

MOBILE COMPUTING

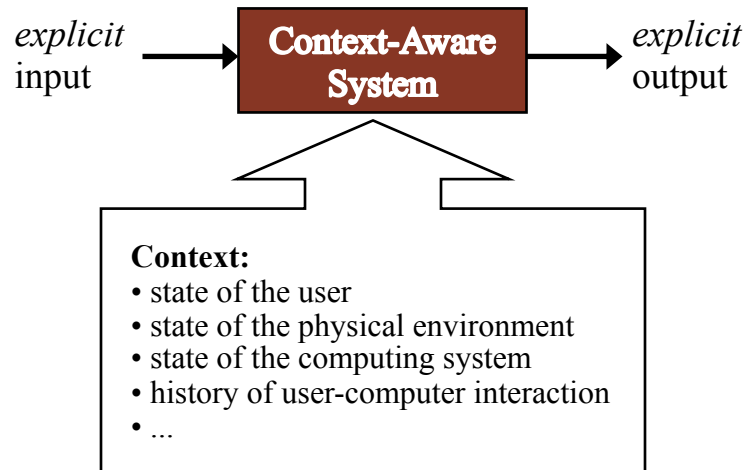
CSE 40814/60814
Spring 2021



System Structure



Context as Implicit Input



What is Context?



Examples of Context

- Identity (user, others, objects)
- Location
- Date/Time
- Environment
- Emotional state
- Focus of attention
- Orientation
- User preferences
- Calendar (events)
- Browsing history
- Behavioral patterns
- Relationships (phonebook, call history)
- ... **the elements of the user's environment that the computer knows about...**

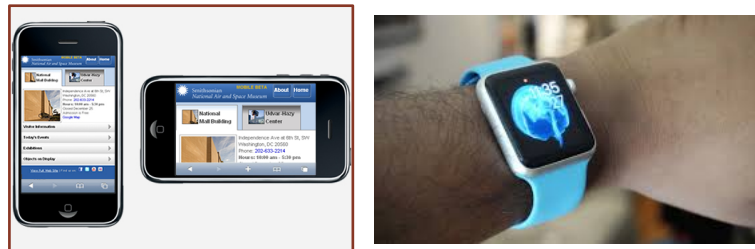
Relevance of Context Information

- Trying to arrange lunch meeting
- Going to a job interview
- Going home after work and making evening plans
- Shopping
- Tourist
- ...



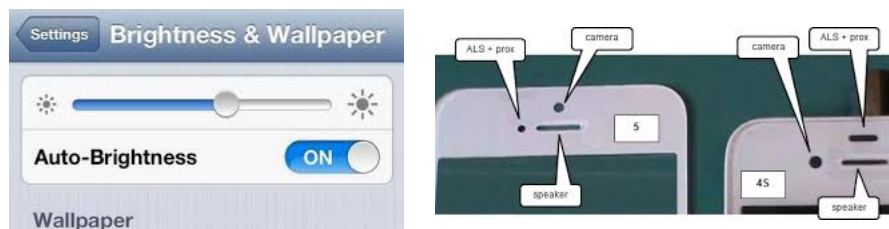
Examples

- Smartphone adjusts the screen to the orientation of the device
- Apple Watch turns on display if arm lifted/rotated
- Orientation is determined by using both a gyroscope and an accelerometer.



Examples

- Phone display adjusts the brightness of the display based on the surrounding area
- Uses a light sensor



Examples

- Device displays user's location, shows route to a desired destination, find nearby stores, geotag images on social media, etc.
- Uses location sensor



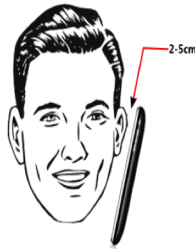
Examples

- The time is displayed on the phone.
 - Time zone change
 - Daylight savings time



Examples

- Device disables touch screen when the user speaks on the phone
- Uses a proximity sensor (infrared signal travel time)



Examples

- **Active Badge** location system
 - One of the first context-aware applications
 - **Context = location**
 - Call-forwarding system
 - Issues
 - Private call forwarding to a public room
 - Call is forwarded to important meeting



Examples

- Schneider trucking trackers
 - Uses GPS to track loads
 - Sends a notification when a load nears its destination
 - Sends emergency notifications when certain conditions are met



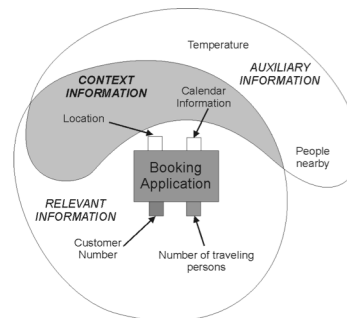
Why Use Context?

- **Reduce cognitive load of user**
- **Proactivity**
 - Set up environment according to user's preferences/history
 - Auto-completion of forms (location, time in timetable)
 - Reminders
- **Search and filter information** according to user's needs
- **Avoid interrupting** the user in inappropriate situations
- **Smart environments**
 - Turn devices on/off, start applications, ... depending on location, time, situation (lecture, meeting, home cinema, ...)
 - Discover and use nearby interaction devices

Definitions of Context

- “Context is **any information that can be used to characterize 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” [Dey et al. 2001]

- **Auxiliary:** not essential
- **Relevant:** can actually be used



Classification I

- **Time** Context (current time, day of week, etc.)
- **Physical** Context (location, temperature, pollution levels, noise levels, etc.)
- **User** Context (characteristics, habits, history, etc.)
- **Computational** Context (user input, customer history from database, network status, etc.)

