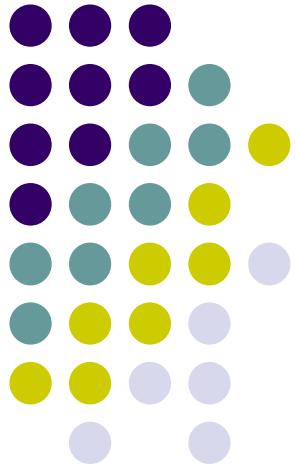
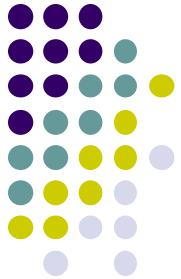
# CS 528 Mobile and Ubiquitous Computing
# Lecture 1a: Introduction

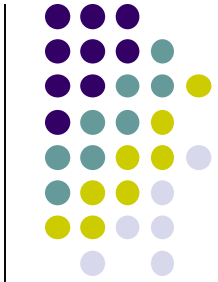
**Emmanuel Agu**



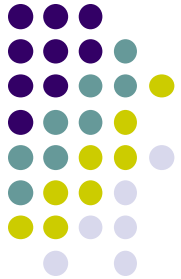


# About Me

# A Little about me

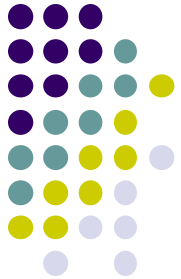


- WPI Computer Science Professor
- Research interests:
  - mobile computing especially mobile health, computer graphics
- Started working in mobile computing, wireless in grad school
- CS + ECE background (Hardware + software)
- Current active research: Mobile health apps
  - E.g: AlcoGait app to detect how drunk Smartphone owner is
    - https://www.youtube.com/watch?v=pwZaoKmfq8c



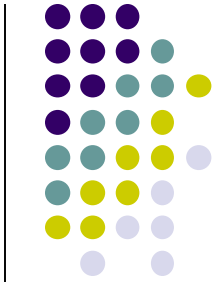
# Administrivia

# 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



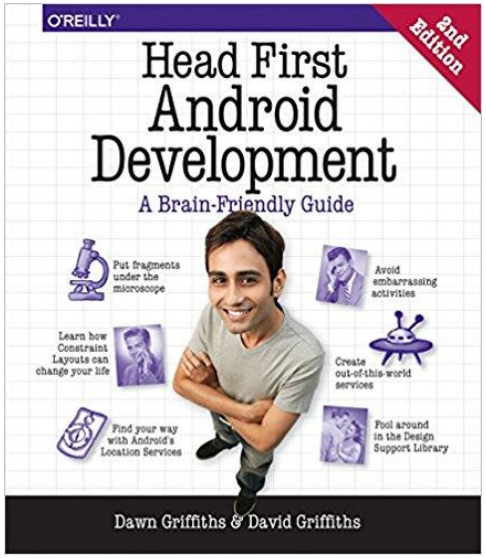
- **Grading policy:**
  - Presentation 15%, Assigned Projects 35%, Final project: 30%, Quizzes: 20%
- **Final project phases:** (See class website for deadlines)
  1. Pick partners, form project groups of 5 members
  2. Submit 1-slide of proposed idea (problem + envisioned solution)
  3. Present project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

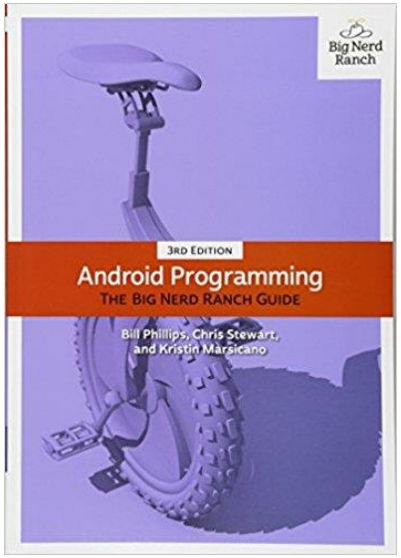
     + plus submit proposal (intro + related work + methodology/design + proposed project plan)
  4. Build app, evaluate, experiment, analyze results
  5. Present results + submit final paper (in week 14)
- **New final project aspect this offering:**
  - Points for degree of difficulty of project

# 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

**Gentle, visual intro**

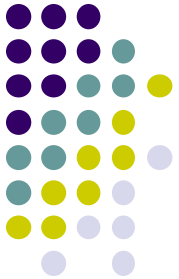



**Bootcamp Tutorial**

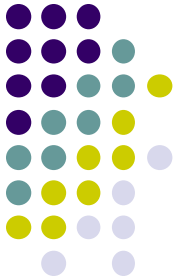
- Will also use official Google Android documentation
- Learn from research papers: Why not text?

