CS 528 Mobile and Ubiquitous Computing
Lecture 1a: 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, wireless in grad school
- CS + ECE background (Hardware + software)
- Current active research: Mobile health apps
  - E.g: AlcoGait app to detect how drunk Smartphone owner is
    - https://www.youtube.com/watch?v=pwZaoKmfq8c

Administrivia

Administrivia: Schedule

- ***Week 1-8:*** I will introduce class, concepts, Android (Students: Android programming, assigned projects)
  - **Goal:** Students acquire basic Android programming skills to do excellent project
  - Programming apps that use mobile & ubicomp components
- ***Week 9:*** Students will present final project proposal
- ***Week 9-14:*** Students work on final project
- ***Week 11:*** Students present on new mobile APIs, components
  - E.g. machine learning in Android, Augmented Reality
- ***Week 14:*** Students present + submit final projects
- Quizzes (5) throughout

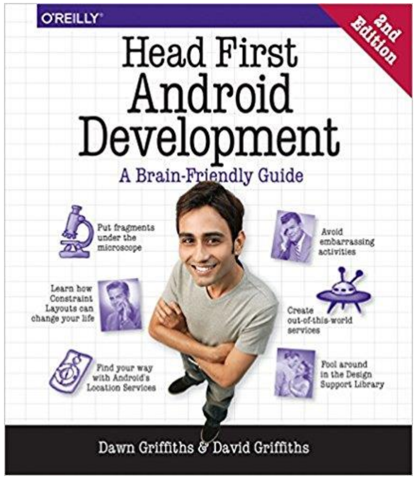
Requirements to get a Grade

- **Grading policy:**
  - Presentation 15%, Assigned Projects 35%, Final project: 30%, Quizzes: 20%
- **Final project phases:** (See class website for deadlines)
  1. Pick partners, form project groups of 5 members
  2. Submit 1-slide of proposed idea (problem + envisioned solution)
  3. Present project proposal

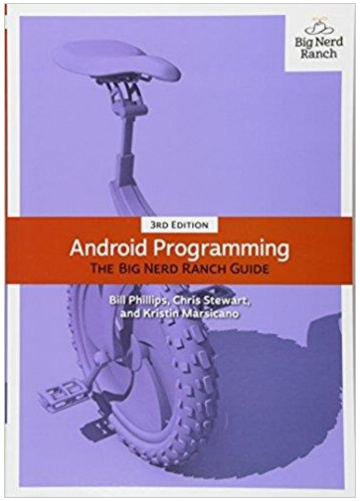
     + plus submit proposal (intro + related work + methodology/design + proposed project plan)
  4. Build app, evaluate, experiment, analyze results
  5. Present results + submit final paper (in week 14)
- **Degree of difficulty of project taken into account in grading rubric**

Course Texts

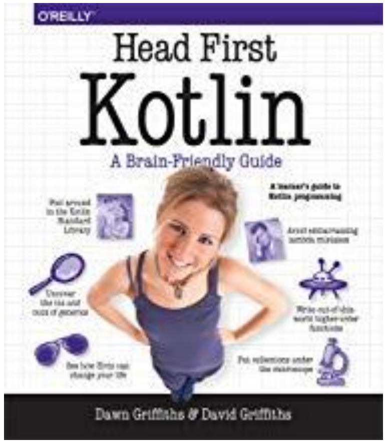
- **Android Texts:**
  - *Head First Android Dev, (2nd ed),* Dawn and David Griffiths, O'Reilly, 2017
  - *Android Programming: The Big Nerd Ranch (Third edition)*, Bill Phillips, Chris Stewart and Kristin Marsicano, The Big Nerd Ranch, 2017


O'REILLY
2nd Edition
Head First Android Development
A Brain-Friendly Guide
Put fragments under the microscope
Avoid embarrassing activities
Learn how Constraint Layouts can change your life
Create out-of-this-world services
Find your way with Android's Location Services
Fool around in the Design Support Library
Dawn Griffiths & David Griffiths

Gentle, visual intro



Bootcamp Tutorial



Visual kotlin intro

- Will also use official Google Android documentation
- Learn from research papers: Why not text?

Grader

May be hired later

Class in 2 Halves

- 2 Halves: About 1 hour 15 mins each half
- Break of about 15 mins
- Talk to me **at the end of class NOT during break**
  - I need a break too

Poll Question

- How many students:
  1. **Own** recent Android phones (running Android 4.4, 5, 6 , 7, 8 or 9?)
  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

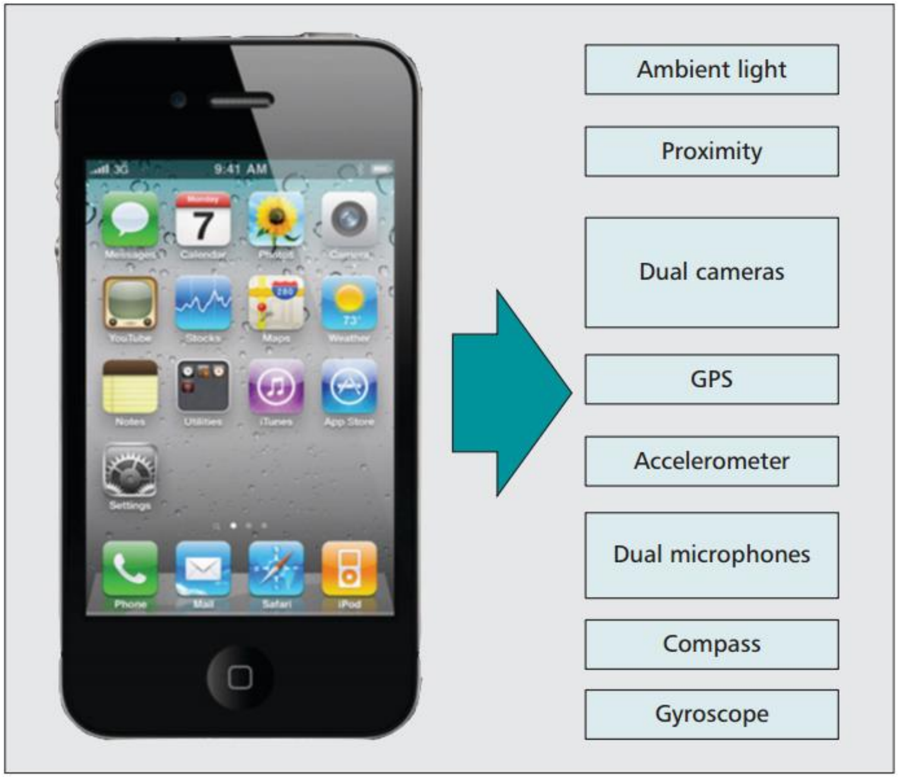
- Smart phones (Blackberry, iPhone, Android, etc)
- Tablets (iPad, etc)
- Laptops
- Smartwatches

SmartPhone Hardware

- Smart = Communication + Computing + Sensors
  - **Communication:** Talk, SMS, chat, Internet access
  - **Computing:** Java apps, JVM, apps
    - Powerful processors: Quad core CPUs, GPUs
  - **Sensors:** Camera, video, location, temperature, heart rate sensor, etc
- Google Pixel XL 3 phone: 8 core 2.5 GHz/1.6GHz kryo CPU, Adreno 630 GPU, 128GB RAM
  - A PC in your pocket!!
  - Multi-core CPU, GPU
  - Runs OpenGL ES, OpenCL and now Deep learning (Tensorflow)

Smartphone Sensors

- Typical smartphone sensors today
  - accelerometer, compass, GPS, microphone, camera, proximity
- Can sense physical world, inputs to intelligent sensing apps
  - E.g. Automatically turn off smartphone ringer when user walks into a class



Growth of Smartphone Sensors

- Every generation of smartphone has more and more sensors!!

