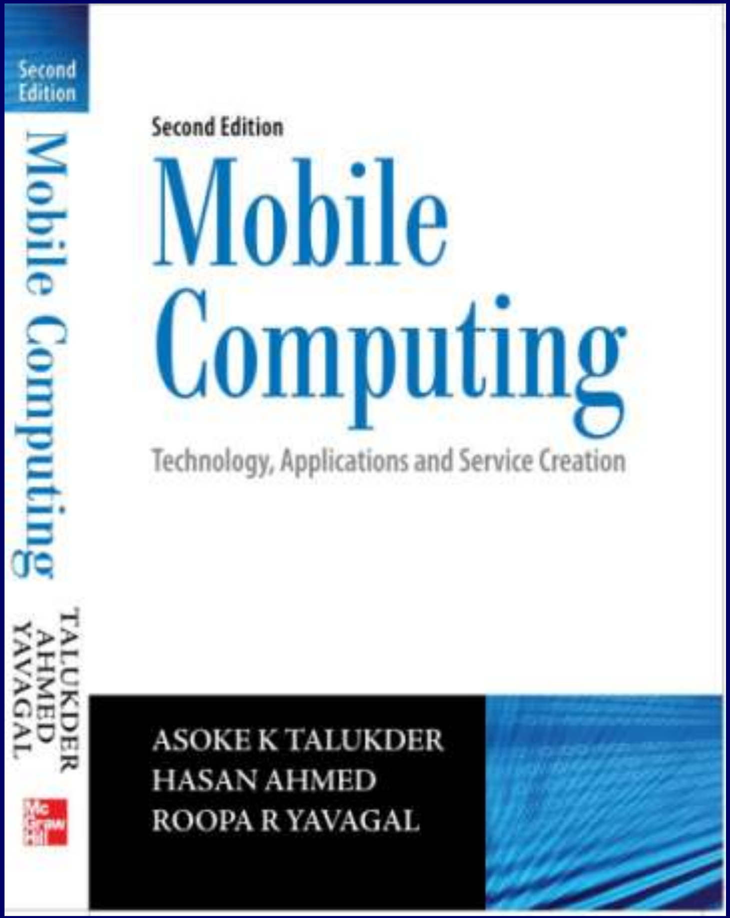


Mobile Computing

Chapter 3

Mobile Computing through Telephony

Asoke K Talukder

Hasan Ahmed

Evolution of Telephony

- ❑ 1876 – First telephone system by Alexander Graham Bell
- ❑ 1892 – Strowger switch installed as first automatic telephone exchange
- ❑ 1960 – Electronic Switching System (ESS) developed by AT&T
- ❑ 1962 – Carrier system went digital
- ❑ 1960’s and 1970’s – Stored program telephone exchanges
- ❑ 1980’s – Wireless telephony emerged
- ❑ 1990’s – Mobile telephony flourished commercially across the world

Public Switched Telephone Network

- ❑ Three categories of nodes – local exchanges, transit exchanges, and international exchanges.
- ❑ Local exchanges are used for subscriber connection.
- ❑ Transit exchanges switch traffic within and between different geographical areas.
- ❑ International exchanges switch traffic to telecommunication networks in foreign countries and other distant networks.
- ❑ Last mile – a physical wire (also known as local loop) that is laid from local exchange to the device at subscriber premises.
- ❑ Last mile is absent in case of GSM or Will network.

Multiple Access Procedures

- ❑ We need to control simultaneous access of radio channel in order to avoid collisions.

- ❑ In a connection oriented communication, collisions are undesirable.

- ❑ For effective utilization, channel has to be utilized intelligently by the use of multiplexing.

- ❑ Four major types of multiple access procedures are Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA) and Space Division Multiple Access (SDMA).

Frequency Division Multiple Access

- The available frequency band is divided into channels of equal bandwidth so that each communication is carried on a different frequency.
- FDMA was used in all the first generation analog mobile networks like TACS in UK and AMPS in USA.

Time Division Multiple Access

- It needs precise synchronization between transmitter and receiver.
- The whole frequency bandwidth is subdivided into sub – bands using FDMA techniques. TDMA is then used in each of these sub – bands to offer multiple access.
- TDMA is more expensive than FDMA.
- GSM uses TDMA.

Code Division Multiple Access

- ❑ CDMA uses spread spectrum technique where each subscriber uses the whole system bandwidth.
- ❑ In CDMA, all subscribers in a cell use the same frequency band simultaneously.
- ❑ To separate the signals in CDMA, each subscriber is assigned an orthogonal code called chip.
- ❑ CDMA is a broadband system.

Space Division Multiple Access

❑ SDMA is a technique where we use different part of the space for multiplexing.

❑ SDMA is used in radio transmission and is more useful in satellite communications to optimize the use of radio spectrum by using directional properties of antennas.

❑ In SDMA, antennas are highly bidirectional while allowing duplicate frequencies to be used at the same time for multiple surface zones on Earth.

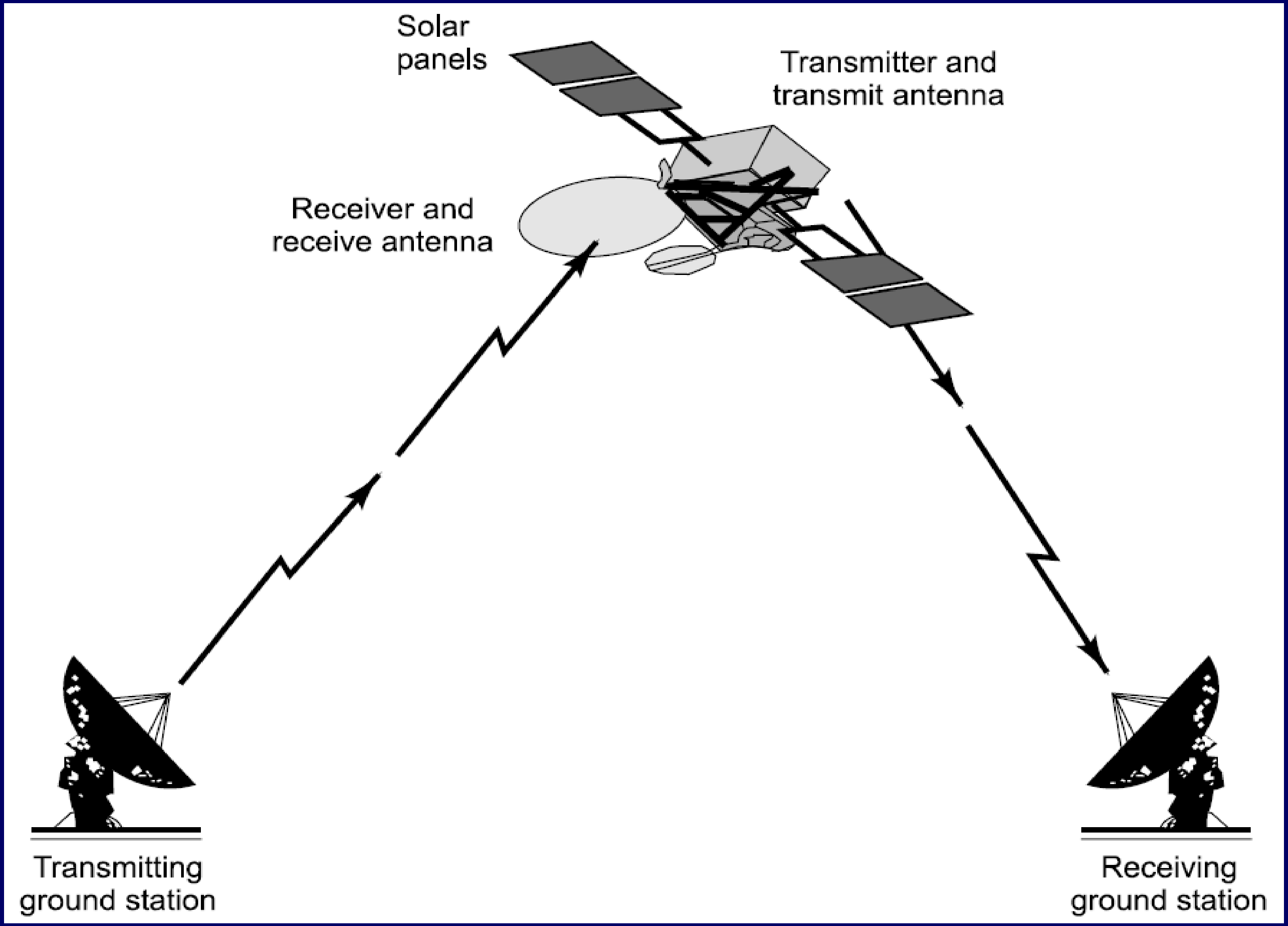
❑ SDMA requires careful choice of zones for each transmitter and also requires precise antenna alignment.

Satellite Communication Systems

- Every communications satellite involves the transmission of information from an originating ground station to the satellite followed by a retransmission of the information from the satellite back to the ground called the uplink and the downlink respectively. Hence, the satellite must have a receiver with receive antennas, and a transmitter with transmit antennas.

- It must also have some methods for connecting the uplink to the downlink for retransmission with amplification; also, it must have electrical power through solar energy to run all of the electronics. The downlink may either be to a select number of ground stations or may be broadcast to everyone over a large area.

Satellite Communication Systems



Satellite Communication Systems

- A properly designed satellite antenna will concentrate most of the transmitter power within a designated area using space division multiplexing.

- One of the biggest differences between a low earth satellite and a geosynchronous satellite is in their antennas. All antennas in use today radiate energy preferentially in some direction.

- The most important application for communication satellites was in intercontinental long distance telephony. The fixed Public Switched Telephone Network relays telephone calls from land line telephones to an earth station, where they are then transmitted to a geostationary satellite.

- The downlink follows an analogous path.

Low Earth Orbit Satellite

- A Low Earth Orbit (LEO) satellite typically orbits around the earth about 400 kilometers above the earth's surface with a time period of about 90 minutes.

- These satellites are only visible from within a radius of roughly 1000 kilometers from the sub-satellite point. Sub-satellite point is the point of intersection of earth's surface with the straight line from the satellite to the center of earth.

- The greatest advantage of LEO satellite is that it does not need high powered rockets—making it less expensive to launch. Also, due to its proximity to the ground, LEO does not require high signal strength.

Medium Earth Orbit Satellite

- A Medium Earth Orbit (MEO), sometimes called Intermediate Circular Orbit (ICO), is the region of space around the earth above low earth orbit of 2,000 kilometres and below geostationary orbit of 35,786 kilometers.

- The most common use for satellites in this region is for navigation, such as the GPS (with an altitude of 20,200 kilometers), Communications satellites that cover the North and South Pole are also put in MEO.

- The orbital periods of MEO satellites range from about 2 to 24 hours. The MEO orbit has a moderate number of satellites.

Geostationary Earth Orbit Satellite

- In geostationary satellite, the orbit of the artificial satellite is such that the orbital speed of the satellite is same as the speed of earth's rotation. Though the satellite is moving at a high speed, from earth it will always appear to be stationary—this is the reason for calling it geo-stationary.

- The GEO satellite could view approximately 42% of the earth. Therefore, a system of three GEO satellites, with the ability to relay messages from one GEO to the other could interconnect virtually all of the earth except the polar regions.

Satellite Phones

- Initially satellite communication was being used for broadcast to stationary TV receivers, and transmission of telephone channels.

- However, demand on mobile phone made some companies to look into satellite phones that will connect a subscriber directly through the communication satellite, where the satellite will function as the transceiver station connecting the mobile phone.

