

# Internet of Things in Education

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# Contents

- About myself
- Quick introduction to IoT
- Deep dive on beacons
- Smart learning environment project
- Fun stuff!

# About myself



- Completed undergrad in the Philippines
- Completed masters & Ph.D. in Singapore
- In software industry for 5 years
- Went back to research & academe
- Now in Vic as lecturer

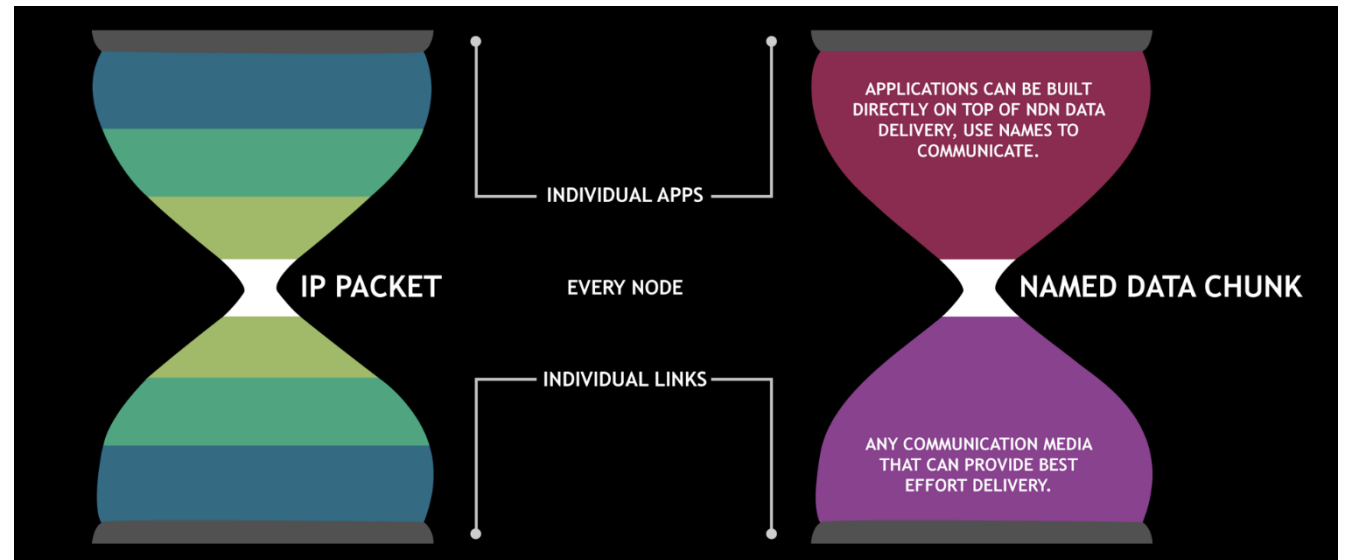
# Biologically-inspired reliable network design

- Incorporating reliability into network design is hard
  - Main challenge is how to balance between **cost-efficiency** and **reliability**
- It turns out, certain species of moulds and fungi have come up with time-tested solutions of a similar network design problem



# NDN for resource-constrained IoT

- Named-data networking is a promising paradigm for IoT
  - Current end-to-end approach is wasteful and unnecessary
  - IoT applications are primarily interested in obtaining data regardless of origin
- However, NDN is not originally designed for resource-constrained IoT devices



# IoT applications

## Smart Health

- Design of IoT solutions for unobtrusive monitoring of health

## Smart Education

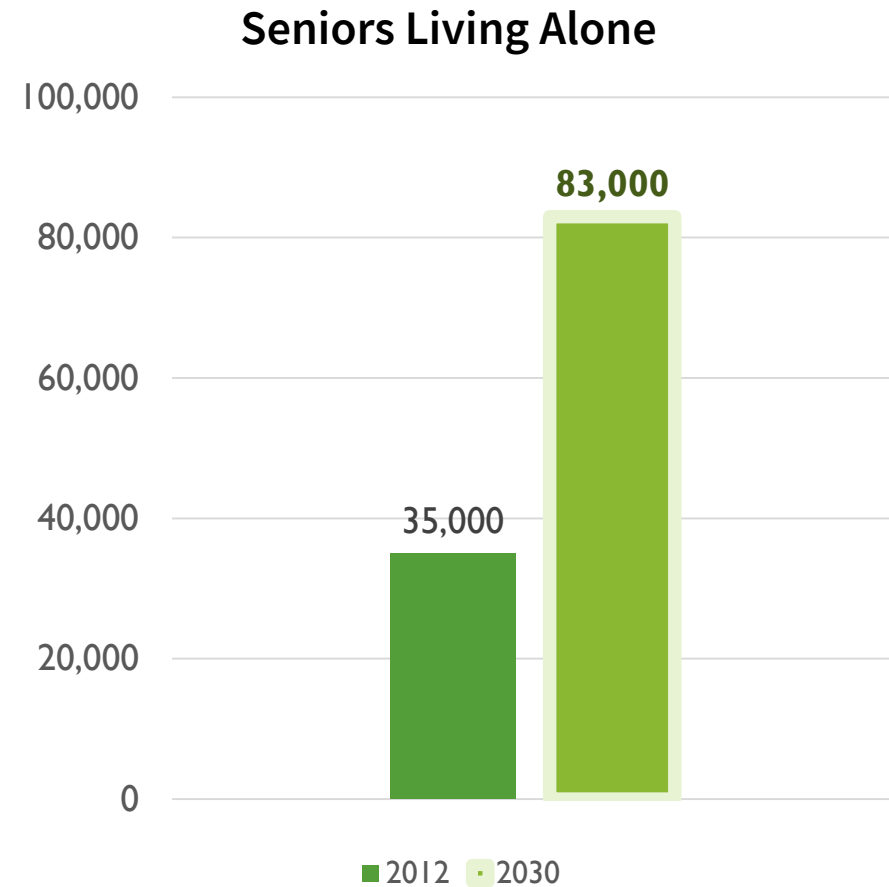
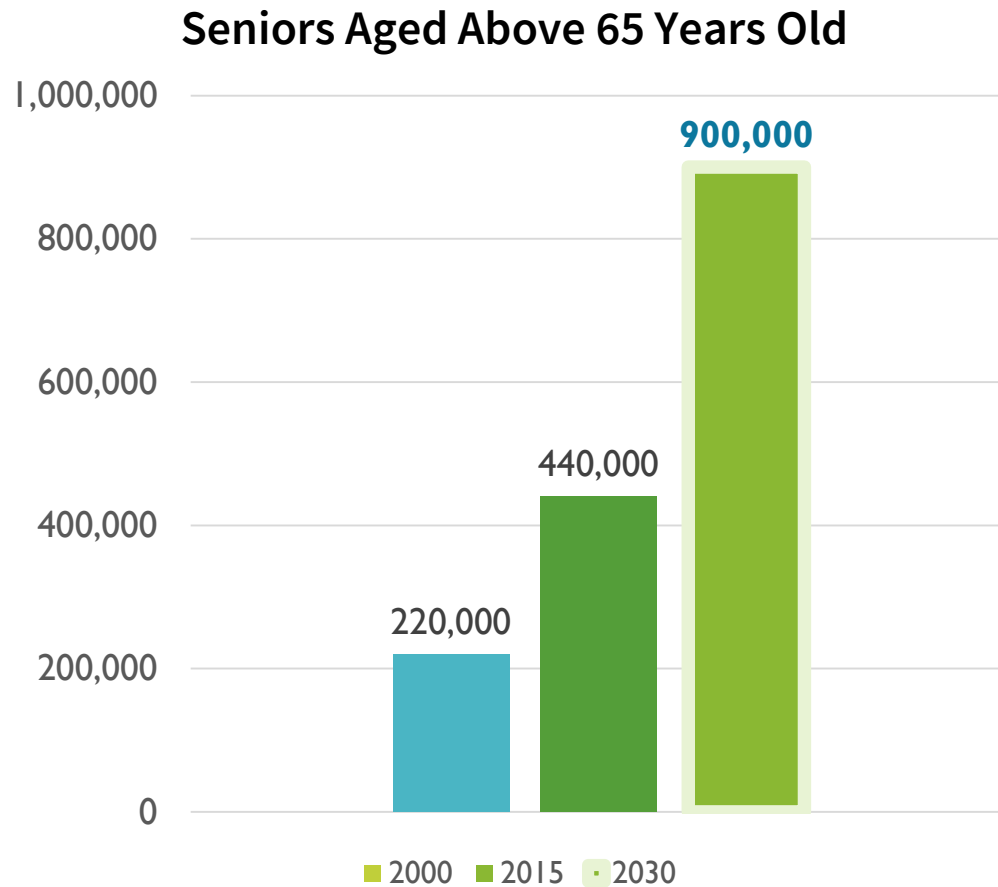
- Design of IoT solutions for measuring classroom environment and student interactions for improving learning experience

## Smart Landscape

- Design of smart objects embedded in outdoor landscapes for various applications

