# Context

## Euan Freeman

euan.freeman@glasgow.ac.uk

University of Glasgow | School of Computing Science

# Outline

What is context?

Situational impairment: how does context limit interaction?

Context-aware computing: what can do we if we know context?

Context ambiguity: how to handle uncertain context?

# Intended Learning Outcomes

**ILO1**: Explain problems associated with human-computer interaction in mobile and ubiquitous usage contexts;

**ILO2**: Critically analyse a proposed mobile interactive system considering its intended usage context;

**ILO5**: Discuss cutting edge developments in mobile human-computer interaction, such as context-aware systems, sensor-based interaction, location-based interaction, and mixed reality;

# What is Context?

Context: the situation in which a device is being used

Context is highly variable for mobile devices

# Context – Location

Context: the situation in which a device is being used

- Location

# Context – Environment

Context: the situation in which a device is being used

- Location
- Environment (light, sound, vibration, etc)

# Context – Motion

Context: the situation in which a device is being used

- Location
- Environment (light, sound, vibration, etc)
- Device motion (e.g., while walking)

# Context – Connectivity

Context: the situation in which a device is being used

- Location
- Environment (light, sound, vibration, etc)
- Device motion (e.g., while walking)
- Connectivity (e.g., cellular, data, location)

# Context – Situational Demands

Context: the situation in which a device is being used

- Location
- Environment (light, sound, vibration, etc)
- Device motion (e.g., while walking)
- Connectivity (e.g., cellular, data, location)
- Situational demands (e.g., holding other items, watching the road)

# Context – Summary

Context: the situation in which a device is being used

- Location
- Environment (light, sound, vibration, etc)
- Device motion (e.g., while walking)
- Connectivity (e.g., cellular, data, location)
- Situational demands (e.g., holding other items, watching the road)

# Activity: What is the context?

*"A cycling equipment manufacturer is developing a new cycling helmet with an integrated augmented reality display. ... Consider the safety implications of using an augmented reality display while cycling."* (2024 exam)

What characteristics of this context can you identify?

# Activity: What is the context?

*"A fast-food delivery company wants to create a smartphone app to help its delivery employees collect orders from restaurants then deliver them to customers, while traveling by bicycle."* (2020 exam)

What characteristics of this context can you identify?
- What is different from the previous slide?

# Situational Impairment

Situational impairment: when the context restricts a person's abilities to interact with a device

Think about how context may make it difficult to:

- Provide input?
- Perceive output?

# Context-Aware Computing

*"With context-aware computing, we now have the means of considering the situation of use not only in the design process, but in real time while the device is in use."*

Think about what a device can do if it knows how it is being used

Albrecht Schmidt: Chapter 14: Context-Aware Computing.
The Encyclopedia of Human-Computer Interaction (2nd Ed)

# Social Context

Humans are good at using context:

- We perceive and process contextual information to determine how to act, even if we aren't consciously aware of it
- We have a shared understanding of situation
  - Most of us agree on what is(not) socially appropriate in certain situations

# Social Context – Example

E.g., walk into a room with the intention of speaking to someone:

- You hear them speaking, but see nobody else in the room;
- You infer that they're probably in a phone conversation;
- You decide to wait until they're finished or acknowledge you, before you say something;

# Social Context – Closed Loop System

Context is part of a closed-loop social interaction system:

- Human perceives sensory information;
- Human combines sensory inputs with prior knowledge;
- Human infers the current context and identifies appropriate behaviour;
- Human makes a decision about how to (inter)act in that setting;

Goal: enable computers to behave in the same way;

# Recap on Context

Context may cause situational impairment
- You need to start thinking about context and its implications

Context-awareness means mobile devices can infer context

# Context Awareness

Computers are not good at using context...

- ... but they're getting better;

Mobile devices have many sensors: ambient light, location, orientation, motion, microphones, cameras, etc.

These can be used to infer context: to adapt user interfaces and present contextually appropriate content/interactions;

# Example: Sensing Techniques

Ken Hinckley et al: Sensing techniques for mobile interaction. UIST 2000.

*"We introduce and integrate a set of sensors into a handheld device, and demonstrate several new functionalities engendered by the sensors, such as recording memos when the device is held like a cell phone, switching between portrait and landscape display modes by holding the device in the desired orientation, automatically powering up the device when the user picks up the device to start using it, and scrolling the display using tilt."*

Explored the interaction possibilities from adding new sensors to a 'dumb' phone: e.g., orientation change, posture detection, flick gestures.

# Example: Active Badge

Roy Want et al.: The Active Badge location system. ACM Transactions on Information Systems 10(1): 91-102, 1992.

