Lesson 1 – Overview of IoT Technologies

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Objectives

- In this lesson, you will be given an overview of the module – the **topics** to be covered, the **assessments** and the **schedule**.
- You will then be introduced to the **6 key enablers** (all starting with the letter C) of a typical IoT application:
  - **C**ollection of sensor data, with the use of a microcontroller
  - (wireless) **C**ommunication
  - (internet) **C**onnectivity
  - **C**loud computing
  - **C**omprehension (or Analysis) of data collected – technically called analytics
  - **C**reation of a mobile or web app

The Topics & schedule

Term 1

- Lesson 1 - Overview of IoT Technologies
- Lesson 2 - Sensor data collection (with the use of Arduino UNO microcontroller)
- Lesson 3 - Wireless communication technologies
- Lesson 4 - Network fundamentals
- Quiz (30% before MST)

Term 2

GP (10%)

- Lesson 5 - Cloud computing basics
- Lesson 6 - Introduction to mobile app development
- Mini Project (20% CD after vacation, 40% implementation before exam)

The Assessments

Online Quiz (30%)

- Coverage: Lessons 1 to 4.
- Format: ~~75~~ 90 MCQ's, closed book, using Lock-down Browser.
- Duration: 1.5 hours.
- Week: before MST.

Mini Project (20% CD + 40% Implementation)

- Requirements & criteria for marking: refer to "Mini Project Specifications".
- Key points: implement an IoT application using Arduino UNO & a mobile app (if necessary).
- Work in pair.
- Present idea for critique in 1st week of 2nd term, before implementation.

Internet of Things?

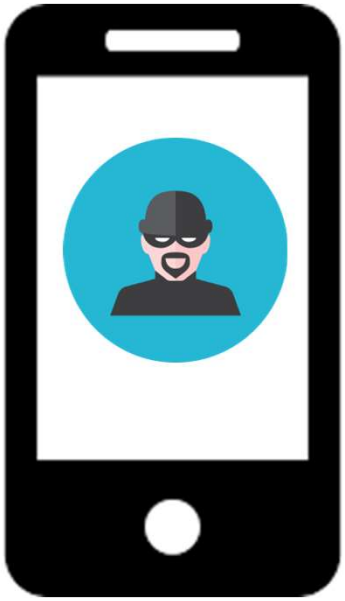
"Things" connected to internet, to exchange data.

IoT helps to improve lives, work & play.

Examples?

Internet of Things? (cont.)

An intruder is detected, when the house owner is away.



A photo is taken, and the house owner is notified.

How can you implement such a project idea?

Internet of Things? (cont.)

This IoT application allows us to travel conveniently from one place to another.

What kind of sensor data is collected, for this to work?

How do the passenger & the driver connect to the internet wirelessly?

Which Cloud platform is Grab residing on? (Hint: Google)

How is the passenger matched to the driver?

How is the passenger charged?

Internet of Things? (cont.)

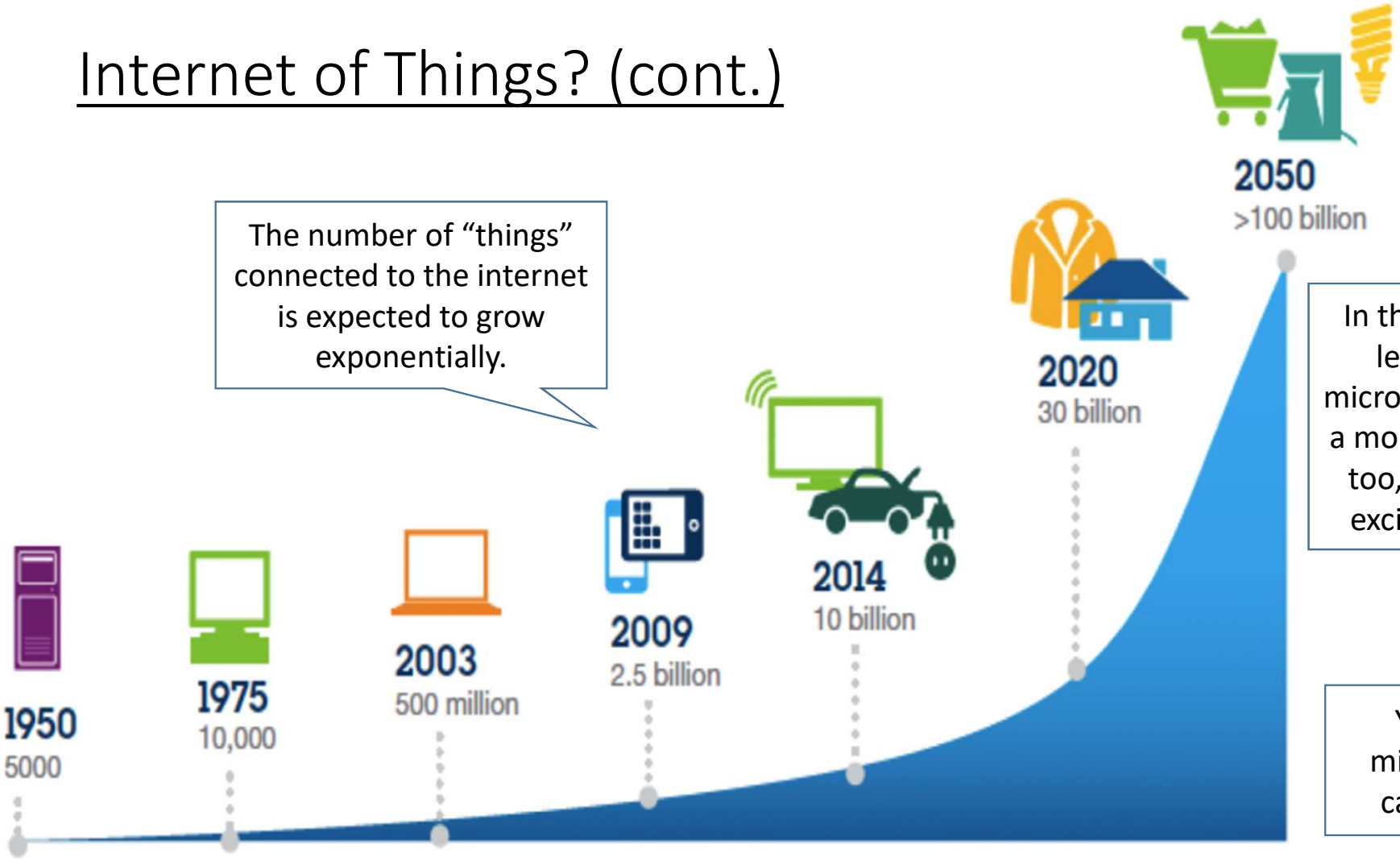
The bin is full.

