MOBILE COMPUTING

CSE-4225

Context-aware Computing (Cont.)

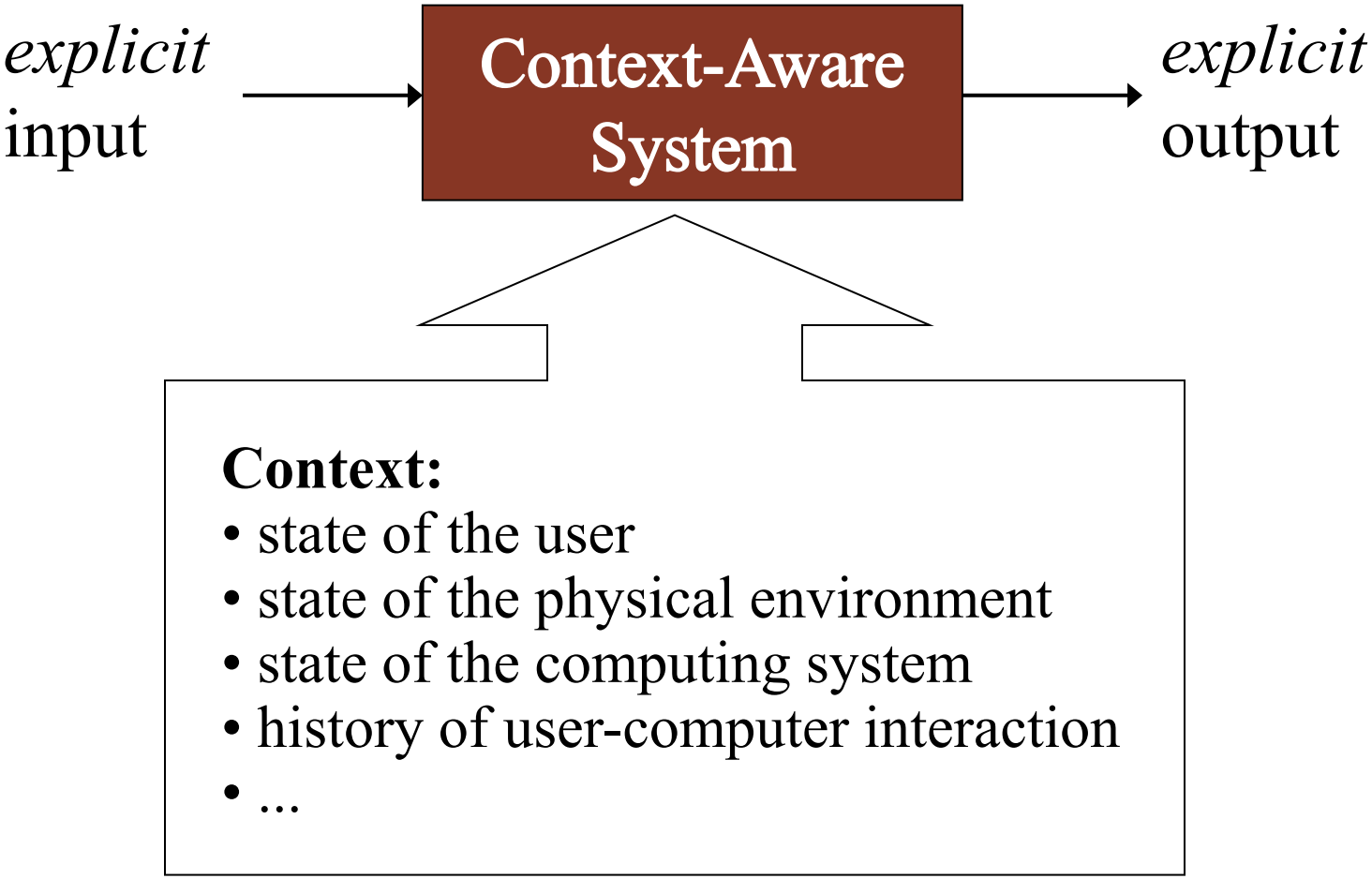
- **Context of a mobile device represents (when using)**
  - Circumstances, situations, applications, or physical environment
- **Mobile phone is operating in a busy, congested area**
  - Device aware: raise the speaker volume, introduce background noises (if intermittent loss of connectivity)
- **This computing Involves user, device, user interface (UI)**

