Mobile Computing

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Objectives

- Define Mobile Computing and look at current trends
- Distinguish between types of Mobility
- Examine Theory Research in Mobility
- Examine Systems Research in Mobility

What is Mobile Computing?

- "The Study of Systems in which computational Components May Change Location".
  - Two types:physical and logical
- "Context Aware Computing"
  - Hosts are aware of other hosts in the vicinity and can publish their services and request the services of others.

Types of Mobile Computing

- Nomadic Computing
  - A wired core network with a wireless periphery
- Ad Hoc Computing
  - Opportunistic temporary networks where all hosts are wireless mobile devices

Trends towards Mobile Computing (1)

- Less Computing is being done on 'Computers' (according to some schools of thought)
- Software is being transparent
  - Most electrical goods (washing machine, microwave, television etc) contain fairly large amounts of software
- Distributed Computing is becoming more mainstream (J2EE, .NET)

Trends towards Mobile Computing (2)

- Software as a service (UDDI, Passport, Hailstorm)
- Mobility of code (RMI)
- Promotion of Components to first class citizens
- Currently most OO software is made up of components wired together at design time
  - To realise the potential of mobile computing components will need to interact across hosts dynamically at run time.

Ubiquitous Computing

- Solving the same problem using many devices and interfaces
  - e.g. using a desktop to send email and dictating an email to a speech to text converter on a mobile.
- True Ubiquitous Computing cannot become a reality until mobile computing matures

Current Problems (1)

- Security
  - Who is allowed to access what?
  - The security in IEEE 802.11b is very lax in most cases anyone with a wireless card can access corporate Intranets
- Authentication
  - How do mobile devices in ad hoc networks verify each others credentials

Current Problems (2)

- Creating a general specification that allows devices to offer rich services
- Creating the right level of middle-ware that addresses the needs of mobile computing such as location and signal strength that is not difficult to program.

Types of Mobility

- Physical
  - Movement of a host in physical space
- Logical
  - Movement of a unit of mobility among hosts

Coordination

- Concerned with mechanisms to discover who is around
  - E.g. Use of Registries in CORBA
  - Passing around acquaintances in Gnutella
- ...Mechanisms to exchange Info
- ...Mechanisms to synchronize actions

Coordination (2)

- Mechanisms for coordination are supplied by
  - Middleware
  - Underlying operating system

Theory Research

- Focus on essential traits of broad classes of mobile systems
- Theory Research in two main areas
  - Models
  - Algorithms

Models

- Enable precise description of existing language/system semantics
- Allow formal reasoning about correctness of such semantics
- Used to highlight parallels and differences among various forms of mobility

Models (2)

- Models are concerned with the formulation of proper abstractions useful in specification and evaluation of mobile systems
- They focus on three aspects
  - Who is allowed to move (Unit of Mobility)
  - Where it can go (Location)
  - Handling context changes (Context)

Unit of Mobility

- Who is allowed to move...
  - This is the unit of mobility which is the smallest component in the system that is allowed to move.
  - ...A code fragment
  - ...A physical device in the real world
- Choice of mobility unit is central to any mobility model

Unit of Mobility (2)

- Typical choice of mobility unit coincides with unit of execution. This unit of execution is commonly called a Mobile Agent
- Finer grained units pervasive in everyday practice.

Location

- Identification of the position of a mobile unit in space
- Location semantics dependent on choice of mobility unit
- Current representations include
  - Cartesian coordinates(e.g. for mobile devices)
  - Host addresses (e.g. for mobile agents)
  - Process Identifiers (e.g. for code fragments)

Context

- Remember "...Mobile computing is context-aware computing"
- Determined by (but different from) current location of unit of mobility
  - E.g. Two Mobile units may be in the same location but perceive different contexts due to different administrative domains

Context (2)

- Context may include resources, services and other system components
- Location changes may lead to sudden context changes and are likely to be abrupt
  - E.g. A mobile agent on different servers has access to different sets of services

Context (3)

- Focus on context is to
  - Detect change of context
  - React to change (often in a timely manner)
- Distinction between
  - Event Based Systems
  - State Based Systems

Context (4)

- Event Based Systems
  - Consider the occurrence of events that are filtered through a given specification
  - The corresponding reaction is usually guaranteed to eventually execute

Context (5)

- State Based Systems
  - Enabling condition is a particular state of the system
  - Reaction is completed before any other state change is performed

Algorithms

- Algorithms used reflect assumptions made about underlying mobile system
- Treatment of space and coordination shapes mobile algorithms
- Current algorithms unsuitable for current shift to mobile computing

Algorithms (2)

- New algorithms needed to address
  - Location changes
  - Frequent Disconnection
  - Varied Resources
  - Power Limitations
  - Communication Constraints
  - Dynamic changes in connectivity pattern

Systems Research

- Systems research in mobile computing focused increasingly on the end user requirements for ease of use and dependability
- Also focused on performance

Systems Research (2)

- Two fundamental areas of research
  - Applications
  - Middleware (m/w)

Applications

- Current trends include manufacturing of increasingly smaller, more powerful, portable computing devices
- Application uses relate to
  - Non interaction with outside sources e.g. Coda File system
  - Accessing remote resources e.g Oracle 8i Lite
  - Tracking Devices e.g Active Badges

Applications (2) - Concerns

- User perception of application with respect to degree of exposure of mobility at application level (e.g. Coda File System)
- Variable Quality of Service
  - Need to provide adaptability

Applications (3) - Concerns

- Security Policies and security demands
  - Movement between administrative domains
- Environmental capabilities
  - Power availability (PDA Vs Notebooks)
  - Connectivity patterns (Base Stations Vs Ad Hoc environment)

Middleware

- Adds mechanisms and services that are much more specialized than those provided by OS within the context of established languages, without modifying syntax or semantics
- Enhances level of abstraction associated with programming effort

Middleware (2)

- Most fertile area of systems research in mobility
- Systems research distinguishable into
  - Middleware for Physical Mobility
  - Middleware for Logical Mobility

Physical Mobility MWare

- Application centred
- Unit of mobility concerned is Mobile Host
- Provision of mechanisms to detect connectivity, variations of Quality of Service, Service Lookups.

Logical Mobility MWare

- New design tool for development of distributed applications
  - Could help improve bandwidth use
  - Could help improve performance
- Provision of object oriented layer on top of Operating System to handle transparent object migration

Logical Mobility Mware (2)

- Unit of mobility could be
  - Unit of execution e.g. mobile agents
  - Finer grained units e.g. Java classes
- Need for mware support of relocation of code and state
- Need for mechanisms that allow different rebinding strategies

Conclusion

- Advances in wireless technology, extensive investments in telephony, and the Internet's ability to provide ubiquitous access to information are the main forces shaping the emergent field of mobile computing
- Mobility challenges old assumptions and demands new kinds of solutions.

References

- Mobility – Milojicic, Douglas, Wheeler (Addison-Wesley)
- Software Engineering for Mobility: A Roadmap – G. Roman, G. Picco, A.L. Murphy