# Grader



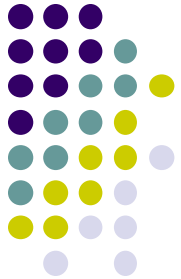
**Will be hired later**

# Class in 2 Halves

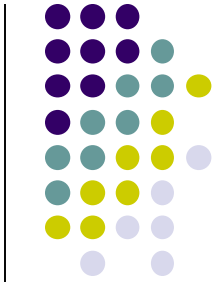


- 2 Halves: About 1 hour 15 mins each half
- Break of about 15 mins
- Talk to me **at the end of class NOT during break**
  - I need a break too

# 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?



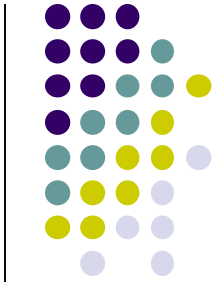
# Mobile Devices

# 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 phone: Quad core 1.6 GHz Snapdragon CPU, Adreno 530 GPU, 4GB 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!!

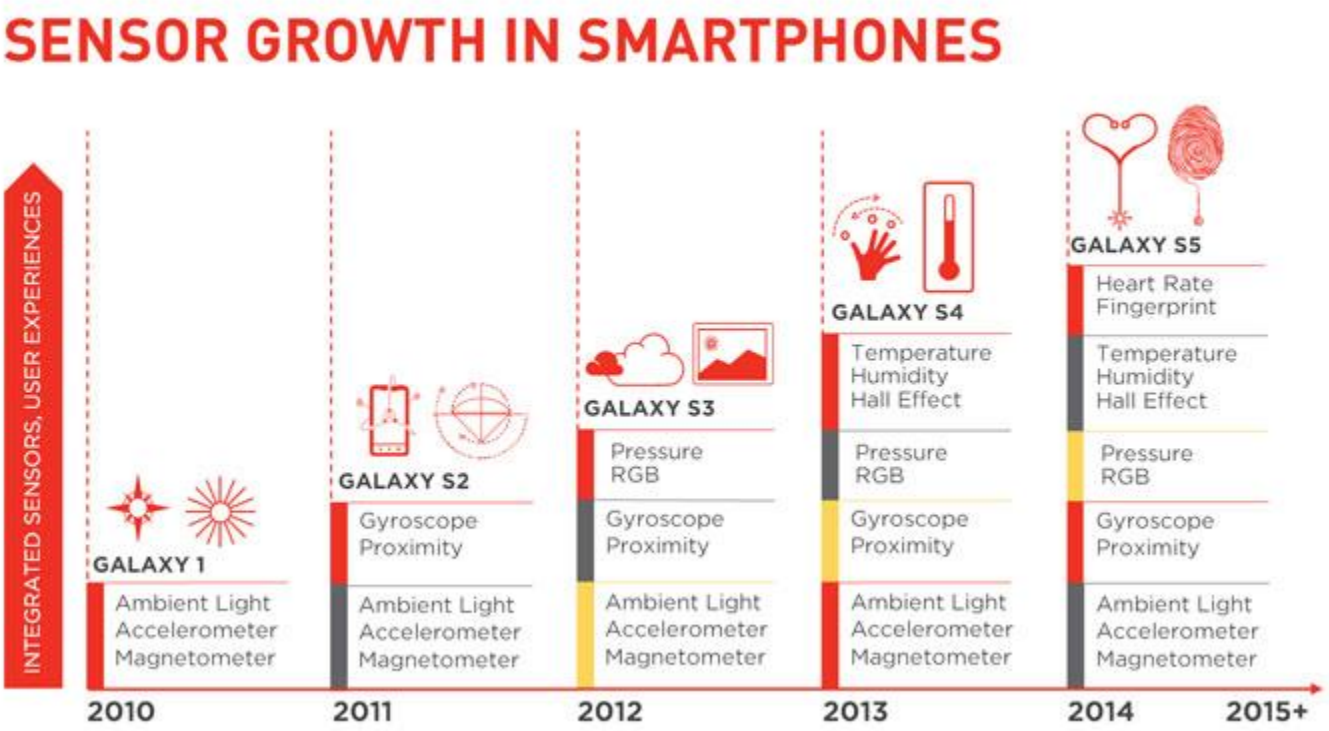
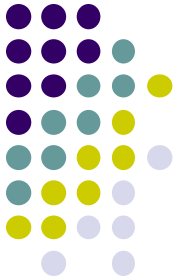



