Introduction to IoT

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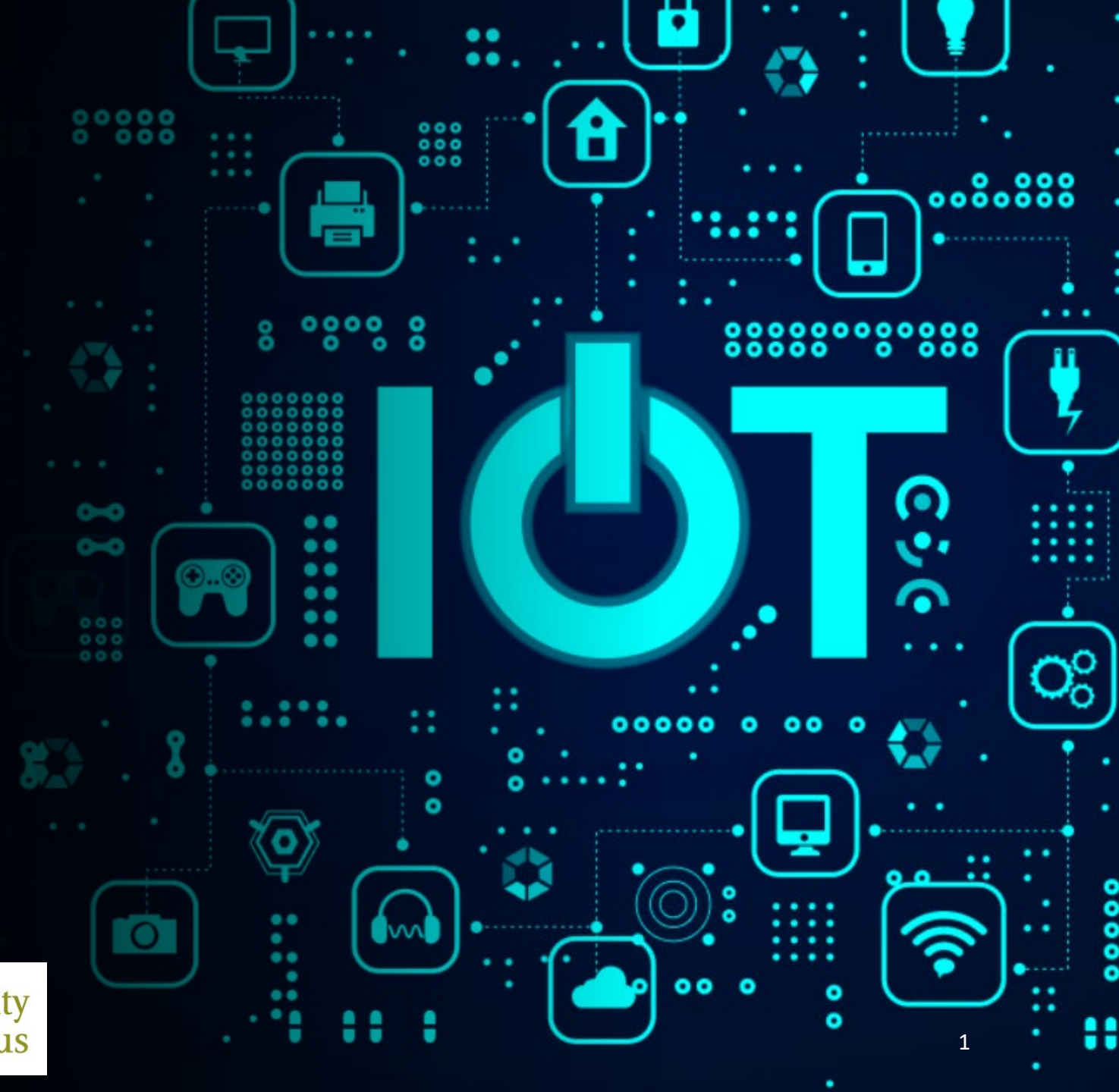

