CS 403X Mobile and Ubiquitous Computing
Lecture 1: Introduction

Emmanuel Agu

About Me

A Little about me

- WPI Computer Science Professor
- Research interests:
  - mobile computing especially mobile health, computer graphics
- Started working in mobile computing in grad school
  - 3 years in wireless LAN research lab (*pre 802.11*)
- CS + ECE background (Hardware + software)
- Current active research: Mobile health apps
  - E.g: AlcoGait app to detect how drunk Smartphone owner is

Administrivia

Administrivia: Schedule

- ***Week 1-3:*** I will present (course introduction, Android programming, assigned projects)
  - **Goal:** Students acquire basic Android skills to do excellent project
- ***Weeks 4 – 7:*** Students will present papers
  - **Goal:** examine cutting edge research ideas
  - Student talks short and sweet (~15 minutes)
  - Discussions
  - Students not presenting submit summaries of any 1 of day's papers
- ***Week 4-7:*** Final project
  - ***Week 5:*** Students propose final project
  - ***Week 7:*** Students present + submit final projects

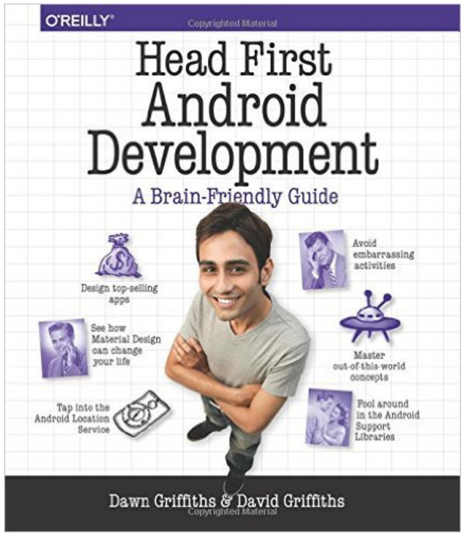
Requirements to get a Grade

- **Seminar class:** Participate in class discussions (6%)
- **Weeks 4-7:** Student paper presentations (15%)
  - Each student will present 1 paper (in groups?)
- Students not presenting, submit summaries of any 1 of week's papers (15%)
- **Projects**: 3 assigned (24%) and 1 final project(s) (40%)
- **Final project:** 5-phases (See website for deadlines)
  - Pick partner + decide project area
  - Brainstorm on ideas
  - Submit proposal intro + related work + proposed project plan
  - Build, evaluate, experiment, analyze results
  - Present results + submit final paper (in week 7)
- **Grading policy:** Presentation(s) 15%, Class participation 6%, Assigned Projects 24%, Final project: 40%, Summaries: 15%

Course Texts

- **Android Texts:**
  - *Head First Android Development,* Dawn and David Griffiths, O'Reilly, 2015
  - *Android Programming: The Big Nerd Ranch (Second edition)*, Bill Phillips and Brian Hardy, The Big Nerd Ranch, 2015

Gentle intro


O'REILLY
Copyrighted Material
Head First Android Development
A Brain-Friendly Guide
Design top-selling apps
See how Material Design can change your life
Tap into the Android Location Service
Avoid embarrassing activities
Master out-of-this-world concepts
Fool around in the Android Support Libraries
Dawn Griffiths & David Griffiths
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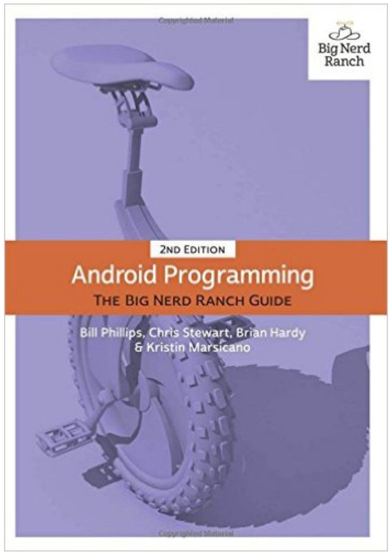


Bootcamp Tutorial

- Will also use official Google Android documentation
- Research papers: Why not text?

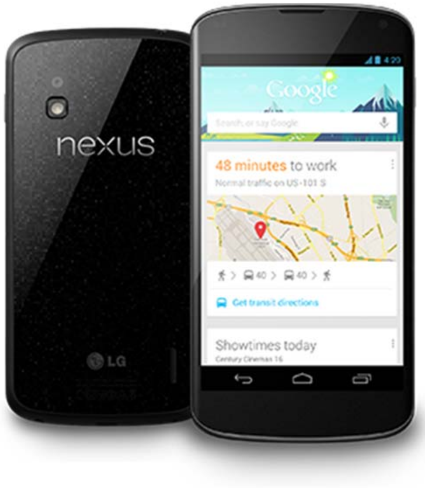
Poll Question

- How many students:
  1. **Own** recent Android phones (running Android 4.4, 5.0 or 6.0?)
  2. **Can borrow** Android phones for projects (e.g. from friend/spouse)?
  3. **Do not own and cannot borrow** Android phones for projects?

Mobile Devices

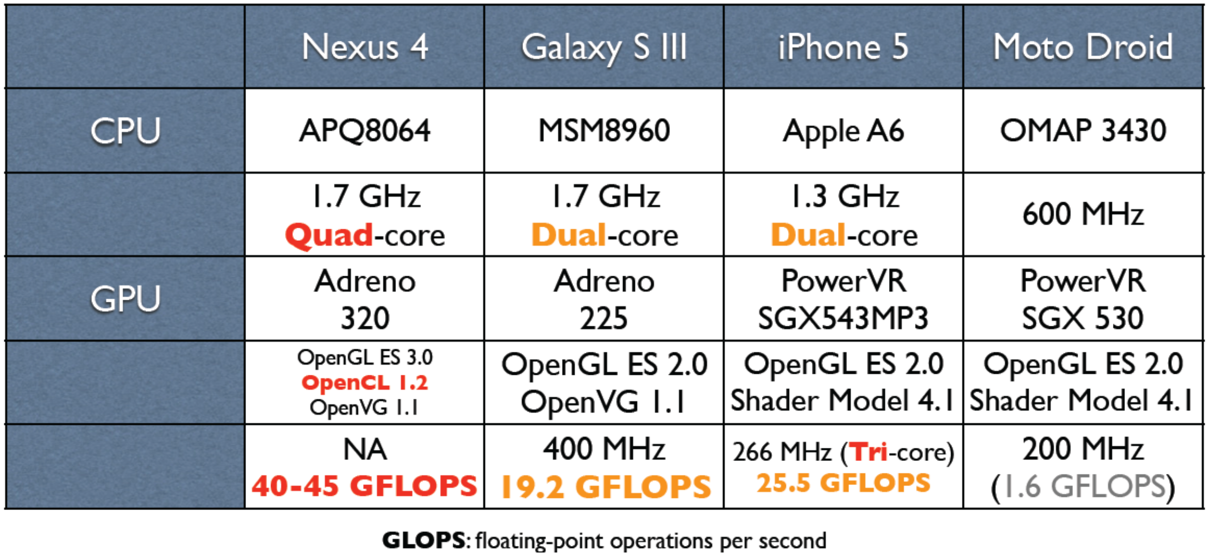
Mobile Devices

- Smart phones (Blackberry, iPhone, Android, etc)
- Tablets (iPad, etc)
- Laptops



SmartPhone Hardware

- **Communication:** Talk, text, Internet access, chat
- **Computing:** Java apps, JVM, apps
  - Powerful processors: Quad core CPUs, GPUs
- **Sensors:** Camera, video, accelerometer, etc
- Smartphone = Communication + Computing + Sensors
- Google Nexus 5 phone: Quad core 2.5 GHz CPU, Adreno 330 GPU