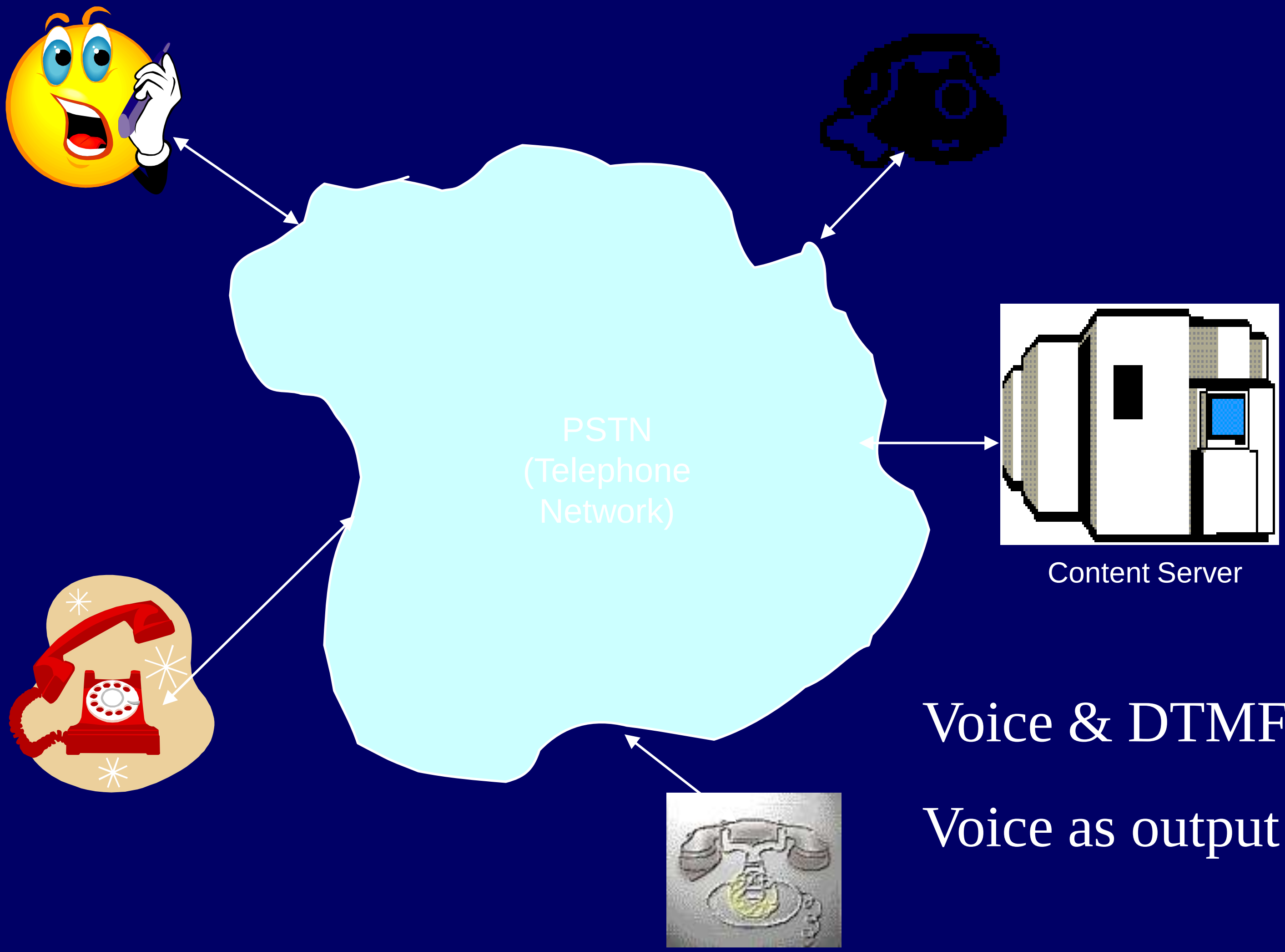
Satellite Phone Companies

- Iridium
- Globalstar
- Thuraya

Mobile Computing through Telephone

- ❑ Computer Telephony Interface (CTI) – accessing applications through voice interface
- ❑ Intelligent Networks (IN) – solving problem of multiple and geographically bounded numbers
- ❑ CTI achieved through Interactive Voice Response Service (IVRS)
- ❑ IVRS – known as Voice Response Unit in USA
- ❑ Audiotex systems – systems based on IVRS and VRU
- ❑ Dual Tone Multi Frequency (DTMF) – extensively used in IVRS

Architecture for CTI



Voice & DTMF as input

Voice as output

Benefits of CTI

- ❑ Easy integration with existing telephone and computer systems irrespective of whether they are state – of – the – art databases or legacy systems

- ❑ Independent of the locale and culture as the same application can be adapted for other languages very quickly

- ❑ Very effective for rural population and senior citizens who are not computer savvy

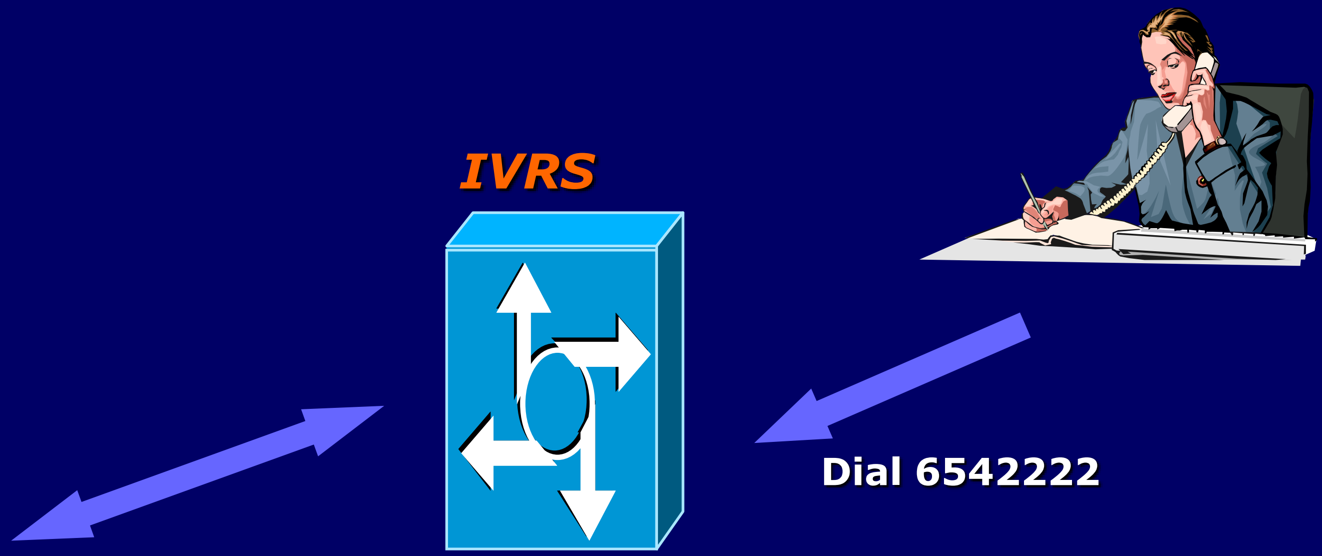
- ❑ Comprehensive voice – processing capabilities designed specifically for small, middle and large – size businesses

- ❑ Provide customized application development tools that are ideal for different size and types of businesses

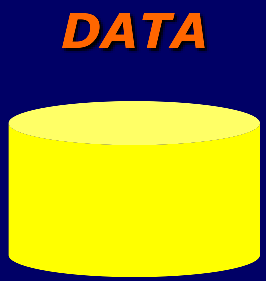
How CTI is different?

- The only difference is User Interface
- Input through DTMF telephone keypad
- Input through rotary telephone
- Input through voice
- Output is always audible sound

Interactive Voice Response Service

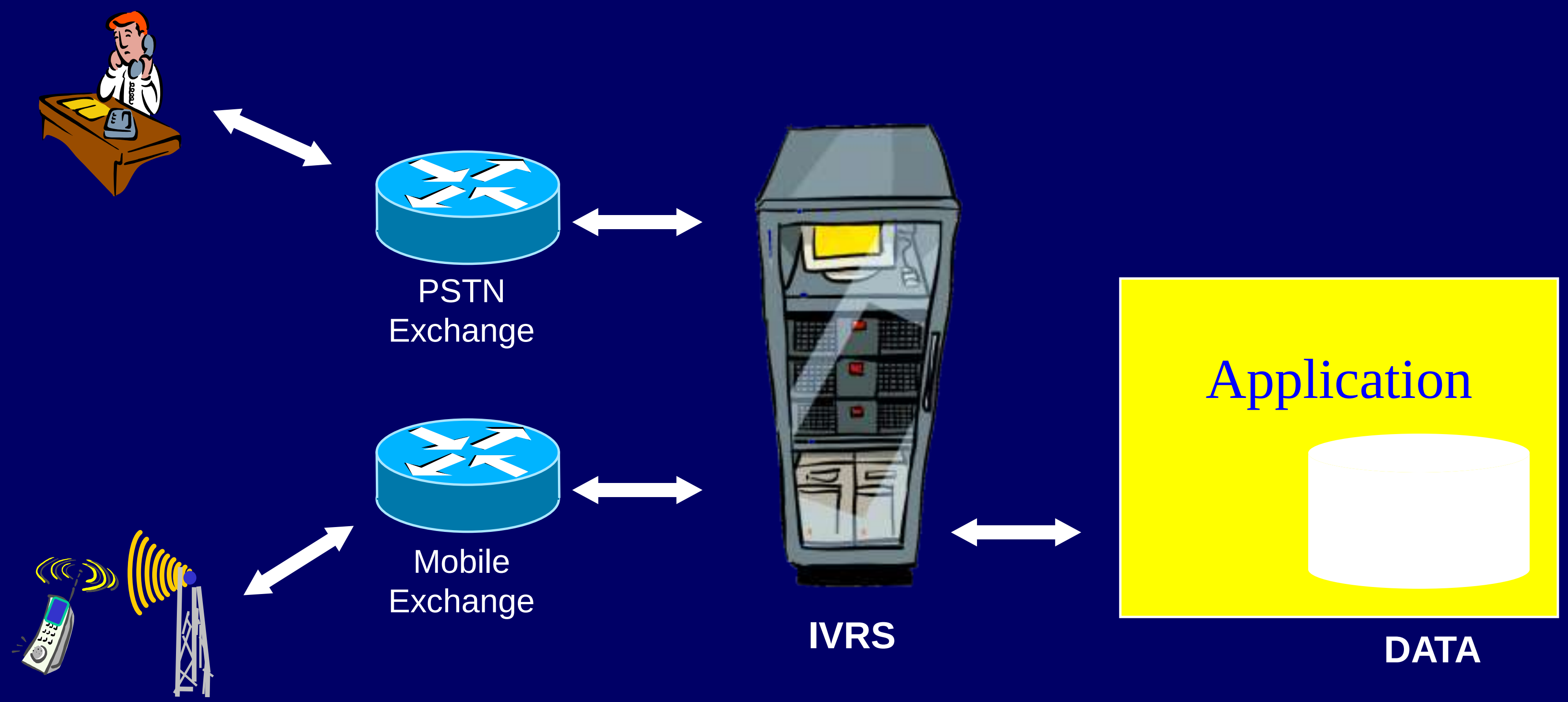


- Pre-recorded voice prompts guide the user to get the relevant information
- User inputs data using the telephone keypad