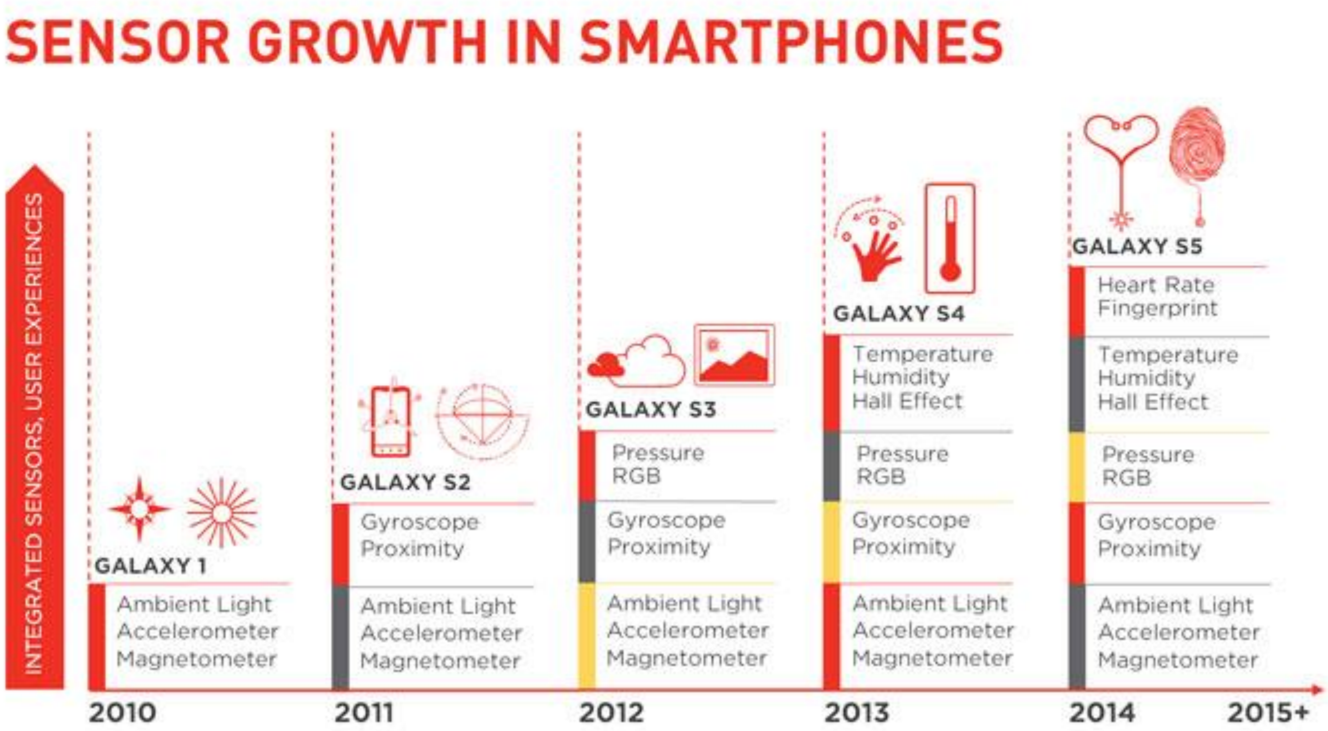


Image Credit: Qualcomm

Future sensors?

- Complex activity sensor,
- Pollution sensor,
- etc

Wireless Networks

Wireless Network Types

- **Wi-Fi (802.11):** (e.g. Starbucks Wi-Fi)
- **Cellular networks:** (e.g. Sprint network)
- **Bluetooth:** (e.g. car headset)
- **Near Field Communications (NFC)**

  e.g. Mobile pay: swipe phone at dunkin donut

Bluetooth

Wi-Fi

NFC

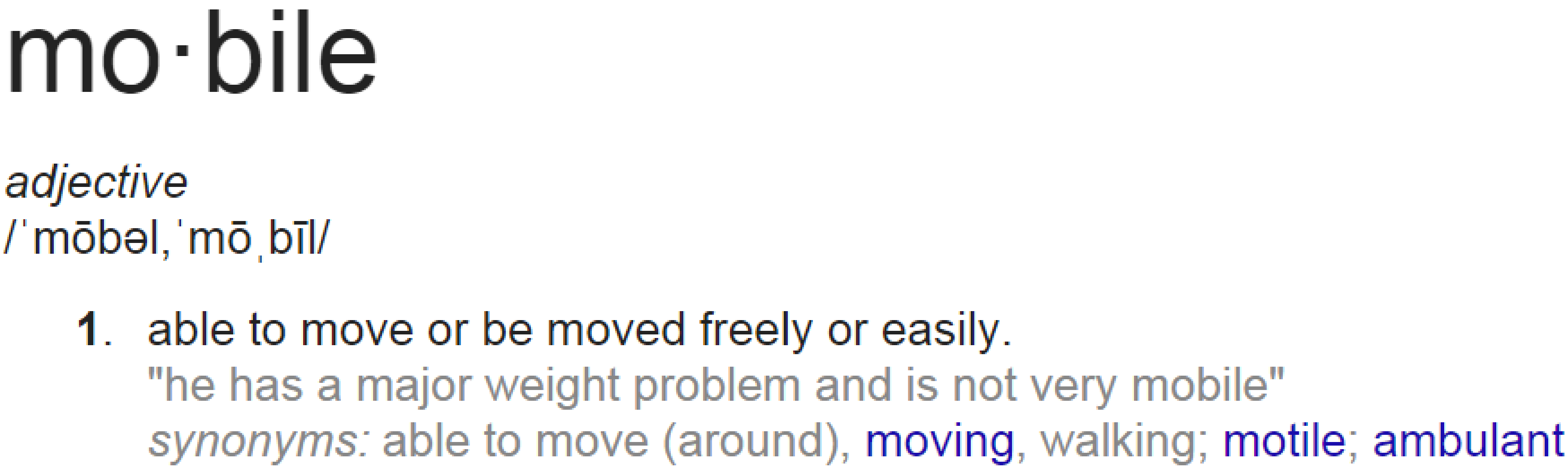
Wireless Networks Comparion

Network Type	Speed	Range	Power	Common Use
WLAN	600 Mbps	45 m – 90 m	100 mW	Internet.
LTE (4G)	5-12 Mbps	35km	120 – 300 mW	Mobile Internet
3G	2 Mbps	35km	3 mW	Mobile Internet
Bluetooth	1 – 3 Mbps	100 m	1 W	Headsets, audio streaming.
Bluetooth LE	1 Mbps	100+ m	.01–.5 W	Wearables, fitness.
NFC	400 kbps	20 cm	200 mW	Mobile Payments

