Building Interactive Systems

Sensing Users

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Pop Quiz

What are the three mantras of this class so far?

1. _
2. _
3. _

What we will cover today

1. Sensing in interaction
2. Sensing modalities
3. Interpreting sensed information
4. Reading group discussion
5. Wednesday HACK 2 review

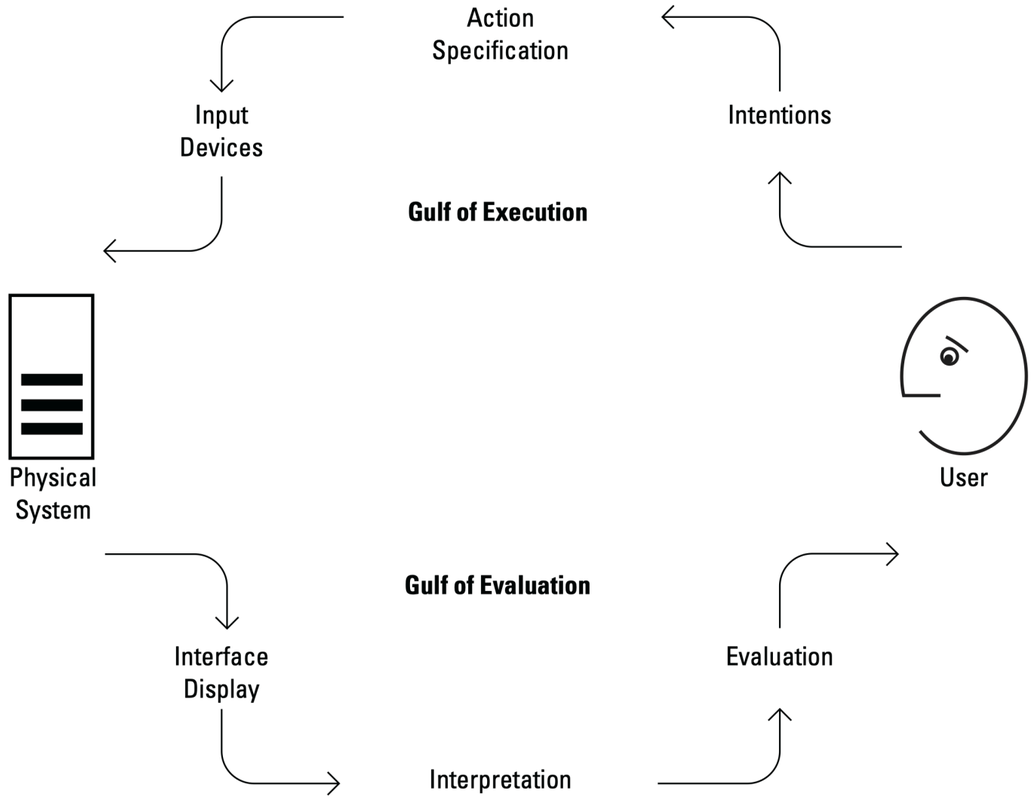
Forms of Interaction

Recap: What is interaction?

Dictionary definition: mutual or reciprocal action or influence [between a system and its user].[1]

The "gulf" model is one characterization of human-system interaction.[2]

Today, we are focusing on the gulf of execution.



[1] https://www.merriam-webster.com/dictionary/interaction

[2] Dubberly et al. (2009). ON MODELING What is interaction? are there different types?. *interactions*.

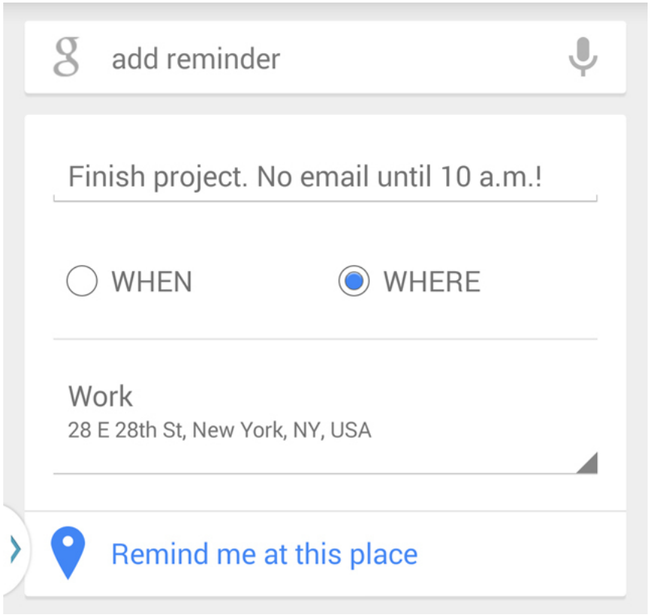
How do system get input from users?