# **Graceful Ageing In-Place: Leveraging Technologies for Holistic and Personalized Care**

# We live in an ageing society





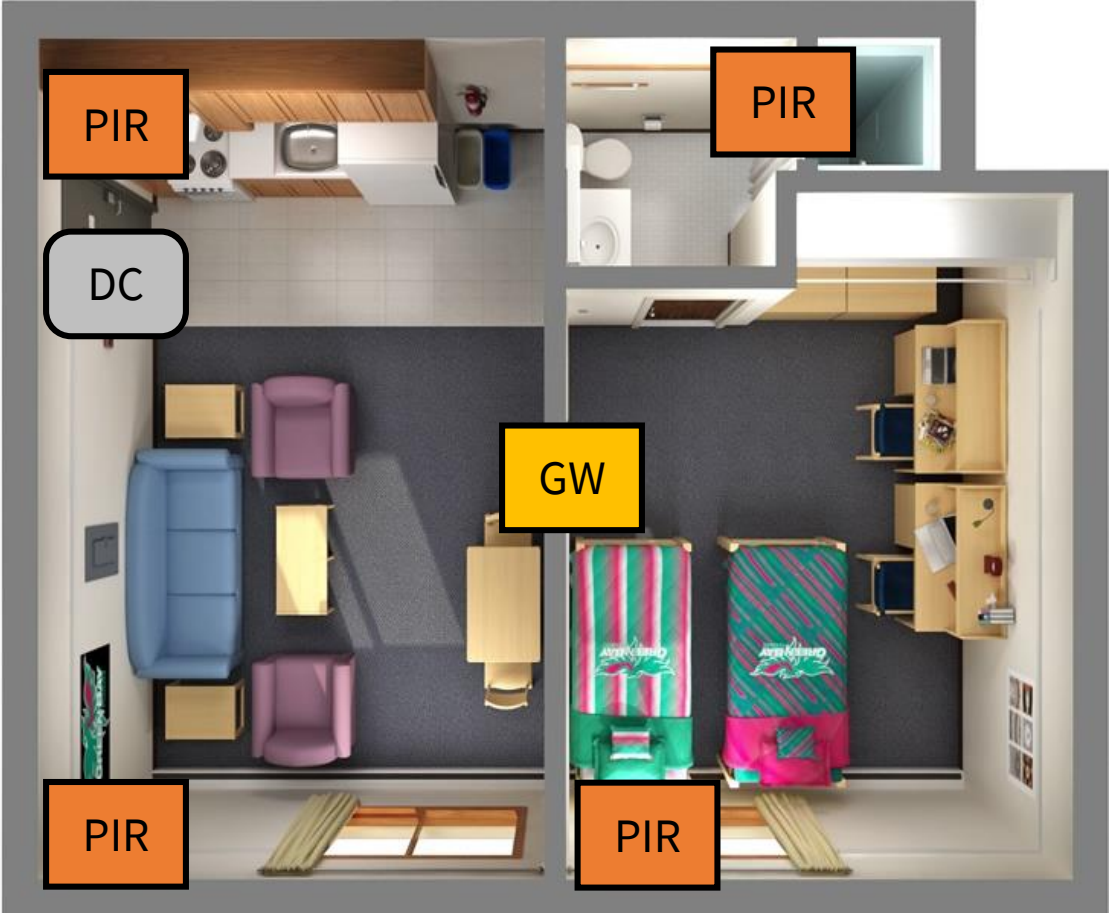
# Ageing-in-place for better quality-of-life

An elderly couple is jogging on a paved path in a park. The woman is wearing a pink long-sleeved shirt and dark pants, and the man is wearing a purple long-sleeved shirt and grey pants. They are both smiling and appear to be in good health. The background shows trees with autumn foliage and a bright, sunny atmosphere.

Stay in close contact with the friends & loved ones

Be free to pursue whatever they want

# A typical elderly monitoring system (EMS)



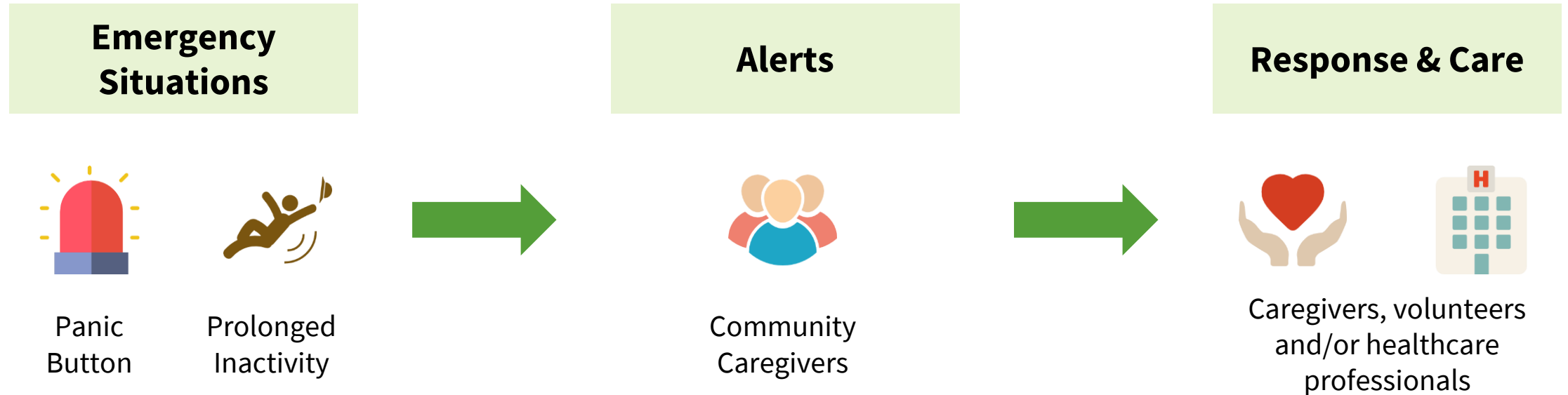
## Legend

- GW** Gateway
- PIR** Motion Sensor
- DC** Door Contact Sensor

## How It Works

- 1** PIR detects no motion for  $T$  hrs
- 2** Alert is triggered to caregiver(s)

