**CS - 684** Embedded Systems
Spring 2018

# Automated Retail Store


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# Goal of the Project

01 The idea is to make a store where customers can purchase products without using a cashier or checkout station.

02 The customers should never have to wait in a line.

03 Just Walk Out shopping experience.

# Understanding the problems

01 Knowledge of **WHAT** the customer is buying. Real-time tracking of weights of the racks in a shelf where the products are placed.

02 Knowledge of **WHERE** the customer is buying. Real-time positional tracking of customers, to get the shelf of interest.

03 Knowledge of **HOW** the customer is buying. A mobile application that will keep track of the actions and charge accordingly on exit.

# Requirements


Digital Load Cell Weight Sensor
Hx711 Weighing Sensors ADC module
Esp32 Wifi Bluetooth Development Board
Mobile device with a GPS tracker*

AWS IoT Services and a Mobile Application

# How might Amazon Go's technology work?

## Who has taken an item?

Bluetooth beacons can identify whose mobile device is nearest the shelf. A dense beacon network can be accurate to within less than 0.5 metres.

The Amazon Go app in the shopper's mobile device will be communicating with the store's beacon network.

## What item was taken?

Shelf cameras will detect when an item has been removed or added and what that item looked like. This data feeds into an AI system.

Artificial Intelligence will likely look at vision, weight and stock location data to make its best guess of what item(s) have been added or removed.

Shelf weight sensors will likely be used to detect the weight of items removed or added. This data feeds into an AI system.

pwc

www.pwc.com.au/digitalpulse

# Deliverables

Showcasing how our tools would work

We will have **specialized shelves** where each of its rack would have its own weight tracking mechanism.

The **mobile application** would keep a track of the products which a customer picked and show it accordingly.

