Mobile Computing

UNIT III:

Mobile Computing Through Telephony: Evaluation of telephony – Multiple access procedures – Satellite Communication Systems-Mobile computing through telephone – Developing an IVR Application – Voice XML – Telephony application Programming Interface. Emerging Technologies: Introduction- Bluetooth – Radio Frequency Identification– Wireless Broadband– Mobile IP – Internet Protocol Version6 – Java Card.

TEXT BOOK

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EVOLUTION OF TELEPHONY

- In 1876, Alexandra Graham Bell developed first telephone system with two way voice communication
- In earlier days each telephone was connected to a central place (Exchange) and from this exchange, the operator would manually connect the call to another subscriber
- The operator will make the calculations for billing and charging
- To make a call to someone outside our local exchange, the operator at our exchange would call an operator at the adjacent exchange and so on
- The first version of automatic exchange was installed in 1892 in US
- In 1960, the first Electronic Switching System (ESS) was developed in US
- In 1965, the first commercial electric central office was put into operation
- In 1976, Bell Labs developed the 4ESS digital toll switch for long distance voice network

Pulse Code Modulation

- PCM is a digitization or modulation technique used to convert analog signal to digital signal
- To encode an analog signal to digital form, the analog signal is sampled at twice its frequency
- The audio voice band frequency is 0 – 4000 Hz
- We take a snapshot of the voice signal's amplitude at $1/8000^{th}$ of a second
- This sample is converted to a number represented by 8 bits
- This type of digitization is called Pulse Code Modulation (PCM)

Public Switched Telephone Network (PSTN)

- A normal telephone system is called PSTN
- The nodes in PSTN can be subdivided into three categories:
    1) Local exchanges (end office) – connecting individual subscribers
    2) Transit exchanges – switch traffic between different geographical areas
    3) International exchanges – switch traffic to telecommunication networks in foreign countries and other networks
- A physical wire (local loop) is laid from the local exchange to the subscriber's telephone
- In case of wireless local loop the communication is managed with radio waves

Multiple Access Procedures (Multiplexing Techniques)

- In a wireless network, the radio channel is shared by multiple subscribers
- To avoid collision, each subscriber should be assigned a dedicated channel
- This is achieved by using different multiplexing techniques:

1) Frequency Division Multiple Access (FDMA) – The available frequency band is divided into channels of equal bandwidth so that each user gets a different frequency. Used in 1G analog transmission

2) Time Division Multiple Access (TDMA) – several users share the same frequency channel of higher bandwidth by dividing it into different time slots. Users transmit their data using their own respective time slot in rapid succession. Used in digital transmission

Different types of TDMA are:

i) Fixed TDMA – The time slot is fixed and static. If a user does not transmit during the timeslot, then the bandwidth is wasted

ii) Dynamic TDMA – Also called Dynamic Reservation TDMA. A scheduling algorithm is used to dynamically allot a variable number of time slots based on the traffic

iii) Packet Reservation Multiple Access (PRMA) – A user can reserve a time slot in advance. Two types of PRMA are:

Multiple Access Procedures (Multiplexing Techniques) contd.

a) Dynamic PRMA (DPRMA) – Each mobile station is responsible for making a reasonable estimate of its bandwidth requirements and then request for resource allocation to the base station

b) PRMA Hindering States – Allows a terminal to transmit during the time interval needed to receive the outcome of a reservation attempt

3) Code Division Multiple Access (CDMA) – It is a broadband system. Each subscriber uses the whole system bandwidth with an assigned code called chip. All subscribers in a cell use the same frequency simultaneously

4) Space Division Multiple Access (SDMA) – used in satellite communication

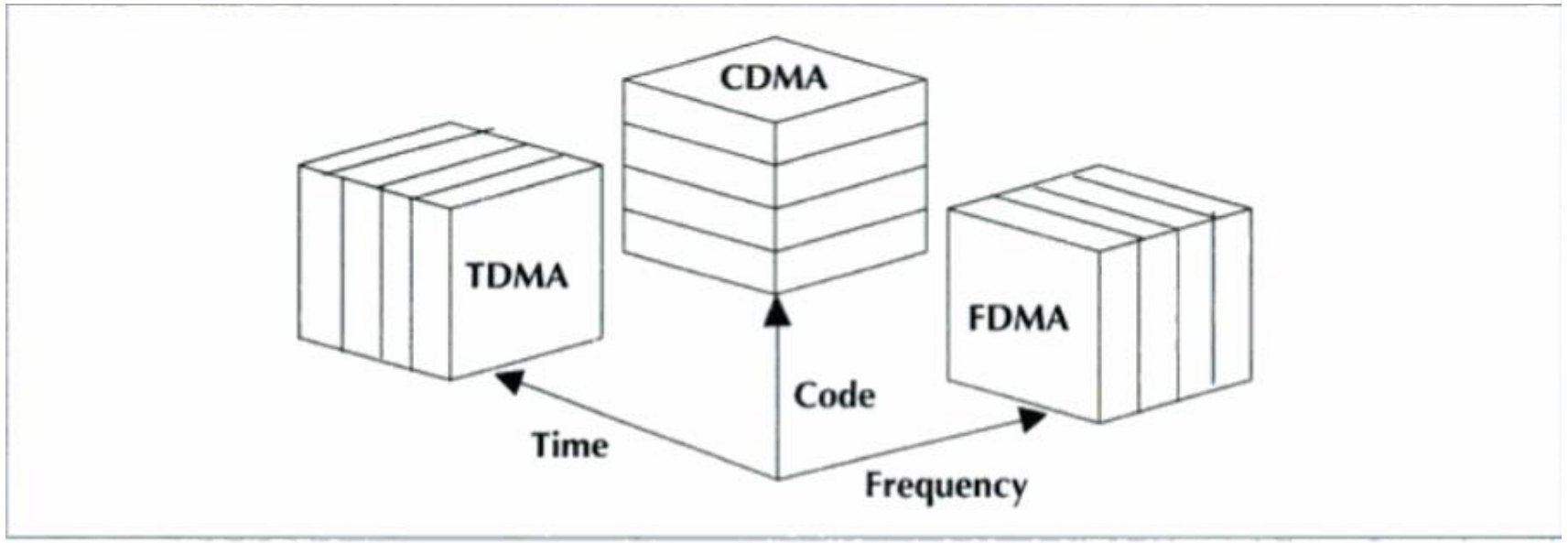


Figure 3.1 Multiple access procedures

Satellite Communication Systems

- In 1957, USSR sent the first artificial satellite Sputnik
- Four months later, US sent Explorer 1
- In 1960, US launched the first communication satellite Echo1 to reflect radio and TV signals
- Every communications satellite involves the transmission of information from an originating ground station to the satellite (uplink) followed by a retransmission with amplification of the information from the satellite back to the ground (downlink)
- The satellite must have a receiver with receive antennas and a transmitter with transmit antennas.
- The electrical power is through solar energy
- Downlink may be multicast to a select number of ground stations or broadcast to everyone
- Different types of Satellites are:

1) Low Earth Orbit (LEO) Satellite – 400 kms above the earth's surface and time period is 90 mins. Advantage is, it is less expensive as it does not need high power rockets to launch
2) Medium Earth Orbit (MEO) Satellite – Also called Intermediate Circular Orbit (ICO). 2000 kms to 35,786 kms above earth's surface and time period is 2 to 24 hrs
3) Geostationary Satellites – Above 35,786 kms. Requires high power rockets

Satellite Communication Systems (contd.)