Table credit: Nirjoin, UNC

Different speeds, range, power, uses, etc

Mobile Computing



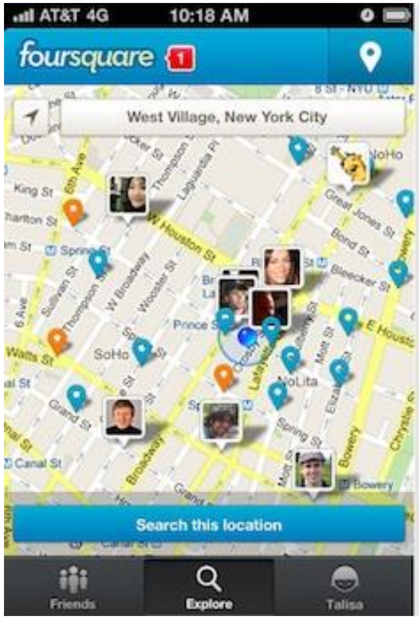
mo·bile

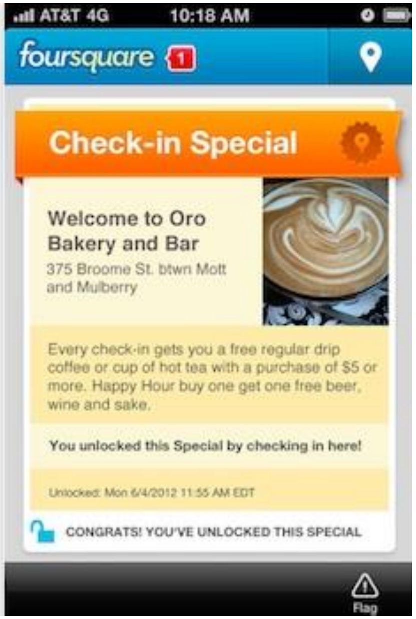
adjective
/ˈmōbəl,ˈmōˌbīl/

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

- Human computes while moving
  - Continuous network connectivity,
  - Points of connection (e.g. cell towers, WiFi access point) might change
- **Note: Human initiates all activity**, (e.g launches apps)
- Wireless Network is *passive*
- **Example:** Using *foursquare.com* on SmartPhone





Check-in Special

Welcome to Oro Bakery and Bar

375 Broome St. btwn Mott and Mulberry

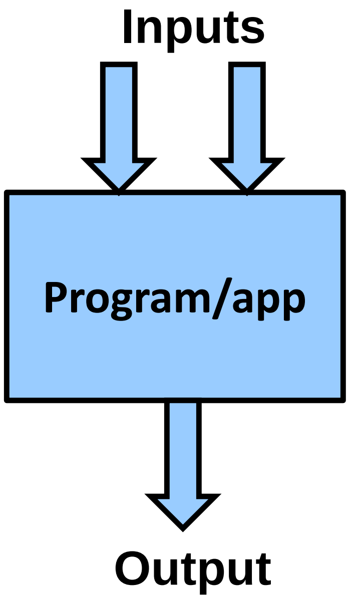
Every check-in gets you a free regular drip coffee or cup of hot tea with a purchase of $5 or more. Happy Hour buy one get one free beer, wine and sake.

You unlocked this Special by checking in here!