The trash collector is notified automatically.

Again, how can you implement such a project idea?

Internet of Things? (cont.)

The number of “things” connected to the internet is expected to grow exponentially.



In this elective, you will learn to program a microcontroller & develop a mobile app, so that you too, can be part of this exciting phenomenon.

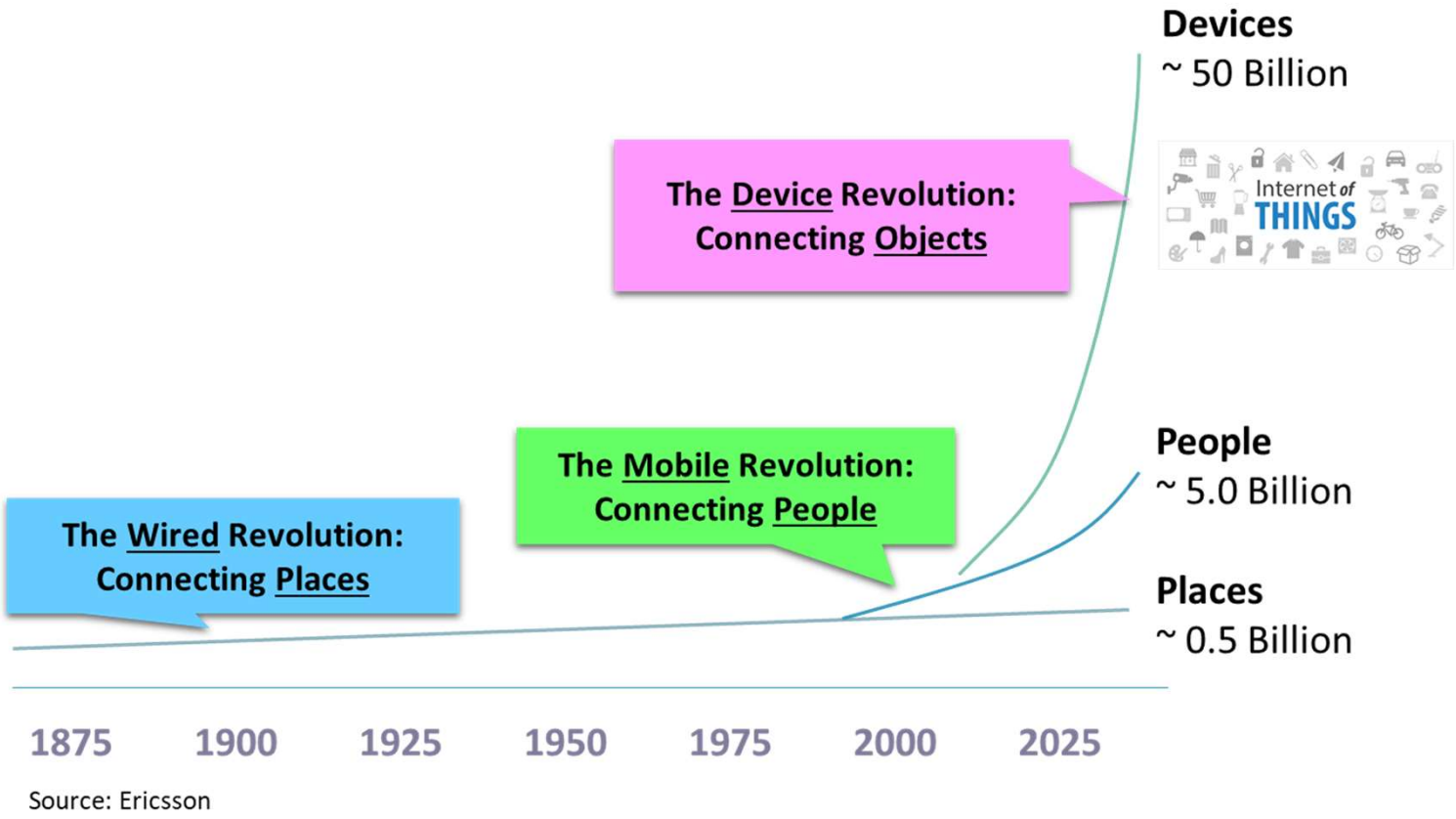
You will be using a microcontroller board called Arduino UNO.

Internet of Things? (cont.)

A short video on IoT.

Internet of Things? (cont.)

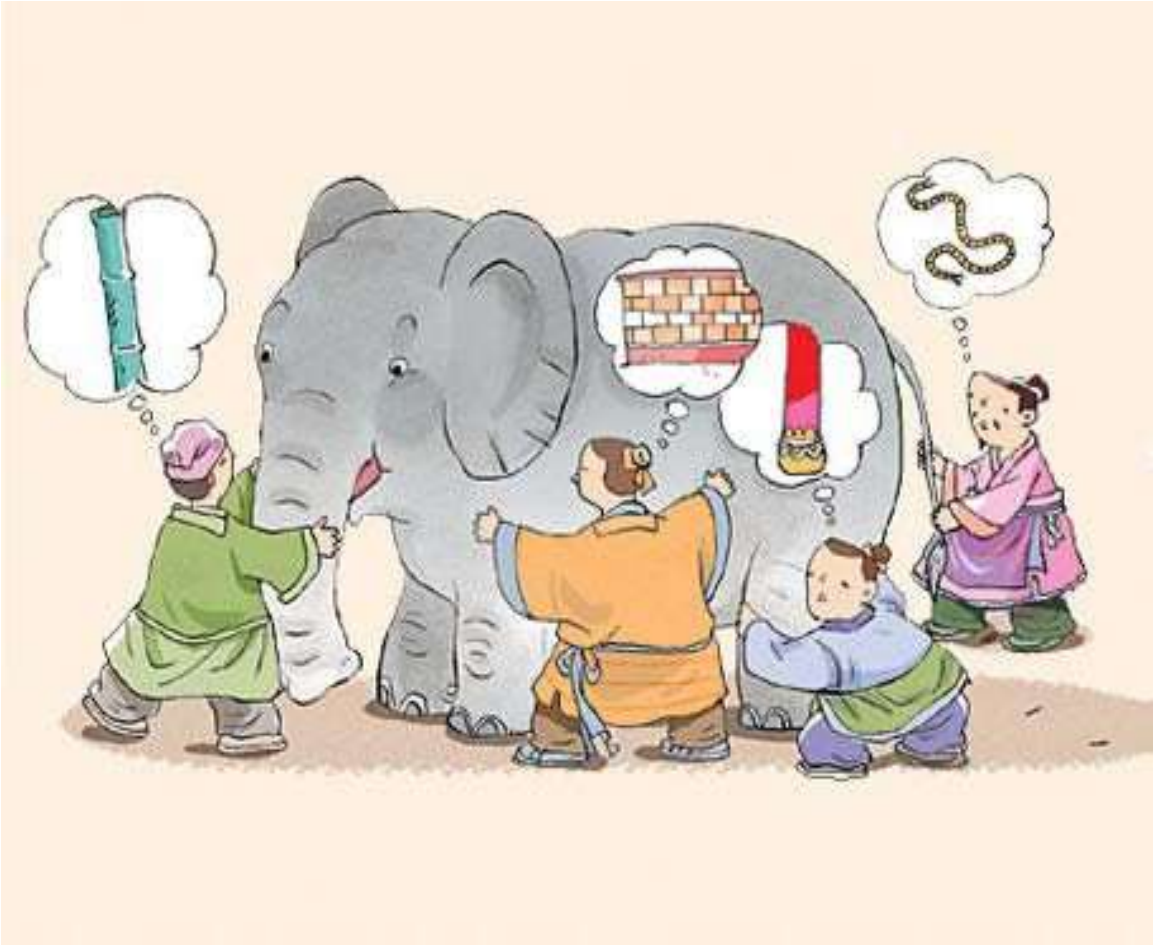
3 revolutions.