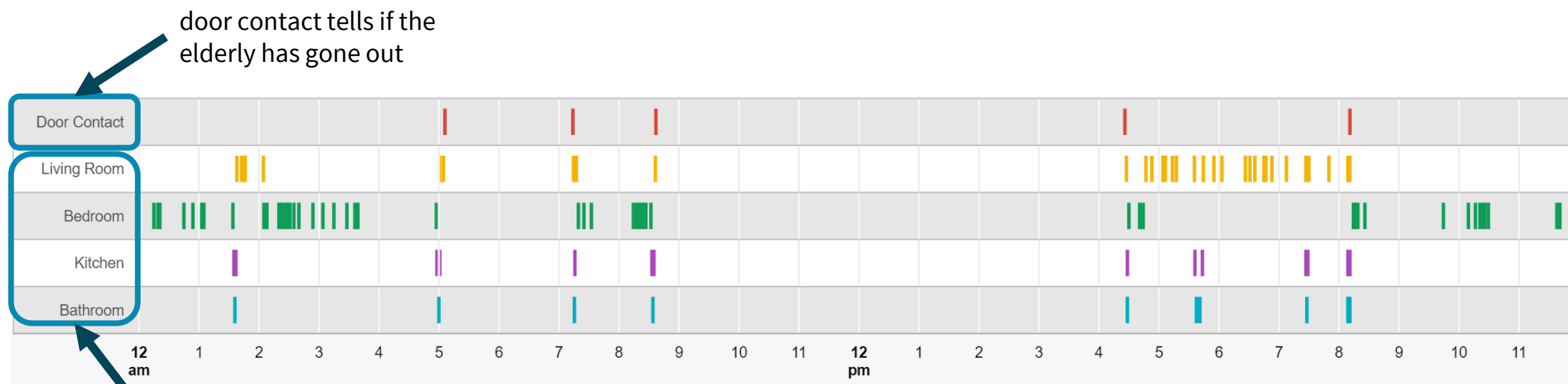
# Reactive care & response



# From reactive to pre-emptive care

1

Patterns of Daily Living

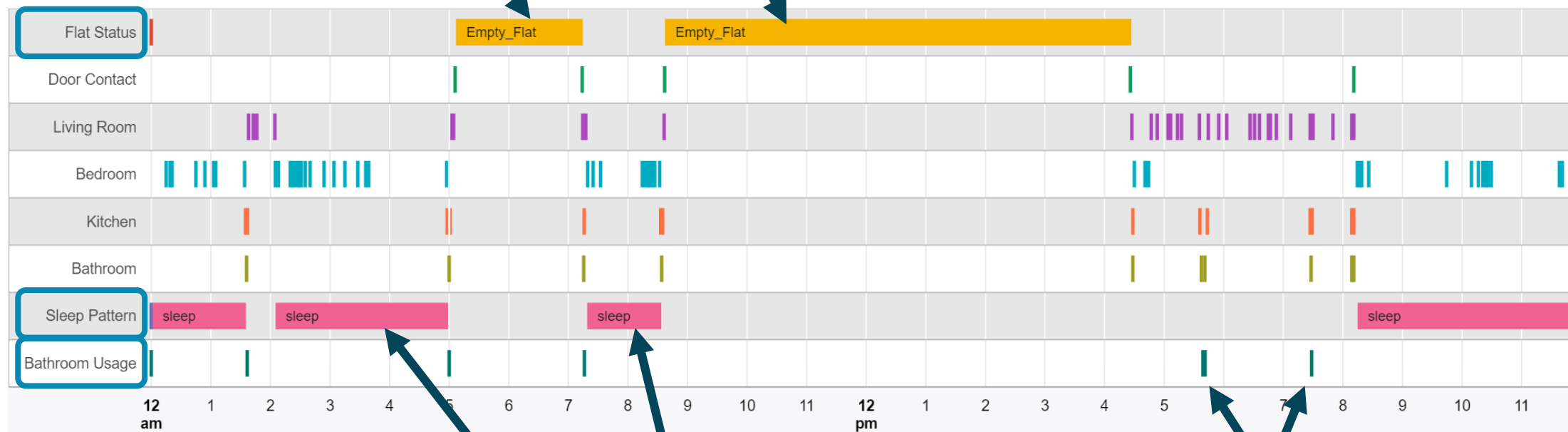


# From reactive to pre-emptive care

1

Patterns of Daily Living

duration and timing that elderly goes out



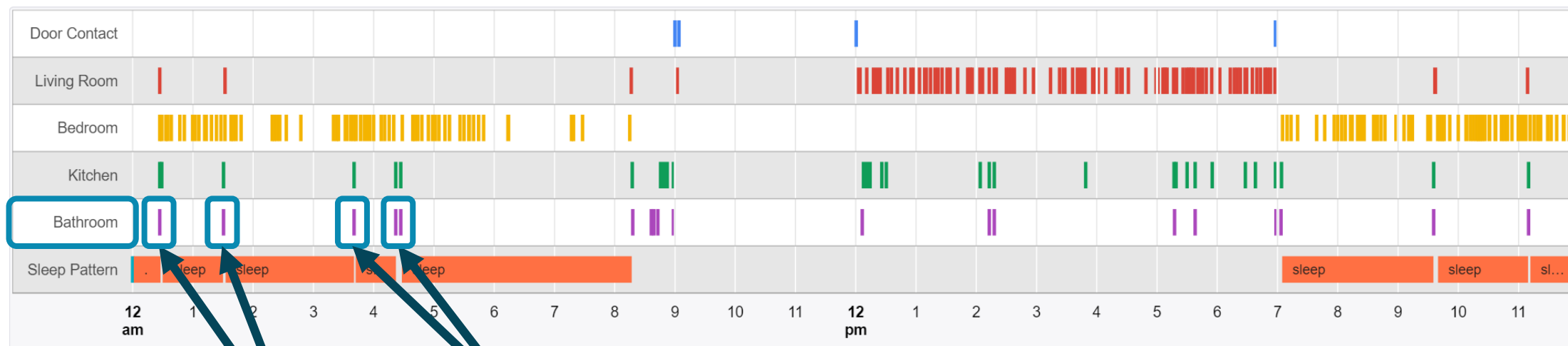
duration and timing that elderly sleeps

bathroom visits

# From reactive to pre-emptive care

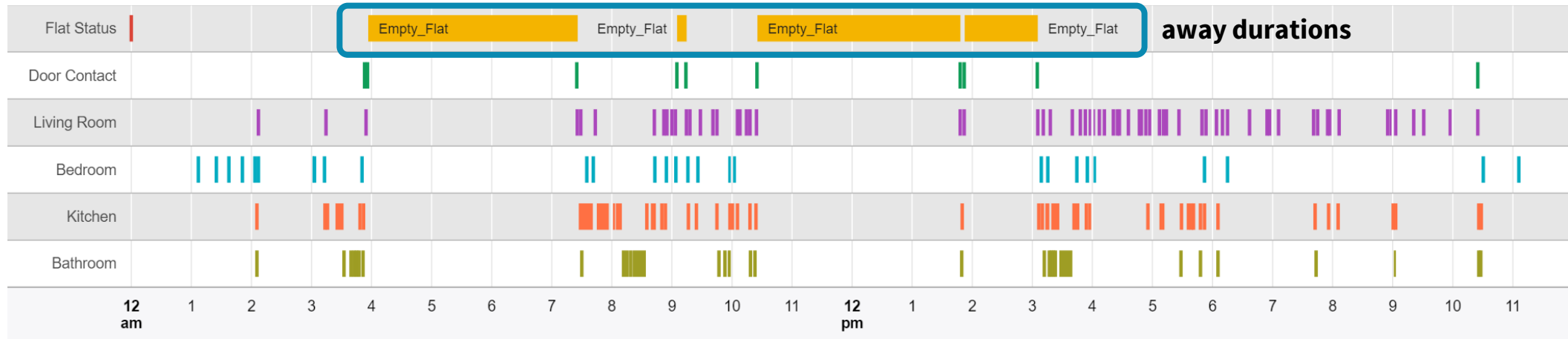
2

Anomalies in Daily Living Patterns



signs of potential nocturia due to frequent bathroom visits at night

# Sensor data can predict loneliness\*



Away durations can predict the loneliness of the elderly: longer away durations mean elderly is less lonely

\*Loneliness is assessed through a survey administered within 2 months of sensor observations



# “Technology is at its best when it is invisible”\*

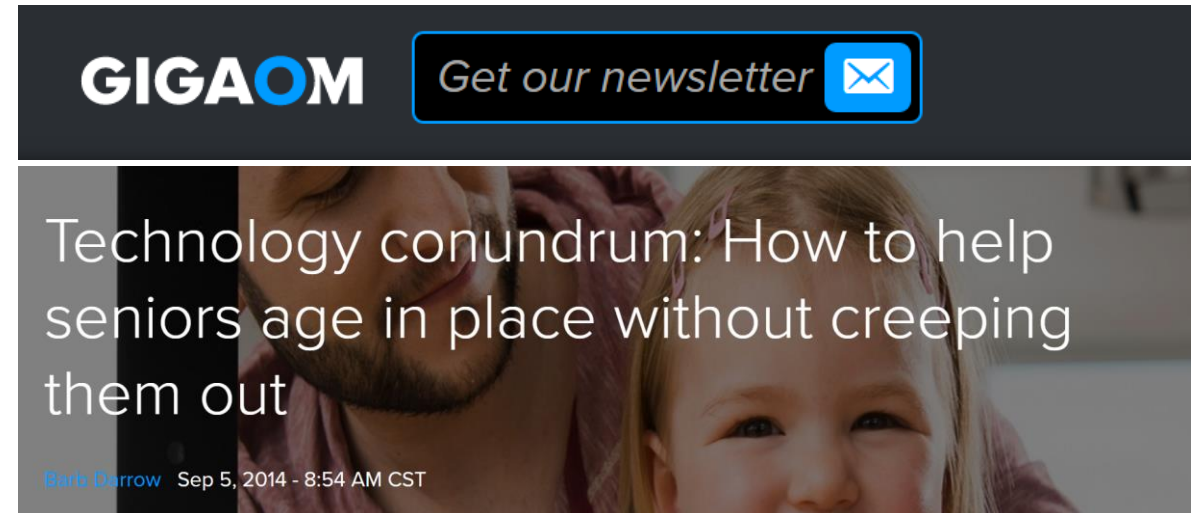
*Elderly prefers technology that is*

**Unobtrusive**

**Passive**

**Respects their privacy**

\*Nassim Nicholas Taleb, Antifragile



The big conundrum for these vendors is providing technology that is drop-dead simple to use — i.e. **doesn't need a ton of charging, resetting, and other futzing** — **and doesn't feel stalker-ish.** No one wants to feel as if she's under surveillance in her own home, but the point of these devices — smartphones, smartwatches, in-home sensors — is, in fact, to watch the senior citizen, albeit with the best of intentions.



# “Haste makes waste”

## The **Clinical** Value



Image credits: Fitbit, Samsung, Beddit

Most consumer products are considered **general wellness products** and **non-medical grade.**

## The New York Times

### *To Reach Seniors, Tech Start-Ups Must First Relate to Them*



Paula Span  
THE NEW OLD AGE OCT. 23, 2015

Remote medical monitoring — of [blood pressure](#) or blood glucose, say — presents potential problems, too. The data will have transient blips, and “sometimes acting on them leads to **overtreatment that does more harm than good.**” Dr. Covinsky said.

Both he and Dr. Leslie Kernisan, a geriatrician in San Francisco who began publishing her [Geritech](#) blog three years ago, groaned when a company called Pixie Scientific proposed embedding monitors in adult incontinence briefs to measure urine pH and other signs of [urinary tract infection](#).

“A disaster,” Dr. Kernisan said. While many older people are “colonized” with bacteria that will show up in urinalyses, they [aren’t sick and don’t need treatment.](#) “It would just lead to **antibiotic overuse.**”

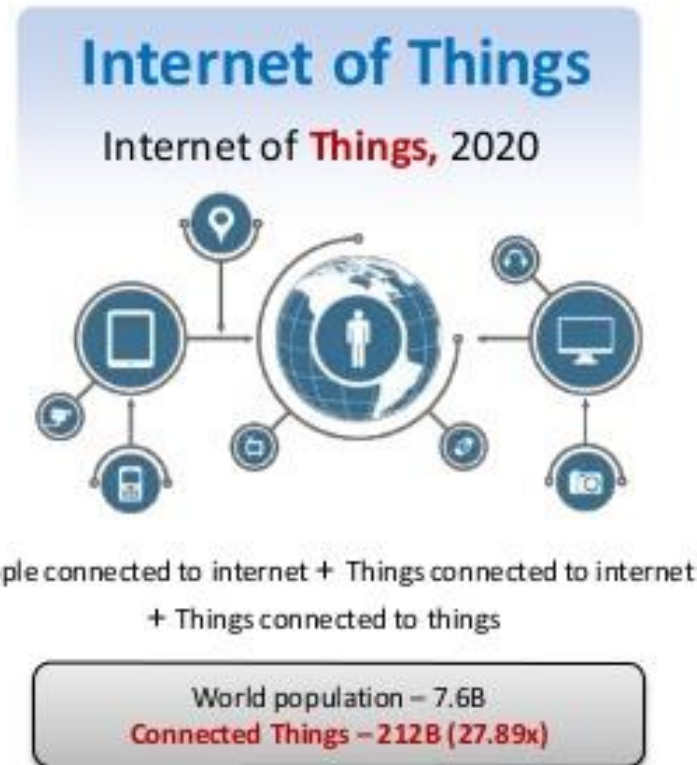
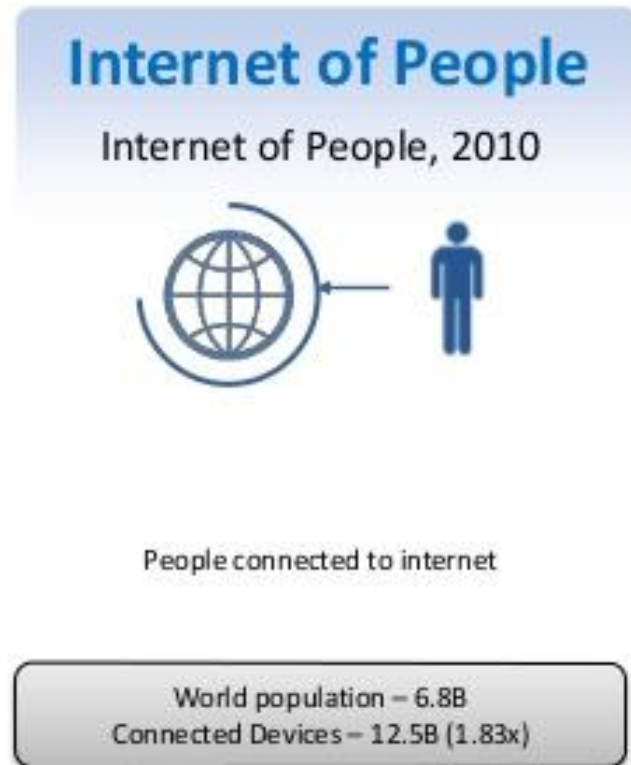
# Quick introduction to IoT

# What is the Internet of Things (IoT)?



- Communicate and connect remotely
- Share Information/Content/Emotions instantly
- Advertise services
- Decision support
- ...