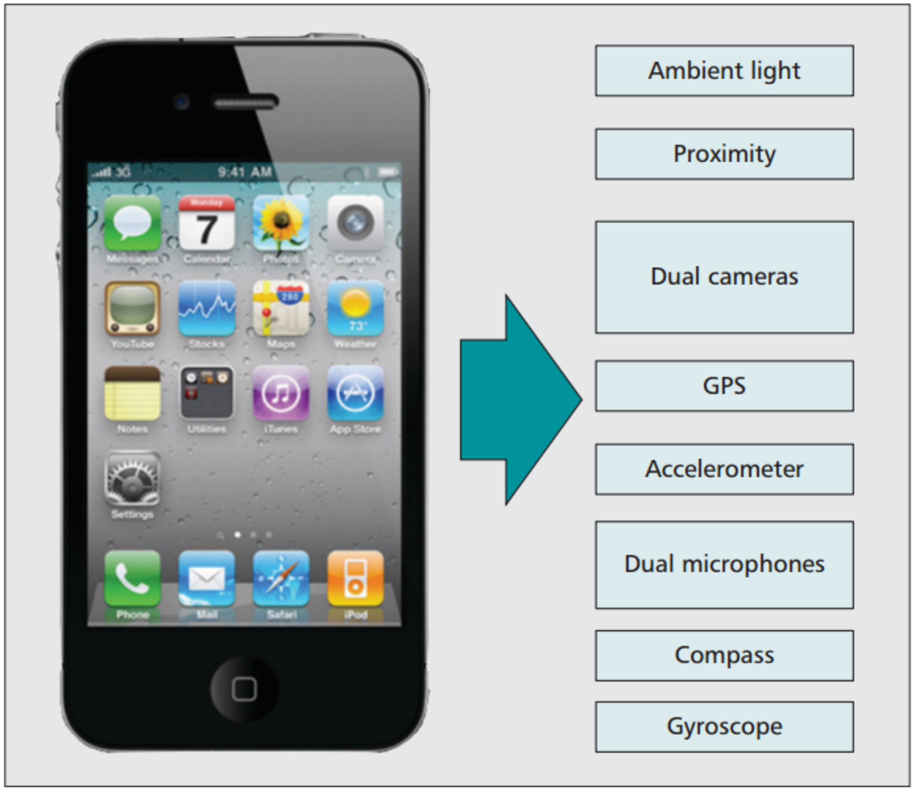
	Nexus 4	Galaxy S III	iPhone 5	Moto Droid
CPU	APQ8064	MSM8960	Apple A6	OMAP 3430
	1.7 GHz **Quad**-core	1.7 GHz **Dual**-core	1.3 GHz **Dual**-core	600 MHz
GPU	Adreno 320	Adreno 225	PowerVR SGX543MP3	PowerVR SGX 530
	OpenGL ES 3.0 **OpenCL 1.2** OpenVG 1.1	OpenGL ES 2.0 OpenVG 1.1	OpenGL ES 2.0 Shader Model 4.1	OpenGL ES 2.0 Shader Model 4.1
	NA **40-45 GFLOPS**	400 MHz **19.2 GFLOPS**	266 MHz (**Tri**-core) **25.5 GFLOPS**	200 MHz (1.6 GFLOPS)

GLOPS: floating-point operations per second

Comparison courtesy of Qian He (Steve)

Smartphone Sensors

- Typical smartphone sensors today
  - accelerometer, compass, GPS, microphone, camera, proximity



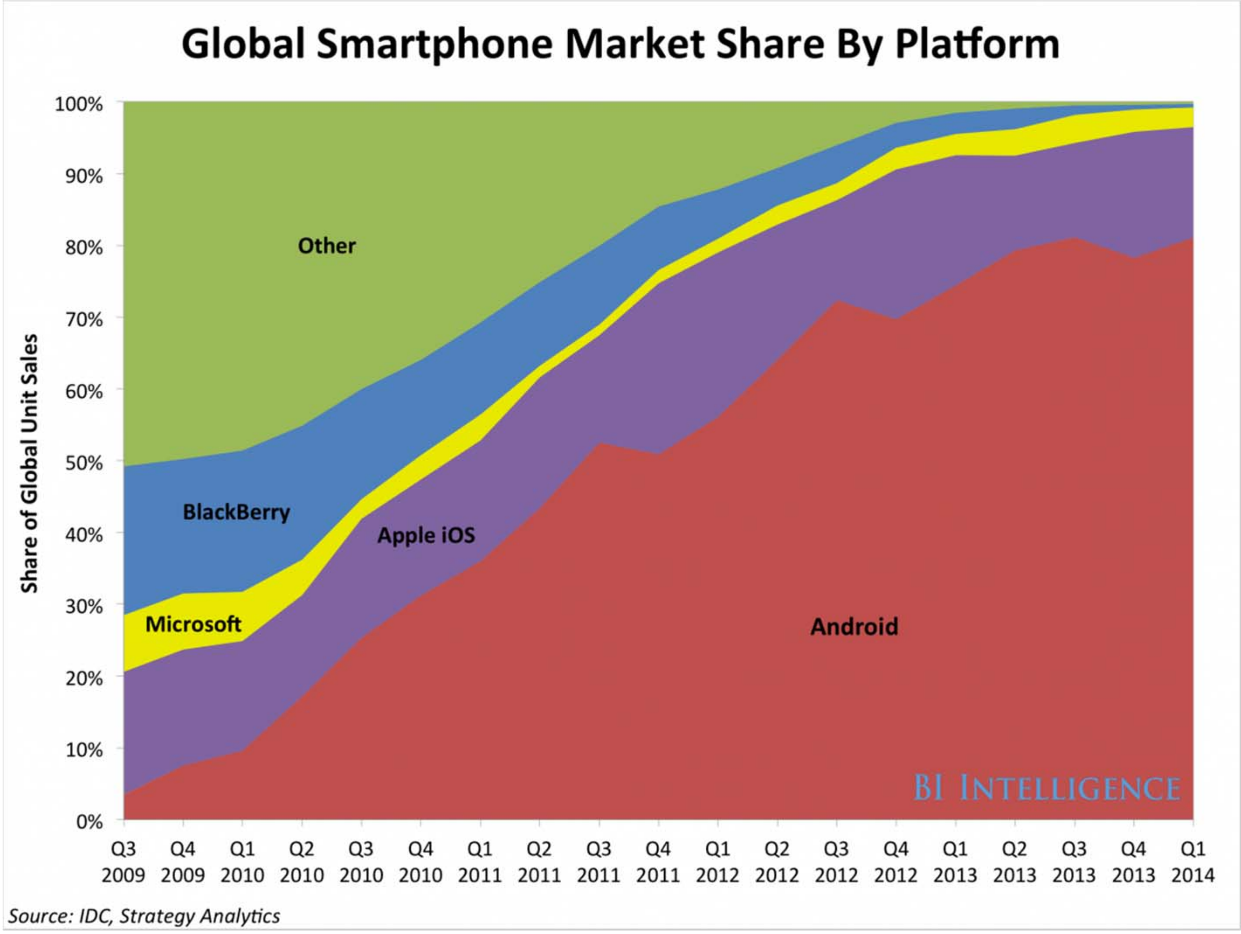
Future sensors?