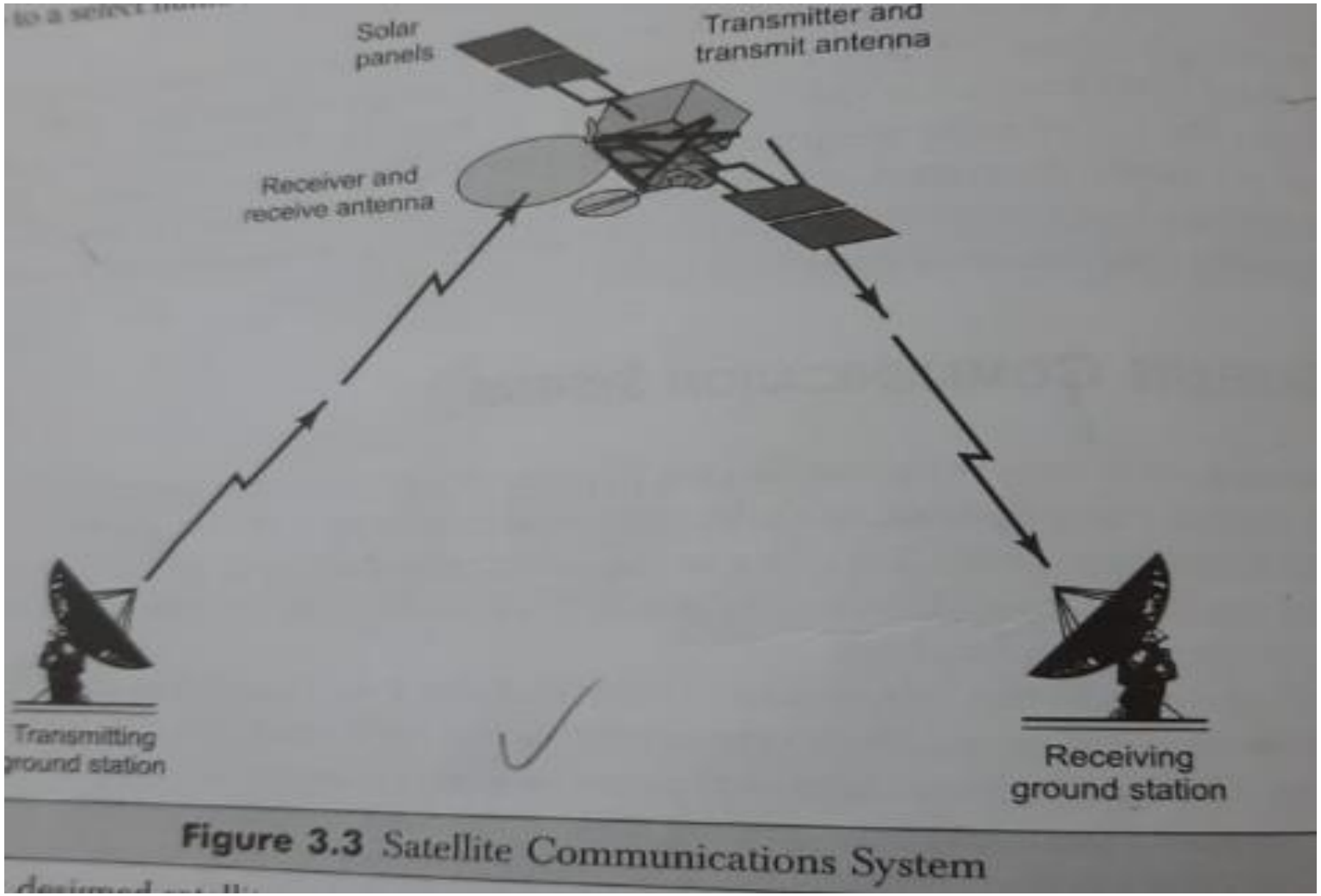


Figure 3.3 Satellite Communications System

Satellite Phones

- Initially satellite communication was used for TV transmission
- When mobile phones were invented, some companies made satellite phones that will connect a subscriber directly through the satellite
- Examples of such companies are:

    1) Iridium – provides voice and data communication satellite phones over the earth using 66 LEO satellites

    2) Globalstar – provides voice and data services using 52 LEO satellites

    3) Thuraya – mainly services Asia and Africa using 3 geostationary satellites

Mobile Computing Through Telephone IVR Architecture

- Earlier, mobile computing applications and services were accessed through voice interface
- This technology was called Computer Telephony Interface (CTI)
- Input to this system is a telephone keyboard and output is a synthesized voice
- Previously, service numbers were used for this and the user was charged for the call
- Nowadays, toll free number is given where the charge is borne by the company
- For voice interfaces, Interactive Voice Response (IVR) is used
- Other terms for IVR are Voice Response Unit (VRU), Computer Telephony (CT), Computer Telephony Interface or Computer Telephony Integration (CTI)

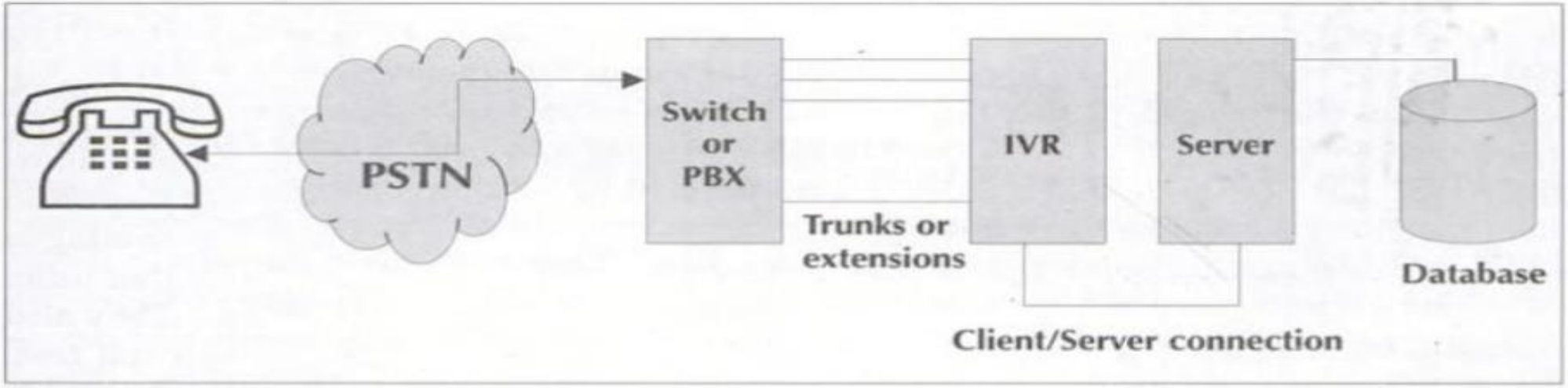


Figure 3.2 The IVR architecture

Mobile Computing Through Telephone – IVR Architecture (contd.)