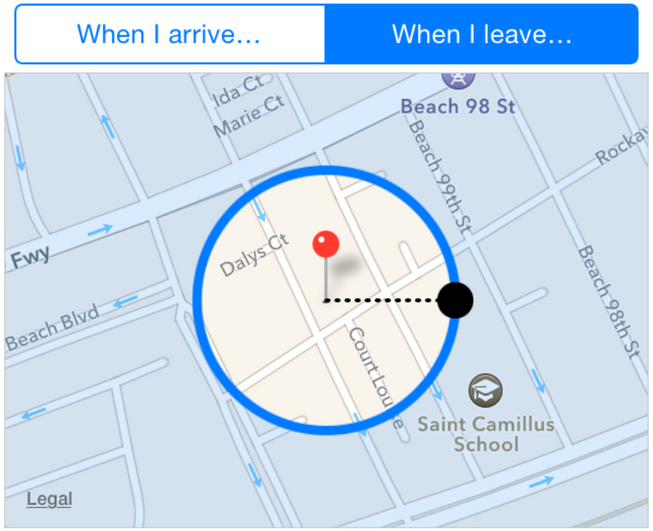
Explicit Interaction: the user tells the computer in a certain level of abstraction (e.g. by command-line, direct manipulation using a GUI, gesture, or speech input) what she expects the computer to do.

Implicit Interaction: an action performed by the user that is not primarily aimed to interact with a computerised system but which such a system understands as input. [3]

[3] Schmidt (2000). Implicit human computer interaction through context. *Personal technologies*.

Examples of implicit & explicit interaction[4]





[4] Images: left, right

Sensing Implications

→ Explicit interaction → sensing signals user give

→ Implicit interaction → sensing signals users give off

Sensing in Explicit Interaction[6]

Capabilities needed for sensing in explicit interaction:

→ **Representation:** Clarity in what input is a needed

→ **Interpretation:** Mapping between input and action

→ **Feedback:** Signaling to the user that the correct input has been received (through displays or system action)

[6] Image

Sensing in Implicit Interaction

Capabilities needed for sensing in implicit interaction:[3]

1. **Perception:** Ability to perceive the use, the environment, and the circumstances
2. **Interpretation:** Mechanisms to understand what the sensors see, hear, and feel
3. **Application:** Applications that can make use of this information

[3] Schmidt (2000). Implicit human computer interaction through context. *Personal technologies*.

Shift from Explicit to Implicit

- → Computing is moving from explicit to implicit
- → Clearer divide between explicit and implicit
  - → Applications on desktop computers, laptops, tablets → *explicit* interaction
  - → Applications on mobile devices, IoT, wearables → *implicit* interaction
- → Implicit interactions are triggered by **context**

What is context?

Definition: Context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.[5]

[5] Dey (2001). Understanding and using context. *Personal and ubiquitous computing*.

Basic building blocks of context:[3]

1. running on a specific device (e.g. input system, screen size, network access, portability, etc.)
2. at a certain time (absolute time, e.g. 9:34 pro; class of time, e.g. in the morning)
3. used by one or more users (concurrently or sequentially)
4. in a certain physical environment (absolute location, type of location, conditions such as light, audio, and temperature, infrastructure, etc.)
5. in a social setting (people colocated and social role)
6. to solve a particular task (single task, group of tasks, or a general goal)

[3] Schmidt (2000). Implicit human computer interaction through context. *Personal technologies*.