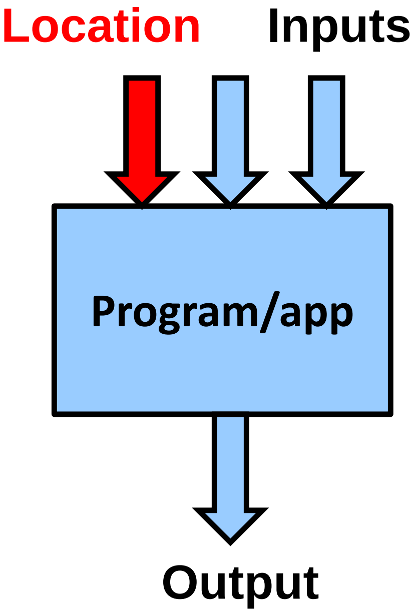
Unlocked: Mon 6/4/2012 11:55 AM EDT

CONGRATS! YOU'VE UNLOCKED THIS SPECIAL

Related Concept: Location-Awareness



Non-mobile app

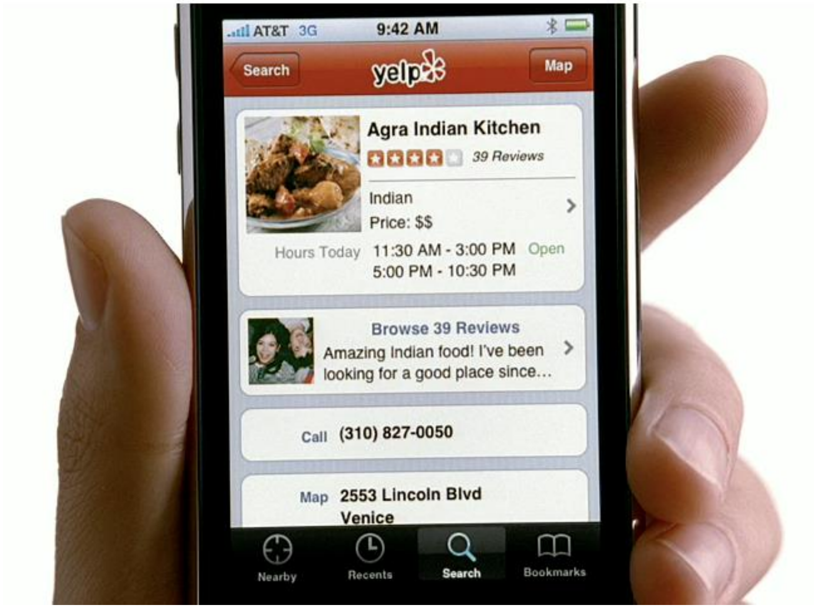


Mobile app

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

Location-Aware Example

- Location-aware 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

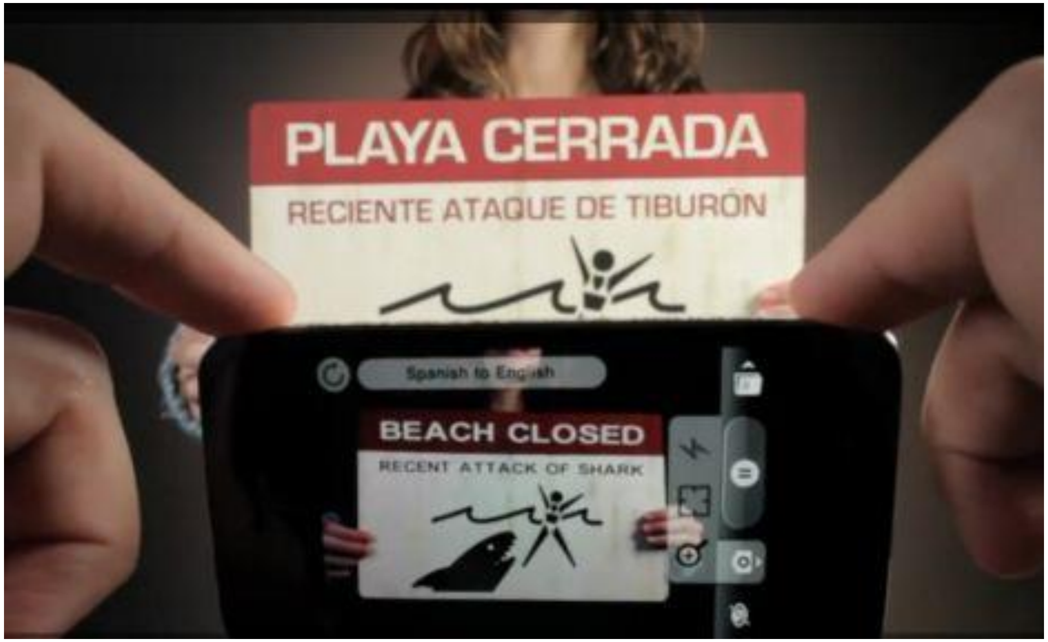
Amazing Indian food! I've been looking for a good place since...

Call (310) 827-0050

Map 2553 Lincoln Blvd
Venice

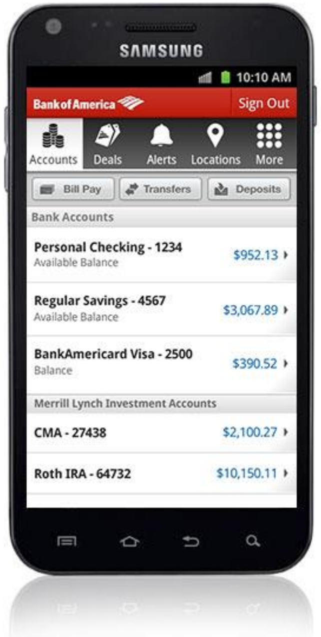
Example of Truly Mobile App: Word Lens

- Translates signs in foreign Language
- Location-dependent because location of sign, language? varies



Some Mobile apps are not Location-Aware

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



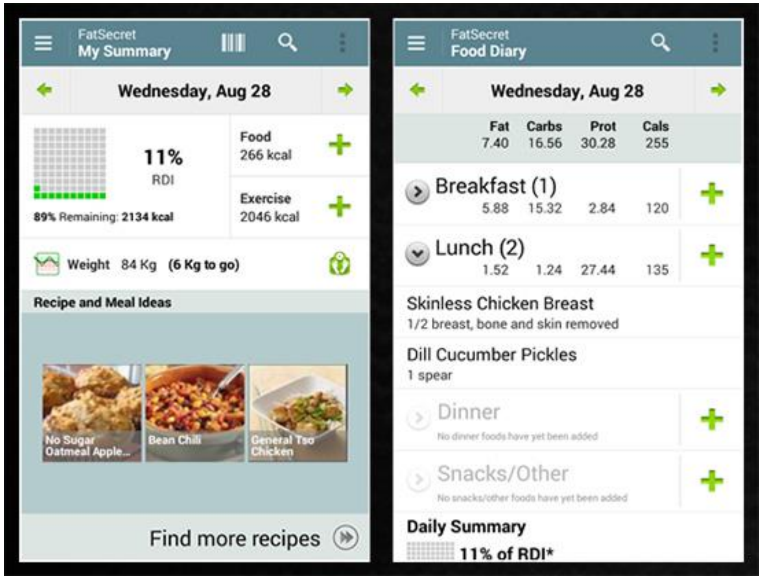
Bank Accounts

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



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

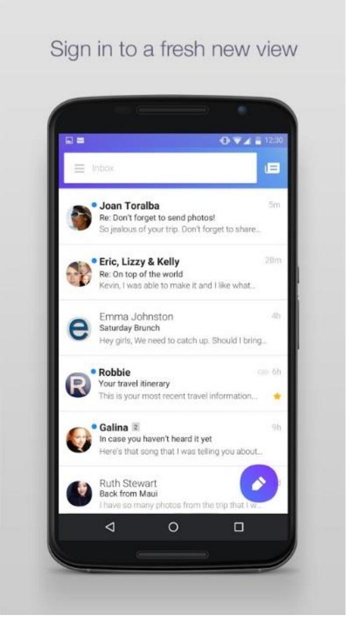
Snacks/Other
No snacks/other foods have yet been added

Daily Summary
11% of RDI*

Diet recording app

- Distinction can be fuzzy. E.g. Banking app may display nearest locations

Which of these apps are Location-Aware?



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...

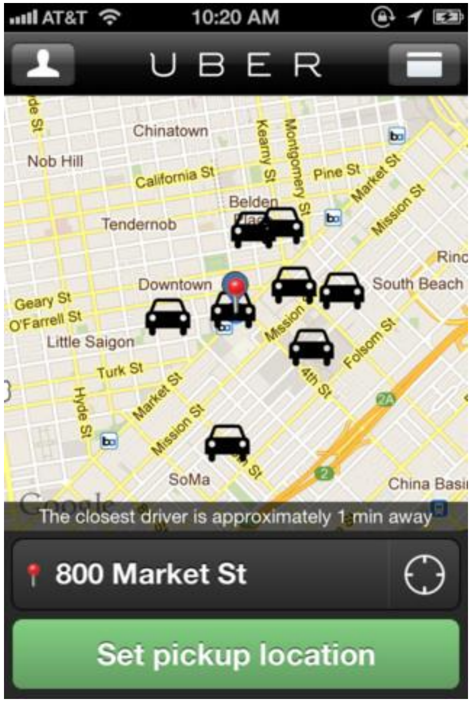
Emma Johnston 4h
Saturday Brunch
Hey girls, We need to catch up. Should I bring...