Context-aware Computing

- **System remains aware of**
  - Past and present surrounding situations/states, circumstances
  - Actions such as the present mobile network, network connection status
  - Surrounding devices or nearest connectivity
  - Physical parameters (present time, day of the week)
  - Different status (battery, memory)
  - Data records (cache, local)

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…

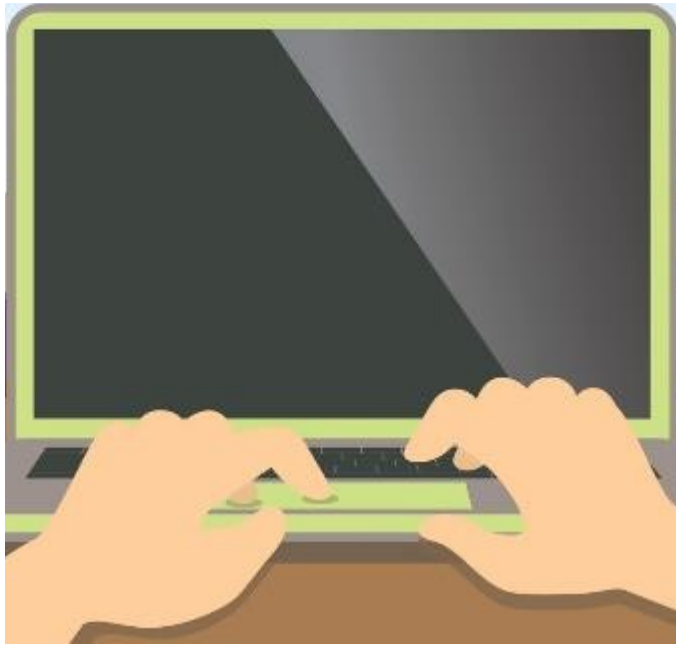
Relevance of Context Information

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

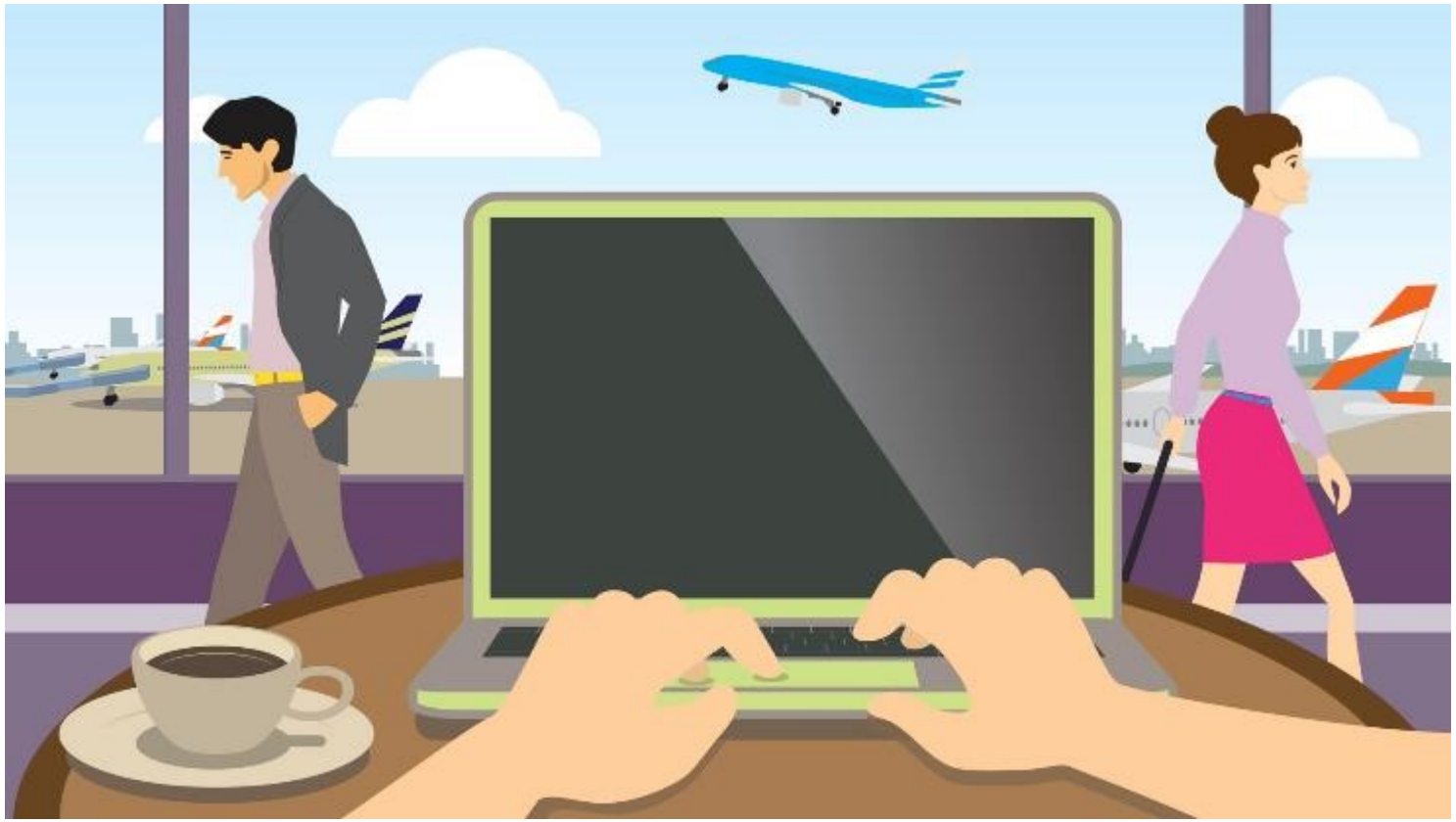
