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## Department of Computer Science and Engineering

Subject Name: **MOBILE COMPUTING** Subject Code: **CS E84**

**UNIT I**

**Introduction:** Wireless and Mobile Computing Architecture – Limitations of wireless and mobile communication – Wireless Telecommunication Networks: Digital cellular Systems, TDMA - CDMA – Wireless Networking Techniques –Mobility Bandwidth Tradeoffs – Portable Information Appliances.

# 2 Marks

**1. What is mobile computing?**

Mobile computing is a technology that allows transmission of data, via a computer, without having to be connected to a fixed physical link.

**2. What is Mobility?**

In mobile computing, mobility refers to characteristics of device to handle information access, communication and business transactions while in state of motion.

A person who moves

- ✓ Between different geographical locations
- ✓ Between different networks
- ✓ Between different communication devices
- ✓ Between different applications

A device that moves

- ✓ Between different geographical locations
- ✓ Between different networks

**3.What are two different kinds of mobility?**

**User Mobility:**

It refers to a user who has access to the same or similar telecommunication services at different places.

**Device Portability:**

Many mechanisms in the network and inside the device have to make sure that communication is still possible while the device is moving.

**4. Find out the characteristics while device can thus exhibit during communication.**

- Fixed and Wired
- Mobile and Wired
- Fixed and Wireless
- Mobile and Wireless

**5. What are applications of Mobile Computing?**

- Vehicles
- Emergencies
- Business
- Replacement of wired networks
- Infotainment
- Location dependent services

Follow-on services:

Location aware services
Privacy
Information services
Support services

Mobile and wireless devices:

Sensor
Embedded controllers
Pager
Mobile phones
Personal digital assistant
Pocket computer
Notebook/laptop

**6. What are the obstacles in mobile communications?**

- Interference
- Regulations and spectrum
- Low Bandwidth
- High delays, large delay variation
- Lower security, simpler to attack
- Shared Medium
- Adhoc-networks.

**7. What is Wireless?**

The term “wireless” refers, in the most basic and obvious sense, to communications sent without wires or cables. It is a broad term that encompasses all sorts of wireless technologies and devices, including cellular communications, networking between computers with wireless adapters, and wireless computer accessories. Wireless communications travel over the air via electromagnetic waves (radio frequencies, infrared, satellite, etc).

**8. What is Wireless Networking**

Networking technologies that connect multiple computers and devices together without wires -- i.e., in a wireless local area network or WLAN -- also fall under the wireless umbrella. Often, instead of referring to just "wireless" for these technologies, the term "wi-fi" or "wifi" will be used. Wi-fi covers technologies that incorporate 802.11 standards, such as 802.11g network cards and wireless routers.

**9. List the types of wireless networks**

Wireless networks use radio waves to connect devices such as laptops to the Internet, the business network and applications. When laptops are connected to Wi-Fi hot spots in public places, the connection is established to that business’s wireless network.

There are four main types of wireless networks:

- Wireless Local Area Network (LAN): Links two or more devices using a wireless distribution method, providing a connection through access points to the wider Internet.
- Wireless Metropolitan Area Networks (MAN): Connects several wireless LANs.
- Wireless Wide Area Network (WAN): Covers large areas such as neighboring towns and cities.
- Wireless Personal Area Network (PAN): Interconnects devices in a short span, generally within a person's reach.

**10. Give Examples for wireless devices.**

Examples of wireless devices include

Cell phones, PDAs, GPS systems, wireless mice, wireless keyboards, remote controls, wireless routers, wireless network cards, and pretty much anything else that doesn't use wires to transmit information**.**

**11. What is meant by wireless and mobile computing architecture?**

The architectural model of a mobile computing environment consists o f stationary and mobile component s . Fixed hosts are connected together via a fixed high - speed network (Mbps to Gbps). Some of the fixed hosts are special computers equipped with wireless interfaces, and are known as base (radio) stations ( BS). They are also known as mobile support stations (MSS). Base stations, which are placed in the center of cellular coverage areas, act as access points between the mobile computers and the fixed network.

**12. What are the limitations of wireless and mobile communication?**

Frequent disconnection .
Limited communication bandwidth .
Heterogeneous and fragmented w ir el ess network infrastructure rapid and large fluctuations in the network QoS.
Security and anonymity
Service relocation
Support for location-sensitive applications **13.**

**Definition of Digital cellular system**

Digital Cellular System: Any cellular phone system that uses digital (e.g. TDMA, GSM, CDMA).

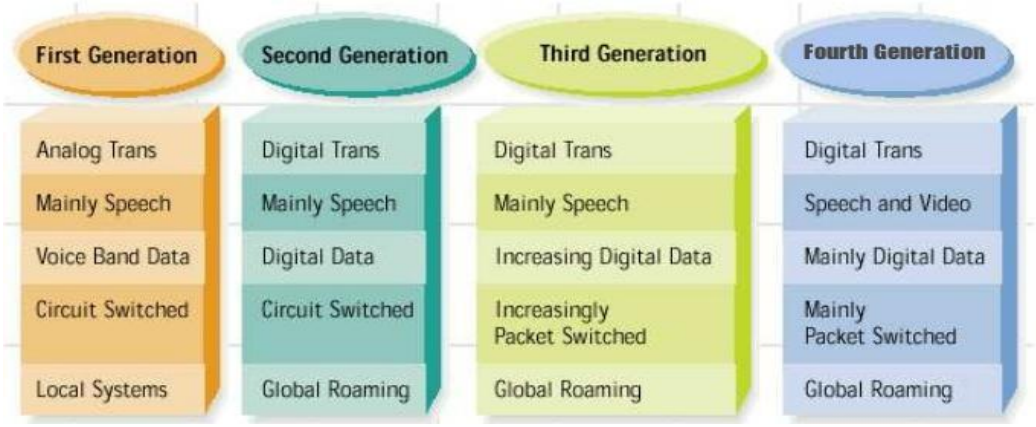
**14.Write Cellular network generation**

1G:First generation Analog cellular system
-Analog voice
2G:First Digital Cellular System
-Digital voice and messaging
2.5G: Digital Cellular System
-Increase in digital data rates
3G: Digital Cellular System with increase in functionality -
Broadband data and voice over IP
4G:Future re-architecting of digital cellular infrastructure -
Increased data throughput

**15. Write the Comparison of 1G to 4G systems.**

| Generation | 1G | 2G | 3G | 4G |
|---|---|---|---|---|
| Wireless Access | Analog | *Digital* | *Digital* | *Digital* |
| | FDMA | TDMA, *CDMA* | *CDMA* | *OFDMA, MC-CDMA* |
| Major Services | Voice | Voice | Voice | *Voice over IP* |
| | | *Internet (text only)* | *Internet (text, images)* | *Rich Internet* |
| Core-network | Circuit-based | Circuit-based | Circuit- and *Packet-based* | *Fully IP-based* |

**16. Write the Evolution of Cellular Networks**




**17. What is meant by TDMA?**

TDMA is a digital transmission technology that allows a number of users to access a single radio frequency channel without interference, by allocating unique time slots to each user within each channel.

**18. What is the purpose of TDMA?**

One problem with TDMA is the wasted bandwidth of unused slots. Time slots are allocated to specific users whether or not they are using the slots (talking or transmitting data). Hughes Systems Network has contributed an enhancement of TDMA known as Enhanced TDMA (ETDMA) that attempts to correct this problem. Instead of waiting to determine whether a subscriber is transmitting, ETDMA assigns subscribers dynamically based on whether a user has voice/data to transmit.

**19. What is meant by CDMA?**

Code-Division Multiple Access (CDMA) offers a solution to the capacity limitation problem. It allows all mobile stations to concurrently use the entire spectrum (all channels) with much less interference. Instead of partitioning either spectrum or time into disjoint "slots", each subscriber is assigned a unique instance of a pseudo-noise digital signal. The transmission signal is "spread" over the entire spectrum, using the noise signal. CDMA is, therefore, known as a spread spectrum modulation scheme.

**20. What are the groups of wireless technologies?**

Wireless technologies can be grouped into at least six major categories: (1) in- room, point to point infrared, (2) in-room radio, (3) in-building radio frequency, (4) campus or metropolitan area packet networks, (5) wide-area packet/circuit switched data networks, and (6) regional-area Satellite Data Networks.

**21. Define mobility-bandwidth tradeoffs.**

In- building cellular offers the highest bandwidth ( bi-directional), but very limited mobility. Micro-cellular offers lower bandwidth but allows for limited-speed mobility; macro-cellular offers much lower bandwidth but allows for the highest degrees of mobility. As can be noticed, in these networks, the larger the coverage area (the cell size), the higher the degree of mobility.

**22. What is the use of portable information appliance?**

It is used to record numeric information. This information was probably very important to the user of this appliance and in some way directly affected his livelihood. It may have actually provided the "function" of counting by allowing the user to create a mark corresponding to a piece of livestock. This would have been very useful to an individual whose society had not yet invented a system of numbers.