Source: Ericsson

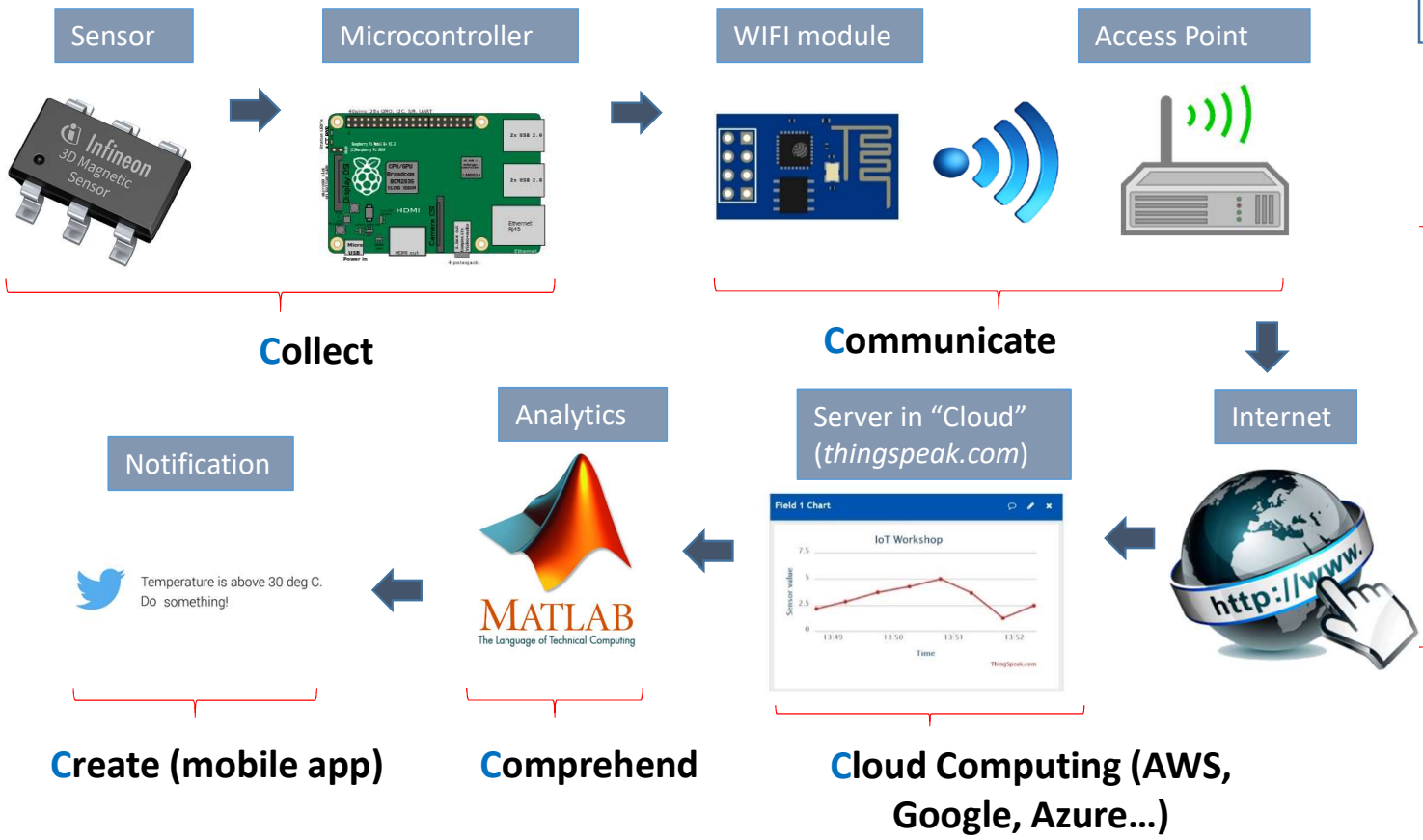
Internet of Things? (cont.)

What exactly is IoT?



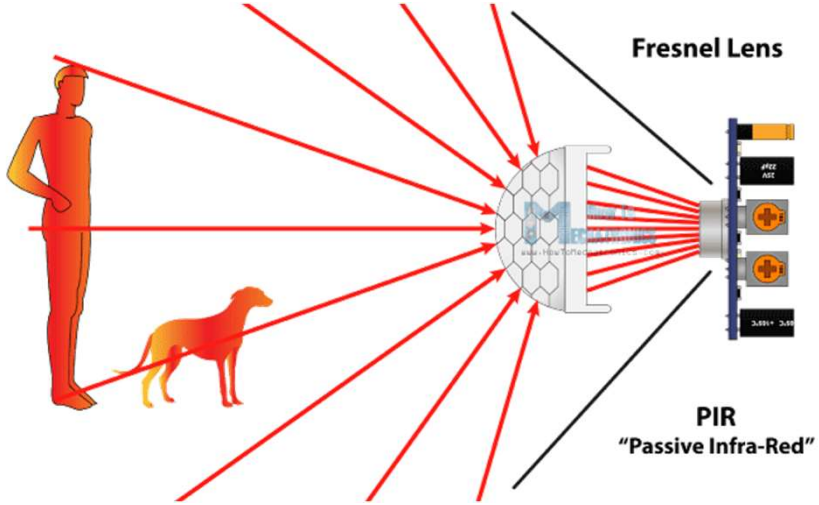
Key enablers of an IoT application

Think about the project you want to do. What are the 6 C's used?