Scene 1

Scene 1

Scene 2



Scene 2

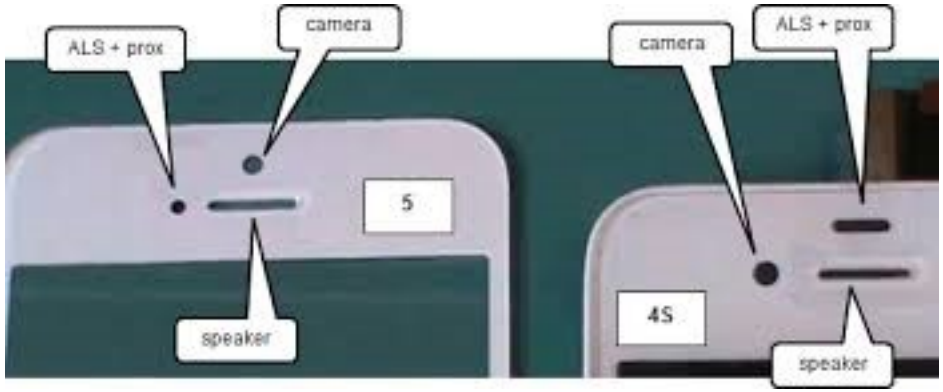


Examples

- 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

Proximate Selection/Contextual Information

Name	Room	Distance
caps	35-2200	200ft
claudia	35-2108	30ft
perfector	35-2301	20ft
snoball	35-2103	100ft

(a)

Distance	Name	Room
20ft	perfector	35-2301
30ft	claudia	35-2108
100ft	snoball	35-2103
200ft	caps	35-2200

(b)

Name	Room	Distance
caps	35-2200	200ft
claudia	**35-2108**	**30ft**
perfector	**35-2301**	**20ft**
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(c)