*"Members of staff wear badges that transmit signals providing information about their location to a centralized location service, through a network of sensors. <...> Location systems raise concerns about the privacy of an individual, and these issues are also addressed."*

One of the earliest context-aware computing systems. Could detect a person's location and, e.g., route calls to the nearest telephone.

# Example: Orientation + Location

Google Weather:

- Uses device orientation to adapt presentation, to make best use of available space
- Uses time and location for relevant forecast
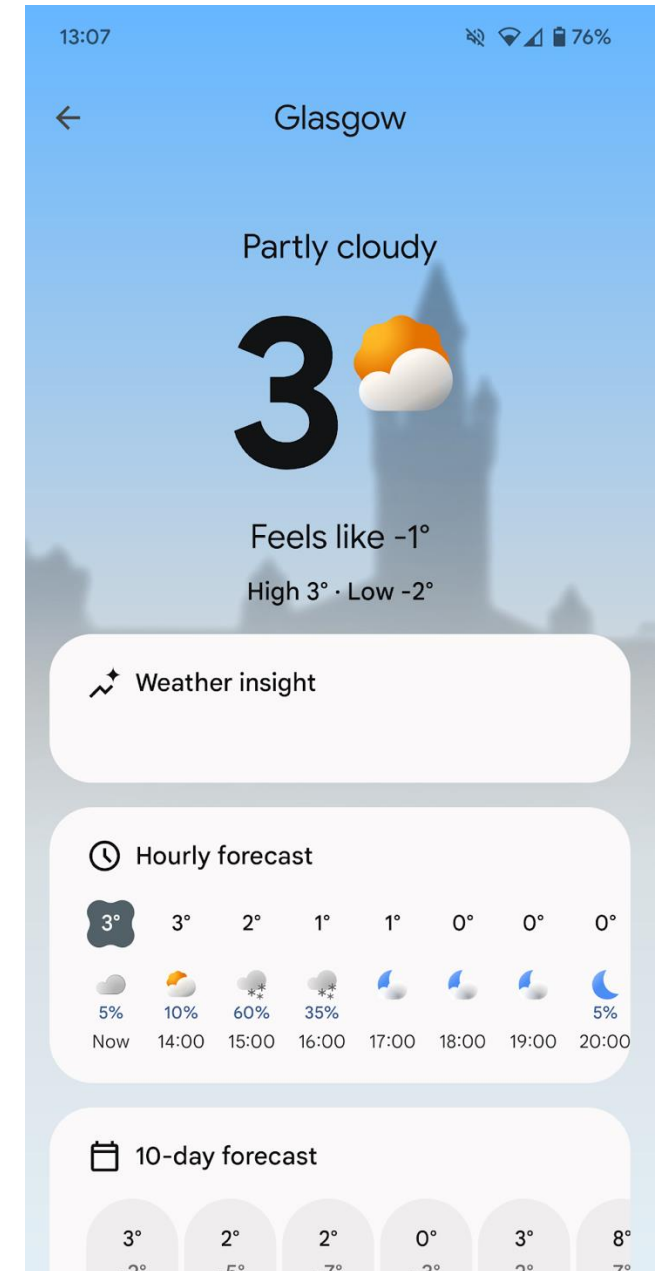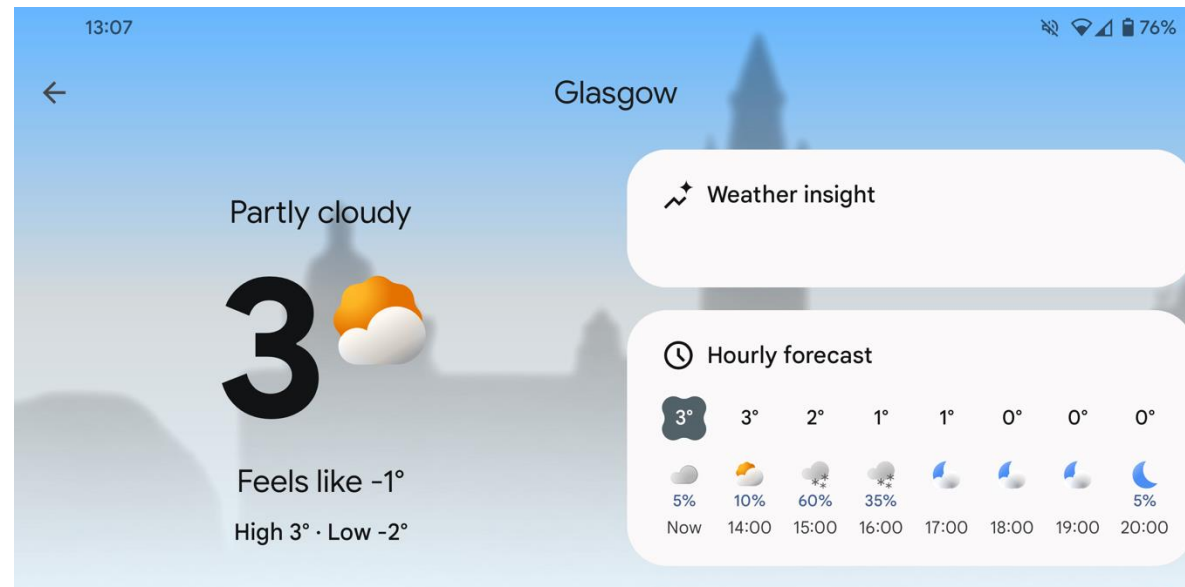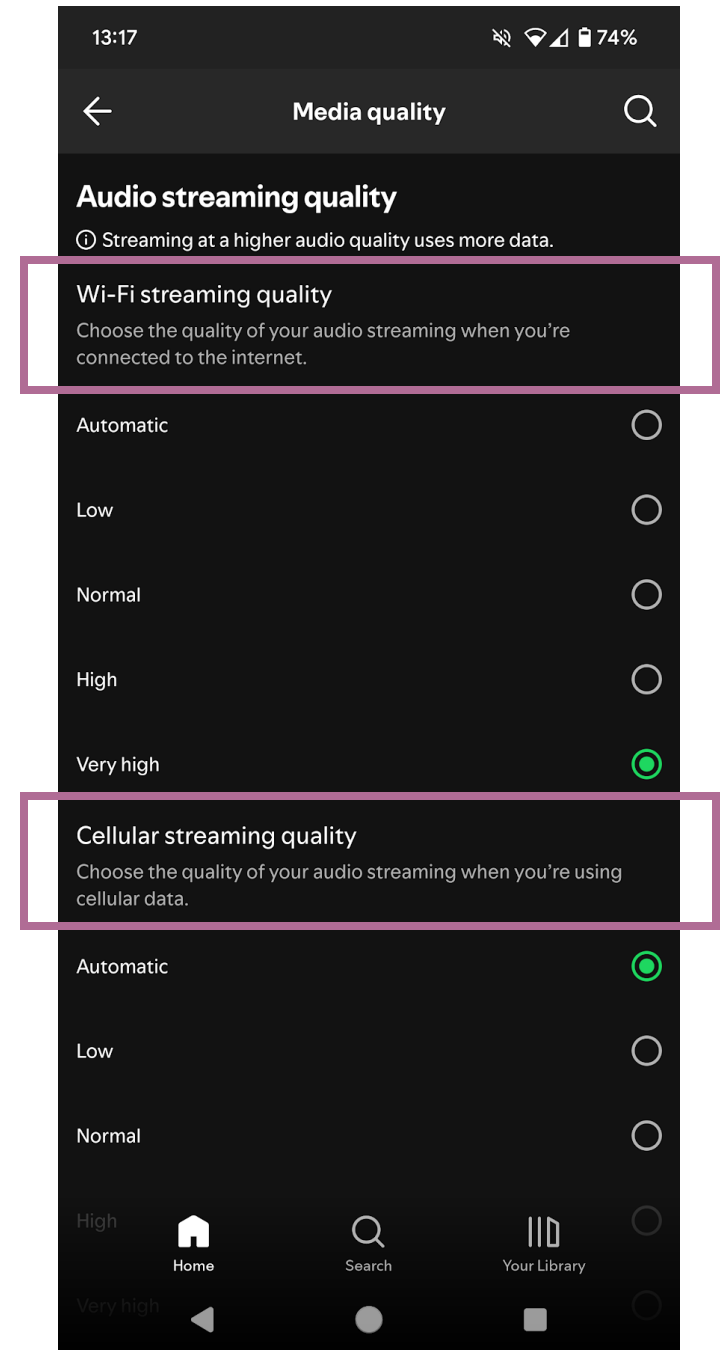
# Example: Location + Time