What is a context-aware system?

Definition: A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task.[5]

→ Key to context-aware systems is the **situation** abstraction.

→ The goal is "applications that do the right thing at the right time for users."[5]

→ Key to building context-aware systems is **sensing**.

[5] Dey (2001). Understanding and using context. *Personal and ubiquitous computing*.

Challenges in context awareness[3]

→ What happens around an application while the application is in use? Are there any changes at all? → **Presence of changes**

→ Do the surroundings (behaviour, environment, circumstances) carry any valuable information? Does it matter for the application? → **Availability Information**

→ Is capturing and extracting the information feasible, acceptable for the application or device (processing cost, sensor cost, weight, etc.)? → **Capturing information**

→ How to understand the information? What interpretation and reasoning is possible, useful? What reaction is appropriate for the application? → **Interpreting information**

[3] Schmidt (2000). Implicit human computer interaction through context. *Personal technologies*.

How do we build context-aware systems?

A simple template: When **[context/situation]** take **[action]**

Examples:

→ When **[I get home]**, **[remind me to take the trash out]**

→ When **[chance of rain is 50%+]**, **[remind me take an umbrella]**

→ When **[the delivery arrives]**, **[open door to accept delivery]**

→ When **[the whole family arrives]**, **[play Christmas album]**

→ When **[I get home from the grocery store]**, **[help me unload the groceries]**

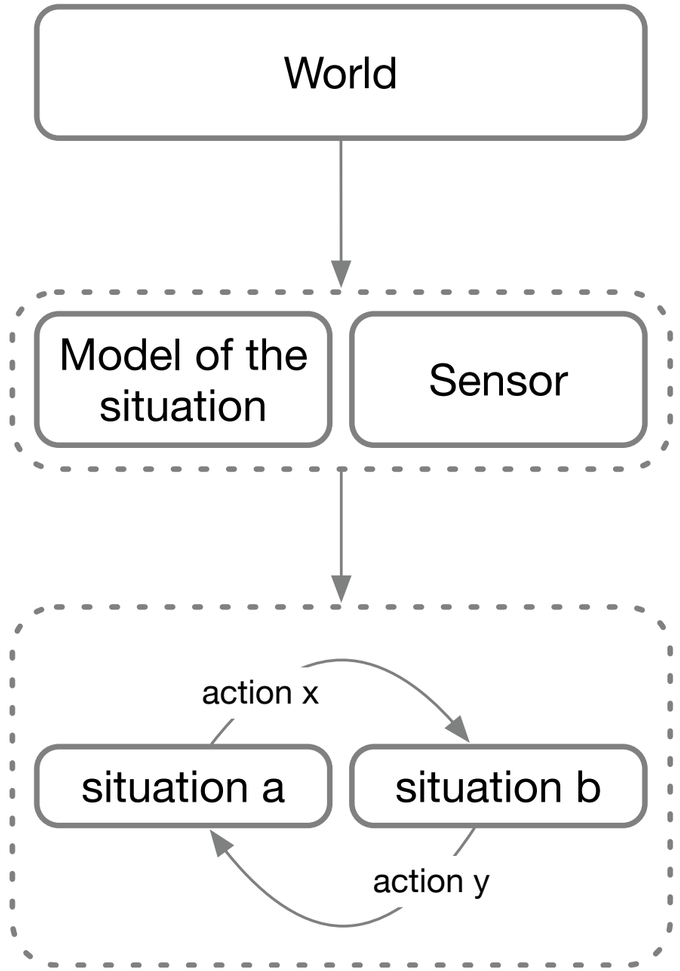
How do we sense situations?

The simple template:

When **[context/situation]** take **[action]**

Extended version:

When **[situation]** changes from **[situation_a]** to **[situation b]**, captured by **[sensor]**, take **[action]**



How do we model situations?

Common elements (a consolidated version of Schmidt's building blocks):[3]

→ **Time/place:** Occurring at a certain time, in a certain place, under certain circumstances

→ **People:** Involving a certain user or a social setting

→ **Task:** Targeting a task or a goal

[3] Schmidt (2000). Implicit human computer interaction through context. *Personal technologies*.