Name	Room	Distance
caps	35-2200	200ft
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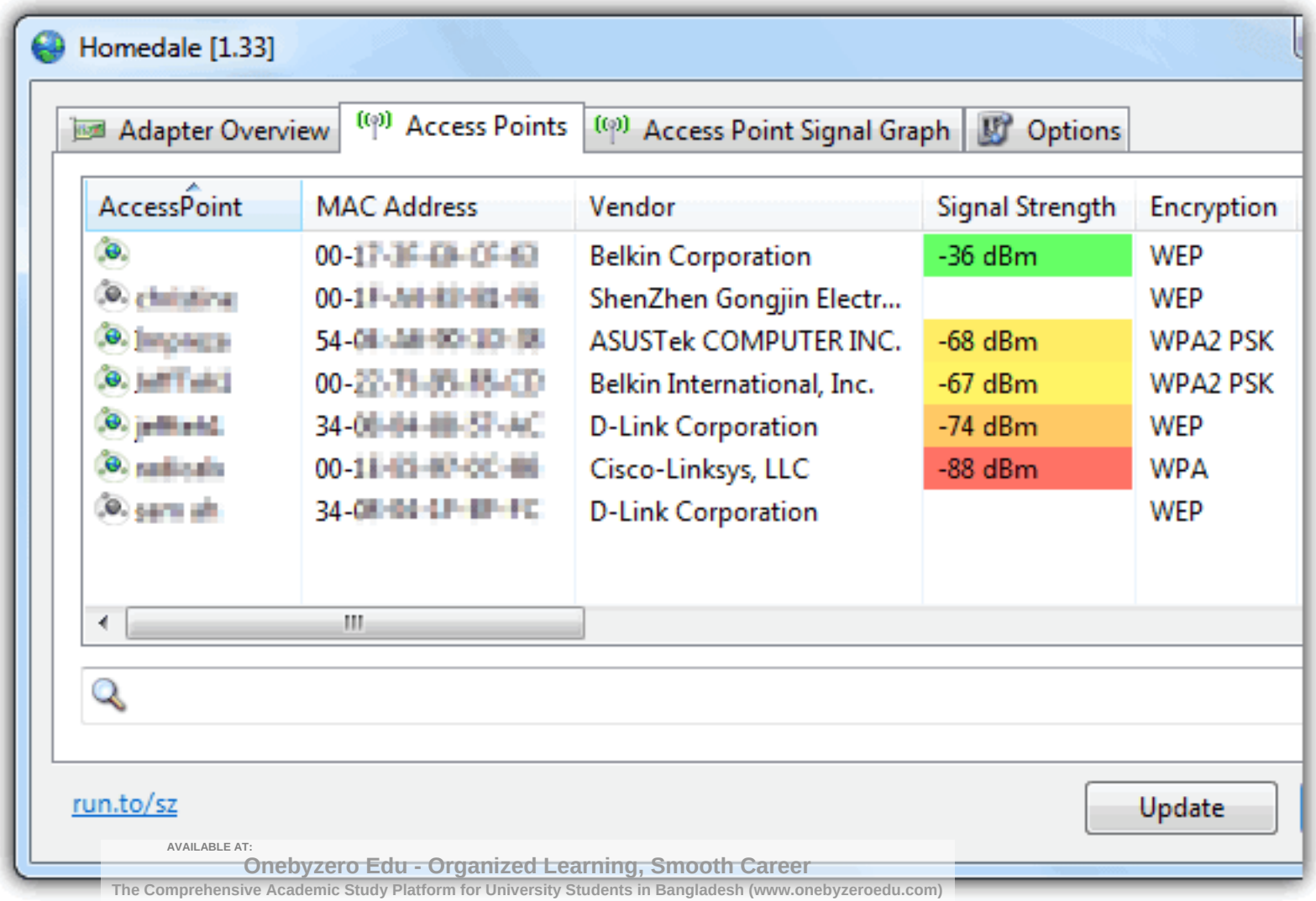
(d)

Table 2: UI Techniques for Proximate Selection

Proximate Selection/Contextual Information

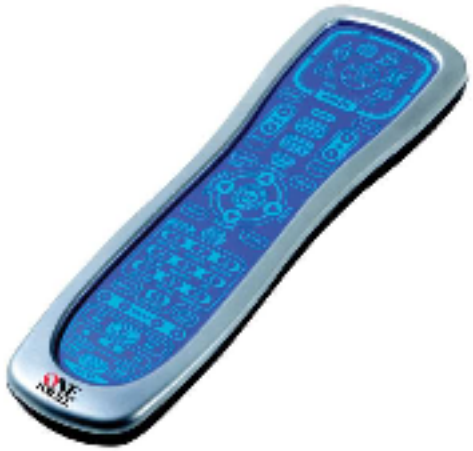


Automatic Contextual Reconfiguration

- Add, remove, or alter components based on context
- Smart notifications on phone (ring, vibrate, auto response)