Google Maps:
- Uses location to recommend nearby restaurants
- Uses location history to highlight places you've been before
- Uses time to suggest places that are currently open
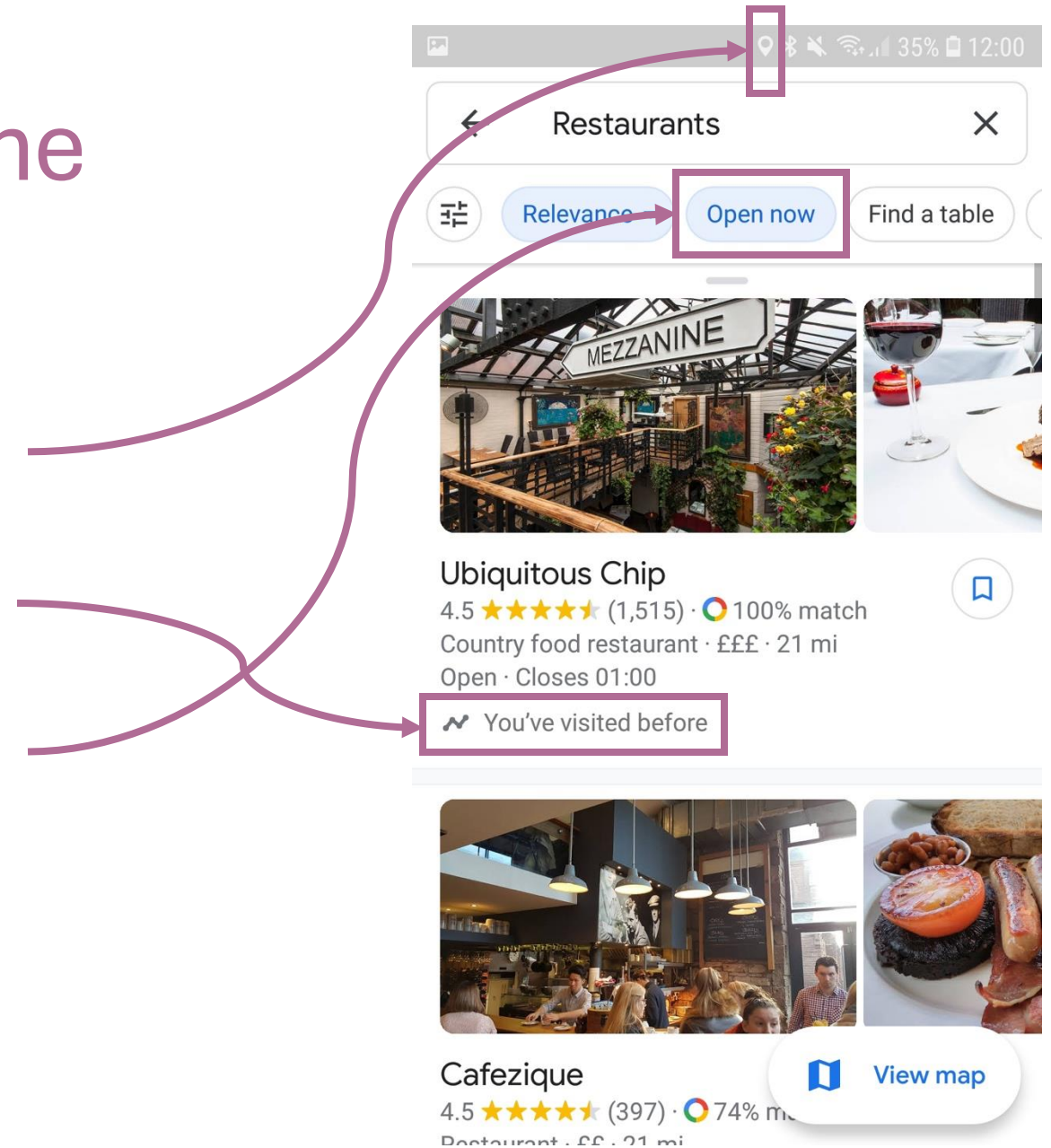
# Example: Connectivity