**Image Credit: Qualcomm**

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)**

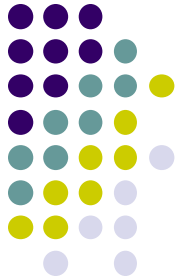
  e.g. Mobile pay: swipe phone at dunkin donut

Bluetooth


Wi-Fi


NFC

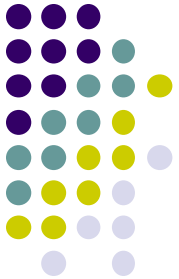
# Wireless Networks Comparion



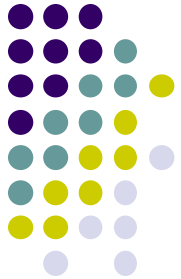
| Network Type | Speed | Range | Power | Common Use |
|---|---|---|---|---|
| WLAN | 600 Mbps | 45 m – 90 m | 100 mW | Internet. |
| LTE (4G) | 5-12 Mbps | 35km | 120 – 300 mW | Mobile Internet |
| 3G | 2 Mbps | 35km | 3 mW | Mobile Internet |
| Bluetooth | 1 – 3 Mbps | 100 m | 1 W | Headsets, audio 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



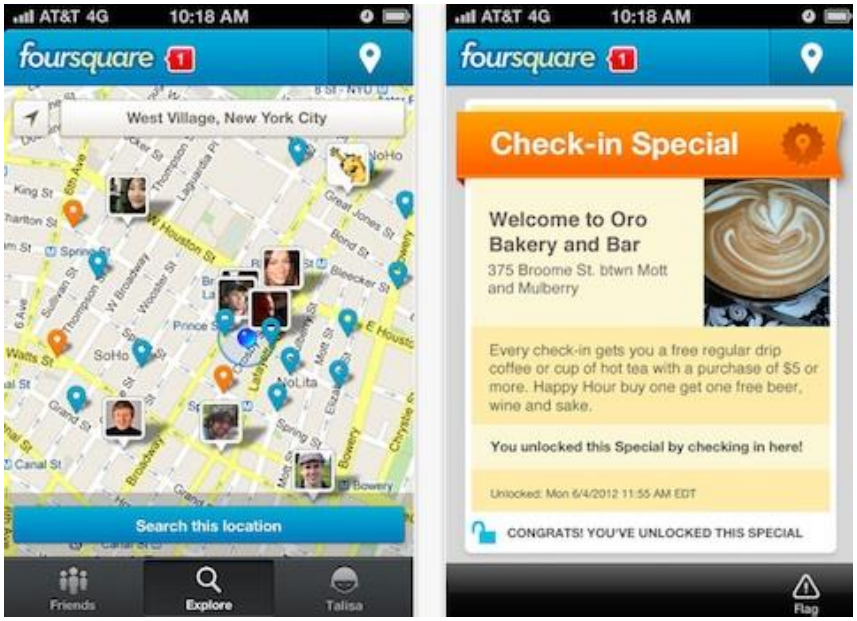
# mo·bile

*adjective*
/ˈmōbəl,ˈmōˌbīl/

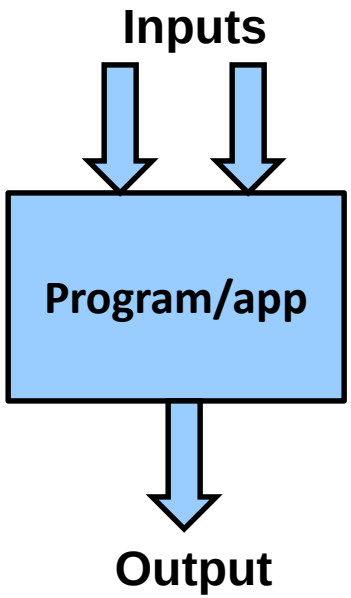
1. able to move or be moved freely or easily.
   "he has a major weight problem and is not very mobile"
   *synonyms:* able to move (around), moving, walking; motile; ambulant

