Mobile and Ubiquitous Computing
System Design Issues

Design Issues in Distributed Mobile Applications

• Association
• Sensing and Context Awareness
• Security and Privacy
• Adaptation
Association

• Devices
  – Appear and disappear from the *space*.
  – Do so unpredictably
  – May be totally new to the *space*.
  – Or may be returning to the *space*.

• They need to be:
  – Perhaps added to the network
  – Brought into Association with resources and applications

• Examples of Association
  – Come on campus and be able to be associated with the printers that are close to you.
  – Be alerted if someone you know is walking near you.
  – Be provided with selling prices in your local area for your goods (not prices in far-away areas).
How does a new device become part of the local network?

We discuss this in the Networking classes

– ARP: discovers addressing at the data link layer

– DHCP provides:
  • A local IP address
  • The local subnet mask
  • IP address of default gateway
  • IP address of DNS server(s)
Application-level Association

• Often managed by *discovery*: *device discovery and/or service discovery.*

• Devices and/or services can register with a directory services
  – New clients can search the directory

• Devices and/or services can reply to broadcasts of requests
  – E.g. Bluetooth, when in *discover* mode, broadcasts the device, and its services.
Bump's Interesting Association Model
A: There are two parts to Bump: the app running on your device and a smart matching algorithm running on our servers in the cloud. The app on your phone uses the phone's sensors to literally "feel" the bump, and it sends that info up to the cloud. The matching algorithm listens to the bumps from phones around the world and pairs up phones that felt the same bump. Then we just route information between the two phones in each pair.

Q: No way. What if somebody else bumps at the same time?
A: Way. We use various techniques to limit the pool of potential matches, including location information and characteristics of the bump event. If you are bumping in a particularly dense area (ex, at a conference), and we cannot resolve a unique match after a single bump, we'll just ask you to bump again.
Association Models

• WeChat "shake"

• Other interesting ones?

• The most common association is membership
  – Sign-up
  – Identify "friends"
Issues in developing Mobile systems

- Association
- Sensing and Context Awareness
- Security and Privacy
- Adaptation
Sensing and Context Awareness

• Sensing:
  – Camera
  – Time
  – Acceleration
  – Location
  – Speed
  – Temperature, moisture, blood sugar, light levels, etc.

• Context awareness
  – In terms of sensed data
  – Also in terms of associated data
  – E.g. If the user is Fred and he is in the TOP SECRET meeting room and there is a display within 1 meter of him and no non-top-secret person nearby, then show information on the display.
Location Sensing

- GPS
- Database of collected Wifi access points
  - stores the access point's MAC address and the GPS location at which it was observed
- Cellular – compute using signal strength to multiple cellular tower locations
- RFID tags – tags are associated with a location
Sensor Networks

- Sensor networks are collections of small distributed computing systems with sensors that are used to monitor the environment, homes, and businesses.
Agricultural Monitoring

Common Sense-Net

http://commonsense.epfl.ch
Common-Sense Net

- Meteorological and Soil Sensors
- Connected to a mote
  - A specialized teeny computer
  - With 802.11 connectivity,
  - Powered by a pair of alkaline batteries

2 AA batteries

Distributed Systems - Mertz & McCarthy
• **Infrastructure to support large-scale sensing and actuation across Carnegie Mellon University.**
  – Examples:
    • infrastructure monitoring
    • first-responder support
    • quality-of-life applications for the disabled
    • water distribution monitoring
    • building power monitoring and control
    • biometric systems for campus security

• **Sensing device examples**
  • cameras
  • battery-operated sensor nodes
  • energy-monitoring devices wired into building power supplies

Internet of Things

• Sensors
  – e.g. light, IR, pulse

• and actuators
  – e.g. motors, solenoids, relays

• with the ability to communicate wired or wirelessly
  – e.g. wifi, bluetooth

• using standard Internet protocols
  – e.g. IP, TCP, UDP

• embedded into physical objects
  – e.g. thermostats, traffic lights, cat collars, doorbells

• to provide enhanced capabilities
  – e.g. intelligent control, convenience, security
Example

• Nest thermostat
• Philips Hue lighting
• Amazon Alexa
• Others you have used?
Raspberry Pi

• $35 computer
• Linux
• Fixed or wifi networking
• I/O Pins
• Can run a Java Web Container
  – Tomcat
  – Glassfish
  – Jetty
VoCore Mini Linux Computer: $39
Issues in developing Mobile systems

• Association
• Sensing and Context Awareness
• Security and Privacy
• Adaptation
Who is allowed to associate?