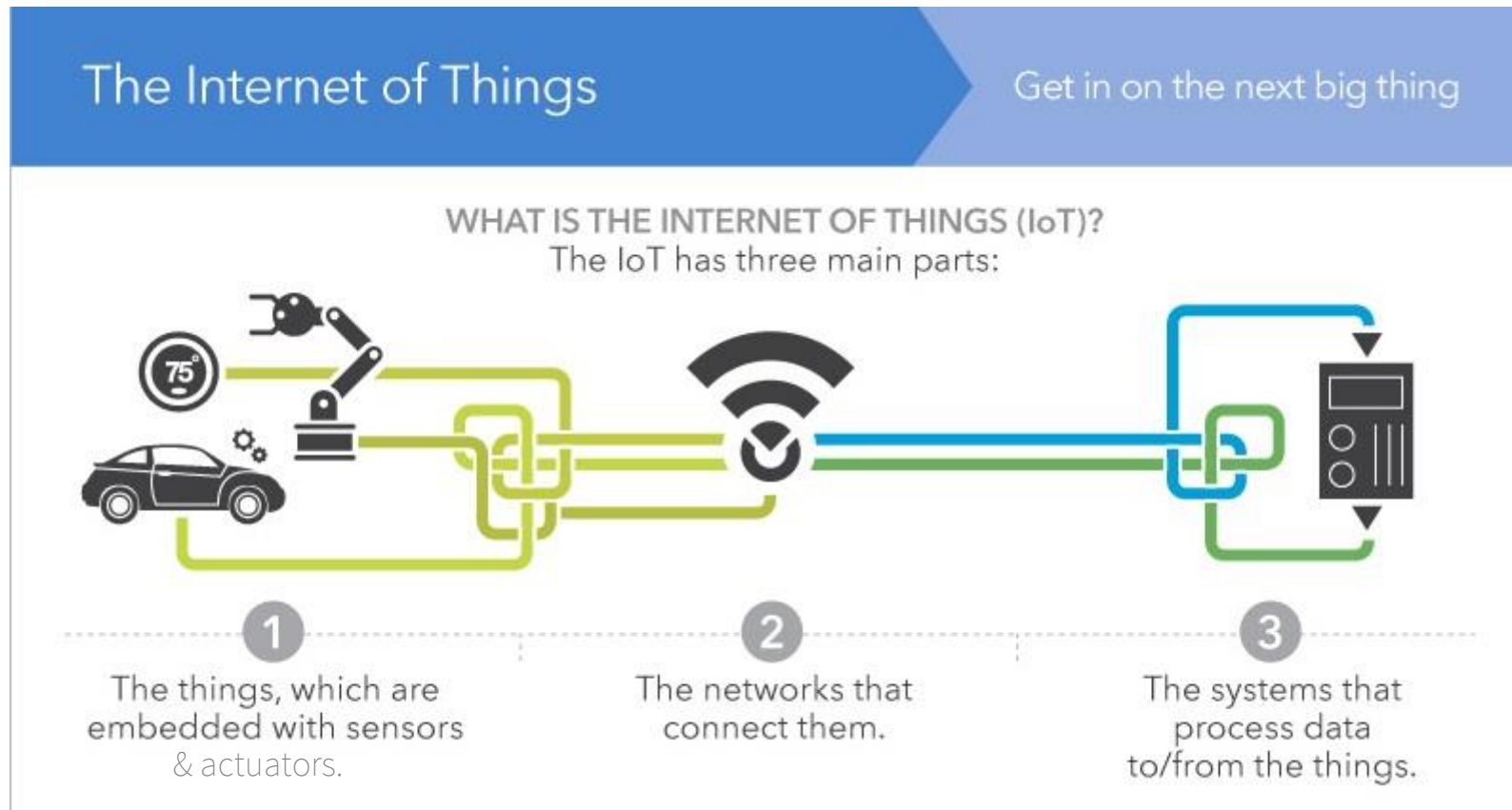
# What is the Internet of Things (IoT)?



- From dumb to smart things
- Sense 'contextual info' in the background
  - Share with other 'things' across internet
  - Make decisions / take action autonomously and anticipatively

Leaving people time to pursue the more important things in life!

# What enables IoT?



Source: <https://www.linkedin.com/pulse/internet-things-iot-dummies-rajat-kochhar>

# The “things” in IoT

- Mimic the role of ‘people’ connected over Internet
  - Express context = sensors
  - Respond = actuators
  - Intelligent = embedded processing/memory
  - Energized = battery/AC/energy-harvesting
  - Identifiable = unique addressing
  - Locatable = positioning
  - Reachable = (at least short-range) connectivity (wired/wireless) with gateway

# Example thing: a room

Motion sensor

Light sensor

Heat pump



# Example of things: your body



Medication adherence



Smart phone activity level tracking



Wearables (elderly, infant monitoring)



