CPET 565/CPET 499
Mobile Computing Systems

Lecture 1
Introduction to Mobile Ubiquitous Computing Systems

Fall 2012

A Specialty Course for Purdue University's M.S. in Technology Graduate Program

Paul I-Hai Lin, Professor

Dept. of Computer, Electrical and Information Technology

Purdue University Fort Wayne Campus

Prof. Paul Lin   1

Mobile Computing?

- Computer History & Applications
  http://www.ecet.ipfw.edu/~lin/Presentation/CompNetApps11_17_files/frame.htm
  - Mainframe (IBM 360)
  - Microcomputers
  - Microcontrollers
- Networking
  - Dialup, TCP/IP, Ethernet LAN, WAN, Wi-Fi, WLAN
  - 802.11, Bluetooth, Zigbee
- Client-Server Computing
  - Web server
  - File Server
  - Database server
- Distributed Computing
- Mobile Computing
- Grid Computing
- Service-Oriented Computing
- Cloud Computing

Prof. Paul Lin   2

What is Mobile Computing?

- Computing enabled by presence of wireless enabled portable devices
- Some other names
  - Pervasive computing
  - Ubiquitous computing
  - Wireless computing
  - Embedded computing
- Wireless communication is needed
- Focus on logical aspect of mobile communication
- What kind of application can be enabled by mobile computing?
- Design issues in mobile application and system

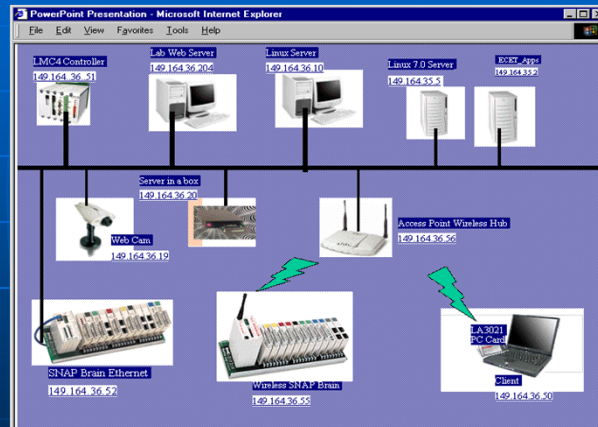## What is Mobile Computing? (cont.)

- The Mobile Wave & Mobile Computing
  - PDAs, Handhelds, Pocket PCs, Smartphone, Tablets, Laptops
  - Networked embedded processors & apps
  - Information & computing anytime, anywhere
  - Mobile apps: business intelligence, commerce, education, learning, office app, entertainment, personal healthcare, social networking, etc
- Distributed computing
  - Nodes (computers)
  - Communications
  - Computing Tasks

An Example Distributed Computing

Mobile Computing Applications
User Groups

- **Cellular phone/Smartphone**
- **Personal Information Management (PIM)**
- **Mobile Internet Access**
- **Mobile Multimedia Entertainment**
- **Business User Applications**
- **Mobile Enterprise**
- **Retail/Supply Chain**
- **Intelligent Transportation**
- **Maintenance and Field Service**
- **Healthcare**
- **Homeland Security/Emergency**
- **Military**

Mobile Computing Applications

- Email
- Internet access
- Personal Information Management (PIM)
- Instant Messaging
- Data & information access
- Location info, GPS
- Context-aware applications
- Audio streaming
- Video streaming
- Cell phone
- VoIP via WiFi

Prof. Paul Lin   7

Mobile Computing Applications

- **Pervasive/ubiquitous computing: computing everywhere**
  - **Home appliances**: refrigerator, washer/dryer, thermometer, microwave, dishwasher, what else - rumba the vacuum cleaner
  - **Mobile devices**: laptop, PDA, PocketPC, iPhone, smartphones, iPad, Tablet
  - **Home electronics**: TV, DVD player, satellite TV set-top boxes, cd, players, Stereos, iPod, Gameboy/Sony psp/Nintendo DS
  - **Location positioning devices** – GPS, MAPs
  - **Automobiles** – every modern car has a network of connected computers
  - **Tags** – RFIDs, SmartCards
  - Sensor network and Smart Dust
  - Wearable computing, ….

Prof. Paul Lin   8

Mobile Computing Constraints

- Resource-poor
  - Battery packs
  - Hardware: Memory, CPU, peripherals
  - Software – Middleware
- Less secure and less reliable
  - Lost or stolen
  - Hostile or unfriendly environment
- Mobile connectivity
  - Dynamic changes in environment: infrastructure
  - Highly variable: bandwidth, latency
  - Reliability: disconnections

What Needs to be Reexamined?