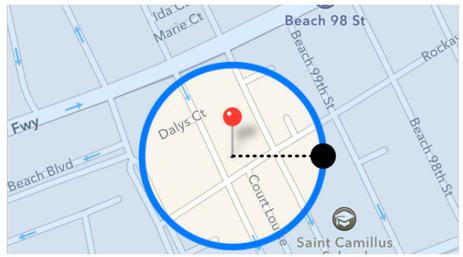
*When **[I get home], [remind me to take the trash out]***

1. Time/place: (arrival at) home
2. People: main user
3. Task: trigger action

1. Time/place:
   `location[home, ...]`
2. People:
   `user[main, ...]`
3. Task:
   `action[remind, ...]`

Change/trigger:

`location[not_home]` → `location[home]`



How to determine change?

Potential triggers:

→ Enter a context

→ Leave a context

→ While in a context

Potential triggers:

→ `situation[not_a]` → `situation[a]`

→ `situation[a]` → `situation[not_a]`

→ `situation[a]`

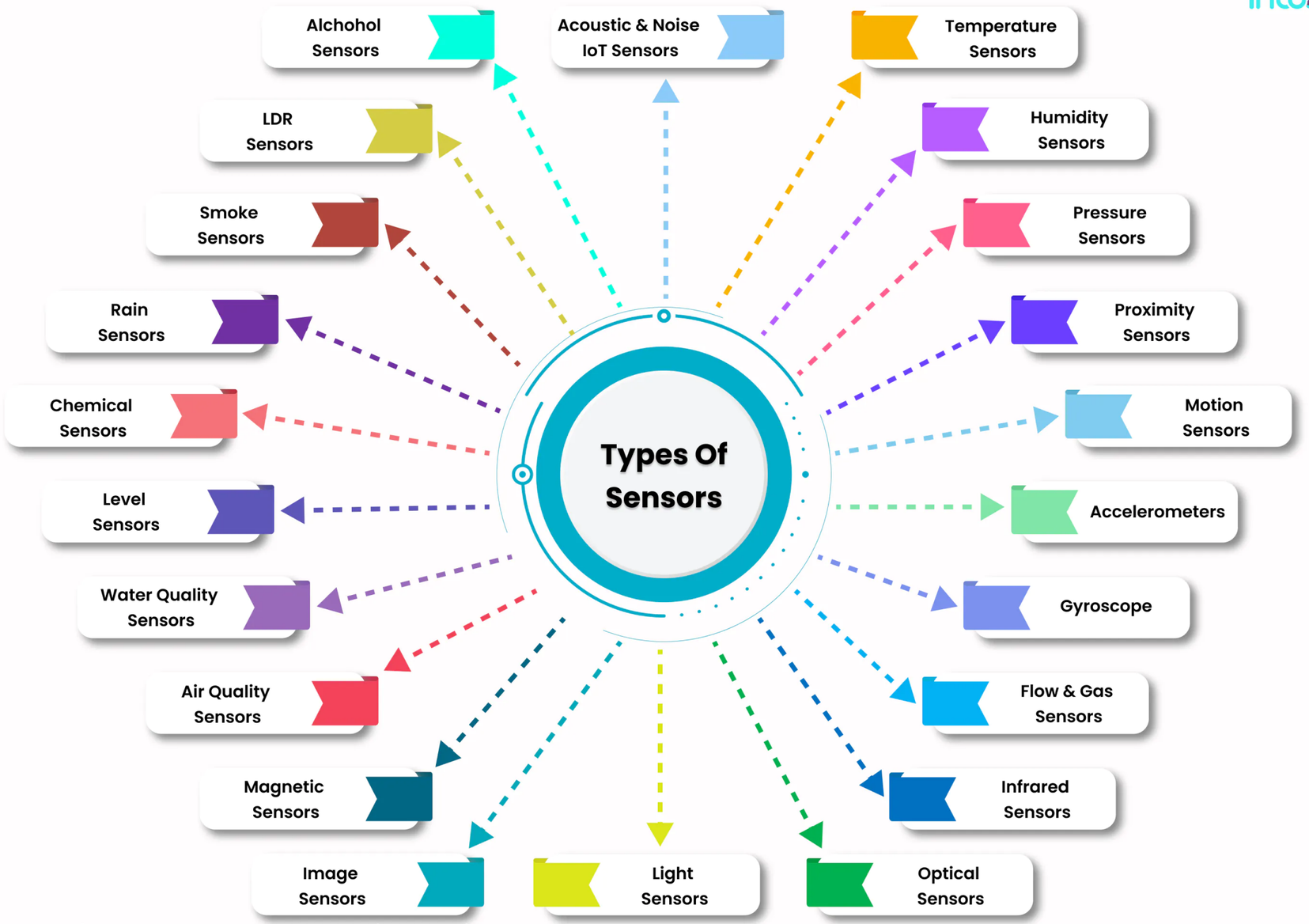
Sensing Modalities

Sensing Approaches

According to Schmidt:[3]

1. Device databases (e.g., a calendars)
2. Input to the system (e.g., press of a button, use of an application)
3. Active environments (e.g., cameras, RFID tags)
4. Context-sensing components (e.g., sensor suite that recognizes "driving")

[3] Schmidt (2000). Implicit human computer interaction through context. *Personal technologies*.



