PERVASIVE COMPUTING
UNIT I INTRODUCTION TO PERVASIVE COMPUTING

Objective

- Explain the term “Pervasive Computing”
- Principles of Pervasive Computing.
- History of Pervasive Computing.
- Calm Technology /Ubiquitous computing/Smart computing.
- Introduction to pervasive computing devices.
- Explain about supporting areas of Pervasive Computing.
- Introduction to various devices technologies.
- Describe various communication technologies involved in Pervasive Computing.

Father of Pervasive Computing

Mark D. Weiser (July 23, 1952 – April 27, 1999) was a chief scientist at Xerox PARC in the United States. Weiser is widely considered to be the father of ubiquitous computing, a term he coined in 1988

“The most profound technologies are those that dissappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it”

Weiser outlined a set of principles describing pervasive computing

- The purpose of a computer is to help you do something else.
- The best computer is a quiet, invisible servant.
- The more you can do by intuition the smarter you are; the computer should extend your unconscious.
- Technology should create calm.
**IBM’s definition of Pervasive Computing**

Convenient access, through a new class of appliances, to relevant information with the ability to easily take action on it when and where you need to.

It is a trend towards an information environment in which users have access to ICTs throughout the environment. This trend is particularly associated with the growth of wireless technologies that allow users to access online information and services remotely and synchronise data between different computers.

Pervasive computing is the trend towards increasingly ubiquitous (another name for the movement is ubiquitous computing), connected computing devices in the environment, a trend being brought about by a convergence of advanced electronic - and particularly, wireless - technologies and the Internet.

Pervasive computing integrates computation into the environment, rather than having computers which are distinct objects.

Other terms for pervasive computing:
- Ubiquitous computing
- Calm technology
- Things that think
- Everyware
- Pervasive internet
- Ambient intelligence
- Proactive computing
- Augmented reality

**Ubiquitous computing**: a world in which computers and associated technologies become invisible, and thus indistinguishable from everyday life.
This invisible computing is accomplished by means of "embodied virtuality," the process of drawing computers into the physical world.

Computing that is omnipresent and is, or appears to be, everywhere all the time; may involve many different computing devices that are embedded in various devices or appliances and operate in the background.

Ubiquitous computing encompasses a wide range of research topics, including distributed computing, mobile computing, sensor networks, human-computer interaction, and artificial intelligence.

**Calm technology** “A technology that which informs but doesn't demand our focus or attention”.

**HISTORY**

1. **Mainframe Computing** - Many people share one large computer
2. **Personal Computing** - Personal computing era: one computer used by one person, requiring a conscious interaction. Users largely bound to desktop.
3. **Internet Computing** - One person uses many services on a worldwide network.
4. **Pervasive Computing** - Many devices serve many people in a personalized way on a global network. Millions of computers embedded in the environment, allowing technology to recede into the background.

### Principles of Pervasive Computing

- Decentralization
- Diversification
- Connectivity
- Simplicity

### Pervasive Computing Technologies

Pervasive computing technologies classified in to four converging areas

- Mobile Computing
- Embedded and Applied computing
- RFID and Sensors
- Mobile and sensor networking
CHARACTERISTICS OF A PERVERSIVE COMPUTING ENVIRONMENT:

- Minimal user distraction
- Collaborative interaction
- User mobility
- Context awareness (user/time/location)
- Resource and location discovery
- Ambient information, calm technology
- Event notification
- Adaptive interfaces
- Invisibility—everyday object augmentation
- Anytime/anywhere
Basic Device Technology Aspects

Device Technology for Pervasive Computing include Power-provisioning technologies, Display technologies, Memory technologies, Communication technologies, Processor technologies, Interfacing technologies, Sensor Technologies and Authentication Technologies.

Technology Aspects

Low-power Device Technologies

Since many of the devices involved in the pervasive computing environment may have to be small in size and may have to live on their battery / power units, consumption of lower power, extension of power provisioning period etc. assume critical significance. In addition, prevention from excessive heating also requires attention. Power requirements can be reduced by several means right from material selection and chip-level designing to software designing and communication system designing. Power provisioning technology including the Battery design technology plays a very important role in the process.