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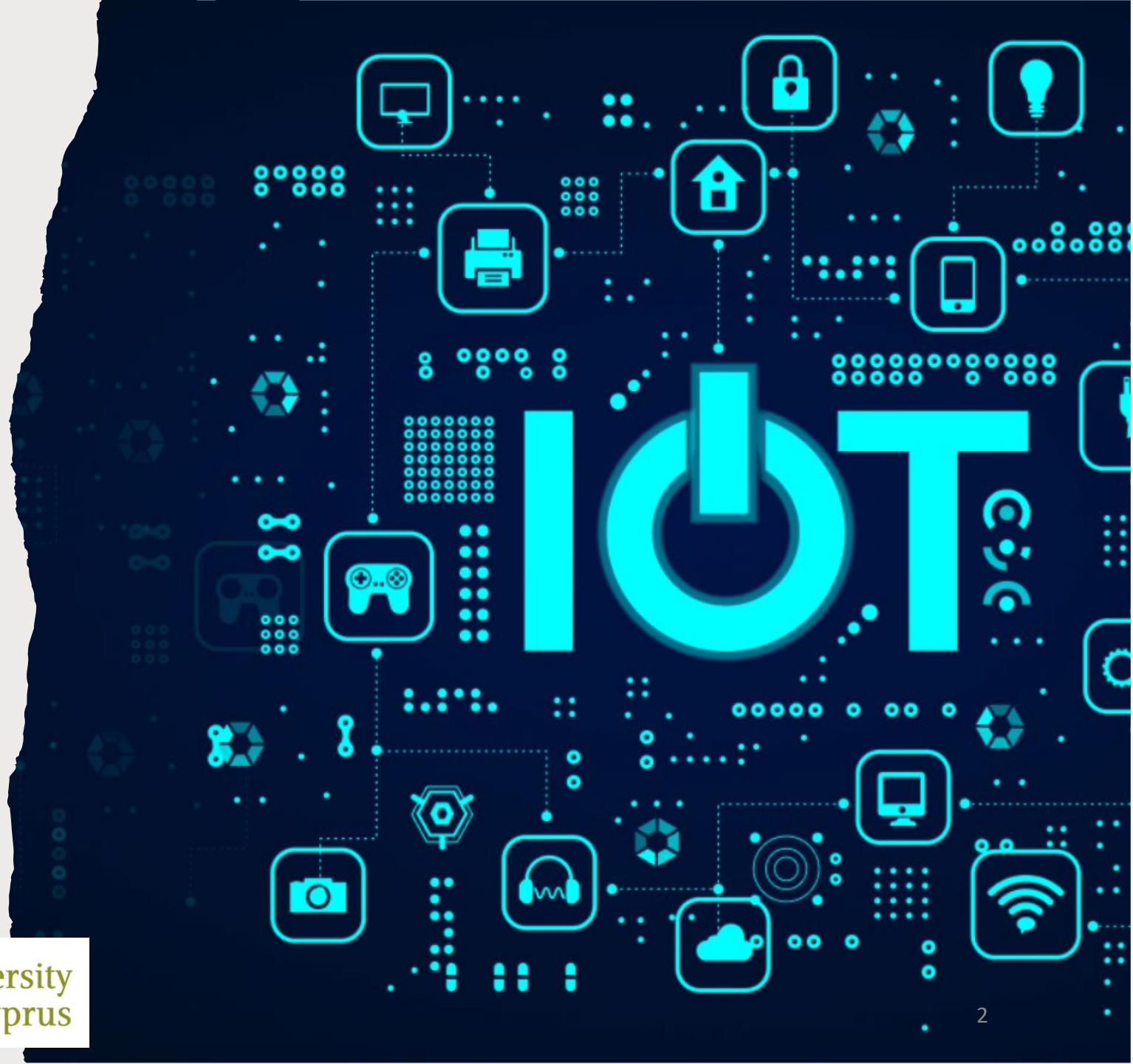

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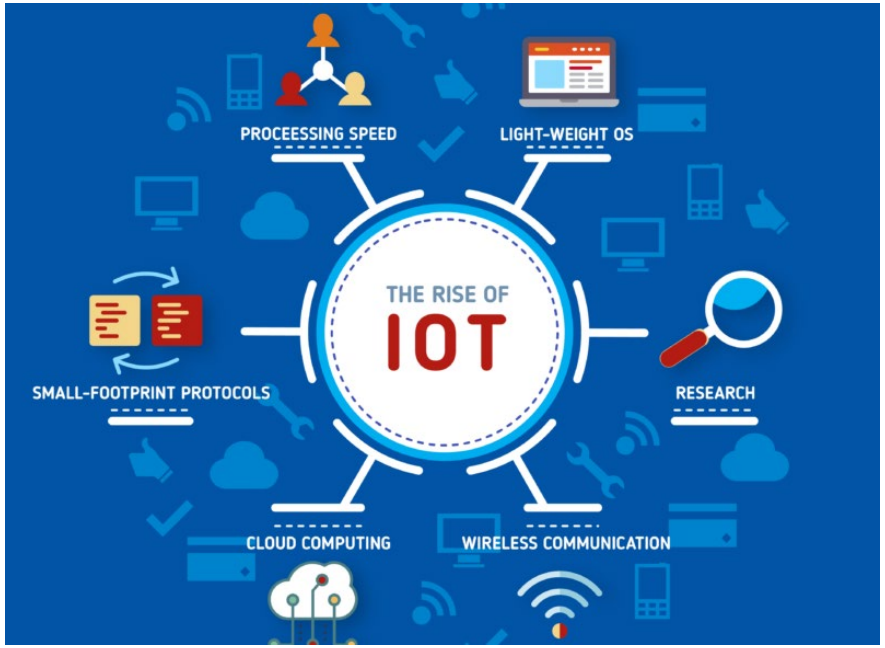
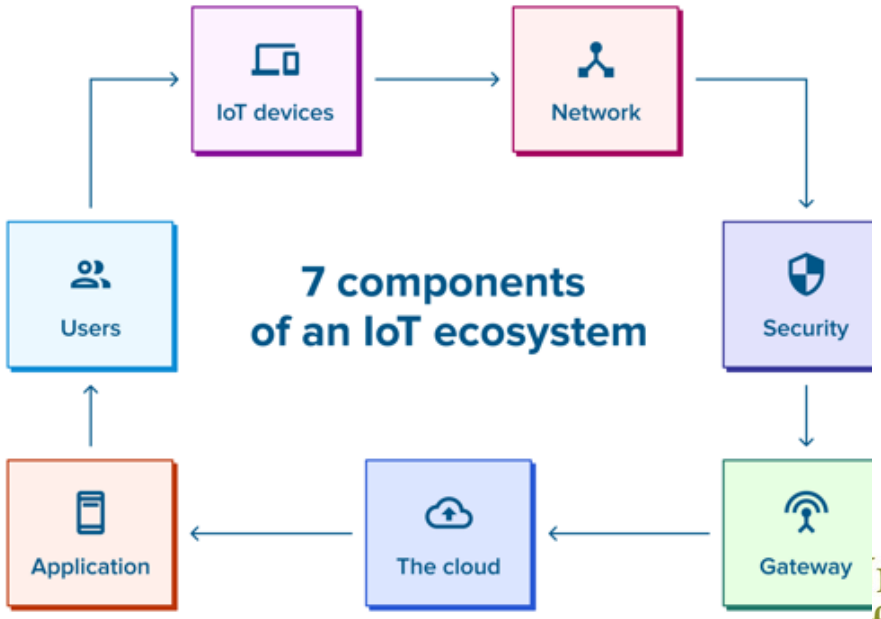
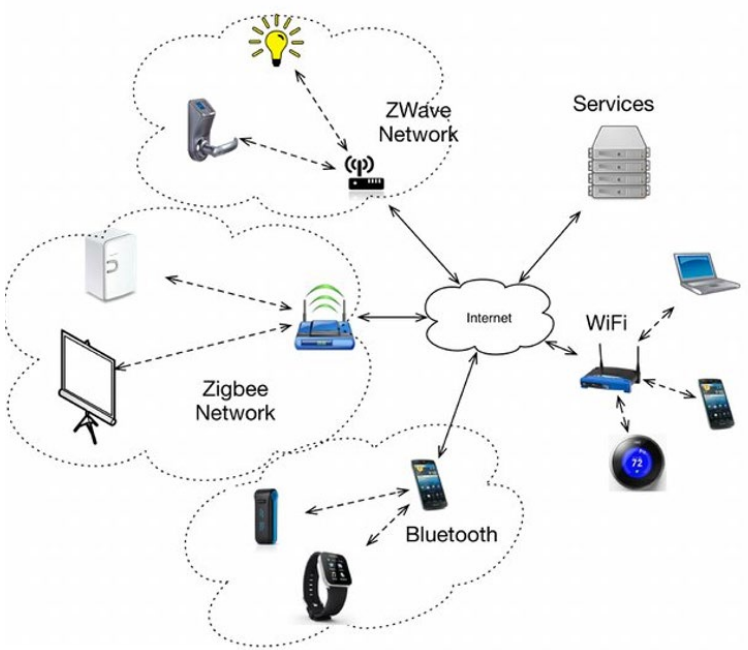