# Mobile Computing

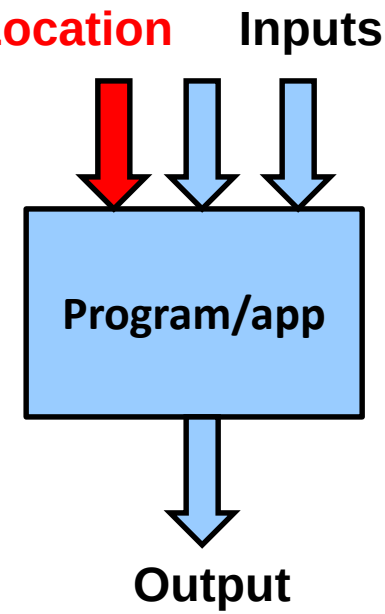
- Human computes  while moving
  - Continuous network connectivity,
  - Points of connection (e.g. cell towers, WiFi access point) might change
- **Note:** Human initiates all activity, (e.g launches apps)
- Wireless Network is *passive*
- **Example:** Using *foursquare.com* on SmartPhone




# 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

# Example of Truly Mobile App: Word Lens

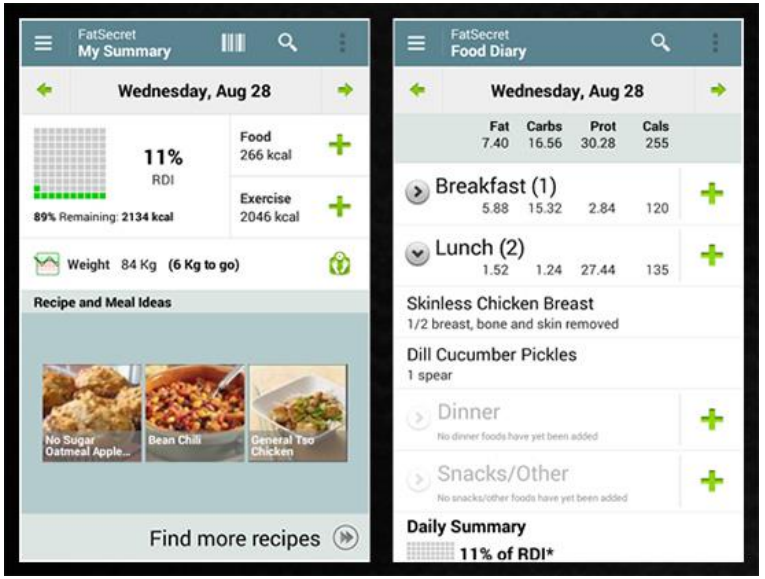
- Translates signs in foreign Language

- 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:**

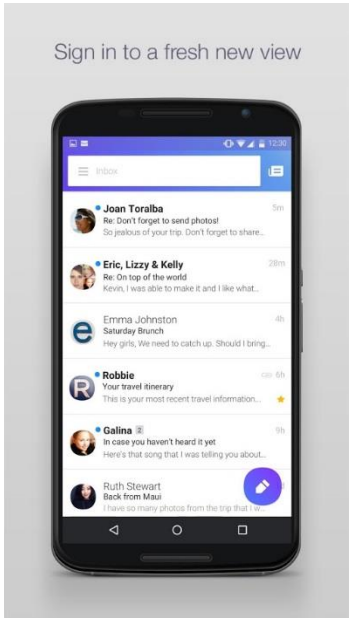

Mobile banking app



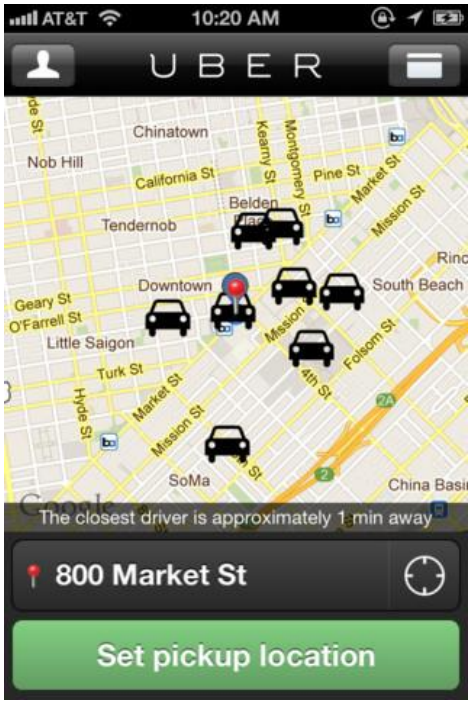

Diet recording app

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