- Heart rate monitor,
- Activity sensor,
- Pollution sensor,
- etc

SmartPhone OS

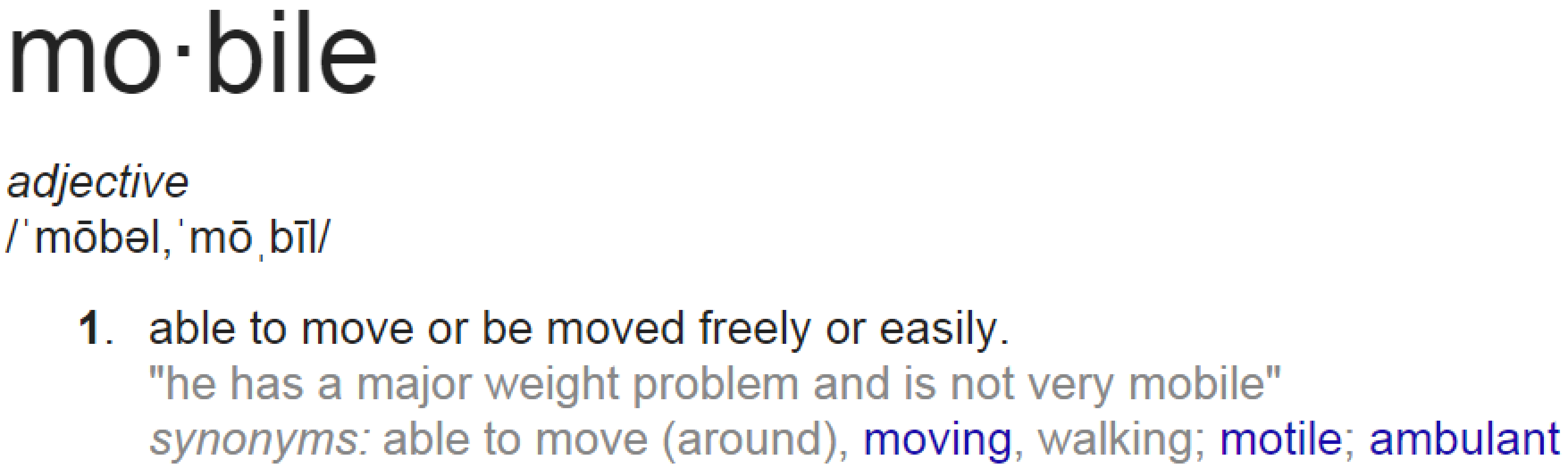
- Over 80% of all phones sold are smartphones
- Android share 78% worldwide
- iOS 18%

Source: IDC,
Strategy Analytics



Source: IDC, Strategy Analytics

Mobile Computing



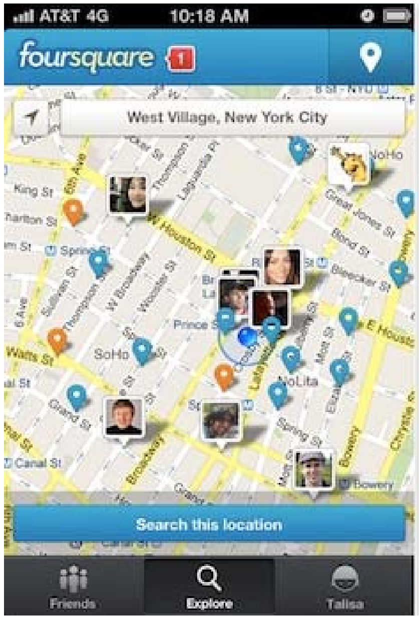
mo·bile

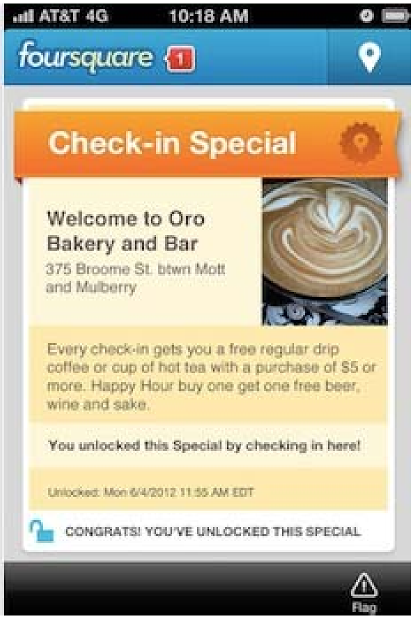
adjective
/ˈmōbəl,ˈmōˌbīl/

1. able to move or be moved freely or easily.
   "he has a major weight problem and is not very mobile"
   synonyms: able to move (around), moving, walking; motile; ambulant

Mobile Computing

- Mobile? Human computes while moving
  - Continuous network connectivity,
  - Points of connection (e.g. cell towers) change
- **Note: Human initiates all activity**, (e.g launches apps)
- Network is mostly *passive*
- **Example:** Using *foursquare.com* on smart phone





Check-in Special

Welcome to Oro Bakery and Bar

375 Broome St. btwn Mott and Mulberry

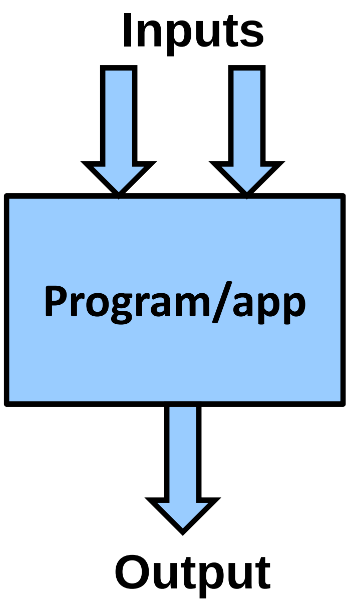
Every check-in gets you a free regular drip coffee or cup of hot tea with a purchase of $5 or more. Happy Hour buy one get one free beer, wine and sake.

You unlocked this Special by checking in here!

Unlocked: Mon 6/4/2012 11:55 AM EDT

CONGRATS! YOU'VE UNLOCKED THIS SPECIAL

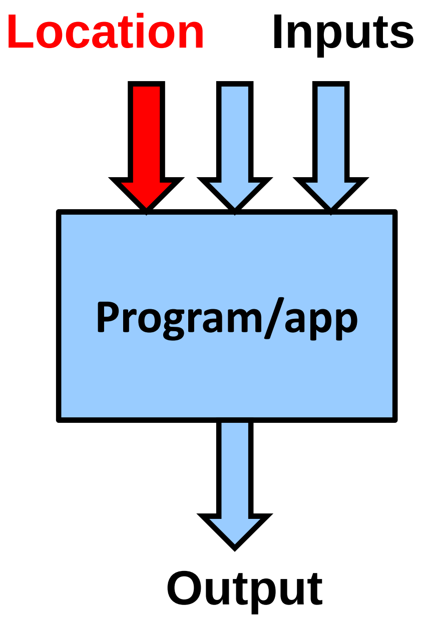
What does mobile mean?


Inputs

Program/app

Output

Non-mobile app


Location

Inputs

Program/app

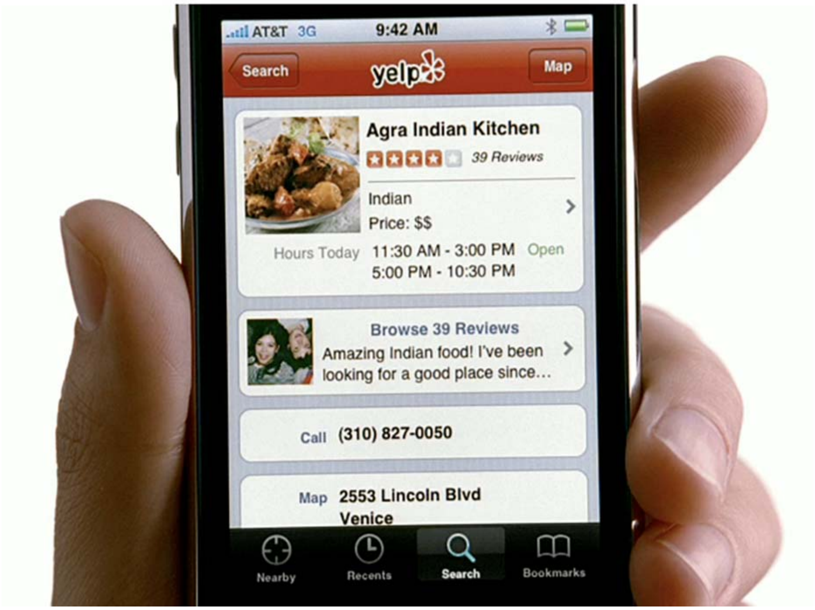
Output

Mobile app

- Mobile computing = computing while location changes
- Location (e.g) must be one of app/program’s inputs
- Different user location = different output (e.g. maps)
- User in California gets different map from user in Boston

What does mobile mean?