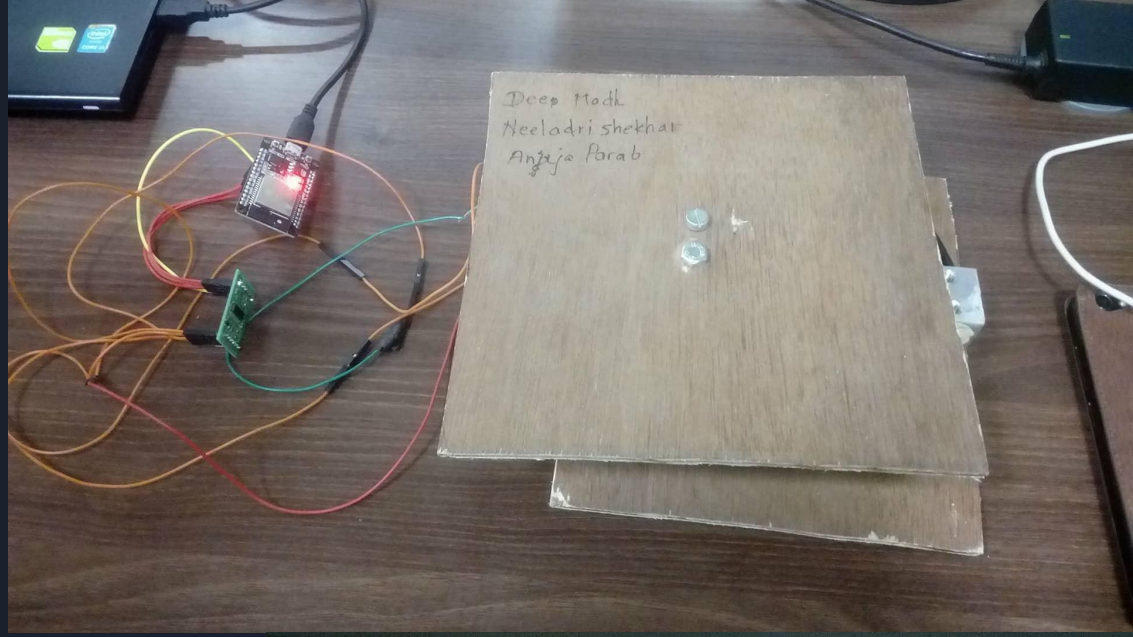

# Deliverables

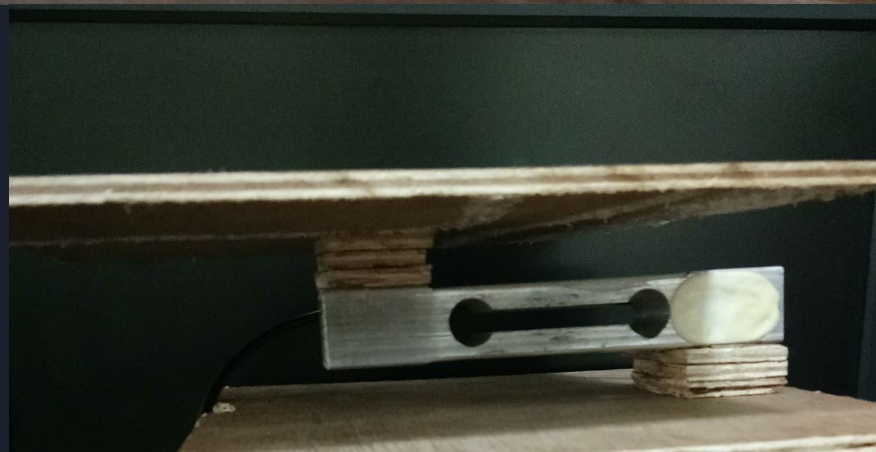
The weight trackers ...

The Digital Load Cell Weight Sensor will give **Analog** signals corresponding to the weights.

This is then transferred to the Hx711 Weighing Sensors ADC module for getting a **Digital** value of the weights.

These values will be uploaded to **Cloud** using the Esp32 wifi module(Relying on the AWS IoT services at the backend)



# Deliverables

The position trackers ...


Primarily we had planned to rely on the **inbuilt GPS** of the mobile device which have an accuracy of less than half a meter.

On a **terrace/balcony** based store this method of tracking works really well.

However for indoors(within walls), because of attenuation and scattering, the accuracy of GPS may drop significantly. Solutions to these would be using **beacon tracking** based upon Bluetooth, Wifi or RFID.

**The prototype uses the in-built wifi module of esp-32 and the consumer mobile for localizing.**

# Challenges

- Returning products to unassigned shelves
  - Have a different returning area for collecting
  - Have products with weights never in multiples
  - Tagging every product separately for tracking
- Exact position of customer picking the product
  - Using supportive iBeacon technologies
  - Localization using Wifi fingerprinting
- Multiple customers near a shelf
  - Have smaller width shelves
  - Multiple weight trackers on the same rack

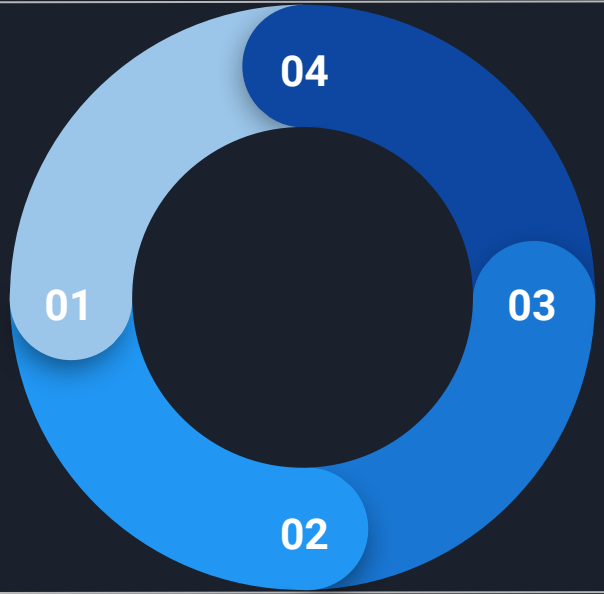
# Test Strategies

## Prototype

Make at least 2  of the localized digital weighing mechanism

## Share

Upload weights to cloud and check for accuracy, latency and implementation delays




## Refine

Setup the positions of shelves, racks accordingly. May vary  on the tracking mechanism

## Get position

Implement GPS first. Get its limitations. If heavy failures then shift to iBeacon tracking.

Secure | https://ap-southeast-1.console.aws.amazon.com/iot/home?region=ap-southeast-1#/dashboard