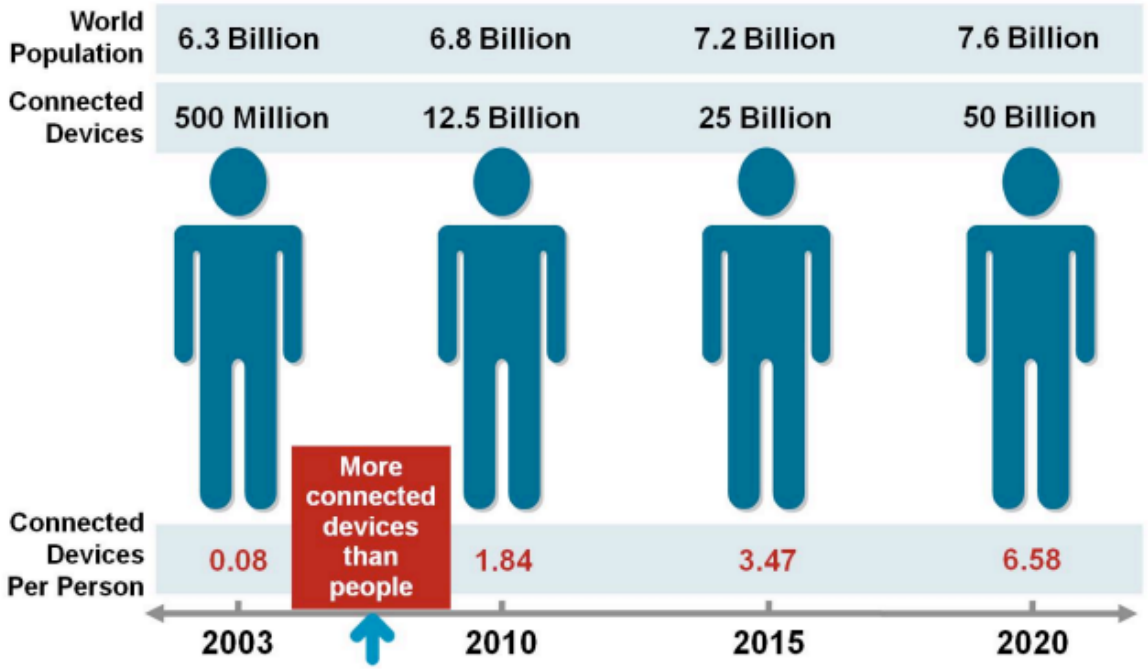
What is IoT and Why is it Important?

In recent years we ‘see’ a huge increase in (IoT based) smart devices (with embedded software) connected to the internet

IoT Network: Different physical objects (things) connected together and with systems to exchange information through internet



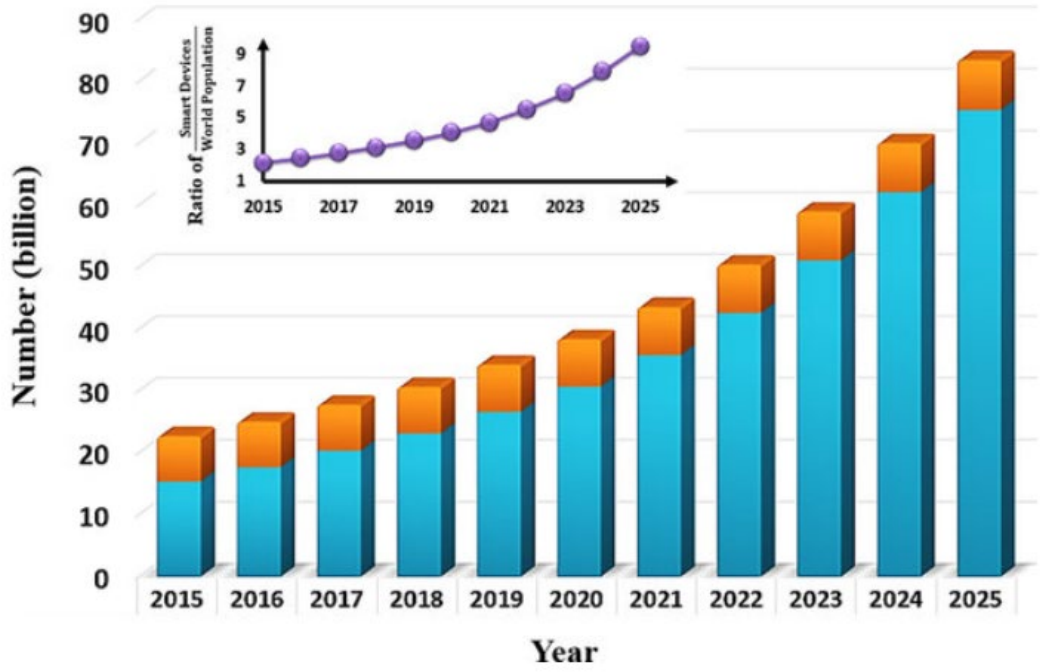
Back in 2011, IBSG pointed out that between 2004-2009 there were more connected devices to the internet that people