- IVR works as the gateway between a voice based telephone system and a computer system
- When a caller dials the IVR number, a ring tone is received by the voice card within the IVR
- The voice card answers the call and establishes a connection between the caller and the IVR application
- The caller uses the telephone keyboard to input data
- When the application needs to send an output to the user, the standard data is converted to voice using TTS (Text To Speech)

Overview of Voice Software

- Voice technology encompasses the processing and manipulation of an audio signal in a Computer Telephony System
- It supports filtering, analyzing, recording, digitizing, compressing, storing, expanding and replaying of audio voice

Mobile Computing Through Telephone – IVR Architecture (contd.)

Voice Driver and API

- Voice driver in an IVR system is used to communicate and control the voice hardware on the IVR system
- A voice driver can make calls, answer calls, identify caller ID play and record sound from the phone line, detect DTMF (Dual Tone Multi Frequency) signals (touch tones)dialled by the caller
- It offers APIs to record the transaction details for billing and audit trials
- It can detect when a caller has hung up

IVR Programming

- There are different voice libraries to interface with the voice driver like:

  libdxxmt.lib – the main voice library

  libsrlmt.lib – the standard runtime library

- These C libraries are used to:

  - utilize all the voice board features of call management

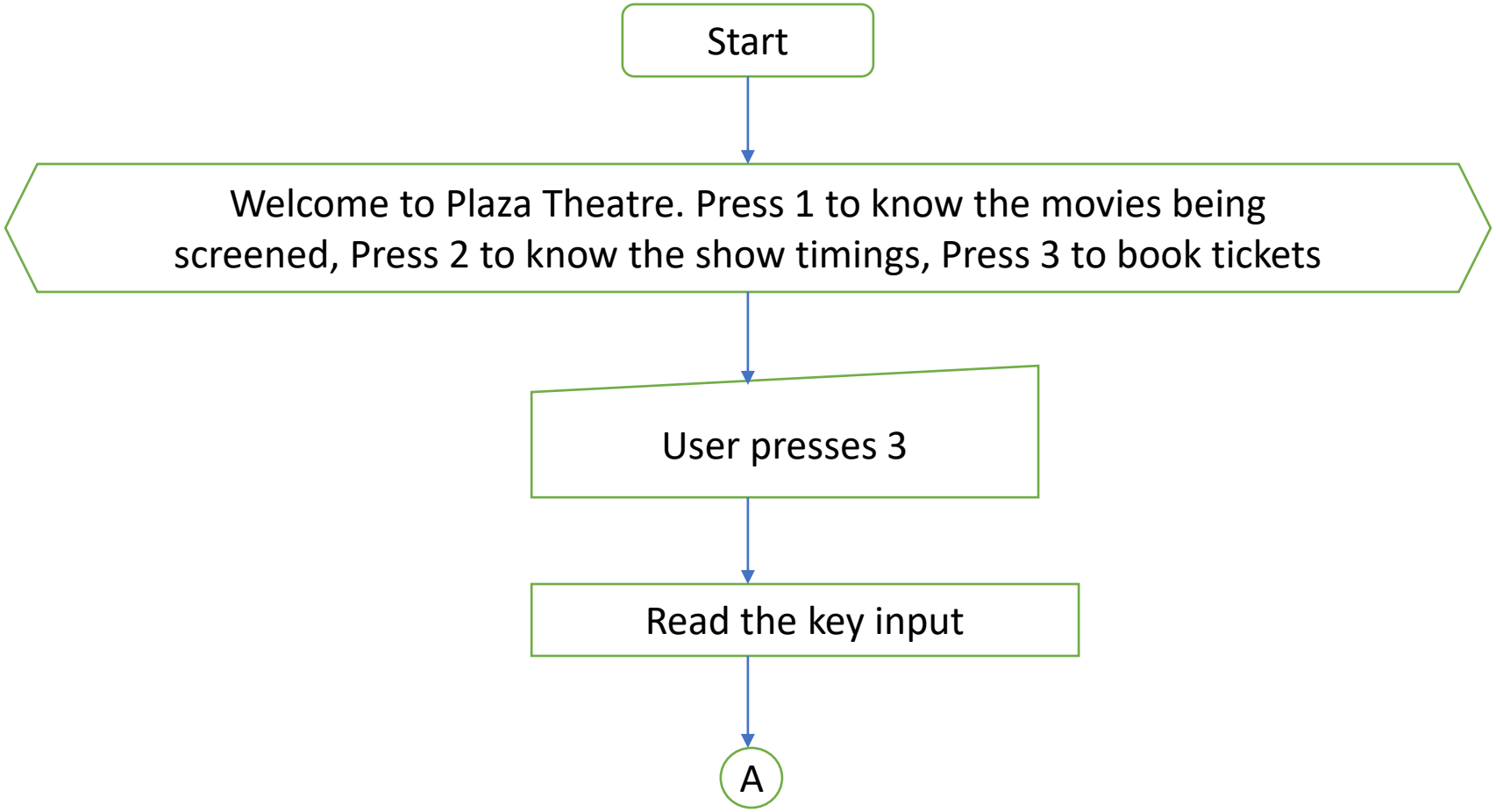
  - configure devices

  - handle events that occur on the devices

  - gather call transaction details

Developing an IVR Application

- IVR application development requires definition of the user interface called Call Flow
- In a call flow we define how the call will be managed
- Example of Call Flow for ticket booking in a theatre is shown below:



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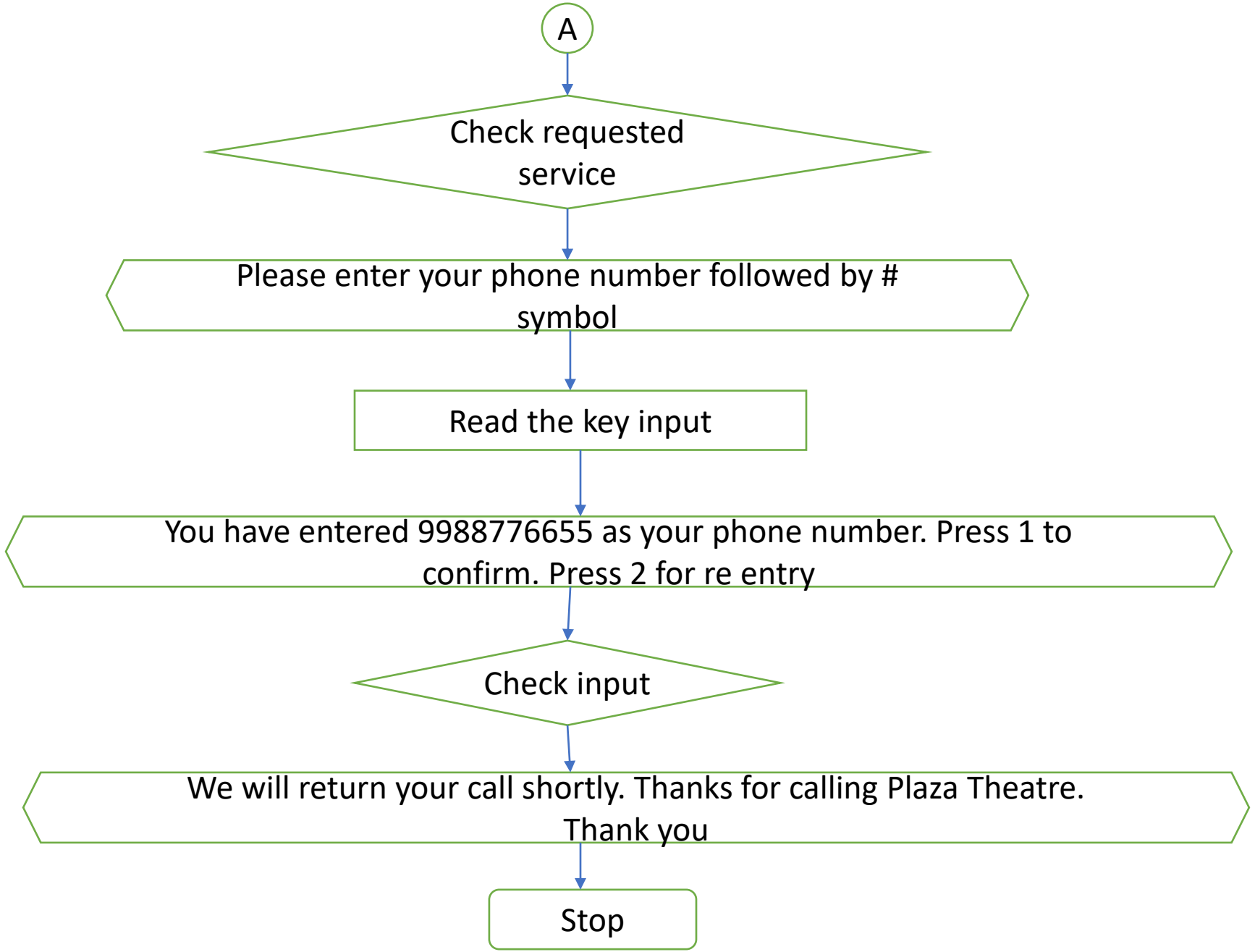
A
Check requested service
Please enter your phone number followed by # symbol
Read the key input
You have entered 9988776655 as your phone number. Press 1 to confirm. Press 2 for re entry
Check input
We will return your call shortly. Thanks for calling Plaza Theatre. Thank you
Stop

Voice XML

- The Voice eXtensible Markup Language (Voice XML) is an XML based markup language for creating distributed voice applications
- Voice XML is designed for creating audio dialogs that feature synthesized speech, digitized audio, recognition of spoken voice and DTMF (Dual Tone Multi Frequency) key input, recording of spoken input, text to speech output, recorded audio output etc
- Using voice XML we can create web based voice applications that users can access through telephon

Architectural Model

- The architectural model for Voice XML has the following components:
    1) Document Server – services requests from a client application
    2) Voice XML Interpreter – Used to execute the client side of the application
    3) Voice XML interpreter context – Used to access the client side of the application
- The server delivers Voice XML documents, which are processed by the Voice XML interpreter

Voice XML Architecture (contd.)

The architectural model for VoiceXML is depicted in Figure 3.5. It has the following components:

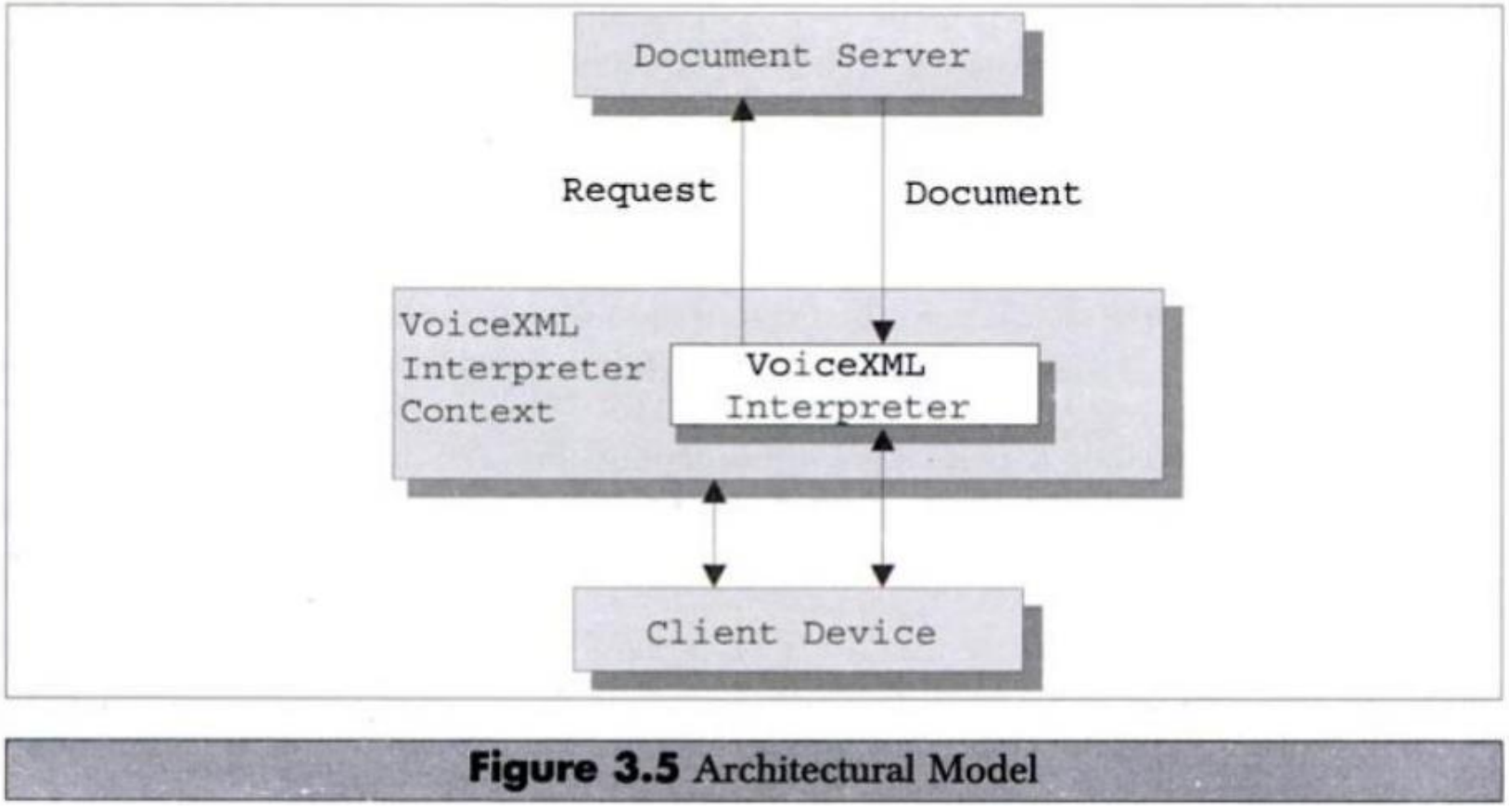

Figure 3.5 Architectural Model

How Voice XML fits into web environment

- Voice XML introduces a new way of presenting the web information
- Instead of presenting the information visually, the voice browser presents the information to the caller in audio using voice XML
- When the caller says a request, the voice browser sends a HTTP request to the web server, which accesses the same back end infra structure, to return information in audio
- This type of portal is known as voice portal and is useful in handsfree situations like driving