Batteries as Power Provisioning Devices

- Key issue: Size and weight of the batteries versus the power capacity and price
- Bottleneck: Relatively slower advances in the battery technology compared to those in other fields like display and storage technologies
- Major choices available: Nickel-Cadmium (NiCd: 12-27 hrs. standby time), Nickel-Metal-Hydride (NiMH: 16-37 hrs. standby time), Lithium- Ion (Li-ion: 21-50 hrs. standby time), Lithium-Polymer Cell based batteries (> 60 hrs. standby time, flexible shapes) etc.
Display Device Technologies

Not all pervasive computing devices need display elements but those needing them may have a range of different requirements in terms of:

- Display-size
- Display-shape
- Display-resolution
- Display-colour richness
- Display viewing angles to be supported
- Display power provisioning constraints
- Display refresh rates etc.

Major Display Device Technologies

- Cathode Ray Tube based Displays (CRTs)
- Liquid Crystal Displays (LCDs)
  - Active Matrix Displays
  - Thin Film Transistor Displays (TFTs)
    - Passive Matrix displays
  - Single Scan Displays (Colour Super-Twist Nematic: CSTNs)
  - Dual Scan Displays (Dual Super-Twist Nematic: DSTN)
  - High-Performance Addressing displays (HPAs)
- **Light Emitting Diode based Displays (LEDs)**
- **Organic LED based Displays (OLEDs)**
  - Instead of crystalline semiconductor material, organic compounds are used
  - Manufacturing process of smaller structures and rich selection of organic compounds enable OLED with any size and color
- **Light-Emitting Polymer based Displays (LEPs)**

- **Chip-on-Glass Displays (CoGs)**
- **Liquid Crystal on Glass Displays (LCoGs)**
  - Integrate picture elements with transistors on a layer of glass
  - Allow manufacturing extremely small display (pixel size of 10 micrometers)

### Pervasive Computing Devices

- Handheld computers
- Windows CE-based handheld computers
- EPOC based-handheld computers
- Sub-notebooks
- Phones
- Cellular phones
- Data transmission capabilities
- Smart phones, Screen PHONES
- Telematics
- Smart cards.
HAND-HELD COMPUTERS

A portable computer that is small enough to be held in one's hand. Although extremely convenient to carry, handheld computers have not replaced notebook computers because of their small keyboards and screens. The most popular hand-held computers are those that are specifically designed to provide PIM (personal information manager) functions, such as a calendar and address book.

Some manufacturers are trying to solve the small keyboard problem by replacing the keyboard with an electronic pen. However, these pen-based devices rely on handwriting recognition technologies, which are still in their infancy.

Windows CE (also known officially as Windows Embedded Compact or Windows Embedded CE post version 6.0, and sometimes abbreviated WinCE) is an operating system developed by Microsoft for minimalistic computers and embedded systems. Windows CE is a distinct operating system and kernel, rather than a trimmed-down version of desktop Windows. Microsoft licenses Windows CE to OEMs and device makers. The OEMs and device makers can modify and create their own user interfaces and experiences, while Windows CE provides the technical foundation to do so. It is not to be confused with Windows XP Embedded which is NT-based. Windows CE is supported on Intel x86 and compatibles, MIPS, ARM, and Hitachi SuperH processors.

A distinctive feature of Windows CE compared to other Microsoft operating systems is that large parts of it are offered in source code form. First, source code was offered to several vendors, so they could adjust it to their hardware. Then products like Platform
Builder (an integrated environment for Windows CE OS image creation and integration, or customized operating system designs based on CE) offered several components in source code form to the general public. However, a number of core components that do not need adaptation to specific hardware environments (other than the CPU family) are still distributed in binary only form.

Development tools

- Visual Studio
- Free Pascal and Lazarus
- Basic4ppc
- Platform Builder
- Embedded Visual C++ (eVC)
- AutoHotkey

**ITRONIX Q200 FEATURES**

The Itronix Q200 is an ultra rugged Pocket PC designed for mobile workers who operate in demanding, mission-critical environments including forestry, meter reading, asset management, inspections, agriculture, surveying, and parking enforcement.

Wherever field personnel are required to work, the Q200 can work alongside them. Its high impact plastic and metal construction provides an exceptionally lightweight, rugged framework, with the strength to withstand the roughest outdoor handling and weather conditions.