***IBSG** = Cisco **I**nternet **B**usiness **S**olutions **G**roup

In a recent research (2018), we also observe more connected devices to internet than people but <u>not in 2011 level</u> prediction

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
World Population	7.25	7.33	7.41	7.48	7.56	7.63	7.71	7.78	7.85	7.92	7.99
Smart Devices	15.41	17.68	20.35	23.14	26.66	30.73	35.82	42.62	51.11	62.12	75.44



The graph above has an exponential curve which leads to a rising amount of devices expected to connect in the near future

Technology Drivers

The usage of IoT in industry is improving store and process of information in order to excel their productivity

4 Key Technologies Drive IoT Development

- Cloud Computing
- Blockchain
- Sensors
- Artificial Intelligence

Cloud Computing

Cloud computing is sharing real-time data, necessary for IoT apps and sensors to keep operate

Means it requires a huge storage and processing place

Cloud ability to rapidly store such amount of data include it as an IoT driving technology

Blockchain

Blockchain is an unchanging archive, shared to help the procedure of recording transactions and spot assets in a business network

Joining forces, Blockchain and IoT create machine to machine exchanges

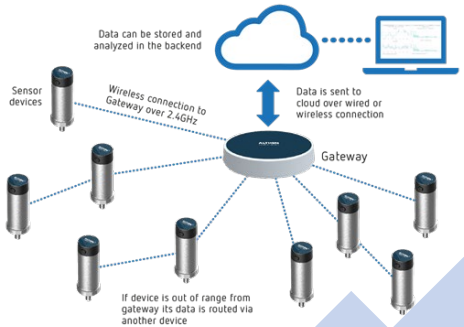
A set of exchanges is used, stored in a database, confirmed from many sources & stored in a common archive in each node

Sensors

We are all familiar (more or less) with sensors e.g. lock/unlock car for distance by sending a signal

Although IoT advanced sensor can do a lot more than lock/unlock the car

- Water level sensors
- Wireless IoT Vibration Sensors



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Artificial Intelligence

As we understand IoT is based on connectivity and sensors with also a vast amount of data which need analysis

Here is where Artificial Intelligence (AI) steps in

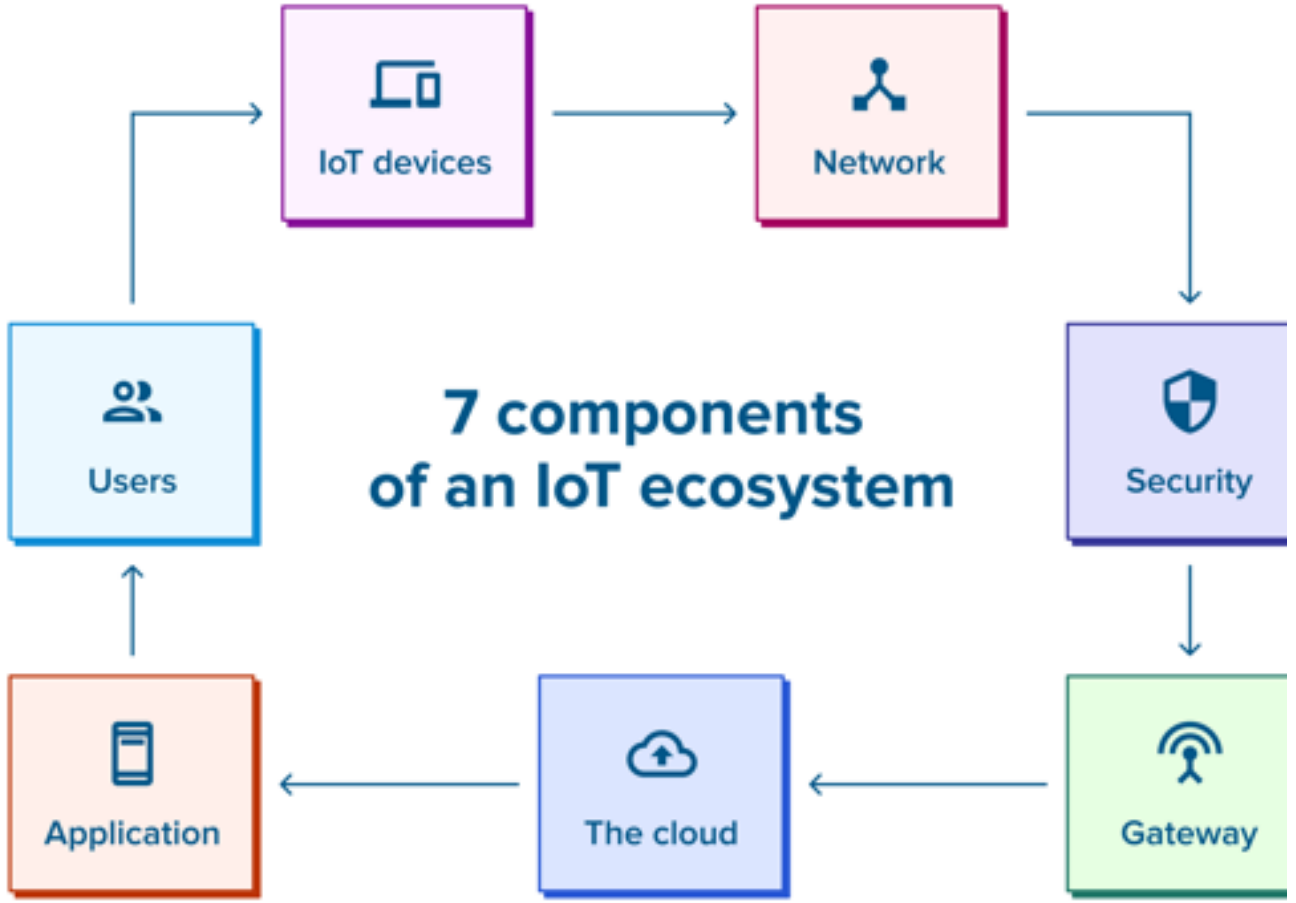
The pair of AI & IoT would provide a leverage in data analysis from IoT devices and help extract important conclusions and ideas