**23 . Explain about PDA .**

PDAs emerged in 1993 amid claims of single-point data organization, ubiquitous and instantaneous communications, and new operating paradigms using glitzy graphical user interfaces (GUI) and handwriting recognition.

**24. Explain about palmtop computers.**

It is likely that wireless network connectivity will trail wired connectivity in terms of performance for the foreseeable future. The best strategy for the developers of portable information appliance is to design products which either provides useful standalone functions such as an electronic still camera, or which complement wired network platforms. The emerging market of Palmtop Computers is a breakthrough in terms of the ability of the Palmtop to complement the desktop computer.

**25. Define communicators.**

The Communicator is a PDA concept that combines the benefits, portability and functionality of digital cellular phones and palmtop co mp u t er s . The idea is to stick a palmtop computer to a cell phone with data capabilities to provide remote access, in addition to the stand-alone form factor applications that can be found on palmtop computers. Internet access, telnet, email, and web browsing are all applications offered by communicators.

**26. What is in building radio frequency?**

This type of network, which is also known as Wireless LAN, expands the range of the infrared and the Bluetooth technologies by increasing the network diameter to about 200m. Unlike infrared and Bluetooth, in-building radio frequency is a cellular network, where mobile computers are allowed to roam within and across cells.

**27. What is campus area packet network?**

This network type encompasses the more traditional "cellular" networking paradigm. It is typified by a "pole top infrastructure" supporting network diameters of 0.2 to 5 miles with data rates of 20-128 kbps. Relay (or router) nodes a r e strategically placed to support the wider network diameter with a small price for increased latency.

**28. Write some of the portable information appliances.**

Two of the portable information appliances, the pocket watch and the printed book are relatively recent inventions which have transformed human society. The pocket watch enabled the level of logistical synchronization between individuals required for

industrialization. Printed books, while not as interactive as paper and pencil, have also evolved as the preferred method for accessing standardized information in a portable format.

**29. Explain satellite networks.**

Satellite technology is still emerging. It is a downlink technology where mobile computers can only receive direct broadcast from a satellite. Outbound communication is initiated by the mobile computer through a modem DIAL-UP or other wireless technology. Hughes Network Systems pioneered the DirecPC net- work which uses the Galaxy satellite and which delivers 400 kbps downlink rate.

**30. Write down the Nokia 9000 specifications (UQ April'13)**

**Table 3.4** The Nokia 9000 Specifications

| Item | Specifications |
|---|---|
| Memory | 8MB total: 4MB OS and applications,<br>2MB program execution,<br>2MB user data storage |
| Processor | embedded INTEL 386 processor |
| Operating System | GeOS TM3.0 |
| E-mail protocols | SMTP, IMAP4, POP3 and MIME1 |
| Weight | 397g |
| Dimensions | 173 x 64 x 38 mm |
| Displays | Grayscale 640x200 (illuminated) LCD |

**31.What are the limitations of Mobile Enivironment (UQ April'13)**

**limitations include:**

- Frequent disconnection caused by one of the following events:
  - handoff blank out in cellular networks; the problem is worse in micro-cellular networks
  - long down time of the mobile computer due to limited battery lifetime
  - roaming-off outside the geographical coverage area of the wireless service
- Limited communication bandwidth impacting the following:
  - quality of service (QoS) and performance guarantees throughput and response time and their variances
- Heterogeneous and fragmented wireless network infrastructure leading to the following problems:
  - rapid and large fluctuations in the network QoS ■

Other problems include:

- security and anonymity
- service relocation
- support for location-sensitive applications

**11 Marks**

**1. Write in detail about mobile computing (5)**

Buzzwords such as *mobile, ubiquitous, nomadic, untethered, pervasive,* and *any time anywhere,* are used by different people to refer to the new breed of computing that utilizes small portable devices and wireless communication networks.

The difference between nomadic and mobile computing is particularly important to point out. Both nomadic and mobile computing require small portable devices. However, the kind of network used in nomadic computing does not allow mobility, or does so in the confines of a building, at pedestrian speed. Examples of such networks are DIAL-UP lines, which obviously do not allow any mobility, and Wireless Local Area Networks (W- LAN), which allow for limited mobility within a building facility.

Nomadic computing refers to the interleaved pattern of user relocation and "in-door" connection. Travelers carrying laptops with DIAL-UP modems are, therefore, nomadic users engaged in nomadic computing. Mobile computing, on the other hand, requires the availability of wireless networks that support "outdoor" mobility and handoff from one network to the next, at pedestrian or vehicular speeds.

A bus traveler with a laptop connected to a GSM phone or a CDPD modem is a mobile user engaged in mobile computing. Figure 1.1 depicts this taxonomy. It also shows ubiquitous computing to be the aggregate ability to compute in both the nomadic and the mobile modes. Mark Weiser, a pioneer and a visionary from Xerox PARC, had different view and definition for ubiquitous computing. The reader is referred to his famous 1991 article in Scientific American [91]. We caution the reader that, in this book, the term mobile computing is used to refer to both nomadic and mobile computing, to reduce the clutter.

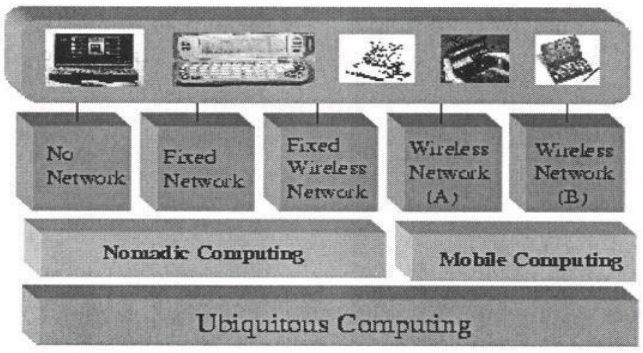



**Figure 1.1** Ubiquitous = nomadic + mobile

**2.Explain wireless and mobile computing architecture (6) APRIL/MAY2014**

The architectural model of a mobile computing environment is shown in Figure 1.6 and consists of stationary and mobile components. Fixed hosts are connected

together via a fixed high-speed network (Mbps to Gbps). Some of the fixed hosts are special computers equipped with wireless interfaces, and are known as base (radio) stations (BS). They are also known as mobile support stations (MSS). Base stations, which are placed in the center of a cellular coverage areas, act as access points between the mobile computers and the fixed network. Mobile computers can be in one of three states. The first state place

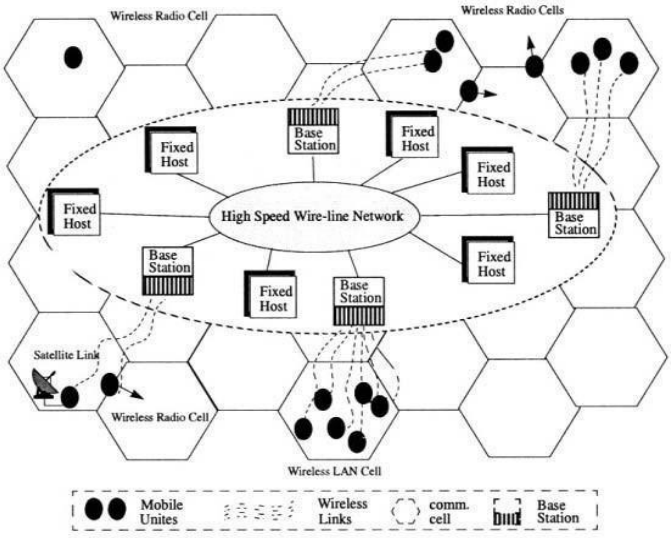
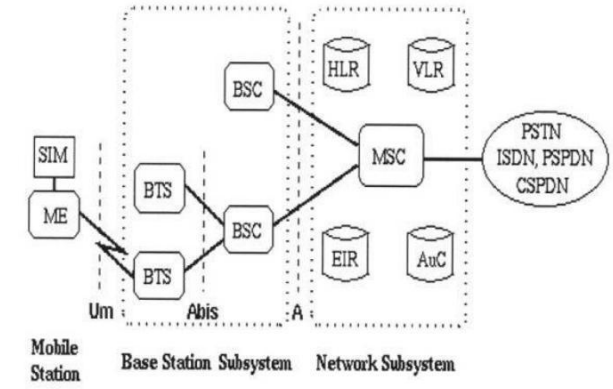



**Figure 1.6** Mobile computing environment

a mobile computer within a cell and capable of communicating. The second state places the mobile computer out of range of any service cell and not ca- pable of communication. The third state places a mobile computer in a cell, communicating, but just ready to cross a cell boundary. These scenarios are depicted in Figure 1.6. Figure 1.6 is a generalized architectural overview of a typical wireless/nomadic system. Many such systems have been deployed both in the United States and Europe as well as in many other parts of the world. One such European sys- tem is the Global System for Mobile Communications (GSM). GSM, which is depicted in Figure 1.7, was originally developed by the European Institute for Research and Strategic Studies in Telecommunications (EURESCOM) as an advanced mobile communications technology. During early stages of deploy- ment, GSM was hailed as a superior wireless technology because the general architecture supported such features as roaming, minimum disruption when crossing cell boundaries, and connectivity to any number of public wired infras- GSM is gaining increased popularity in North America. Figure 1.8 quantifies GSM penetration in terms of number of states with GSM services in the US.




