Chapter 10. Wireless Access to Networks , and Wireless Networks

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Introduction to Wireless Access to Networks , and Wireless Networks

Context

This chapter extends the previous three chapters by showing how wireless transmission, perhaps from mobile units, may be used to give access to the conventional networks treated in those units. It also extends those units by showing how the networks themselves may be constructed using wireless technology.

Introduction

Wireless networks have considerable appeal as an alternative to conventional (wired) networks in some circumstances, and are essential if mobility is a requirement. With a wireless network, there are obviously no wiring problems and no clutter of wires. This makes them much easier to install, and also makes them more flexible when changes to the network are needed. .

We first consider wireless LANs, which are interesting in themselves but also expose many of the ideas fundamental to the operation and development of wireless networks in general. The architecture of wireless LANs is described and elaborated by examining, in line with the treatment of conventional LANs presented in unit 6, their topologies and protocols.

Then ways in which personal communication networks can be developed by giving radio access to conventional wired networks, notably the telephone network and the Internet, are explored. We examine the issues involved in using a portable unit to gain wireless access to these existing conventional wired networks.

Finally, we look at the principles that underlie satellite communication systems, specifically those based on the use of satellites in low earth orbit. These systems turn the situation created by the previously described networks on its head by providing, in effect, a network that moves relative to its users rather than one where the users move relative to the network.

Objectives

At the end of this module, you should be able to:

- analyse the architecture of wireless LANs;
- explore the issues involved in giving portable units access to existing wired networks;
- draw out the ideas involved in the design of satellite-based personal communication networks.

Wireless transmission

In parallel with this unit, you should read relevant chapters in your textbooks".

Wireless networks have considerable appeal as an alternative to conventional (wired) networks in some circumstances, and are essential if mobility is a requirement. With a wireless network, there are obviously no wiring problems and no clutter of wires. This makes them much easier to install, and

also makes them more flexible when changes to the network are needed. If portable computers and devices are to be connected to a network, whether for personal use or in an organisational application, wires clearly cannot be used and wireless communication becomes essential.

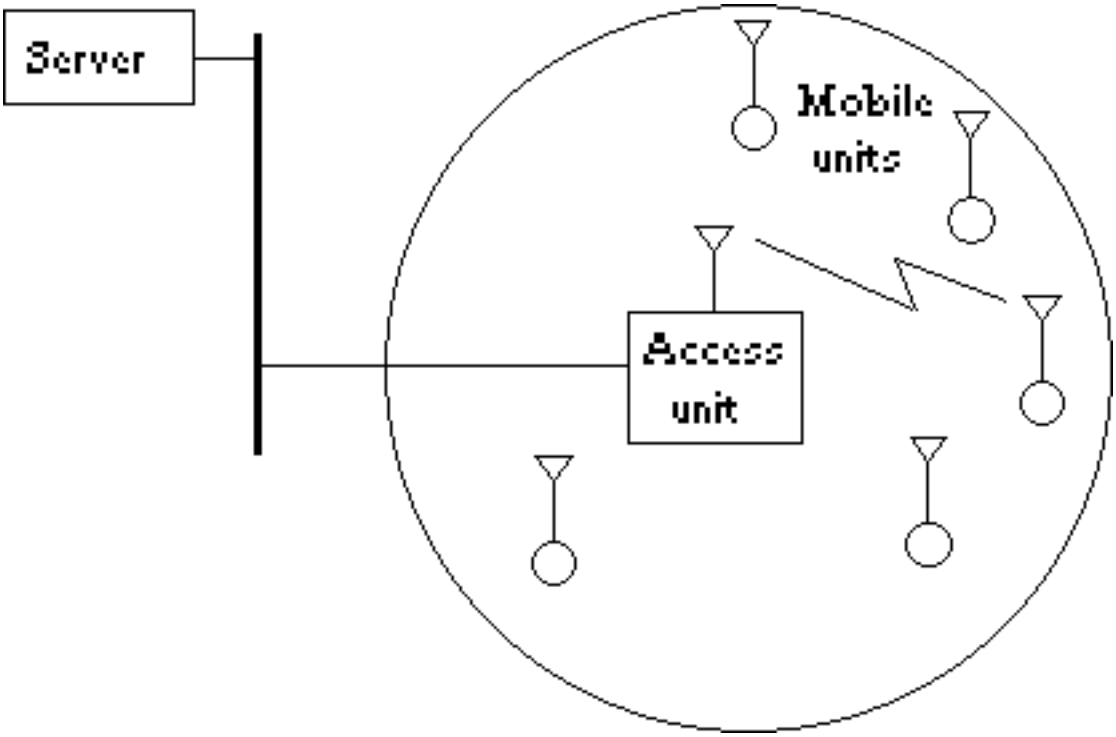
We first consider wireless LANs, which are interesting in themselves but also expose many of the ideas fundamental to the operation and development of wireless networks in general. We then examine the issues involved in using a portable unit to gain wireless access to a conventional wired network such as the telephone network. Finally, we look at networks which are based on the use of satellites in low earth orbit, as these systems turn the previous situation inside out by, in effect, making the network move relative to its users.