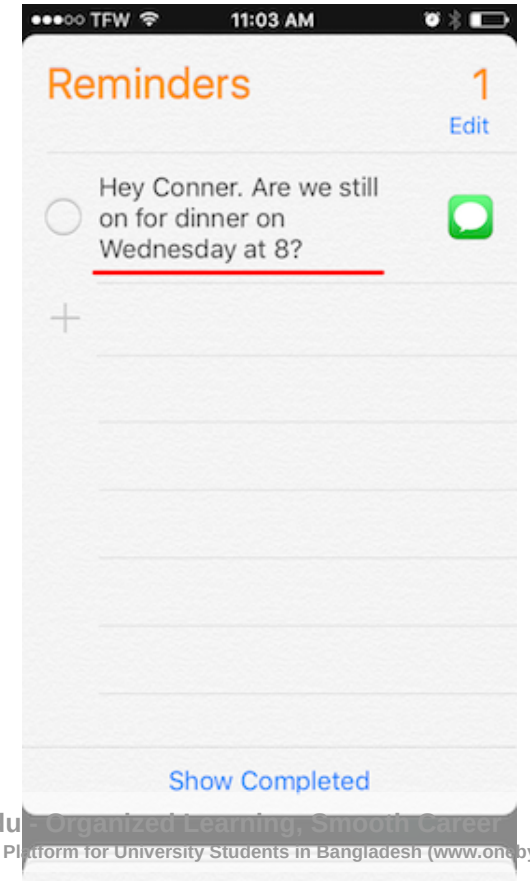
Contextual Commands

- Users can parameterize commands with context-filtered values; execution changes based on context
- Example: universal remote control



Context-Triggered Actions

- Simple if-then condition-action rules, automatically invoked
- Reminder: if I step into the car on weekday morning and don't have suitcase with me, remind me to get it



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

Types of Context: Train Booking App

- Customer provides customer# and booking details (**explicit input**)
- Location, time are required and can be automatically derived from context information (**implicit input**)
- Additional information: current temperature, number of people around you, what you wear, heart rate, …

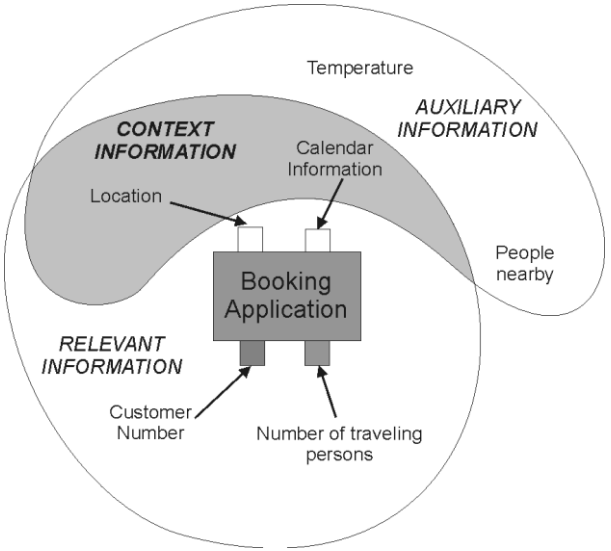
Types of Context

- **Time** Context (current time, day of week, etc.)
- **Physical** Context (location, temperature, etc.)
- **User** Context (characteristics, habits, history, etc.)
- **Computational** Context (user input, customer history from database, network status, etc.)
- **Structural** Context
  - telephone directory: including a name, an address, and a 11-digit number
  - collection of these records shows an interrelationship thus defines a context
- **Temporal** Context
  - defines the interrelation between time and the occurrence of an event or action.
  - Example: voice user interface (VUI)

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

- **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, subtle)
  - 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

