# Core Course-XV-17PCS11 MOBILE COMPUTING

**Credits: 4**

## Course Objectives

- To introduce the characteristics, basic concepts and system issues in mobile computing
- To study the various concepts like GSM, CDMA, and 3G of Mobile Communications
- To illustrate architecture and protocols in mobile computing

## UNIT - I

Mobile Computing - Dialog Control - Networks - Middleware and Gateways - Application and

Services - Developing Mobile Computing Applications - Standards - Standard Bodies - Players

in Wireless Space. Mobile Computing Architecture: Architecture for Mobile Computing - Three

Tier Architecture - Design Considerations for Mobile Computing

## UNIT - II

Mobile Computing Through Telephony: Evolution of Telephony - Multiple Access Procedure - Mobile Computing Through Telephone - Voice XML - TAPI - Emerging Technologies: Bluetooth - RFID - Mobile IP - IPV6.

## UNIT - III

GSM: Global System for Mobile Communications - GSM Architecture - GSM Entities - Call Routing in GSM - GSM Address and Identifiers - Network Aspects in GSM. SMS: Mobile Computing Over SMS - SMS - Value Added Services through SMS.

## UNIT - IV

GPRS: GPRS and Packet Data Network - GPRS Network Architecture - Data Services in GPRS

- Billing and Charging in GPRS. WAP: Evolution of Wireless Data and WAP - GPRS Applications.
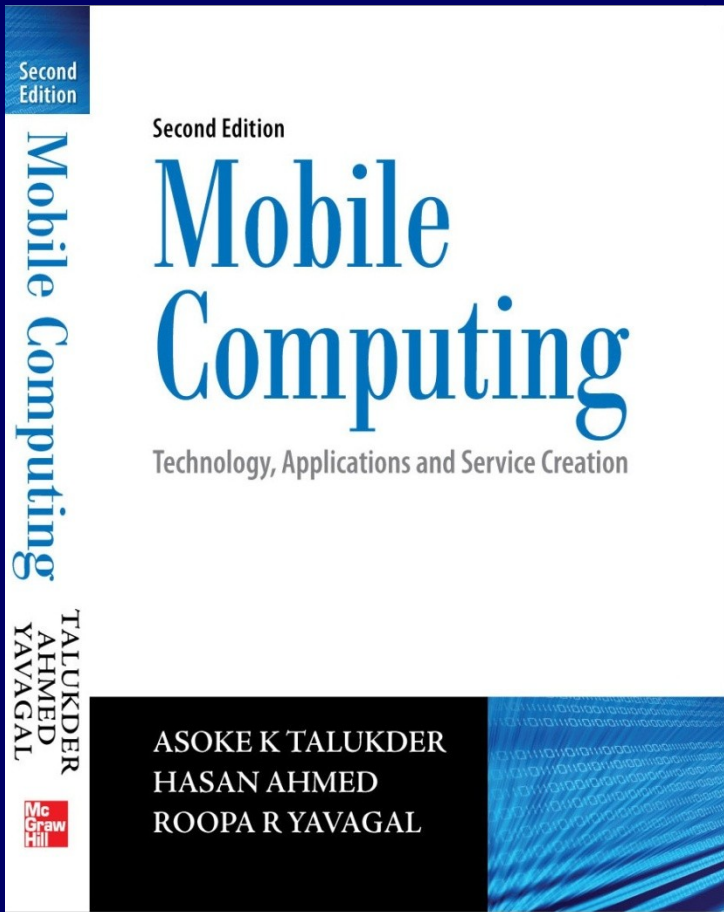
## UNIT - V

CDMA and 3G: Introduction - Architecture CDMA versus GSM - IEEE 802.11Standards - Wireless Data. Wireless LAN: Introduction - Wireless Advantages - Wireless LAN Architecture - Types of Wireless LAN - Mobility in Wireless LAN - Wireless LAN Security. Next Generation Networks - OFDM - MPLS - Wireless asynchronous transfer Mode - Multimedia Broadcast Services.

## TEXT BOOK

1. Asoke K Talukder, Roopa R Yavagal, Mobile Computing, Second Edition, Tata McGraw Hill Publishing Company Limited, 2010.

## REFERENCE BOOKS

1. Jochen Schiller, Mobile Communications, Pearson Education, Second Edition, 2011
2. William C.Y. Lee , Mobile Cellular Telecomunications, Second Edition, McGraw Hill, *1995*

**Second Edition**

**Mobile Computing**

Technology, Applications and Service Creation

**ASOKE K TALUKDER**
**HASAN AHMED**
**ROOPA R YAVAGAL**

# Mobile Computing

# Chapter 1
# Introduction

Asoke K Talukder

Hasan Ahmed

# Information … the foundation

- Information is power

- Information – the key ingredient of decision making process

- Information – the basic differentiator between human beings and animals

- Information – the harbinger of new technologies and concepts

- Information – the underlying foundation of world's greatest economies

- Information – the currency of today's businesses

- Information – the basic need for proliferation of human civilization

# Is it fiction or fact ?

# Where are we moving to ?

| | Yesterday | Today | Tomorrow |
|---|---|---|---|
| **Computing means …** | Centralized mainframes to distributed | Distributed to centralized servers | Centralized servers with ubiquitous computing, ASP, etc. |
| **Protocols** | Proprietary | Industry Standard -TCP/IP, GSM, etc. | TCP/IP, Bluetooth IEEE W LAN, CDMA, 3G, etc. |
| **Access** | Direct terminals, Private Networks, etc. | Global (restricted) through Internet & VPR | Ubiquity (anywhere, anytime, any device) through Internet & WVPR |
| **Content** | Data only | Data / Images | Data, Voice, Streaming & Real time multimedia |
| **Access media** | Character mode, Teletype, fixed wired devices, etc. | GUI, Multimedia, fixed wired device & Internet | Pervasive / Ubiquitous, wired, wireless, Internet, & Intelligent Networks |
| **Application management** | Centralized | Centralized / Distributed | Static/Mobile agents, Centralized, Distributed, etc. |

# Mobility … the basic human instinct

❑ Mobility differentiates animals from plants

❑ Human beings – the most adventurous and risk taking creation

❑ Examples:

- Man going to Moon

- British coming to India

- Indian entrepreneurs success in USA

- Spread of Buddhism in far east

# Physical to logical mobility

❑ Early milestones of mobility

▪ Joseph Henry sends electric current to ring a bell over one mile of wire in 1830.

▪ Samuel F B Morse invented telegraph and sent "What hath God wrought ?" from Washington to Baltimore over 40 miles on May 24, 1844.

▪ Alexander Graham Bell sent the first telephonic message over wire on March 10, 1876, in Boston, Massachusetts.

# For computing while being mobile, we need …

❑ Access to data

❑ Access to information

❑ Access to knowledge

❑ Access to wisdom

# Fruits of the past – Dotcom boom and burst

❑ Dotcom boom established Internet as the Information Super Highway.

❑ Appetite for data is going to increase in every sphere of social life.

❑ Business sense makes a business sense.

❑ Mobility is going to be the key technology driver for future.

❑ Global service portability is going to be critical to the success of enterprises wireless proliferation.

❑ Mobile computing is a reality.

# Milestones for the Internet

- ❑ 1957 – ARPA founded following USSR's Sputnik launch
- ❑ 1961 – Leonard Kleinrock, MIT – first paper on "Packet Switch"
- ❑ 1964 – Paul Baran, RAND, No single outage point
- ❑ 1965 – TX-2 at MIT Lincoln Lab and AN / FSQ-32 at System Development Corporation (Santa Monica, CA) are directly linked (without packet switches) via a dedicated 1200 bps phone line
- ❑ 1971 – Ray Tomlinson invents email
- ❑ 1972 – First public demo of Internet in ICCC, Telnet / FTP invented
- ❑ 1983 – 1st January TCP / IP became the Internet protocol
- ❑ 1991 – Tim Berners Lee invents World Wide Web
- ❑ 2000 – Internet boom
- ❑ 2002 – Dotcom bust

# Motivations for Mobile Computing

❑ Think of …

▪ You are traveling. You are in a place you are not familiar with. It is quite late at night. Suddenly you had a flat tyre, or it started raining, or you need to  catch a train from the nearest station.

▪ You need to know train timing, direction to the station, or the nearest hotel with direction, or where you are, etc.

▪ You need an alert if any of the robots goes down for more than 5 minutes.

▪ You want to be notified if a particular mail is received in your mailbox from a very important client.

# Mobile Computing

Can be defined as "a computing environment over physical mobility"

❑ The user should be able to access data, information, or other logical objects from any device in any network while on the move.

❑ It should allow a user to perform a task from anywhere using a computing device in the public, corporate and personal information spaces.

❑ The communication bearer should be spread over both – wired and wireless media.