Collection of sensor data

GPS



PIR

- A **sensor** converts a **physical** quantity (e.g. temperature) into an **electrical** quantity (e.g. voltage).
- Common sensors are motion sensor (PIR or Passive Infra Red sensor), GPS (or Global Positioning System) sensor & Ultrasonic ranger.
- You will learn the characteristics & applications of various sensors & actuators, and how to use these with a microcontroller.

Ultrasonic

Do you know how they can be used?

Collection of sensor data (cont.)

- A **microcontroller** is a small computer on a single IC (or Integrated Circuit).
- We will use **Arduino UNO** and write program using **C language**, to collect data from the sensors & control the actuators.
- Along the way, you will learn the **main features** of the Arduino UNO, and various **flow controls**, such as loops, if-else statements, functions etc.

Can you find the SMT ("surface mount") component on this board?

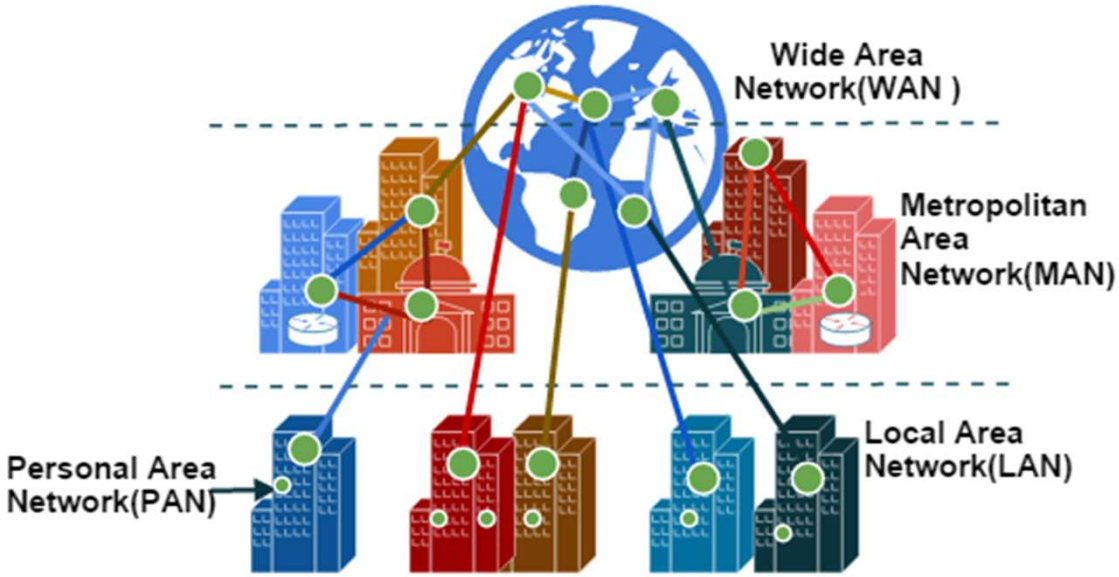
Wireless communication

- Different wireless comm. technologies vary in the **range**, **data rate**, **power consumption** and hence **applications**.
- We will focus on **Bluetooth**, **WiFi** & **Cellular**.
- We will discuss briefly various **modulation techniques** & **multiple access techniques**.

Do you know when you use each of these wireless comm. technology?

Networking

- You may have heard of terms such as
  - **PAN** (Personal Area Network) vs
  - **LAN** (Local Area Network) vs
  - MAN (Metropolitan Area Network) vs
  - **WAN** (Wide Area Network)

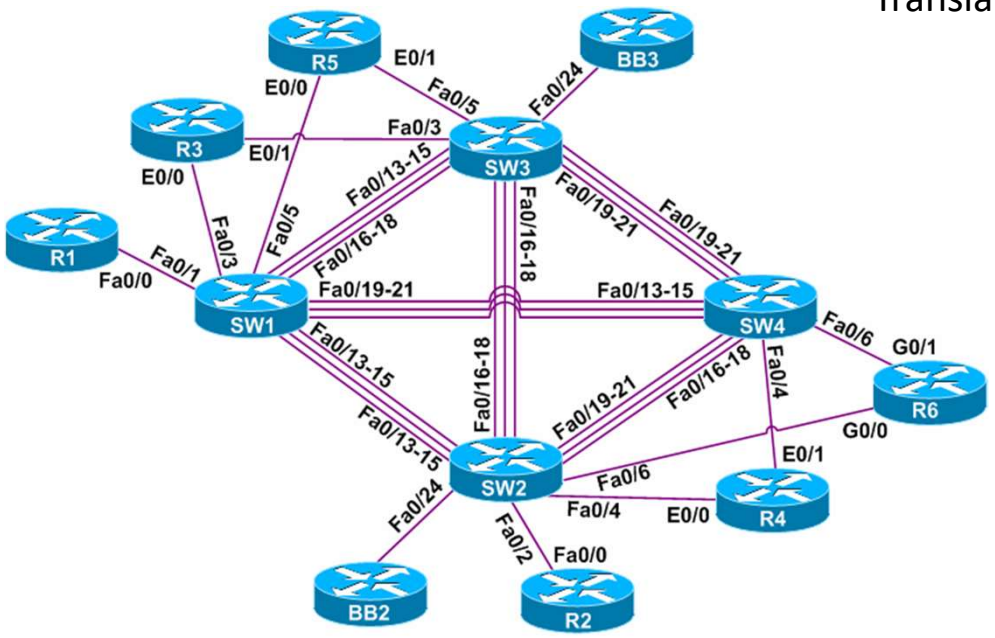


Your mini project will involve **monitoring** & **control** via various networks.

What is the difference between PAN, LAN & WAN?

Networking (cont.)

Can you name a few end devices at home?



- We will cover some fundamentals of networking, so you will learn about these:
  - The roles of **end devices**, **switches** & **routers** in a network.
  - How **IP** (or Internet Protocol) **addresses** allow data packets to be sent from a source to a destination via a network.
  - The concepts of **MAC** (or Media Access Control) addresses, **DHCP** (or Dynamic Host Configuration Protocol), **NAT** (or Network Address Translation), **Port Numbers** & **DNS** (or Domain Name System) etc.

