52504 Mobile Software and Applications

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52504 Forum

https://local.cis.strath.ac.uk/teaching/ug/classes/52.504/

General Information (1)

- Goal
  - An appreciation of the issues involved in mobile and ubiquitous computing with a bias on systems issues
  - A taste of mobile software development
- Timetable
  - Lectures
    - Monday 10:00 – 11:00 Col 430
    - Tuesday 10:00 – 11:00 LT 4.01A
  - Lab
    - Friday 15:00 – 17:00 LT11
    - They start on week 2
    - Preparation for the Programming Exercise
    - Demonstration and marking of Programming Exercise

General Information (2)

- Assessment – 100% coursework
  - Programming exercise (individual) – 40%
    - A mobile phone assistant for your shopping
    - Focus on your own phone and Java ME
    - Other options possible on your own
    - Support: labs to prepare you for it
    - Published next week and Due on week 10
  - Ubiquitous computing scenario (groups of 5?) – 45%
    - Develop (on paper) a ubiquitous computing application for a university environment
    - (a) Application identification (15%) – Due week 8
    - (b) Detailed Scenario and Presentation (30%) – Due week 11
  - Class participation (individual) – 15%
    - Class tasks (background research or research paper reading) spread throughout the semester (weeks 2-10)

What Can My Phone Do?

What brand and model is it?

What OS does it run?

(type and version)

How can I program it?

(supported languages, target for programming)

What are its technical characteristics?

(UI (input and output), processor (type and clock), memory (fixed and cards), networking (bandwidth), sensors, battery (key characteristics, drain, weight))

Answers to the forum by Friday at 16:00!

Mobile computing (1)

- Exploit connectedness of devices that move around in the physical world
  - Mobile computing = Portable Devices + Wireless Networking
- Wireless connectivity: Infrared, WiFi, Bluetooth, GPRS and 3G
- Portable devices: Laptops, Notebooks, Netbooks, PDAs, Smart Phones, Tablets
  - Rise of handheld computing
    - Trade off smaller size and battery capacity against limited processing power, smaller screen, etc.
    - Same (sometimes more) range of wireless connectivity as laptops
    - Blurring the distinction between purpose devices and PDAs and mobile phones

Mobile computing (2)

- Distributed computing with additional challenges
  - Wireless communication
  - User Mobility
  - Device Portability

  - Design pressure may be released by sacrificing certain properties
    - Different roles for portable devices, but distinctions are blurred!
    - Internet Suspend/Resume model!

Wireless communication (1)

- Infrastructure-based
  - Wired infrastructure with base stations offering wireless connectivity
  - User moves between base stations retaining connectivity
  - Most computation and communication carried out in the infrastructure
  - How to provide continuous connectivity for mobile devices that pass in and out of range of base stations?
- Infrastructure-less – Ad-hoc networking
  - All communication takes place through the wireless network
  - How to enable collections of devices to wirelessly communicate with one another when there is no infrastructure? – ad-hoc networks (mobile or not)
  - Core problem: direct wireless connectivity between two devices is often not available

Wireless communication (2)

- Wireless communication is lower quality than wired
  - The surrounding environment interacts with signals
    - Blocking, noise, echoes
    - Lower bandwidth, high error rates, more frequent disconnection
      - Increased latency – retransmissions, retransmission timeout delays, error control protocol processing, short disconnections
  - Mobility introduces additional problems
    - Move out of coverage
    - Move into higher interference areas
    - Large numbers of users may overload network

Wireless communication (3)

- Wireless communication is susceptible to disconnection
  - Spend resources to try and prevent disconnection
  - Spend resources to cope more gracefully with disconnection
  - The more autonomous a mobile computer the better it tolerates disconnection
  - Masking network failures
    - Asynchronous operation for short disconnection & round-trip latency
    - Decoupling actual communication from message consumption/production - Prefetching and lazy write-back

Wireless communication (4)

- Wireless networks offer less bandwidth than wired networks
- Network bandwidth is divided among users
- More cells can improve network capacity
  - Overlap cells on different wavelengths
    - Limited scalability – electromagnetic spectrum is a scarce resource
    - More flexible – allows software allocation of bandwidth
  - Reduce transmission range – more cells fit the same area
    - Simpler, reduces power requirements, decreases signal corruption
    - Transceivers covering less area can achieve higher bandwidth