SIM Subscriber Identity Module | BSC Base Station Controller | MSC Mobile services Switching Center
ME Mobile Equipment | HLR Home Location Register | EIR Equipment Identity Register
BTS Base Transceiver Station | VLR Visitor Location Register | AuC Authentication Center

**Figure 1.7** GSM architecture

The PCS system with AIN services outlined in Figure 1.9 is comparable to the overlay internetworking system described by Katz and Brewer [69]. The PCS/AIN system shown above is comprised of many different forms of communications (e.g. cellular, PCS, wired, POTS (Plain Old Telephone Service), etc.) with a centralized management scheme as defined by the Telcordia AIN standards. There exists interconnection across planes and between overlay planes to establish service attributes. One of the many issues to be addressed is how do wireless service providers and application developers create, deploy, and control applications support services given the systems described above.

**3. Write the limitations of the wireless and mobile environment (5)**

The limitations of wireless and mobile environment are as follows:

- Frequent disconnection caused by one of the following events:
  – handoff blank out in cellular networks; the problem is worse in micro- cellular networks
  – long down time of the mobile computer due to limited battery lifetime
  – voluntary disconnection by the mobile user
  – disconnection due to hostile events such as theft and destruction
  – roaming-off outside the geographical coverage area of the wireless service
- Limited communication bandwidth impacting the following:
  – quality of service (QoS) and performance guarantees
  – throughput and response time and their variances
  – efficient use of battery due to long communication delays (wireless interface requires battery energy during the slow send and receive)
- Heterogeneous and fragmented wireless network infrastructure leading to the following problems:
  – rapid and large fluctuations in the network QoS

  – mobility transparent applications perform poorly without some sort of mobility middleware or proxy.

  – poor end-to-end performance of different transport protocols across networks of different parameters and transmission characteristics.

- Other problems include:
  - security and anonymity
  - service relocation
  - support for location-sensitive applications

There are other limitations related to platform and application development methodologies and languages. Operating systems for portable devices (other than laptops) are yet to reach maturity. Palm-OS, Windows-CE, EPOCH, and GeOS are the most significant operating systems developed for mobile computing. A version of Linux for hand-held devices is also being developed.

These operating systems are light weight with simplified, single-address space memory management. Application portability across these operating systems is currently a major problem. The use of Java is currently limited due to the in- adequate performance of JVM on most of these platforms. Development of mo- bile applications on these platforms is typically done through platform-specific SDKs supplied by the operating system vendors. Windows-CE development can also be done using Microsoft Visual C++.

**4. Write in detail about wireless telecommunication networks (6)**

Today, person to person voice communications, enabled by the telephone, is still perhaps the most powerful technology available to the average person. The benefit to cost ratio of this technology for the individual is enormous. An individual can use a telephone to conduct commerce, earn a paycheck in count- less ways, call for medical assistance, consult experts worldwide on any topic, and essentially obtain almost any critical information imaginable. The most sophisticated part of this technology is not in the telephone handset itself but in the enormous worldwide communications network to which the handset is attached.

The introduction of cellular telephones has certainly improved the individuals ability to access (or be accessed by) this voice network in any location. But the global network is now providing more than person to person voice communications. Data, images, and live video are now routinely transferred to the individual desktop computer. It is expected that these expanding capabilities will soon be available within some type of portable information appliance.

There are several well-established cellular infrastructures available today in different parts of the world. The European community has standardized largely on GSM. North America has broad AMPS coverage with a number of other standards competing in the PCS frequencies. Japan deployed the PHS infrastructure everywhere. A brief comparison of these predominant standards is shown in Table 2.1

**Table 2.1** PHS, AMPS and GSM wireless technologies

| | PHS | AMPS | GSM |
|---|---|---|---|
| Usage area | Cordless (in-home) Mobile/ In-building (Japan) | Mobile/ In-building (N. America) | Mobile/ In-building (Europe) (N. Africa/Asia) |
| Applicable travel speed | slow driving | driving speed | driving speed |
| Voice signal | Digital | Analog | Digital |
| Frequency band | 1.9 GHz | 900 MHz | 900 MHz |
| Channel multiplex number | 4 | 1 | 8 |
| Radio wave coverage | Indoor: 50–100m Outdoor: 100–400m | 1.5–10km | 1.5–10Km |
| Terminal to terminal communication | Possible | Not possible | Not possible |
| Data communication | 32 kbps (plan) | 14 kbps | 9.6 kbps |
| Standby time | around 200 hrs | up to 20 hrs | up to 40 hrs |
| Talk time | 5 hrs | up to 150 min | up to 240 min |
| Terminal output | less than 10 mW | 600 mW | 800 mW |
| Modulation method | Shifted QPSK | FM | GMSK |
| Voice transmission speed | 32 kbps, ADPCM | Analog | 22.8 kbps |

**5.Explain in detail about D igital cellular systems (11) (UQ April'13)**

Analog cellular systems such as North America's AMPS have the disadvantage that they are very expensive to expand and grow. Each mobile phone requires a dedicated channel to communicate in a cell site. The only way to expand in AMPS is to build additional cell sites which cost in the range of $500,000 to $1,000,000.

In 1988, the Cellular Telecommunications Industry Association (CTIA) com- missioned a subcommittee called Advanced Radio Technology to define alter- native technologies that allows the cost effective cellular expansion in the US. Proposed technologies focused on Multiple Access network technologies. The first digital system accepted by CTIA is the TDMA system, which stands for Time Division Multiple Access and which allows users to share the radio channel through time division. The second digital system accepted by CTIA is CDMA, which stands for Code Division Multiple Access, and which allows users to share the entire radio spectrum through different, uniquely assigned codes for transmission and reception. In the next subsections, we briefly describe the TDMA and CDMA cellular systems.

**Time-Division Multiple Access (TDMA) APRIL/MAY2014**

TDMA is a digital transmission technology that allows a number of users to ac-cess a single radio frequency channel without interference, by allocating unique time slots to each user within each channel. Currently, a single channel is di- vided into six time slots,

with each signal using two slots. This provides a 3 to 1 gain in capacity of AMPS. In dispatch systems (e.g. Motorola iDEN), a dispatch signal uses one time slot, thus providing a 6 to 1 gain in capacity. D-AMPS, GSM, iDEN and several PCS systems currently use TDMA. The Telecommunications Industry Association (TIA) provided an early standard for TDMA over AMPS, known as IS-54, which required digitizing the voice signal, compressing it and transmitting it in regular series of bursts, interspersed with other users' conversations. Second generation standard for TDMA by TIA is the IS-136 which uses TDMA on the control channel. TDMA is expected to be called TIA / EIA-136 once it becomes an ANSI standard.

One problem with TDMA is the wasted bandwidth of unused slots. Time slots are allocated to specific users whether or not they are using the slots (talking or transmitting data). Hughes Systems Network has contributed an enhancement of TDMA known as Enhanced TDMA (ETDMA) that attempts to correct this problem. Instead of waiting to determine whether a subscriber is transmitting, ETDMA assigns subscribers dynamically based on whether a user has voice/data to transmit. A phone conversation with long pauses will, therefore, not cause a loss of bandwidth, and will increase the spectral efficiency of TDMA. Today, TDMA is becoming a very popular air interface. Over 8 million digital subscribers worldwide utilize the IS-54 and IS-136 today. In the US alone, three of the top four carriers are deploying TDMA IS-136.

**Code-Division Multiple Access (CDMA) APRIL/MAY2014**

In frequency and time division multiplex systems, several hundred channels are available within the spectrum allocation of a carrier service. One channel of one base station is used for each conversation. Upon handoff, the subscriber station is directed via messaging to discontinue use of the old channel and tune to the new one. Without reusing the frequency assigned in the spectrum, the total number of cells that can be deployed can not exceed the available number of channels. Frequency reuse is very essential to the design of cellular systems that are based on frequency division multiplex.

Frequency reuse utilizes the fact that the attenuation of electromagnetic fields tends to increase with distance. Therefore, to reuse the frequency without incurring significant interference, only non-adjacent cells are assigned the same frequencies. Ideally, cellular frequency reuse is achieved by imposing a hexagonal array of cells in a service area. A seven cells hexagonal array is shown in Figure 2.1. Seven frequency channels represented by different gray levels are used, one for each cell. The hexagonal array can be replicated and connected, providing a larger coverage area, without using any but the seven frequency channels. Systems that use frequency reuse includes AMPS in North America, NMT in Scandinavia, and TACS in the United Kingdom.