Once associated, what resources or services can I use?

Once associated, who else will know that I’m there, and what can they learn from me?
Sensing and privacy

• Be careful about what you are sensing...

• “Google has admitted that its Street View cars had ‘accidentally’ collected data from unsecured wi-fi networks in more than 30 countries.”
  – http://www.bbc.co.uk/news/technology-11000854

• Apple had a "bug" (since fixed) that tracked your location data and stored it on your phone and synced computer.
Issues in developing Mobile systems

- Association
- Sensing and Context Awareness
- Security and Privacy
- Adaptation
Adaptation

- Adapt application based on the resources of the device, and its context.
- Adapt
  - Presentation to fit the screen
  - Use of JavaScript to fit the devices capabilities
  - Media quality to fit the screen and device capabilities
  - Language to fit the user
  - Information to fit the physical context.
    - Give only movie times in the future, and in nearby theaters
Mobile OS Market Share

Source: Forecast numbers by IDC Worldwide Quarterly Mobile Phone Tracker, December 2, 2015.
http://www.idc.com/getdoc.jsp?containerId=prUS40664915
Mobile Browser Market Share (Nov 2016)

- Chrome: 55.35%
- Safari: 26.76%
- Android Browser: 8.11%
- Opera Mini: 5.86%
- Microsoft Internet Explorer: 1.31%
- Firefox: 0.79%
- Opera: 0.43%
- Other: 1.38%

Source: https://www.netmarketshare.com/browser-market-share.aspx?qprid=0&qpcustomd=1
Varies by Country

MOBILE OPERATING SYSTEM MARKET SHARE
Version 4.0 February 2013

GLOBAL MARKET SHARE AT A GLANCE

USA
- Apple iOS: 50.5%
- Android: 40.2%
- BlackBerry: 2.7%
- Other: 8.7%

UK
- Apple iOS: 43.9%
- Android: 22%
- BlackBerry: 28.4%
- Other: 4.7%

GERMANY
- Apple iOS: 35.7%
- Android: 54.4%
- Nokia: 2%
- Other: 7.9%

FRANCE
- Apple iOS: 49.4%
- Android: 41.2%
- Nokia: 2.2%
- Other: 7.2%

SPAIN
- Android: 64.6%
- Apple iOS: 29%
- Other: 3.9%

BRAZIL
- Nokia: 23.1%
- Android: 44.4%
- Apple iOS: 12.2%
- Other: 20.3%

ARGENTINA
- Android: 62.8%
- Nokia: 18.5%
- Apple iOS: 7.6%
- Other: 12%

PERU
- Android: 53.8%
- Nokia: 14.4%
- Apple iOS: 18.8%
- Other: 14.1%

MEXICO
- Apple iOS: 23.9%
- Android: 44.8%
- Nokia: 14.2%
- Other: 17.1%

AUSTRALIA
- Android: 67%
- Apple iOS: 29.7%
- Nokia: 1%
- Other: 2.3%

RUSSIA
- Nokia: 22.8%
- Android: 36.3%
- Apple iOS: 18.9%
- Other: 10.8%

INDIA
- Nokia: 52.1%
- Samsung: 14.2%
- Android: 14.2%
- Other: 11.3%

JAPAN
- Apple iOS: 52.6%
- Android: 44.8%
- Other: 2.6%

SOUTH KOREA
- Apple iOS: 90.1%
- Android: 8.5%
- Other: 1.4%

CHINA
- Nokia: 3.3%
- Android: 17.1%
- Apple iOS: 14.3%
- Other: 10.4%

Data Source: http://connect.icrossing.co.uk/wp-content/uploads/2013/01/iCrossing_2013_Mobile_Market_Share.gif
Data from StatCounter
How is Mobile Web Different Than Desktop?