# Example of things: your home



Track down those lost keys



Make sure the oven is off



Keep your plants alive

# Example of things: your city



Stop driving in circles

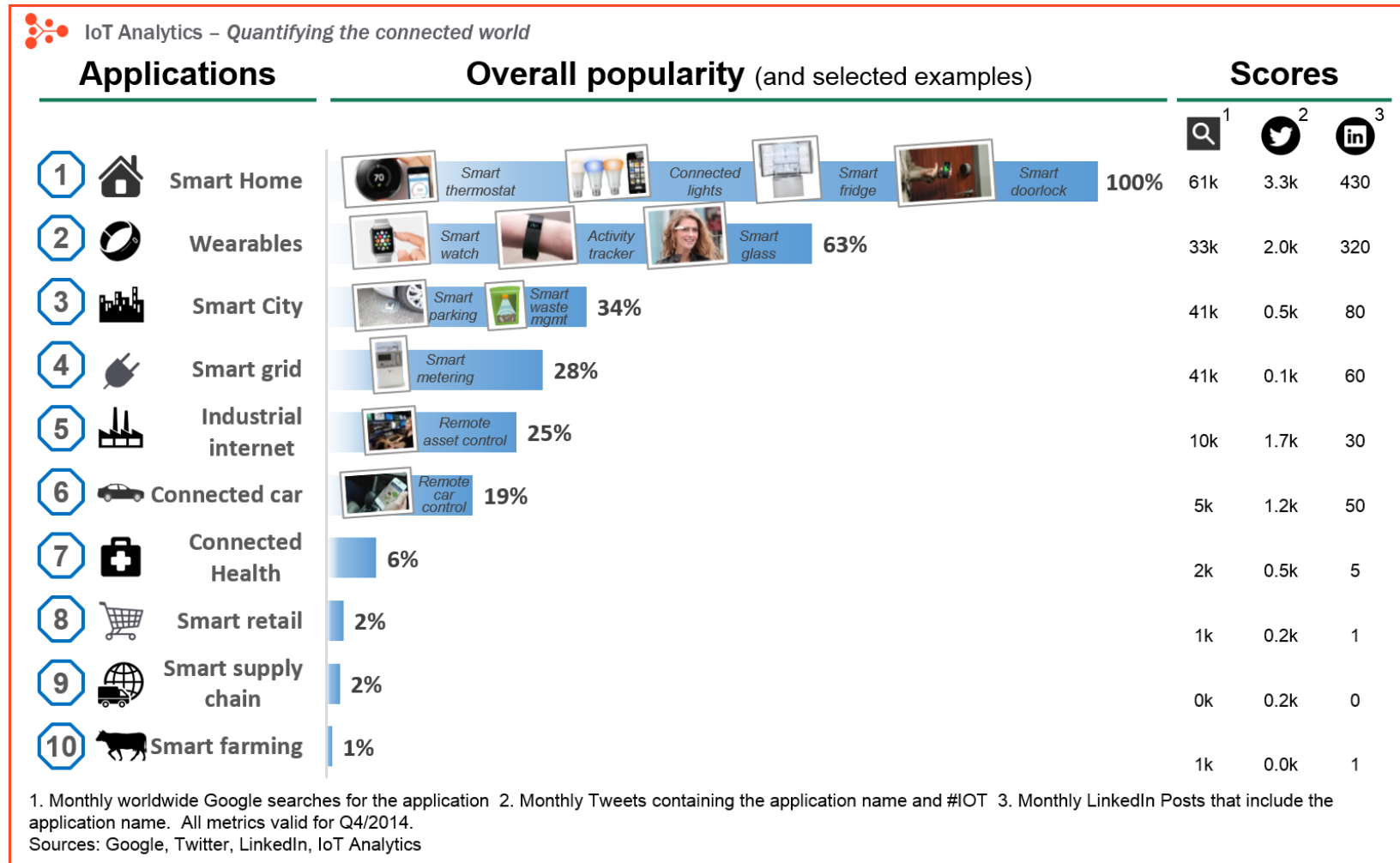


Keep streets clean



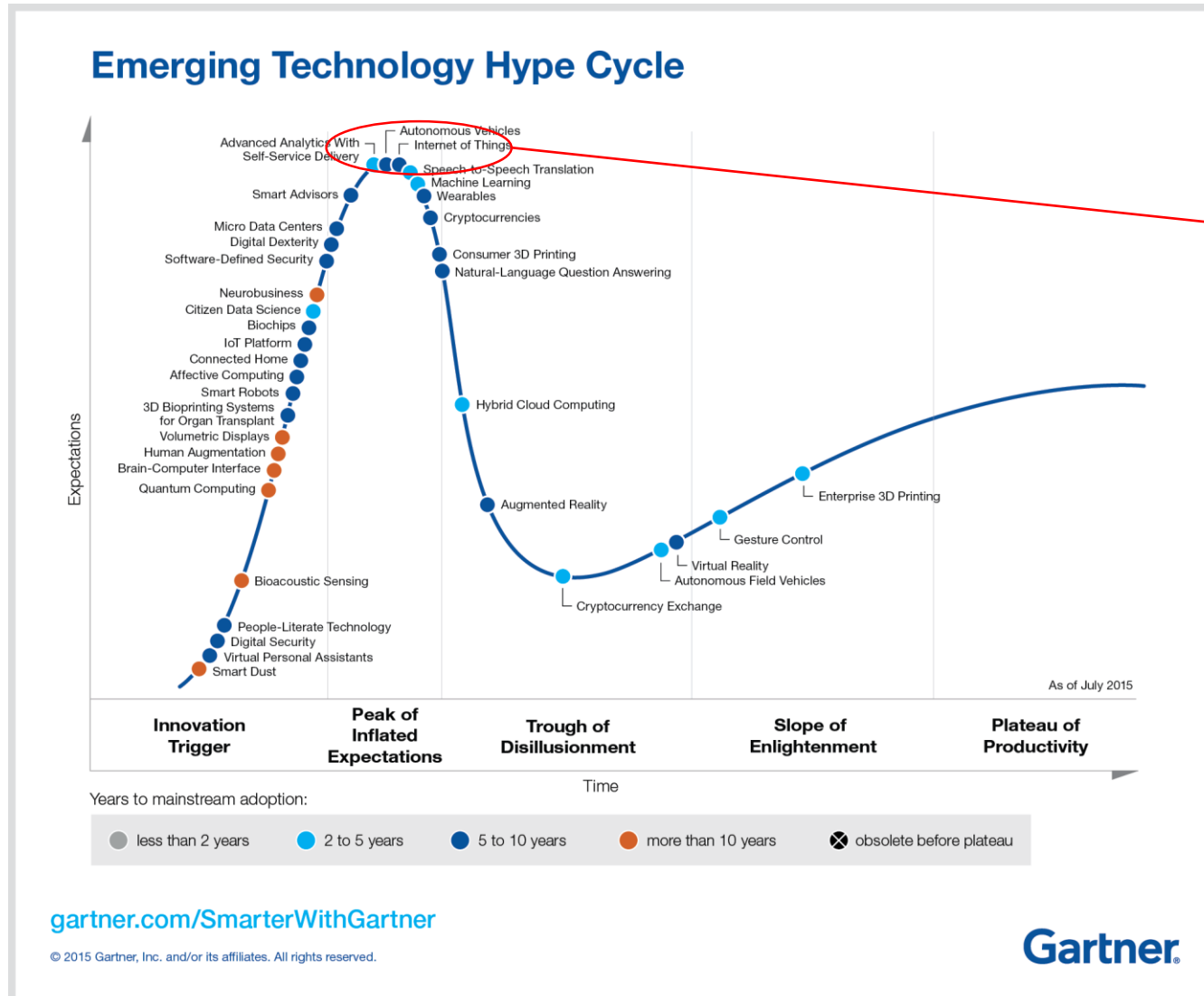
Report municipal issues

# Popular IoT application domains



Source: <https://iot-analytics.com/10-internet-of-things-applications/>

# Where is IoT today?



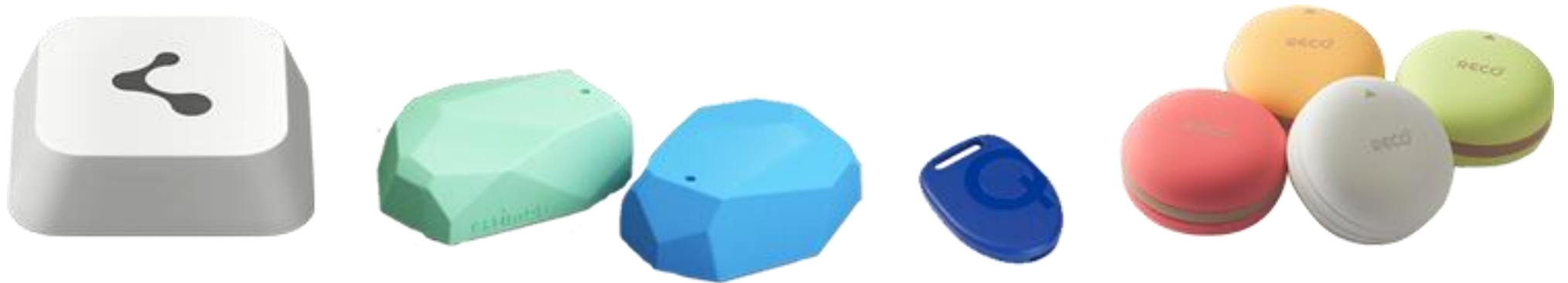
## Peak of Inflated Expectations

- Early publicity produces a number of success stories – often accompanied by scores of failures
- Some companies take action; most don't
- 5-10 years to mainstream adoption

# Deep dive on Beacons

# What are beacons in IoT?

A beacon is a low-cost, *low-powered* hardware device which *periodically emits* a *Bluetooth Low Energy (BLE)* signal

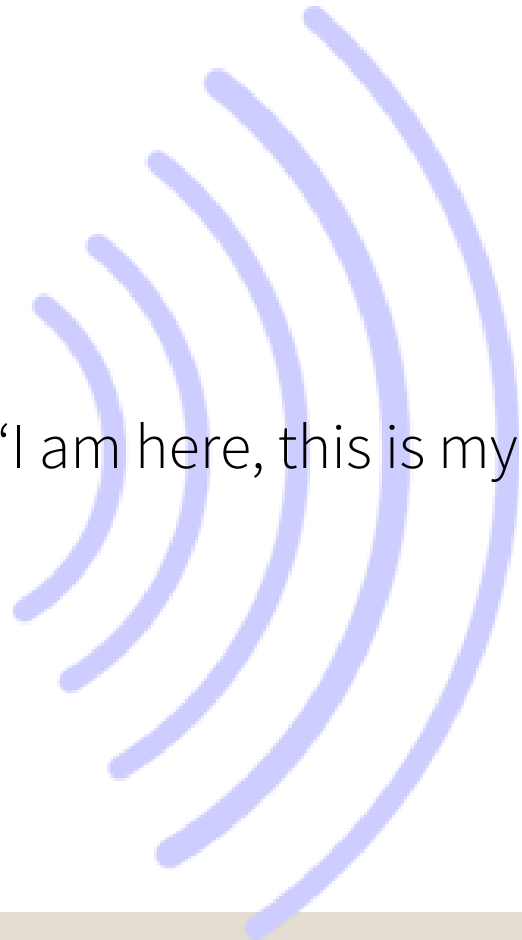


# In layman's terms...

A beacon is a device that continuously transmits a radio signal saying “I am here, this is my ID”



“I am here, this is my ID”



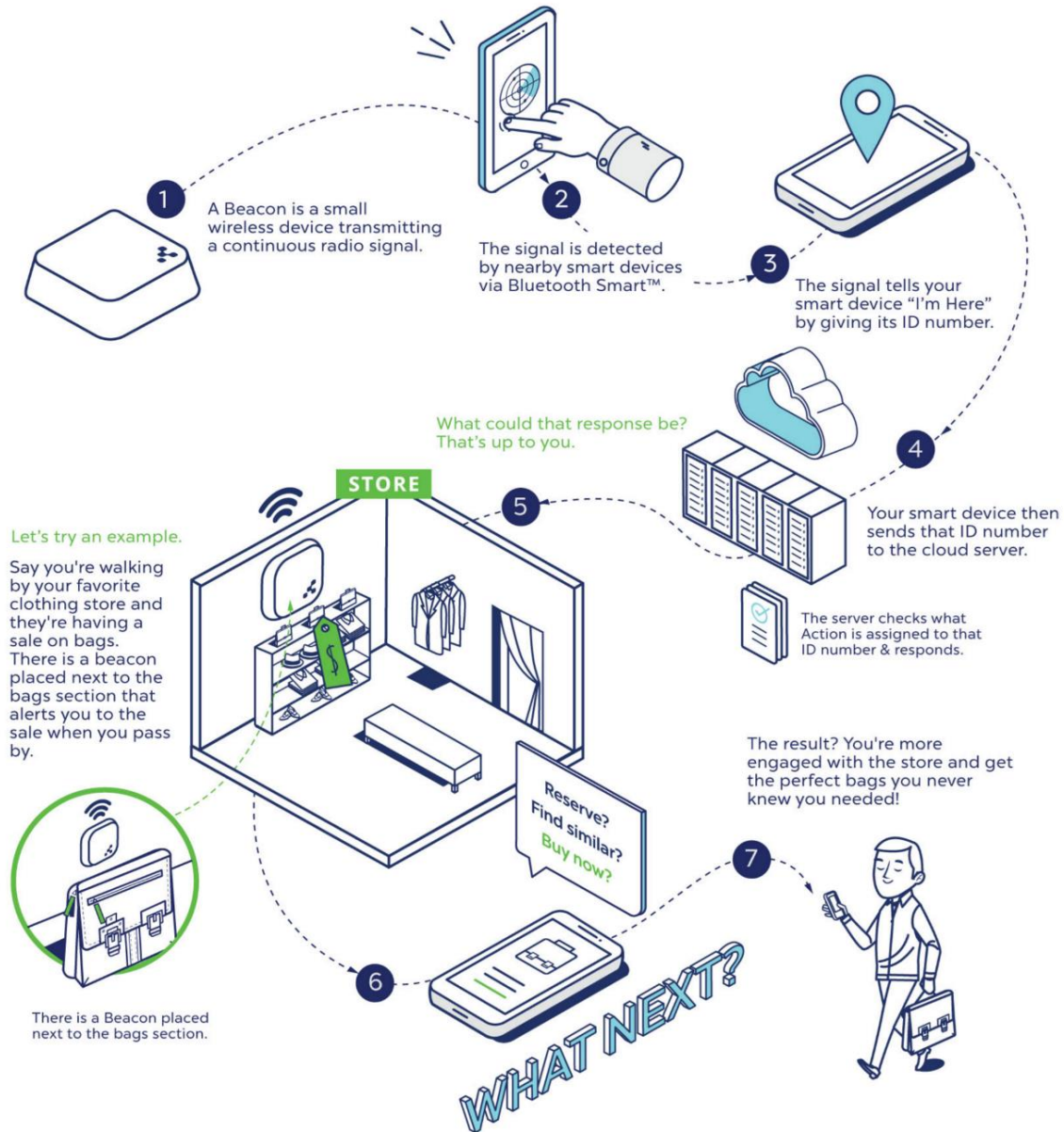
A device that can understand the radio signal (i.e., decode BLE signal) can then do something about the content of the signal