Why are IP addresses such as 192.168.1.101 needed?

What exactly is routing?

More on MAC address, DHCP, NAT, Port Numbers, DNS later…

Cloud Computing

- What is Cloud Computing?

Have you used Cloud Computing before?

Note the 3 well known providers of Cloud services.

By using Cloud Computing, an organisation pays for the computing resources (processors, storage) needed.

What do you thing are the key benefits of using cloud computing, instead of maintaining your own servers in an organisation?

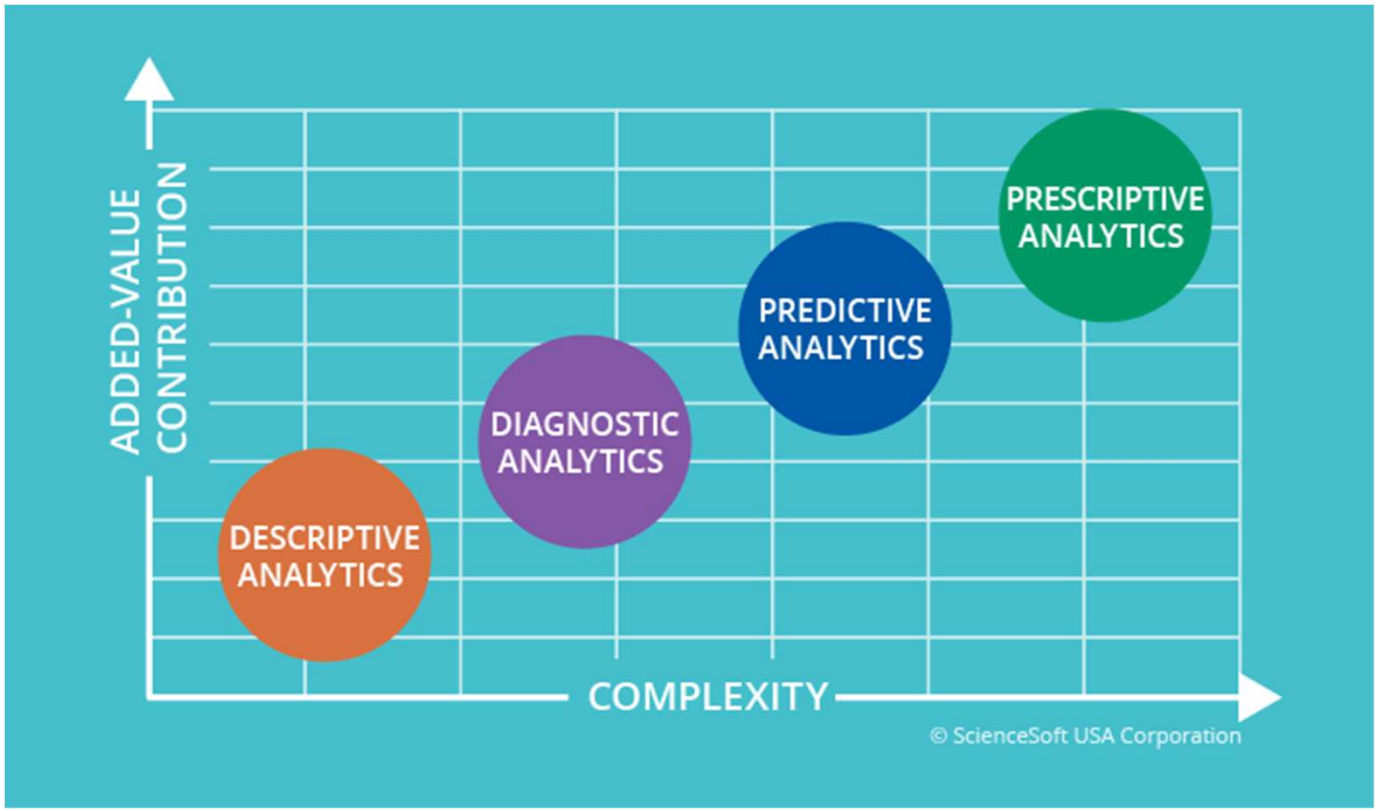
Cloud Computing (cont.)

- Why Cloud Computing?
- You will set up a cloud platform for **sensor data upload**, **analysis**, **visualization** and event-triggered **notification**.

How have you personally benefited from Cloud Computing?

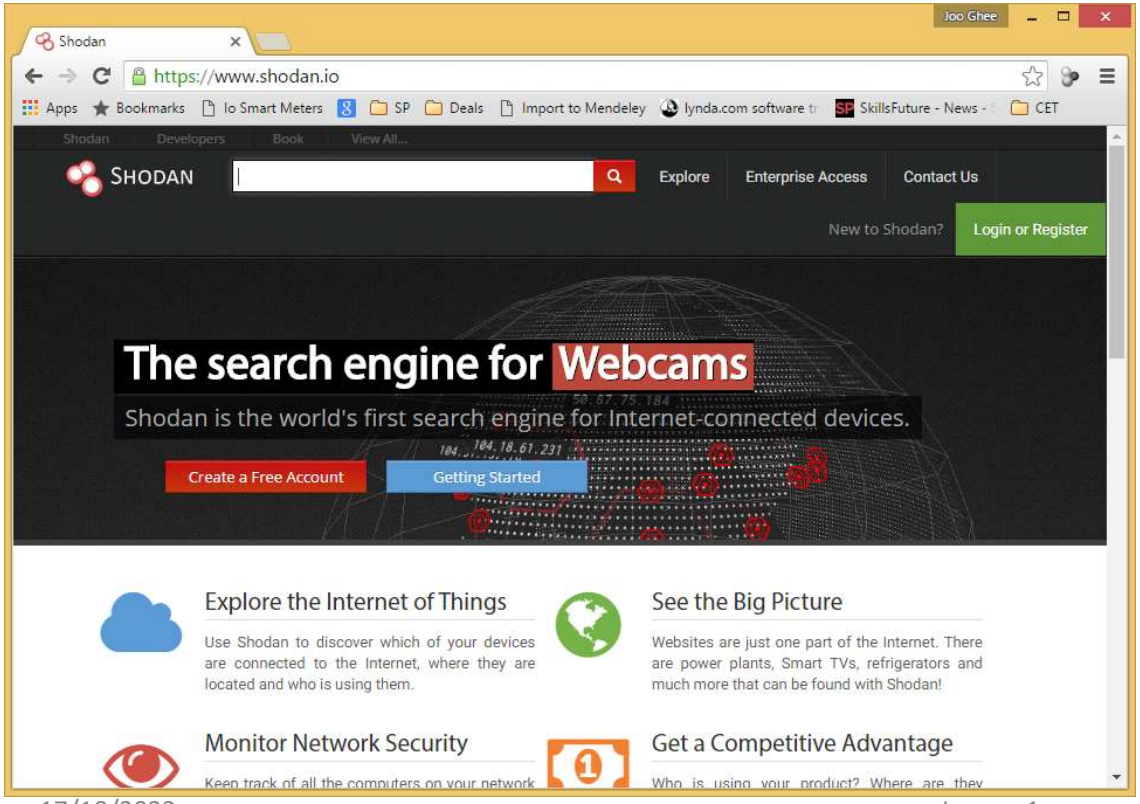
Data Analytics

- This is about **making sense** of the data collected.
- In general, the more **effort** you put in, the greater the **benefits**.