- Smaller bandwidth
- More frequently users are paying by the MB/GB
- Smaller display
- Touch vs mouse
  - Or no pointing device at all on older feature phones
- Less computing power
- Making more use of computing and communication depletes batteries faster.
- Less browser memory
- Less cache space
- Limited keyboard
- Small keyboard keys
Mobile Markup History

- **WML** – Wireless Markup Language
  - Older, simpler markup language for low-power devices.
  - Dialect of XML
  - For monochrome devices with low memory and power.
  - Eg:

```xml
<?xml version="1.0"?>
<!DOCTYPE wml PUBLIC "-//WAPFORUM//DTD WML 1.1//EN" "http://www.wapforum.org/DTD/wml_1.1.xml" >
<wml>
  <card id="main" title="First Card">
    <p mode="wrap">This is a sample WML page.</p>
  </card>
</wml>
```

- This structure of cards looks similar to today's jQuery Mobile JavaScript framework
Other Old Markup Languages

• **CHTML**
  – Compact HTML
  – On Japanese DoCoMo mobile network

• **XHTML Basic**
  – Around 2000 by W3C
  – Simpler than HTML

• **XHTML-MP (Mobile Profile)**
  – & CSS Mobile Profile 2.0
  – ECMAScript-MP or *Mobile JavaScript*
    • Essentially JavaScript as implemented in desktop browsers.
      – (Differences are pretty esoteric.)
Mobile Markup on Smartphones Today

• Most of HTML5 & CSS3
  – Typically similar to desktops
• See: http://mobilehtml5.org
Mobile Markup History

• WML – Wireless Markup Language
  – Older, simpler markup language for low-power devices.
  – Dialect of XML
  – For monochrome devices with low memory and power.
Other Old Markup Languages

• CHTML
  – Compact HTML
  – On Japanese DoCoMo mobile network

• XHTML Basic
  – Around 2000 by W3C
  – Simpler than HTML
  – Preceded XHTML-MP
Mobile Markup Today

• HTML, XHTML, a lot of HTML5
  – On many smart phones
  – Same as on desktops
  – Also CSS3 (the latest desktop styling standard)

• But be aware of your market. Smartphones can be very rare in some markets.
How do you adapt?

Range of mobile screen sizes across smartphones and tablets

Source: http://www.jacobsclievenger.com/blog/mobile-device-screen-sizes-resource-guide/
Device Awareness

• Reply differently depending on what device makes request.
• 3 HTTP headers provide clues of what the device is:
  1. User-Agent
     • Identifies the mobile browser and almost always the device manufacturer and model.
     • BlackBerry8330/4.3.0 Profile/MIDP-2.0 Configuration/CLDC-1.1 VendorID/105
     • Collection of mobile agent strings:
       – [link]
  2. X-Wap-Profile
     • Link to an XML profile of the phone’s capabilities
     • E.g.
       [link]
  3. Accept
     • Supported MIME types
     • E.g. text/html, application/xhtml+xml, etc.
• Device capabilities databases exist
  – E.g. Wireless Universal Resource File (WURFL)

• E.g. Samsung SGH T139
  – Fairly cheap phone ($20, no contract)
  – [http://www.tera-wurfl.com/explore/?action=wurfl_id&id=samsung_sgh_t139_ver1](http://www.tera-wurfl.com/explore/?action=wurfl_id&id=samsung_sgh_t139_ver1)
    – 220x176 Display
    – Full HTML4
    – Full Ajax support
Device Awareness

• These 3 headers should provide enough info
• BUT
  – Headers can be missing
  – Have inaccurate values
  – Have invalid URLs
A much more flexible and reliable solution is to use feature detection.

– Don't try (or trust) basing decisions globally on the capabilities of a browser
– Rather, each time a feature cannot be universally assumed, test for it before using it.

Richard Cornford and Garrett Smith give a very good discussion of device vs feature detection:

Bottom line:
– Use feature detection, not browser detection.
Two strategies for Feature Detection

• Graceful degradation
  – Design for modern browsers
  – Where features are not available, provide a simpler alternative
    • If not possible, alert the user
      – Don't allow it to invisibly fail

• Progressive enhancement
  – Design with a baseline of usable functionality
  – Enrich the user experience step-by-step by testing for features before using them.
Progressive Enhancement Example

Basic HTML

Order of Navigation

1. Homepage Change the order for Homepage 1
2. Contact Us Change the order for Contact Us 2
3. About Us Change the order for About Us 3
4. Latest News Change the order for Latest News 4