aws Services Resource Groups Anuja Singapore Support

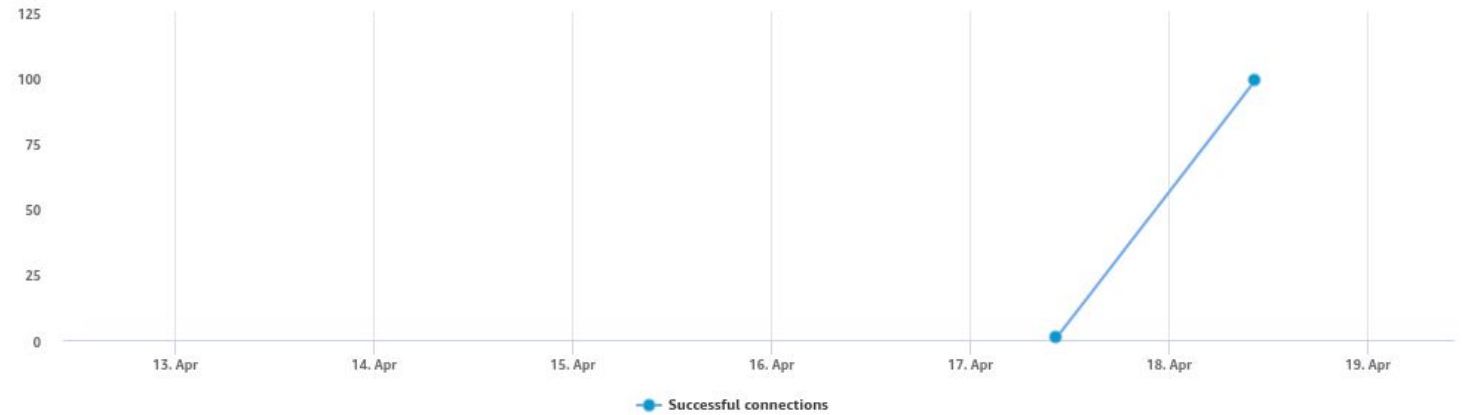
AWS IoT

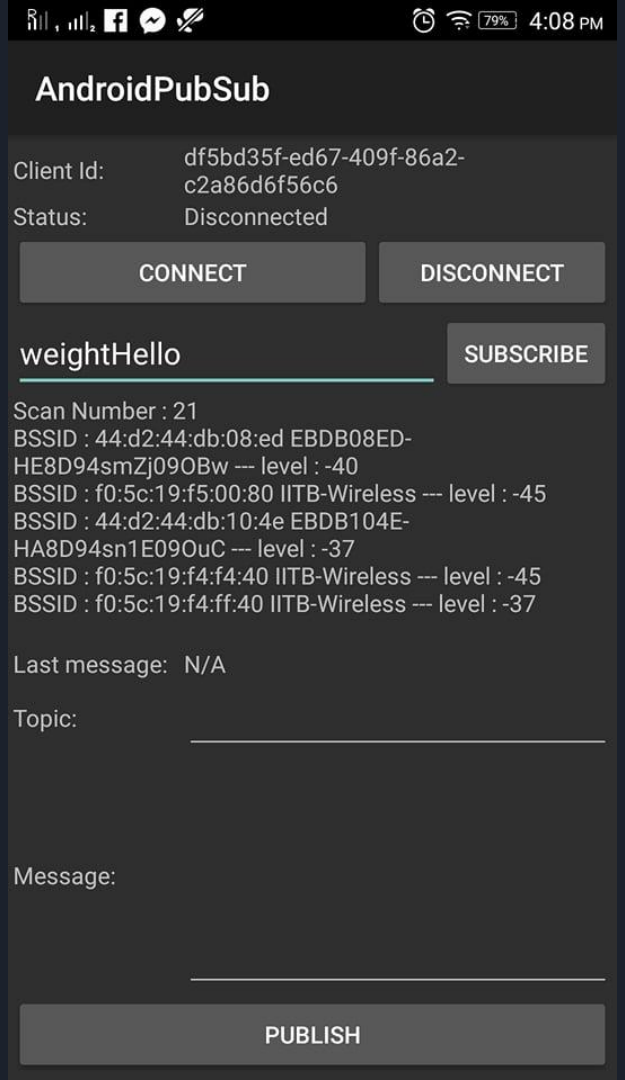
- Monitor
- Onboard
- Manage
- Secure
- Act
- Test