Internet of Things (IoT) ecosystem

Is a broad network of connected and interdependent devices and technologies that are applied by specialists towards a specific goal (e.g. smart city)

7 components of an IoT ecosystem

- IoT devices
- Security
- Network
- Gateway
- The cloud
- Application
- Users



7 Components of an IoT Ecosystem

1st IoT Devices

Devices work together in a domain such as **sensors** and **actuators**

Sensors collect data about the domain and 'take notes' on parameters such as temperature, moisture, etc

Actuators as the name implies, they do an action after they have a certain command

e.g. Turn on the light when there is dark outside

7 Components of an IoT Ecosystem

2nd Network

Network is the component in charge of the interaction (in a ecosystem) between:

- Smart Devices
- Gateway
- Cloud

E.g. exercise smart bracelet

Procedure:

1st Collects the heart pulse

2nd Connect to smartphone via Bluetooth and send the information

3rd Information transfer to an app and sync with the cloud to other servers

7 Components of an IoT Ecosystem

3rd Security

This component is in charge of:

- Access control in the ecosystem
- Safe information movement
- Avoidance of information leakage
- Look for dangerous software

E.g. plenty of IoT devices do not have authentication passwords or there are very easy to crack → Easy job for a hacker attack

7 Components of an IoT Ecosystem

4th Gateway

A device moving data through it from sensors with destination the cloud and the way back

E.g. Router

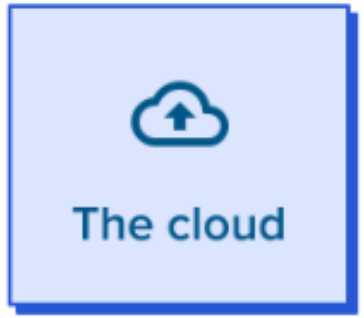
A house router from where we are connected to the internet

7 Components of an IoT Ecosystem

5th Cloud

In case of a bunch of computer link to internet, capacity of Cloud can be used for:

- Storage information
- Deep Analysis
- Management



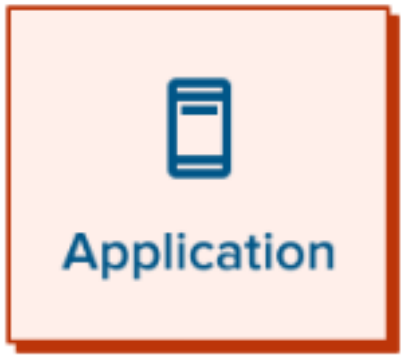
E.g. Creating an IoT ecosystem can take a massive number of smart devices with an exponential number of data

Therefor, cloud technologies for storage are there for our help!

7 Components of an IoT Ecosystem

6th Application

A connection helping user be able to managing the smart devices that are linked to the IoT ecosystem



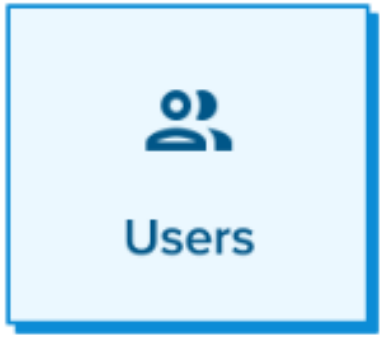
E.g. Did you leave your smart home without locking the door?

No problem! Open the app on your smartphone and a click is enough to lock them!