# Different names of Mobile Computing

- ❑ VHE – Virtual Home Environment
- ❑ Anywhere, anytime information
- ❑ Nomadic computing
- ❑ Pervasive computing
- ❑ Ubiquitous computing
- ❑ Global service portability
- ❑ Wearable computers
- ❑ Context aware computing

# Attributes of ubiquity

- ❑ Network Mobility
- ❑ Bearer Mobility
- ❑ Device Mobility
- ❑ Session Mobility
- ❑ Service Mobility
- ❑ Host Mobility
- ❑ User Mobility

# Network Mobility

❏ User should be able to move from one network to another network and use the same service.

Example: User moves from Hong Kong to Singapore and uses the same GSM phone to access the corporate application.

# Bearer Mobility

❑ User should be able to move from one bearer to another while using the same service.

Example: User is unable to access the WAP bearer due to some problem in the GSM network then he should be able to use voice or SMS bearer to access that same corporate application.

# Device Mobility

❑ User should be able to move from one device to another and use the same service.

Example: User is using a PC to do his work. During the day, while he is on the street he would like to use his Palmtop to access the corporate application.

# Session Mobility

❑ A user session should be able to move from one user - agent environment to another.

Example: An unfinished session moving from a mobile device to a desktop computer is a good example.

# Service Mobility

❑ User should be able to move from one service to another.

Example: User is writing a mail. Suddenly, he needs to refer to something else. In a PC, user simply opens another service and moves between them. User should be able to do the same in small footprint wireless devices.

# Host Mobility

❑ User should be able to move while the device is a host computer.

Example: The laptop computer of a user is a host for grid computing network. It is connected to a LAN port. Suddenly, the user realizes that he needs to leave for an offsite meeting. He disconnects from the LAN and should get connected to wireless LAN while his laptop being the host for grid computing network.
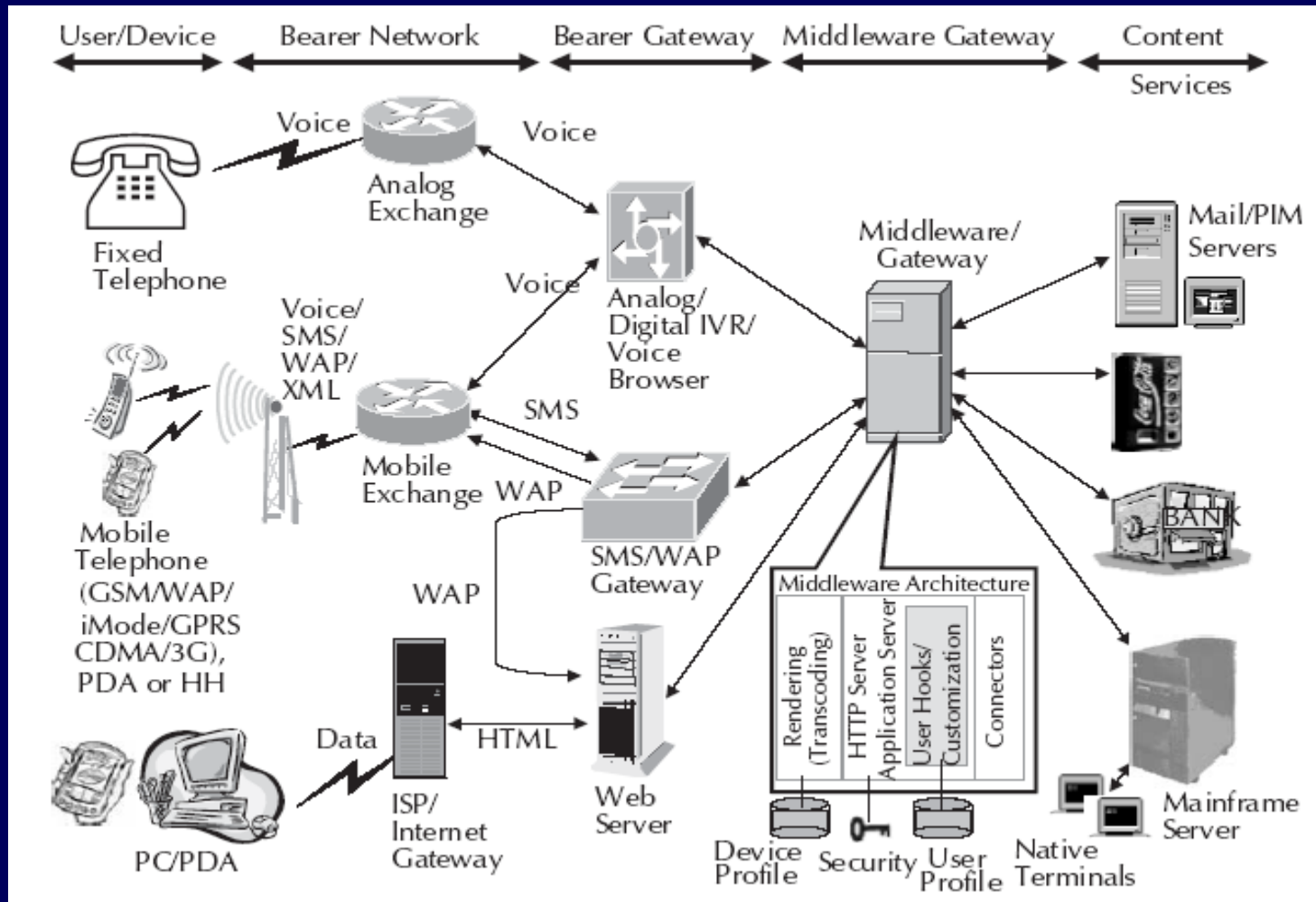
# User Mobility

❑ User should be able to move from one physical location to another location and use the same service.

Example: User moves from London to New York and uses the Internet in either place to access the corporate application.

# Mobile Computing Functions
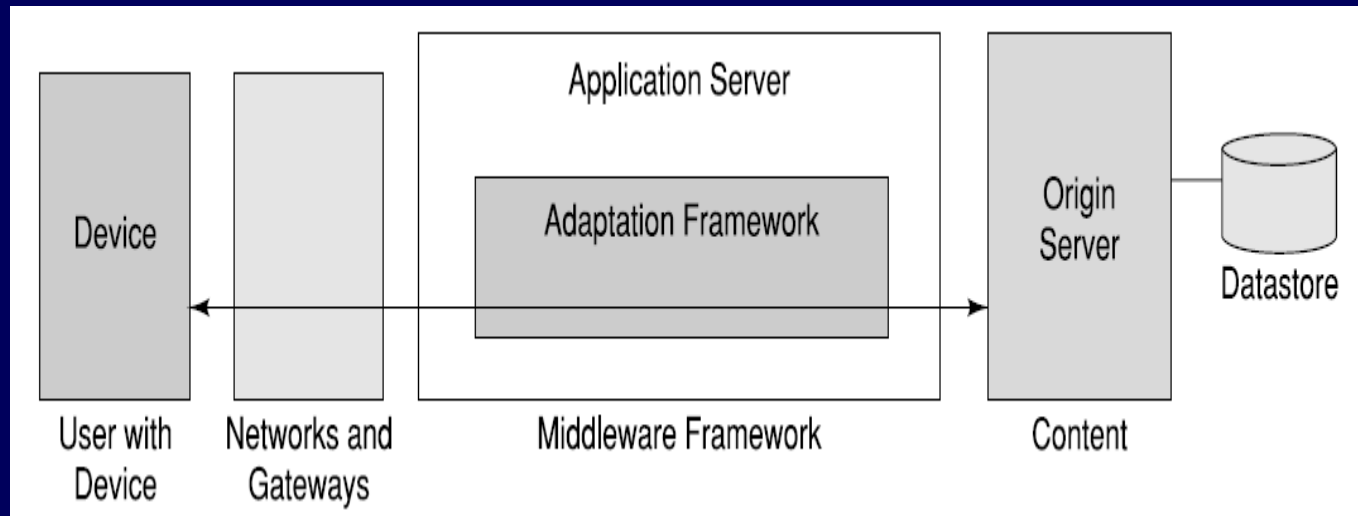
# Mobile Computing Environment

# Mobile Computing Devices

❑ The usage of devices are becoming more and more integrated.

❑ The Human Computer Interaction (HCI) plays a critical role in effectiveness, efficiency and user experience.

❑ The challenges in HCI are:

- Interaction must be consistent from one device to another.

- Interaction has to be appropriate for a particular device and environment in which the system is being used.

# Dialogue Control

There can be two types of user dialogues:

❑ Long session oriented transactions

❑ Short transactions

# Networks for Mobile Computing

Mobile Computing can use different networks such as:

❑ Fixed line telephone networks

❑ GSM

❑ GPRS

❑ ATM

❑ Frame Relay

❑ ISDN

❑ CDMA

❑ CDPD

❑ DSL and many more as such …

# Middleware and Gateways

A software layer between a user application and operating system can be termed as middleware. Gateways are deployed when there are different transport bearers or networks with dissimilar protocols. The various types are:

❑ Communication middleware

❑ Transaction processing middleware

❑ Behavior management middleware

❑ Communication gateways

❑ Database middleware

❑ Message oriented middleware

# Mobile applications

❑ Mobile application at static state (Portable Computing)

   - Computing while being mobile (may not be networked)

❑ Occasionally connected computing

   - Computing while being mobile and occasionally connected

❑ Vehicular (mobile and connected)

   - Computing while being mobile and always connected

# Mobile application attributes

❑ It needs a multi layer architecture.