Spotify:

- Uses connection type to determine quality

# Context Awareness – Quality of Life

These examples use context for 'quality of life' improvements:
- They attempt to make 'smart' decisions to save user effort
  - i.e., you don't need to do these things yourself

Context is…
- Multi-faceted: but fusing information modalities gives us a better idea of the usage scenario (e.g., location + time + calendar appointments?)
- Difficult to infer: too many bad decisions frustrates users
- Potentially bad for privacy?

# Context Awareness – Prior Context

Context is what is happening now

Context-aware systems can also consider prior context
- Can a system learn from previous situations?
    - e.g., what actions the user took, whether interaction was successful, etc.
- e.g., notifications about train or traffic delays
    - Considers patterns in your location history, learns your commute, etc
- e.g., recommendations about apps you are likely to use next
    - Considers time of use, apps used 'together', etc

# Interaction Modalities

Consider all senses and capabilities:

- Interaction doesn't need a touchscreen (i.e., visual + finger contact)

Example:

- Context: {dark, motion corresponding to gait, last touch 240s ago}
- Inference: {phone in pocket, user walking}
- Action: present navigation instructions using audio

Example:

- Context: {meeting in calendar, flat device orientation, ambient noise}
- Inference: {phone on table, user in meeting, other people in room}
- Action: present notifications on smart-watch using vibration + icons only

# Recap on Context Awareness

Why make context-aware mobile experiences?