The Q200 sits comfortably and securely in the palm of a hand, with a large numeric keypad at the user's fingertips. At just 1.75 pounds, it can be easily clipped to a belt or carried on a wrist strap. The unit includes separate alpha and numeric keypads, and its backlit color display is easy to read in all lighting conditions.

Built from the ground up to comply with military drop and sealing specifications, the Q200 has virtually limitless uses in a multitude of applications. Designed and
manufactured to the high-performance standards required for industrial market use, the Q200 can handle rough treatment and extreme weather conditions.

Best-in-class performance, most rugged product in its class, easiest to use and hold! These and many other attributes make the Q200 ideal for mission critical handheld computing needs.

- Intel XScale 400MHz PXA 255 processor
- Windows CE .NET 4.2 Operating System
- 128MB low power SDRAM
- 256MB, 512MB, 1GB, 2GB, or 4GB for storage and operating system
- Integrated 10/100Mbps Ethernet LAN via cable adapter or Desk Mount
- 3.8” 1/4 VGA color display offers enhanced visibility across high and low light environments, even direct sunlight
- One user accessible PC Card slot provides for future expansion
- Resistive touch screen allows use of passive pen or finger
- Advanced 3000 mAh LiION rechargeable battery pack for all day use
- 52-key lighted keyboard with epoxy coated keys for durability with separate numeric keypad
- Connects to PC via high-speed USB or serial port
- Rugged and waterproof design. Withstands a 6 foot drop onto concrete and complete submersion in water
- Extreme operating temperatures, 140°F to -4°F
- Weighs only 1.76 lbs. with battery
- Ergonomic design for more comfort and single-handed use
- Each Q200 includes a battery charger, rechargeable battery pack, serial ActiveSync cable, USB ActiveSync cable, pen, backstrap, one year warranty
SUBNOTEBOOK

A subnotebook (sometimes also called mini notebooks or ultraportable) is a class of laptop computers that are smaller and lighter than typical notebooks.

These computers are often confused with the "Ultra-Mobile PC" category, which is the name of a platform of small form-factor tablet PCs. Unlike UMPCs, they generally are found to run full desktop operating systems such as Windows or Linux, rather than specialized software such as Windows CE, Palm OS or Internet Tablet OS. They are also sometimes confused with netbooks which are a different category of devices that branched off from mini notebooks in general with the coming of the first of such devices, the EEE PC, these are most often much less expensive than Subnotebooks, and optimized for use as portable Internet capable devices.

Subnotebooks are smaller than laptops but larger than handheld computers. They often have smaller-sized screens, less than 14 inches, and weigh less than typical laptops, usually being less than 2 kg (4.4 lbs). The savings in size and weight are usually achieved partly by omitting ports or having removable media or optical disc drives. Many can be paired with docking stations to compensate.

SMARTPHONE

A smartphone is a mobile phone that offers more advanced computing ability and connectivity than a contemporary basic 'feature phone'. Smartphones and feature phones may be thought of as handheld computers integrated within a mobile telephone, but while
most feature phones are able to run applications based on platforms such as Java ME or BREW, a smartphone allows the user to install and run more advanced applications based on a specific platform. Smartphones run complete operating system software providing a platform for application developers.

Growth in demand for advanced mobile devices boasting powerful processors, abundant memory, larger screens and open operating systems has outpaced the rest of the mobile phone market for several years. According to a study by ComScore, in 2010 over 45.5 million people in the United States owned smartphones and it is the fastest growing segment of the mobile phone market, which comprised 234 million subscribers in the United States.

Operating systems that can be found on smartphones include Symbian (including S60 series), iOS, Palm WebOS, BlackBerry OS, Samsung bada phones running Linux, Binary Runtime Environment for Wireless, Windows Mobile, Android and Maemo. WebOS, Android and Maemo are built on top of Linux, and the iOS is derived from the BSD and NeXTSTEP operating systems, which all are related to Unix.

A smartbook is a concept of a mobile device that falls between smartphones and netbooks, delivering features typically found in smartphones (always on, all-day battery life, 3G connectivity, GPS) in a slightly larger device with a full keyboard. Smartbooks will tend to be designed to work with online applications.
Smartbooks use the ARM processor, which gives them much greater battery life than a netbook which uses a traditional Intel x86 processor. They are likely to be sold initially through mobile network operators, like mobile phones are today, along with a wireless data plan.