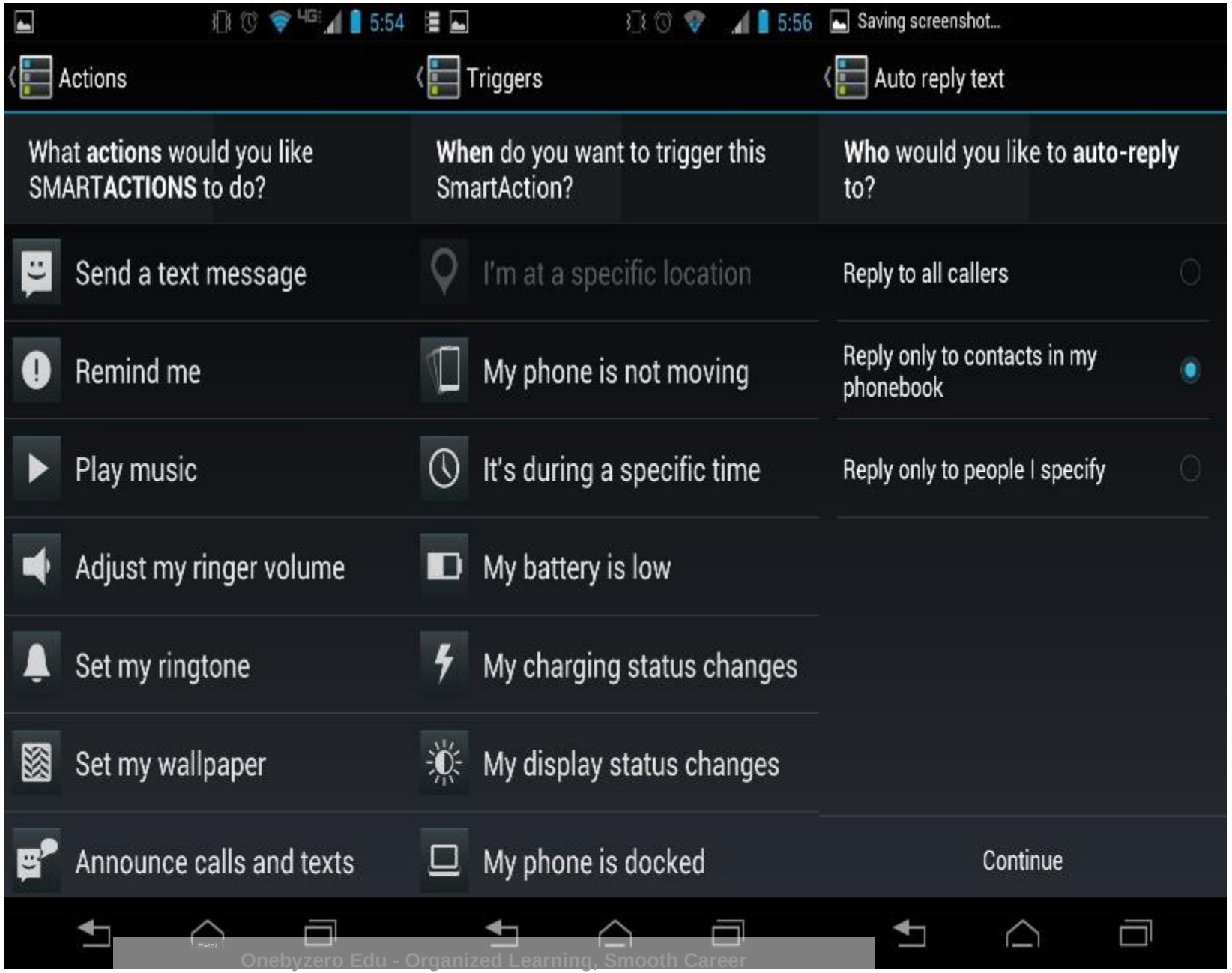
- **User preferences**
  - May not match what the device does!
  - Everyone is different!
    - What is your idea of “nighttime”?
    - What is your idea of “warm”? Or “loud”?
- **Information overload**
  - Can overwhelm the user

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