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...

a. Yahoo mail mobile



The closest driver is approximately 1 min away

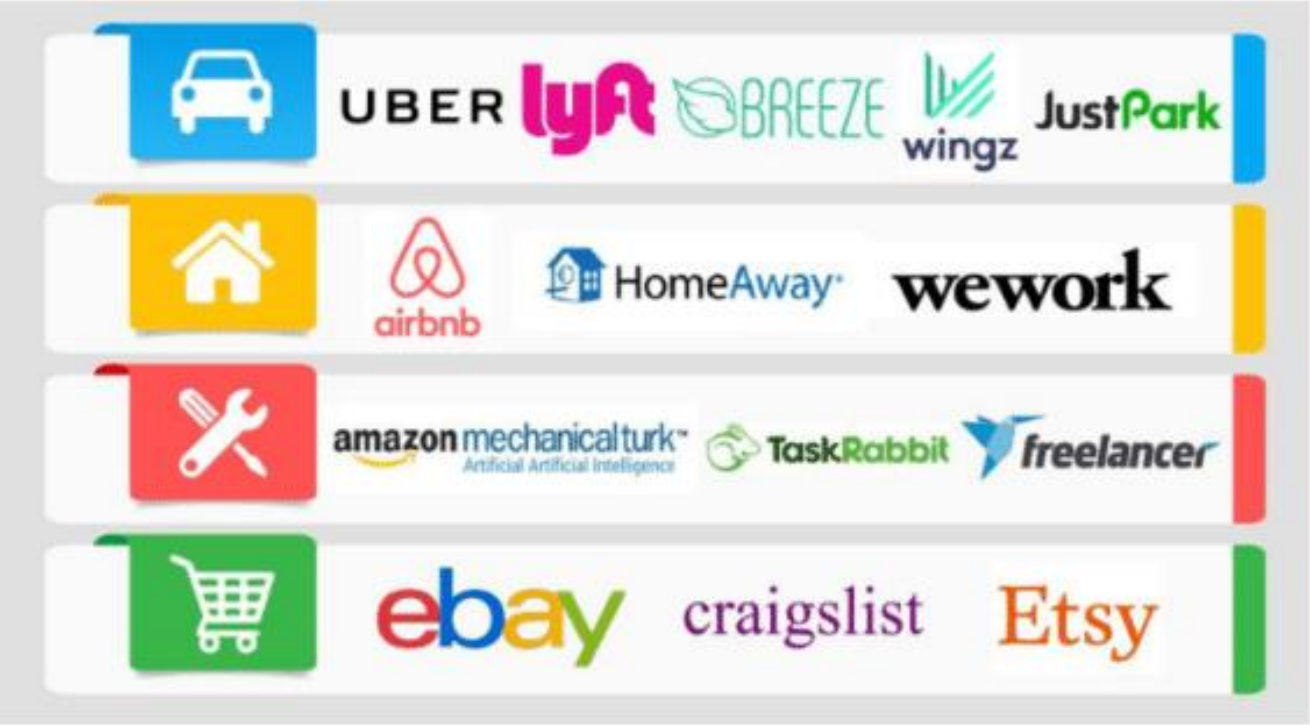
800 Market St

Set pickup location

b. Uber app

Notable: Sharing Economy Apps

- **Idea:** Share resource, maximize under-utilized capacity
- **E.g.** Uber: share care, Airbnb: Share house



Mobile Device Issue: Energy Efficiency

- Most resources increasing exponentially *except* battery energy (ref. Starner, IEEE Pervasive Computing, Dec 2003)

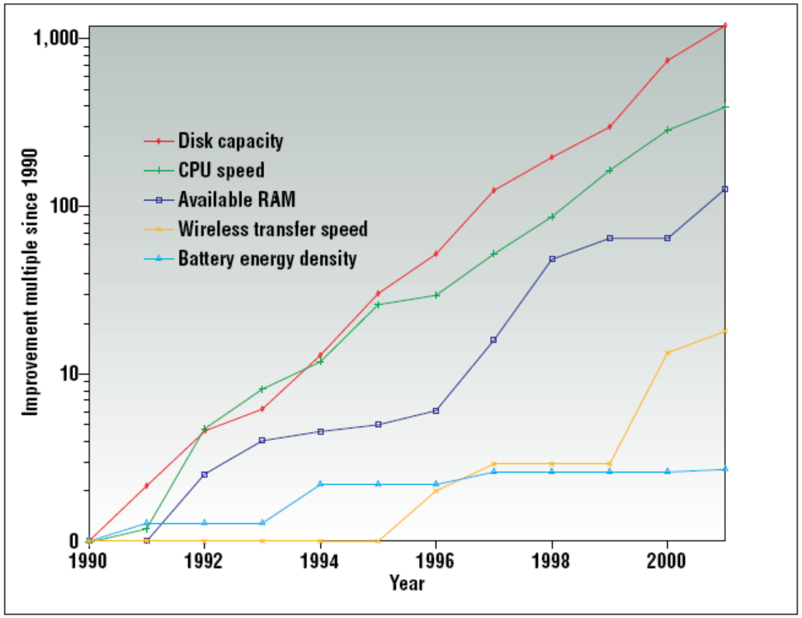
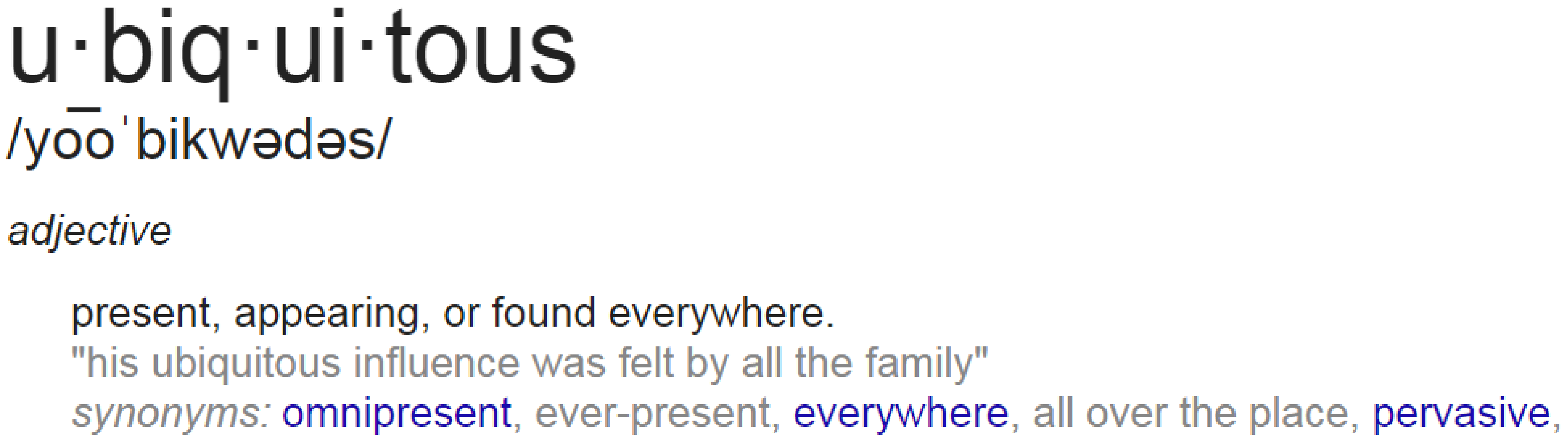


Figure 1. Improvements in laptop technology from 1990–2001.