**TELEMATICS**

Telematics:

- The integrated use of telecommunications and informatics, also known as ICT (Information and Communications Technology). More specifically it is the science of sending, receiving and storing information via telecommunication devices.
- Telematics includes but is not limited to Global Positioning System technology integrated with computers and mobile communications technology in automotive navigation systems.

Most narrowly, the term has evolved to refer to the use of such systems within road vehicles, in which case the term vehicle telematics may be used.
BIOMETRICS

Biometric characteristics can be divided in two main classes:

- Physiological are related to the shape of the body. Examples include, but are not limited to fingerprint, face recognition, DNA, Palm print, hand geometry, iris recognition, which has largely replaced retina, and odor/scent.
- Behavioral are related to the behavior of a person. Examples include, but are not limited to typing rhythm, gait, and voice. Some researchers have coined the term behaviometrics for this class of biometrics.

It is possible to understand if a human characteristic can be used for biometrics in terms of the following parameters:

- Universality – each person should have the characteristic.
- Uniqueness – is how well the biometric separates individuals from another.
- Permanence – measures how well a biometric resists aging and other variance over time.
- Collectability – ease of acquisition for measurement.
- Performance – accuracy, speed, and robustness of technology used.
- Acceptability – degree of approval of a technology.
- Circumvention – ease of use of a substitute.

A biometric system can operate in the following two modes:

- Verification – A one to one comparison of a captured biometric with a stored template to verify that the individual is who he claims to be. Can be done in conjunction with a smart card, username or ID number.
- Identification – A one to many comparison of the captured biometric against a biometric database in attempt to identify an unknown individual. The
identification only succeeds in identifying the individual if the comparison of the biometric sample to a template in the database falls within a previously set threshold.

SMART CARD

A smart card, chip card, or integrated circuit card (ICC), is any pocket-sized card with embedded integrated circuits. There are two broad categories of ICCs. Memory cards contain only non-volatile memory storage components, and perhaps dedicated security logic. Microprocessor cards contain volatile memory and microprocessor components. The card is made of plastic, generally polyvinyl chloride, but sometimes acrylonitrile butadiene styrene or polycarbonate. The card may embed a hologram to prevent counterfeiting. Smart cards may also provide strong security authentication for single sign-on within large organizations.

The following characterizes smart cards:

- Dimensions are normally credit card size. ID-1 of the ISO/IEC 7810 standard defines them as nominally 85.60 by 53.98 millimetres (3.370 × 2.125 in). Another popular size is ID-000 which is nominally 25 by 15 millimetres (0.984 × 0.591 in) (commonly used in SIM cards). Both are 0.76 millimetres (0.030 in) thick.
- Contains a tamper-resistant security system (e.g. a secure cryptoprocessor, secure file system) and provides security services (e.g. protects in-memory information).
- Managed by an administration system which securely interchanges information and configuration settings with the card, including card hotlisting and application data updates.
- Communicates with external services via card reading devices, such as ticket readers, ATMs etc.

**Benefits:**

Smart cards can be used for identification, authentication, data storage and application processing.
Processor Technologies

- **Intel’s SpeedStep processor technology**

  Intel’s SpeedstepTM technology based processors and their successors are capable of:

  - Changing the internal clock frequencies
  - Adapting core voltage to changes in power supply
  - Switching of selective parts of the CPU cores / CPU on or off depending on whether the current calculations require them to be available
  - Using the reduced the clock rate and voltage of the processor core while on batteries, leading to significant power saving.
  - Switching between these modes is transparent to user and is usually fast <however, while the system is connected to external power supply, the full clock rate and core voltage is available to processor resulting into maximum performance>

- **Transmeta’s Crusoe processor technology**

  - Total numbers of transistors are reduced in an attempt to save the power consumption
  - Software replaces the functionalities which otherwise would have been provided in hardware by the eliminated set of transistors
  - Software dynamically translates the original instructions into another set of instruction for the processor
  - A technology called LongRunTM reduces the power consumption even more by reducing the processor's voltage on the fly when processor is idle