7 Components of an IoT Ecosystem

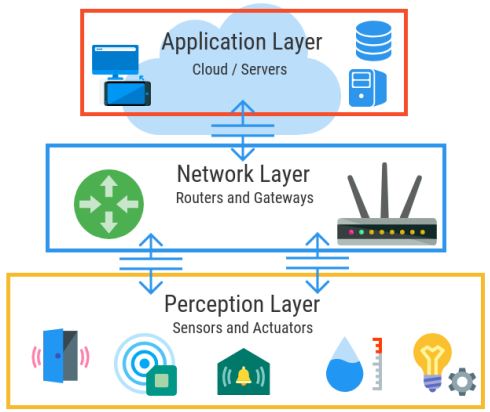
7th Users

Anyone who interacts with IoT ecosystem e.g. Using IoT smart devices



E.g. **YOU**

IoT Protocols



Types of IoT Protocols

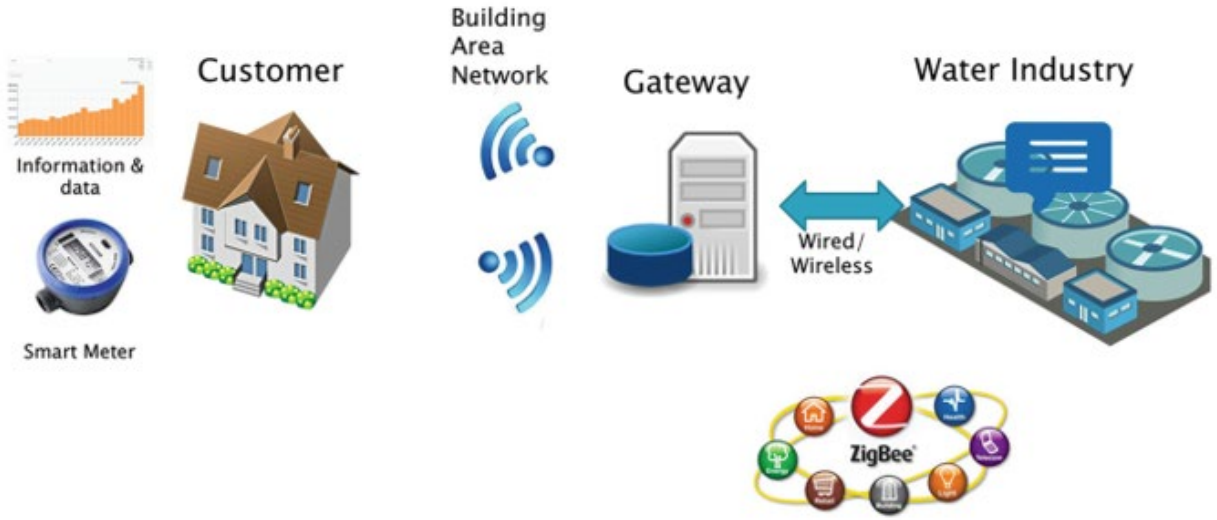
IoT Network Protocols

IoT Data Protocols

IoT Protocols

- IoT communication protocols are modes of communication that protect and ensure optimum security to the data being exchanged between connected devices

- Types of IoT Protocols:
  - Network
  - Data



IoT Network Protocols

These protocols which are a group of communication protocols link smart devices to the network

By applying network protocols, it is allowed the end-to-end data communication for the network scope

Example of IoT Network Protocols are:

- HTTP (HyperText Transfer Protocol)
- LoRaWan (Long Range Wide Area Network)
- Bluetooth
- **ZigBee**

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IoT Data Protocols

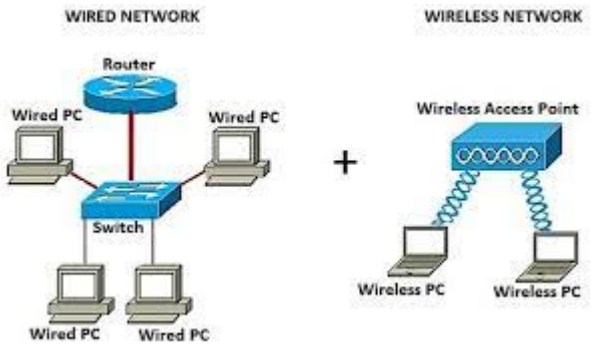
IoT Data Protocols link low power smart devices

They communicate with point-to-point method with no Internet connection and hardware operated by user

Communication in these protocols is feasible with wired or cellular network

Example of IoT Data Protocols are:

- Message Queue Telemetry Transport (MQTT)
- Constrained Application Protocol (CoAP)
- Advanced Message Queuing Protocol (AMQP)
- **Machine-to-Machine (M2M) Communication Protocol**
- Extensible Messaging and Presence Protocol (XMPP)



ZigBee

- An IoT protocol aid smart devices to work together, normally operated in home automation.
- ZigBee mostly used in industry supporting low-rate data transfer between short distances (e.g. in security systems & smart homes)

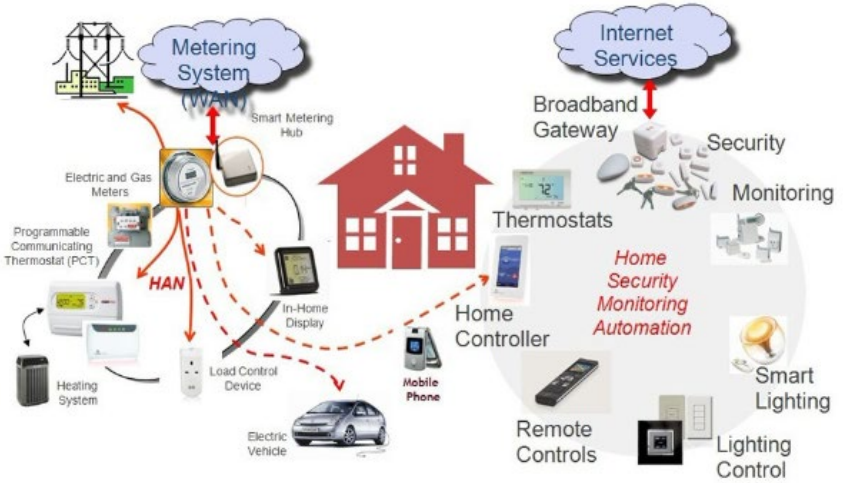
ZigBee

ZigBee links through a common path alike products and control them from a pc or even a smartphone

ZigBee also gives the opportunity of reduce the costs instead of automating the whole household

Advantages of ZigBee

- Secure cellular interaction
- Easy to install
- Low electricity consumption & simple to expand
- Remote control through internet or by hand (at location)
- ..



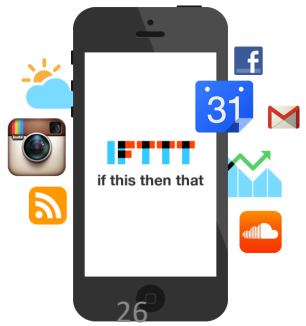
In which devices is ZigBee applicable?

ZigBee protocol can use any kind of sensors e.g. motion, temperature, Co2

Also can be connected with alarms, air conditions, IP camera, roller shutters..