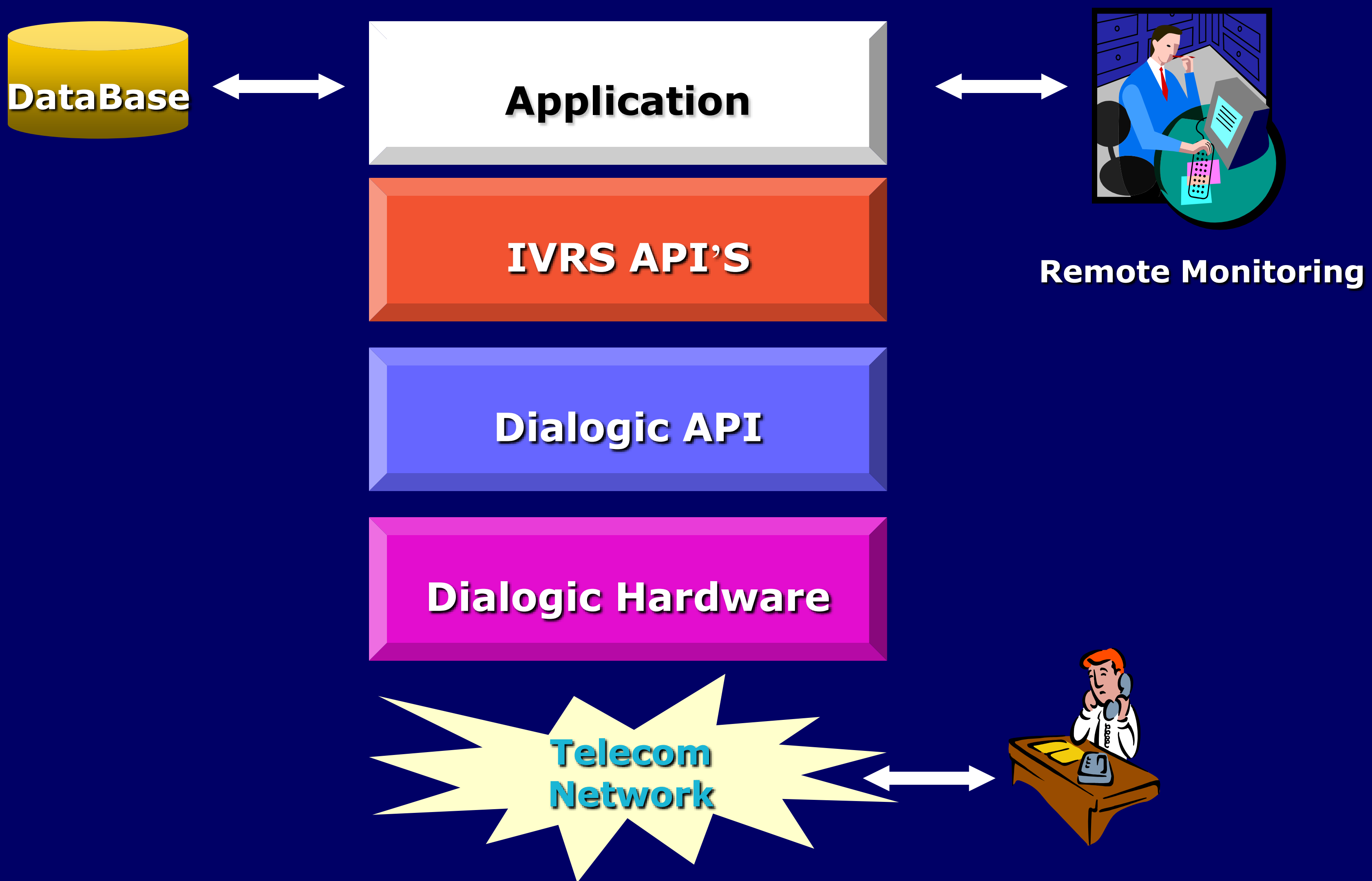


- Enterprise E-mail / Data
- Flight related information
- Legacy data

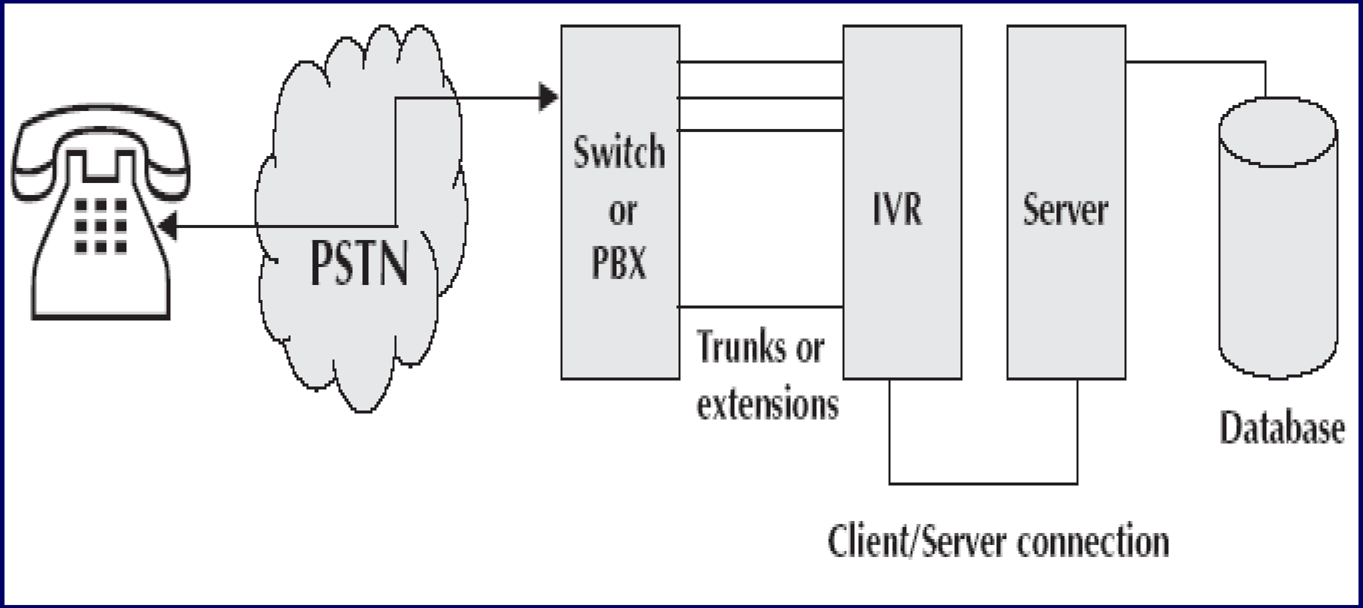
Deployment for IVRS



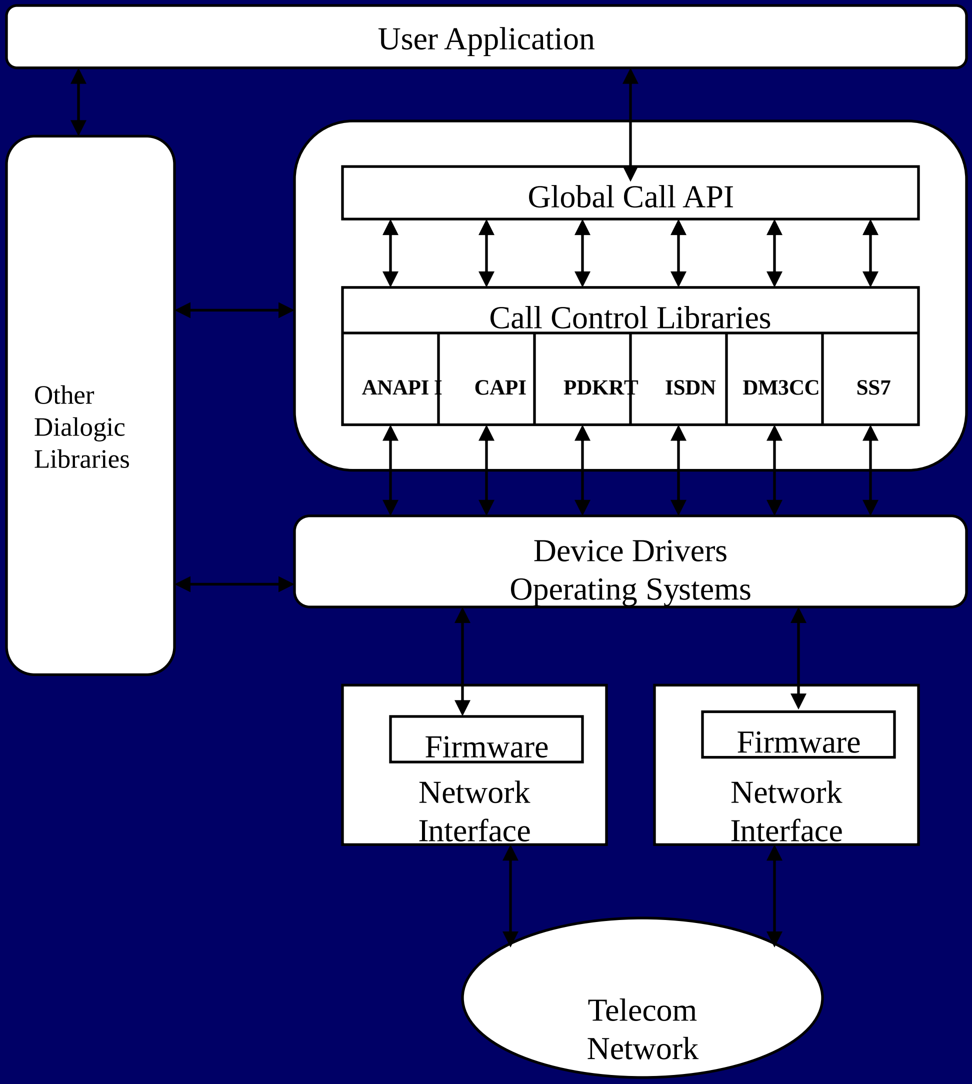
Architecture for IVRS



Architecture for IVRS – in general



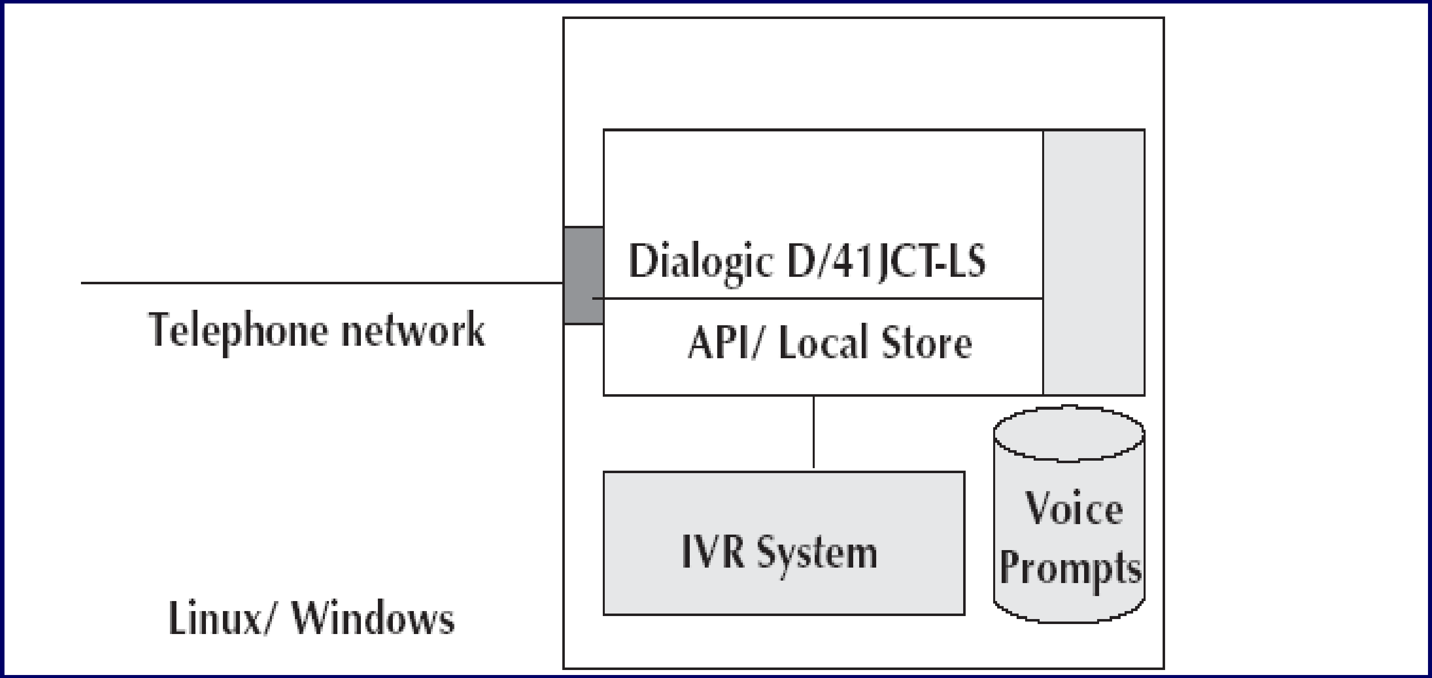
Dialogic architecture for IVRS



IVRS enables solutions like …

- Text to speech conversion
- Voice / music messaging
- Inbound and outbound call processing
- Audiotex premium rate services
- Intelligent call directing and routing
- Voice mail
- Billing information and fax on demand.
- Reminder service

Inside an IVRS



IVRS – Interface to exchange

- **Physical Interface :**

  Analog : RJ 11

  Digital : 2Mbps E1 interface (75 ohm / 120 ohm)

- **Digital Signaling :**

  ISDN-Primary Rate Interface

  R2-MFC

  SS#7

Features of IVRS – I

- Touch tone input (DTMF)
- Caller identification detection
- Multiple application hosting
- DNI based application routing
- Out dialing
- Call transfer
- Audio recording
- Text – to – speech conversion

Features of IVRS – II

- CDR
- GUI based remote monitoring
- Call statistics (Web Interface)
- Database access
- Data access through Internet
- Support of standard voice file format (.vox, .wav, etc)

Features of IVRS – III

- Input through
  - Telephone keypad
  - Rotary dial
  - Voice recognition
- Numeric input (avoid alphabetic input)
  - Convert numeric input to other types of input through menu
- Alphabetic input can be OK if played back
- Output through
  - Synthesized voice
  - Text – to - speech

Using IVRS through telephone keys

- Alphabets A, B and C on key 2
- Alphabets C, E and F on key 3
- Alphabets G, H and I on key 4
- Alphabets J, K and L on key 5
- Alphabets M, N and O on key 6
- Alphabets P, Q, R and S on key 7
- Alphabets T, U and V on key 8
- Alphabets W, X, Y and Z on key 9

Using IVRS – DTMF frequencies

	1209 Hz	1336Hz	1477Hz
697 Hz	1	2/ABC	3/DEF
770Hz	4/GHI	5/JKL	6/MNO
852 Hz	7/PQRS	8/TUV	9/WXYZ
941 Hz	*	0	#

Synthesized Voice

- ❑ Prerecorded syllables or part of the response recorded into separate files and stored in persistent storage

- ❑ As and when necessary, these files will be played through programming logic the way we do convert numeric to text in a bank cheque

- ❑ Example: 123 = one.vox + hundred.vox + twenty.vox + three.vox

where .vox is pre – recorded voice

Voice driver and API's

- Used to communicate and control voice hardware on IVRS system
- Can make calls, answer calls, identify caller, play and record sound from phone line and detect DTMF signals
- Can tear down a call detect that caller has hung up
- Offers API's to record transaction details

IVRS Programming

- Voice libraries are supported by Dialogic to interface with voice driver
- Voice libraries exist for single and multithreaded applications
- C function libraries exist for a number of purposes
- Standard run time library provides a set of common functions independent of device and applicable to Dialogic devices

Single threaded programming model

- ❑ Enables a program to control multiple voice channels within a single thread
- ❑ Allows development of applications where multiple tasks need to be coordinated simultaneously
- ❑ Supports both polled and call back event management

Multithreaded programming model

- ❑ Uses functions that block application execution until the function completes
- ❑ Applications control each channel from a separate thread or a process
- ❑ Enables IVRS system to assign distinct applications to different channels dynamically in real time

Voice API's

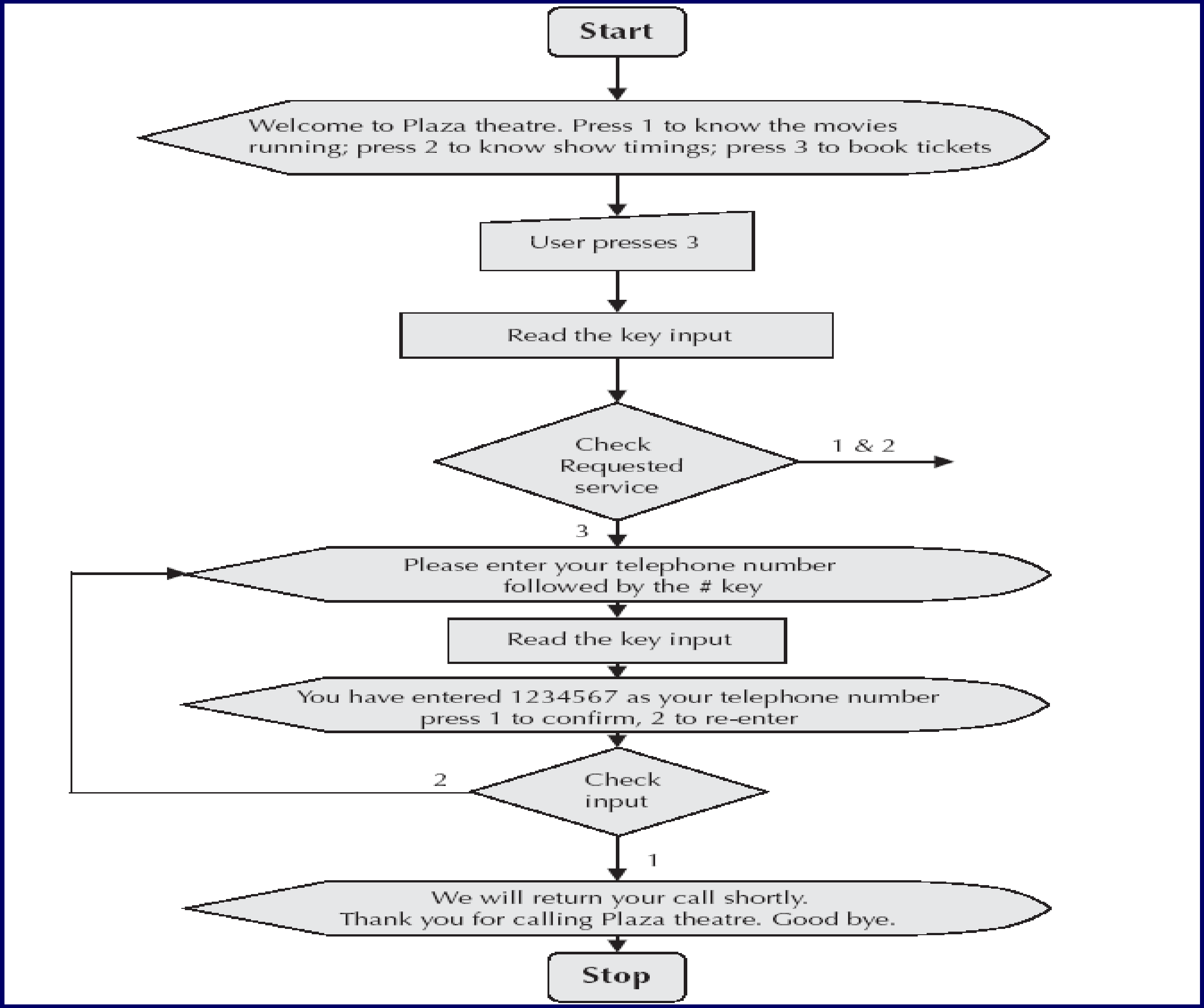
- ❑ Dialogic provides API's to use voice board
- ❑ API's are available for:

- Device management
- Configuration functions
- I/O functions
- Play and record functions
- Tone detection and generation functions
- Call control functions

Dialogic IVRS functions

❑ **dx_open( )**	- opens a voice channel
❑ **dx_close( )**	- closes a voice channel
❑ **dx_wtcallid( )**	- waits for rings and reports Caller ID
❑ **dx_getdig( )**	- gets digits from channel digit buffer
❑ **dx_play( )**	- plays recorded voice data
❑ **dx_playvox( )**	- plays a single .vox file
❑ **dx_playwav( )**	- plays a single .wave file
❑ **dx_rec( )**	- records voice data
❑ **dx_recvox( )**	- records voice data to a single .vox file
❑ **dx_recwav( )**	- records voice data to a single .wave file
❑ **dx_dial( )**	- dials an ASCII string of digits

A typical IVRS call flow



IVRS applications – I

- **Virtual Receptionist**:

Having a hard time finding someone to answer the phones and route calls? Active call center can answer and screen your phone calls, take messages, or even route.

- **Automated Information Retrieval:**

Give yourself more time to deal with important issues. Create simple touch tone menus that will allow your customers to retrieve directions, contact information, store hours, special promotions, and more.

IVRS applications – II

❑ **Interactive Voice Response with content from databases:**

Integrate with your databases and deliver retrieved information back to the caller. For example, a caller might request his order status by entering their order number via touch – tone.

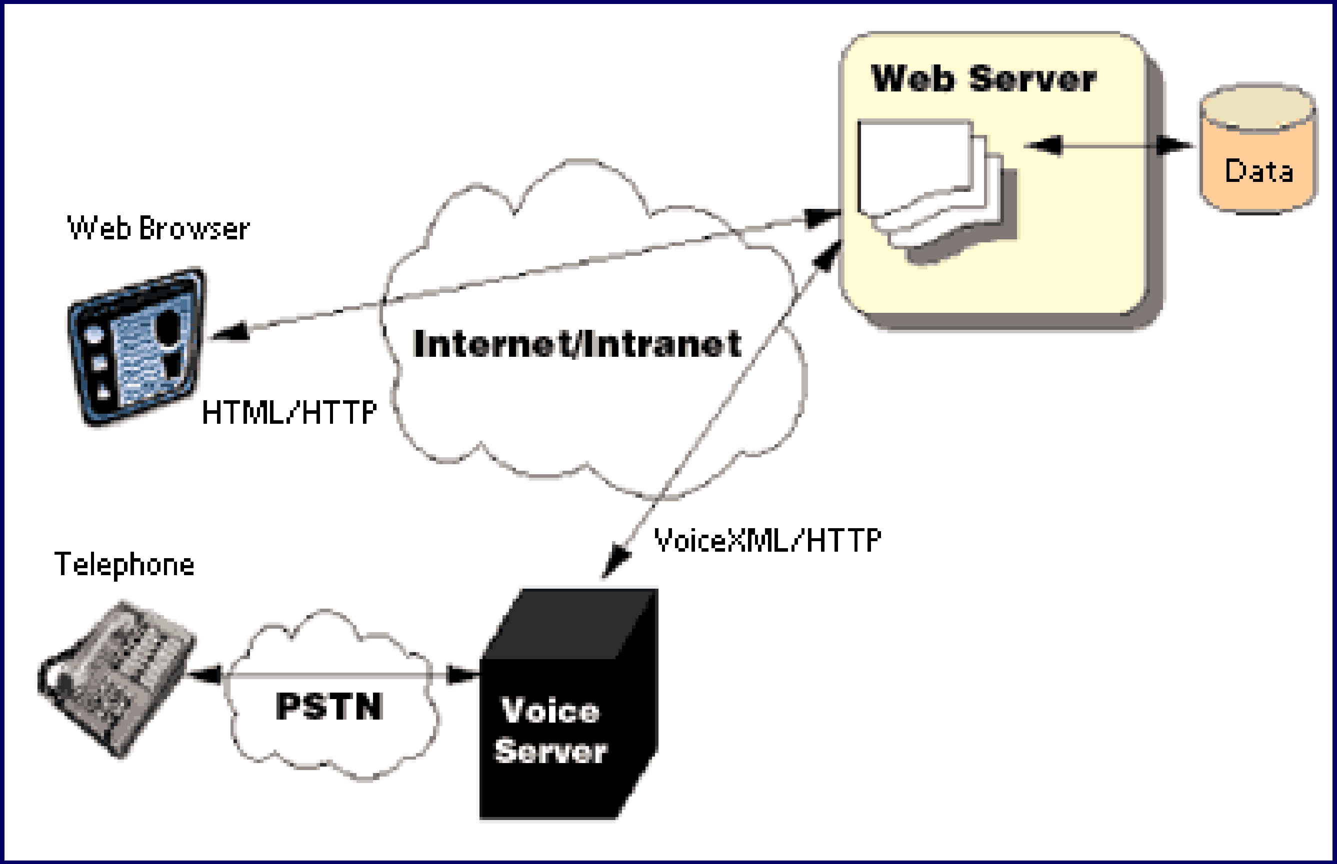
❑ **Need to send SMS:**

With this revolutionary technology, you can send SMS from your landline phone to any mobile in the world.

IVRS applications – III

- Hands free and eyes free communication
- Voice messaging and voice enabled infotainment services
- Prepaid and calling card call management
- Self configuring systems
- Flight schedules & status
- Voice mail and voice portals
- Telebanking
- Binary downloads
- Songs on request
- Telephone directory
- Call centres

Voice XML



Web Server
Data
Web Browser
Internet/Intranet
HTML/HTTP
VoiceXML/HTTP
Telephone
PSTN
Voice
Server

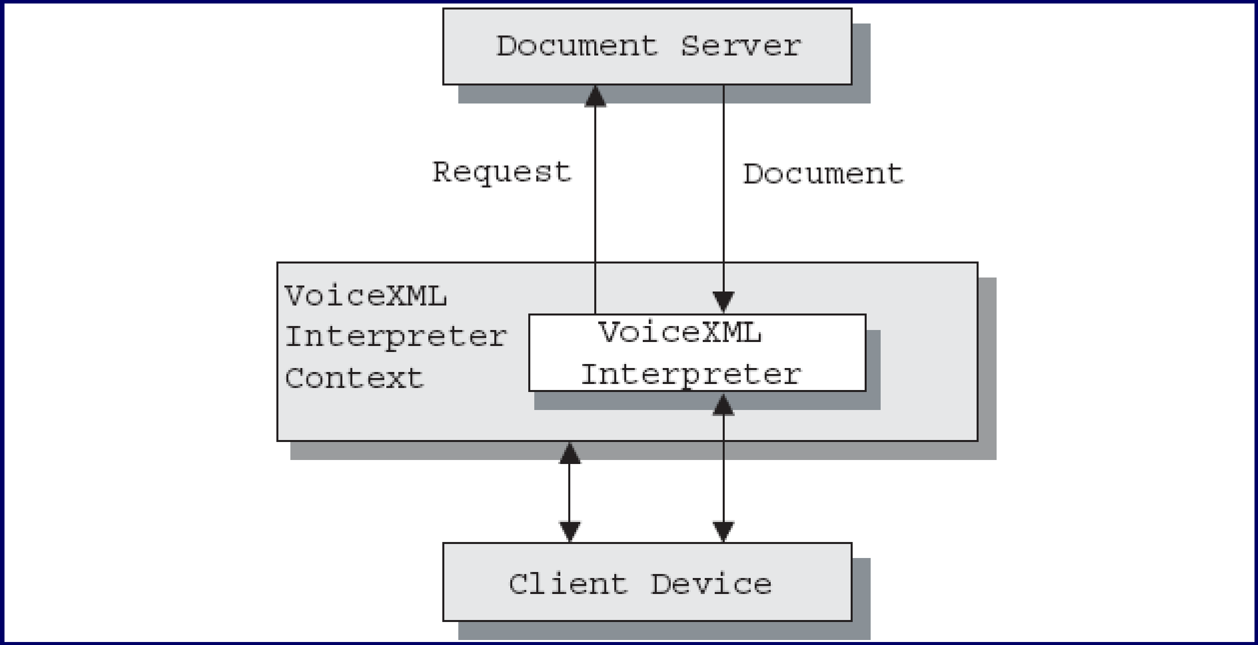
Voice XML

- XML based mark up language for creating distributed voice applications
- Creates audio dialogs that feature synthesized speech, digitized audio, spoken voice recognition and DTMF key input
- Helps creation of web based voice applications that users can access over telephone

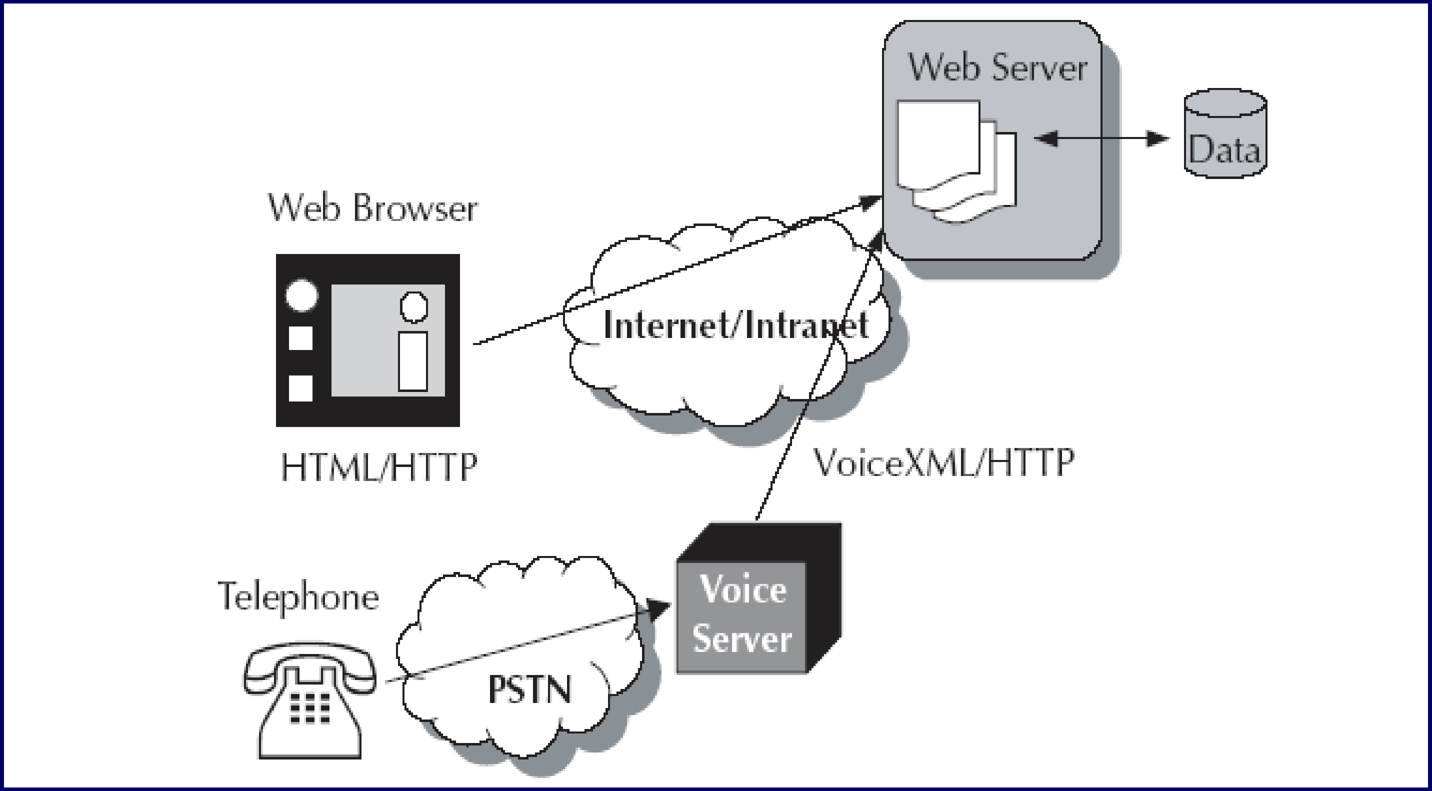
Features of Voice XML dialogs

- Spoken input
- DTMF input
- Recording of spoken input
- Synthesized speech output
- Recorded audio output
- Dialog flow control
- Scoping of input

Architecture for Voice XML



Voice XML in web environment



Voice XML in web environment

- ❑ Voice server manages several voice browser sessions.
- ❑ Each voice browser session includes one instance of voice browser, speech recognition engine and text – to – speech engine.
- ❑ Voice browser renders and interprets Voice XML documents.
- ❑ Voice and telephone are needed to access web information and services over voice browser.
- ❑ Voice XML application defines a series of dialogs between user and computer.
- ❑ The user is always in a dialog at any time and each dialog determines the next dialog to transition to.
- ❑ Transitions are specified using URI’s.