- Operating systems
- File systems
- Database systems
- Programming Languages
- Communication architecture and protocols
- Hardware and architecture
- Real-Time, multimedia, QoS
- Security
- Application requirements and design

Adaptability – the Key to Mobile Computing

- Scenario – searching for information
  - Adaptive to location, user's preference
- Scenario - Video streaming application
  - Adaptive to available resource, video contents
  - Continuous streaming
    - Routing video stream packets
    - Access points
    - New IP address

Adaptability – the Key to Mobile Computing

- Vision
  - Dynamic changes in computing environment
  - System agility
    - Speed and accuracy with which an adaptive application detects and responds to change in computing environment
  - Roam seamlessly
  - Perform computing and communication task uninterrupted
  - Less human intervention
- A example: mobile video streaming
  - Routing video stream packets
  - Access points
  - New IP address

Adaptability – the Key to Mobile Computing

- Fundamental to mobile computing is various techniques in hardware/software to adapt to resource availability
  - Take into account contextual information including user preferences
- Wireless sensor networking is enabling technology for pervasive/ubiquitous computing
- Middleware deals with the heterogeneity of the mobile devices.
- Who should be responsible for adaptation
  - system or application?
  - Application transparent or application aware?

Application Transparent

- Transparency – the ability of system to hide some characteristics of underlying implementation from users
  - Access transparency
  - Location transparency
  - Failure transparency
- Application works with no modification in mobile environment
- Proxy can be provided to hide the differences between the stationary and mobile environment from applications.
- Adaptive system is responsible for adaptation

Application-Aware Adaptation

- Adaptive system is responsible for adaptation
  - Does application-transparent way of adaptation suffice in mobile computing?
  - Performance issue, difficult for system adaptive to different applications, manual intervention may be needed
- Allows Applications to react to mobile resource changes
- How?
  - Collaboration between System and individual Applications
  - System monitors resource levels and notifies applications of relevant changes
  - Application then adapts to the change

Application-Aware Adaptation

- Multimedia Application
  - Application Examples
    - Video conferencing on mobile devices
    - Watch live video from Remote server on mobile devices
  - Operating condition changes
    - Move/bandwidth changes
      - Request other peer/server
      - Lower quality video
    - Battery power level changes
      - Conserve energy
      - Reducing the intensity of the back light (display)

Mechanisms for Adaptation

- Mechanisms for adaptation
  - Adapting Functionality of Mobile Application
  - Adapting Data – delivered
- Adapting Functionality
  - Classic client-server systems assume
    - location of client and server hosts do not change
    - connection among them does not change
  - Functionality between client and server is statically partitioned
  - Varying the Partition of duties in Client-Server model in mobile computing
    - Connected - Client-Server (CS) model
    - Disconnected – Mobile client works autonomously

Adapting Functionality

- Change dynamically the functionality of the computational entities
- Client/Server system assume
  - Resource-poor mobile client requests a resource-rich server to perform expensive computation
  - Request-Response model
- Services
  - Web pages ← Web servers
  - Database server
  - Temporary IP addresses
  - Name translation

Adapting Functionality

- Extended Client/Server
  - Maintain the state of the clients: hard state, soft state
  - Soft state
    - Updated periodically to avoid automatic deletion
    - Useful in systems with dynamic configurations
  - Soft state used in
    - Resource Reservation Protocol (RSVP, RFC 4604, 4605)
    - Internet Group Management Protocol (IGMP)
  - Request service → Sleep (conserve energy) → Wake up (get result)

Adapting Data

- Varying according to the quality of data (fidelity)
- Quality of Service (QoS) requirements in information access application
  - Information quality
  - Performance
    - Latency: from the Mobile client's perspective
    - Throughput: from the system's perspective
- Data maintained at remote server
  - Reference copy
  - Up-to-date
- Mobile client – may choose to access or manipulate data item of lower fidelity

Adapting Data

- Fidelity
- Agility
  - Speed and accuracy with which the application detects and responds to changes
- Consistency
- Data quality
  - Video data – frame rate and image quality
  - Spatial data such as topographic maps – minimum feature size
  - Telemetry data – sampling rate and timeliness

Prof. Paul Lin

21

Adaptations How To

- Adaptive to detectable changes in their environment
- Software detects changes
  - Middleware layers or Operating system
  - E.g. TCP protocol
- State –based approach
  - Changes in mobile computing are viewed as State Transitions
    - Strongly connected
    - Weak connectivity
    - Weak connectivity/Disconnected $\rightarrow$ Strong connectivity
    - Disconnected

Prof. Paul Lin

22

11

Where ? Adaptations

- Client /Proxy/Server
- Adapting to the hardware/software capabilities
  - in the proxy and/or at the server
- Adapting to the connectivity of the mobile device:
  - at the server and/or the client
- Adapting to the resource availability at the mobile device: at the client

Where ? Adaptations

- Proxies:
  - Filtering data and connections (security firewalls)
  - Modifying control data (network address translator)
  - Transcoding (converting data, content transformation)
- Proxy reduces Bandwidth demands and allow legacy and non standard client to communicate with the server