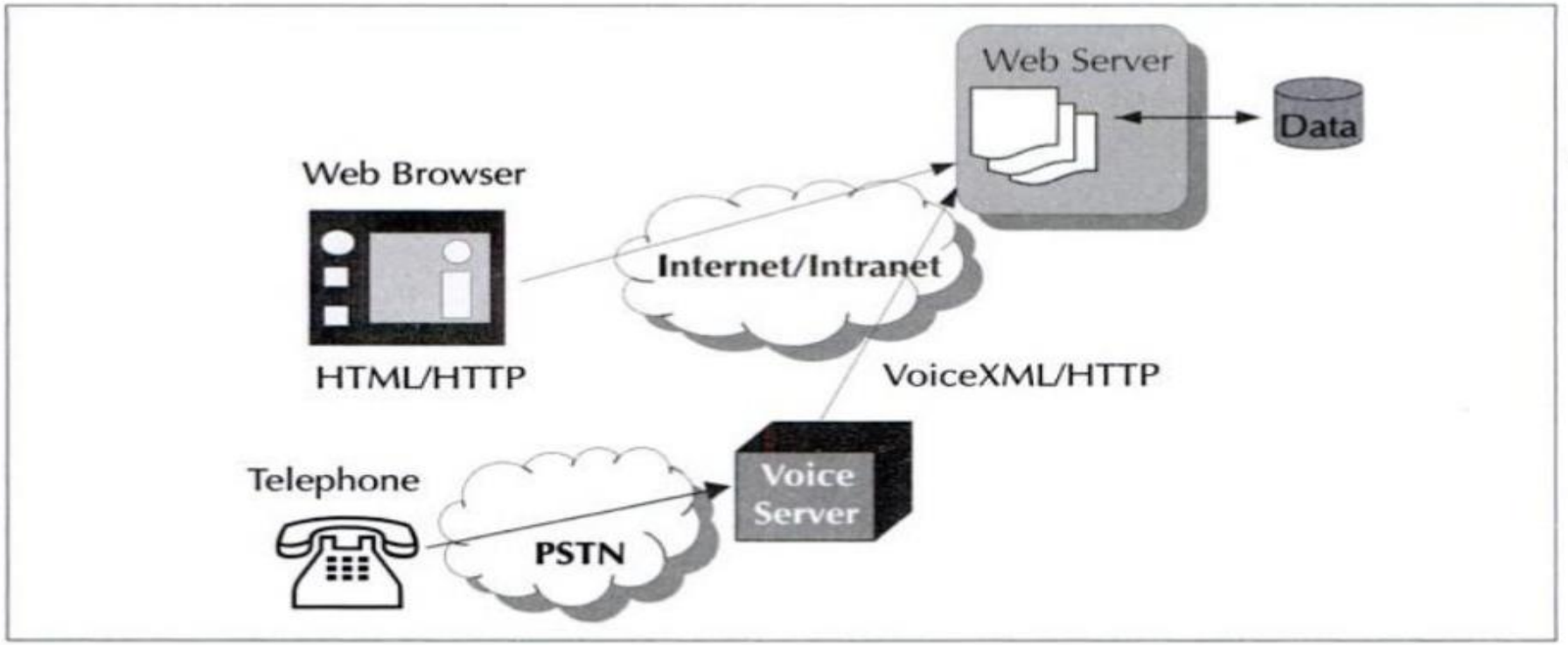

Figure 3.6 Voice browser and voice portal over VoiceXML Architecture

Voice XML Elements

<assign> - assign a value to a variable

<audio> - play an audio clip within a prompt

<block> - a container of executable code

<catch> - catch an event

<choice> - define a menu item

<menu> - a dialog for choosing amongst alternative destinations

Telephony Application Programming Interface (TAPI)

Speech Application Programming Interface (SAPI)

- Developed jointly by Intel and Microsoft, TAPI and SAPI are two standards that can be used when developing voice telephony applications
- Through TAPI and SAPI a program can talk over telephones or video phones to people or phone connected resources
- It uses simple user interface to set up calls. (Eg: clicking on their picture to call a person)
- See who the user is talking to
- Attach voice greeting with ana email
- Set groups and security measures such that a service can receive phone calls from certain numbers only

Emerging Technologies - Bluetooth

- Bluetooth technology allows users to make an adhoc wireless connection between devices like mobile phones, desktop or notebook computers without any cable.
- Devices carrying Bluetooth-enabled chips can easily transfer data at a speed of about 1 MBps in basic mode within a 50 m range or beyond through walls, clothing and luggage bags

Bluetooth Protocol

- Bluetooth supports both unicast and multicast connections
- Bluetooth protocol uses the concept of master and slave
- The master and slave together form a piconet. Upto 7 slaves can be set to communicate with a master
- Several piconets can be linked to form a scatternet. A device from one piconet also acts as a member of another piconet
- A master in one piconet can be a slave in another piconet