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[13] An All-Inclusive Guide On The Top IoT Sensors In The Market

Emerging Sensing Approaches

- From "traditional" sensors to "non-sensors"
  - E.g., Synthetic Sensors[8]
- Sensors that use existing infrastructure
  - E.g., Wall++[9]
- Sensors that generate their own power
  - E.g., Sozu[10]

[8] Laput et al. (2017). Synthetic sensors: Towards general-purpose sensing. *In CHI 2017*. [Video]

[9] Zhang et al. (2018). Wall++ room-scale interactive and context-aware sensing. *In CHI 2018*. [Video]

[10] Zhang et al. (2019). Sozu: Self-powered radio tags for building-scale activity sensing. *UIST 2019*. [Video]


Woodsaw


Wall++
Interactive & Context Sensing Walls
© Disney

Sozu

Self-Powered Radio Tags for Building-Scale Activity Sensing

Interpretation

What do we do with sensor information?

General approaches:

1. **Adapt** — much more common, often background processes, users could opt out
2. **Proactive action** — less common, can be disruptive, usually requires opt in

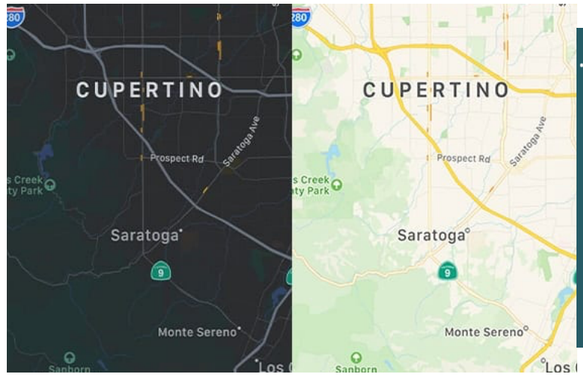
Adapt[3] [7]