IFTTT (IF This Then That)

In case of ZigBee and IFTT connection it can give updates e.g. weather, phone information, from sensors (if connected) and more



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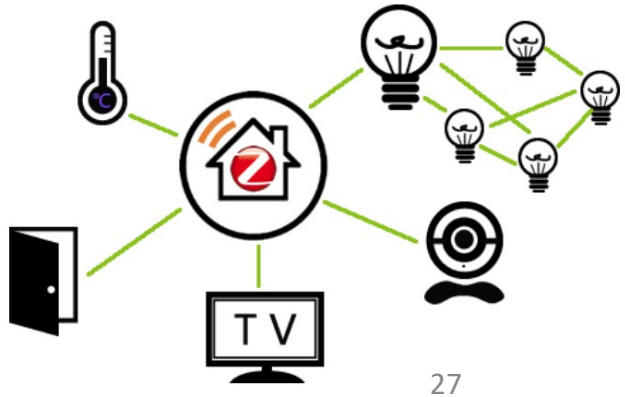
ZigBee and Wireless Connection

The spectrum which normal has a control unit is ≤ 100 m outside and ≤ 50 m inside

Although due to mesh topology occasionally applied the signals are transmitted between devices and as a result increase range

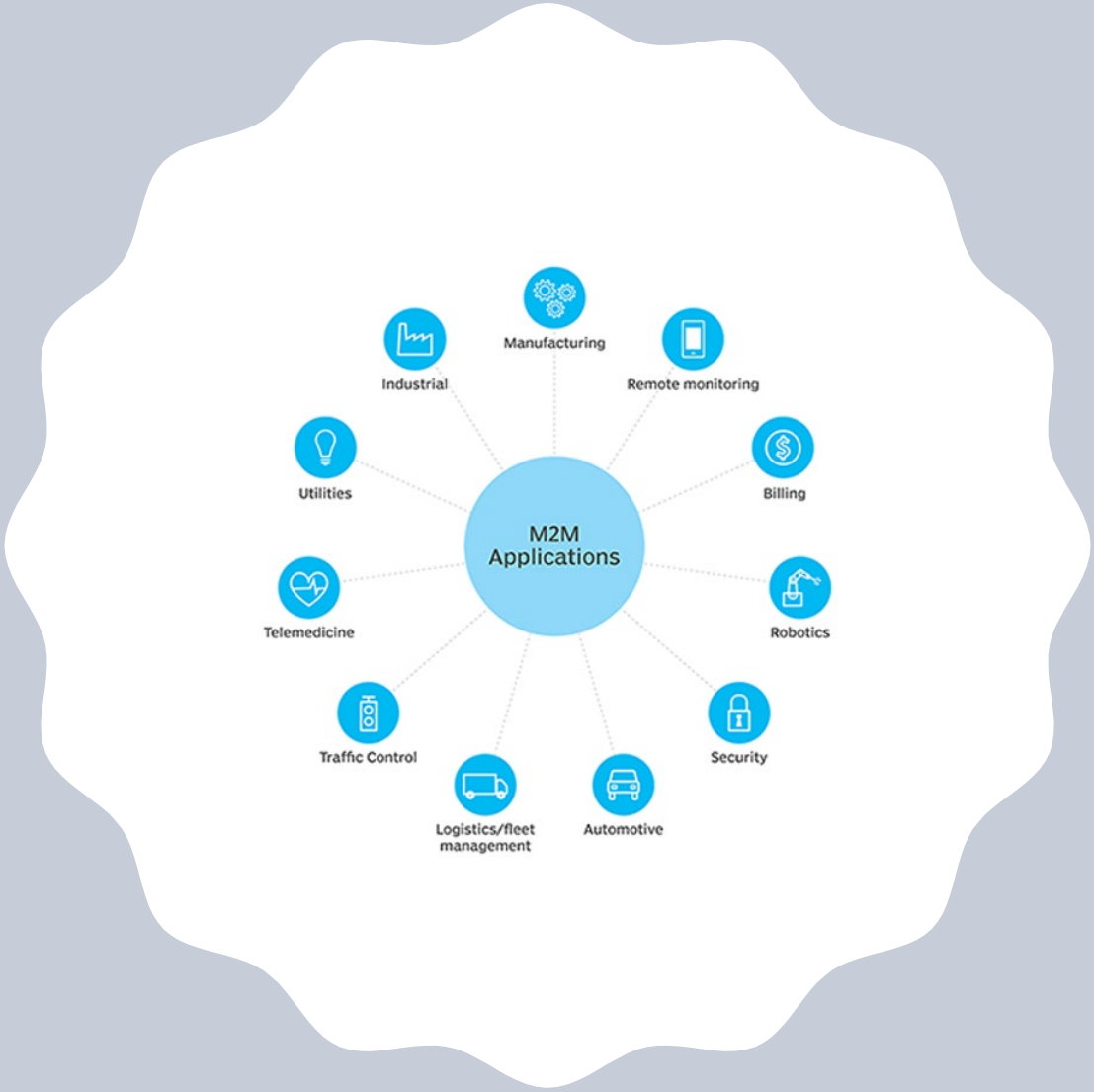
Therefor with increase of devices, the range increases



M2M Protocol

M2M (Machine 2 Machine) Protocol is a direct electronic communication among machines, devices and systems.