In reality, cell coverage areas are highly irregular, and do not compare to the ideal hexagons shown in Figure 2.1. And even if ideal hexagons are possible, the frequency division approach offers limited capacity. Take AMPS as an example. Each AMPS operator in North America is allocated 416 channels (30KHz each). In a seven-way reuse hexagon, each cell will be allocated 416/7 = 59 channels. In this example, the capacity of cellular systems can not grow beyond the bandwidth offered by 59 channels, which is 1.8MHz.

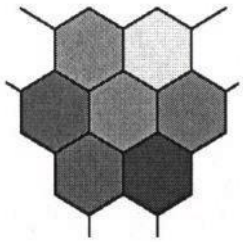


**Figure 2.1** A hexagonal array of seven cells using seven different channels

Code-Division Multiple Access (CDMA) offers a solution to the capacity lim- itation problem. It allows all mobile stations to concurrently use the entire spectrum (all channels) with much less interference. Instead of partitioning ei- ther spectrum or time into disjoint "slots", each subscriber is assigned a unique instance of a pseudo-noise digital signal. The transmission signal is "spread" over the entire spectrum, using the noise signal. CDMA is, therefore, known as a spread spectrum modulation scheme. The spreading technique is also known as Direct Sequence scheme.

Frequency Hopping is another spreading technique, where the different segments of the subscriber conversation (or data) known as frames are transmitted on a sequence of randomly chosen frequencies within the spectrum. In either direct sequence or frequency hopping, the subscriber unit must communicate with the base station to agree on the direct sequence (the pseudo random digital code) or the sequence of frequencies to hop through. Signal interference in CDMA (between neighboring cells) is much less sensitive to most of the system parameters and is confined within a predictable average. This is one reason CDMA is attractive since it is easier to predict the achieved bandwidth based on the acceptable Noise to Signal Ratio (NSR) and the gain of signal spreading.

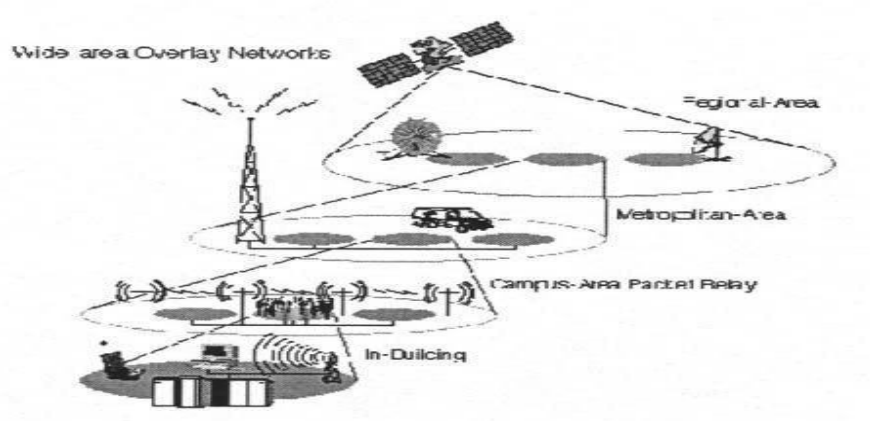



**Figure 2.2** Wireless network overlay (Katz et. al)

Originally, CDMA was invented by Claude Shannon, who suggested that through noise-like carrier waves, bandwidth can be increased. Versions of CDMA has been in use for quite sometime by the military for the different reason of security. Transmitted signal is difficult to decode by an intercepting party due to the spreading and the unknown spreading noise signal. It is known by the military to be a Low Probability of Intercept (LPI) and Low Probability of Detection (LPD) air interface scheme. Since late 1980s, CDMA has been mi- grating into civilian applications and is now reaching

maturity and impressive market penetration. Future wireless networks known as third and fourth generation wireless networks (based on where you are in the globe) are mostly based on CDMA .

**6. Explain the wireless network technology (11)**

Wireless technologies can be grouped into at least six major categories: (1) in- room, point to point infrared, (2) in-room radio, (3) in-building radio frequency, (4) campus or metropolitan area packet networks, (5) wide-area packet/circuit switched data networks, and (6) regional-area Satellite Data Networks. These six classes of networks have unique technologies which constrain the nature of the applications which can be supported by each of them. A similar taxonomy is provided in. Typically, an overlay of two or more network categories is used to provide continuous coverage in a mixed nomadic/mobile environment. Figure 2.2 shows an overlay of several network technologies. In the following subsections, we briefly summarize the characteristics and differences of these networks.

**In-room Infrared**

The in-room infrared class of networks generally has a network diameter of about 40–50m and supports bandwidths of about 1 Mbps. Applications supported by this type of infrastructure are limited to E-mail and collaborative- work applications due to the limited range of the system. The Infrared Data Association (IrDA) provides the most common standard used today for this network technology.

**In-room Radio Frequency**

The in-room radio frequency class of networks emerged in 1998 with the organized effort of the Bluetooth Special Interest Group. Bluetooth is a low-cost, short range radio that connects mobile PCs with other Bluetooth devices within a radius of about 10m. Very low energy consumption and about 1Mbps transmission speed makes this type of network attractive and suitable for inter-office device communication.

Hospital intensive care units, bank tellers, and desktop component inter connect may be example applications that could utilize in-room RF wireless technologies. The proliferation of portable devices such as 3COM's Palm Pilot, Windows-CE hand-held computers, and highly portable and powerful laptops such as the IBM Think Pads may incorporate Bluetooth transceivers to bridge the in-room wireless technology with fixed network infrastructures. The challenge laying ahead is to identify a suitable API for applications that will run a top this specific technology. Such API will allow for the design of ""infrastructure literate" applications that can accommodate the user expected performance levels while maintaining consistency across the infrastructure.

**In-building Radio Frequency**

This type of network, which is also known as Wireless LAN, expands the range of the infrared and the Bluetooth technologies by increasing the network diameter to about 200m. Unlike infrared and Bluetooth, in-building radio frequency is a cellular network, where mobile computers are allowed to roam within and across cells. Several standards are available today for this type of networks including the IEEE 802.11 and the Open-air interface.

Examples of Wireless LANs include Lucent/NCR WaveLAN and Proxim RangeLAN. Both ISA and PC Card interfaces are available with support or Windows and Linux. Proxim also provides additional support to a variety of Windows-CE devices. Wireless LANs can be used in both Infrastructure and Ad-Hoc Modes. In the former, Access Points are used and are connected to the fixed network through a dedicated router port. Wireless or nomadic devices with Wireless LAN interfaces access the network through the access point in the coverage area (cell). In this mode, the wireless LAN is used as a wireless extension of a fixed, high-speed network infrastructure (hence the name).

In the ad-hoc mode, several portable devices with wireless LAN interfaces are placed in the transmission range of each others. Each device is capable of communicating with any other device directly, without the help of any networking infrastructure. A private network is used to configure the network software (TCP/IP) among the ad-hoc group of devices. Ad-hoc networks is becoming increasingly important technology.

This technology, even though highly mature at this point in time, faces a few challenges. First, the IEEE 802.11 standard does not seem to be universally accepted (at least not yet). The OpenAir interface consortium, for instance, provides a competing proposal that is gaining popularity. Also, there is a lack of consensus on which air interface to use (direct sequence or the frequency hopping). Another challenge lies in the fact that wireless LANs are MAC-level networks that do not understand important features of IPv6 such as Multicast, RSVP, among other features. Unless, somehow, these features are implemented for wireless LANs, certain applications will be difficult to implement.

**Campus/Metropolitan Area Packet Networks**

This network type encompasses the more traditional “cellular” networking paradigm. It is typified by a “pole top infrastructure” supporting network diameters of 0.2 to 5 miles with data rates of 20-128 kbps. Relay (or router) nodes are strategically placed to support the wider network diameter with a small price for increased latency. For example, typical latency between a mo- bile device and the first relay node is about 40ms (assuming an uncongested network), and about 20ms between relay nodes.

**Wide-Area Packet/Circuit Switched Data Networks**

This network is comprised of a more familiar set of technologies and Regional Bell Operating Company (RBOC) services. One such offering is the Cellular Digital Packet Data (CDPD) service which is a packetized wireless transport that utilizes the unused channels of a cellular infrastructure. Motorola’s ARDIS and iDEN systems, Ericsson’s RAM (now called MobiTex), and the European GSM system are contained in this taxonomy. The iDEN network (Integrated Digital Enhanced Network) is a packet based voice/data network that uses the Mobile-IP networking protocol to route data packets.

Not only is this technology capable of supporting larger diameter networks, but they also tend to have lower bandwidths and higher latency effects than do the in-building networks. This tends to present a unique set of problems in application development. Significant body of research on network and system adaptation through infrastructure awareness components has been or is being conducted. However, the

transformation of this research into commercially available "mobility middleware" is yet to occur.