Bluetooth Protocol Stack

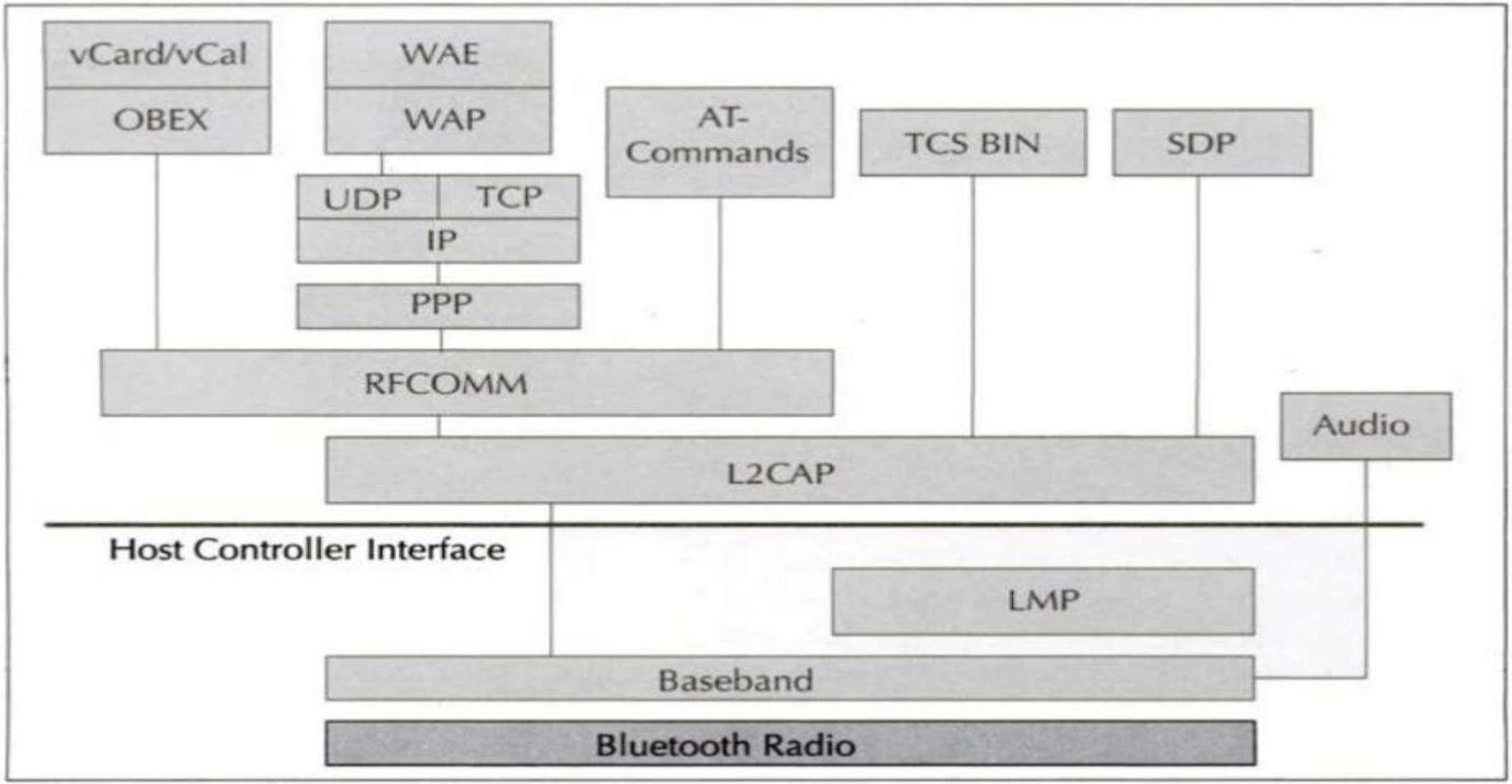

Figure 4.2 Blutooth Protocol stack

Bluetooth Protocol Stack

- **Bluetooth Core Protocols:**

1. **Baseband –** The baseband and Link control layer enables the physical RF link between Bluetooth units forming a piconet
2. **Link Manager Protocol (LMP) –** When two Bluetooth devices come within each other's radio range, link managers of either device discover each other . LMP then engages itself in peer to peer message exchange. These messages perform various security functions starting from authentication to encryption
3. **Logical Link Control and Adaptation Protocol (L2CAP) –** This layer is responsible for segmentation of large packets and the reassembly of fragmented packets
4. **Service Discovery Protocol(SDP) –** SDP enables a Bluetooth device to join a piconet. Using SDP a device inquires what services are available in a piconet and how to access them

- **Cable Replacement Protocol:**

1. **RFCOMM –** It is a serial line communication protocol

- **Telephony Control Protocol:**

1. **Telephony Control Specification Binary (TCS BIN) –** It defines the call control signalling protocol for set up of speech and data calls between Bluetooth devices
2. **AT Commands –** It defines a set of AT commands by which a mobile phone can be used and controlled as a modem for fax and data transfers

Bluetooth Protocol Stack (contd.)

- **Adopted Protocols:**

1. **PPP Bluetooth** – Point to Point protocol is the of taking IP packets to/from the PPP layer and placing them onto the LAN
2. **TCP/IP –** Used for communication across the Internet.
3. **OBEX Protocol –** It defines a folder listing object, which can be used to browse the contents of folders on remote devices
4. **Content Formats –** vCard and vCalender specifications define the format of an electronic business card and personal calender entries. vMessage and vNote are used to exchange messages and notes

Bluetooth Security

- For security, Bluetooth offers authentication, key exchange, encryption, frequency hopping of 1600 hops/sec are used
- The cipher algorithm known as SAFER+ is used to authenticate a device's identity

Bluetooth Application Models

1. **File Transfer –** transfer data objects from one device to another
2. **Internet Bridge –** A mobile phone or cordless modem acts as modem to the PC providing dial up networking and FAX capabilities without need for physical connection
3. **LAN access –** Multiple data terminals use a LAN access point (LAP) as a wireless connection to an Ethernet LAN
4. **Synchronization –** provides device to device synchronization of data
5. **Headset –** used as a remote device’s audio input and output interface

Radio Frequency Identification (RFID)

- RFID is a transponder carrying an ID that can be read through radio frequency interfaces
- These transponders are known as RFID tags
- When the tag is attached to an object, it provides identification for the object.
- The object could be item in a retail store, goods in transit, entity in a manufacturing shop, vehicle in a parking lot, a pet, book in a library etc
- **Three categories of RFID tags:**

1. **Based on Frequency –** Low frequency tags have short reading ranges, lower system costs and suitable for slow moving objects. Eg: security access, asset tracking and animal identification

   High frequency tags are offer long read ranges, high data transfer speeds and suitable for fast moving objects. Eg: Railway wagon tracking, automated toll collection
2. **Based on Application –** RFID used for livestock is different from tag used in the railroad.

   RFID tag contains two segments of memory: One segment is a factory set and used to uniquely identify a tag. In the other segment, application specific data can be stored
3. **Based on Power –** Based on power consumption, there are two types of tags: Active and Passive

   i) Active RFID tags – Powered by an internal battery and are typically read/write. High cost

   ii) Passive RFID tags – No own power source. Obtains operating power from the reader's antenna. Read only and less expensive

Radio Frequency Identification (RFID) contd.

- The reader emits radio waves in any range from 1 cm to 25 m or more
- When an RFID tag passes through the electromagnetic zone of the reader, it detects the reader's activation signal.
- The reader decodes the data encoded in the tag's IC chip and the data is passed to the host computer for processing.
- A basic RFID system consists of three components:
  - A transponder programmed with unique information (Tag)
  - A transceiver with decoder (Reader)
  - An antenna or coil

Areas of Application of RFID

1. Transportation and Logistics
2. Manufacturing and Processing
3. Security
4. Animal tagging
5. Retail store
6. Community Library
7. Road toll management
8. Postal tracking
9. Time and attendance

Wireless Broadband (WIMAX)

- Wireless MAN is called WIMAX (Worldwide Interoperability for Microwave Access)
- WIMAX provides wireless transmission of data using a variety of transmission modes from point to multipoint links to portable and fully mobile internet access