Essentials of Voice XML

- ❑ First line will always contain <?xml> element.
- ❑ Second line will always contain <vxml> element.
- ❑ Every Voice XML tag <tag> must have a associated </tag>.
- ❑ Last line should contain </vxml>.
- ❑ Prompts, grammar, form, events and links are building elements of a Voice XML document.

Prompts in Voice XML

- ❑ Information is presented through audio prompts.
- ❑ Prompts can be either pre – recorded audio or synthesized speech.
- ❑ <prompt> is used to generate TTS.
- ❑ Any text within body of prompt element is spoken.
- ❑ The software shall read out “Would you like coffee, tea, milk or nothing?” in

<prompt> Would you like coffee, tea, milk or nothing </prompt>

Grammar in Voice XML

- ❑ Every dialog has one or more speech or DTMF grammars associated with it.
- ❑ <grammar> is used to define what the caller can say to the application at any given time.
- ❑ Three types of grammar are supported: Inline, External and Built – in.
- ❑ Inline grammars are defined right in the Voice XML document.
- ❑ External grammars are specified in another file and referenced from within Voice XML document code.
- ❑ Built – in grammars are pre – specified grammars.

Forms in Voice XML

- ❑ Forms are a way of developing dialog with the caller.
- ❑ A Voice XML form is a process to present information and gather input from the caller.
- ❑ A Voice XML form is a collection of one or more fields that the caller fills in by saying something.
- ❑ Fields tell the caller what to say and define words and phrases that the caller can say.
- ❑ Based on the caller’s input, the application takes an appropriate action.

Events in Voice XML

- Events is Voice XML is a mechanism to handle situations thrown by the platform under a variety of circumstances such as when the user does not respond, requests help, etc.

Links in Voice XML

- Links support a mixed initiative.
- It specifies a grammar that is active whenever the user is in the scope of the link. If user input matches the link's grammar, control transfers to link's destination URI.
- Links can be used to throw an event to go to a destination URI.

Example of Voice XML document

```
<?xml version="1.0"?>
<vxml version="1.0">
<form id="add_funds">
        <field name="amount" type="currency">
                <prompt>How much?</prompt>
        </field>
        <field>
                <prompt>Charge to credit card or tuition
bill?</prompt>
                <grammar> credit card | credit | tuition | tuition
bill</grammar>
                </field>
</form>
</vxml>
```

Elements of Voice XML – I

<assign>	Assign a variable a value
<audio>	Play an audio clip within a prompt
<block>	Container of (non – interactive) executable code
<break>	JSML element to insert a pause in output
<catch>	Catches an event
<choice>	Define a menu item
<clear>	Clears one or more form item variables
<disconnect>	Disconnect a session
<div>	JSML elements
<dtmf>	Specify a touch – tone key grammar
<else>	Used in <if> elements
<elseif>	Used in <if> elements
<emp>	JSML element to change speech output

Elements of Voice XML – II

❑<enumerate>	Shorthand for enumerating choices in a menu
❑<error>	Catches an error event
❑<exit>	Exits a session
❑<field>	Declares an input field in a form
❑<filled>	An action executed when fields are filled
❑<form>	Presents information and collects data
❑<goto>	Goes to another dialog
❑<grammar>	Specifies a speech recognition grammar
❑<help>	Catches a help event
❑<if>	Simple conditional logic
❑<initial>	Declares initial logic
❑<link>	Specifies a transition
❑<menu>	Dialog for choosing amongst alternatives
❑<meta>	Defines a meta data item as a name/value pair

Elements of Voice XML – III

❑<noinput>	Catches a no – input event
❑<nomatch>	Catches a no – match event
❑<object>	Interacts with a custom extension
❑<option>	Specifies an option in a <field>
❑<param>	Parameter in <object> or <subdialog>
❑<prompt>	Queues TTS and audio output to the user
❑<property>	Control implementation platform settings
❑<pros>	JSML element to change the prosody of speech
❑<record>	Records an audio sample.
❑<reprompt>	Plays a field prompt when a field is re-visited
❑<return>	Returns from a sub – dialog
❑<sayas>	Modifies how a word or phrase is spoken
❑<script>	Specifies a block of ECMA script
❑<subdialog>	Invokes another dialog as a sub – dialog of the current one

Elements of Voice XML – IV

❑<submit>	Submit values to a document server
❑<throw>	Throws an event
❑<transfer>	Transfers the caller to another destination
❑<value>	Inserts the value of a expression in a prompt
❑<var>	Declares a variable
❑<vxml>	Top – level element in each Voice XML document

JSpeech Markup Language (JSML)

- JSML defines a specific set of elements to mark up text to be spoken, and defines the interpretation of those elements so that there is a common understanding between synthesizers and documents producers of how marked up text will be spoken.

- JSML elements provide a speech synthesizer with detailed information on how to 'speak' text and thus, enables improvements in the quality, naturalness and understandability of synthesized speech output.

- JSML defines elements that describe the structure of a document, provide pronunciations of words and phrases, indicate phrasing, emphasis, pitch and speaking rate, and control other important speech characteristics.

- JSML is designed to be simple to learn and use, to be portable across different synthesizers and computing platforms, and to be applicable to a wide range of languages.

Telephony Application Programming Interface

- In Telephony Application Programming Interface (TAPI), a developer can develop voice based services without going too deep into it.
- Speech Application Programming Interface (SAPI) is also one such standard.
- The use of available API's of TAPI and SAPI shall save the programmer of the pain of trying to program hardware directly.
- TAPI includes interface for convergence of both traditional PSTN and IP telephony.

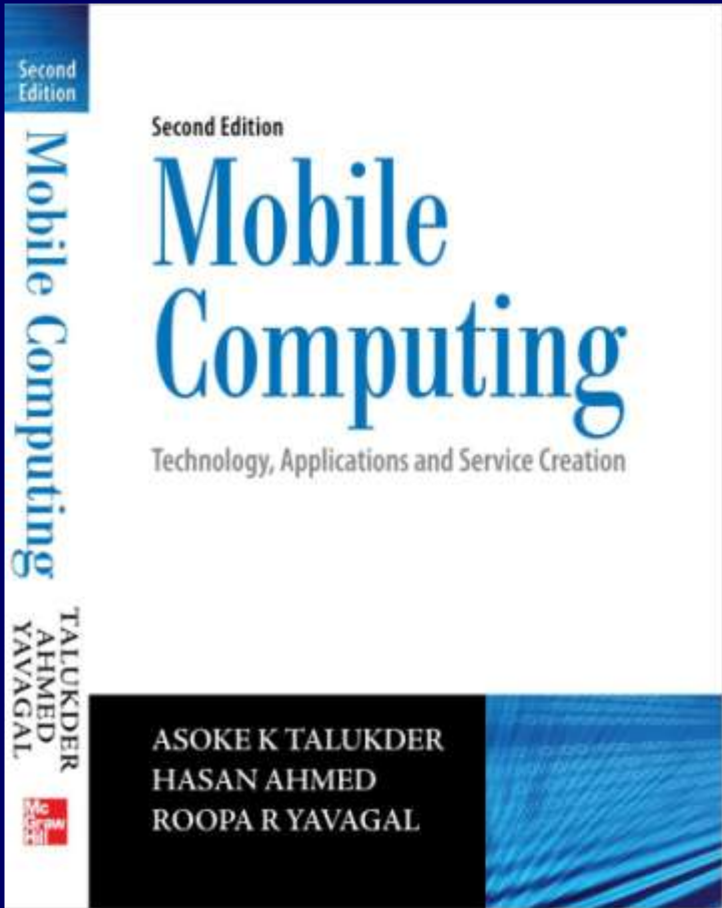
Benefits of TAPI

- Simple user interfaces to set up calls
- GUI to set up conference call
- See whom you are talking to
- Make voice attachments with electronic mails
- Users can hear voice attachments when reading mails
- Send and receive faxes
- Set and configure group and security measures

Next Chapter

Emerging Technologies

Thanks



Mobile Computing

Chapter 4

Emerging Technologies

Asoke K Talukder

Hasan Ahmed

Emerging Technologies

- Bluetooth
- Radio Frequency Identification (RFID)
- WiMAX
- Mobile IP
- IPv6
- Java Card

Bluetooth

- Name comes from nickname of Danish king Harald Blåtand
- Allows users to make ad hoc wireless connections between devices like mobile phones, desktop or notebook computers wirelessly
- Data transfer at a speed of about 720 Kbps within 50 meters (150 feet) of range or beyond through walls, clothing and even luggage bags
- Built into a small microchip
- Operates in a globally available frequency band ensuring worldwide interoperability
- Managed and maintained by Bluetooth Special Interest Group

Bluetooth Protocol

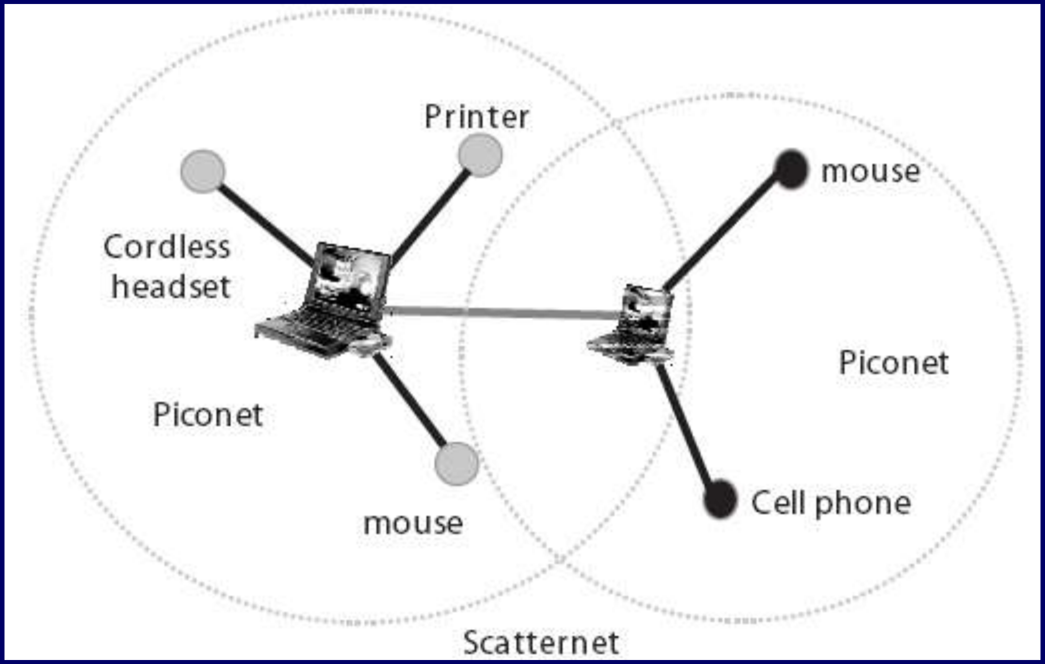
- ❑ Uses the unlicensed 2.4 GHz ISM (Industrial Scientific and Medical) frequency band
- ❑ 79 available channels spaced 1 MHz apart from 2.402 GHz to 2.480 GHz
- ❑ Allows power levels starting from 1mW (covering 10 centimetres) to 100mW (covering upto 100 meters) suitable for short device zone to personal area networks within a home
- ❑ Supports both unicast (point-to-point) and multicast (point-to-multipoint) connections
- ❑ Bluetooth protocols are a collection of many inter-related protocols

Bluetooth Protocol

- ❑ Uses the master and slave relationship
- ❑ Master and slaves together form a Piconet when master allows slaves to talk
- ❑ Up to seven 'slave' devices can be set to communicate with a 'master' in a Piconet
- ❑ Scatternet is formed when several of piconets are linked together to form a larger network in an ad hoc manner