- Reduce interaction time by taking actions on a user's behalf
- Allow users to focus on completing their task
- Expose users to new opportunities (e.g., new nearby coffee shop)
- Overcome situational impairments (e.g., increase screen brightness)
- Create elegant but efficient UIs (e.g., reduce irrelevant information)
- Improve situational awareness (e.g., when walking/cycling/driving)
- … and more – what else can you think of?

# Context Ambiguity

Uncertainty is inherent in context sensing;
- It's difficult to make an inference from the ambiguous information

Information quality can vary:
- e.g., poor connectivity in rural areas
- e.g., poor GPS signal in dense urban areas

Ambiguity in information:
- e.g., ambiguous motion: is user cycling or walking?
- e.g., is it dark because it's late, or phone is in pocket?
- e.g., is device moving quickly because I'm driving my car or on a bus?

# Context Ambiguity – Usability Issues

Poor context inference can lead to inappropriate actions:

- e.g., presenting irrelevant content
- e.g., acting in undesired ways

Inappropriate context awareness can frustrate users:

- e.g., difficult to undo unintended actions
- e.g., uncertainty about why things aren't working as expected

# Context Ambiguity – Feedback

Consider how to display context information and system state:

- Use ambiguous information as an interaction 'resource'
- Help users discover what is happening
  - Leading to insights about why the system is behaving the way it is

Users can 'fill in the gaps' and find their own explanation

William Gaver et al.: Ambiguity as a resource for design.
Proceedings of the SIGCHI Conference on Human Factors in
Computing Systems, 233-240, 2003.
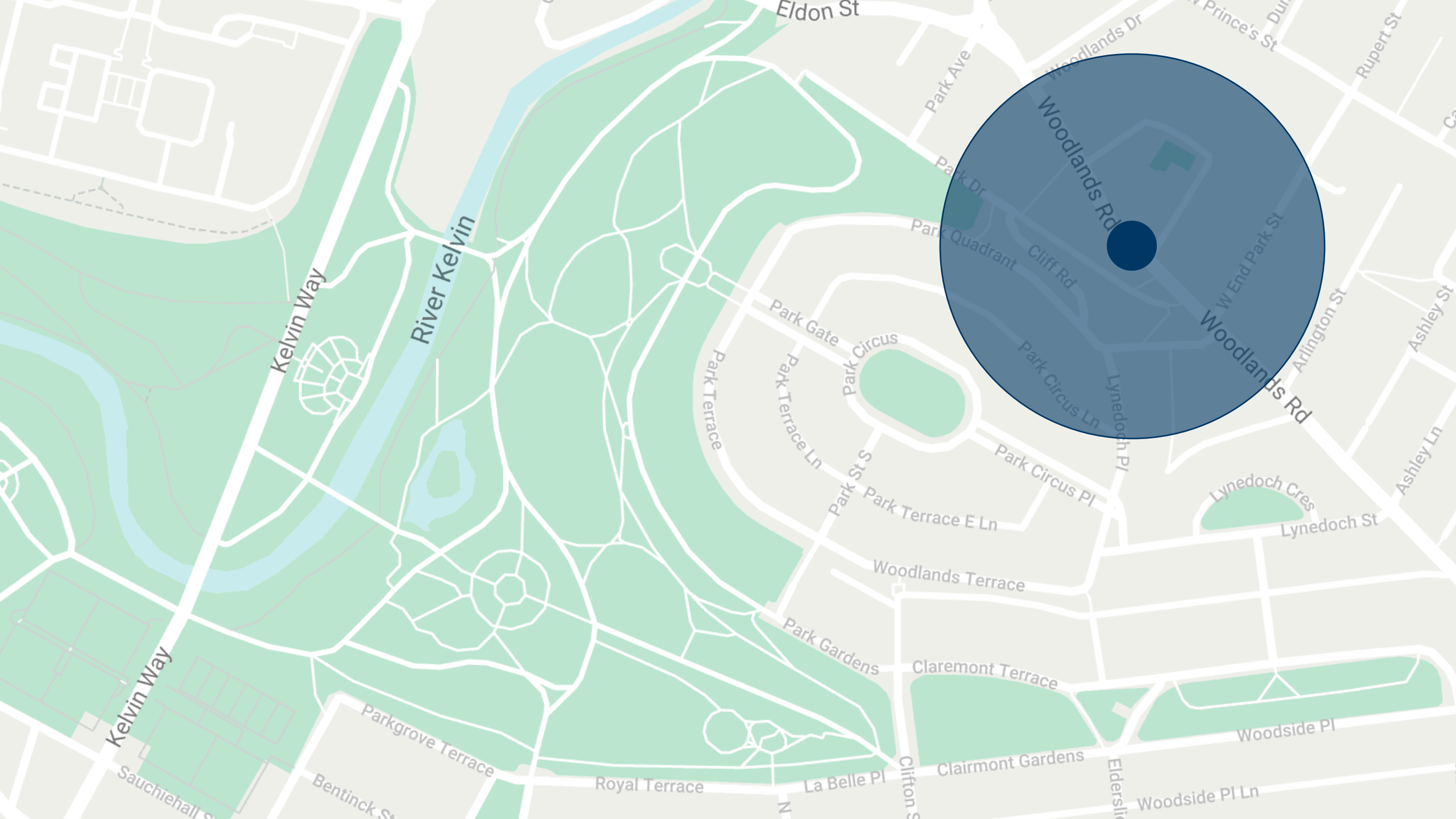
# Location Ambiguity