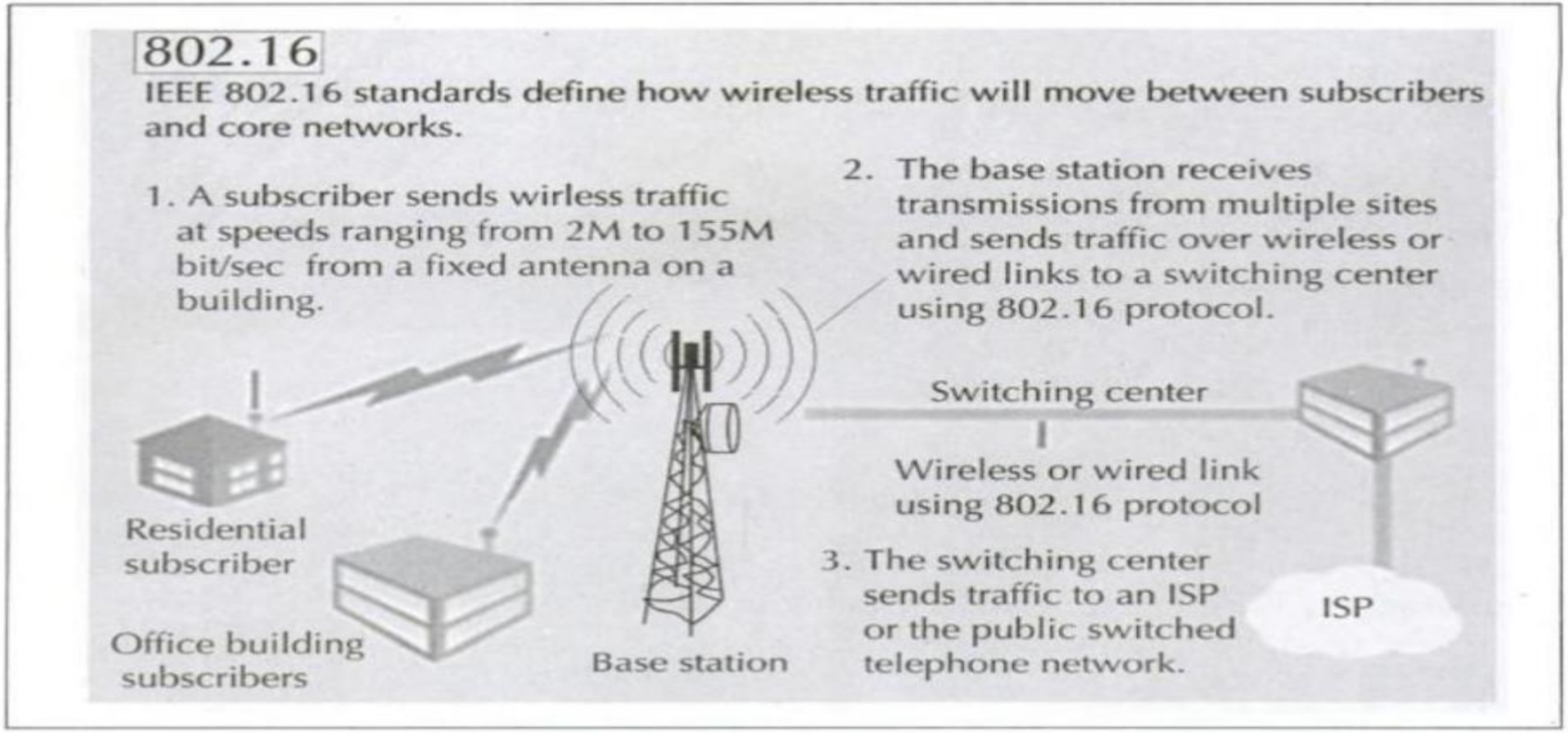

Figure 4.4 The WirelessMAN (wireless metropolitan area network)

Wireless Broadband (WIMAX) contd.

- WiMAX provides network access to buildings through exterior antennas communicating with radio base stations
- WiMAX has three layer architecture:

1. **The Physical Layer –** specifies the frequency band, the modulation scheme, error correction techniques, synchronization between transmitter and receiver, data rate and the multiplexing structure
2. **The Media Access Control (MAC) Layer –** responsible for transmitting data in frames and controlling access to the shared wireless medium.
3. **Convergence layer –** provides functions specific to the service being provided.

Broadband Applications – Wireless broadband allows higher data rates in homes, offices and mobile environments

Broadband Mobile Cellular System – High data rates and high speed mobility are achieved by installing moving base stations and fixed radio ports uniformly distributed along the median of the roadway. The moving base stations allow communication links to be established between the mobile units travelling on the roadway and a fixed communication network through the fixed radio ports

Mobile IP

- Mobile computing offers seamless computing and data networking facility when the user is in the state of mobility and changes the network
- IP addresses are assigned to a node from a set of addresses assigned to a network
- IP address of a node is a combination of network address (most significant 24 bits) and the node address (least significant 8 bits)
- IP address will change when the node moves from one subnet to another
- So, in Mobile IP, each mobile node is given two IP addresses: Home address and Care of address
- Home address is the original static IP address of the node and known to everybody as the identity of the node
- Care of address changes at each new point of attachment
- Home agent is a router on a mobile node’s home network which forwards data to the mobile node through a tunnel when it is away from home
- Home agent also maintains current location information of the mobile node
- Foreign agent is a router on the node’s visited network and delivers data to the mobile node that were tunnelled by the home agent
- When the mobile node detects that it has moved to a foreign network, it registers with the foreign agent and obtains a care of address

Mobile IP contd.

- The mobile node registers its new care of address with its home agent
- The home agent forwards all incoming data packet to the foreign network using the care of address

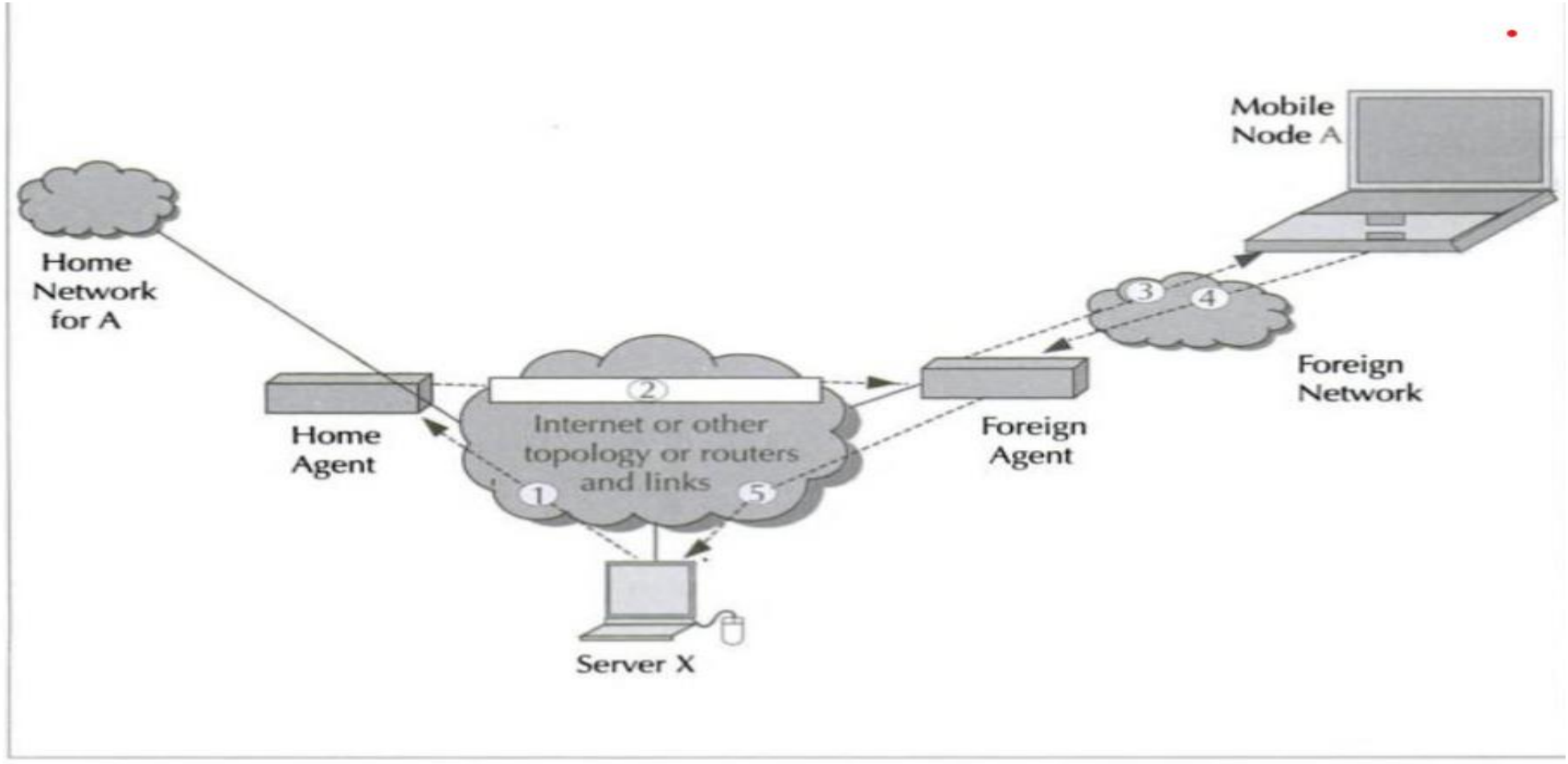

Figure 4.6 Mobile IP architecture

Mobile IP contd.