Bluetooth Protocol

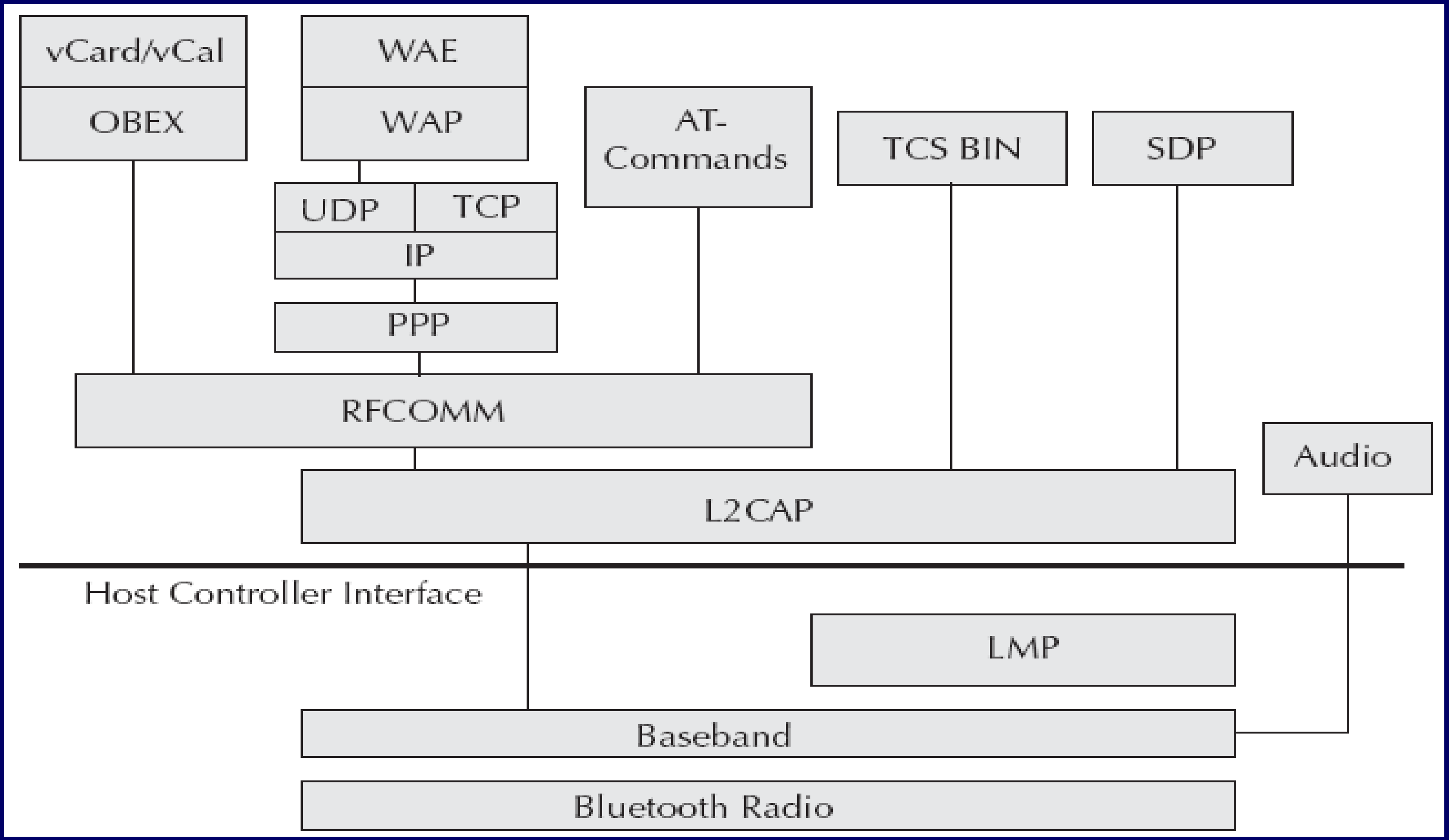
- Scatternet is a topology where a device from one piconet also acts as a member of another piconet wherein a device being a master in one piconet can simultaneously be a slave in the other one



Bluetooth Protocol

- ❑ Bluetooth Core protocols plus Bluetooth radio protocols are required by most of Bluetooth devices
- ❑ Uses spread spectrum technologies at the Physical Layer while using both direct sequence and frequency hopping spread spectrum technologies
- ❑ Uses connectionless (ACL–Asynchronous Connectionless Link) and connection-oriented (SCO–Synchronous Connection-oriented Link) links
- ❑ Cable Replacement layer, Telephony Control layer and Adopted protocol layer form application-oriented protocols

Bluetooth Protocol Stack



OBEX – Object Exchange Protocol

WAE – Wireless Application Environment

WAP – Wireless Application Protocol

LMP – Link Manager Protocol

TCS BIN – Telephony Control Specification Binary

SDP – Service Discovery Protocol

RFCOMM – Radio Frequency Communication

L2CAP – Logical Link Control and Adaptation Protocol

Bluetooth Protocol Stack

1. Bluetooth Core Protocols
2. Cable Replacement Protocol
3. Telephony Control Protocols
4. Adopted Protocols

Bluetooth Core Protocols

- Baseband – enables physical RF link
- Link Manager Protocol (LMP) – manages devices in range, power modes, connections, duty cycles, etc.
- Logical Link Control and Adaptation Protocol (L2CAP) – segmentation and re-assembly of fragmented packets with their multiplexing
- Service Discovery Protocol (SDP) – Enables a device to join a piconet

Cable Replacement Protocol

- Radio Frequency Communication (RFCOMM) - emulates RS-232 control and data signals over Bluetooth baseband protocol

Telephony Control Protocols

- Telephony Control Specification Binary (TCS BIN) - defines the call control signaling protocol and handles mobility management for groups of Bluetooth TCS devices
- Attention (AT) Commands - defines a set of commands by which a mobile phone can be used and controlled as a modem for fax and data transfers

Adopted Protocols

- Point-to-Point Protocol (PPP) - means of taking IP packets to/from the PPP layer and placing them onto the LAN
- Transmission Control Protocol/Internet Protocol (TCP/IP) - used for communication across the Internet
- Object Exchange (OBEX) Protocol - session protocol to exchange objects and used to browse the contents of folders on remote devices
- Content Formats - used to exchange messages and notes and synchronize data amongst various devices

Bluetooth Security

- ❑ Offers security infrastructure starting from authentication, key exchange to encryption
- ❑ Uses the publicly available cipher algorithm known as SAFER+ to authenticate a device’s identity

Bluetooth Application Models

Each application model in Bluetooth is realized through a Profile. Profiles define the protocols and protocol features supporting a particular usage model. Some common profiles are:

- File Transfer
- Internet Bridge
- LAN Access
- Synchronization
- Headset

RFID

- Radio Frequency Identification
- Radio transponder (known as RFID tags) carrying an ID (Identification) can be read through radio frequency (RF) interfaces
- Tag is attached to the object and data within the tag provides identification for the object
- Object could be an entity in a manufacturing shop, goods in transit, item in a retail store, a vehicle in a parking lot, a pet, or a book in a library

RFID System

Comprises of different functional areas like:

- ❑ Means of reading or interrogating the
- ❑ Mechanism to filter some of the data
- ❑ Means to communicate the data in the tag with a host computer
- ❑ Means for updating or entering customized data into the tag

RFID Tags

Three basic criteria for categorisation:

- Frequency
- Application
- Power levels

RFID tags based on frequency

- Works on six frequencies of 132.4 KHz, 13.56 MHz, 433 MHz, 918 MHz, 2.4 GHz and 5.8 GHz
- Low frequency range tags are slow in data transfer and suitable for slow moving objects, security access, asset tracking and animal identification applications
- High frequency range tags offer long reading ranges and high data transfer speed and are used for fast moving objects like railway wagon tracking and identification of vehicles on freeways for automated toll collection
- Higher the frequency, higher the data transfer rates

RFID tags based on applications

- ❑ Speed of the object and distance to be read determines the type of tag to be used
- ❑ RFID systems follow contact-less and non line-of-sight nature of the technology
- ❑ Tags can be read at high speeds
- ❑ RFID tag contains two segments of memory - one segment is a factory set and used to uniquely identify a tag while the other one is used by the application
- ❑ Read/write capability of a RFID system is an advantage in interactive applications such as work-in-process or maintenance tracking

RFID tags based on power levels

- Two types - Active and Passive tags
- Passive tags are generally in low frequency range
- Tags at higher frequency range can be either active or passive

Active Tags

- Powered by an internal battery and are typically read/write
- Memory can vary from a few bytes to 1MB
- Battery supplied power of an active tag generally gives it a longer read range
- Greater the size, greater the cost and a limited operational life

Passive Tags

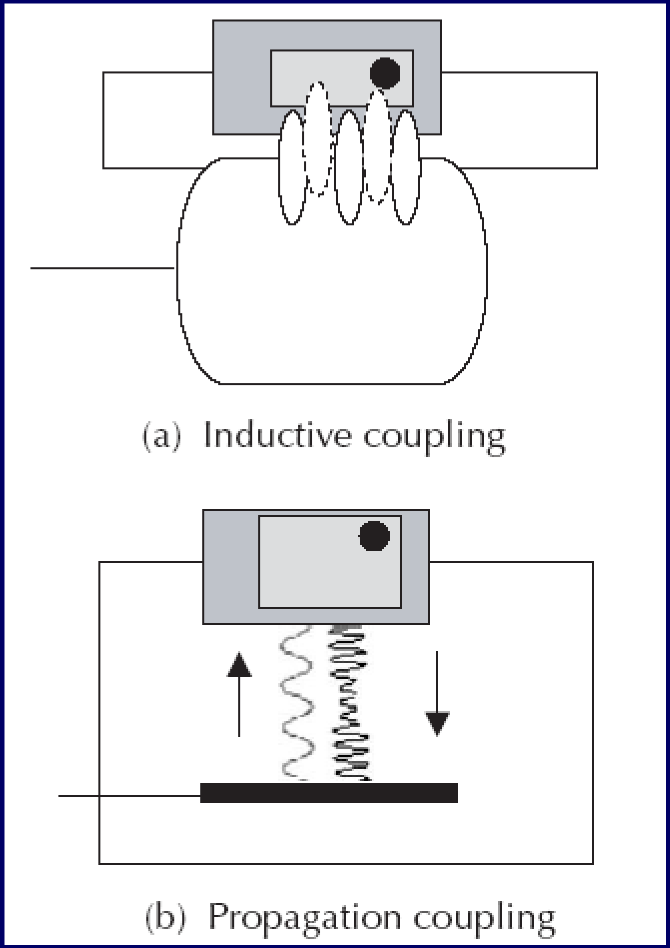
- ❑ Operate without own power source
- ❑ Obtains operating power from the reader's antenna
- ❑ Data within a passive tag is read only and generally cannot be changed during operation
- ❑ Lighter, less expensive and offer a virtually unlimited operational life
- ❑ Have shorter read ranges than active tags and require a high powered reader
- ❑ Data is usually 32 to 128 bits long

Components of an RFID system

- ❑ A transponder programmed with unique information (RFID tag)
- ❑ A transceiver with decoder (a reader)
- ❑ An antenna or coil

Close proximity passive tags rely on electromagnetic or inductive coupling techniques whereas active tags are based upon propagating electromagnetic waves techniques

Coupling in Passive and Active RFID tags



(a) Passive RFID tags

(b) Active RFID tags

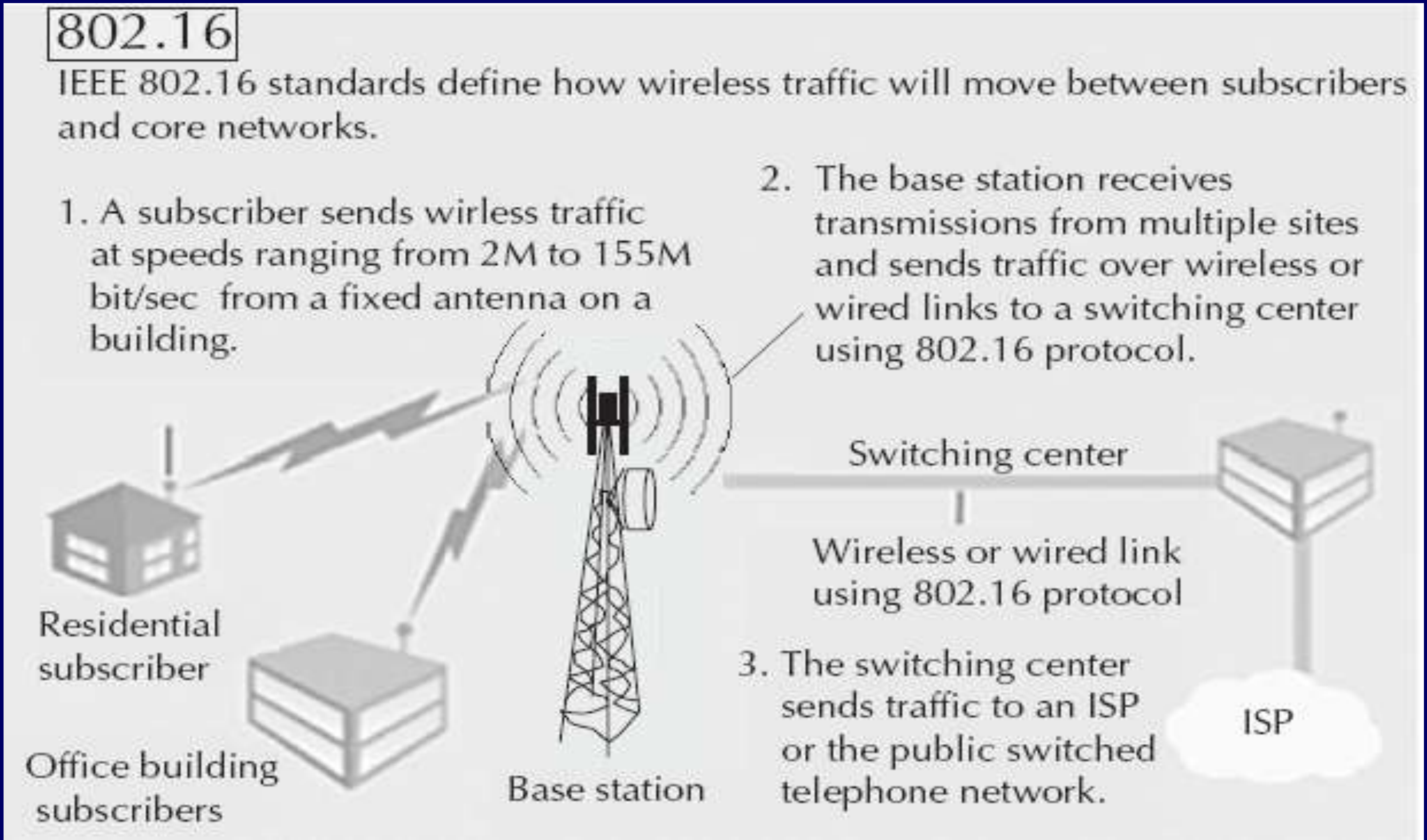
Application areas for RFID

- Transportation and Logistics
- Manufacturing and Processing
- Security
- Animal tagging
- Retail store and enterprise stores
- Community library
- Time and attendance
- Postal tracking
- Airline baggage reconciliation
- Road toll management