Wireless communication (5)

- Software techniques
  - Compression, Logging (bulk operations) – combination
  - Lazy write-back (purging updates) & Prefetching (but bad guesses)
  - Intelligent scheduling of communication
- High bandwidth variability
  - Much greater variation in network bandwidth – from plugged to wired
  - Applications dealing with variability
    - Assume high bandwidth and operate only while plugged in
    - Assume low bandwidth and not take advantage of higher bandwidth when available
    - Adapt to the currently available resources – different levels of quality

Wireless communication (6)

- Different network qualities in different places
- Ability to concurrently access multiple transceivers – wireless & wired
- Switching interfaces when moving indoors/outdoors
  - Different medium or different protocol

- Wireless link security can be compromised more easily
- Crossing security domains complicates security
- Encryption can achieve secure communication over insecure channels

User mobility (1)

- Mobility increases context information volatility
  - Volatility shifts design tradeoffs
- Context information
  - Devices network address changes dynamically
  - Current location affects configuration parameters and answers to user queries
  - Moving away from a nearby server increases the communication path

User mobility (2)

- User mobility changes device network address
  - Active network address usually cannot be moved to a new address
- Solutions
  - Selective broadcast
    - Ask all cells for current device address
    - Can be selective when only approximate location information is available
  - Central services
    - Current address of all devices maintained in a logically centralised database
    - Distribution, replication and caching can improve availability and response time

User mobility (3)

- Home bases
  - Only a single server knows the current address
  - Suffers from availability problems – no replication
  - Home base address migration problem!
    - Lower volatility
- Forwarding pointers
  - Depositing a copy of the new address at the old one
  - Messages are forwarded along pointer chains
  - Updates of pointers can reduce chain length
  - Fast but prone to failures – commonly used to speed others
  - Requires active entities for message forwarding

User mobility (4)

- Location dependent information is traditionally configured statically
- Dynamic configuration
  - Factor out this information intelligently
  - Provide mechanisms to obtain configuration data
- Location-awareness
  - Absolute and relative locations
- Privacy
  - Balancing flexible access to location information while protecting privacy

User mobility (5)

- Locality migrates as users move
- Communication paths can grow disproportionally to actual movement
  - Longer communication path – longer latency, greater risk of disconnection, higher consumption of network capacity
- Dynamic adaptation
  - Load balancing concerns may outweigh the importance of communication locality

User mobility (6)

- Routing in MANETs
  - The problem: routing algorithms relying on network topology are inappropriate when the topology changes two often
    - E.g. link-state or distance vector
  - New algorithms: Temporally Ordered Routing Algorithm (TORA), Dynamic Source Routing (DSR), Ad-hoc On demand Distance Vector (AODV), etc.
  - Main characteristic: reactive nature
    - Demand for communication drives routing information building
  - Multicast services are similarly the focus of research

Device portability (1)

- Device value must exceed the trouble of carrying it around
  - Small, light weight, durable, long battery life
  - Specialised hardware must justify consumption of power and space
- Portability issues
  - Low power
  - Risk to data
  - Small user interface
  - Small storage capacity

Device portability (1)

- Batteries are the largest source of weight
  - Too small batteries undermine portability
- Minimise power consumption
  - Reduce capacitance – greater VLSI integration and multi-chip modules
  - Reduce voltage (square) – low voltage chips
  - Reduce clock frequency – trade computational power for battery savings – dynamic change of clock frequency – processors that perform more work on each clock cycle
- Power can be conserved by efficient operation
  - Power management software – spinning down internal disk or turning off screen lighting
  - Application can play a role – reduce computation, communication and memory – less frequent execution of periodic operations
  - Trading talking for more listening in communications can save power
    - In mobile phones transmission requires 10 times more power than reception

Device portability (2)

- Portability increases the risks of physical damage, unauthorised access, loss and theft
- Minimising essential data minimises risks
- Encryption can prevent unauthorised access
  - Care is needed during authenticated sessions
- Copies can safeguard data against loss
  - Backups?
  - Immediate copying of data