- Mobile IP supports three procedures:

1. **Discovery –** In this procedure, he mobile node identifies the home and the foreign agents.
   Home and foreign agents transmit advertisements about themselves
   The mobile node receives this advertisement packet and compares the network portion of the router's IP address with the network portion of its own IP address
   If they do not match, then the mobile node knows it is in a foreign network
2. **Registration –** The mobile node receives a care of address from the foreign network
   The mobile node sends a registration request to the home agent with the care of address
   The home agent updates its routing table and sends a registration reply to the mobile node
3. **Tunneling –** Home agent informs other nodes in the home network that all data with the destination address of the mobile node should be delivered to the home agent
   The home agent encapsulates the data packet with source address (of home agent) and destination address (care of address of the node)
   Thus the data packet will reach the mobile node

Mobile IP contd.

Cellular IP

- Whenever the mobile node moves to a new subnet with a different foreign agent, the care of address will change.
- This new care of address needs to be communicated to the home agent
- This process works well for slow moving hosts
- For a high speed mobile host, the rate of update of the addresses needs to match the rate of change of addresses
- Otherwise packets will be forwarded to the wrong (old) address
- To solve this problem, a new protocol called Cellular IP is designed
- In Cellular IP, none of the nodes know the exact location of a mobile host.
- Packets addressed to a mobile host are routed to its current base station on a hop by hop basis where ach node only needs to know on which of its outgoing ports to forward packets
- This is referred to as Mapping

Internet Protocol Version 6 (IPV6)

- IPV6 expands the available address space of IPV4
- IPV6 uses 128 bit addresses for each packet
- It has global addresses (Internet) and local addresses (within a subnet)
- 48 bit for external routing, 16 bit for subnet number and 64 bit for local LAN segment

IPV6 Security – IPV6 uses a security protocol called IPsec (IP security) to provide confidentiality, integrity and authenticity. IPsec security architecture consists of security associations, security protocols, cryptographic algorithms and key management

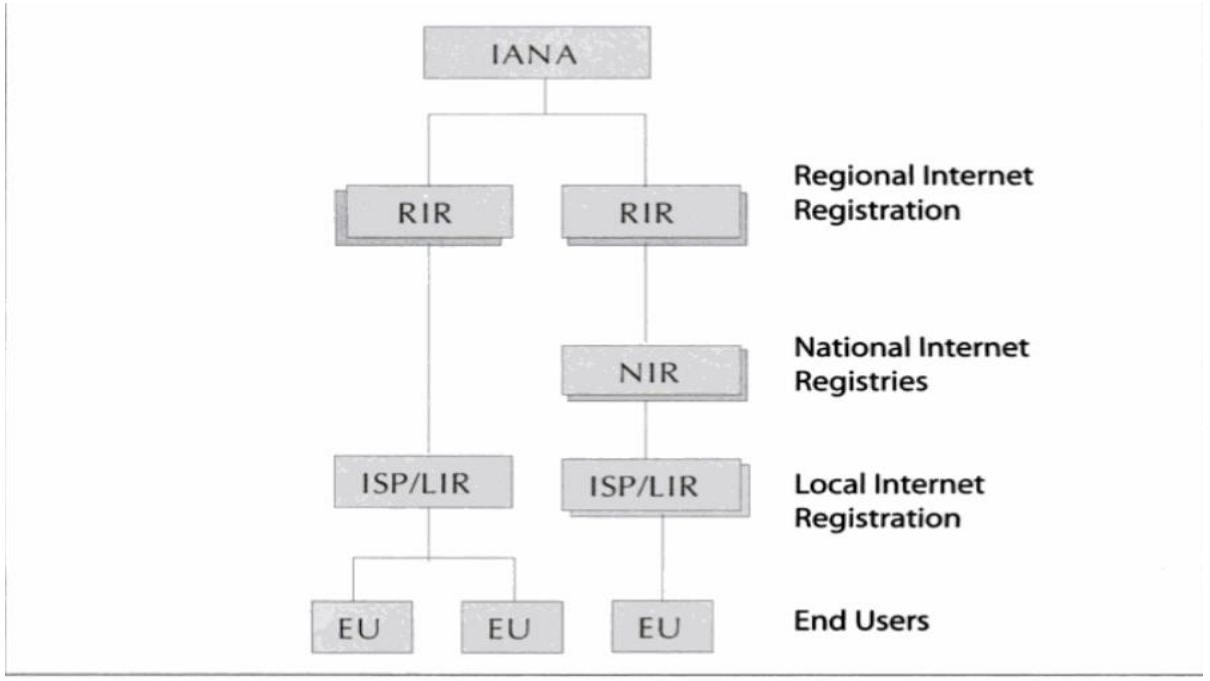

Figure 4.11 Hierarchical addressing of IPv6

IPV6 contd.

Basic differences between IPV4 and IPV6 :

1. Foreign agents are not required for Mobile IPV6 as it does not need special support from local routers
2. Route optimization is a fundamental part of Mobile IPV6
3. The IPV6 Neighbour Unreachability Detection assures symmetric reachability between the mobile node and its default router in the current location
4. Most packets sent to a mobile node while away from home in Mobile IPV6 are sent using an IPV6 routing header rather than IP encapsulation
5. Mobile IPV6 is decoupled from any particular link layer as it uses IPV6 Neighbour Discovery instead of ARP (Address Resolution Protocol)
6. The dynamic home agent address discovery mechanism in Mobile IPV6 returns a single reply to the mobile node
7. The directed broadcast approach used in IPV4 returns separate replies from each home agent

JAVA Card

- Java Card is a smart card with Java framework
- Smart card is a plastic card with intelligence and memory. Eg: SIM card
- Smart cards are capable of carrying data, functions and information on the card
- A smart card is embedded with either

    i) a microprocessor and a memory chip or

    ii) only a memory chip with a non programmable logic
- A microprocessor card has a resident intelligent program which can add, delete and manipulate information on the card
- A memory card can store some information for some pre defined operation
- Smart cards have now emerged as multi function cards. To allow interoperability, Java was chosen.
- Smart cards with Java framework are called Java cards
- A Java SIM card may have 8 or 16 bit micro processor running at speeds between 5 MHz – 40 MHz with 32K – 128K bytes of EEPROM (Electronically Erasable Programmable Read Only Memory)
- The Java Card Virtual Machine is split into 2 parts: one that runs off card and one that runs on card