If more advanced styling is available

Order of Navigation

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Homepage</td>
<td>1</td>
</tr>
<tr>
<td>Contact Us</td>
<td>2</td>
</tr>
<tr>
<td>About Us</td>
<td>3</td>
</tr>
<tr>
<td>Latest News</td>
<td>4</td>
</tr>
</tbody>
</table>

If JavaScript available to implement drag & drop

Order of Navigation

Homepage

Latest News

Contact Us

About Us

Save new order

Images source: https://www.smashingmagazine.com/2009/04/progressive-enhancement-what-it-is-and-how-to-use-it/
Responsive Web Design

• A strategy of web design for multiple screen sizes
• Uses:
  – Fluid grids expressing sizes in terms of percents, not pixels
  – Modify size of media using relative units
    • Keep them within their bounding elements
    • Images
    • Media
    • Font size
  – Crossing size thresholds switch to completely different designs
    • Accomplished using media queries
Responsive Web Design

• Coined by Ethan Marcotte
  – Visit: http://alistapart.com/article/responsive-web-design
    • Also published a book: Responsive Web Design

• Notice in his examples:
  – Fluid design using relative sizes
  – Media size changing
  – Crossing size threshold alters type of navigation
Mobile First

• A philosophy of web design
• Design for mobile first, and desktop second
• Counter to what has been done historically, of mobile 2\textsuperscript{nd}
• Benefits of Mobile First:
  – Focus on the platform on which you will reach the most users
  – Forces designers to focus on the most important content and functionality
  – Allows for using technologies on mobile:
    • touch events
    • geolocation
    • accelerometer
• Articulated by Luke Wroblewski
Summary of current design practices

• Progressive Enhancement
Via:
• Responsive Design
• Mobile First

• Frameworks exist to help implement this approach
• E.g.
  – Twitter Bootstrap
  – Zurb Foundation
  – jQuery Mobile (being less well supported)
jQuery Mobile

• Supports a unified UI framework
• Across all popular mobile device platforms
  – phones and tablets
• Built on jQuery (a desktop UI framework)
• Themeable design
• Supports touch events
• Accessibility for assistive technologies
• Embodies *progressive enhancement*
• http://jquerymobile.com/
MISM Capstone: Disaster Assessment App

Where are you?

I think you're standing on:
Forbes Ave
Correct
I'm on Forbes Ave
Incorrect
I'm on a different street

Number of floors: 2

Is there a basement? Yes No
Is the basement occupied? Yes No

Please describe the way in which the basement is being used:
for storage

How much water is in the living area? 12 inches
How much water is in the basement? 12 inches
Is the electricity on? Yes No
Is the gas on? Yes No
Mobile Deployment Options

- **Native**
  - E.g. Android, iOS
  - Requires redeveloping for each architecture
    - 2 code bases

- **Native with Development Framework**
  - Use a framework that compiles to multiple native applications
    - E.g. Corona (http://www.coronalabs.com)
      - Develop code in Lua
Mobile Deployment Options

• Mobile Web
  – Develop in HTML / CSS / JavaScript
  – Accessed in a browser
  – Can install local icon to launch to site
    • Use local storage to store information when off line
    • Use manifest to cache application to use when off line
    • Sync when Internet is again available.

• Hybrid
  – Develop in HTML / CSS / JavaScript
  – Wrap in a browser wrapper to create native apps
  – Wrapper provides access to phone hardware not accessible from the browser
  – Apache Cordova (https://cordova.apache.org) is an open source native wrapper
Recap: Issues in Mobile Systems

• Association
  – Discovering and linking to contextual services
• Sensing and Context Awareness
  – Using environmental inputs (e.g. accelerometer, gps)
  – Associative data (e.g. membership)
  – And other data (e.g. time of day, bus schedule)
• Security and Privacy
  – Guarding against:
    • Unauthorized access to information or services
    • Unauthorized modification of information.
    • Disrupting the access to information or services.
• Adaptation
  – Native vs Common Development Framework vs Hybrid apps vs Web apps
  – If Web or Hybrid
    • Use feature detection to determine capabilities of the client device
    • Use Progressive Enhancement based on those capabilities
      – Responsive Web Design (RWD, or Responsive Design)
      – Mobile first