# Which of these apps are Location-Aware?




a. Yahoo mail mobile




b. Uber app

# Mobile Device Issue: Energy Efficiency

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

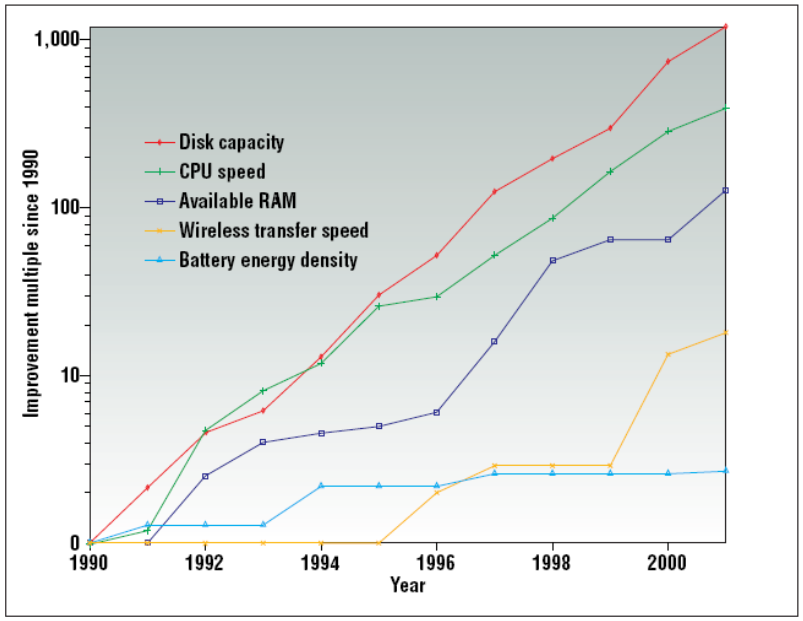
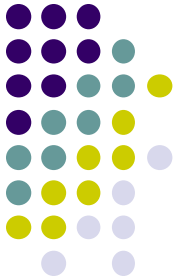



Figure 1. Improvements in laptop technology from 1990–2001.

- 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,

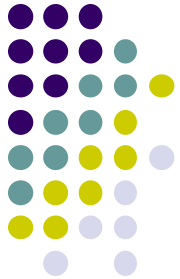
# Ubiquitous Computing

- 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

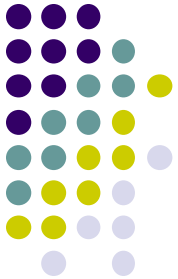
# User Context

- 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

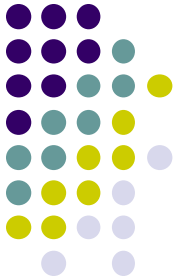
# Sensor

- **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)