**Satellite Networks**

Satellite technology is still emerging. It is a downlink technology where mobile computers can only receive direct broadcast from a satellite. Outbound communication is initiated by the mobile computer through a modem DIAL-UP or other wireless technology. Hughes Network Systems pioneered the DirecPC net- work which uses the Galaxy satellite and which delivers 400 kbps downlink rate. DirecPC also transmits continuous streams of multimedia information ranging from CNN broadcasts, to news, sports, and financial news feeds. Other Low Earth Orbit (LEO) systems are in planning and deployment phases including the Internet in the Sky project.

**7. Explain mobility-bandwidth tradeoffs (5)**

Another classification of the current wireless networking technology can be based on the "degree of mobility" offered by these networks. Multi-cellular wireless infrastructures range from in-building cells, to micro-cells (urban coverage), to macro-cells (suburban coverage), to satellite (global coverage). In- building cellular offers the highest bandwidth (bi-directional), but very limited mobility. Micro-cellular offers lower bandwidth but allows for limited-speed mobility; macro-cellular offers much lower bandwidth but allows for the high- est degrees of mobility.

As can be noticed, in these networks, the larger the coverage area (the cell size), the higher the degree of mobility. Satellite net- works are an exception and do not follow this trend. They offer the highest downlink bandwidth (no uplink possible with satellite networks), but they do not offer any mobility. Instead, they require a satellite dish to be stationed aiming at the satellite. Figure 2.3 shows a mapping of the mobility/bandwidth classification onto individual wireless networking technologies. In this mapping, mobility is further classified into indoor and outdoor, with outdoor mobility ranging from stationary, walking (pedestrian pace), and vehicular speed.

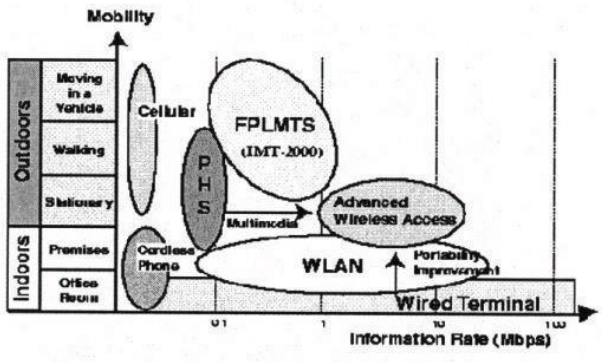



**Figure 2.3** Mobility-bandwidth tradeoffs

The current mapping of wireless technology to the mobility/bandwidth classification is bound to change. At least this is ITU's and ETSI's vision and expectation of the third and fourth generation networks. For example, wireless LANs (an in-building technology) is expected to evolve into a network that allows for limited-speed mobility. Also, macro-cell

networks are expected to improve on the bandwidth they offer. Figure 2.4 depicts this expected evolution.

## 8. Write about systems issues (6)

The rapid expansion of wireless Wide Area Network (WAN) services, wireless Local Area Networks (LANs), satellite services such as Hughes' Direct PC and the planned Low Earth Orbit (LEO) systems have created a large and fragmented wireless infrastructure. Given such a diverse set of technologies, the need to support mobile applications remains critical and even strategic to many industries.

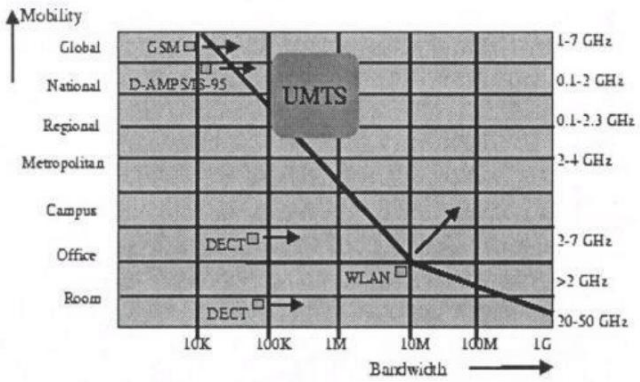



**Figure 2.4** Expected mobility/bandwidth tradeoffs in 3G and 4G networks

**Table 2.2** Application classes with examples

| Application Class | Example Applications |
|---|---|
| Interactive Video | Video Conferencing, Distance Learning, etc. |
| Interactive Audio | Telephone, Digitized Voice over the Internet |
| Interactive Text/Data | Transaction Management, Credit Verification |
| Interactive Image | Teleconferencing, Collaborative Workgroups |
| Video Messaging | Multimedia E-mail |
| Audio Messaging | Voice Mail |
| Text/Data Messaging | E-mail, Telex, FAX |
| Image Messaging | High-Resolution FAX |
| Video Distribution | Television, VOD, PPV |
| Audio Distribution | Radio, Audio Feed, etc. |
| Text Distribution | News Feed, Netnews |
| Image Distribution | Weather Satellite Pictures |
| Video Retrieval | VOD |
| Audio Retrieval | Audio Library |
| Text/Data Retrieval | File Transfer |
| Image Retrieval | Library Browsing |
| Aggregate LAN | LAN Interconnection or Emulation |
| Remote Terminal | Tele–commuting, Telnet |
| Remote Procedure Call | Distributed Simulation |

**Table 2.3** Wideband CDMA Standard

| | |
|---|---|
| Frequency band | 2 GHz |
| Carrier bandwidth | 5 MHz |
| Chip rate | 5,115 Mcps |
| Frame length | 10 ms |
| Voice | 0.4-16 kbps |
| Video | 128 kbps |
| Packet data | up to 128 kbps |

The ability to scale performance and latency while accommodating an increasing user density is of paramount importance when designing and/or selecting a wireless infrastructure for a particular application. The choice of a wireless infrastructure must take into consideration the attributes of the application and the applications class of service requirements including bandwidth, network latency, service coverage, and general performance issues. Table 2.2 summarizes application classes as stringently defined by ITU-T Recommendation. These classifications have some loose definitions. For example, "interactive" usually means conversational, implying a person on either end of the application connection.

The term "messaging" generally refers to a person talking to a machine. An example would include leaving voice mail or sending a FAX. The term " retrieval" is generally thought of as a machine transferring information to a person. Also, the term "distribution" is typically thought of as a machine sending to people or machines who listen passively. The Client/Server architecture is a primary example of this application class. Application updates may include human intervention, but could be automated. The last five application classes listed in Table 2.2 are considered machine-to-machine interactions, al- though they may have to be "user" activated, while the actual transaction is between machines.

**Multimedia Applications**

As of today, there are limitations which prevent the effective exploitation of wireless networks by portable information appliances beyond the area of voice communications, text messaging, and limited data. While it is technically possible to transmit multimedia information such as a motion video clip from the internet into a portable wireless device, the standards, infrastructure bandwidth limitations, service costs, data compression technology, and power consumption considerations make this impractical at this time (1999). This limitations can be attributed to existing standards, which are limited in the level of service they can provide to the user of a portable information appliance. While they are effective for voice and text messaging, these standards do not support graphics intensive internet browsing or real time video at a high enough speed to make them practical.

In the case of video, the MPEG 1 standard provides for 352 X 240 pixel resolution, comparable to VCR quality video, and requires 1.14 Mbps data rate. This is well beyond any of the deployed wireless network standards. Today, consumer expectation is set by MPEG 2, which supports high resolution video of 1920 X 1080 pixels, which requires up to 80 Mbps of bandwidth (typical applications of this standard, however, may only require 6 to 8 Mbps).

To achieve wireless motion video data rates for portable devices, new wireless infrastructure standards will have to be deployed. One such standard is the Wideband CDMA approach proposed by Ericsson has the specifications shown in Table 2.3.

This standard has been adopted by the European community for the next generation of cellular service and could be implemented globally by 2002. The motion video quality enabled by such a service would, however, be less than MPEG 1 in terms of resolution and/or frame rate.

**9.Write in detail about portable information appliances historical evolution (11)**

The first portable information appliance was probably a piece of stone or clay with markings on it, used to record numeric information. This information was probably very important to the user of this appliance and in some way directly affected his livelihood. It may have actually provided the "function" of counting by allowing the user to create a mark corresponding to a piece of livestock. This would have been very useful to an individual whose society had not yet invented a system of numbers. Given the lifestyle of such an individual, ease of use, portability, durability, and reliability were all essential. Ease of use probably meant that the individual marks had to be deep enough in the appliance so as to be detectable by touching.

This would have been necessitated by the need to count goats in a heads-up mode while incrementing through the marks with the thumb. Once utilized, this appliance would have to be stowed in an extremely portable fashion so that it did not interfere with other activities such as attempting to frighten away predators, throwing sharpened sticks at predators and most importantly, running away from predators. Durability would have been important since the user did not have the means to protect the device from temperature variations, moisture, abrasion, and shock. To the user, this device may have played a very important role in establishing his credibility, accountability, and responsibility with respect to the rest of his community.

As the technology of mathematics and writing developed, human civilization progressed onward to the papyrus scroll (Figure 3.1) and ink pen. This appliance was highly portable and could convey very complex information. The user interface took a while to learn (reading and writing), and until relatively recently, only a limited number of individuals were able to use the technology. Still pen and paper persisted for several thousand years and is still the preferred portable information technology for most of the worlds population.