Reveal uncertainty through feedback:

- So users know ambiguity is present and might affect system behaviour
- So users know if their corrective actions are having a positive effect
- Why? Users are often forgiving of systems that are honest…
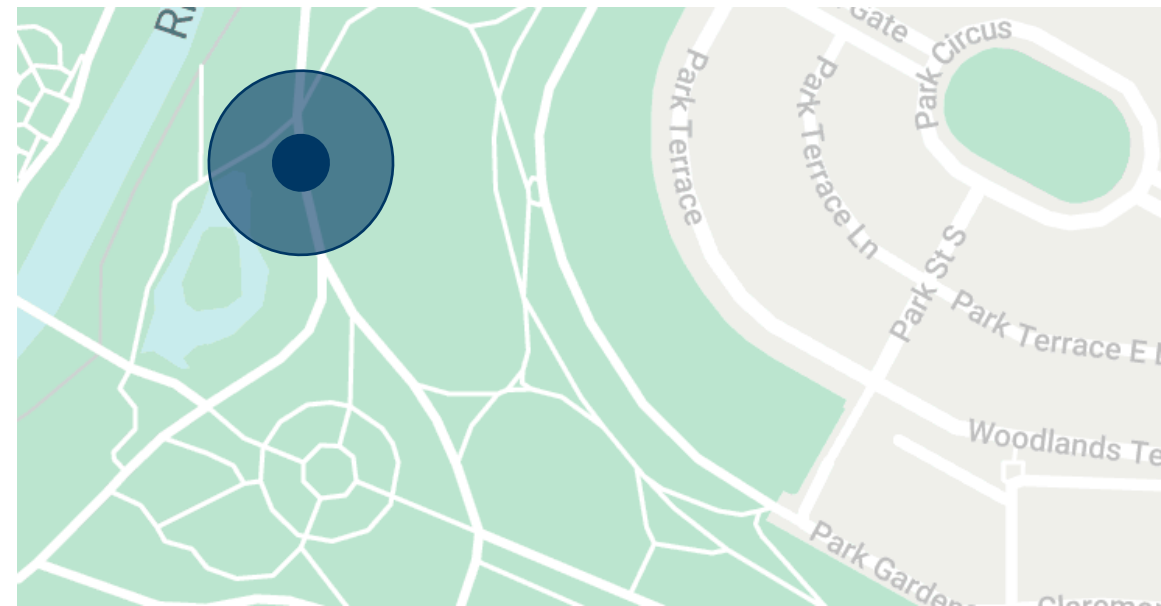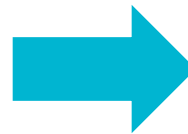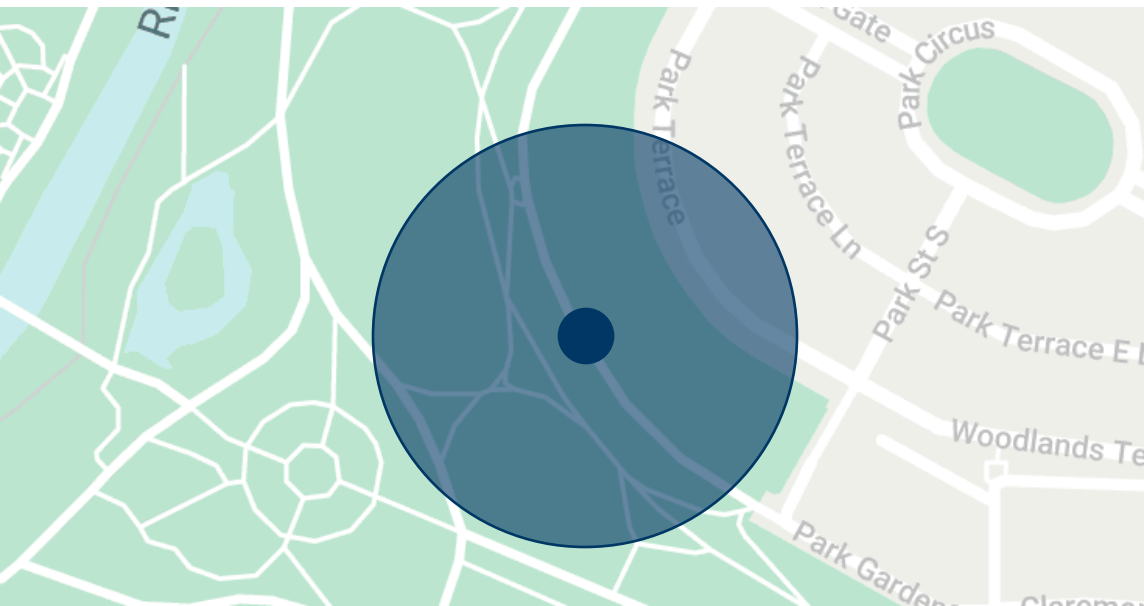
# Location Representation