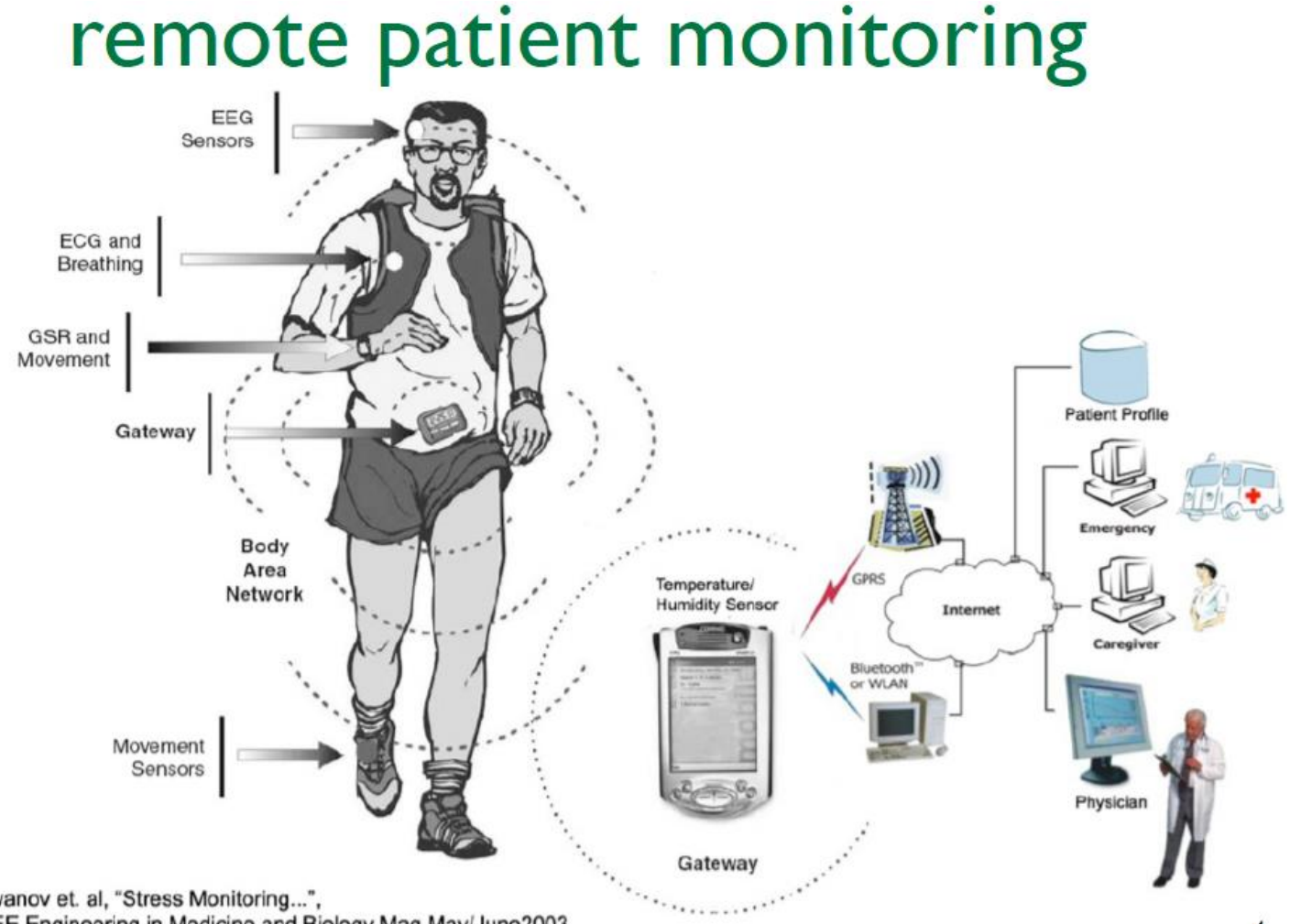
RFID tags

Tiny Mote Sensor, UC Berkeley



# Ubiquitous Computing: Wearables

# Ubiquitous Computing: Wearable sensors for Health



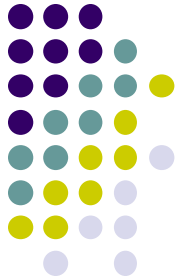

Jovanov et. al, "Stress Monitoring...",
IEEE Engineering in Medicine and Biology Mag.May/June2003

# UbiComp: Wearables, BlueTooth Devices


*Body Worn*
*Activity Trackers*


*Bluetooth*
*Wellness*
*Devices*

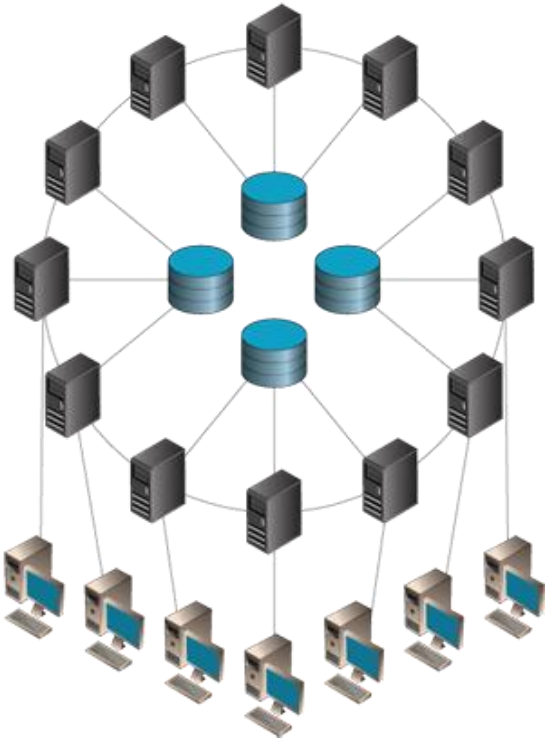
External sources of data for smartphone



# 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

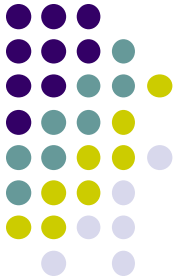
- ***Mobile computing example:***
  - John has SPRINT PCS phone with web access, voice, SMS messaging.
  - He runs apps like facebook and foursquare, continuously connected while walking around Boston