- **Motorola’s Dragon Ball processor technology**

- **Deprecated now!**

- **Intel’s X-Scale processor technology**
• This is next generation of ARM-processors that have replaced the Intel StrongARM series

Memory Technologies

• Register class elements
• Cache memory elements
• Primary Memory elements

RAM

• SRAM
• DRAM
• Ut-RAM
• MRAM
• FRAM
• MBM

ROM

• Secondary Memory
  o Flash Disks
  o Magnetic Disks
  o Optical Disks
  o Magento-Optical Storages
  o Magentic Tape Storage
Interfacing Aspects

Interfacing technologies

Major Interfacing technologies:

- Navigation technologies
- Haptic interfacing technologies
- On-screen / Touch-panel technologies
- Voice interfacing technologies
- Video-interfacing technologies
- Handwriting-based interfacing technologies
- Hybrid interfacing technologies

Navigation

- To operate applications in mobile devices
- User navigates through a menu structure using navigation keys
- Integrated cursor key-deliver signal for four directions (can be pressed and turned: each corresponds to an action)
- Nokia 7110-Navi roller

Haptic Interfaces

- A rotating control with force feedback and a integrated push button
- Sensors detect the position of the knob and integrated motor produces feedback of torque when rotated (programmable)
- Haptic marks define positions of specific feedback force changes
- User feel a resistance generated by motor when reaching a haptic mark
- Force increases until reach the mark, after the knob passes the position force decreases
- Used to move across a menu

Respective significance of Fitaly, Tegic T9, Octave methods of keyboards vis-à-vis traditional QWERTY layout based keyboards / keypads, in the context of mobile handheld devices:

- **Fitaly:**
  - Merit / Significance: Speeds up input of text, letters selected as per likely occurrence frequencies and ensuring minimization of inter-letter travel distance (to no more than 2 positions), supports 220 ANSI/ISO Latin-1 character set, supports accents, available in on-screen as well as mechanical forms
  - Demerit: Specific to English language’s estimated usage patterns, needs to be practiced for a while before use, needs to learn ‘sliding’ for accents’ use etc.

- **Tegic T9:**
• Merit / Significance: Requires lesser number of keystrokes for textual input due to support for predictive text by combining use of dictionary and linguistic rules ‘embedding, resolution of word-ambiguity is supported through prompts, available in on-screen as well as mechanical forms

![Image of a text editor with predictive text features]

• Demerit: Requires sizeable software support and computing resources (instruction cycles and memory)

- **Octave:**

  • Merit / Significance: Commands available to support multiple language dictionaries, available in on-screen as well as mechanical forms although second form is more popular, gesture-based iconic support for certain insertions, word-recognition supported by dictionary, ability to resolve stroke-ambiguity with the help of dictionary

  ![Image of hand gesture with text]

  • Demerit: Requires sizeable software support and computing resources (instruction cycles and memory)
• **Traditional QWERTY:**
  
  • Merit / Significance: Simplicity in design and use, available in on-screen as well as mechanical forms
  
  • Demerit: Requires more space and may be difficult in use in case of devices with very small form-factor

**Handwriting Recognition**

• It is feasible due to sufficient processing power and touch sensitive displays
  
  • Cursive handwriting recognition is much more complex than individual letters (printed).

**Word Recognition**

• most expensive, in terms of computing power
  
  • hard to recognize complete handwritten words
  
  • most natural way of writing –most difficult to recognize
  
  *Require very precise data capture and provides delayed feedback

  *Eg: Calligrapher-Psion Series 5*

  ![pervasive]

**Character Recognition**

• Some methods limited to separated character recognition
  
  • Need the stylus lifted between the characters
  
  • Require some cooperation from users-achieve high recognition rate
  
  • Limited number of ways to draw a letter so as to recognize
Eg: Graffiti i/p method –Palm OS devices

- Some device method can be trained to user’s habit
- Some others expect the exact style to recognize
- Customization is possible in case of single user.
- Several profiles have to be maintained for more than one person: memory, computing power need to be more with the devices

Localization

- Languages with more number of alphabets, symbols need special consideration
- Dedicated input methods with standard character set
- Combination of strokes, set of phonics to form a symbol

Eg: CJKOS (Chinese, Japanese, Korean languages)