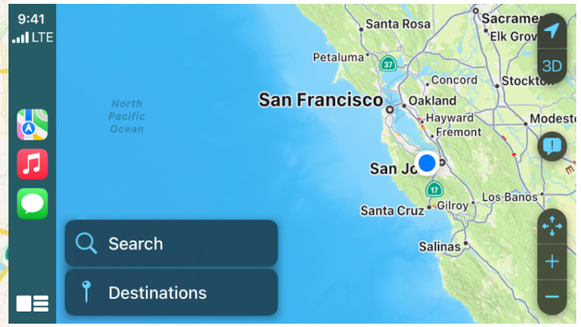
→ Adapt I/O to the current situation

→ Limit need for input

→ Reduce selection space

→ Manage interruptions





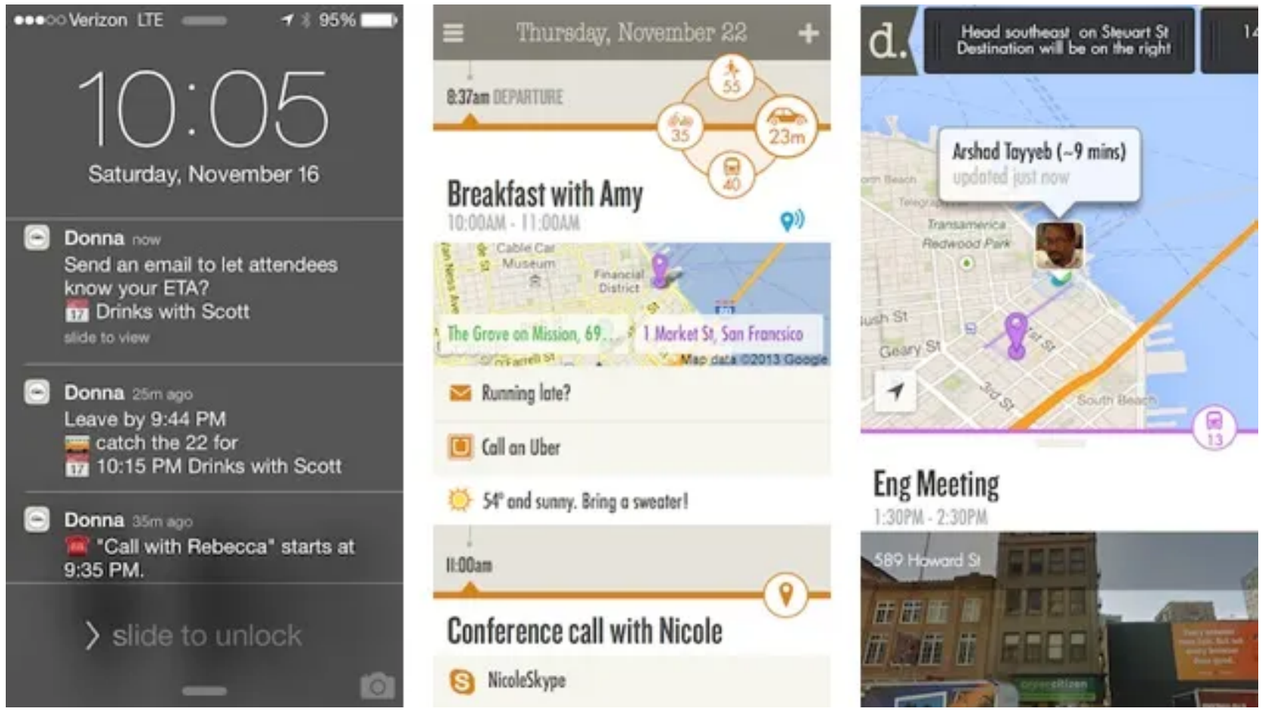
[3] Schmidt (2000). Implicit human computer interaction through context. *Personal technologies*.

[7] Images: top-left, top-right, bottom-left, bottom-right

Proactive Action

→ Automate actions the user might take

→ E.g., emailing meeting attendees that the user is running late (e.g., Donna[11])



[11] Image

Reading Group Discussion

1. **R1:** Overstimulation of senses, e.g., when you're at Disney World. Five sensing: more objective for communication; more subjective senses are harder to work with.

2. **R2:** Users are reluctant to allow cameras; more concern about "who was doing something," rather than "what was done."

3. **R3:** Making sense of sensing from different cameras — triangulation; valuable insights from what is sensed. Classroom is very complicated; different teaching formats. Interpretation is hard to operationalize (e.g., engagement). Qualitative interpretation of sensor data can be important. Example: capturing student posture, which might have different causes.

→ Privacy, security questions around sensing: What is sensed, what is stored (e.g., featurizing data), protecting what is collected.

HACK 2 Preview

HACK 2: Sensing Users[12]

1. Brainstorm an implicit interaction application
2. Models of the abstraction, system
3. Prototype the application
4. Demonstrate the application

→ #1, #2 are due in 1 week

→ #3, #4 are due in 2 weeks

→ Report due in 2 weeks + 2 days

[12] Image