# Video on Estimote beacon technology

<https://www.youtube.com/watch?v=JrRS8qRYXCQ>



# What Are Beacons & How Do They Work?



# Types of beacon technology

Popular beacon protocols:

1. iBeacon (Apple)



2. Eddystone (Google)



3. AltBeacon (Radius Network)



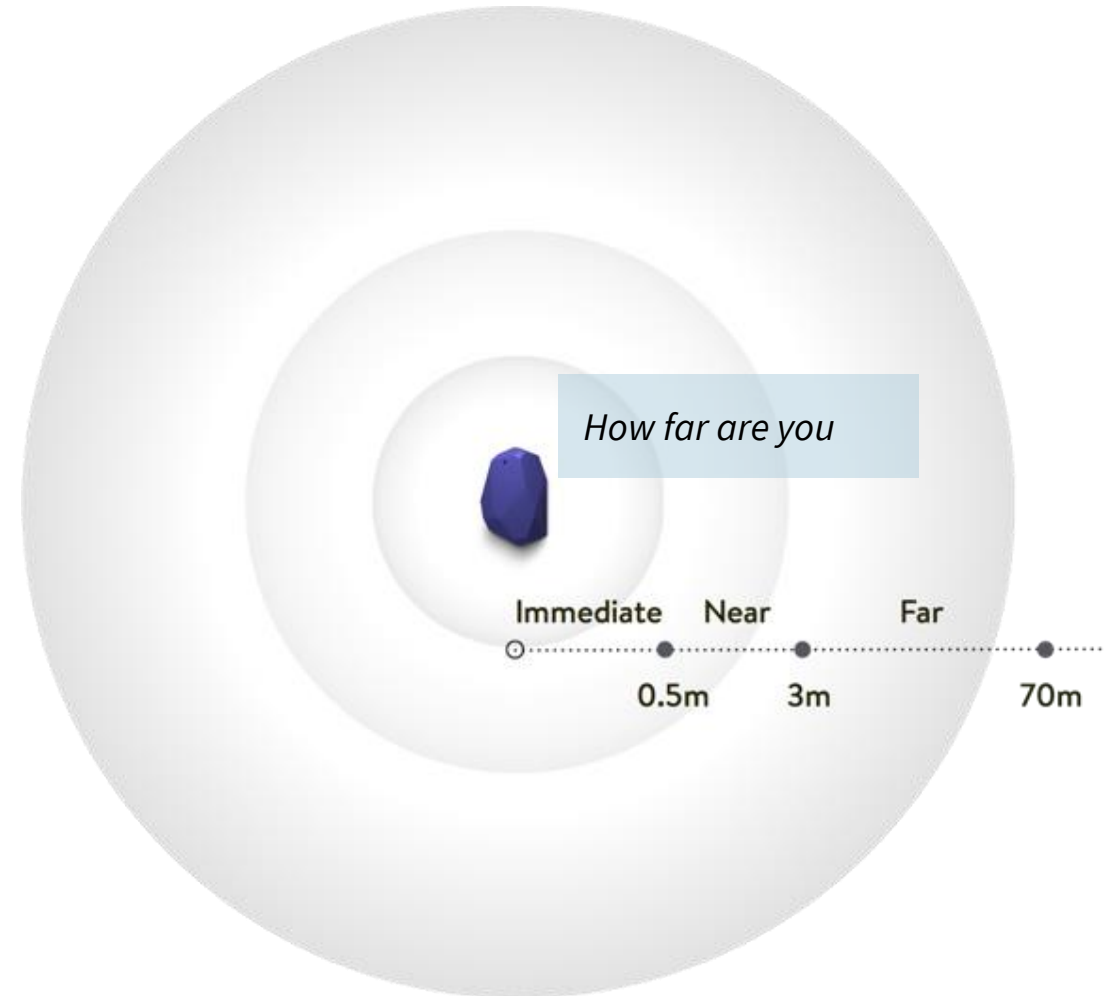
4. Nearables (Estimote)



The kind of data that is transmitted depends on the Beacon technology that is used.

# Beacon application - Ranging

Ranging **returns a list of beacons in range**, together with an estimated proximity to each of them.



An application of ranging - [video](#)

# Beacon application - Region Monitoring

Monitoring a region enables your app to know when a device **enters** or **exits the range** of beacons defined by the region.



An application of region monitoring - [video](#)

# Smart Learning Environment Project

# Overview

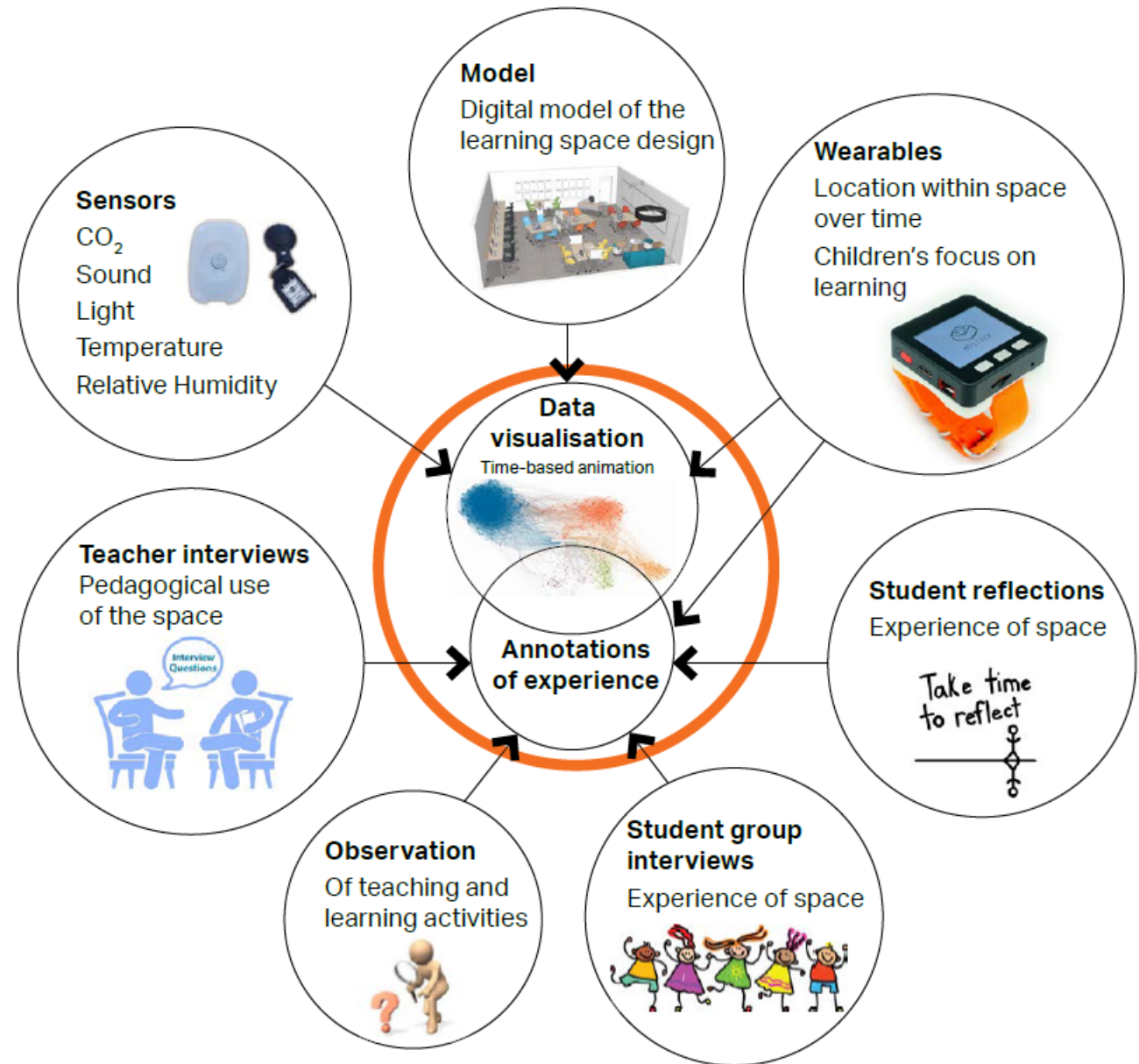
- Student experience within different types of learning spaces in schools is under-researched
- Using IoT, this research aims to better understand how the design and use of a learning environment influences student experience





# Research framework

- Data to be gathered include:
  - physical characteristics of space
  - **student and teacher location**
  - observed use of space
  - experience of teachers and students within the space
- Data analysis:
  - time lapse animation of the use of space and physical characteristics
  - annotations of the experience of children and teachers