❑ For data mobility, it needs network of networks.

❑ For data portability, it needs data / file to be on a centralized server.

❑ It requires a universal thin client (executable in any device) only to do the rendering at the device.

❑ Execution environment should be independent of rendering.

# Effect of mobility on protocol stack

❑ Application

 - adaptations with context awareness and security

❑ Transport

 - congestion, flow control, QoS and security

❑ Network

 - addressing, routing and security

❑ Link

 - media access and handoff

❑ Physical

 - transmission errors and interference

# Limitations of Mobile Computing

❑ Limitations of the wireless network

    - heterogeneity of fragmented networks

    - frequent disconnections

    - limited communication bandwidth

❑ Limitations imposed by mobility

    - lack of mobility awareness by system / applications

    - route breakages

❑ Limitations of the mobile computer

    ❑ short battery lifetime

    ❑ limited capacities (memory, processing speed, etc.)

# Applications and services

There are six basic categories:

❑ Personal (wallet, diary, etc.)

❑ Perishable (news, sports, stock quotes, etc.)

❑ Transaction oriented (bank transactions, mobile shopping, etc.)

❑ Location specific (restaurant guide, map service, etc.)

❑ Corporate (ERP, inventory, business alerts, etc.)

❑ Entertainment (fun, games, etc.)

# Examples of applications

❑ **News:** This is a very big basket of applications having different types of news. News could be political, current affair, breaking news, business news, sports news, community news, etc.

❑ **Youth:** This is a very high growth market with different applications to suit the style and lifestyle of the youth. These are primarily messaging based application like person – to – person messaging, chat, forums, dating, etc.

❑ **Weather:** There are different types of applications and services where mobile computing can make a difference. If we look at very closely when a person is on a vacation, and driving from one city to another, access to weather information can sometime save lives. .

# Examples of applications

❑ **Corporate application:** Standard corporate information is one of the most desirable information set for mobile workers. This will include corporate mail, address book, appointments, MIS applications, corporate Intranet, etc.

❑ **Sales Force Automation:** This group will offer many applications. This will cater the large population of sales personnel. Applications will include sales order booking, inventory enquiry, shipment tracking, logistics related applications, etc. These applications will be very effective over wireless devices.

❑ **m-broker:** Getting correct and timely information related to different stocks is very important. Also, online trading of stocks while on move is quite critical for certain lifestyle.

# Examples of applications

❑ **m-banking & telebanking:** We need to access our banks for different transactions. If telebanking can be made ubiquitous, it shall help everybody. Many banks in India are offering banking over mobile phones using SMS.

❑ **m-shopping:** It will help to do different types of shopping using mobile devices like Palmtop, PocketPC, mobile phone, etc. Buying a drink from a vending machine at an airport using a mobile phone may be very handy especially when you do not have change.

❑ **Micropayment based applications:** Micropayments are these final transactions where the amount of money involved in a transaction is not very high. Micropayments using mobile phones can help rural people to do business in a much effective way.

# Examples of applications

❑ **Interactive games:** Many mobile network operators have started offering different types of contest and interactive games to be played using mobile phone.

❑ **Interactive TV shows:** Many TV companies around the world use SMS as a bearer for interactive TV. This has also started in India where some of the leading TV companies are using SMS to make TV programmes interactive.

❑ **Experts on call:** Application system for experts, where experts use this while they are mobile to schedule their time and business. Others use this to schedule business with the expert.

❑ **GPS based systems:** Applications related to location tracking come under this category. This could be as simple as tracking a vehicle or even tracking an individual who got lost or struck due to bad weather.

# Examples of applications

❑ **e - governance:** These applications are very important to bridge the digital divide. The Bhoomi project of Karnataka government has computerized two crore land records of 67 lakh farmers living in 30,000 villages in the state. Many such projects in the Government can be made electronic, resulting into better and faster access to information managed by the government.

❑ **Virtual laboratories:** There are many labs and knowledge repositories around the world. These types of applications make the facility of these labs available across the boundary of culture and countries.

❑ **Community forums:** There are different social and community meetings. On making them electronic, it may help increase the involvement of more people to participate in community developments.

# Mobile Computing examples

❑ **Job facilitator:** These could be either proactive alerts or information related to jobs.

❑ **Telemetric applications:** Almost every industry and sphere of life has the need for telemetric applications. Examples could be monitoring and control in manufacturing industry; vehicle tracking; meter reading; health care & emergency services; vending machine monitoring; research; control and service request for different emergency services like power plants; etc.

❑ **Downloads:** Different types of downloads starting from ringing tone to pictures are part of this family. In many countries, these types of applications are very popular.

# Mobile Computing examples

❑ **Corporate knowledge based applications:** Nowadays, there are many applications which offer knowledge base. If a company has some knowledgebase, the same is required to be ubiquitous.

❑ **Community knowledge based applications:** Knowledge is power. Like in a corporation, knowledge is equally important for a community. Making knowledge ubiquitous always help the society at a large.

❑ **Distance learning:** Applications related to distance learning may be very desirable for developing countries. Simputer with voice interface can change the economics of the rural India with these kind of applications.

# Standards – Why are they necessary ?

Standards are documented agreements containing technical specifications to be consistently used as rules, guidelines, or definitions of characteristics.

❑ Standard and Proprietary technologies

❑ Adaptation of technology in USA and Europe

# ETSI

❑ European Telecommunications Standards Institute

❑ It is an independent, non – profit standardization institution catering to telecommunications industry, based in Europe but having a worldwide scope.

❑ ETSI's prime objective is to support global harmonization by providing a forum in which all the key players can contribute actively.

# ISO

❑ International Organization for Standardization

❑ ISO is a worldwide federation of national standards bodies from more than 140 countries, one from each country.

❑ The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity.

# OMA

❑ Open Mobile Alliance

❑ The Open Mobile Alliance (OMA) has been established by the consolidation of the WAP Forum and the Open Mobile Architecture initiative.

❑ It intends to grow the market for the entire industry by removing barriers to interoperability and supporting a seamless and easy-to-use mobile experience for end users.

# IEEE

❑ Institute of Electrical and Electronics Engineers

❑ IEEE is an organization that produces standards, which are developed and used internationally.

❑ IEEE-SA demonstrates strong support of an industry-led consensus process for the development of standards and operating procedures and guidelines.

# EIA

❑ Electronics Industry Association

❑ EIA is a national trade organization within USA that includes the full spectrum of U.S. electronics industry.

❑ EIA is a partnership of electronic and high-tech associations and companies whose mission is promoting the market development and competitiveness of the U.S. high-tech industry through domestic and international policy efforts.

# ITU

❑ International Telecommunications Union

❑ ITU was founded on the principle of cooperation between governments and the private sector.

❑ ITU Telecommunication Standardization Sector (ITU-T)'s mission is to ensure an efficient and on-time production of high quality standards (Recommendations) covering all fields of telecommunications.

# W3C

❑ World Wide Web Consortium

❑ W3C develops interoperable technologies (specifications, guidelines, software, and tools) to lead the Web to its full potential.

❑ By promoting interoperability and encouraging an open forum for discussion, W3C is committed to leading the technical evolution of the Web.

# 3GPP

❑ 3$^{rd}$ Generation Partnership Project

❑ 3GPP is to produce globally applicable technical specifications and technical reports for 3$^{rd}$ Generation mobile system.

❑ The scope was subsequently amended to include the maintenance and development of the Global System for Mobile communication (GSM) technical specifications and technical reports including evolved radio access technologies.

# ANSI

❑ American National Standards Institute

❑ ANSI plays an important part in creating international standards that support the worldwide sale of products, which prevent regions from using local standards to favor local industries.

❑ ANSI has been one of the fore runner standards organization in computing for more than three decades.

# UMTS

❑ Universal Mobile Telecommunications System

❑ UMTS is synonymous with a choice of WCDMA radio access technology that has already been selected by many licensees worldwide.

❑ UMTS represents an evolution in terms of services and data speeds from today's second generation mobile networks like GSM.

# Bluetooth

❑ Bluetooth wireless technology is a worldwide specification for a small-form factor, low cost radio solution that provides links between mobile computers, mobile phones, other portable handheld devices, and connectivity to the Internet.

❑ The standards and specification for Bluetooth are developed, published and promoted by the Bluetooth Special Interest Group.

# IMT 2000

❑ International Mobile Telecommunications 2000

❑ It is an ITU standard for 3G wireless communication.

❑ It provides a framework for worldwide wireless access by linking diverse terrestrial and satellite networks.