To Do

Do Review Questions 1, 2 and 3.

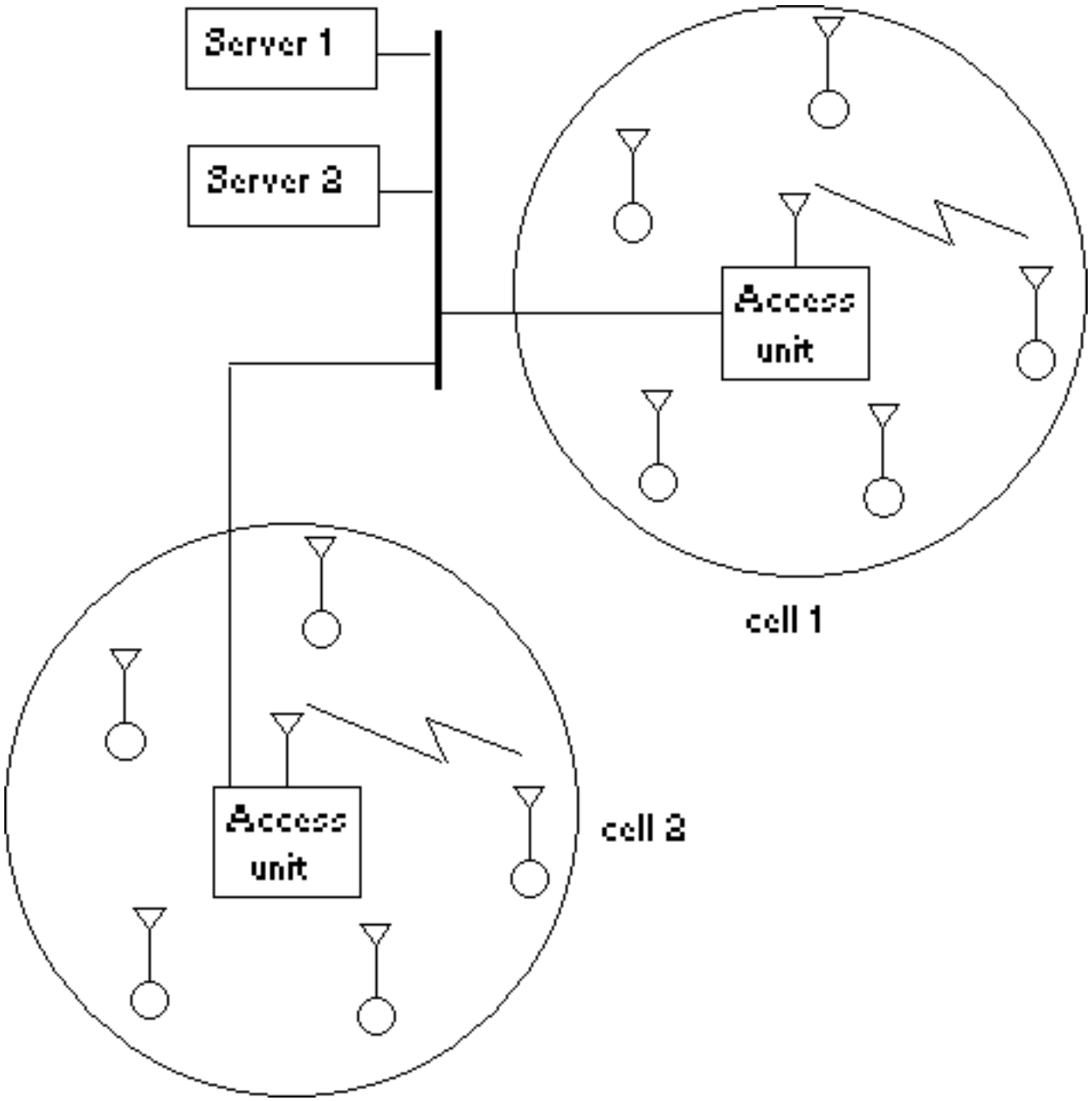
Wireless LANs

A typical structure for a wireless LAN is shown below:



The server and a radio access unit are attached to a cable. The mobile (or portable) units communicate with the Access unit by radio. When all the units have transmitters of the same power, they will only be able to communicate with the Access unit when they are within range. The coverage area naturally forms a 'cell' within which the LAN and its resources are available to the users of the mobile units.

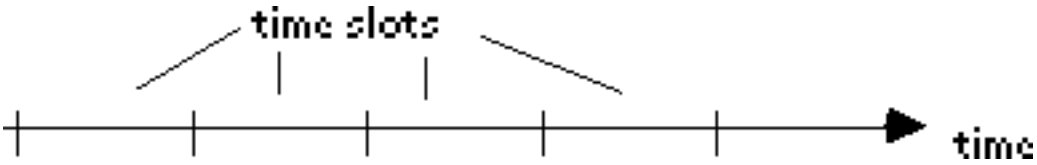
A wireless LAN can support two (or more) separate communities each with its own cell. The mobile units belonging to the respective communities must use different radio frequencies to communicate. This not only differentiates between the members of different communities, but prevents interference from transmissions near the edge of one cell interfering with those in another. In fact, this means that cells can overlap.



As with conventional LANs, some form of access control is needed. Since a wireless LAN is a broadcast system (the radio signals are broadcast, and every mobile unit in the cell can receive them) as is a conventional LAN, it is possible for a wireless LAN to use the same access control methods as a conventional LAN. Contention methods have been used, in particular the CSMA/CD schemes used by Ethernets. It has, however, proved beneficial to adapt this scheme slightly. Adaptations include:

CSMA/CA. The CA stands for collision avoidance, and the idea is to avoid collisions rather than letting them happen and cleaning up the mess afterwards (as with collision detection - CD). A unit with a frame to send first listens to the medium and waits until it is free, as with CSMA/CD. But, when the medium is free, it waits a further short random time before transmitting its frame. This wait ensures avoidance because, when two units are waiting for an ongoing transmission to end and they both find the medium free at the same time, the random duration of the extra wait allows one to transmit first, while the other will find the medium in use and will have to wait even longer.

Slotted CSMA/CD and slotted CSMA/CA. In slotted systems, a unit can only send a frame in assigned time slots.



Thus, with these schemes, the units contend for a time slot, and collisions are either detected and dealt with, or avoided.

To Do

Do Review Questions 4, 5 and 6.

Carry out Activity 1.