Two other portable information appliances, the pocket watch and the printed book (Figures 3.2 and 3.3) are relatively recent inventions which have transformed human society. The pocket watch enabled the level of logistical synchronization between individuals required for industrialization. Printed books, while not as interactive as paper and pencil, have also evolved as the preferred method for accessing standardized information in a portable format. Thus, paper and pencil, the printed book, and the pocket watch have been the dominant portable information appliances since the dawn of the industrial revolution.

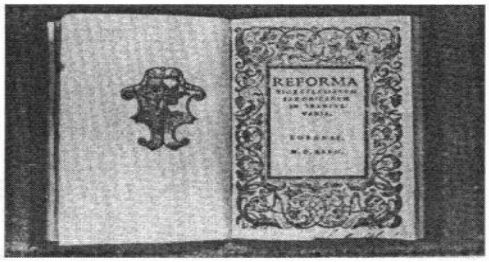



**Figure 3.3** Printed book

The invention of the semiconductor technology in the Early 1960s began a transformation in portable information appliances, the full impact of which has yet to be realized. The first widely adopted electronic portable information appliance appeared in the early 1970s in the form of electronic calculators. Development work on these products began in the mid 60s and these designs exploited state of the art discrete transistor technology. By late 1960s, however, companies such as Texas Instruments, Rockwell and Intel had identified handheld calculators as a way to grow the market for Integrated Circuit technology. In 1970 there were several bulky hand-held calculators on the market at price points of around $300 and above.

By 1975, calculators had shrunk to pocket size and had fallen below the $20 price point. The age of portable electronic devices, enabled by the integrated circuit, was upon us. About this time, digital watches also began to replace mechanical watches which had been in place for hundreds of years.

By the early 1980s portable video camcorders had sold over 1 million units worldwide and penetration of portable electronics to the consumer had begun in earnest. This rapid penetration was driven by the compelling application of acquiring and storing motion video images. This trend was further accelerated by the introduction of 8mm format models which were highly miniaturized.

Personal organizers, such as the Sharp Wizard, were also introduced in this time frame and were most successful in Japan, where the use of personal computers was somewhat lagging that of North America. In North America, they were popular among technophiles but in general, these products tended to be a disappointment to individuals that had experienced desktop computing and found little compatibility between organizers and desktops.

Cellular phones have seen remarkable penetration worldwide . By the late1980s over 10 million units had been s old worldwide and the cell phone became a necessity for many and a status symbol for many others.

By the early 1990s, over one million Notebook computers had been sold world- wide as these products demonstrated their usefulness by turning spreadsheets and word processing into portable capabilities. Early models, in the late 1980s, from companies like Toshiba and Compaq, featured Monochromatic reflective LCDs. These systems were quite

adequate for word processing and spread- sheets and were quickly adopted by traveling professionals. Transfer of data in and out of the notebook was achieved through magnetic disk. Prices remained relatively high ($2,000 +) due to two factors. First of all, manufacturers want to maintain high margins so the focus of the Notebook industry was on saturation of the business market, in effect, competing with desktop products. The second factor was the desire on the part of the user

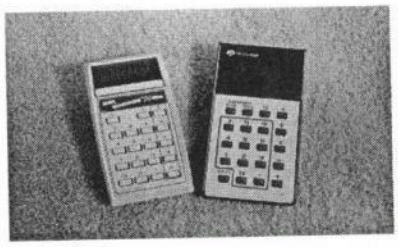


**Figure 3.4** An early calculator

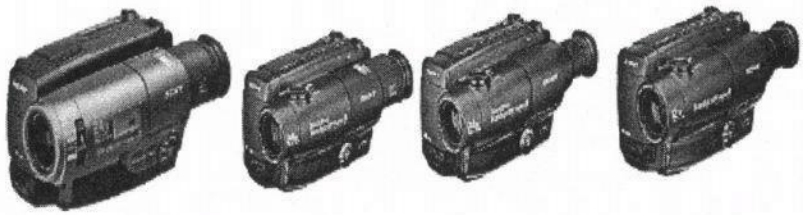


**Figure 3.5** Portable video cameras (camcorders)

to have high performance which matched as nearly as possible that of a desktop system.

By the early to mid 1990s, several manufacturers were experimenting with the Personal Digital Assistant (PDA) product concept. These products attempted to span a gap between the personal organizer products and the notebook computer products. These products tended to compromise the miniaturization of organizers and lacked the full functionality of notebooks. Furthermore, they were typically crippled with an over sold and poorly performing handwriting recognition capability.

Most importantly, these early products tended to compete with, rather than complement the desktop or notebook computer. Several manufacturers attempted to add wireless communications to their PDA products to make them more appealing. Still, the lack of integration with the desktop PC and the bandwidth limitations of the wireless telecommunications infrastructure caused these products to fail. The telecommunications infrastructure in the mid 1990s offered only wire line and cellular modem capabilities with fairly low bandwidth (about 14.4 Kbs) for portable products.

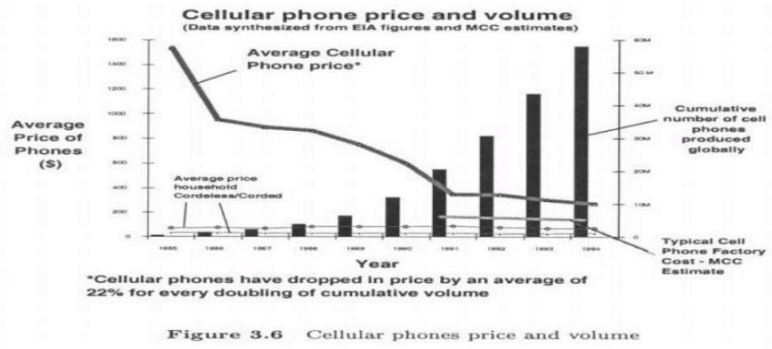



Figure 3.6 Cellular phones price and volume

**10. Write about the advent of the PDA (11)**

PDAs burst onto the scene in 1993 and mounted a headlong assault into the commercial market-place only to be quickly repulsed. When the initial exuberance subsided, the resulting carnage throughout the industry was both severe and widespread. Now, with forces re-marshaled and armed with a new generation of products, this same industry is attempting another assault, this time targeting the application specific vertical marketplace.

PDAs emerged in 1993 amid claims of single-point data organization, ubiquitous and instantaneous communications, and new operating paradigms using glitzy graphical user interfaces (GUI) and handwriting recognition. Most if not all of these claims fell short of consumer expectations. The reasons, while obvious in hindsight, lay hidden at the time. They were: high customer expectations, immature applications, and incompatible and unrealized infrastructures.

By 1993, the PC industry had introduced its most recent line of laptop computers which included computational and storage capacities that rivaled their most powerful desktop companions, even though computational and storage capacity had been doubling every 12 months in recent years. Grazing on these fertile fields had fattened the software industry and had bred a generation of software developers with inefficient development skills and tools. This in turn lead to unwieldy applications whose weaknesses were masked only by the raw computational and storage capacities of the hardware they ran on.

The result was that few wiry developers, and even fewer wiry applications existed that were capable of operating in the computational, power and storage barren environment of the PDA. Coincidentally, when the first PDAs appeared practically none were supported by third party software and embedded applications beyond the basic notepad, calendar, and calculator were virtually nonexistent.

Early on it was clear the success of the PDA rested heavily upon a variety of component and service infrastructures with the most critical of these enablers being wireless communications. In 1993, riding a sustained boom of 40% growth per year and giddy about recent cooperative initiatives, the cellular service providers boasted claims of a complete domestic wireless data infrastructure (CDPD) by the end of 1994. This effort, seemingly coordinated in its announcement, was enthusiastically received by the PDA industry but within a year the initiative would stall and lose much of its support. The breakdown came in

the radio module that provides the link between the PDA and the wireless network. Initially predicted to be PCMCIA sized, it was soon realized that the requisite data radios would be both larger and more power hungry that anyone predicted. When they emerged, larger than some of the PDAs they were supposed to support, both industries recoiled under the letdown.

As if this was not enough, the whole industry was elevated to a high state of excitement, by a barrage of hype filled announcements, using phrases like *"Imagine if"* and *"Have you ever ... you will".* Every technology announcement from new processor architectures to handwriting recognition techniques added fuel to the flames. Claims like *"desktop performance in your palm", "time saving user interfaces", "ubiquitous communications", "transportable applications", "laptop functionality",* and more were touted loud and long. Market analysts and prognosticators joined in the frenzy, seemingly unable to separate future dreams from first article hardware.

As such, market expectations were set high, and high they stayed, as one product after another fell short and slammed into the reality wall. In fact, the ring of these claims still echoed in the ears of customers as they tried to use products that were expensive, bulky, fragile, unsupported, incompatible, uncooperative and unstable.