- Truly mobile app must have different behavior/output for different locations
- Example: Mobile yelp
  - **Example search:** Find Indian restaurant
  - App checks user's location
  - Indian restaurants **close to user's location** are returned



Agra Indian Kitchen

39 Reviews

Indian

Price: $$

Hours Today 11:30 AM - 3:00 PM Open
5:00 PM - 10:30 PM

Browse 39 Reviews

Amazing Indian food! I've been looking for a good place since…

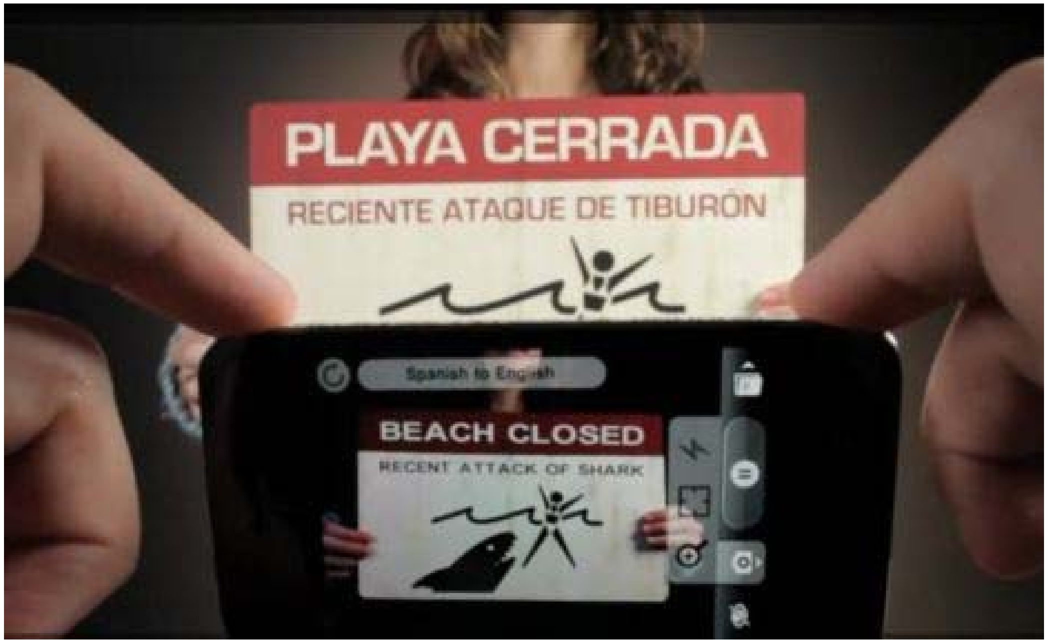
Call (310) 827-0050

Map 2553 Lincoln Blvd
Venice

Example of Truly Mobile App: Word Lens

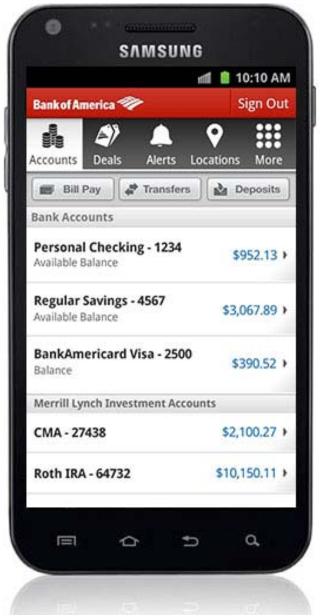
- Translates signs in foreign Language

- Location-dependent because sign location varies



Some apps are not truly mobile?

- If output does not change as location changes, not truly mobile
- Apps run on mobile phone **just for convenience**
- Output does not change as location changes
- **Examples:**



Bank Accounts

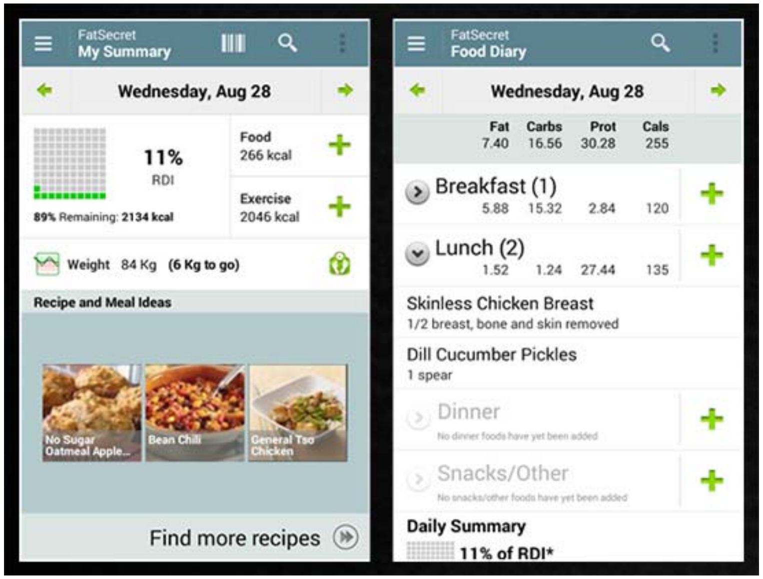
Personal Checking - 1234 Available Balance	$952.13
Regular Savings - 4567 Available Balance	$3,067.89
BankAmericard Visa - 2500 Balance	$390.52

Merrill Lynch Investment Accounts

CMA - 27438	$2,100.27
Roth IRA - 64732	$10,150.11

Mobile banking app

Internet Retailer app



Wednesday, Aug 28

11%
RDI

89% Remaining: 2134 kcal

Food
266 kcal

Exercise
2046 kcal

Weight 84 Kg (6 Kg to go)

Recipe and Meal Ideas

Wednesday, Aug 28

	Fat	Carbs	Prot	Cals
	7.40	16.56	30.28	255
Breakfast (1)	5.88	15.32	2.84	120
Lunch (2)	1.52	1.24	27.44	135

Skinless Chicken Breast
1/2 breast, bone and skin removed

Dill Cucumber Pickles
1 spear

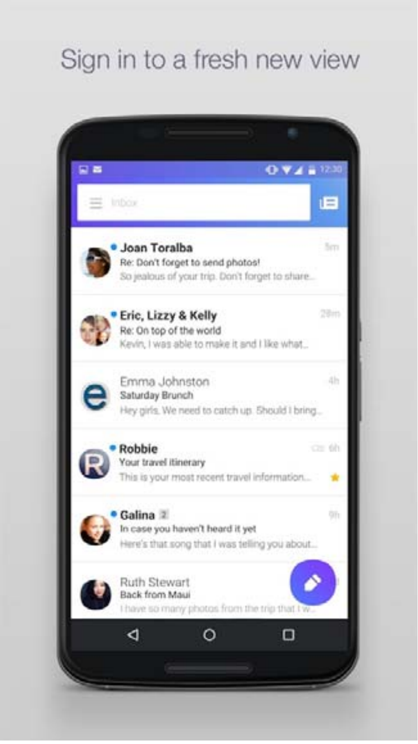
Dinner
No dinner foods have yet been added

Snacks/Other
No snacks/other foods have yet been added

Daily Summary
11% of RDI*

Diet recording app

Which of these apps are truly mobile?



