
- The most popular VoIP application is *Skype.*

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Cadet Learning Activity

- Using a wireless enabled device, Cadets should turn on WiFi and identify any Networks or Access Points within range of your device, noting down:
  - The network names (SSID).
  - Which networks are open and which have security enabled.
- Connect to a Wi-Fi network which you are authorised to access.
- Using the device Wi-Fi settings, explore as much information about the Wi-Fi connection as possible, for example
  - Security and encryption type.
  - Speed.
  - Channel number and frequency.
  - Signal level.
  - Client MAC and IP addresses.

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Satellite & Data Communications

Lesson 3:

Principles of Bluetooth

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Bluetooth

- In this lesson you will learn about Bluetooth, including:
  - Technology.
  - Operation.
  - Applications.

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Bluetooth Technology

- Bluetooth® is a type of wireless Personal Area Network technology used with very short range, low power, inexpensive radio devices.
- It was originally intended to be a convenient alternative to cables when interconnecting local computing devices.
- Products conforming to IEEE 802.15.1 Bluetooth technical standard are interoperable with the specification version for which they are designed.
  - Version 1.0 of the standard was released in 1990 and has seen many revisions.
  - Version 2.0 allow users to exchange data wirelessly between paired devices up to 2 to 3 MHz.
- Devices operate in the 2.4 GHz ISM band reserved for unlicensed users and can therefore be used without restriction around the world.
- The name originates from the 10th century King of Denmark, Harold Bluetooth, who was famous for uniting Scandinavian tribes.



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Class and Range

- Manufacturers of Bluetooth devices can provide the communication range needed to support uses for their solutions.
- Depending on the application, range may vary depending on class of radio transmitter used in a device:
  - *Class 3* transmitters have a range of up to 1m.
  - *Class 2* transmitters, most commonly found in mobile devices, have a range of 10m.
  - *Class 1* transmitters, used primarily in industrial applications, have a range of 100m.
- Range can be reduced by physical obstructions between devices.

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Discoverability

- Every Bluetooth device has a unique MAC *address.*
- When switched on, the Bluetooth protocol lets devices discover each other by transmitting a message alerting other Bluetooth devices nearby.
- A user selectable security feature determines whether or not the device is visible to others within the area.
- If several Bluetooth devices are set to discoverable mode, they can all search for and locate each other as long as they remain within range.

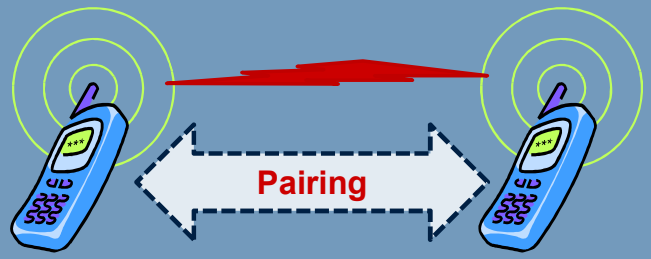


iPhone Bluetooth settings

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Pairing

- Pairing is a procedure followed to determine if two Bluetooth devices can communicate on discovering each other.
- Using the original method, both devices are configured with the same 4-digit PIN code called *passkeys*.
- A new simple secure pairing method was later introduced whereby:
  - Users either confirm that both devices are displaying the same 6-digit device generated passkey or observe the passkey on one device and enter into the other
  - Devices negotiate the use of 128 bit AES encryption to secure communications.
- On establishing a link, both devices can exchange short bursts of data in packets.



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Bluetooth Device Applications

- Bluetooth is used in an ever-increasing range of applications:
  - **Automotive:** hands-free calling, music, smartphone apps, navigation units, monitoring vehicle diagnostics, traffic, driver health.
  - **Consumer Electronics:** game boxes, watches, music players.
  - **Health and Wellness:** activity sensors to monitor medical parameters.
  - **Mobile Telephony:** smartphones, hands-free calling systems, headsets, speakers.
  - **PC and Peripherals:** laptops, headsets, printers, keyboards, mice.
  - **Sports and Fitness:** sensors to measure pace, pulse, distance, other workout information.
  - **Smart Home:** home automation, security, smart energy, entertainment.

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Cadet Learning Activity

- Cadets should list all the Bluetooth enabled devices they use for wireless mobile data communications in their everyday life and discuss the different applications.
- Using some of these devices, turn on the Bluetooth connection and identify any devices within range of the device, noting down any information about the devices e.g. the device names, MAC addresses, etc.
- Pair with another Bluetooth device you are have permission to connect to and identify and explore the following:
  - The type of devices.
  - The device applications.
  - The pairing method for the connection.
  - The maximum communications range (and hence the class of Bluetooth device).
  - The effect of walls, buildings, trees, vehicles etc. on communications.

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Summary of Module (Learning Outcome) 4

- You should now know about the types and roles of wireless mobile data communications including:
  - Mobile networks.
  - Wi-Fi.
  - Bluetooth.

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