Location representation uses abstraction:

- Simplify information in a way that helps users make their own judgement
- Hide less relevant information:
  - e.g., number of GNSS satellites, signal strength, last signal update time
- Dynamically responds to the situation
  - e.g., users can see the quality get better/worse as they move

# Connectivity Representation

Connectivity indicators are abstractions:

- Designed to hide underlying complexity
  - Signal strength is constantly fluctuating
  - Quantified in units that lack meaning to most people
- Gives users a meaningful frame of reference
  - e.g., a 'full' Wi-Fi icon implies a good signal strength
  - e.g., an 'empty' Wi-Fi icon tells the user they might want to reposition their router

Users recognise variability via the abstraction

- e.g., "good" or "bad" without needing to know more
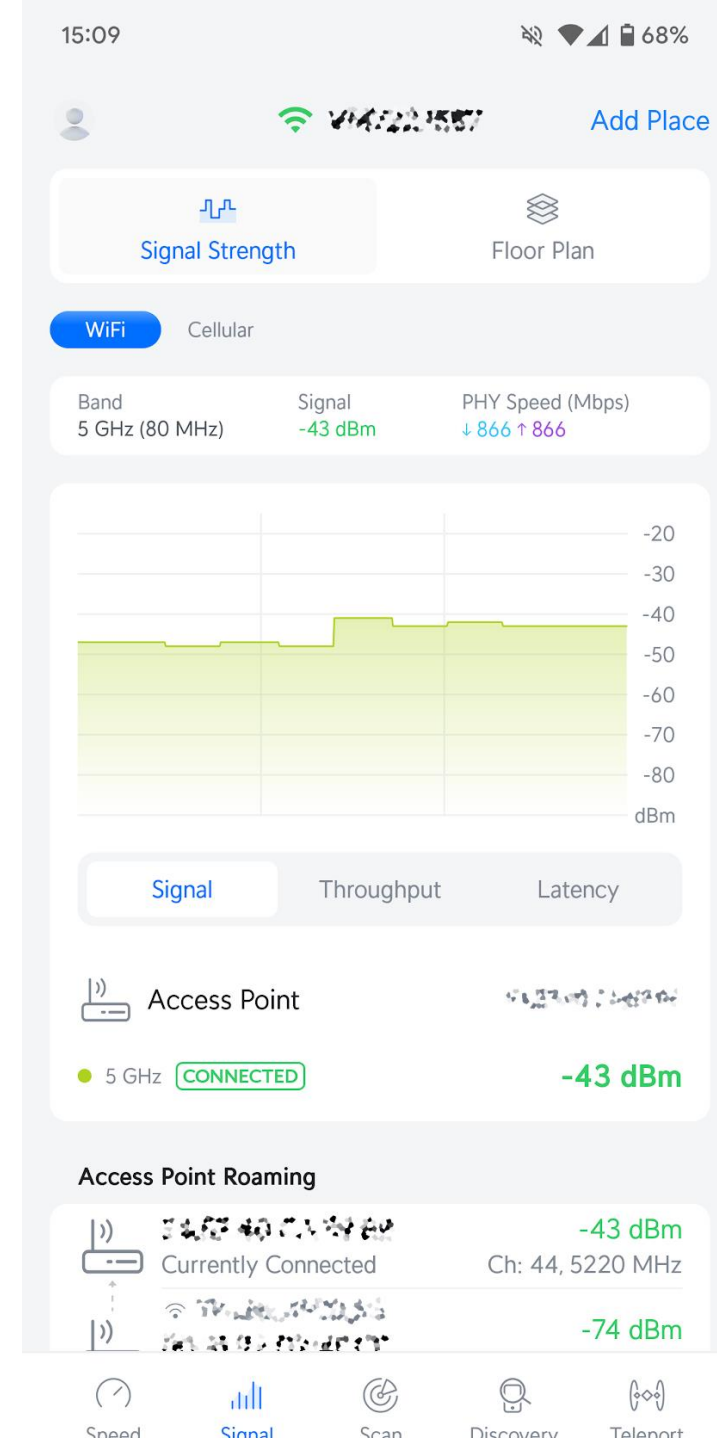
# Summary