Sign in to a fresh new view

Joan Toralba 5m
Re: Don't forget to send photos!
So jealous of your trip. Don't forget to share...

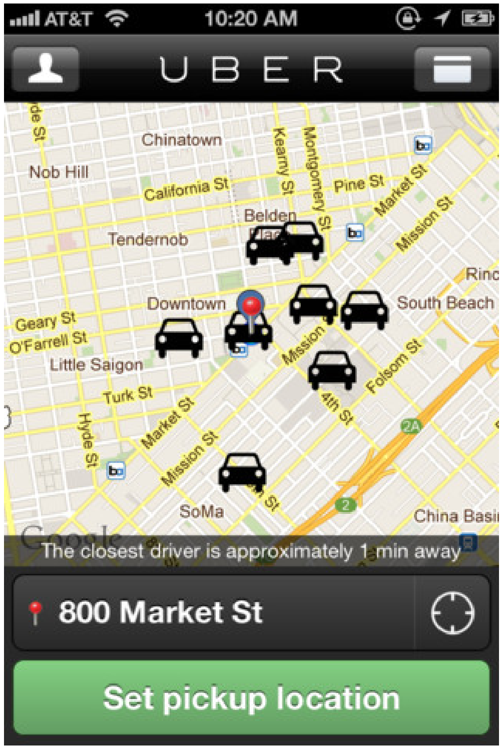
Eric, Lizzy & Kelly 28m
Re: On top of the world
Kevin, I was able to make it and I like what...

Emma Johnston 4h
Saturday Brunch
Hey girls. We need to catch up. Should I bring...

Robbie 6h
Your travel itinerary
This is your most recent travel information...

Galina 2 9h
In case you haven't heard it yet
Here's that song that I was telling you about...

Ruth Stewart
Back from Maui
I have so many photos from the trip that I w...



The closest driver is approximately 1 min away

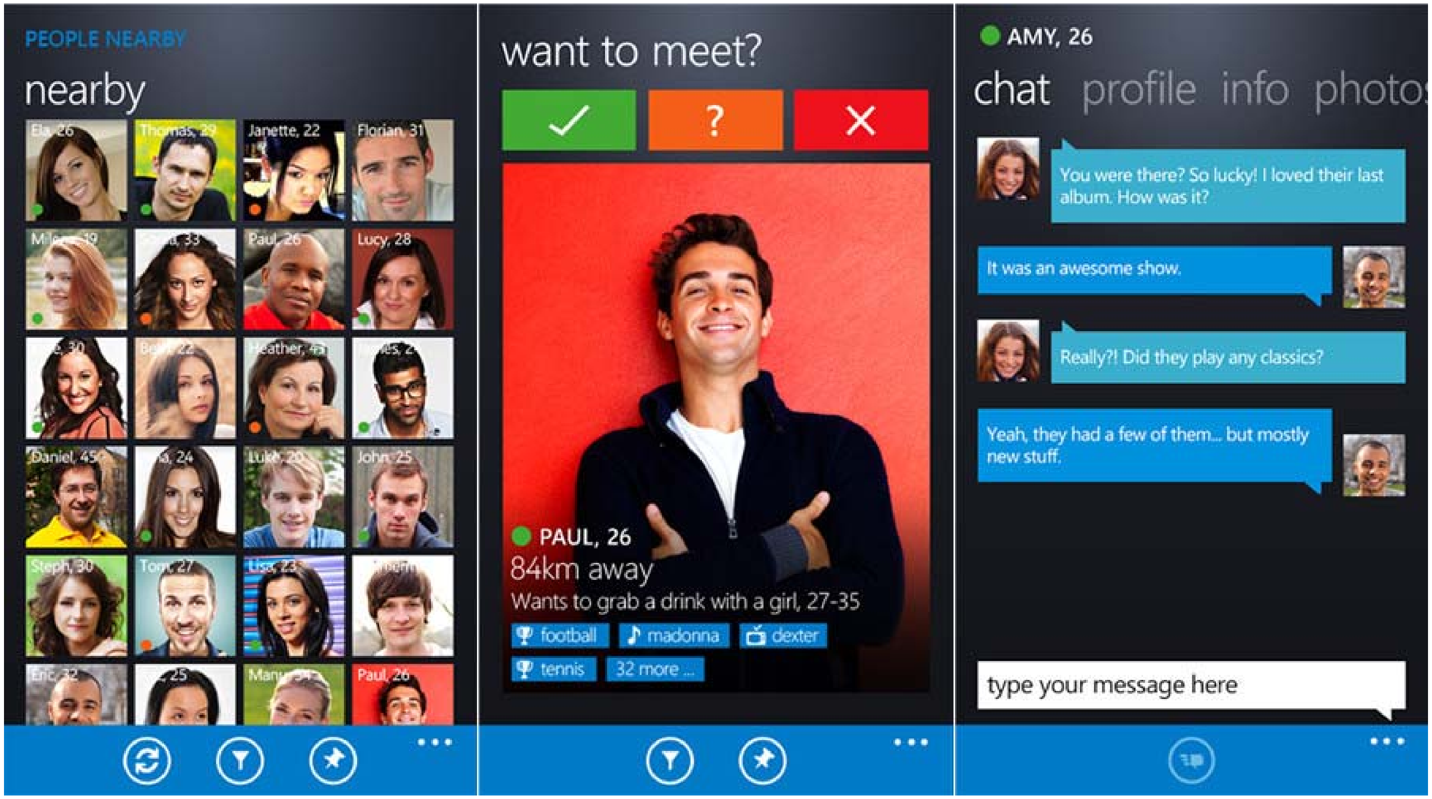
800 Market St

Set pickup location

a. Yahoo mail mobile

b. Uber app

Which of these apps are truly mobile?



PAUL, 26
84km away
Wants to grab a drink with a girl, 27-35

You were there? So lucky! I loved their last album. How was it?

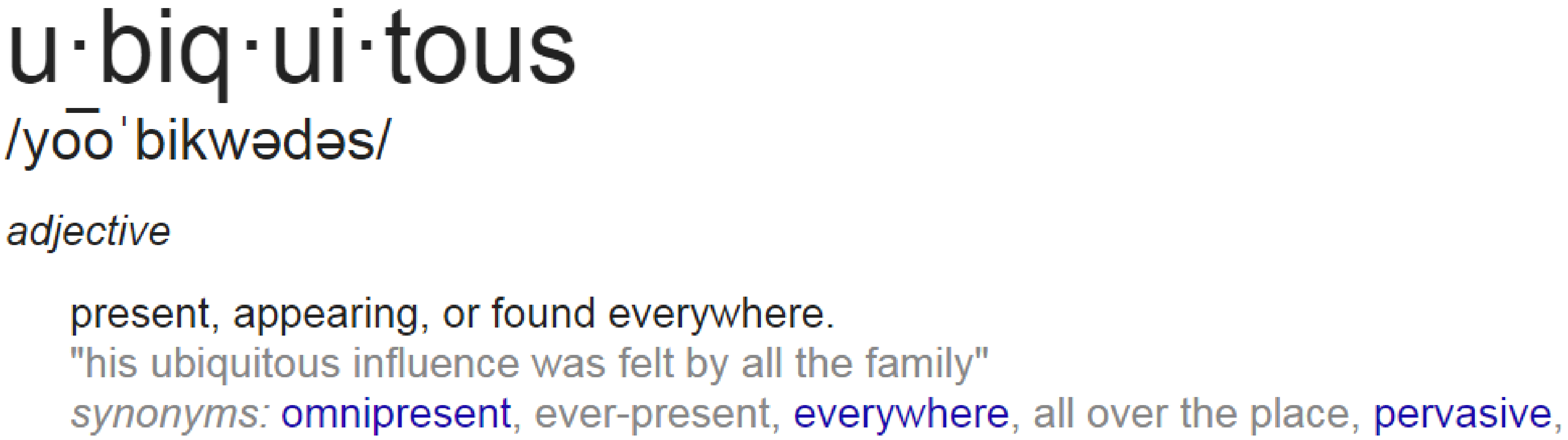
It was an awesome show.