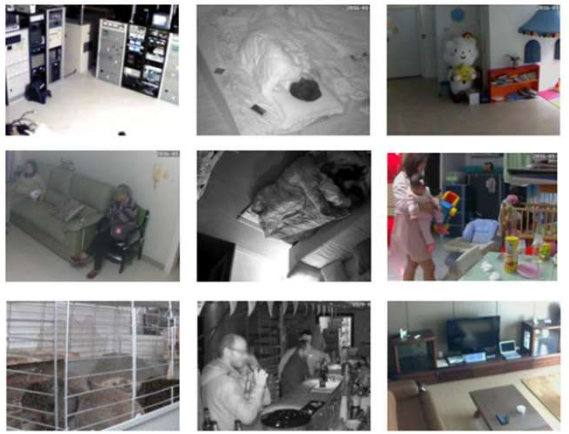


Network Security

- With more devices at home & in the office connected to the internet, network security has become even more important.



Don't assume everything is OK.



Network Security (cont.)

- Some recommendations for network security are:
  - Do your research before purchase
  - Secure your device immediately after purchase
  - Adopt secure password practices
  - Continue to update your firmware when available
  - Consider disconnecting your insecure IoT device
  - Turn off IoT devices when not in use or periodically if otherwise always on
  - Protect your routers and Wi-Fi networks
  - Avoid a single point of failure
  - Pay attention to mobile device security
  - Consider using anti-virus and intrusion detection products that protect IoT devices.
  - Get technical assistance with IoT security

Which of these do you actually practise?

Mobile App Development

- Apple iOS
  - Programming language – Swift
  - IDE – Xcode
  - Appstore
  - Closed-source, with open source components
- Android
  - Programming language – Android (java-based)
  - IDE – Android Studio
  - Google Play
  - Open source

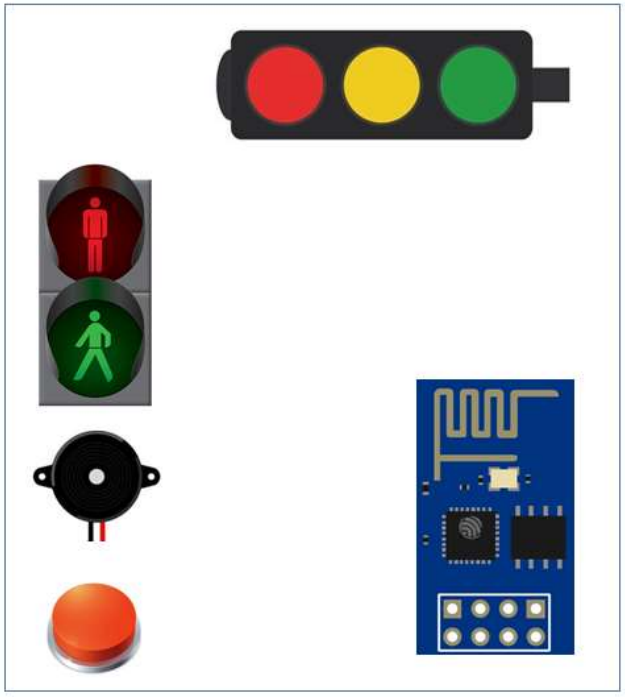
- You will learn to develop simple mobile apps using a **graphical method**.
- You will learn to create a **user interface**, to **handle events**, & to use **phone features** such as GPS location, contact list, camera or accelerometer.
- You will even learn to **distribute** your app to other users!

iOS 20% vs Android 80%.

Project idea?

- Using what you will learn, you will be able to implement IoT projects, such as these:

Traffic Lights



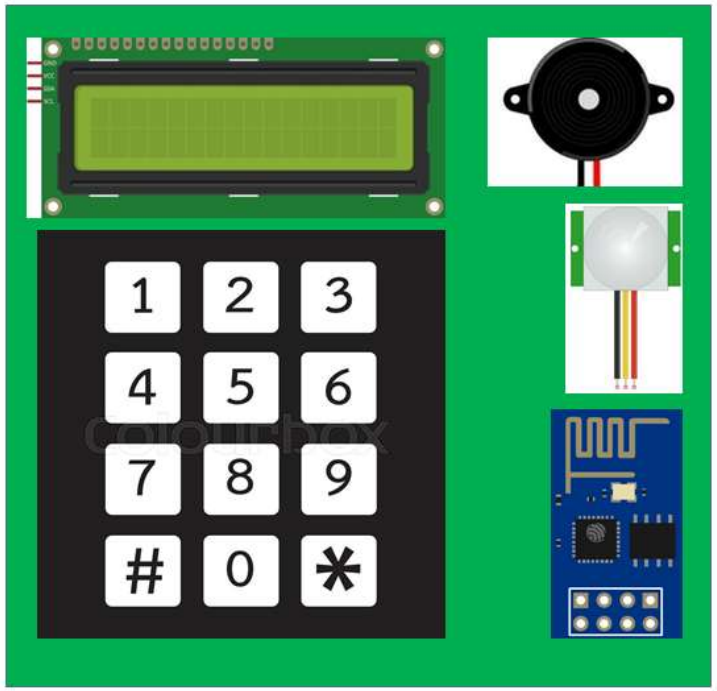
If an ambulance needs to rush a patient to the hospital, all the traffic lights (in the direction of the ambulance) can be changed to green.

The emergency situation should not cause an accident to happen i.e. the lights should not changed suddenly .

If there is no emergency, the traffic & pedestrian lights will operate normally.

Project idea? (cont.)