Speech Recognition

- The most natural input method
- Space required in order to integrate into mobile devices
- Most expensive technology in terms of computing power
- Computers today have the capability of recognizing of continuous speech
- Will be available with mobile in near future

- Features like making call by just pronouncing the name stored earlier
- Operate appliances in car using Speech Recognition using set of words
- Operate bank account through phone
Operating System Aspects

Operating Systems for Pervasive Computing Environments

• Types of Operating Systems
  
  o Classification based on location of functionalities:
    ▪ Centralised OSes
    ▪ Networked OSes
    ▪ Distributed OSes

  o Classification based on Kernel / Core Styling
    ▪ Monolithic Kernel based OSes
    ▪ Microkernel based OSes
    ▪ Exokernel based OSes

  o Classification based on hardware form-factor and scope
    ▪ Server-class OSes (with and without real-time support)
    ▪ Workstation-class OSes (with and without real-time support)
    ▪ Embedded OSes (with and without real-time support)

Identifying Requirements of Operating Systems for Pervasive Computing Systems

• Identify classes of applications to be run atop the target OS

• Estimate the exact set of corresponding functionalities to be supported at the lower levels

• Identify additional performance and security-specific constraints that may be required to be satisfied

• Identify the hardware architectures over which the solution is expected to be built
• Identify the availability of ready-to-use device drivers for the devices expected to be supported

• Weigh the effects of various trade-offs at the OS-level to affect the targeted class / classes of applications

A Brief Comparison of Select Operating Systems

• Symbian OS:
  o Set of application engines for PIM, messaging, browsing; object exchanging (e.g. vCalendar & vCard);
  o Integrated APIs for data management, text, clipboard and graphics
  o Multithreaded kernel with real-time support
  o Support for a range of CPU architectures, peripherals, memory types
  o Support for a range of messaging systems including multimedia messaging (MMS), SMS; internet mail using POP3, IMAP4, SMTP etc. with attachments
  o Support for audio / video recording / playback / streaming; image conversion; voice recognition etc.
  o Support for protocols including TCP/IP (dual mode IPv4/IPv6) and WAP; infrared (IrDA), Blue tooth, USB;
  o Support for multihoming capabilities and link layer Quality-of- Service (QoS) on GPRS/UMTS networks
  o Support for 3G along with GSM circuit switched voice and data and packet-based data (GPRS and EGPRS); CDMA circuit switched voice, data and packet-based data (IS -95, cdma2000 1x, and WCDMA);
  o Extensible telephony subsystem APIs
o Support for Internationalisation through the Unicode Standard version 3.0

o Over-the-air (OTA) data synchronization support using SyncML; PC-based synchronization over serial, Bluetooth, Infrared and USB; a PC Connectivity framework providing the ability to transfer files and synchronize PIM data

o Support for device management

o Support for security through full encryption and certificate management, secure protocols (HTTPS, SSL and TLS), WIM framework and certificate-based application installation

o Support for content development options for C++, Java (J2ME) WAP etc.;

o Support for variety of user inputs – generic input mechanism supporting full keyboard, 0-9*# (numeric mobile phone keypad), voice, handwriting recognition and predictive text input.

• Variants of Microsoft Windows

  o Windows XP Embedded
  o WinCE

  ▪ Memory management:
   ▪ Support for protected Virtual Memory Management (upto 32 MB per process), special heap-support for File System / Registry / Object Store <max. size of Object Store: 256 MB>
   ▪ Security:
   ▪ Support for cryptography with a Crypto Library+ Crypto API, support for SD and Smart Cards
   ▪ Footprint:
   ▪ About 400 kb for the OS Core / Kernel
   ▪ About 3 MB with Kernel + all modules
   ▪ About 8 MB with Kernel + all modules + MS Word / PowerPoint / IE etc.
- User-interface:
  - Simple, intuitive, generally consistent, Menu-driven, Iconic
- User management:
  - Designed for single user support only
- Energy-awareness aspects:
  - Support for energy-saving enabled at the kernel level

- Variants of Linux
  - ARM-Linux
  - BlueCat Embedded Linux
  - RT-Linux

- PalmOS
- QNX Neutrino

- Variants of JavaOS
  - JavaOS
  - Java for Business

- BeOS

**Major constraints specific to recognition accuracy of Speech Recognition Systems as components of pervasive computing environment:**