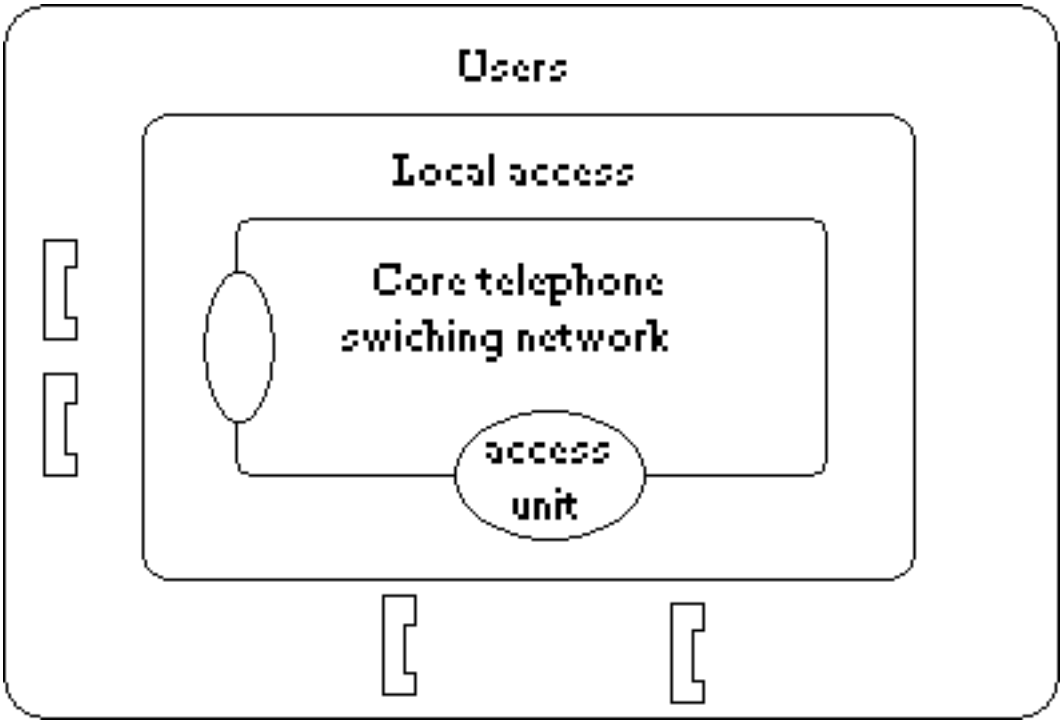
Wireless access to terrestrial networks

Terrestrial networks such as the telephone network and the Internet have, until recently, always been accessed from fixed access points such as a telephone hand set or a computer which, because they too unwieldy to move, are permanently situated somewhere, perhaps on a desk. As increasing numbers of people expect to be able to carry their telephone with them, different ways to access the telephone network have had to be provided. In much the same way, more people expect to be able to carry their portable computer with them so as to be able, for example, to send and read their electronic mail wherever they may be. Wireless access is the key development that makes it possible to use terrestrial networks from mobile units. And when widespread wireless access to these units has been provided they become personal communication networks in the sense that they are always accessible from devices that people carry with them rather than from devices that always remain on the same desk top.

In other words, the key to personal communications is mobility. When the access devices are mobile, they become personal in a way that a static devices situated on desks never can.

To show how this change has come about, we examine the developments that have occurred to the telephone network.

The telephone network can be conceptualised as a layered system as shown:



The user layer contains the users and their access devices. The Local access layer provides these devices with access to the core telephone switching network, the main purpose of which is to provide connectivity so that any user may communicate with any other.

In the old-fashioned telephone system, the access devices were fixed telephones, the access layer gave access through a wired connection from each telephone to its local access unit, a telephone exchange. The core network provided connectivity with switches located at the exchanges.

The key change to the telephone network that makes it double as a personal communication network is to develop the access layer so that it also supports wireless access. Portable telephones can exchange radio signals with the access unit: the access unit can convert signals from a portable phone to signals suitable for the telephone network and vice versa.

This is fine when you want to make a call, as your portable phone communicates with the access unit of the cell you happen to be in. But what happens when someone wants to call you? Or, in the jargon of telephony, how is the 'address migration problem' to be solved? Actually, this problem can be divided into two parts, each of which has two broad solutions. The parts are:

1. Locating the phone.

   The possible solutions are:

   a. System takes responsibility

      The central telephone system broadcasts a 'Where are you?' query to which the phone must reply.

   b. Portable units take responsibility

      Each phone regularly notifies the system of its location.