- Some energy saving strategies:
  - **Energy harvesting:** Energy from vibrations, charging mats, moving humans
  - **Scale content:** Reduce image, video resolutions to save energy
  - **Auto-dimming:** Dim screen whenever user not using it. E.g. talking on phone
  - **Better user interface:** Estimate and inform user how long each task will take
    - E.g: At current battery level, you can either type your paper for 45 mins, watch video for 20 mins, etc

Ubiquitous Computing



u·biq·ui·tous

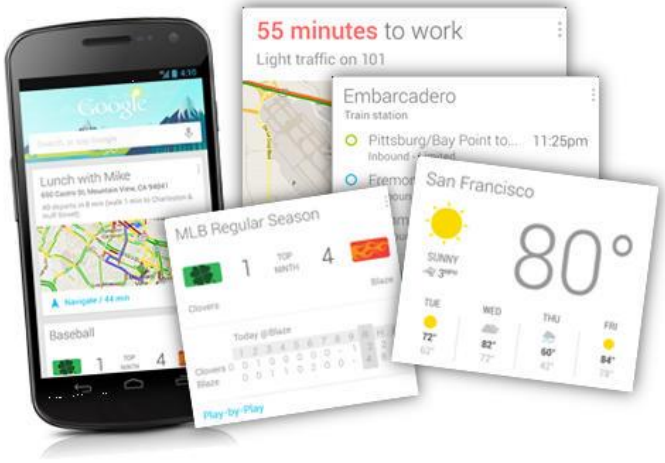
/yo͞oˈbikwədəs/

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 *active* specialized assistants to assist human in tasks (reminders, personal assistant, staying healthy, school, etc)
- App figures out user's current state, intent, assists them
- **How?** 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 Assistant, feed informs user of
  - Driving time to work, home
  - News articles user will like
  - Weather
  - Favorite sports team scores, etc
- Also supports 2-way conversations



User Context

- Imagine a genie/personal assistant who wants to give you all the “right information” at the right time
  - Without asking you any questions
- Examples:
  - Detect traffic ahead, suggest alternate route
  - Bored user, suggest exciting video, etc
- Genie/personal assistant needs to passively detect user’s:
  - Current situation (Context)
  - Intention/plan

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 advises:* 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

Sensor

- **Example:** E.g. door senses only human motion, opens
- **Sensor:** device that can sense physical world, programmable, multi-functional for various tasks (movement, temperature, humidity, pressure, etc)
- Device that can take inputs from physical word
    - Also includes camera, microphone, etc
- Ubicomp uses data from sensors in phone, wearables (e.g. clothes), appliances, etc.

(courtesy of MANTIS project, U. of Colorado)