Wireless Broadband

- Also known as Wireless Metropolitan Area Network (Wireless MAN) and Wireless Microwave Access (WiMAX)
- IEEE 802.16 standard released in April 2002
- Offers an alternative to high bandwidth wired access networks like fiber optic, cable modems and DSL
- Provides network access to buildings through exterior antennas communicating with radio base stations
- Networks can be created in just weeks by deploying a small number of base stations on buildings or poles to create high capacity wireless access systems

Overview of IEEE 802.16



Sub-standards of IEEE 802.16

- IEEE 802.16.1 - Air interface for 10 to 66 GHz
- IEEE 802.16.2 - Coexistence of broadband wireless access systems
- IEEE 802.16.3 - Air interface for licensed frequencies, 2 to 11 GHz

Basics of IEEE 802.16

IEEE 802.16 standards are concerned with the air interface between a subscriber's transceiver station and a base transceiver station

- The Physical Layer
- MAC Layer
- Convergence Layer

Physical Layer

- Specifies the frequency band, the modulation scheme, error-correction techniques, synchronization between transmitter and receiver, data rate and the multiplexing structure
- Both TDD and FDD alternatives support adaptive burst profiles in which modulation and coding options may be dynamically assigned on a burst-by-burst basis
- Three physical layer for services: Wireless MAN-SC2, Wireless MAN-OFDM and Wireless MAN-OFDMA

Medium Access Control Layer

- ❑ Designed for point-to-multipoint broadband wireless access
- ❑ Addresses the need for very high bit rates, both uplink (to the base station) and downlink (from the base station)
- ❑ Services like multimedia and voice can run as 802.16 MAC is equipped to accommodate both continuous and bursty traffic

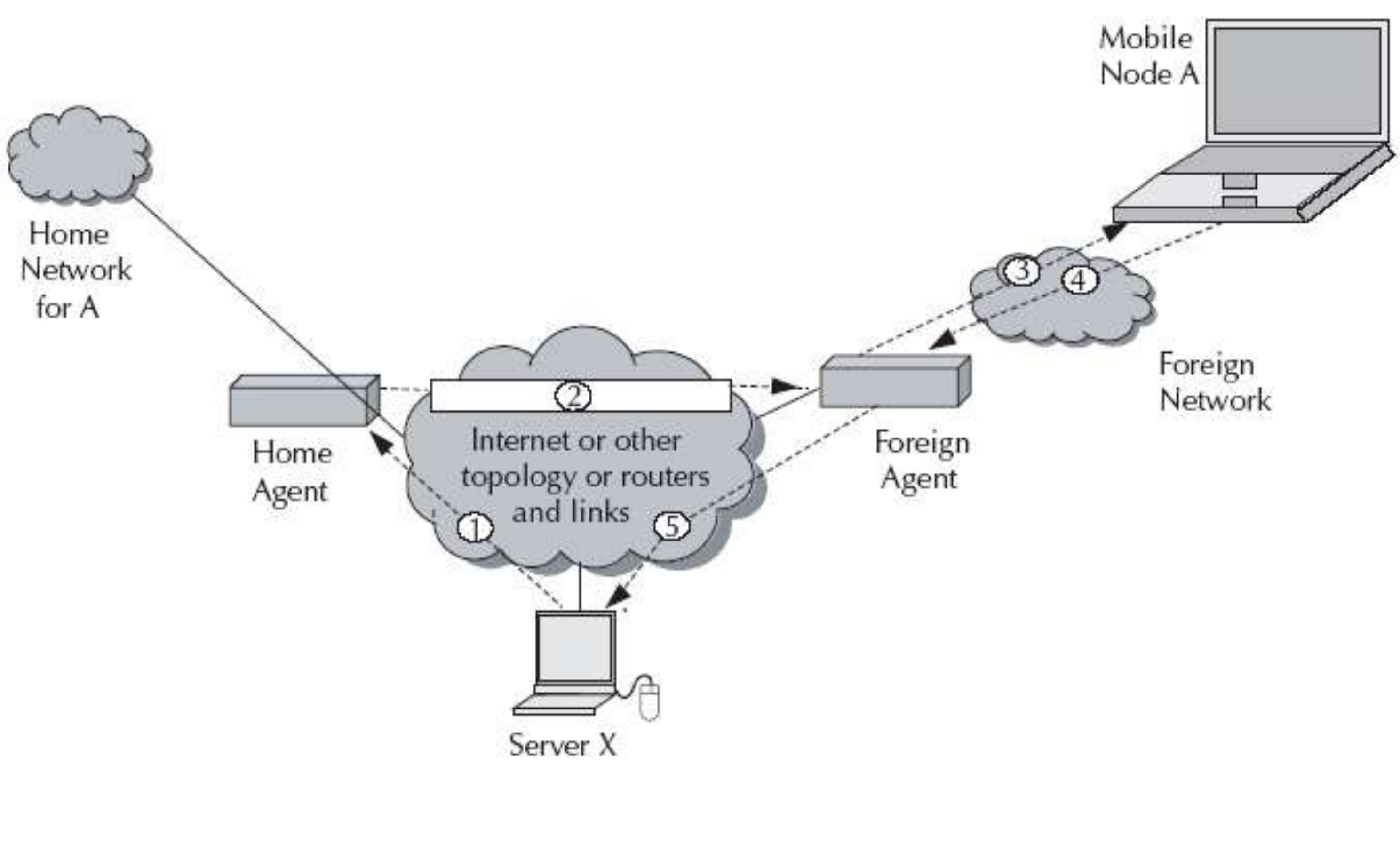
Convergence Layer

- Provides functions specific to the service being provided
- Bearer services include digital audio/video multicast, digital telephony, ATM, Internet access, wireless trunks in telephone networks and frame relay

Mobile IP

- ‘Mobile IP’ signifies that, while a user is connected to applications across the Internet and the user’s point of attachment changes dynamically, all connections are maintained despite the change in underlying network properties
- Similar to the handoff/roaming situation in cellular network
- Mobile IP allows the mobile node to use two IP addresses called home address and care of address
- The home address is static and known to everybody as the identity of the host
- The care of address changes at each new point of attachment and can be thought of as the mobile node’s location specific address

Working of Mobile IP



Working of Mobile IP

Let's take the case of mobile node (A) and another host (server X). The following steps take place:

- ❑ Server X wants to transmit an IP datagram to node A. The home address of A is advertised and known to X. X does not know whether A is in the home network or somewhere else. Therefore, X sends the packet to A with A's home address as the destination IP address in the IP header. The IP datagram is routed to A's home network.

Working of Mobile IP

- At the A's home network, the incoming IP datagram is intercepted by the home agent. The home agent discovers that A is in a foreign network. A care of address has been allocated to A by this foreign network and available with the home agent. The home agent encapsulates the entire datagram inside a new IP datagram, with A's care of address in the IP header. This new datagram with the care of address as the destination address is retransmitted by the home agent.

- At the foreign network, the incoming IP datagram is intercepted by the foreign agent. The foreign agent is the counterpart of the home agent in the foreign network. The foreign agent strips off the outer IP header, and delivers the original datagram to A.

Working of Mobile IP

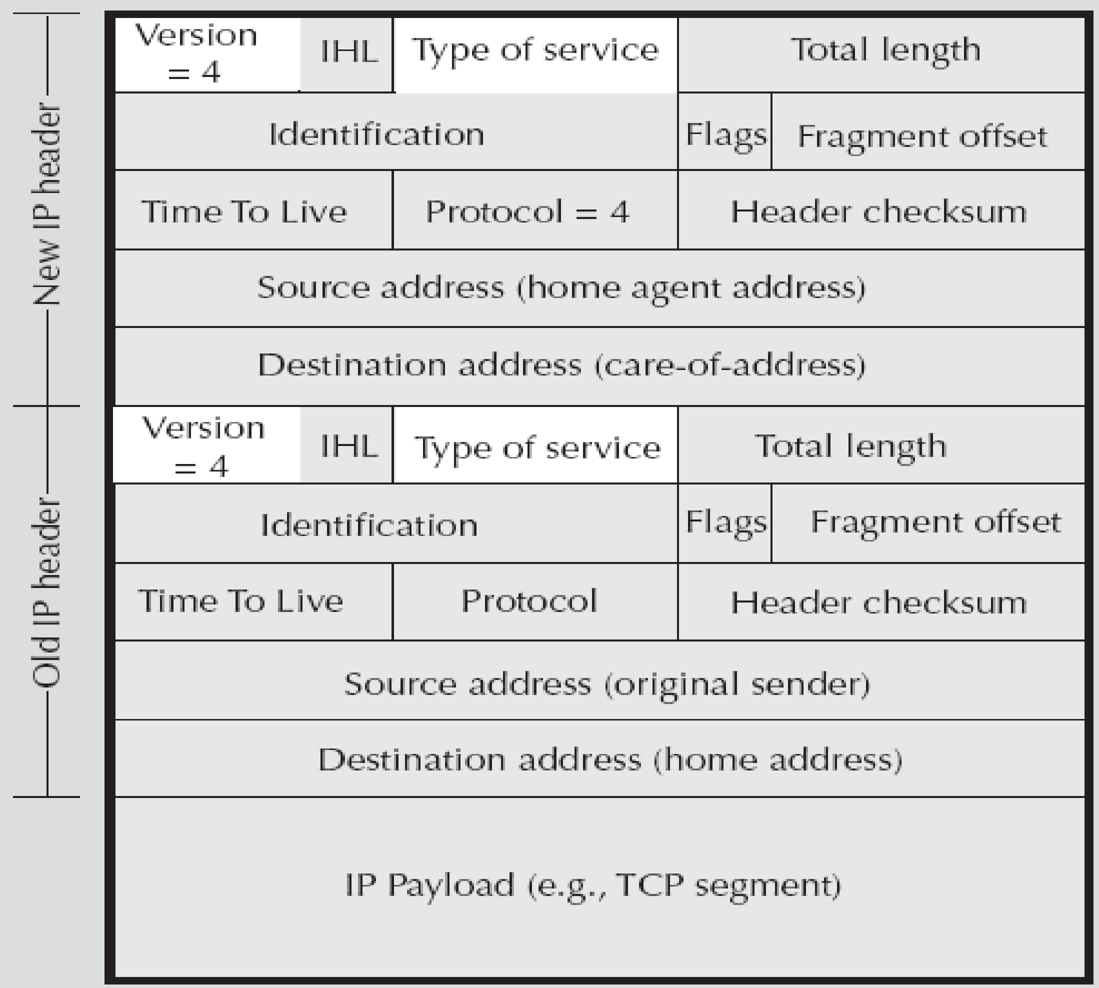
- A intends to respond to this message and sends traffic to X. In this example, X is not mobile; therefore X has a fixed IP address. For routing A's IP datagram to X, each datagram is sent to some router in the foreign network. Typically, this router is the foreign agent. A uses X's IP static address as the destination address in the IP header.

- The IP datagram from A to X travels directly across the network, using X's IP address as the destination address.

Working of Mobile IP

- Discovery - A mobile node uses a discovery procedure to identify prospective home agents and foreign agents.
- Registration - A mobile node uses a registration procedure to inform its home agent of its care-of address.
- Tunneling - Tunneling procedure is used to forward IP datagrams from a home address to a care of address.

IP headers in Mobile IP



Unshaded fields are copied from the inner IP header to the outer IP header.

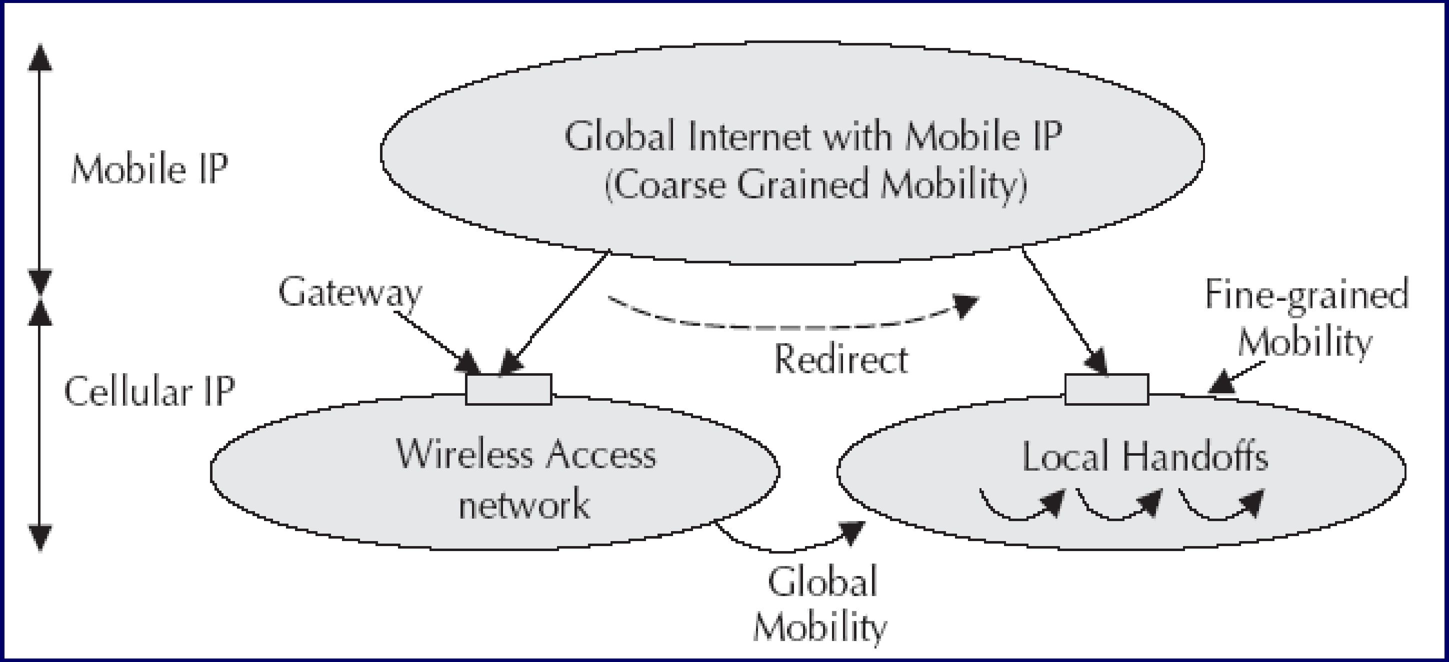
Cellular IP

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 each node only needs to know on which of its outgoing ports to forward packets. This limited routing information (referred as mapping) is local to the node and does not assume that nodes have any knowledge of the wireless network topology. Mappings are created and updated based on the packets transmitted by mobile hosts.