Device portability (3)

- Size constraints impose small user interface
- Traditional user interface elements are not practical
  - Buttons replaced by handwriting, gesture and voice recognition
    - Handwriting recognition – slower than typing but removal of keyboard improves size and durability – quite good performance with training, even better with context information – context information may be limited and recognition of user intentions difficult
    - Speech production and recognition – allows hands-free and eye-free operation – good performance both with training and speaker independent – requires substantial storage and processing power – inappropriate in a lot of situations (noise, quiet environments, privacy)
  - Pointing devices: pen instead of mouse
    - Usage differs, parallax problems, coverage of screen area

Device portability (4)

- In a mobile device disks can be a liability
  - Consume more power than memory except when off-line
  - May crash when treated indelicately
- Copying with limited storage
  - Compressing file systems and virtual memory pages
  - Accessing remote storage over the network?
  - Sharing code libraries?
  - Using interpreted script languages

?? Computing (1)

- Nomadic Computing
  - Network connection from arbitrary and changing locations
    - No permanent connection
    - May not involve wireless networking
  - Network related functions carried out at fixed hosts
- Internet Suspend/Resume model!
- Ubiquitous Computing
  - Ubiquitous = found everywhere
  - Pervasive?
  - Exploit increasing integration of computing devices with physical world

?? Computing (2)

- Mark Weiser's vision
  - From multiple users to one computer, to one computer per user, to multiple computers to one user
    - Computers multiply in form and function to suit different tasks
  - Computers will disappear – weave themselves into the fabric of everyday life until they are indistinguishable from it
    - Devices are not necessarily invisible!
- Wearable computing
  - Devices attached on the person's clothing even within the fabric, or worn like watches, jewellery, spectacles, etc.
  - Operation without user manipulation
- Context-aware computing
  - Computer systems automatically adapting their behaviour according to physical circumstances
    - Anything physically measurable or detectable
- Tangible computing, Augmented reality

Volatile systems

- Systems where changes are common not exceptional
  - Spontaneous
  - High dynamism and unpredictable change
- Forms of volatility
  - Device and communication failures
  - Change in communication characteristics
  - Creation and destruction of associations
    - Logical communication relationships between software components resident on the devices
- Volatility is not a defining property of mobile and ubiquitous systems
  - Mobile and ubiquitous systems exhibit all the above forms of volatility due to the way they are integrated with the physical world

Volatile systems – Smart spaces

- Space is important for mobile and ubiquitous computing
- Smart space = any physical place with embedded services, ones provided only or principally within that physical space
  - Usually contains relatively stable computing infrastructure
- Device appearance and disappearance
  - Physical mobility and logical mobility
    - Mobility only becomes interesting when the mobile components changes some of its associations with other components as a result
  - Evolution of static devices – e.g. smart homes
  - Device failure
  - Although may appear similar to a first approximation, the rate of change is important and there are still important differences

Volatile systems – Device model

- Limited energy
  - Devices typically running on batteries that are difficult to change
  - Different task consume different amounts of power
  - Algorithms need to be sensitive to the energy they consume
  - Battery discharge increases the probability of device failure
- Resource constraints
  - Limitations imposed by power, size and form constraints
  - Efficient algorithms and resource augmentation!
- Sensors and actuators
  - Sensors measure physical parameters and provide them to software components
    - Accuracy is a major issue
  - Actuators are software controllable devices that affect the physical world
  - Motes, Smart-its – TinyOS

Volatile systems – Spontaneous interoperation

- Interoperation = component interactions during association
  - Association is different from connectivity
- In smart spaces associations change in order to take advantage of interaction opportunities with local components

Pre-configured	Spontaneous
Service-driven: *email client and server*	Human-driven: *web browser and web servers* Data-driven: *P2P file-sharing applications* Physically-driven: *mobile and ubiquitous systems*

Volatile systems (cont.)

- Volatile connectivity
  - Disconnection in wireless connections is more likely
  - Variable bandwidth and latency due to changing error rates
- Lowered trust and privacy
  - Trust in volatile systems is problematic because of spontaneous interoperation
  - Privacy is a major issue for user because of system sensing capabilities