Really?! Did they play any classics?

Yeah, they had a few of them... but mostly new stuff.

c. Badoo dating app

Ubiquitous Computing



u·biq·ui·tous

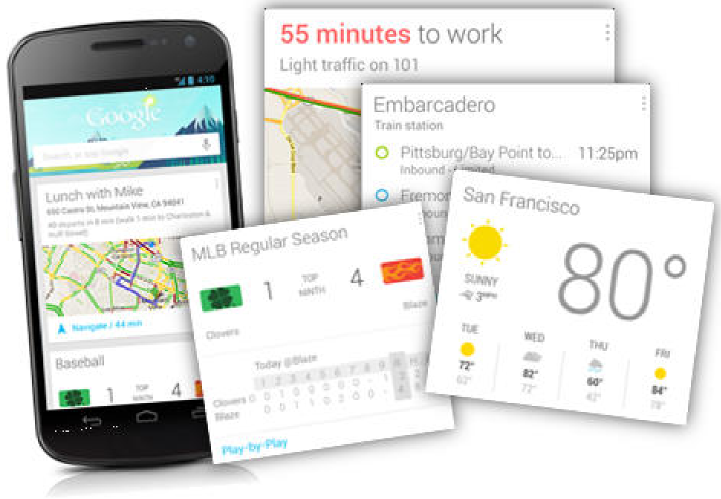
/yo͞oˈbikwədəs/

adjective

present, appearing, or found everywhere.
"his ubiquitous influence was felt by all the family"
synonyms: omnipresent, ever-present, everywhere, all over the place, pervasive,

Ubiquitous Computing

- Collection of specialized assistants to assist human in tasks (reminders, personal assistant, staying healthy, school, etc)
- Array of *active* elements, sensors, software, Artificial intelligence
- Extends *mobile computing* and *distributed systems* (more later)
- **Note:** System/app initiates activities, has intelligence
- **Example:** Google Now app



Ubicomp Senses User's Context

- Context?
  - *Human:* motion, mood, identity, gesture
  - *Environment:* temperature, sound, humidity, location
  - *Computing Resources:* Hard disk space, memory, bandwidth
  - *Ubicomp example:*
    - *Assistant senses:* Temperature outside is 10F (environment sensing) + Human plans to go work (schedule)
    - *Ubicomp assistant advise:* Dress warm!
- Sensed **environment + Human + Computer resources** = ***Context***
- *Context-Aware* applications adapt their behavior to context

Sensing the Human

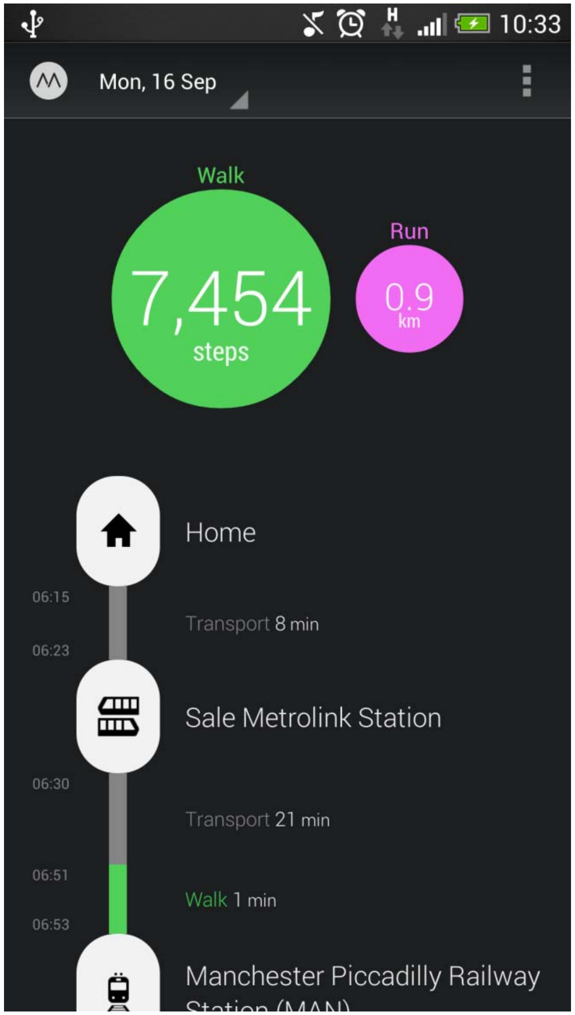
- Environmental sensing is relatively straight-forward
  - Use specialized sensors for temperature, humidity, pressure, etc
- Human sensing is a little harder (ranked easy to hard)
  - **When:** time (Easiest)
  - **Where:** location
  - **Who:** Identification
  - **How:** (Mood) happy, sad, bored (gesture recognition)
  - **What:** eating, cooking (meta task)
  - **Why:** reason for actions (extremely hard!)

5 W's + 1 H

- Human sensing (gesture, mood, etc) easiest using cameras
- Research in ubiquitous computing integrates
  - location sensing, user identification, emotion sensing, gesture recognition, activity sensing, user intent