To make matters worse, costs were high and sales were low. The average price for a PDA in 1993 exceeded $750, some like the AT&T EO had prices that went as high as $2000– well outside the reach of many of the target customers. Consequently, in the first two years there were just 350,000 units sold. The volumes were so low in fact, that unlike most consumer electronics, they never crested the cost-experience wave which along with competition has the unrelenting ability to drive prices asymptotically toward the cost of the raw materials.

There were other problems as well with this initial surge of PDAs, but they served only to add to the mass confusion. The industry backlash, however, was both clear and severe. With hundreds of millions of dollars invested, two of the major players (AT&T EO, and IBM Simon) dropped out completely. The others fell back and re-grouped trying to understand what went wrong. What went wrong was equally as clear. Consumers were demanding usefulness and the first round of PDAs with limited applications and practically no communications simply did not fit the bill. Only a small percentage of the devices sold were ever really used. The vast majority were simply discarded amid the disappointment and frustration of the once excited user.

Today, the landscape has changed significantly. Unlike the excitement of the past, PDAs are now met with suspicion and skepticism. Regardless, a new battalion of products is moving into the fray. This time, however, there is an attempt to reduce the type, and in some cases manufacturers are trying to distance themselves from the past by avoiding the name PDA altogether, choosing instead names like pocket organizer and personal information manager (PIM).

Despite the reduction in hype, demands on and customer expectations of the PDA have continued to rise. One reason for this is that the laptop computer performance has continued to double every year. This, along with even higher resolution displays, improved

ergonomics increased multimedia functions and more powerful applications has helped set a new standard for PDAs to meet. While PDAs have made progress in their operating systems, applications and third party support, they still fall woefully short of customer expectations.

Meanwhile, internet usage has erupted. Reliance on data stored in the myriad of html web sites, not to mention email services, has made wide area communications even more critical to the PDA paradigm than ever. Unfortunately, however, 18 months after ubiquitous wireless data services were promised by the cellular carriers, CDPD is in serious trouble. Southwestern Bell and Air touch have essentially stopped their CDPD deployment, leaving major holes like Los Angles, New Orleans and Atlanta in domestic coverage. This lack of clarity in the wireless infrastructure has caused confusion throughout the industry and continues to threaten the viability of the PDA.

This problem is compounded by the fact that the PDA manufacturers seem to rely on third parties to supply wireless modules for their products. This architectural approach results in a variety of inefficiencies and is due to a lack of expertise in wireless implementation. The integration of digital and RF circuitry at the semiconductor level will solve this problem in the future, but today, vendors that do not excel in both computing and communications design suffer a handicap.

Not surprisingly, a detailed look at the current offering of PDAs reveals that they are an outgrowth of PC concepts, utilizing the same worldwide components and manufacturing infrastructure that has been optimized to support desktop and laptop products. The silicon integration, displays, component size, software applications and substrate densities of this infrastructure has driven the PDA into one of 2 directions: either toward a fully functional product that is too large to be practical or toward a product that meets the ergonomics requirements of the paradigm, but that severely limits functionality and performance to fit.

The result is that while the average price of the new PDAs has dropped to $575.00, not much else has changed. Still starved for applications this new generation will not likely outsell its predecessors in the consumer marketplace, even though many industry projections say otherwise. Almost in recognition of this fact the strategists now say that the vertical market is the new focus of their attention but this is no panacea. The demands of the vertical market are many times more stringent than that of the consumer market and the procurement motivation is much less of an impulse. What is worse, the entrenched competitors like Symbol, Norand, and Telxon understand the operating environment and applications of the vertical market better, and will prove tenacious in their desire to maintain market share.

Prom the Early 1960s through the Mid 1990s, the advances in portable information appliances were impressive. Within the confines of a portable notebook, continuously increasing levels of computing power and display quality had been achieved. Ubiquitous, wireless voice communications via cellular phone had be- come common place. Consumers recorded hundreds of millions of hours of video data every year using hand-held camcorders. These products drove the development of important technologies. Silicon integration evolved from discrete transistor devices to single chips containing over 6 million

transistors. Portable displays had evolved from simple numeric segment displays with less than 100 pixel elements into full color displays with over half a million pixels. Electronic and mechanical packaging technology was capable of connecting thousands of components in a compact volume compared to only a few tens of parts at the start of this period. Batteries in the early 60s could store no more than 100 watt-hours per litre. Their capacity today is up to 200 watt-hours per litre.

For all of these advances in hardware technology, however, many of these portable information appliances still seemed as static as the printed book. If they were connected to the outside world at all, it was through a low band- width wireless voice channel which was often unreliable for data transfer. Furthermore, the Internet appeared and created heightened expectations about information access. Without mobile access to the growing global information network, these portable devices would not live up to their

**11. Explain the following in Detail. (UQ April'13)**

**(a)Explain palmtop computers (5)**

**(b) Hand-held computers (6)**

It is likely that wireless network connectivity will trail wired connectivity in terms of performance for the foreseeable future. The best strategy for the developers of portable information appliance is to design products which either provide useful standalone functions such as an electronic still camera, or which complement wired network platforms. The emerging market of Palmtop Computers is a breakthrough in terms of the ability of the Palmtop to complement the desktop computer.

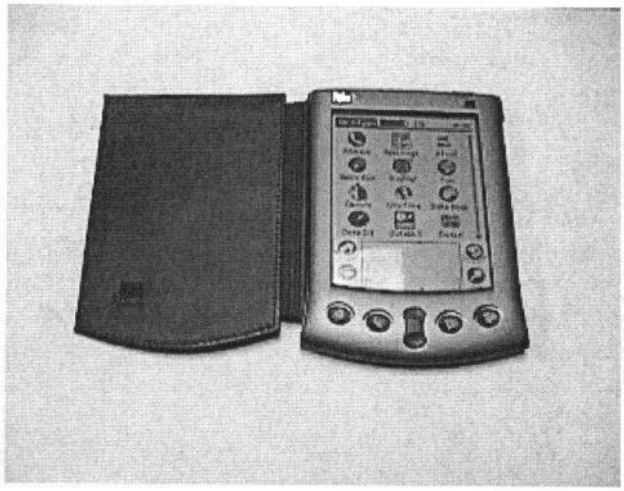


**Figure 3.7** The Palm Pilot V

**The Palm Pilot**

The Pilot is a highly portable appliance which is the first truly viable substitute for traditional pencil and paper technology. With desktop synchronization, this device allows the desktop user to augment the networked desktop computing experience with a portable time management interface. While the Pilot is unlikely to provide services like high quality real-

time video in the near future, this product concept has made important inroads into sensibly merging the interactions of portable and stationary information appliances.

Many other contemporary product designers have failed to take this approach by attempting to combine and therefore replace other devices. One example would be a smart phone that combines the functions of a cellular phone and a notebook computer. Such product concepts often end-up compromising the features which make the individual products appealing. For instance, may smart phones have poor display quality, unusable keypads, poor battery life, poor performance, and are much bulkier than most cellular phones. The result is a product that does not effectively replace either of the products that it is competing with.

**Hand-held computers**

The hand-held computer is another device that attempts to complement the desktop. It is much more capable than a Palm Computer, larger in size and weight, but can not be fitted in a pocket. Since their first emergence, hand-held computers have been competing with the Palm Computer market.

**Table 3.1** The Palm Pilot V Specification

| Item | Specifications |
|---|---|
| Size | 4.7" x 3.2" x 0.4" (L x H x W) |
| Weight | 4.0 oz. (including batteries) |
| Storage Capacity | 2MB: 6000 addresses, 3000 appointments (approx. 5 years), 1500 to do items, 1500 memos, and 200 email messages. |
| Battery life | 4-12 weeks (based on use) on 2 AAA batteries |
| Connectivity | RS-232C 9-Pin connector and 25-pin adapter; IR port; TCP/IP ready |
| Operating System | Palm OS |
| Applications | Date Book, Address Book, Mail, To Do List, Memo Pad, Expense, Calculator, Security, Games, HotSync, Others |


Figure 3.8 Sharp Power Zaurus hand-held computer

**Sharp Power Zaurus**

**Table 3.2** Sharp Power Zaurus specification

| Item | Specifications |
|---|---|
| Processor | MIPS RISC Processor |
| Memory | 16MB (ROM Upgradeable) |
| Display | 6.5 High-Contrast Color LCD Touch Screen with Backlight (viewable area measured diagonally) |
| Colors | 256 |
| Resolution | 640 x 240 |
| Contrast control | Keyboard |
| Keyboard | 64 Keys + 7 One Touch Application Keys |
| PC Card | one Type II slot |
| Audio | WAV file compatible with microphone, speaker, and external record button |
| Expansion Ports | Serial Port, PC Link, Printing |
| IR Port | IrDA 1.1 (115.2 kbps)compliant |
| Dimensions (w x d x h) | 7.3 x 3.7 x 1.2 (186mm x 95mm x 29.6mm) |
| Weight | 17.3 oz (490g) |
| Operating system | Windows CE |

The Sharp Power Zaurus is a popular hand-held computer that competes with the Palm Computer market. The Zaurus which is depicted in Figure 3.8 is best described in terms of its specifications listed in Table 3.2.