# IoT device

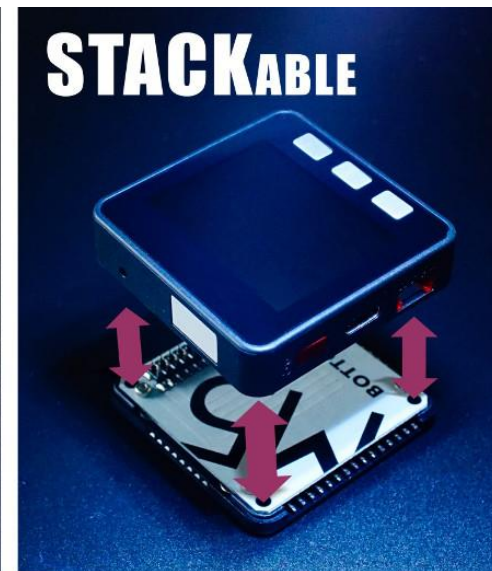
## M5Stack



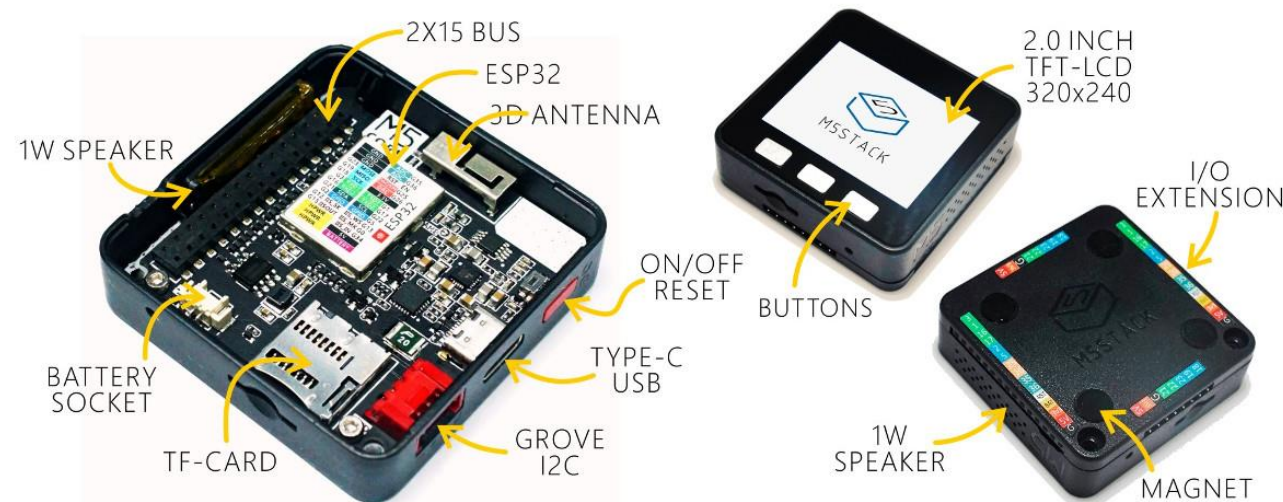
- Based on ESP32
- Arduino-compatible
- WiFi and Bluetooth
- Speaker
- Supports Grove I2C sensors



# More on M5stack

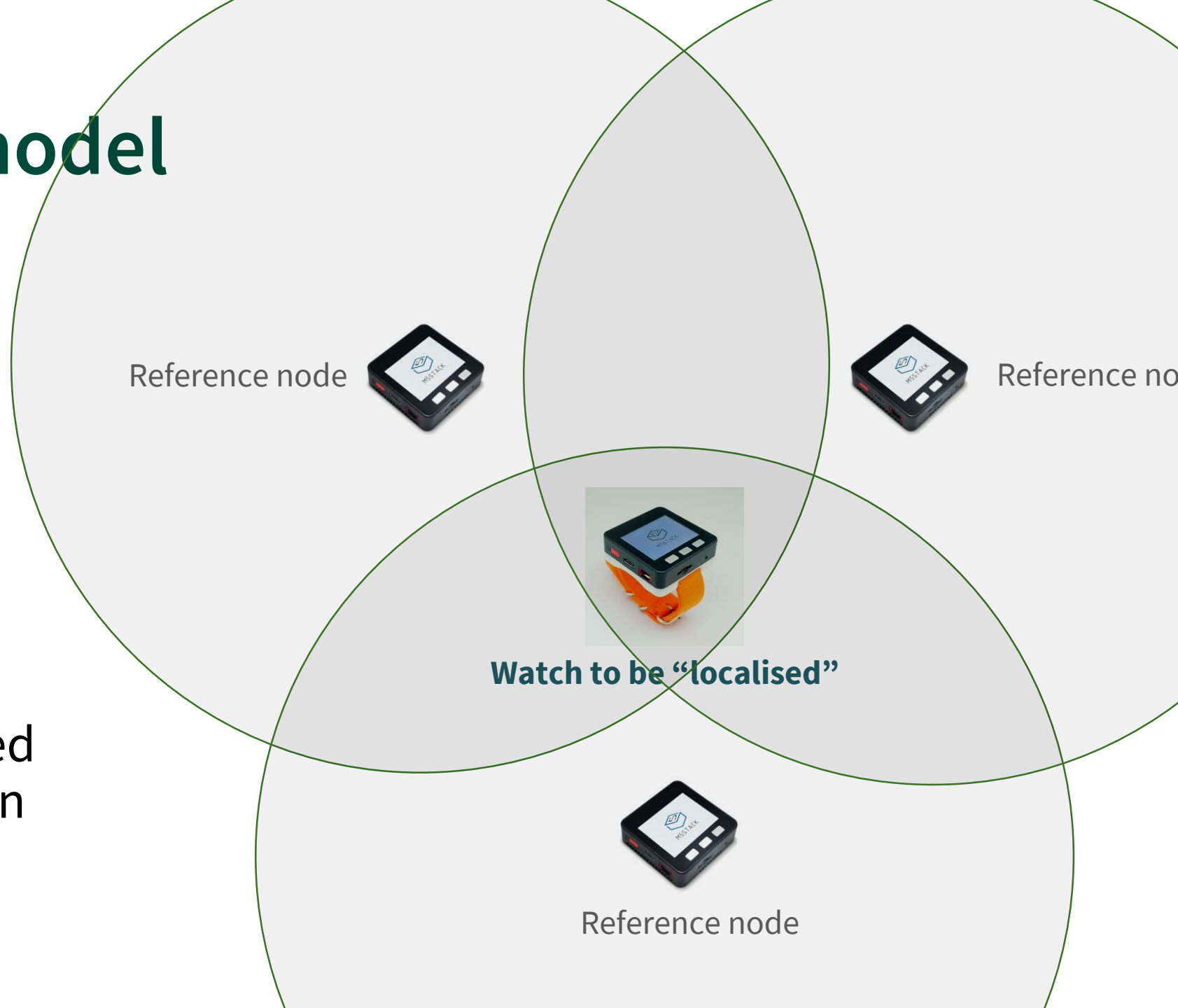


It owns  
Powerful  
**ESP32**  
&  
Rich Features



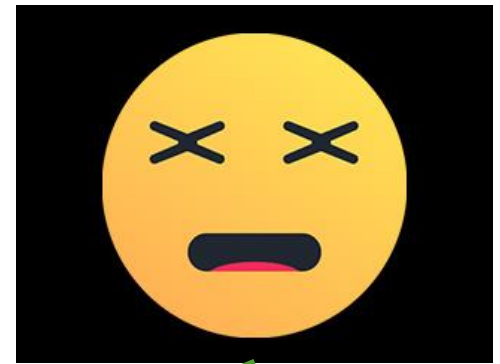
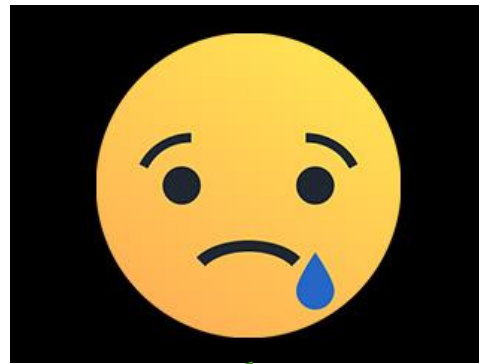
# Conceptual model

- Reference nodes periodically send beacons
- Watch stores **signal strength** of received beacons
- Algorithm will be used to find watch location



# Student feedback

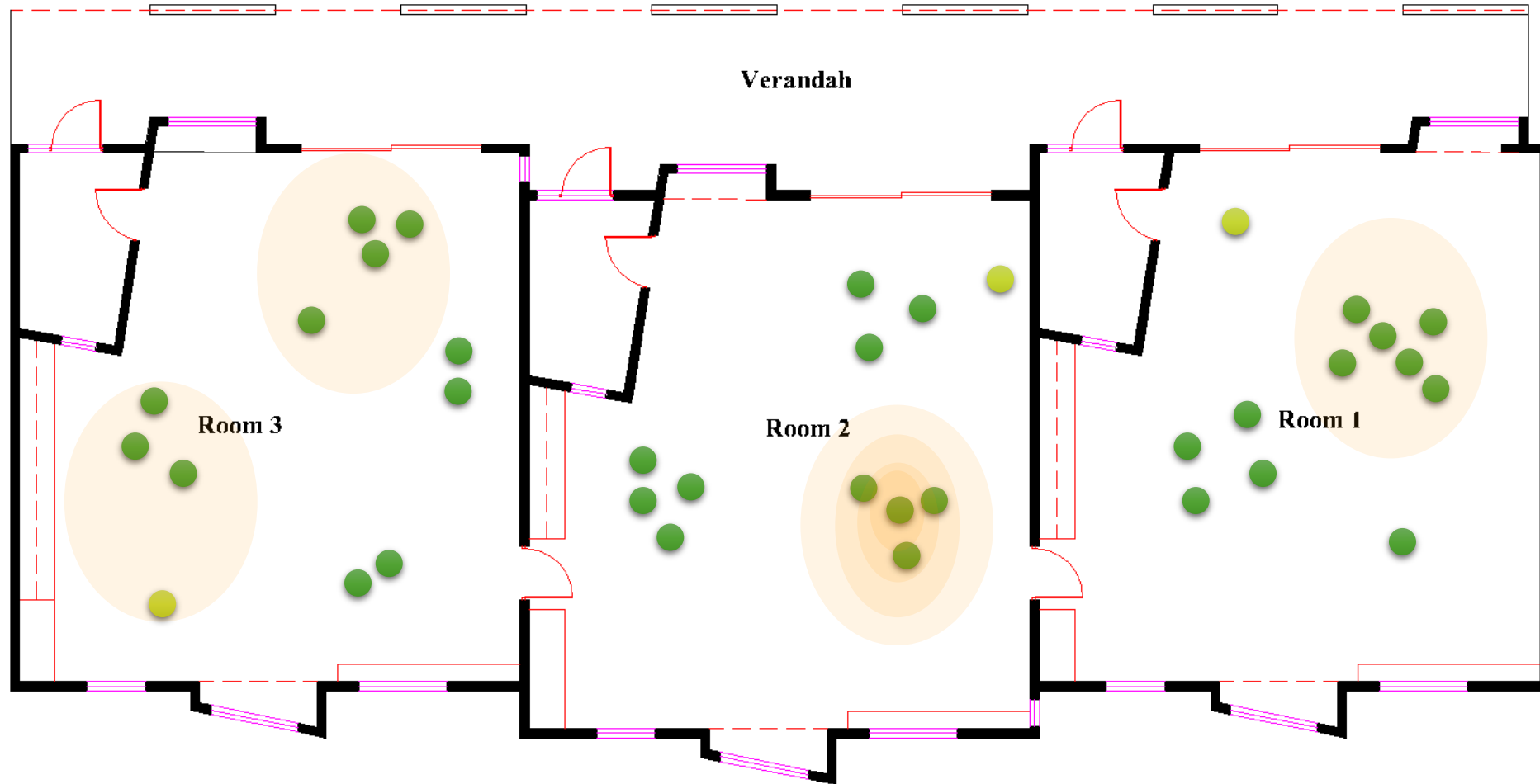
- Student can feedback learning experience by pressing one of the buttons