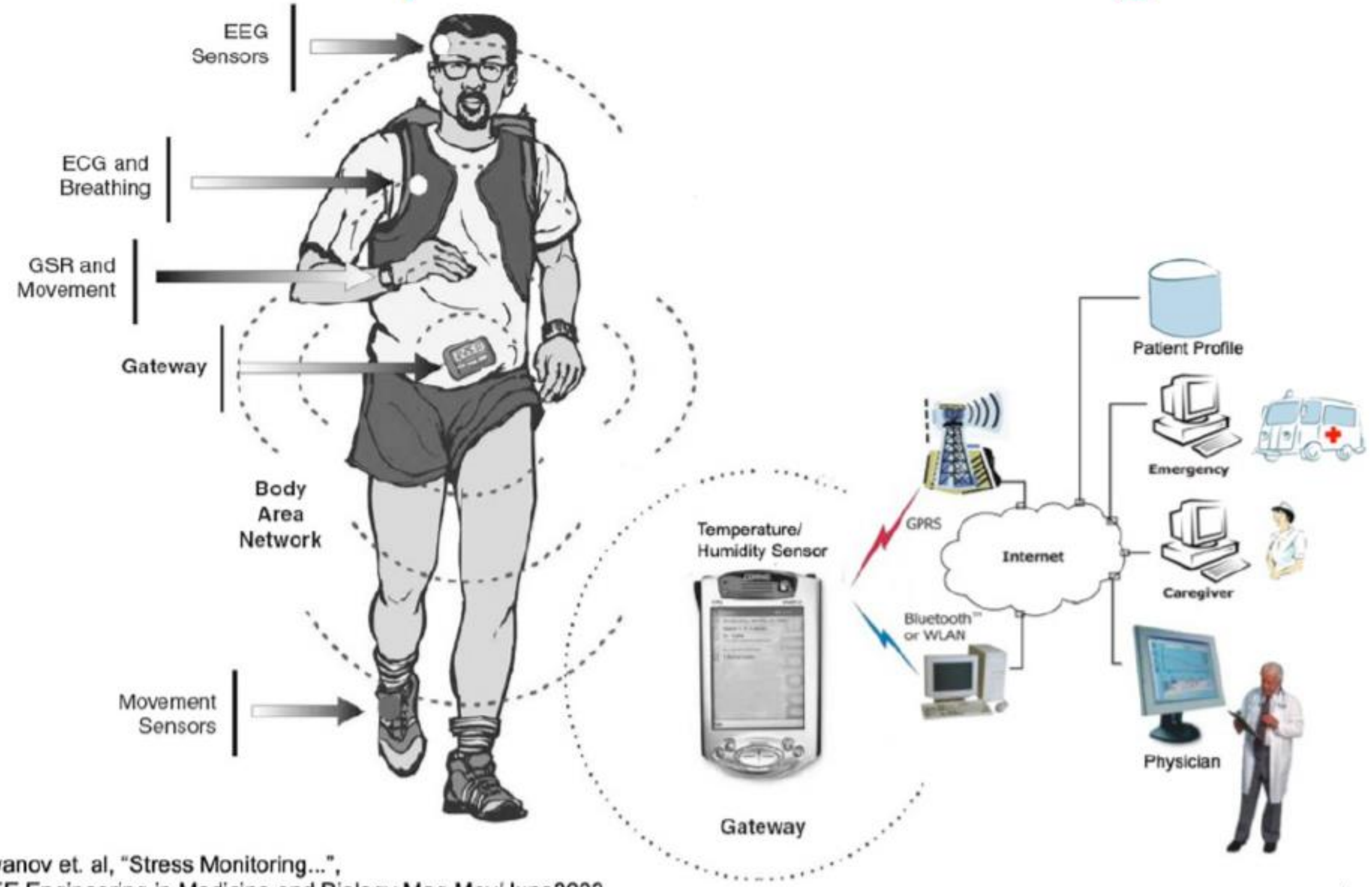
RFID tags

Tiny Mote Sensor, UC Berkeley

Ubiquitous Computing: Wearables

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

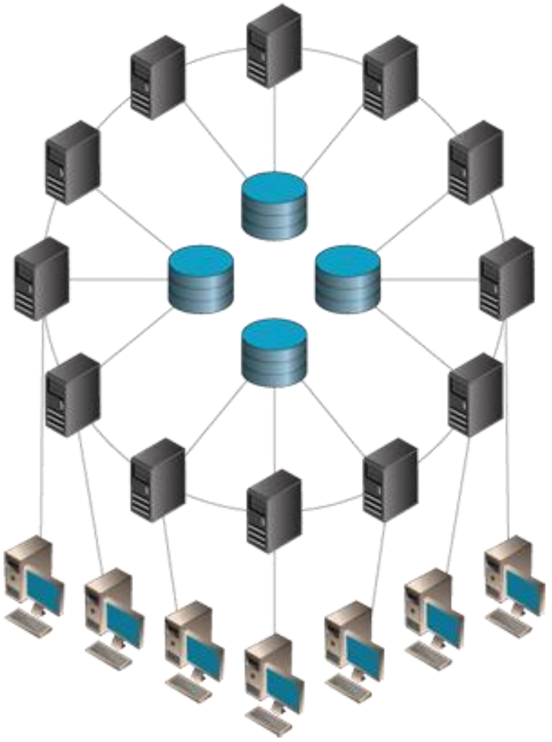
Bluetooth
Wellness
Devices

External sources of data for smartphone

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

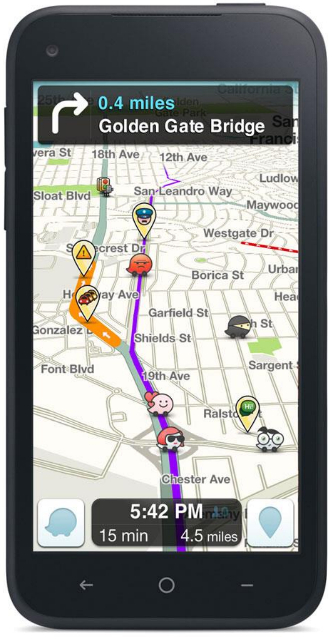
Ubiquitous Computing Example

- ***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

SmartPhone Sensing

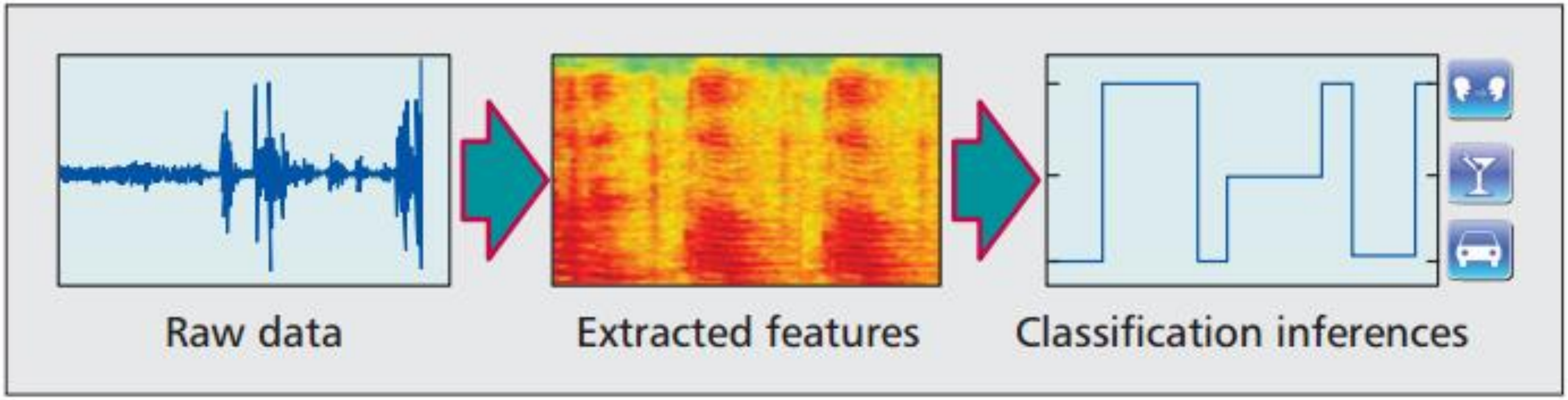
Smartphone Sensing

- Smartphone used to sense human, environment
- ***Example:*** Human activity sensing (e.g. walking, driving, climbing stairs, sitting, lying down)
- ***Example 2:*** Waze crowdsourced traffic