**Figure 3.9** The VADEM Clio tablet hand-held PC

**Table 3.3** VADEM Clio specification

| Item | Specifications |
|---|---|
| Processor | MIPS 4000 |
| Storage | 24MB ROM, 16MB RAM |
| Display | 9.4" 640X480, 256 color |
| Operating System | Windows CE 2.1 |
| Connectivity | IR port and built-in 33.6 kbps modem |
| I/O | keyboard, pen, and Type II PC card |

**VADEM Clio**

Clio is a Windows CE based hand-held PC with a swing-top design that pro- vides three modes of interaction: keyboard, pen and tablet, and presentation modes. The three modes are achieved by swinging and/or folding the display around the keyboard base. The specifications of the Clio, which is shown in Figure 3.9 are listed in Table 3.3.

## 13. Explain communicators (11)

The Communicator is a PDA concept that combines the benefits, portability and functionality of digital cellular phones and palmtop computers. The idea is to stick a palmtop computer to a cell phone with data capabilities to provide remote access, in addition to the stand-alone form factor applications that can be found on palmtop computers. Internet access, telnet, email, and web browsing are all applications offered by communicators.

**Table 3.4** The Nokia 9000 Specifications

| Item | Specifications |
|---|---|
| Memory | 8MB total: 4MB OS and applications,<br>2MB program execution,<br>2MB user data storage |
| Processor | embedded INTEL 386 processor |
| Operating System | GeOS TM3.0 |
| E-mail protocols | SMTP, IMAP4, POP3 and MIME1 |
| Weight | 397g |
| Dimensions | 173 x 64 x 38 mm |
| Displays | Grayscale 640x200 (illuminated) LCD |

### Nokia 9000

The Nokia 9000 is the most popular communicator, not only because of its appearance in the hands of Agent 007 in one of his recent movies (1997), but because of the unprecedented unique features and capabilities. The Nokia 9000 combined a compact personal organizer with Internet access and a versatile voice and text messaging system. The organizer includes: an address book, note editor, calendar with to-do list, calculator, and world clock.

A built-in browser, Telnet, and a VT100 Terminal emulation are built-in applications that bring the Internet to the mobile user anywhere GSM coverage is available. A multi-protocol email client, Short Message System (SMS) and a Fax application are also bundled to provide a wide spectrum of communication alternative, of course, in addition to the digital voice phone interface.

The specifications of the Nokia 9000 are listed in Table 3.4. Figure 3.10 depicts two pictures of the communicator. The picture to the right shows the communicator on a recharge base station and reveals the cell phone side of the device. The picture to the left shows an open communicator with a Web page on the backlit display.

Figure 3.10 Nokia 9000i Communicator

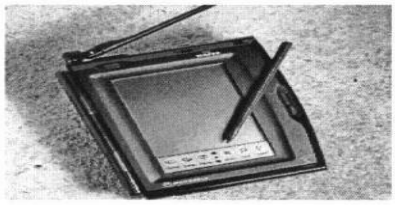


Figure 3.11 Motorola Marco hand-held computer

**Motorola Marco**

The Marco wireless communicator was introduced to the market one year be-fore the Nokia 9000 communicator (in 1995). It featured a built-in two-way wireless packet data modem allowing users to send and receive messages. The Marco Wireless Communicator, depicted in Figure 3.11, also included a fax and data modem, allowing information to be communicated through any telephone network. To augment its functionality, the Marco was equipped with two PCMCIA Type II slots to allow users to simultaneously operate third- party software applications and add memory to store more data. The Marco

Figure 3.12 Motorola Envoy hand-held computer

weighs 1.8 pounds and is 7.5 inches high, 5.8 inches wide, and 1.4 inches deep. The device features a bright portrait screen that allows easy reading in many lighting conditions.

At the time the Marco was introduced, Motorola had the vision of creating the first "wireless Newton". Newton OS 1.3 was therefore used. A similar product based on the Magic Cap operating system (from General Magic) was introduced in parallel. That was the Envoy depicted in Figure 3.12.

Unfortunately, the Apple Newton did not make it and despite all the software and personal information management tools loaded in the Marco, Motorola had only sold several thousand units before the device production was discontinued.

**14.Write about sub-notebooks (micro-notebooks) (6)**

As mobile users continue to demand lightweight, long battery life, and rugged portable computers, advances have been made in a number of diverse product concepts including what is now known as higher performance "micro- notebooks", or sub-notebooks.

Table 3.5 shows the specifications of the Sony PCG-707C sub-notebook that is depicted in Figure 3.13.

**Table 3.5** Sony PCG-707C Sub-Notebook Specifications

| Item | Specifications |
|---|---|
| CPU | 233MHz Pentium Processor with MMX Technology and 256KB L2 cache |
| Memory | 64MB EDO RAM standard |
| Hard drive | 3.2GB, 2.5" (6.35 cm) disk |
| FDD | External with port replicator |
| Pointing device | Glide pad |
| PCMCIA card slot | Type II slot x 1, CardBus support |
| I/O ports | USB, VGA monitor, FDD, ASK and IrDA, PS/2, Modem (North America only), Mic-in, Audio |
| Dimensions | (W x D x H) 10.2" x 8.3" x 0.83" |
| Weight | 1.40 kg (3.09 lbs) |
| Power supply | Li-ion battery pack (approx. 2.5 hours)<br>With optional add-on battery (approx. 8.5 hours)<br>Universal AC adaptor (100-240V AC, 50/60Hz) |

**Figure 3.14** HP Soujourn notebook

**NOTEBOOKS**

The notebook computer has enjoyed great success as the portable extension of the desktop computing environment. Notebooks are now starting to replace desktops for many users. Today the notebook market provides a most wanted portability by an increasing majority of users. We provide one example of notebooks which is the HP Soujourn. It weighs 3.2 pounds and is less than 0.71in thick. It uses an Intel Tillamook 233-MHz processor and comes with a 2.1 GB hard disk and a 64 MB of memory. Its display is limited though to only 12.1in SVGA. The HP Soujourn is shown in Figure 3.14.

**15.Write about laptops (6)**

Laptops are designed to replace the desktop. They can also be envisioned as nomadic desktops that can be easily moved from one place to another. The users of laptops require high performance, large high quality displays, and occasional portability. Such laptops may have maximum capabilities (as of 1999) such as up to 15.0in Color TFT (1024x768), integrated AC adapter, two battery support, up to 14GB disk storage, and 256MB memory. These capabilities come at the price of limited portability with these laptops weighing up to 8 Ibs.

**Figure 3.15** Fujitsu Lifebook 900 laptop

**Table 3.6** Fujitsu Lifebook 900

| Item | Specifications |
|---|---|
| Model Number | 985TX |
| Processor | Intel Pentium 233MHz with MMX Technology |
| System Memory | 32 Megabyte SDRAM (included), Up to 160 Meg |
| System Cache | 512k L2 Cache |
| Bus Architecture | PCI/CardBus |
| Display | 13.3in LCD TFT Active Matrix Color |
| Video Memory | 4 Megabytes SGRAM EDO |
| Maximum Resolution | 1024 x 768/16M |
| Video | MPEG I/MPEG II |
| Zoomed Video | 3D Graphics |
| TV Out | 1280 x 1024/256 (External Monitor) |
| Hard Drive | 5GB EIDE (Formated Size) |
| Floppy Drive | 1.44 Meg Removable |

It have only provide only one example of a laptop since almost all mobile users are familiar with laptops and their capabilities. The specifications of the Fujitsu Life book 900 laptop is summarized in Table 3.6. The laptop is depicted in Figure 3.15.


**Figure 3.16** HP capture, store, communicate device

**16.Write about other information appliances (5)**

HP CapShare

HP's Capshare 910 is a hand-held portable device that allows mobile users to capture, store, communicate and print documents, The 5.5L x 4.1H x 1.5W (inches) device shown in Figure 3.16 weighs 12.5 oz and uses two AA NiMH rechargeable batteries that last for 100 document capture followed by a down- load. Typically, a mobile user capture documents from a newspaper or a magazine and then stores the document into

his laptop or other portable device. Both PDF and TIFF formats are supported. The device has 4MB of memory and can capture from business cards and small receipts up to legal-size documents or 25in. newspaper columns. Maximum capture area of 119 square inches. A standard letter-size page takes about 6 seconds to capture.


**Figure 3.17** First in-dash PDA

**Clarion AutoPC**

The Clarion AutoPC (depicted in Figure 3.17) is the first in-dash personal digital assistant. It integrates cellular telephony, Internet email, navigation software, GPS satellite tracking, contacts information and calendar, real-time information feeds (e.g. stock quotes and traffic information) in a single device. Hands-free interaction is possible through a speech recognition interface.