# Current status

- Pilot trial in progress this week
- Localisation algorithm to be developed after data collection
- Output of localisation will be used for data visualisation

# Output



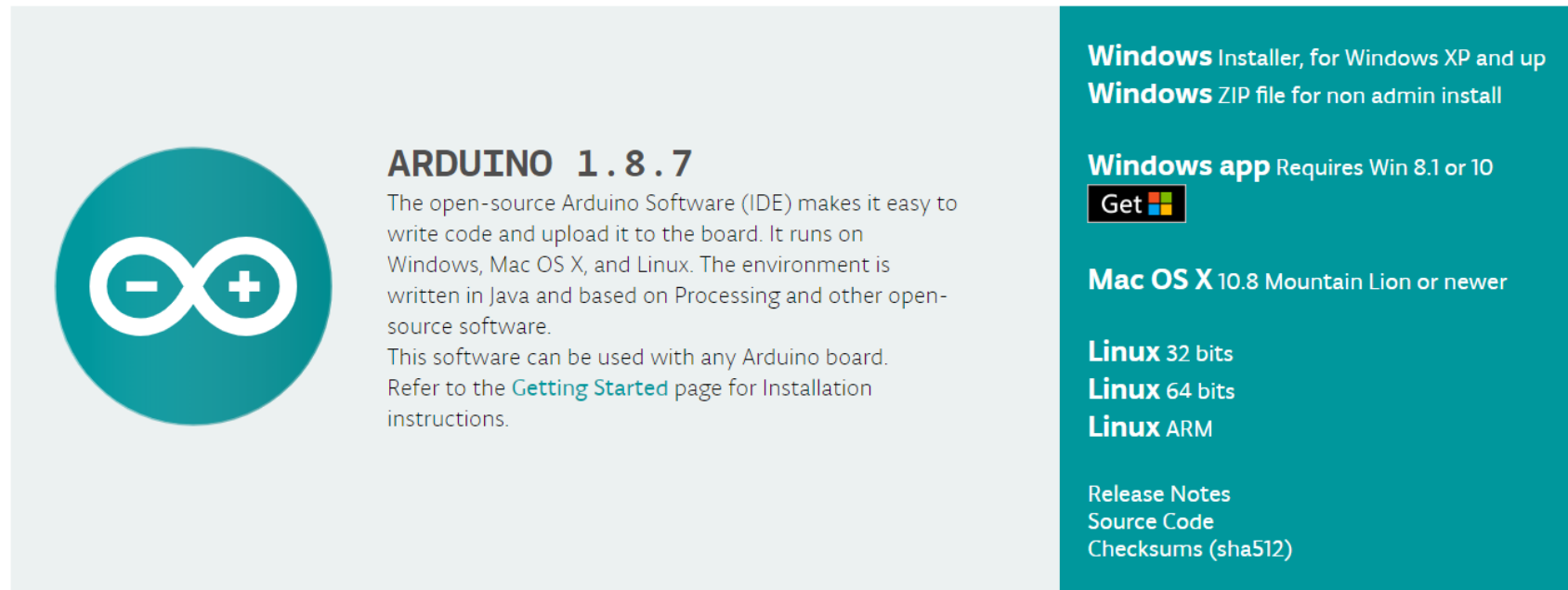
# Fun stuff!

Programming the M5Stack

# Requirements - 1

- Arduino IDE (<https://www.arduino.cc/en/Main/Software>)

Download the Arduino IDE




The image is a screenshot of the Arduino IDE download page. It features a teal background with white text and icons. On the left, there is a circular logo with a white infinity symbol containing a minus sign on the left and a plus sign on the right. To the right of the logo, the text reads 'ARDUINO 1.8.7' followed by a paragraph describing the IDE as open-source software that runs on Windows, Mac OS X, and Linux. Below this, it states that the software can be used with any Arduino board and refers to a 'Getting Started' page for installation instructions. On the right side of the page, there are several download options: 'Windows Installer, for Windows XP and up', 'Windows ZIP file for non admin install', 'Windows app Requires Win 8.1 or 10' (with a 'Get' button and the Windows logo), 'Mac OS X 10.8 Mountain Lion or newer', 'Linux 32 bits', 'Linux 64 bits', and 'Linux ARM'. At the bottom right, there are links for 'Release Notes', 'Source Code', and 'Checksums (sha512)'.

**ARDUINO 1.8.7**

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software.

This software can be used with any Arduino board. Refer to the [Getting Started](#) page for Installation instructions.

**Windows** Installer, for Windows XP and up  
**Windows** ZIP file for non admin install

**Windows app** Requires Win 8.1 or 10  
Get 

**Mac OS X** 10.8 Mountain Lion or newer

**Linux** 32 bits  
**Linux** 64 bits  
**Linux** ARM

Release Notes  
Source Code  
Checksums (sha512)

# Requirements - 2

- M5Stack Library
- Can be searched and installed in latest Arduino IDE
  - Sketch -> Include Library -> Manage Libraries...
  - Type m5stack in search bar
  - Select row and install



# Requirements - 2

If not in library:

- Go to <http://www.m5stack.com/assets/docs/>
- Follow instructions to setup for your operating system

# Requirements - 3

- Arduino-esp32 (<https://github.com/espressif/arduino-esp32>)
- Follow instructions to setup for your operating system

# Hello world

```
#include <M5Stack.h>

void setup() {
  M5.begin(); //start m5stack device
  M5.Lcd.setBrightness(30); //lower the brightness to save power
  M5.Lcd.clear(); //start device with blank screen
  M5.Lcd.println("Hello world!"); //print to LCD
}

void loop() {}
```

# Dealing with buttons

```
#include <M5Stack.h>

void setup() {
  M5.begin(); //start m5stack device
  M5.Lcd.setBrightness(30); //lower the brightness to save power
  M5.Lcd.clear(); //start device with blank screen
}

void loop() {
  M5.update();

  if (M5.BtnA.wasReleased()) {
    M5.Lcd.println('A');
  } else if (M5.BtnB.wasReleased()) {
    M5.Lcd.println('B');
  } else if (M5.BtnC.wasReleased()) {
    M5.Lcd.println('C');
  }
}
```

# Dealing with SD card

```
#include <M5Stack.h>
#include <SD.h>

void setup() {
  M5.begin(); //start m5stack device
  M5.Lcd.setBrightness(30); //lower the brightness to save power
  M5.Lcd.clear(); //start device with blank screen

  //Make sure SD card module can be initialise
  if(!SD.begin()) {
    M5.Lcd.println("Card mount failed");
    return;
  }
  //Make sure SD card is mounted
  if(SD.cardType() == CARD_NONE) {
    M5.Lcd.println("No SD card attached");
    return;
  }
  M5.Lcd.println("SD card mounted successfully");
}

void loop() {}
```

# Dealing with SD card – drawing a JPG

```
#include <M5Stack.h>
#include <SD.h>

// Same as in previous exercise
void setup() {...}

void loop() {
  M5.update();

  if (M5.BtnA.wasReleased()) {
    M5.Lcd.drawJpgFile(SD, "/img/emoji/happy.jpg");
  } else if (M5.BtnB.wasReleased()) {
    M5.Lcd.drawJpgFile(SD, "/img/emoji/sad.jpg");
  } else if (M5.BtnC.wasReleased()) {
    M5.Lcd.drawJpgFile(SD, "/img/emoji/bored.jpg");
  }
}
```

# Scanning for BLE beacons - 1

- Initializing the BLE for scanning

```
BLEScan *bleScan;

BLEDevice::init(""); //Initialise BLE module
bleScan = BLEDevice::getScan(); //create new scan
bleScan->setAdvertisedDeviceCallbacks(new MyAdvertisedDeviceCallbacks());
//set callback
bleScan->setActiveScan(false); //active scan (true) uses more power, but
get results faster

// interval window modification
bleScan->setInterval(200);
bleScan->setWindow(200);
```

# Scanning for BLE beacons - 2

- Callback

```
//BLE scan callback
class MyAdvertisedDeviceCallbacks: public BLEAdvertisedDeviceCallbacks {
    void IRAM_ATTR onTimer(){}

    void onResult(BLEAdvertisedDevice advertisedDevice) {
        String address = advertisedDevice.getAddress().toString().c_str();
        String rssi = String(advertisedDevice.getRSSI());
        Serial.println(address + ":" + rssi);
        M5.Lcd.println(address + ":" + rssi);
    }
};
```



# Scanning for BLE beacons - 3

- Starting scan

```
// start scanning for 10 seconds  
bleScan->start(10);
```

# Exercise

Write an Arduino sketch for M5Stack that does the following:

- Show the happy emoji once watch receives a BLE beacon with RSSI of at least -60 from device with address `b4:e6:2d:8b:7d:0b`
- Show the sad emoji once watch receives a BLE beacon with RSSI of less than -60 from device with address `b4:e6:2d:8b:7d:0b`
- Clear screen (blank) if no BLE beacon is received from device with address `b4:e6:2d:8b:7d:0b`