Intruder Alarm



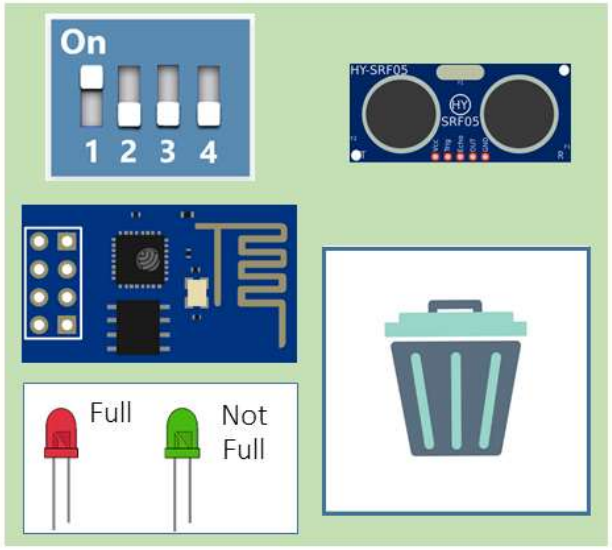
If a person is detected, he will be prompted to enter the password.

If the correct password is not entered within the time limit, the buzzer will be turned on...

A notification will also be sent to the registered mobile phone.

Project idea? (cont.)

Intelligent Bin



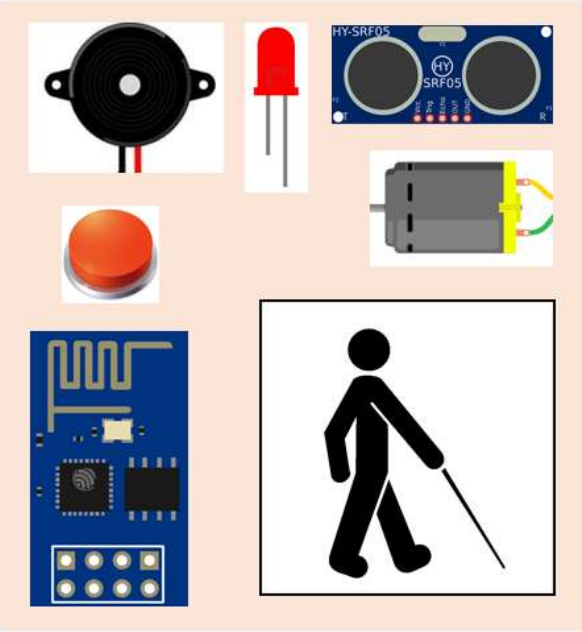
The ultrasonic ranger can detect if the bin is full or not.

If it is full, the bin ID (as set on the dip switches) will be sent out wirelessly, to inform the cleaner.

The red LED will be made to blink, so that the cleaner can locate the full bin easily. The green LED will light up when the bin is not full.

Project idea? (cont.)

Blind Man Stick



The visually impaired presses the button to start operation.

The ultrasonic ranger can detect if there is an obstacle.

If there is an obstacle, the LED will blink, the DC motor will turn and the buzzer will beep.

The ESP01 can send information on the button & ultrasonic ranger readings to the cloud for some analytics to be performed.

A possible add-on is a GPS module, to track the person's whereabout.

Project idea? (cont.)

In the sensor mode, if a person is detected and the temperature is above a certain threshold, the fan (DC motor) will be switched on automatically.

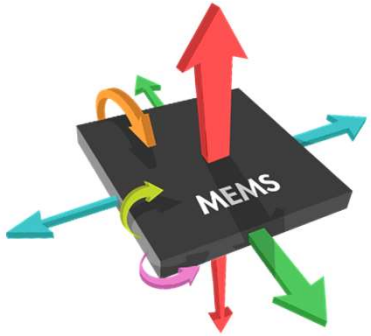
In the sensor mode, if a person is detected and the ambient brightness is below a certain threshold, the lamp (LED) will be switched on automatically.

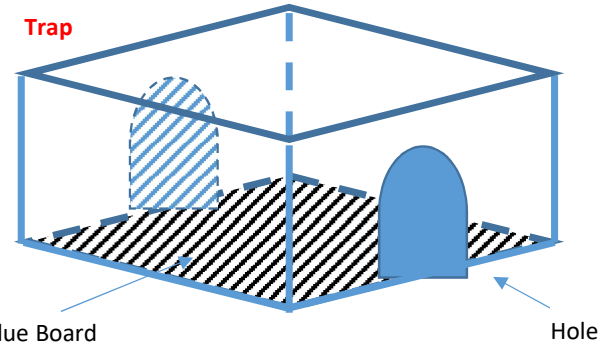
Pressing the button will cycle the mode through off ⇨ on ⇨ sensor mode.

The fan & lamp are controlled independently and the ESP01 allows data to be sent to the cloud, or even internet control.

Lab Exercises

- Exercise 1.1 – The 6 C's in an IoT application
- Exercise 1.2 – Sensors & actuators
- Exercise 1.3 – Wireless comm. technologies
- Exercise 1.4 – An IoT project idea



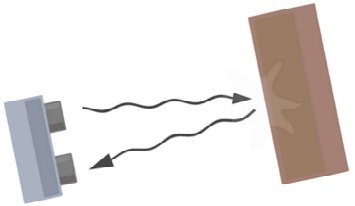


Bluetooth®

Exercise 1.1 – The 6 C's in an IoT application

For the Grab application, fill in the table below:

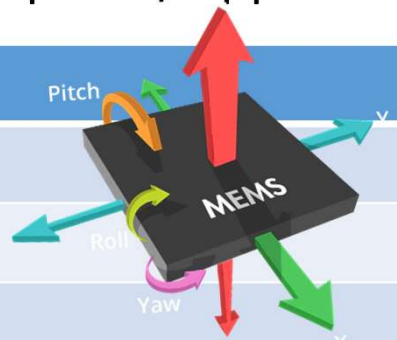
6 C's	What are they?
Collection of sensor data (GPS location of ???)	
(Wireless) Communication (BT? WiFi? Cellular?)	
(Internet) Connectivity (PAN? LAN? MAN?)	
Cloud computing (Google Cloud? Azure? AWS?)	
Comprehension (or analysis) of data collected	
Creation of (a mobile or web) app	-- (no need to fill) --

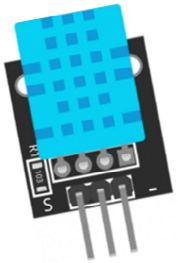


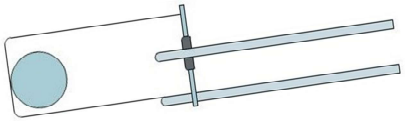
Exercise 1.2 – Sensors & actuators

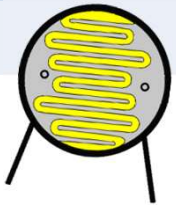
a.) Match each of the sensors / input devices below to its description / application:

Sensor / input device	Description / application
Moisture sensor	Detect object not upright
PIR sensor	Measure brightness
Tilt switch	Detect rain, or dryness in soil
LDR	Give the longitude & latitude
Ultrasonic ranger	Detect motion in the X, Y, Z axes
Temp & humidity sensor	Detect motion
3 axis sensor	Measure temperature & humidity
GPS module	Measure obstacle distance



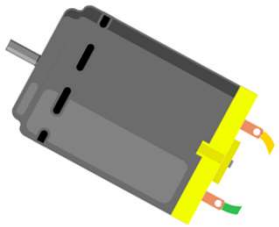


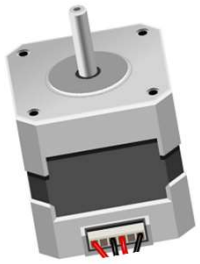


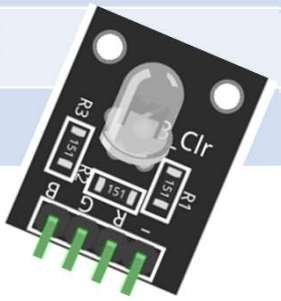


Exercise 1.2 – Sensors & actuators (cont.)

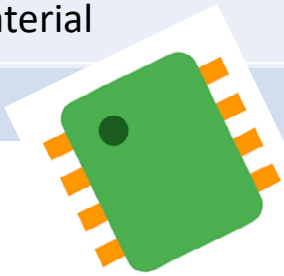
b.) Match each of the actuators / output devices below to its description / application:







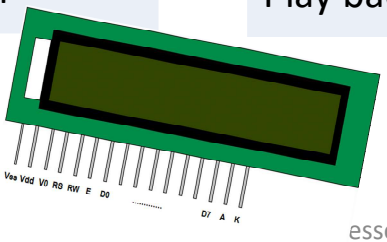
Actuator / output device	Description / application
RGB LED	Rotate continuously over 360 degree, even in both directions
Servo motor	Produce light in different colours
DC motor	Move over 180 degree
Stepper motor	Allow a small current to control the flow of a large current
Relay	IC (Integrated Circuit) version of a relay
Solenoid	Suck in or push out a piece of magnetic material
SSR	Move in small steps



Exercise 1.2 – Sensors & actuators (cont.)

c.) Match each of the user interface devices below to its description / application:

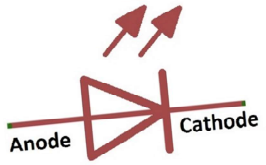
User interface	Description / application
Keypad	Facilitate local storage of data
LCD	Authenticate a person by the tap of a card
Voice playback	Allow user to input characters / numbers
SD card	Prompt the user or give him / her instruction / info
RFID	Identify a person uniquely
Fingerprint sensor	Play back an audio file as prompt, or for entertainment



Exercise 1.3 – Wireless comm. technologies

Match each of the wireless communication technologies below to its application:

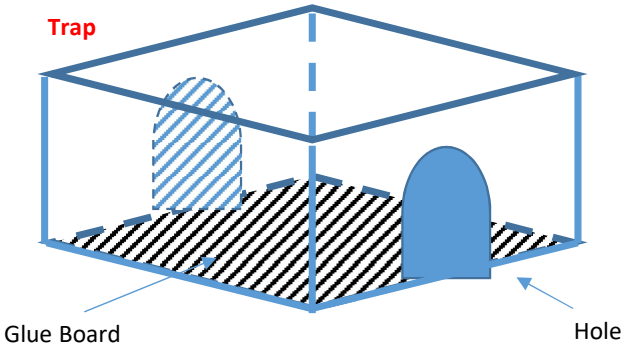
Wireless comm. tech	Description / application
Bluetooth	Allow appliances such as TV to be controlled remotely
Wifi	Prevent shoppers from taking out merchandise before paying
Cellular	Allow end devices to connect to an access point or a router
RFID	Enable transfer from end devices belonging to the same person
NFC	Allow long distance communication, via the use of base stations
IR	Enable cashless payment

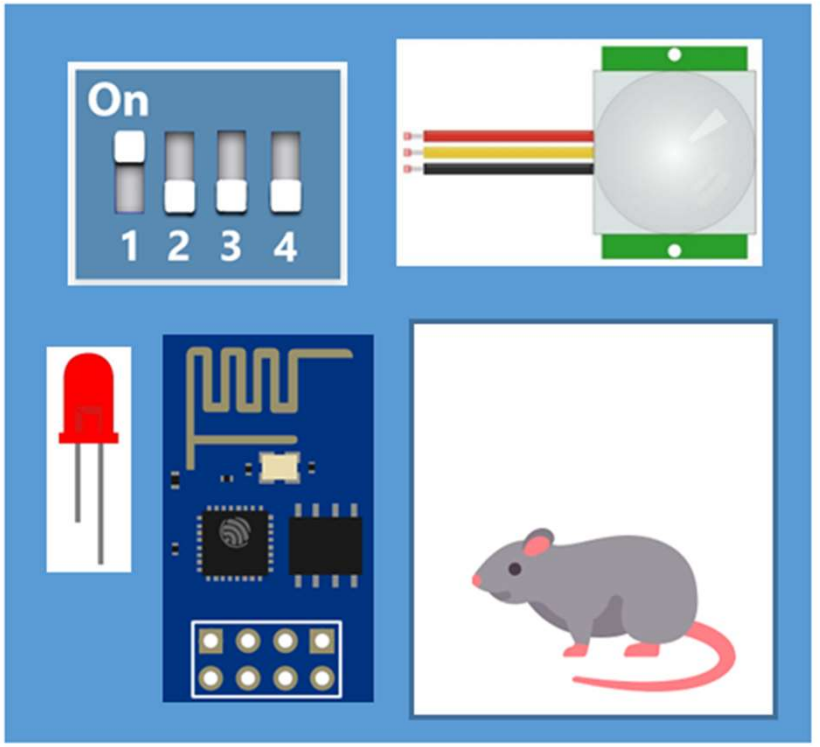


Exercise 1.4 – An IoT project idea

A simple mouse trap consists of a box with 2 holes at 2 ends, and a glue board.

Suggest how it can be made “intelligent” with the use of a motion sensor, a WiFi module, an LED & a few dip switches.






Thank
You!