- **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



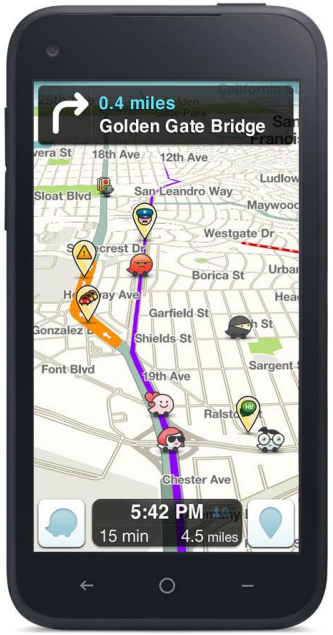
# SmartPhone Sensing

# Smartphone Sensing

- Smartphone used to sense human, environment

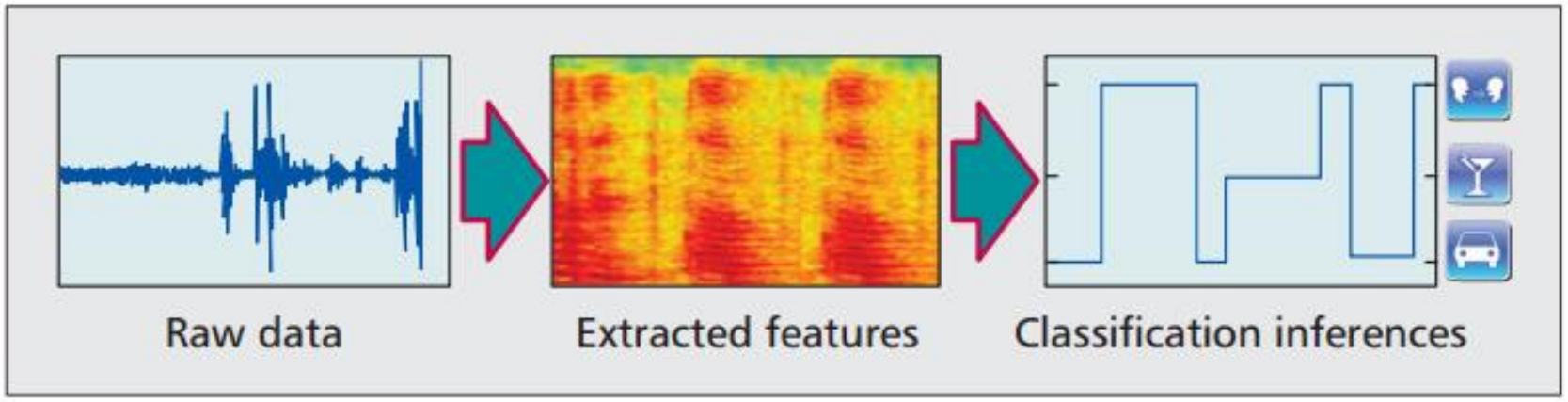
- ***Example:*** Human activity sensing (e.g. walking, driving, climbing stairs, sitting, lying down)