# CDG

❑ CDMA Development Group

❑ The CDG is an international consortium of companies who have joined together to lead the adoption and evolution of CDMA wireless systems around the world.

❑ By working together, the CDG members will help ensure interoperability among systems, while expediting the availability of CDMA technology to consumers.

# PAM Forum

❑ Presence and Availability Management Forum

❑ The Presence and Availability Management (PAM) Forum is an independent consortium with a goal to accelerate the commercial deployment of targeted presence and availability applications and services that respect users' preferences, permissions and privacy.

❑ PAM Forum will define a framework for the various standards and specifications needed for context/location aware applications.

# Parlay Group

❑ The Parlay Group is a multi – vendor consortium formed to develop open, technology – independent application programming interfaces.

❑ Parlay integrates intelligent network (IN) services with IT applications via a secure, measured, and billable interface.

❑ Parlay will also help develop location/context aware applications and services.

# IETF

❑ Internet Engineering Task Force

❑ IETF is the standard-making body for Internet and related technologies.

❑ IETF is an open international community of network designers, operators, vendors and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet.
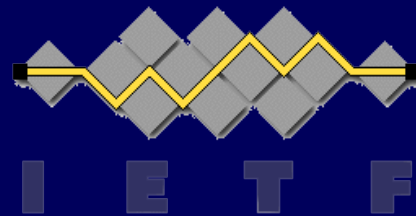
# DECT

❑ Digital Enhanced Cordless Communications

❑ It is an ITSI standard for portable phones.

❑ DECT is known in ITU as a 3G system and is commonly referred to as IMT-FT (IMT Frequency Time).

# WiMAX Forum

❑ Worldwide Interoperability for Microwave Access

❑ WiMAX forum is dedicated to certifying the operations of interconnecting products.

❑ WiMAX aims to provide wireless data over long distances in different forms ranging from point – to – point links to full scale mobile access networks.

# TTA

❏ Telecommunications Technology Association

❏ TTA is an IT standards organization catering to development of new standards based in Korea.

❏ It provides one stop services for comprehensive IT standards.

# Wi-Fi Alliance

❑ Wi-Fi owns trademark to Wi-Fi.

❑ It was previously known as Wireless Ethernet Compatibility Alliance.

❑ It is focused on interoperability and compatibility of Wi-Fi devices and pledges itself to continuous improvements in design and better user experience.

# ARIB

❑ Association of Radio Industries and Businesses

❑ ARIB is an institution, based in Japan, dedicated to efficient use of radio spectrum and its implications in businesses.

❑ It also works in the area of frequency change support.

# CCSA

❑ China Communications Standards Association

❑ It is an attempt of Chinese Ministry of IT to adapt to reform telecommunications industry and market.

❑ It aims for being a nationally unified standards organization in China.

# DLNA

❑ Digital Living Network Association

❑ It is a cross-industry association of consumer electronics, computing industry and mobile device companies .

❑ The objective of DLNA is to enable a seamless environment for sharing digital multimedia content across heterogeneous devices and networks.
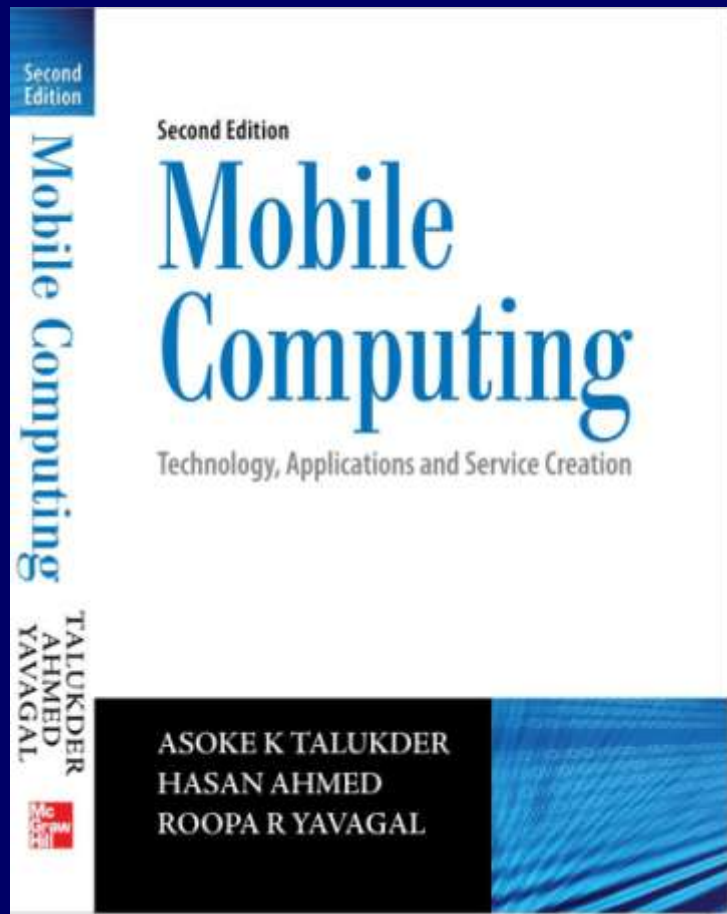
# Players in the wireless space

The stakeholders in the wireless network are:

- ❑ Regulatory authorities

- ❑ Operator or service provider

- ❑ Subscriber

- ❑ Equipment vendors

- ❑ Research organizations

# Next Chapter

## Mobile Computing Architecture

# Thanks

# Mobile Computing

## Chapter 2

## Mobile Computing Architecture

Asoke K Talukder

Hasan Ahmed

# History of Computers - I

❑ German engineer Konrad Zuse developed a computer called Z3 to design airplanes and missiles in 1941 during World War II.

❑ In 1943, the British developed a computer called Colossus for cryptanalysis to decode encrypted messages transacted by Germans.

❑ In 1944, Howard H. Aiken developed the Harvard – IBM Automatic Sequence Controlled Calculator Mark I, or Mark I for short.

❑ Electronic Numerical Integrator and Calculator, better known as ENIAC, was developed by John P. Eckert and John W. Mauchly in 1946.

❑ In 1945, John von Neumann introduced the concept of stored program.

# History of Computers - II

❑ In 1947, the invention of the transistor by J. Bardeen, Walter H. Brattain, and William Shockley at Bell Labs changed the development scenario of digital computers. The transistor replaced the large, energy hungry vacuum tubes in first generation computers.

❑ Jack Kilby, an engineer with Texas Instruments, developed the Integrated Circuit (IC) in 1958.

❑ By the 1980's, Very Large Scale Integration (VLSI) squeezed hundreds of thousands of components onto a chip that led the development of third generation computers.

❑ All these early computers contained all the components we find today in any modern day computers: like printers, persistent storage, memory, operating systems, and stored programs. However, one aspect of modern day computers was missing in these machines – the networking aspect of today's computers.

# History of Internet – I

❑ Following the successful launch of Sputnik in 1957 by the Russians, USA felt the need of research in certain focused areas. Therefore, Advance Research Project Agency (ARPA) was formed to fund Science and Technology projects and position USA as a leader in technology.

❑ In early sixties, Leonard Kleinrock developed the basic principles of packet switching at MIT.

❑ During the same period, Paul Baran in a series of RAND Corporation reports recommended several ways to accomplish packet switch network.

❑ In 1965, working with Thomas Merrill, Lawrence G. Roberts connected the TX – 2 computer in Massachusetts to the Q-32 in California with a low speed dial – up telephone line creating the first computer network.

# History of Internet – II

❑ In 1971, Ray Tomlinson at BBN wrote the software to send and read simple electronic mail.

❑ In October 1972, demonstration of the ARPANET was done at the International Computer Communication Conference (ICCC). This was the first public demonstration of this new network technology to the public. It was also in 1972 that the initial "hot" application – electronic mail, was introduced.

❑ In 1986, the US NSF initiated the development of the NSFNET which provided a major backbone communication service for the Internet.

❑ In Europe, major international backbones such as NORDUNET and others provided connectivity to a large number of networks. Internet slowly evolved as the universal network of networks, which connects almost every data networks of the world with a reach spread over the whole of earth.

# History of Internet – III

❑ On October 24th, 1995, the FNC unanimously passed a resolution to officially define the term Internet. According to this resolution, the definition of Internet is "Internet refers to the global information system that – (i) is logically linked together by a globally unique address space based on the Internet Protocol (IP) or its subsequent extensions / follow – ons; (ii) is able to support communications using the Transmission Control Protocol / Internet Protocol (TCP/IP) suite or its subsequent extensions / follow – ons, and / or other IP – compatible protocols; and (iii) provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein."

❑ V. Bush through his July 1945 essay "As We May Think", described a theoretical machine called a "memex", which was to enhance human memory by allowing the user to store and retrieve documents linked by associations.

# History of Internet – IV

❑ During 1960s, D. Engelbart prototyped an "oNLine System" (NLS) that does hypertext browsing, editing, etc. He invents the mouse for this purpose.