- Resource availability in terms of processing power, memory and available time for each instance of recognition
- Complexity due to isolated and continuous recognition needs,
- Secondary storage’s capability to store required supporting data affecting dictionary and other data
- Context-variance implications
- Complexity arising out of Speaker-dependent and Speaker-independent device requirements
- Extent of training needed and its regulation
- Security and other implications
• Connectivity Aspects

Role of communication architectures in pervasiveness

• The pervasive computing system needs at least two basic elements to be pervading everywhere they are required to pervade:
  o Computing elements to take care of computational needs; and,
  o Communication elements to interconnect these computing elements either through wires or wirelessly (with / without mobility).

• From the end user’s perspective and in many a practical situations, the wireless communication based mobile computing is becoming increasingly important.

• From the back-end systems’ viewpoint, however, due to its sheer traffic volume, low error rates, better noise immunity and low cost, the wireline communication based computing still remains an attractive option.

• Therefore, hybrid architectures will possibly continue to exist even though end users may not be even aware of it.

Identifying multi-technology mobile communication architectures of relevance

• Several generations
• Gradual enhancements
• Coexistence & transition

Generations of Wireless Communication Networking Standards

• First Generation Global Mobile Radio standard : 1G
  o Only voice, No data

• Second Generation Global Mobile Radio standard : 2G
  o GSM: 9.6 Kbps <circuit switched voice / data>
  o Enhanced Second Generation Global Mobile Radio standard :2.5G
  ▪ GSM-GPRS <combination of circuit and packet switched voice / data>
  ▪ GPRS-136: <100Kbps <packet switched>

• Third Generation Global Mobile Radio standard: 3G
  o CDMA2000, <= 2Mbps <packet switched voice / data>

• Fourth Generation Global Mobile Radio standard : 4G (near future)
  o ? 20-40 Mbps <packet switched voice / data>
Inside the GSM Network Subsystem

• **MSC** (Mobile Services Switching Center) acts like a normal switching node and provides the connection to the fixed networks (such as the PSTN or ISDN).

• **HLR** (Home Location Register) contains information of each subscriber registered in the corresponding GSM network, along with the current location of the mobile. There is logically one HLR per GSM network.

• **VLR** (Visitor Location Register) contains selected information from the HLR, necessary for call control and provision of the subscribed services and each mobile currently located in the geographical area controlled by the VLR.

• **EIR** (The Equipment Identity Register) is a database that contains a list of all valid mobile equipment on the network.

• **AuC** (The Authentication Center) is a protected database: secret key of SIM GSM uses TDMA/FDMA to share the limited radio spectrum wherein the FDMA part divides frequency of the not more than 25 MHz B/W into 124 carrier frequencies spaced 200 kHz apart.; and Each of these carrier frequencies is then divided in time, using a TDMA scheme. GSM is a circuit-switched digital network.

**SGSN** (the Serving GPRS Support Node) keeps track of the location of the mobile within its service area and send/receive packets from the mobile, passing them on, or receiving them
from the GGSN. GGSN (Gateway GPRS Support Node) converts the GSM packets into other packet protocols (e.g. IP / X.25) and sends them out into another network.

- **GPRS** users can share the resource (Radio link) which is used only when users are actually sending or receiving data.

- **GPRS** is based on GMSK which is a modulation technique known as Gaussian minimum-shift keying. It can support a theoretical upper limit of speed up to 171.2kbps as against the GSM’s 9.6Kbps.

- In GPRS, a channel that is 200kHz wide, is divided into 8 separate data streams, each carrying maximum 20kbps (14.4kbps typical) whereas in GSM we use only one channel.