2. Recording the location.

   The possible solutions are:

   a. Variable

      The record is always kept by the access unit of the cell in which the phone is located. If the phone moves to another cell, the record has to move with it.

   b. Fixed

      The record is kept permanently by the access unit of the cell in which the phone is most often located. If the phone moves to another cell, a pointer to the record is created and stored by the access unit of that cell. If a phone moves fairly rapidly through several cells, a chain of forwarding pointers will be created.

This gives four possible ways for a portable phone to operate (one of the two location methods with one of the two recording methods). Not all the pairings are well matched.

With so many ways for a mobile telephone to operate, the difficulties of creating a standard form of operation are clear, but a widely accepted standard is necessary before a mobile phone can be used anywhere in the world. This problem has been exacerbated by the rapidly changing technology, one facet of which has been the change from analogue to digital transmission for local access. The core telephone network is digital, and uses special-purpose computers for switching. When the local-access transmissions are analogue, analogue-to-digital conversion takes place at the access units (the local exchanges). But the mobile phones themselves must perform the analogue-to-digital conversion if the local-access transmissions are to be digital. The most widely accepted standard for digital mobile phones is GSM.

To Do

Do Review Questions 7, 8, 9 and 10.

Carry out Activities 2, 3, 4 and 5.

Satellite-based systems

The transmissions exchanged with satellites are, of course, wireless transmissions. In satellite-based systems, a satellite acts as the access unit, and its associated cell is the area on the earth's surface to which it can provide coverage, that is, its 'footprint'. Any unit, such as a satellite phone, that is in this cell can communicate via the satellite.

The satellites first used by telecommunication systems were situated in the so-called geosynchronous orbit, where the satellite orbits the earth at the same rate as the earth rotates so that, from a fixed point on the earth's surface, the satellite appears to be stationary. This orbit has a radius of approximately 36,000 km. Unfortunately, the time needed for a transmission to go to and return from a satellite (about 0.5 seconds) is long enough to cause an uncomfortable delay for the participants in a conversation.

Subsequently, systems that use the low-earth orbit where the orbital radius is between 150 and 1500 km, have been developed and deployed. The lower orbit means that the transmission delay is not appreciable but also that a satellite is moving relative to a fixed position on the earth's surface such as the one where a person making a call from a satellite phone is standing. For this reason, to be able to give coverage at one point on the earth's surface, let alone to give coverage at all of them, a system must have a number of satellites.

This means that, in definite contrast to the situation with terrestrial systems, the network is moving relative to its users. One consequence of this is that the ability to deal with mobile communications is inherent.

Calls are made as normal, communicating with the satellite that is overhead at the time. To be able to receive a call, a satellite phone notifies the network of its presence. The satellite that it notifies can determine the position of the phone to within some necessary accuracy, and then the system can work out which satellite must transmit so that calls can reach it.

During a call of any length, the satellite originally above a phone will move, and the phone will leave its cell. This is overcome by arranging that a satellite 'hands-off' a call before the phone passes out of its cell. It will be handed to the following satellite whose cell will next contain the phone. The hand-off itself is similar to the one that takes place when a car driver is making a call with a cellular phone while driving down a motorway and passing through successive cells. The hand-off takes place as the car (and the phone) moves from one cell to the next. The only difference is that, with a cellular system, the phone moves through the cell, while with a satellite system, the cell moves over the phone.

Iridium, developed by Motorola, was the first low-earth orbit satellite system to be fully deployed, although several similar systems are in development. It is intended as a purpose-built personal communication system that provides global coverage by ensuring that there is always a satellite overhead that can be contacted from a portable Iridium phone. There are 66 Iridium satellites, and the orbital radius of the satellites is approximately 800 km.

To be able to receive a call, an Iridium phone notifies the network of its presence. The satellite that it notifies can determine the position of the phone to within 10 km, after which the system determines which satellite must transmit to it. Any hand-offs that are needed are carried out automatically.