❑In 1991, Tim B. Lee invented Hyper Text Markup Language (HTML) and Hyper Text Transport Protocol (HTTP). Tim wrote a client program and named it as "World Wide Web", which finally became the "www" (World Wide Web) and became almost synonymous with Internet.

# Internet – The Ubiquitous Network

❑ Two ubiquitous networks – the telecommunications network and the Internet

❑ Glue for telecommunications network – SS#7 (loosely)

❑ Glue for the Internet – TCP/IP

❑ Three basic types of content – audio, video and text

❑ Three main segments of any network – Core, Edge and Access

❑ Core – backbone of network and looks at the traffic from the stream of bits point of view

❑ Edge – responsible for the distribution of traffic and looks at the traffic from the service point of view

❑ Access – deals with last mile of transmission

# Architecture of Mobile Computing

The three tier architecture contains the user interface or the presentation tier, the process management or the application tier and the data management tier.
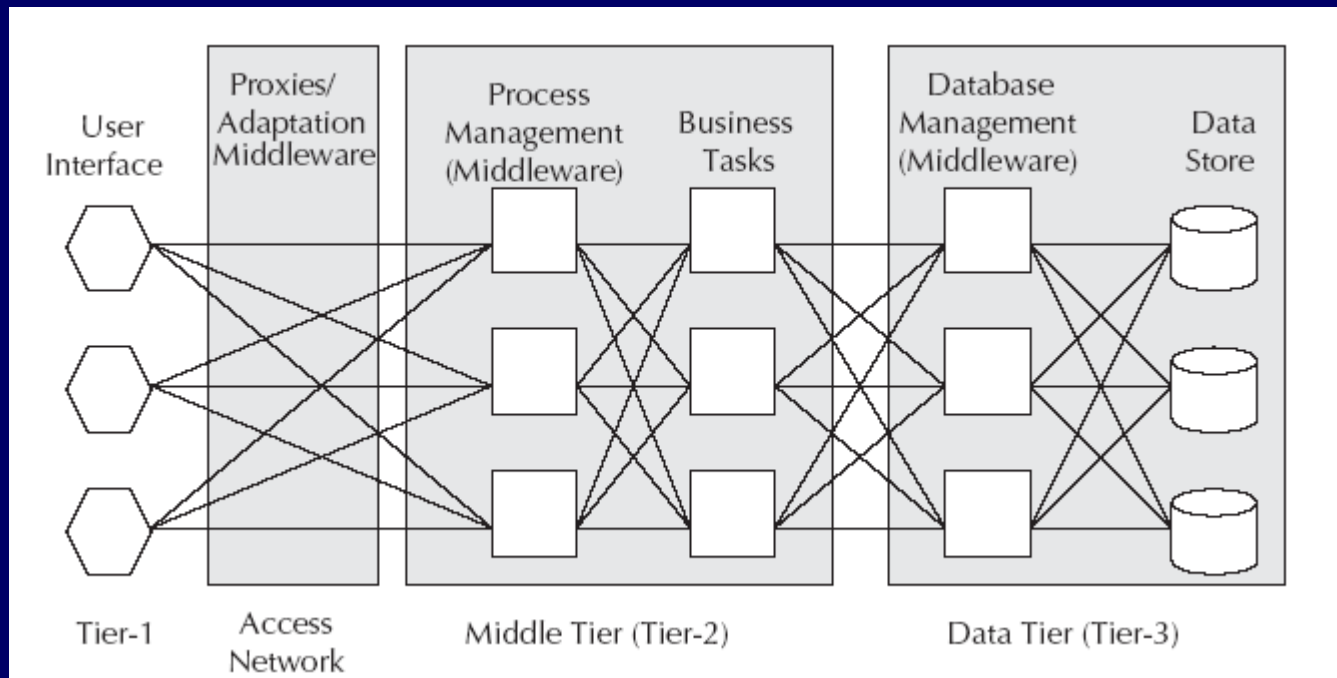
# Mobile Computing Architecture
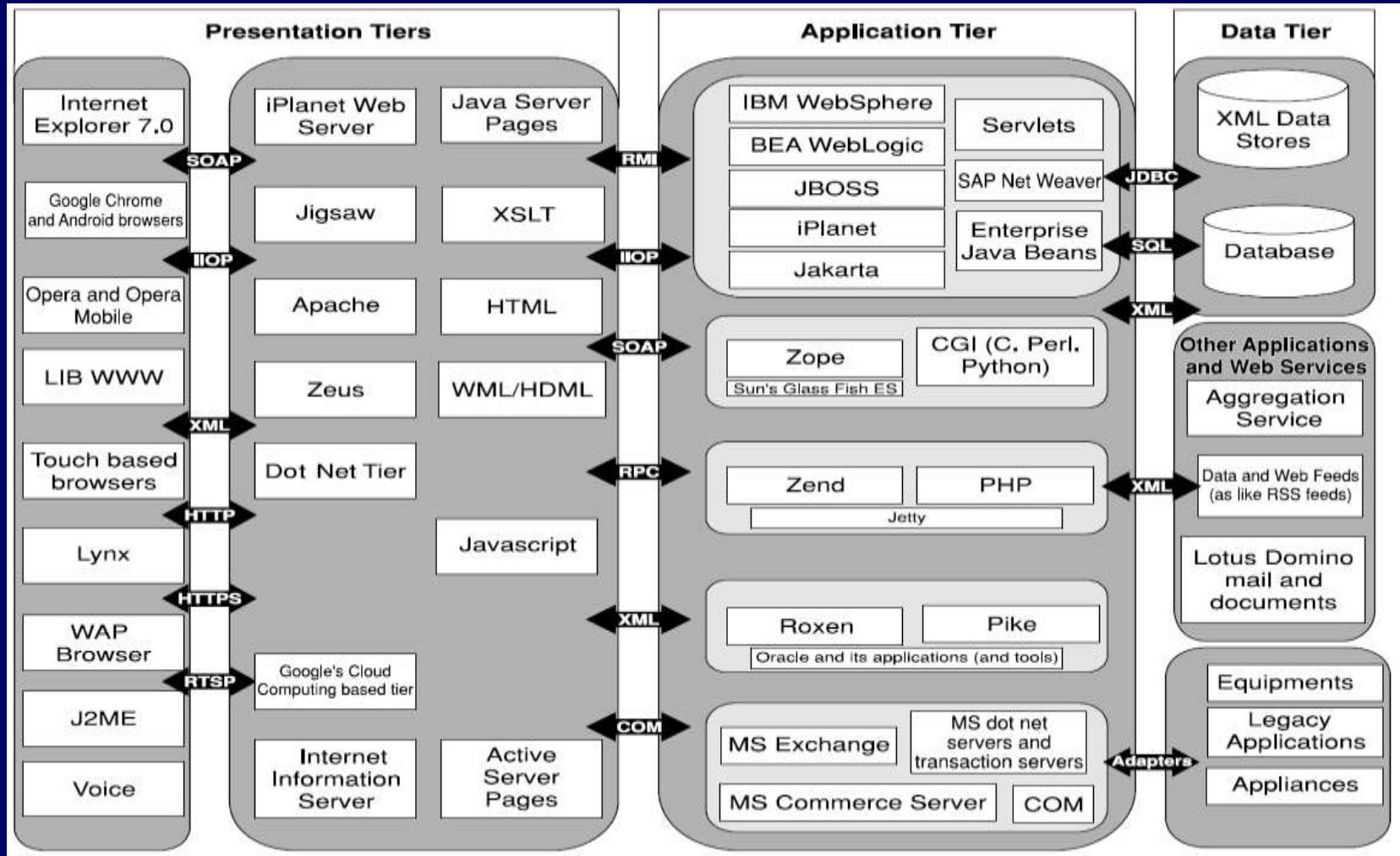
# Presentation Tier

❑ Responsible for presenting the information to the end user

❑ Run on the client device and offer all the user interfaces

❑ Includes web browsers, WAP browsers and client programs

# Application Tier

❑ Independent of presentation and database management

❑ Handles functions related to middleware

❑ Middleware – layer of software sitting between the operating system and user facing software

❑ Many types of middleware – Message Oriented Middleware, Transaction Processing Middleware, Communication Middleware, Distributed Objects and Components, Transcoding Middleware, Web Services, etc.

# Message Oriented Middleware

❑ Loosely connects different applications through asynchronous exchange of messages

❑ Works independent of platform or processor configuration

❑ Generally asynchronous and peer to peer

❑ Works in publish / subscribe fashion

❑ Examples – MQ series from IBM, JMS, etc.