UbiComp Example: Moves App

- Counts Smartphone users steps through the day



10:33

Mon, 16 Sep

Walk

7,454 steps

Run

0.9 km

Home

06:15

Transport 8 min

06:23

Sale Metrolink Station

06:30

Transport 21 min

06:51

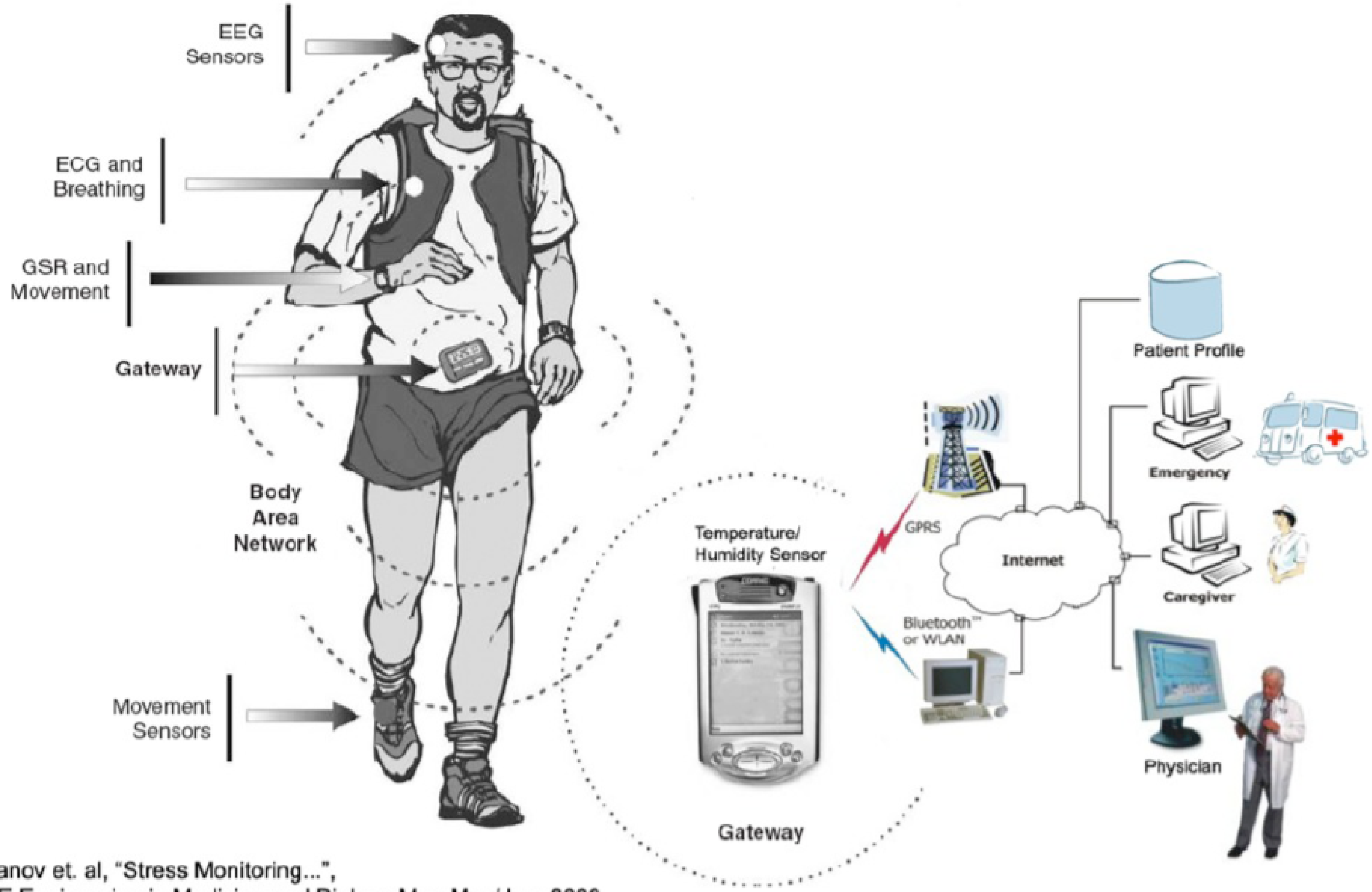
Walk 1 min

06:53

Manchester Piccadilly Railway Station (MAN)

Ubiquitous Computing: Wearable sensors for Health

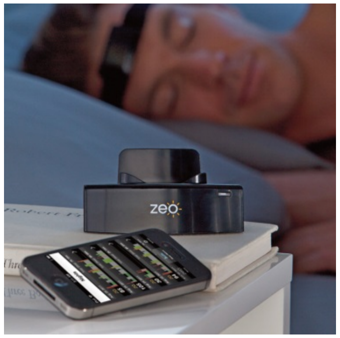
remote patient monitoring



Jovanov et. al, "Stress Monitoring...",
IEEE Engineering in Medicine and Biology Mag.May/June2003

UbiComp: Wearables, BlueTooth Devices

Body Worn
Activity Trackers

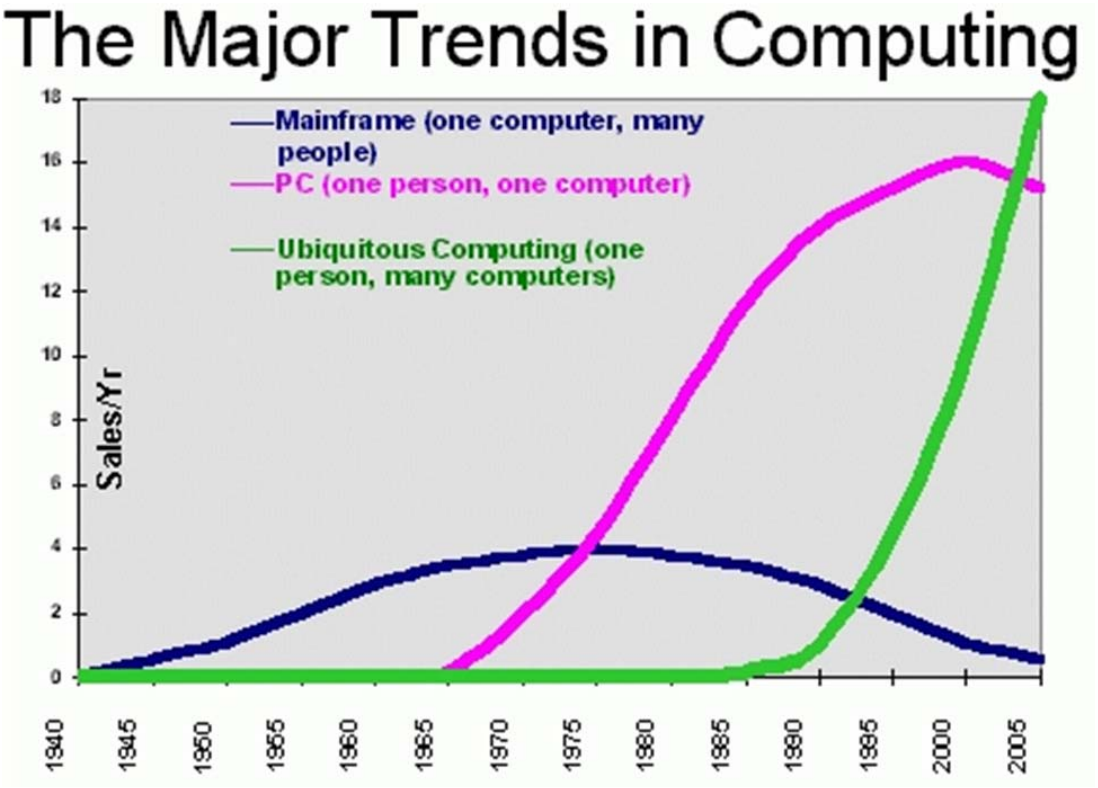


Bluetooth
Wellness
Devices

External sources of data for smartphone

A lot (Explosion) of Devices

- *Recent Nokia quote:* More cell phones than tooth brushes
- Many more sensors envisaged
- ***Ubiquitous computing:*** Many computers per person

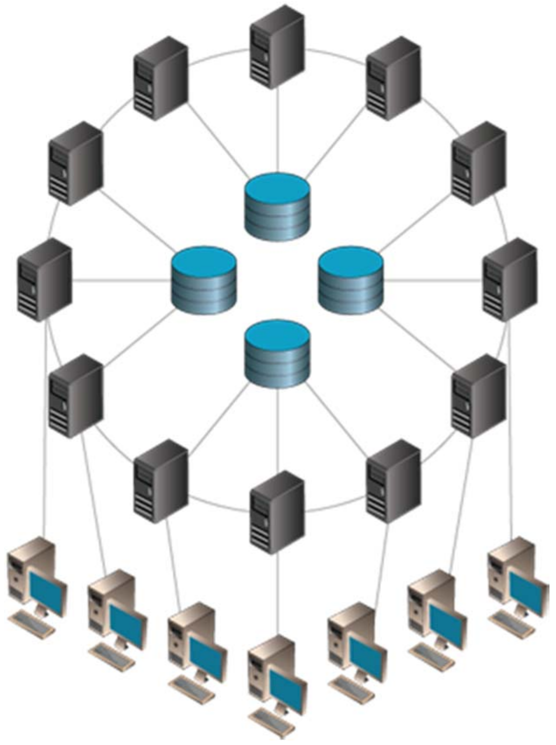


Definitions: Portable, mobile & ubiquitous computing

Distributed Computing

- Computer system is physically distributed
- User can access system/network from various points.
- E.g. Unix cluster, WWW
- Huge 70's revolution

- ***Distributed computing example:***
  - WPI students have a CCC account
  - Log into CCC machines,
  - Web surfing from different terminals on campus (library, dorm room, zoolab, etc).