To Do

Do Review Questions 11, 12 and 13.

Carry out Activities 6 and 7.

Activities>

Activity 1 - Cell

Investigate what exactly determines the size and shape of a 'cell'.

You can find a discussion of this activity at the end of the chapter.

Activity 2 - Location

Assess the relative merits of the general methods for locating a mobile phone and for recording that information. Also assess the relative success of the match in the four possible combinations of location and recording methods.

You can find a discussion of this activity at the end of the chapter.

Activity 3 - WAP

The Wireless Access Protocol (WAP) is intended to give access from mobile devices to the Internet. Find out about WAP and the kind of devices it is used with.

You can find a discussion of this activity at the end of the chapter.

Activity 4 - WAP Problems

Explore the problems associated with the design of a WAP enabled access device in the light of the conflict that follows from the expectation that these devices will be as small as a mobile telephone and yet will be expected to display Web pages.

You can find a discussion of this activity at the end of the chapter.

Activity 5 - Mobile Users

Explore the problems associated with the usage of a mobile Internet access device. Just what kind of needs are mobile users likely to have for such a device?

You can find a discussion of this activity at the end of the chapter.

Activity 6 - Personal Communication Networks

Find out about personal communication networks (both current and planned) other than Iridium that are based on the use of low-earth orbit satellites. Determine their technical characteristics and the nature of the services they offer.

Activity 7 - Cellular Coverage

Complete cellular coverage of an area is usually represented by a honeycomb of regular hexagons. Given that cells are actually circular, why is the hexagonal representation a good one while, at the same time, misleading? How do the hexagons relate to the circles that would directly correspond to the cells? How do the overlapping areas obtained when the circles are drawn relate to the hand-offs that need to take place as a mobile user moves through the area covered by the cells?

Find out more about the hand-off process and how it is implemented.

You can find a discussion of this activity at the end of the chapter.

Review Questions

Review Question 1

Why is it essential for a mobile networked device to use wireless transmission?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 2

What are the mobile devices used to gain access to, respectively, the telephone network and the Internet?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 3

What are the practical advantages of a wireless network over its wired counterpart?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 4

What is a 'cell'?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 5

A wireless LAN has two Access Units. Can the cells associated with the units overlap? Can they coincide?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 6

What is the essential difference between the access control methods known as CSMA/CA and CSMA/CD? What is the essential difference between the procedures used to implement these methods?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 7

Taking the layered view of the telephone network, as illustrated, what provides the local access layer when fixed handsets are used to make telephone calls, and when a mobile unit is used to make a call?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 8

Given that speech is analogue and the core telephone network layer is digital, analogue-to-digital conversion must take place somewhere. Where can it occur?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 9

What are the consequences for the local access layer when analogue-to-digital conversion occurs at the handset and when it occurs at the access unit?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 10

The core telephone network layer is basically a computer network with its computers filling the roles of telephone exchanges. What is the basic activity carried out by each exchange computer? What activity does this correspond to in a packet-switched network?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 11

What is a satellite's 'footprint'? How does a footprint relate to a cell?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 12

Signals to geostationary satellites are transmitted from specially constructed ground stations, and not from portable units. Why is this?

You can find an answer/comment for this review question at the end of the chapter.

Review Question 13

Why are satellites in low-earth orbit used for personal communication systems?

You can find an answer/comment for this review question at the end of the chapter.

Discussion Topics

1. Since lost calls are not unheard of with ordinary mobile phones where the caller usually remains in one cell, are lost calls likely to be more common with WAP-enabled devices and with systems based on low-earth orbit satellites?

2. The frequencies for radio transmission are a limited resource, and their allocation must be regulated to prevent interference between different systems. Governments have taken to auctioning blocks of frequency for radio transmission. Does this seem a good way to deal with allocation?

3. There seems to be a certain health hazard attached to the use of mobile telephones and other mobile devices. How should we proceed so as to minimise these hazards?