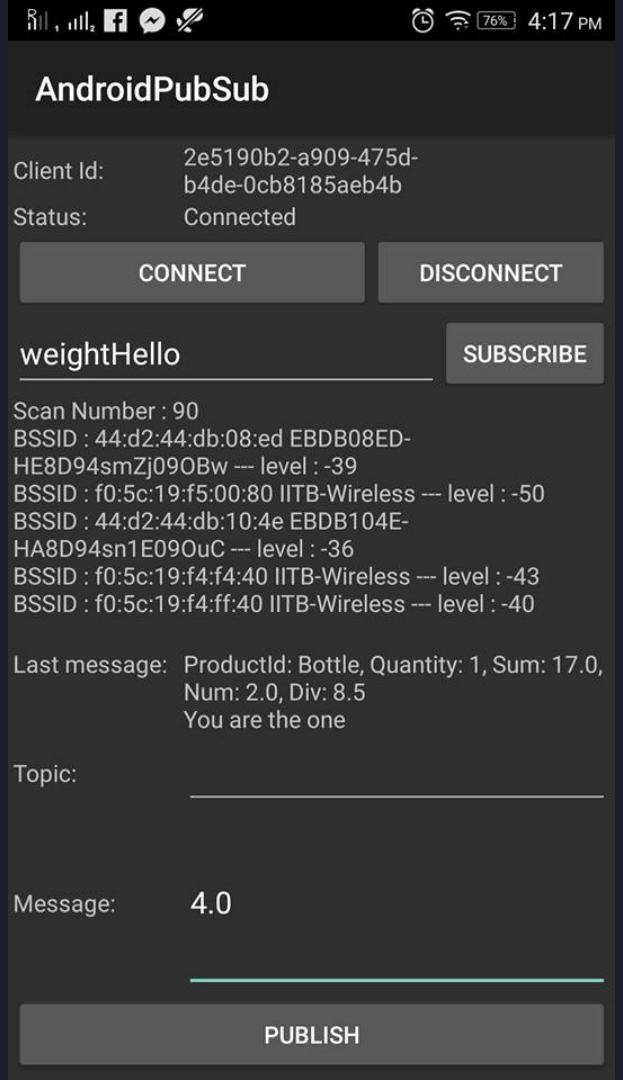
# Monitor

Week

## Successful connections



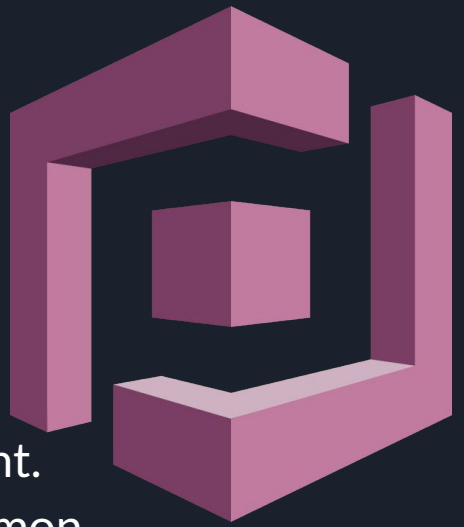

79% 4:08 PM
AndroidPubSub
Client Id: df5bd35f-ed67-409f-86a2-c2a86d6f56c6
Status: Disconnected
CONNECT
DISCONNECT
weightHello
SUBSCRIBE
Scan Number : 21
BSSID : 44:d2:44:db:08:ed EBDB08ED-HE8D94smZj09OBw --- level : -40
BSSID : f0:5c:19:f5:00:80 IITB-Wireless --- level : -45
BSSID : 44:d2:44:db:10:4e EBDB104E-HA8D94sn1E09OuC --- level : -37
BSSID : f0:5c:19:f4:f4:40 IITB-Wireless --- level : -45
BSSID : f0:5c:19:f4:ff:40 IITB-Wireless --- level : -37
Last message: N/A
Topic:
Message:
PUBLISH


76% 4:17 PM
AndroidPubSub
Client Id: 2e5190b2-a909-475d-b4de-0cb8185aeb4b
Status: Connected
CONNECT
DISCONNECT
weightHello
SUBSCRIBE
Scan Number : 90
BSSID : 44:d2:44:db:08:ed EBDB08ED-HE8D94smZj09OBw --- level : -39
BSSID : f0:5c:19:f5:00:80 IITB-Wireless --- level : -50
BSSID : 44:d2:44:db:10:4e EBDB104E-HA8D94sn1E09OuC --- level : -36
BSSID : f0:5c:19:f4:f4:40 IITB-Wireless --- level : -43
BSSID : f0:5c:19:f4:ff:40 IITB-Wireless --- level : -40
Last message: ProductId: Bottle, Quantity: 1, Sum: 17.0, Num: 2.0, Div: 8.5
You are the one
Topic:
Message: 4.0
PUBLISH

# Arduino console output for ESP 32

```
Reading: 0.87 kg
Reading: 0.87 kg
Reading: 0.87 kg
Reading: -0.00 kg
picked something
Publish Message:{'messageType':'weightChange','productID':'Bottle','quantity':1,'wifiSignal':[{'BSSID':'BE:2F:3D:89:EC:60','strength':-37},{'BSSID':'44:D2:44:DB:10:4E','strength':-57}]}
Reading: -0.00 kg
Received Message:{'messageType':'weightChange','productID':'Bottle','quantity':1,'wifiSignal':[{'BSSID':'BE:2F:3D:89:EC:60','strength':-37},{'BSSID':'44:D2:44:DB:10:4E','strength':-57}]}
Reading: -0.00 kg
Received Message:{'messageType':'purchase','customer id':'Neeladri', 'product Id' : 'Bottle', 'quantity':1}
Reading: -0.00 kg
Reading: -0.00 kg
Reading: -0.00 kg
```

# Future Work



- Implementation of a Database at the MQTT servers(AWS **DynamoDB**) for customer tracking and product management.
- Scaling the model for multiple weighing scales across a common micro-controller, multiple product management, etc.
- Implementation of different tracking models (viz. GPS, iBeacon, RF) for a more generalized purpose and testing its limits.
- **Cognito** based user identification and implementing different roles via IAM policies for multiple **User-Pools**.

# Thank you!

A working solution that exists today.

It works... and has similar ideas.
A store of only Vending machines