- ***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

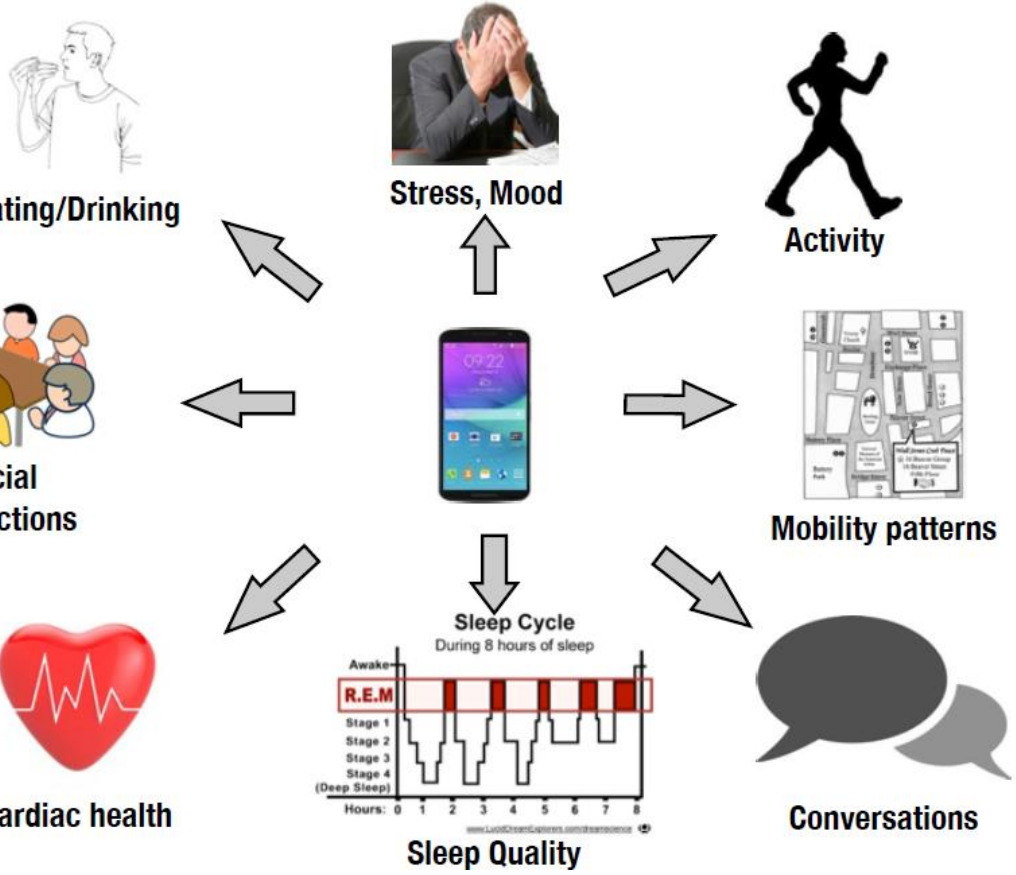
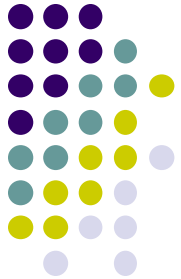



Image Credit: Deepak Ganesan, UMass



# Internet of Things (IoT)

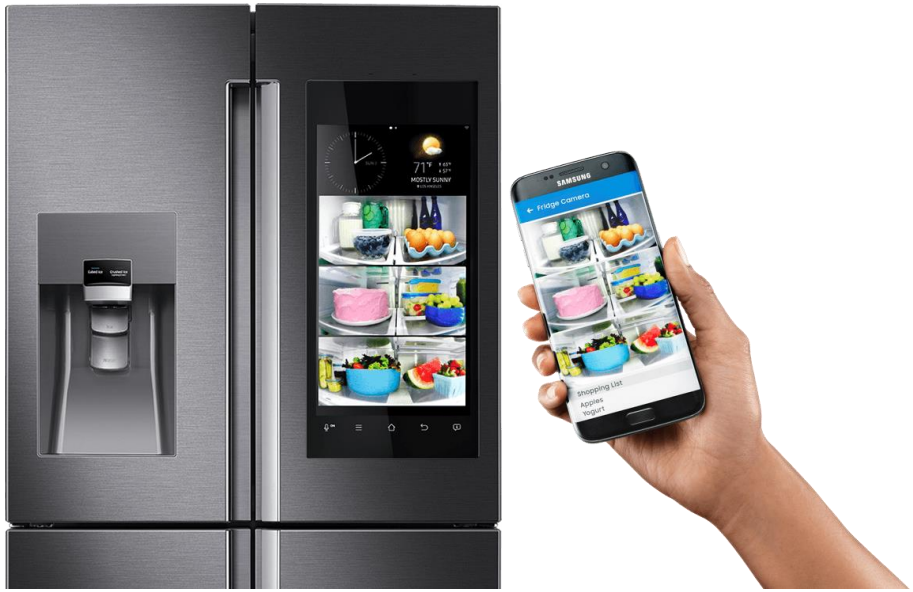
# Internet of Things

- Internet extended to connect Devices

# IoT: Networked Smart Things (Devices)

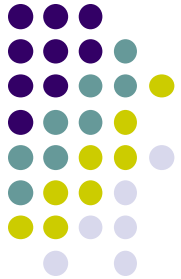
- Smart things: Can be accessed, controlled over the network, learns users patterns


**Nest Smart thermostat**
- Learns owners manual settings
- Turns down heat when not around



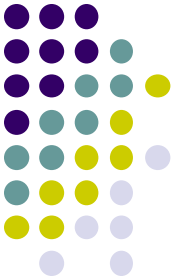

**Smart Fridge**
- See groceries in fridge from anywhere

# 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

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