# Transaction Processing Middleware

❑ Provides tools and environment for developing transaction based distributed applications

❑ Capable of providing services to thousands of clients in a distributed client – server environment

❑ Independent of database architecture

❑ Example – CICS from IBM
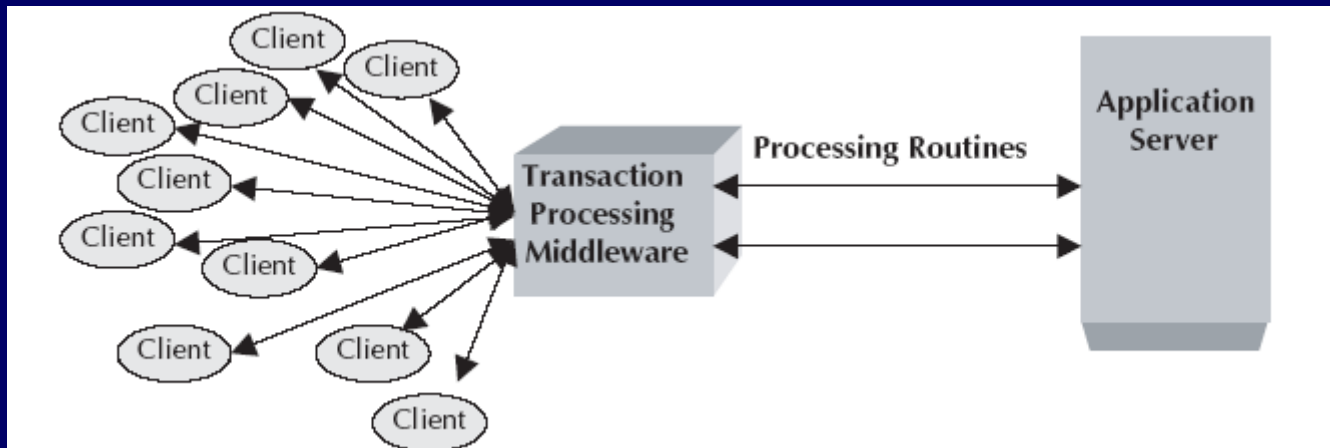
# Communication Middleware

❑ Used to connect one application to another

❑ Quite useful in the telecommunications world

❑ Uses mediation server to automate the telnet protocol to communicate to nodes in the network

❑ Example – Using telnet to connect one application to another

# Distributed Objects and Components

❑ Handles open distributed object computing infrastructure

❑ Example – Common Object Request Broker Architecture (CORBA)

❑ CORBA – a vendor independent infrastructure

❑ CORBA – highly interoperable across heterogeneous platforms

# Transcoding Middleware

❑ Used to transcode one format of data to another suiting the needs of the client

❑ Useful for content adaptation to fit the needs of device

❑ Example – Internet Content Adaptation Protocol (ICAP) from IETF

# ICAP

❑ Aimed at providing simple object based content vectoring for HTTP services

❑ Lightweight protocol to do transcoding on HTTP messages

❑ Similar to executing a RPC on a HTTP request

❑ Adapted messages can either be HTTP requests or HTTP responses

# Data flow in an ICAP environment
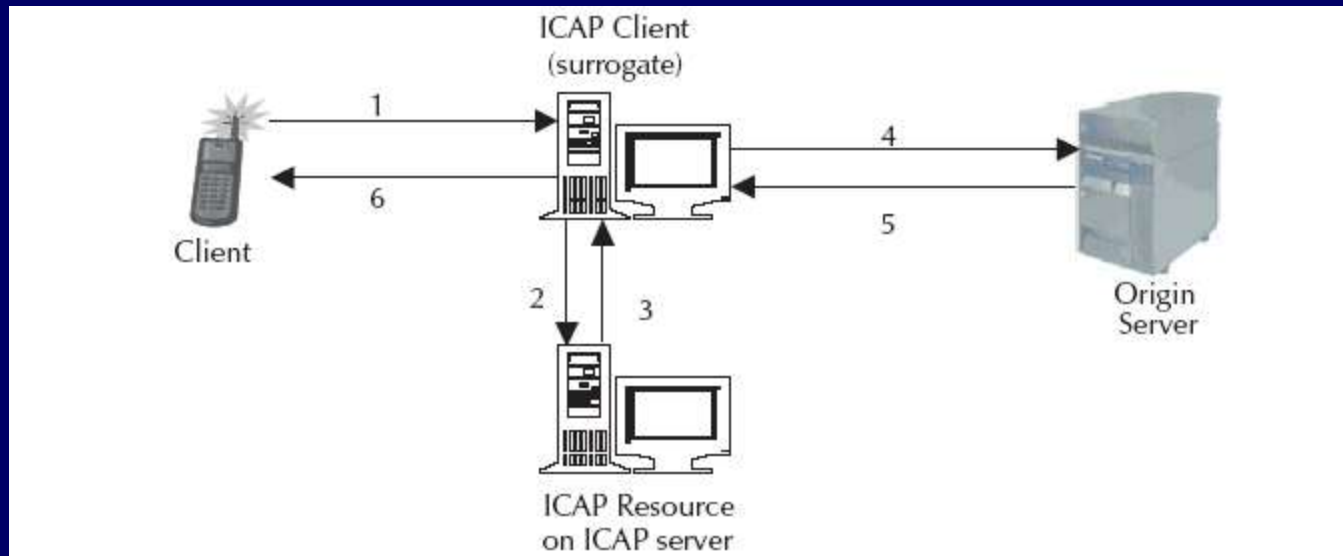


1. A user agent makes a request to an ICAP-capable surrogate (ICAP client) for an object on an origin server.

2. The surrogate sends the request to the ICAP server.

3. The ICAP server executes the ICAP resource's service on the request and sends the possibly modified request, or a response to the request back to the ICAP client.

Continued…

ICAP Client
(surrogate)

Client

Origin
Server

ICAP Resource
on ICAP server
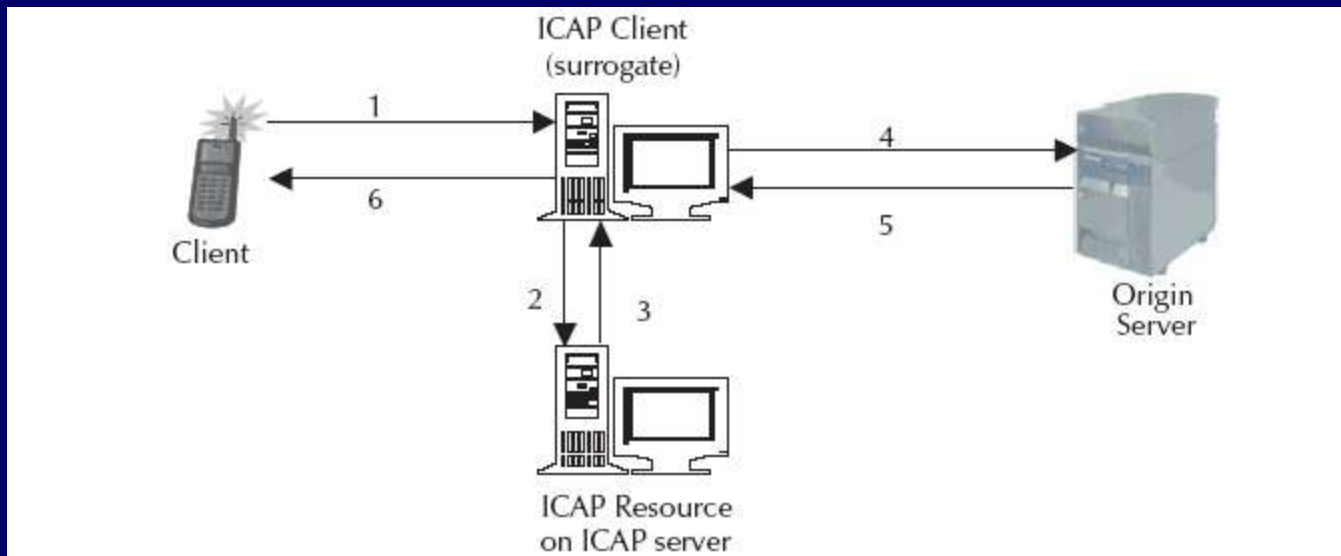
4. The surrogate sends the request, possibly different from the original client request, to the origin server.

5. The origin server responds to the request.

6. The surrogate sends the reply (from either the ICAP server or the origin server) to the client.

# Web Services

❑ Provides a standard means of communication and information exchange among different software applications

❑ Public interfaces and bindings are defined using XML

❑ Standards for service requestor and service provider

❑ Service requestor – find and discover the description of services

❑ Service provider – publish the description of services it provides

# Data Tier

❑ Used to store data needed by the application and acts as a repository for both temporary and permanent data

❑ Can use XML for interoperability of data with other systems and data sources

❑ Might incorporate the use of Database Middleware and SyncML

❑ Database Middleware – interfaces application programs and the database

❑ Database Middleware – helps business logic run independent and transparent from database technology and database vendor

# SyncML

❑ Emerging standard for synchronization of data access from different nodes

❑ Promotes a single common data synchronization protocol that can be used industry wide

❑ Supports naming and identification of records and common protocol commands to synchronize local and network data

❑ Works over all networks used by mobile devices – wired and wireless

# Design Considerations

❑ Context information is the information related to the surrounding environment of an actor in that environment.