Context: the situation in which a device is being used:

- Location
- Environment
- Device motion
- Connectivity
- Situational demands
- And more…

Situational impairment: when the context restricts a person's abilities to interact with a device

# Summary

Computing devices can have context awareness:

- Numerous sensors that can infer something about usage context
- Context-aware computing can be beneficial

But context sensing is prone to uncertainty and ambiguity:

- May have negative implications for usability
- Good feedback and representation may help mitigate context ambiguity

# Lab Exercise Review

## Task 2: change colour of 'clear' and 'checkout' buttons

- Need to override the component defaults – using schema args

```
<!-- Create menu items -->
<a-entity position="-2.0 1.0 -3" rotation="0 20 0">
    <a-plane ... button="item_id: 1; item_name: Burger; item_price: 3.0;"></a-plane>
    <a-plane ... button="item_id: 2; item_name: Cheeseburger; item_price: 3.2;"></a-plane>
    <a-plane ... button="item_id: 3; item_name: Pizza; item_price: 7.0;"></a-plane>
    <a-plane ... button="item_id: 4; item_name: Chips; item_price: 2.0;"></a-plane>
    <a-plane ... button="item_id: 5; item_name: Ice Cream; item_price: 2.5;"></a-plane>
    <a-plane ... button="item_id: 6; item_name: Drink; item_price: 1.0;"></a-plane>
    <a-plane ... button="item_id: 7; color: #006630; hover: #228852;" color="#006630"></a-plane>
    <a-plane ... button="item_id: 8; color: #B30C00; hover: #D52E22;" color="#B30C00"></a-plane>
</a-entity>
```

# Lab Exercise Review

Task 3: updating UI content with selected items
- Need to build a list of selected items
- We know the selected item via the schema variable 'item_name'

```
var basket = document.querySelector('#info_text').getAttribute('value');

document.querySelector('#info_text').setAttribute('value', basket + "\n" + data.item_name);
```
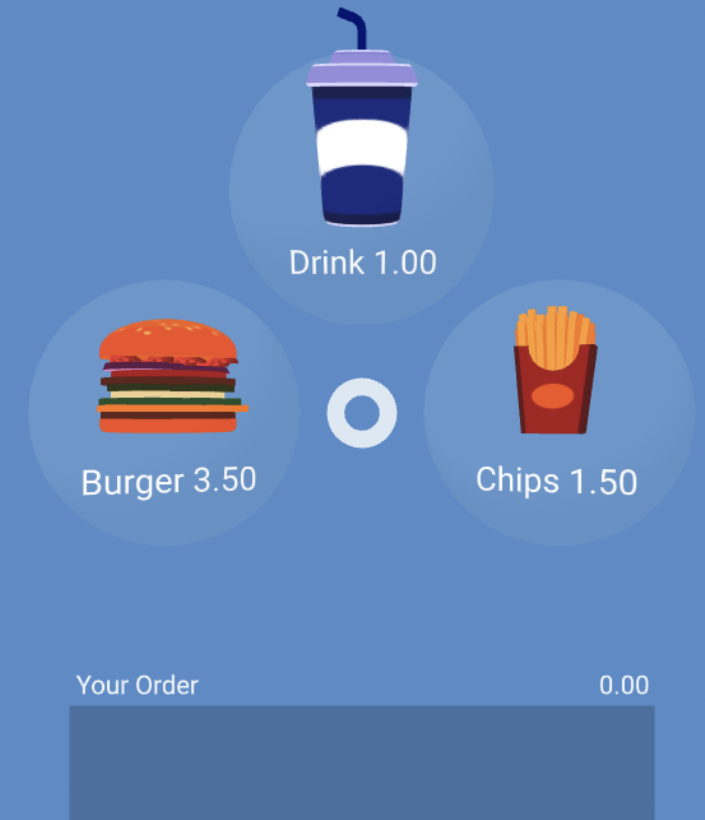
# Lab Exercise Review

Optional tasks (recommended) use similar principles:

- Adding appropriate event-driven functionality to modify the user interface

# Lab Exercise Preview

Next week we extend today's lab exercise with animated 3D content:

- Fun and visually appealing
- … but also gives useful dynamic feedback!



Drink 1.00

Burger 3.50

Chips 1.50

Your Order                                                    0.00

# Lab Exercise Preview

By the end of next week's lab you should be able to:

- Use assets to create rich and engaging interactive prototypes
- Use animations to give dynamic feedback via user interface elements