Cellular IP

- ❑ Uses two parallel structures of mappings through Paging Caches (PC) and Routing Caches (RC)
- ❑ PCs maintain mappings for stationary and idle (not in data communication state) hosts
- ❑ RC maintains mappings for mobile hosts
- ❑ Mapping entries in PC have a large timeout interval, in the order of seconds or minutes. RCs maintain mappings for mobile hosts currently receiving data or expecting to receive data

Relationship between Mobile IP and Cellular IP



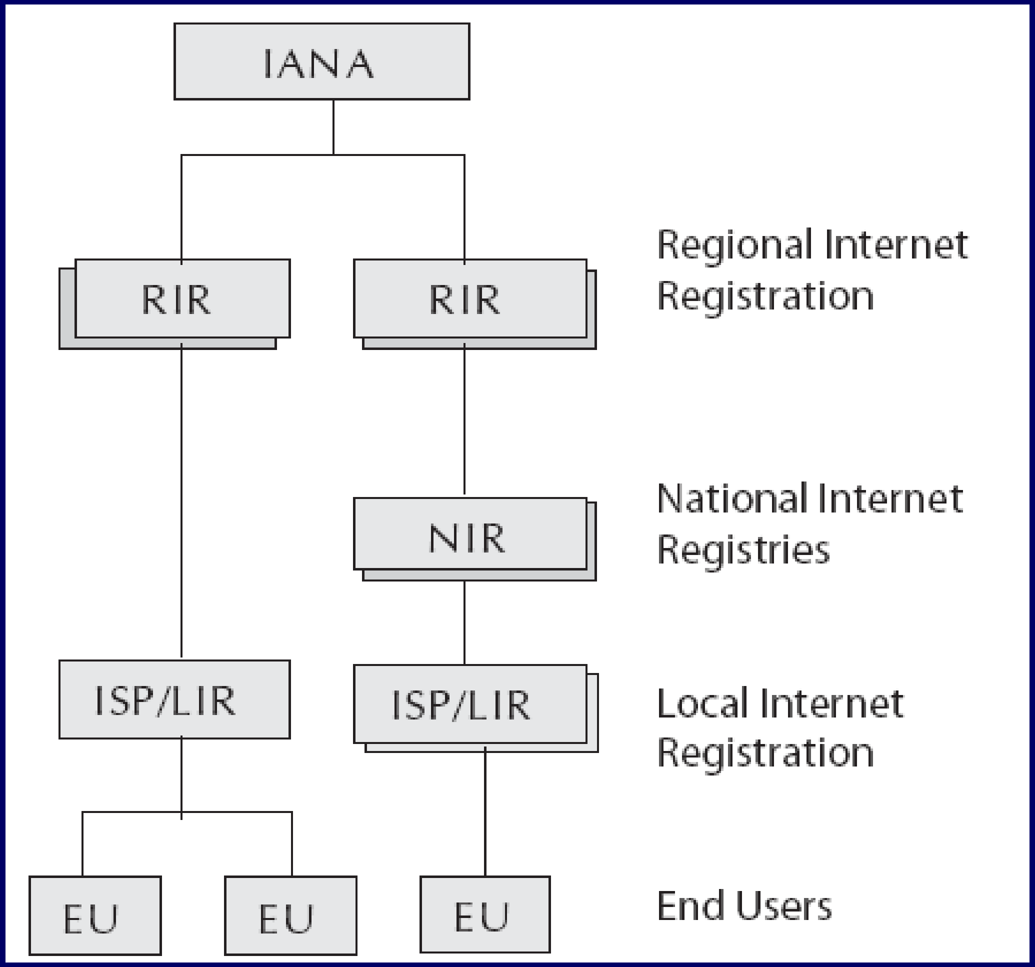
Internet Protocol version 6

- ❑ Successor to today's IP version 4 protocol (IPv4)
- ❑ Internet Engineering Task Force (IETF) has produced a comprehensive set of specifications (RFC 1287, 1752, 1886, 1971, 1993, 2292, 2373, 2460, 2473, etc.) that define the next-generation IP protocol originally known as 'IPNg'
- ❑ Uses 128 bit addresses for each packet creating a virtually infinite number of IP addresses (approximately 3.4*10**38 IP addresses) as opposed to 3758096384 IPv4 addresses

IPv6

- There are global addresses and local addresses
- Global addresses are used for routing of global Internet
- Link local addresses are available within a subnet
- IPv6 uses hierarchical addressing with three level of addresses
- Includes a Public Topology (the 48 bit external routing prefix)
- Site Topology (typically a 16 bit subnet number)
- Interface Identifier (typically an automatically generated 64 bit number unique on the local LAN segment)

Hierarchical addressing of IPv6



IPv6 Security

- Comes native with a security protocol called IP Security (IPSec)
- IPSec protocol is a standards-based method of providing privacy, integrity and authenticity to information transferred across IP networks

Features of IPSec

- ❑ Diffie-Hellman key exchange mechanism for deriving key between peers on a public network
- ❑ Public key cryptography to guarantee the identity of the two parties and avoid man-in-the-middle attacks
- ❑ Bulk encryption algorithms, such as 3DES, for encrypting the data
- ❑ Keyed hash algorithms, such as HMAC, combined with traditional hash algorithms such as MD5 or SHA for providing packet authentication
- ❑ Digital certificates signed by a certificate authority to act as digital ID cards
- ❑ IPSec provides IP network layer encryption

Migrating from IPv4 to IPv6

- ❑ Migration of the network components to be able to support IPv6 packets. Using IP tunneling, IPv6 packets can propagate over an IPv4 envelope. Existing routers can support IP tunneling.

- ❑ Migration of the computing nodes in the network. This will need the operating system upgrades so that they support IPv6 along with IPv4. Upgraded systems will have both IPv4 and IPv6 stacks.

- ❑ Migration of networking applications in both client and server systems. This requires porting of the applications from IPv4 to IPv6 environment.

Interconnecting IPv6 networks

- Tunneling is one of the key deployment strategies for both service providers as well as enterprises during the period of IPv4 and IPv6 coexistence.
- Tunneling service providers can offer an end-to-end IPv6 service without major upgrades to the infrastructure and without impacting current IPv4 services.

Tunneling Mechanisms

- ❑ Manually created tunnels such as IPv6 manually configured tunnels (RFC 2893)
- ❑ IPv6 over IPv4 tunnels
- ❑ Semiautomatic tunnel mechanisms such as that employed by tunnel broker services
- ❑ Fully automatic tunnel mechanisms such as IPv4 compatible

Mobile IP with IPv6

- ❑ IPv6 with hierarchical addressing scheme can manage IP mobility much efficiently.
- ❑ IPv6 also attempts to simplify the process of renumbering which could be critical to the future routing of the Internet traffic.
- ❑ Mobility Support in IPv6, as proposed by the Mobile IP working group, follows the design for Mobile IPv4. It retains the ideas of a home network, home agent and the use of encapsulation to deliver packets from the home network to the mobile node's current point of attachment.
- ❑ While discovery of a care of address is still required, a mobile node can configure its a care of address by using Stateless Address Auto-configuration and Neighbor Discovery. Thus, foreign agents are not required to support mobility in IPv6.

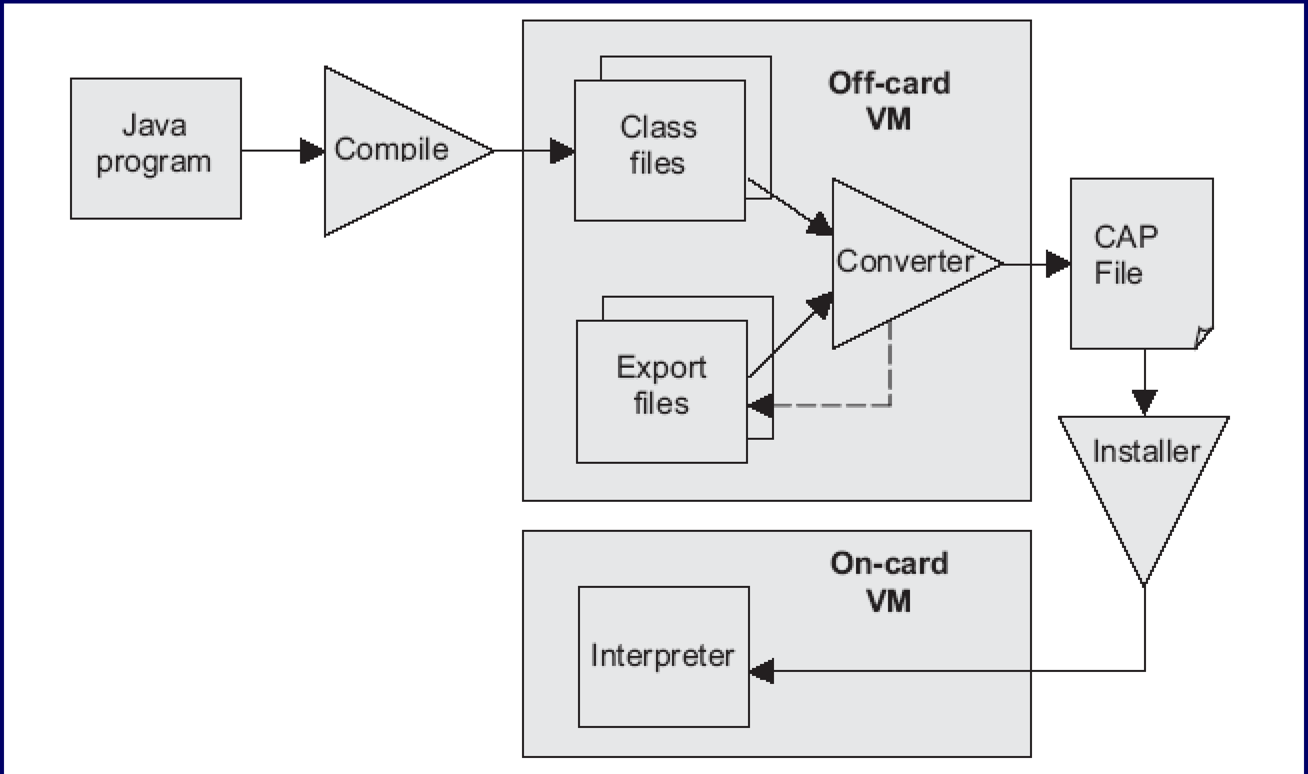
Java Card

- Smart card with Java framework
- Smart card is a plastic card with intelligence and memory
- A smart card is embedded with either (i) a microprocessor and a memory chip or (ii) only a memory chip with non-programmable logic
- A microprocessor card can have an intelligent program resident within the card which can add, delete, and otherwise manipulate information on the card
- A memory card can store some information for some pre-defined operation

Java Card

- ❑ Java was chosen as the vehicle for interoperability
- ❑ All the microprocessor based smart cards now offer Java API framework on the smart card
- ❑ Java Card technology preserves many of the benefits of the Java programming languages such as productivity, security, robustness, tools, and portability
- ❑ For Java card, the Java Virtual Machine (JVM), the language definition, and the core packages have been made more compact to bring Java technology to the resource constrained smart cards

Architecture of Java Card



Functioning of Java Card

- Java card technology supports OTA (Over The Air) downloads
- Applications written for the Java Card platform are referred to as applets
- Challenge of Java Card technology on smart card is to fit Java system software in a resource constraint smart card while conserving enough space for applications
- The Java Card virtual machine on a smart card is split into two parts; one that runs off-card and the other that runs on-card

Functioning of Java Card

- ❑ Many processing tasks that are not constrained to execute at run time, such as class loading, bytecode verification, resolution and linking, and optimization, are dedicated to the virtual machine that is running off-card where resources are usually not a concern
- ❑ The on-card components of Java Card include components like the Java card virtual machine (JCVM), the Java card runtime environment (JCRE), and the Java API
- ❑ Task of the compiler is to convert a Java source into Java class files
- ❑ The converter will convert class files into a format downloadable into the smart card while ensuring the byte code validity

Functioning of Java Card

The converter checks the classes off-card for

- ❑ Well formedness
- ❑ Java Card subset violations
- ❑ Static variable initialization
- ❑ Reference resolution
- ❑ Byte code optimization
- ❑ Storage Allocation.
- ❑ The java card interpreter
- ❑ Executes the applets
- ❑ Controls run-time resources
- ❑ Enforces runtime security

Functioning of Java Card

- ❑ Following conversion by the off-card VM into CAP (Converted APlet) format, the applet is transferred into the card using the installer
- ❑ Applet is selected for execution by the JCRE
- ❑ JCRE is made up of the on-card virtual machine and the Java Card API classes and performs additional runtime security checks through applet firewall
- ❑ Applet firewall partitions the objects stored into separate protected object spaces, called contexts and controls the access to shareable interfaces of these objects
- ❑ It is then executed on JVCM which is scaled down version of standard JVM (Java Virtual Machine)

Next Chapter

Global System for Mobile Communications (GSM)

Thanks