❑ Mobility implies that attributes associated with devices and users will change constantly.

❑ Such changes shall mean that content and behavior of applications should be adapted to suit the current situation.

❑ Some examples are:

1. Content with context awareness

2. Content switch on context

3. Content transcoding on context

# Concerning contexts in Mobile Computing

The following contexts need to be taken care of:

- ☐ User context

- ☐ Device context

- ☐ Network context

- ☐ Bandwidth context

- ☐ Location context

- ☐ Time context

- ☐ Environment context

- ☐ Charging context

- ☐ Security context

# Handling user context

❑ Who is the user?

❑ In Trusted Personal Devices (TPD), and certain desktop environments user can be assumed from a particular environment. For example, anybody from IIIT – B campus can access IEEE digital library.

❑ In general, desktops are shared devices and user context is dynamic.

# Handling device context

❑ What is the device behavior?

❑ What is the display size?

❑ Does it support color?

❑ Does it support SyncML?

❑ What bearers it support?

❑ Is there any shared object between applications in device and server?

❑ Can we identify the device without ambiguity (like IMEI)?

# Handling network context

❑ What is the security policy in the network?

❑ What are the available bearers in the network?

❑ What are the different nodes in the network?

❑ Does the network offer positioning information?

❑ What are the different services available within the network?

❑ What are the services the user has subscribed to?

# Handling bandwidth context

❑ What is the bandwidth available for this network?

❑ What is the bandwidth the subscriber is allowed to?

❑ Is there any service level agreement on bandwidth between the user and network?

❑ Who pays for the bandwidth?

# Handling location context

❑ Can we locate the device?

❑ What is the positioning information (For example, is the car facing north way or south way in the highway)?

# Handling time context

❑ Can we identify the timezone of the client?

❑ Can we get the timestamp of the client?

❑ Can we synchronize the clock?

❑ Providing information based on time. For example, I finish my meeting at 4:00 PM, the system (Cyberguide from Georgia Tech) can tell me that I can visit a museum and the close by aquarium followed by dinner in an Indian restaurant.

# Handling environment context

❑ What are the environmental conditions of the surrounding?

❑ Essential for sensor based networks

❑ Essential for telematic applications

❑ Essential for embedded systems

# Handling charging context

❑ Who pays for this service?

❑ How to collect the usage information?

❑ Whom to send the information for billing the end user?

❑ What are the principles of sharing the revenue with other service providers?

# Handling security context

❑ What is the security context?

❑ Can we authenticate the device?

❑ Can we authenticate the user of the device?

❑ Is the network trusted? If not, what is required to build the trust?

❑ Is the network encrypted?

❑ What types of encryption does the client support?

❑ Does the client have a WIM (Wireless Identification Module)?

❑ Does the client have a private key?

# Content architecture in Mobile Computing
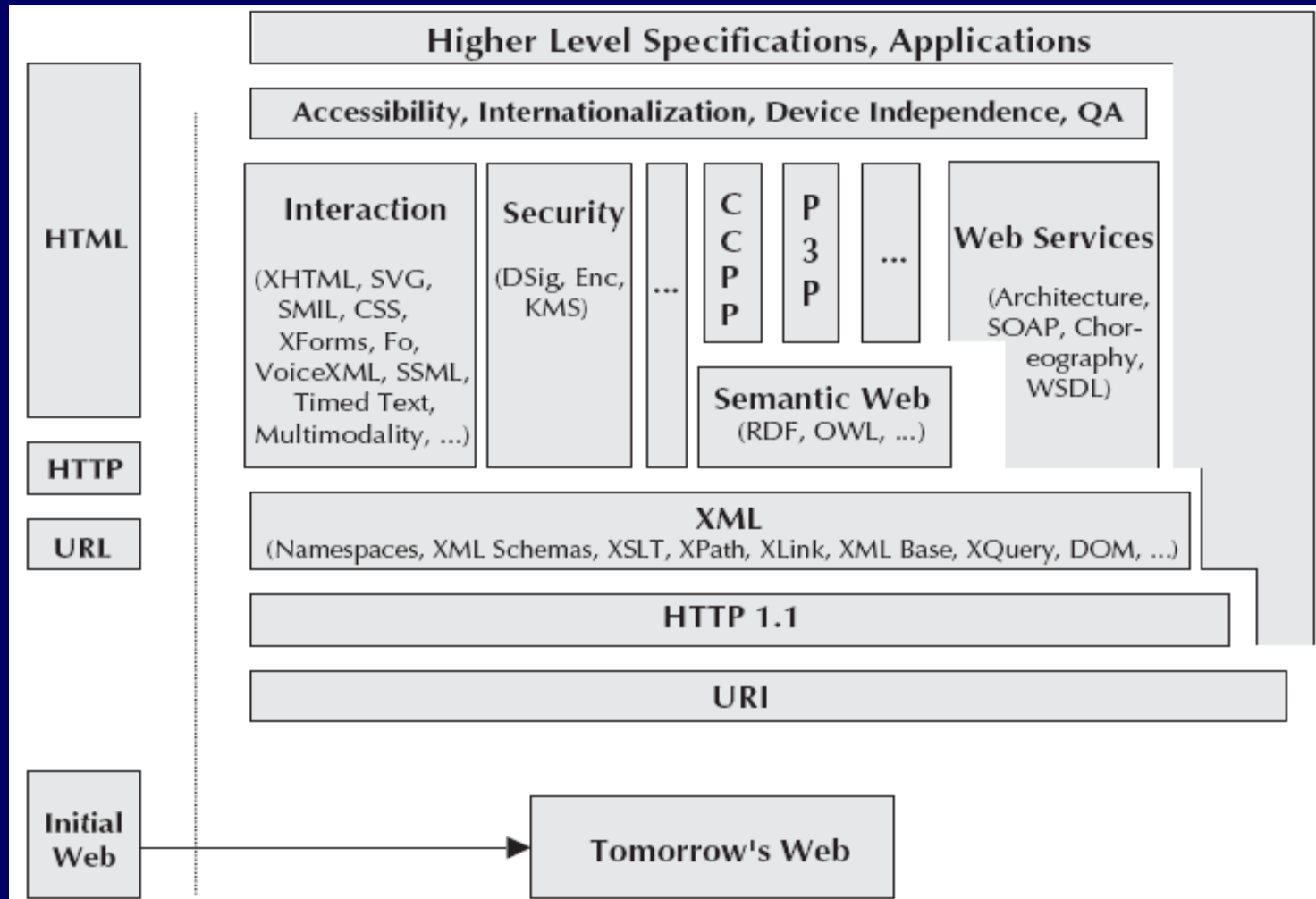
# Client Context Manager (CCM)

❑ Maintains information pertaining to:

1. Mobile devices
2. Users
3. Location
4. Network
5. Environment around each mobile device

# Challenges with CCM

❑ Context definition: Defining context attributes with interoperability in mind; how will every GPS device know the current data format?

❑ Context sensing: The way context data is obtained; e.g. GPS data acquisition

❑ Context representation: The way context information is stored and transported; e.g. transmitting such information

❑ Context interpretation: The way the context data is interpreted; e.g. we might need additional GIS information to interpret the GPS data

# Contexts handled by CCM

❑ Identity

❑ Spatial and temporal information

❑ Environmental information

❑ Social information

❑ Proximity and availability of resources

❑ Physiological measurements

❑ Activity

❑ Schedules and agendas

# Functions of the CCM

❑ Responsible for receiving raw context data, collating the data into a useful form and disseminating it to context consumers.

❑ Present context information to consumers in suitable and interoperable form.

❑ Context model should allow aggregation.

❑ Dynamic updates should be possible.

❑ Context history should be available.

❑ Context should be filtered.

# Composite Capabilities/Preference Profiles

❑ Proposed W3C standard for describing device capabilities and user preferences

❑ Based on Resource Description framework (RDF)

❑ Can be serialized using XML

❑ Origin server or proxy can perform some sort of content to device matching

❑ Abbreviated  as CC/PP

# CC/PP in action

❑ Device sends serialized profile model with request for content.

❑ Origin server receives serialized RDF profile and converts it into an in – memory model.

❑ The profile for the requested document is retrieved and an in – memory model is created.

❑ The device profile model is matched against the document profile model.

❑ A suitable representation of the document is chosen. Either content switch on context or content transcoding on context is employed.

❑ Document is returned to device and presented.