Answers and Comments

Activity 1

Essentially, the size and shape of a cell are determined by the characteristics of the radio antenna used for the transmission of the radio signals. A simple antenna radiates signals equally in all directions, causing the cell to be circular. Since radio signals become weaker the further they go (or, more accurately, they are dispersed over a larger wave front), the size (in this case, the radius) of the cell is determined by the strength of the transmitted signals. A directional antenna, however, tends to radiate

signals in one direction. When such an aerial is used the cell will not be circular, and its precise shape will depend on the characteristics of the directional antenna.

Activity 2

There are four ways of fitting together a means of locating a phone and a way of recording the location. For various reasons, some pairings are better than others. For example: When the system enquires of the phone's whereabouts, it is simpler to be able to direct the enquiry to a fixed location. On the other hand, if the phone reports its location, it is simpler to record that information locally.

Activity 3

WAP-enabled devices will support this standard means of accessing the Internet. Early devices of this kind include WAP-enabled telephones.

Activity 4

The requirement to fit a large (or sufficiently large) screen on a small device clearly requires compromise. Small screens will involve the inconvenience of scrolling or panning across the displayed page. Large screens will require larger and more unwieldy devices. It will help if the pages to be displayed are designed with the requirements of a smaller screen in mind.

Activity 5

Presumably users will want access to timely information. In the business area this will include items such as news and changing prices: in the entertainment area it may include items such as sports scores. Pure entertainment, such as games, may well figure, as will enhanced forms of messaging.

Activity 7

A honeycomb of hexagons completely tiles an area, indicating complete coverage at the expense of distorting the shape of the cells. Circular tilings either overlap or leave gaps. A hexagon is to be taken as indicating a circular cell where the circle has the same centre as the hexagon and a circumference passing through its vertices. The call of a mobile user passing through a grid of circular cells needs to be handed off each time the user leaves one cell and enters another. This has to be done by passing through the area where the cells overlap. At this point, the mobile phone is in the coverage area of two cells, the one it is about to leave and the one it is entering. In this way, the overlapping areas can indicate that the need for a hand-off is imminent, and the cell that is the target for the hand-off.

Review Question 1

Just imagine the situation if a wire dangled from a 'mobile' device as it and its user moved around!

Review Question 2

A mobile telephone, and, perhaps, a WAP-enabled mobile telephone.

Review Question 3

It is easier to install, easier to change, and, if its users need to be mobile while they use it, more convenient.

Review Question 4

The (circular) area within which mobile units must be located to be within range of the wireless transmitter.

Review Question 5

The cells can overlap as long as different wireless transmission frequencies are used with each cell. The cells can coincide if their transmitters are in the same place and they use transmissions of the same power but with different frequencies.

Review Question 6

The former avoids collisions, while the latter allows collisions and then sorts out the mess. Collision avoidance is implemented by resolving the conflict between simultaneous demands for access before access is granted, while collision detection resolves the conflict after access has been gained.

Review Question 7

The wires from the fixed telephone to the local exchange, and the wireless transmissions between the mobile phone and the access unit at the local exchange, respectively.

Review Question 8

At the telephone handset or at the local exchange.

Review Question 9

When analogue-to-digital conversion occurs at the handset, the local access layer must convey digital signals, and must use an appropriate signalling method and protocol. When it occurs at the access unit, the local access layer must convey analogue signals, again by using an appropriate signalling method and protocol.

Review Question 10

The exchange computers switch digitised speech towards its destination. This corresponds to routing in a packet-switched network.

Review Question 11

A satellite's footprint is the area on the surface of the earth to which it can provide coverage. To that extent, a satellite's footprint constitutes a cell.

Review Question 12

The signal power needed to ensure that signals reach the satellite with sufficient strength is beyond the capability of a portable unit. (And also beyond what is safe for human exposure.) Conversely, the signals returned by the satellite are so weak on their reception that highly sensitive equipment is needed that is well beyond the capability of any portable unit.

Review Question 13

Because the power requirements then come within the range of capabilities of portable units as do the sensitivity requirements for receiving signals from satellites.