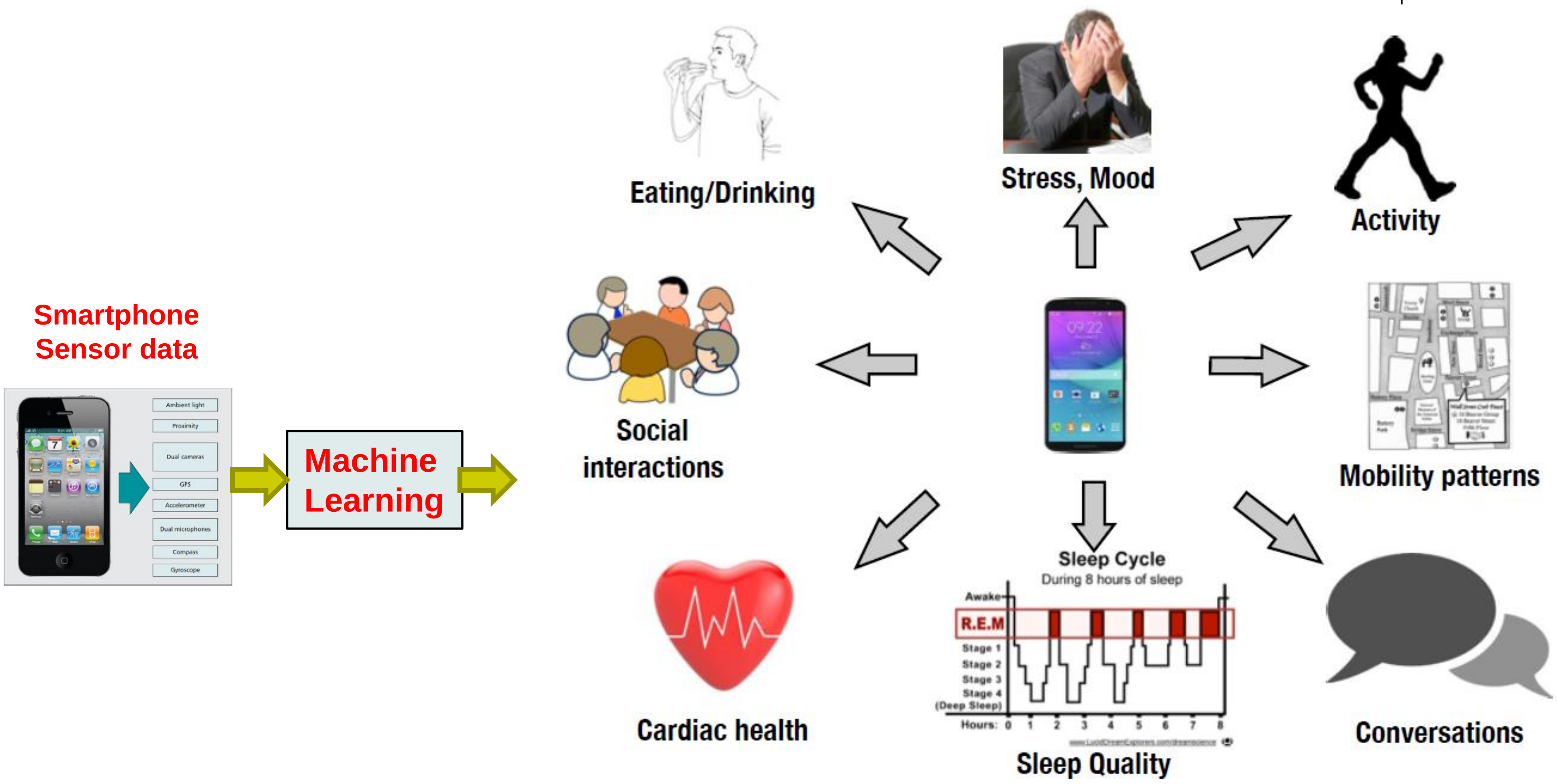
Sensor Processing

- Machine learning commonly used to process sensor data
  - Action to be inferred is hand-labelled to generate training data
  - Sensor data is mined for combinations of sensor readings corresponding to action
- Example: Smartphone detects user's activity (e.g. walking, running , sitting,) by classifying accelerometer sensor data



What Can We Detect/Infer using These Sensors

Smartphone Sensing!!



Smartphone Sensor data

Machine Learning

Eating/Drinking

Stress, Mood

Activity

Social interactions

Mobility patterns

Cardiac health

Sleep Quality

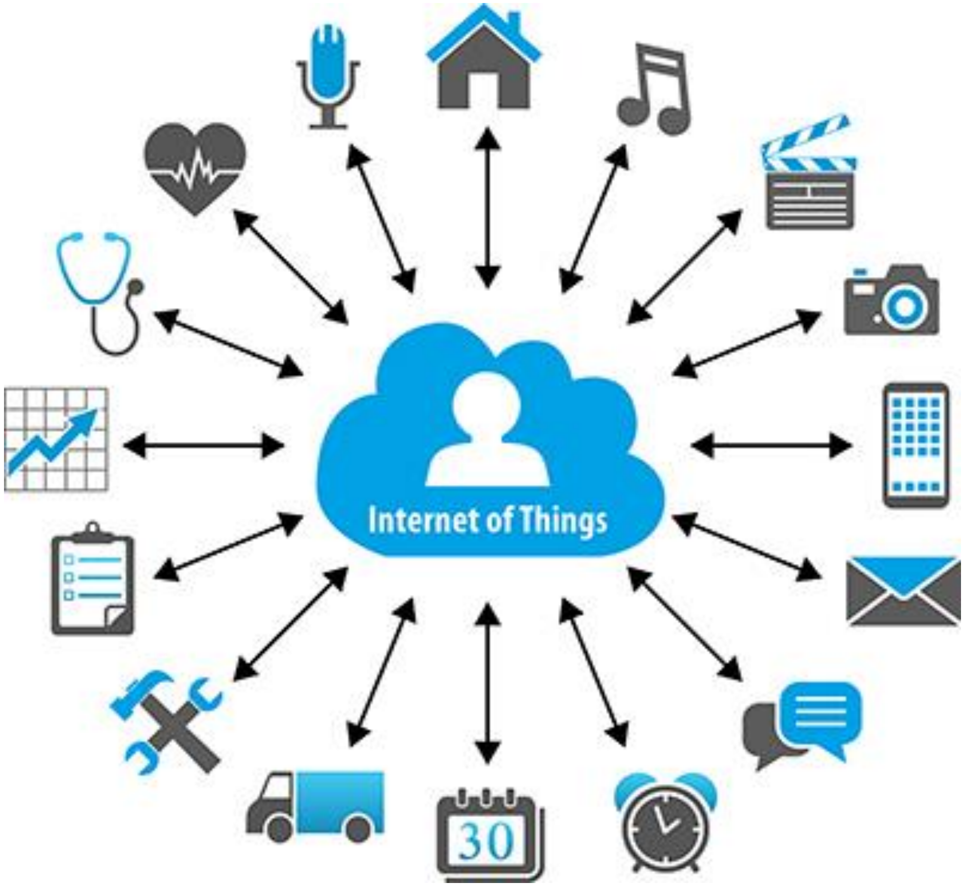
Conversations

Image Credit: Deepak Ganesan, UMass

Internet of Things (IoT)

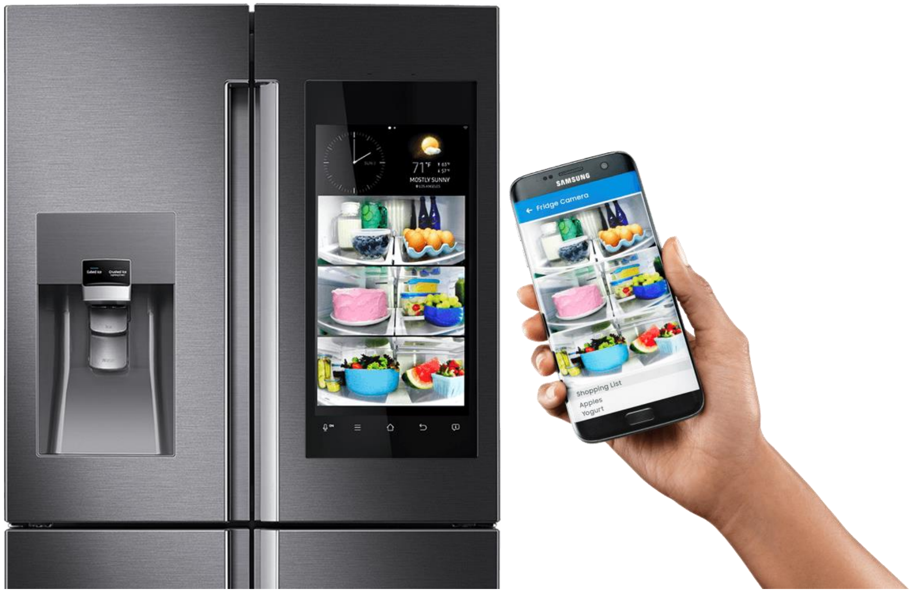
Internet of Things

- Internet extended to connect Devices



IoT: Networked Smart Things (Devices)

- Smart things: Can be accessed, controlled over the network, learns users patterns



Nest Smart thermostat

- Learns owners manual settings
- Turns down heat when not around

Smart Fridge

- See groceries in fridge from anywhere

Other Ubicomp Systems

- **Smart Homes:** Continuously monitors elders who live in smart home, automatically dials 911 if elder ill, fall
  - Falls kill many old people who live alone

- **Smart buildings:** Senses presence of people, ambient temperature, people flow, dynamically adjusts heating/cooling
  - Can save over 40% of energy bill

- **Smart Cities:** Real time data from Sensors embedded in street used to direct drivers to empty parking spots
  - About 30% of traffic jam caused by people hunting for parking

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