- **Finer points:** network is fixed, Human moves

Portable (Nomadic) Computing

- **Basic idea:**
  - Network is fixed
  - device moves and changes point of attachment
  - No computing while moving

- *Portable (nomadic) computing example:*
  - Mary owns a laptop
  - Plugs into her home network,
  - **At home:** surfs web while watching TV.
  - Every morning, brings laptop to school, plug into WPI network, boot up!
  - **No computing while traveling to school**

Mobile Computing Example

- Continuous computing/network access while moving, automatic reconnection

- ***Mobile computing example:***
  - John has SPRINT PCS phone with web access, voice, SMS messaging.
  - He runs apps like facebook and foursquare, continuously connected while walking around Boston

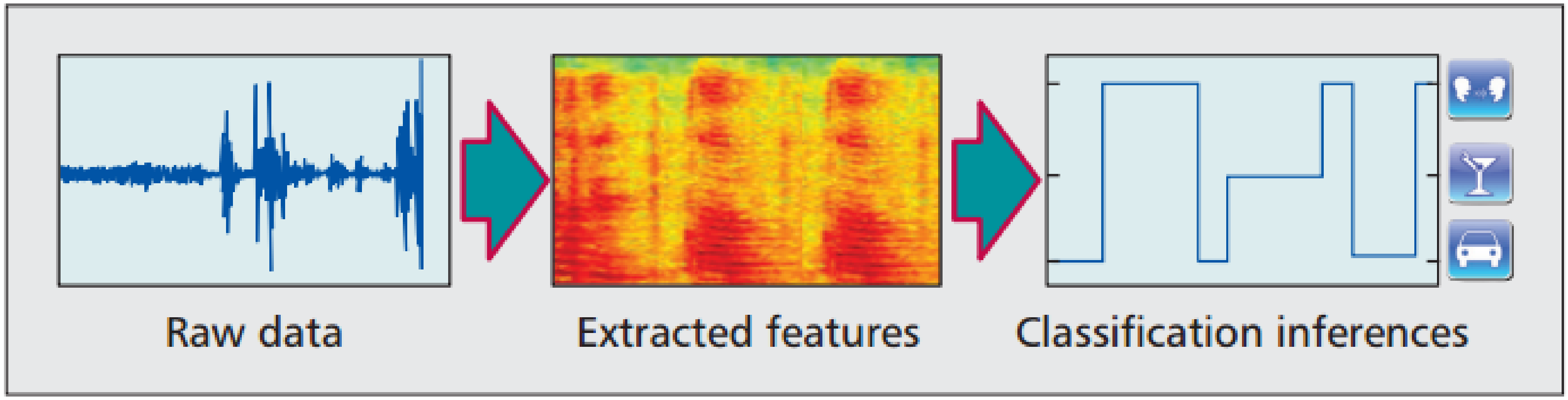
- **Finer points:**
  - John and mobile users move
  - Network deals with changing node location, disconnection/reconnection to different cell towers

Ubiquitous Computing Example

- ***Ubiquitous computing:*** John is leaving home to go and meet his friends. While passing the fridge, the fridge sends a message to his shoe that milk is almost finished. When John is passing grocery store, shoe sends message to glasses which displays "BUY milk" message. John buys milk, goes home.
- **Core idea:** ubiquitous computing assistants **actively** help John
- Issues:
  - Sensor design (miniaturization, low cost)
  - Smart spaces
  - Invisibility (room million sensors, minimal user distraction)
  - Localized scalability (more distant, less communication)
  - Uneven conditioning
  - Context-awareness (assist user based on current situation)
  - Cyber-foraging (servers augment mobile device)
  - Self-configuring networks

Sensor Processing

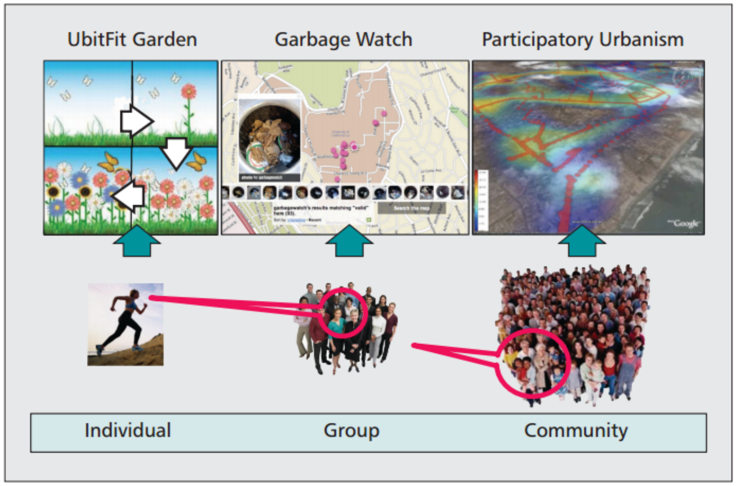
- **Machine learning** commonly used to process sensor data into higher level actions
  - Example: accelerometer data classified into user actions (walking, running, jumping, in car, etc)



Mobile CrowdSensing

Mobile CrowdSensing

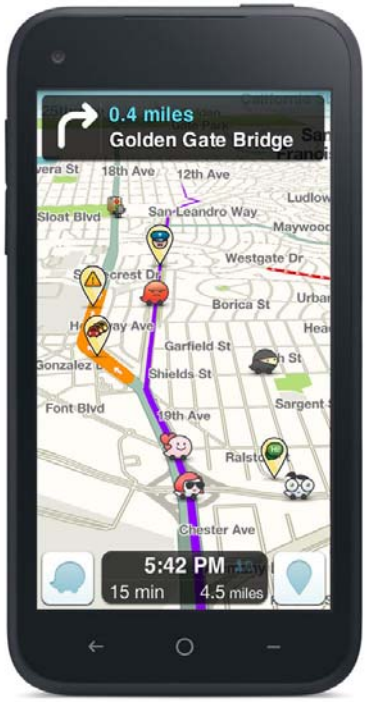
- **Personal sensing:** phenomena pertain to individual
  - E.g: activity detection and logging for health monitoring
- **Group:** friends, co-workers, neighborhood
  - GarbageWatch to improve recycling, neighborhood surveillance
- **Community sensing (mobile crowdsensing):**
  - Many people contribute their individual readings
  - **Examples:** Traffic, air pollution, city noise maps, bike routes, fuel price



Mobile Crowd Sensing

- *Classic example:* Comparative shopping
- Compare price of toothpaste at CVS before buying

- *Example 2:* Waze crowdsourced traffic



Sense What?

- **Environmental:** pollution, water levels in a creek
- **Transportation:** traffic/road conditions, available parking
- **City infrastructure:** malfunctioning hydrants and traffic signs
- **Social:** photoblogging, share bike route quality, petrol price watch
- **Health and well-being:**
  - Share exercise data (amount, frequency, schedule),
  - share eating habits and pictures of food

Wireless Networks

Wireless Network Types

- Wi-Fi (802.11) (e.g. Starbucks Wi-Fi)
- Cellular networks (Wide area)
- Bluetooth
- Near Field Communications (NFC)

Bluetooth

Wi-Fi

NFC

References

- Android App Development for Beginners videos by Bucky Roberts (thenewboston)
- Ask A Dev, Android Wear: What Developers Need to Know, https://www.youtube.com/watch?v=zTS2NZpLyQg
- Ask A Dev, Mobile Minute: What to (Android) Wear, https://www.youtube.com/watch?v=n5Yjzn3b_aQ
- Busy Coder's guide to Android version 4.4
- CS 65/165 slides, Dartmouth College, Spring 2014
- CS 371M slides, U of Texas Austin, Spring 2014