# Simplest use of CC/PP
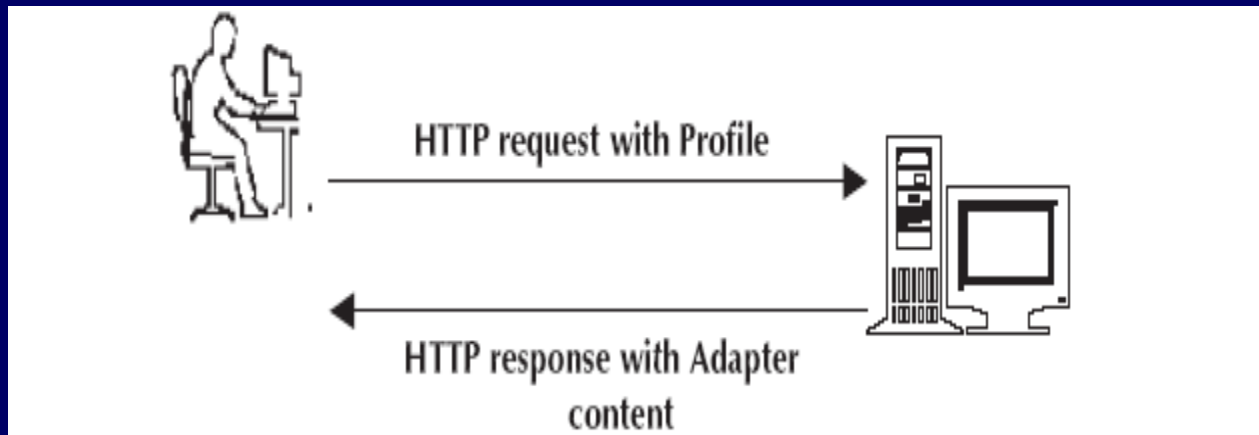
# Format for RDF

```xml
<?xml version="1.0"?>
<!-- Checked by SiRPAC 1.16, 18-Jan-2001 -->
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
     xmlns:ccpp="http://www.w3.org/2000/07/04-ccpp#">

  <rdf:Description rdf:about="Profile">

    <ccpp:component>
      <rdf:Description rdf:about="TerminalHardware">
        <!--  TerminalHardware properties here  -->
      </rdf:Description>
    </ccpp:component>

    <ccpp:component>
      <rdf:Description rdf:about="TerminalSoftware">
        <!--  TerminalSoftware properties here  -->
      </rdf:Description>
    </ccpp:component>

    <ccpp:component>
      <rdf:Description about="TerminalBrowser">
        <!--  TerminalBrowser properties here  -->
      </rdf:Description>
    </ccpp:component>

  </rdf:Description>
</rdf:RDF>
```

# Example for RDF

```
<rdf:Description rdf:about="MyProfile">

  <ccpp:component>
    <rdf:Description rdf:about="TerminalHardware">
      <rdf:type rdf:resource="HardwarePlatform" />
      <display>320x200</display>
    </rdf:Description>
  </ccpp:component>

  <ccpp:component>
    <rdf:Description rdf:about="TerminalSoftware">
      <rdf:type rdf:resource="SoftwarePlatform" />
      <name>EPOC</name>
      <version>2.0</version>
      <vendor>Symbian</vendor>
    </rdf:Description>
  </ccpp:component>

  <ccpp:component>
    <rdf:Description rdf:about="TerminalBrowser">
      <rdf:type rdf:resource="BrowserUA" />
      <name>Mozilla</name>
      <version>5.0</version>
      <vendor>Symbian</vendor>
      <htmlVersionsSupported>
        <rdf:Bag>
          <rdf:li>3.0</rdf:li>
          <rdf:li>4.0</rdf:li>
        </rdf:Bag>
      </htmlVersionsSupported>
    </rdf:Description>
  </ccpp:component>

</rdf:Description>
```

# Parser for RDF

❑ Java based RDF parser (SiRPAC) is available free on the web.

❑ SiRPAC can be used to parse serialised RDF into triples.

❑ Triples are the output of RDF parsers and are of the form triple (subject, predicate, object).

❑ Using triples, it is possible to build a CC/PP model. The model is updated whenever new context data are sent from context sources.

# Policy Manager

❑ Responsible for controlling policies related to mobility

❑ Should be able to define policy for documents/services and assign roles to user

❑ Should assign roles to users like
  – Permission
  – Prohibition
  – Obligations

❑ Policy combined with context should determine
  – what action(s) the user is allowed to perform?
  – what action(s) the user is obliged to perform?
  – the policy applicable

# Semantic Web

❑ Facilitates putting machine understandable data on the web

❑ Facilitates web definition and linking in a way to be useful for machines in the context of automation, security, filtering, integration and data reuse

❑ Increases the modularity of web applications

❑ Built on syntaxes which use URI's to represent data

❑ Such syntaxes are called Resource Description Framework (RDF) syntaxes

# Security Manager

❏ Secures connection between client device and origin server

❏ Should handle
  – Confidentiality (managed by encryption)
  – Integrity (managed by algorithms)
  – Availability (relates to peripheral security)
  – Non – repudiation (managed by digital signatures)

# Platform for Privacy Preference Project

❑ Emerging standard defined by W3C

❑ Enables websites to express their privacy practices in a standardized format retrievable and interpretable by user agents

❑ Any discrepancies between a site's practices and the user preferences can be flagged as well

❑ Does not provide any mechanism for ensuring that websites act according to their policies

❑ Intended to be complementary to both legislative and self–regulatory programmes

# Adaptability Manager

❏ Based on context and policy , it should adapt to:

    – Content

    – Behaviour

    – Other aspects

❏ May take any number of actions depending upon the information passed to it by Context Manager

❏ May include appending location – specific information to documents

# Content adaptation

❑ Content should be able to adapt to dynamic situations.

❑ Adaptation can be static or dynamic.

❑ Content adaptation can be performed either at content level in server or agent level in client.

❑ Content adaptation can be handled by middleware as well.

❑ Content adaptation needs to consider the physical and logical capabilities of the device, effective network bandwidth and payload (total number of bits delivered to the agent for static parts).

# Content transcoding

The resource requirements for the client devices can be determined by:

❑ Static content size in bits

❑ Display size

❑ Streaming bit rate

❑ Colour requirements

❑ Compression formats

❑ Hardware requirements

# Types of content transcoding

- ❑ Spatial transcoding

- ❑ Temporal transcoding

- ❑ Colour transcoding

- ❑ Code transcoding

- ❑ Object or semantic transcoding

# Content rating and filtering

❑ Need to ensure social discipline in the electronic world

❑ Platform for Internet Content Selection (PICS)

❑ PICS – W3C proposed standard for web content rating

❑ PICS – set of technical specifications for labels that help software and rating services to work synergistically

❑ PICS – services should choose their own criteria for proper identification and filtering of content

❑ Rating can be though self labeling or third party labeling

❑ Originally designed to help parents and teachers control children access to the Internet

❑ Also includes code signing and privacy

# RSACI

❑ Acronym for Recreational Software Advisory Council – Internet

❑ Has a PICS compliant rating system called Resaca

❑ Resaca has four categories – violence, nudity, sex and language

❑ Has a rating range from 0 to 4

❑ 0 means no potentially offensive content

❑ 4 means highest level of offensive content

❑ PICS – a general meta data system

❑ PICS labels – helpful in finding desirable content on the web

❑ PICS – enables more sophisticated commerce, communication, indexing and searching services

# Content Aggregation

From the content aggregator's perspective, services are of two categories:

❑ Single service request – works at user level and for one user

Example : A user may request a webpage in Hindi from proxy server. Here, the user buys both the content and translation service.

❑ Group service request – works for a group of users

Example : The content aggregator has some arrangement for advertisement. It examines all HTML pages and inserts an advertisement at an appropriate place.

# Seamless Communication

❑ A ubiquitous system involves availability and accessibility from anywhere, anytime and through any network or device.

❑ Seamless communication shall involve seamless handovers and seamless roaming.

❑ Handoff is the process by which the connection to the network is moved from one base station to another within the same network without discontinuing the service.

❑ Roaming shall involve the point of attachment moving from one base station of one network to a base station of another network.

# Aspects of Seamless Communication

❑ Authentication across network boundaries

❑ Authorization across network boundaries

❑ Billing and charging data collection

❑ End – to – end data security across roaming

❑ Handoff between wireless access points

❑ Roaming between networks

❑ Session migration

❑ IP mobility

# Autonomous Computing

The purpose of autonomous computing is to free users and system administrators from the details of the system operation and maintenance complexity. It combines the following functions:

❑ Self configurable

❑ Self optimizing

❑ Self healing

❑ Self protecting

❑ Self upgradable

# Context aware systems

The following information needs to be handled in a mobile computing environment for making a system context aware:

❑ Location information

❑ Device information

❑ Network information

❑ User information

❑ Environment information

# Global Positioning System

❑ Gives the exact positioning on Earth

❑ Funded and controlled by US Department of Defense

❑ Has three parts – the space segment, the user segment and control segment.

❑ Has 24 satellites , each in its own orbit 11,000 nautical miles above Earth.

# Making existing applications mobile enabled

❑ Enhancing an existing application

❑ Renting an application

❑ Developing a new application

❑ Buying a packaged solution

❑ Bridging the gap through middleware

# Next Chapter

## Mobile Computing through Telephony

## Thanks