Classification II

- **External (physical)**
 - Context that can be measured by hardware sensors
 - Examples: location, light, sound, movement, touch, temperature, air pressure, etc.
- **Internal (logical)**
 - Mostly specified by the user or captured monitoring the user's interaction
 - Examples: the user's goal, tasks, work context, business processes, the user's emotional state, etc.

Challenges

- **Self-Awareness:**
 - Context-awareness helps technology to "get it right"
 - But context is hard to sense (quantity, subtleness)
 - Computers are not self-aware like humans
- When the system does the wrong thing
 - auto-locking car doors
 - screen saver during presentation
 - microphone amplifying a whisper

Challenges

- **Intelligence**

- Context data must be coupled with the ability to interpret it, but computers are bad at “common sense”.
- More rules ≠ intelligence
- More rules = more complexity, harder to understand

- Keep “**Human in the Loop**”?
 - computers can detect, aggregate, portray information
 - allow human users to interpret and act on it
 - is this a good strategy for all context-aware systems?

Challenges

- **Programming:**

- Developers have **little experience with devices that gather the data** (e.g., gyroscopes).
- Data gathered from a sensor **must be interpreted correctly** in order for it to be useful.
- Context comes from various sources and in order for this data to be useful it **must be combined correctly** (i.e., the gyroscope and accelerometer working together to determine orientation).
- The context **changes constantly in real time**.

Challenges

- **Usability vs. control?**
 - **Automation** reduces the amount of work that users have to do
 - Users like the idea of a device that completes tasks on their behalf
 - However, when users use these devices they feel a **loss of control** if a device has a high level of automation

Challenges

- **Privacy**
 - Should law enforcement be able to access the history of a user?
- **Correctness**
 - Errors fusing data
 - Detection errors
 - Interpretation errors
- **Complexity**
 - Difficult to develop, maintain, understand
 - Reduces accuracy of the application

Challenges

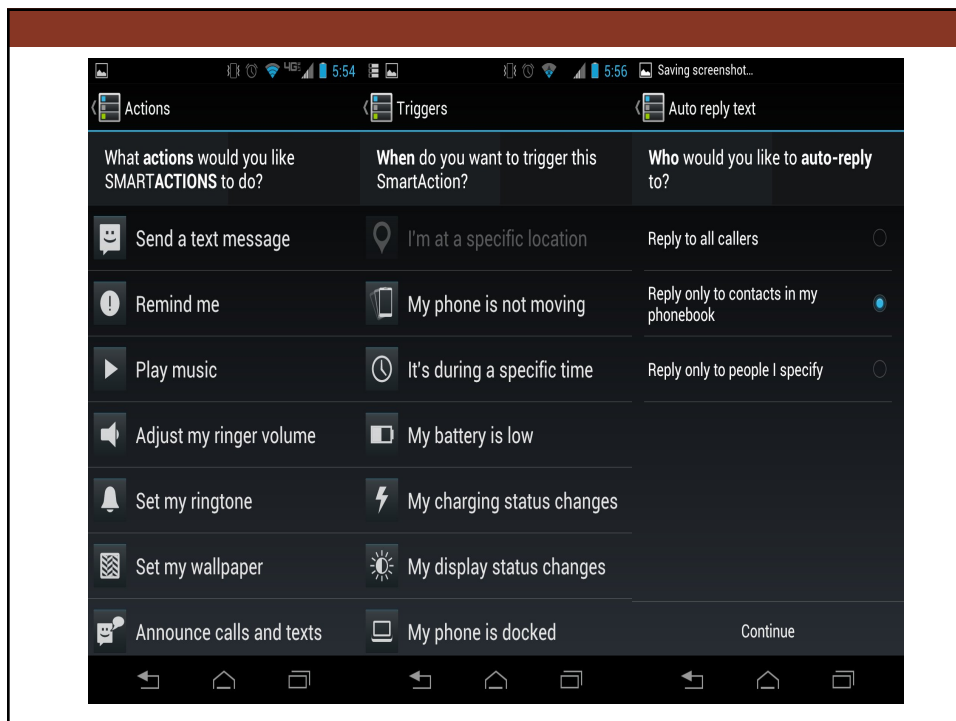
- **User preferences**
 - May not match what the device does!
 - Everyone is different!
 - What is your idea of “nighttime”?
 - What is your idea of “warm”? Or “loud”?
- **Information overload**
 - Can overwhelm the user

Solutions

- Keep an appropriate level of automation (avoid uncertainty)
 - The more automation we have, the less control we have over what is happening.
 - What happens if we give all control to machines?
 - Would you trust your phone to give you a dose of medicine?
 - Keep a balance between uncertainty and automation.

Solutions

- Avoid unnecessary interruptions
 - Phone flashes a notification every 30 seconds
 - Eventually the user will ignore it!
- Avoid information overload
 - Too much information can overwhelm the user, and bog down the device
 - Example: Walking down a busy street a user's device is bombarded with suggestions of places to shop



Solutions

- Keep an appropriate level of system status visibility
 - Allow the user to see what action the device is taking
 - Be sure the user understands *why* the device is performing the action
- Account for the impact of Social Context
 - A loud alert is not ideal for all situations
- Allow for the personalization of individual needs
 - Allow user to change location names (set a location name to “home” for example)

Solutions

- Secure the user’s privacy
 - Selling information to advertisers...is this right?
 - Giving information to the police, when does this cross the line?
 - Sharing context information with others—
Facebook location