**The 3G:**

- 3G Stands for the Third Generation,
- Used in the context of new wireless mobile communication systems /services,
- Leverages the progress made in cellular technologies with the advances made in the Internet-based communication / services and the fixed wireline communication technologies,
- Is a general-purpose communication network / service architecture,
- Allows freedom to end users from being aware of location of request / provision of services,
- Puts more emphasis on the services than on the underlying delivery technologies,
- Aims to play a key role in aiding the On-Demand service paradigm.
- Is not a single -technology architecture; instead allows a multi-technology solution.
Design of Pervasive Computing Systems

Pervasive Computing System Design Approaches

Recollect that Four Principles of Pervasive Computing are:

- Distributedness / Decentralization
- Diversification / Specialized services
- Connectivity (regular or intermittent)
- Simplicity

Possible solution approaches

- Top-down approach
- Bottom-up approach
- Hybrid approach
- Ad-hoc / one-off approach

Each approach may involve usual steps of analysis, streamlining of specifications, identification of constraints, issues and choices; and finally, validation through formal or informal methods.

Principal issues related to design of Pervasive Computing Systems include:

- Feature-specific issues
- Form-factor-(size)-specific issues
- Power-provisioning issues
- Weight-specific issues
- Shape-specific issues
- Cooling-specific issues
- Connectivity-specific issues
- User Interface-specific issues
- Body-safety-specific issues <not for all devices>
• Security-specific issues
• Processor-choice-specific issues
• Operating System-specific issues
• Development and execution-environment-specific issues
• Cost-specific issues
• Regulatory issues

Criteria for acceptable pervasive computing design solutions include characteristics like

• Privacy & Security
• Effectiveness of Approach Across Networks
• Economic considerations
• Quality considerations
• Monitoring mechanisms
• Adaptability and Flexibility
• Practicability
• Sustainability

Key terms

➢ Computing
➢ Ubiquitous
➢ Ambient
➢ Adaptable
➢ Convergence
➢ Embed
➢ Augmentation
1. Key Term Quiz

1) ………….. introduced the idea of ubiquitous computing

2) At present ………..batteries are used in mobile phones.

3) In Organic LED based Displays instead of……………….., organic compounds are used.

4) ……………..technology doesn't demand our focus or attention.

5) ……………. university deals with OXYGEN project.

6) Changing the internal clock frequencies is possible with ………………..

7) Thin Film Transistor Displays uses ……………..matrix technology.

8) ……………..display technology allows manufacturing display unit of pixel size of 10 micrometers.

9) ……………. concept is followed in messaging in mobile phones.

10) Calligrapher and Graffitti, the terms related to ………..recognition.

Multiple Choice Questions

1. The term Ubiquitous computing is coined by

   a. Bill Gates       c. Mark Weiser
   b. Richard Stevens  d. Stallings

2. Which one of the following is not a pervasive device

   a. Mobile phone      c. PDA
   b. Sub notebooks     d. Gramaphone
3. GMSK stands for
   a. Ground mobile switching key         c. Guided medium switching key
   b. Gaussian minimum-shift keying       d. Granular minimum-shift keying

4. Power conservation scheme not matches with
   a. LCD                                b. LED
   c. CRT                                c. TFT

5. Standby time of NiMH batteries
   a. 12-27 h                             b. 16-37 h
   c. 6-10 h                              d. 21-50

6. MIPS stands for
   a. mega input program source          c. multiple input program selector
   b. million instructions per second     d. motion picture input standard

7. Rate of data loss less in…..communication
   a. microwave                           c. Bluetooth
   b. IR                                  d. PSTN

8. EPOC supports
   a. PASCAL                               c. OPL
   b. FORTRAN                             d. JCL
9. which path correct pair
   a. AMPS - 1G   b. AMPS - 3G   c. AMPS-1G
   CDMA- 3G     WCDMA-1G     CDMA-2G
   WCDMA-2G     CDMA-2G     WCDMA-3G

10. Dynamic heap available with
    a. Palm         c. Microsoft
    b. Mac         d. Google

**Two mark Questions**

1) What is pervasive computing?
2) State Moore’s law
3) Define e-business and m-business.
4) List any five pervasive devices.
5) What are the principles of pervasive computing?
6) Define calm technology
7) Define Telematics
8) Write short notes on 3G.
9) List the characteristics of a pervasive computing environment
10) Define pipelining
**Big Questions**

1. Describe the principles of pervasive computing with examples.

2. With neat diagram explain Biometrics system.

3. Explain the Palm OS architecture and development cycle

4. Write short notes on

5. a.J2EE

6. b.J2ME

7. c. Real time Java

8. Explain Mobile IP

9. Describe the mechanism behind distributed services