- Cost-effective and
- Use public networks
- Create an environment where two machines:
  - Communicate and
  - Exchange data



M2M communication protocols industry examples:

- Smart Homes
- Automated Vehicle Authentication
- Vending Machines
- ATM Machines

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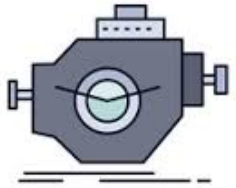
M2M Applications

M2M communication normally is applied remotely e.g. in a case of a vending machine

That machine is sending a signal to the distributor network (another machine) for a refill in case of a shortage of goods

Normally industry dealing with utilities using M2M in order to:

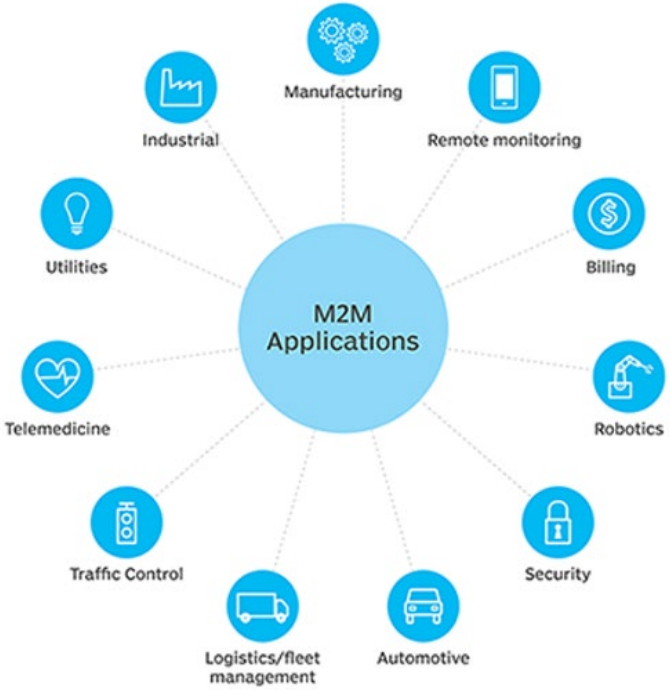


- Avoid wasting energy
- Spot construction site factors like pressure, temperature, speed..

Key Features of M2M

Some key features of M2M are:

- Low Power Consumption
- Regular data exchange in small amounts
- Control of time data send and received (in certain times)
- Accepting delays in time
- ..



M2M Requirements

Some requirements of M2M are:

- Having a schedule for exchange messages
- Selection on the route for the message communication
- Anonymity
- Scalability (Additions)
- ..

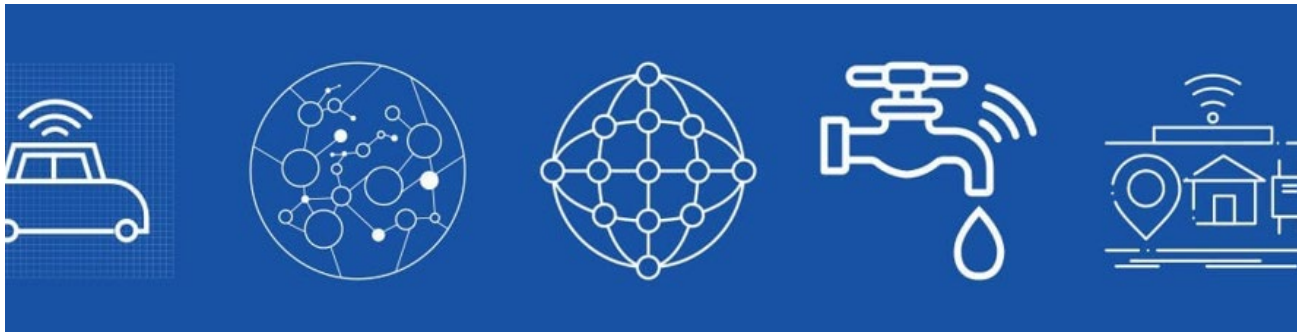
M2M Security

Normally in matter of security, machines are:

- Resistant to sabotage (tamper resistant)
- Internal secure
- Use encryption for communication security
- ..

M2M network decomposing or manage data discretion and its availability are other factors help on security risks

IoT Architecture



IoT Architecture

It consists of the devices, network structure, and cloud technology that allows IoT devices to communicate with each other.

A basic IoT architecture consists of three layers:

- Perception
- Network
- Application

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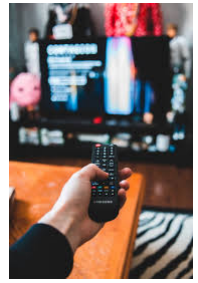
IoT Architecture Importance



IoT Architecture is a tool for administrators to **control** and **assist** IoT smart devices

These devices have a huge range such as an lamp switched on and sensors of pressure in a nuclear plant

The control and the support of all these IoT devices can be ensured with the right distribution and process of data

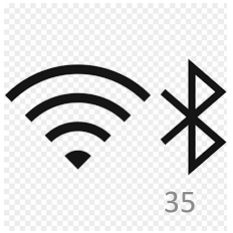
5 Layers of IoT Architecture

These **5 layers** can shed a light on key details about the data usage in the architecture **better than 3** (world preferred) **layers**

Perception → This layer illustrates the physical IoT devices which take data needing processing e.g. robotics, autonomous cars

Transport → This part provides the cloud with the data (or for processing) taken from perception layer

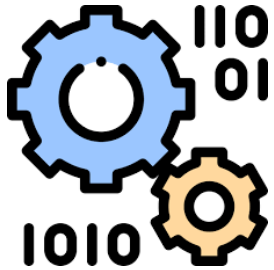
The current layer is using internet gateways to progress data to be process by technologies such: Wi-Fi, Bluetooth..



5 Layers of IoT Architecture

Processing → In case data move to cloud or for processing, server transform data to information

E.g. IoT sensor collects data of temperature changes, AI can spot the malfunction by check & compare the temperature to baseline



Then server sends a message to the unit responsible to put down the temperature

5 Layers of IoT Architecture

Application → Sometimes humans intervene in the process in case of rules not followed

Therefor, in this layer administrator is dealing with IoT devices synchronisation

Business → Here the information becoming intelligence which help us to take decisions

IoTivity

An open-source software framework enabling seamless device-to-device connectivity to address the emerging needs of the Internet of Things

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An Open source IoT - Overview

As it was referred previously billions of smart devices are connected to internet and the number is growing exponentially

Now what we have to make sure, is to obtain a secure and definitive connection in between those devices and with the internet

As an answer of the above challenge, here it comes the IoTivity project

An Open source IoT - Overview

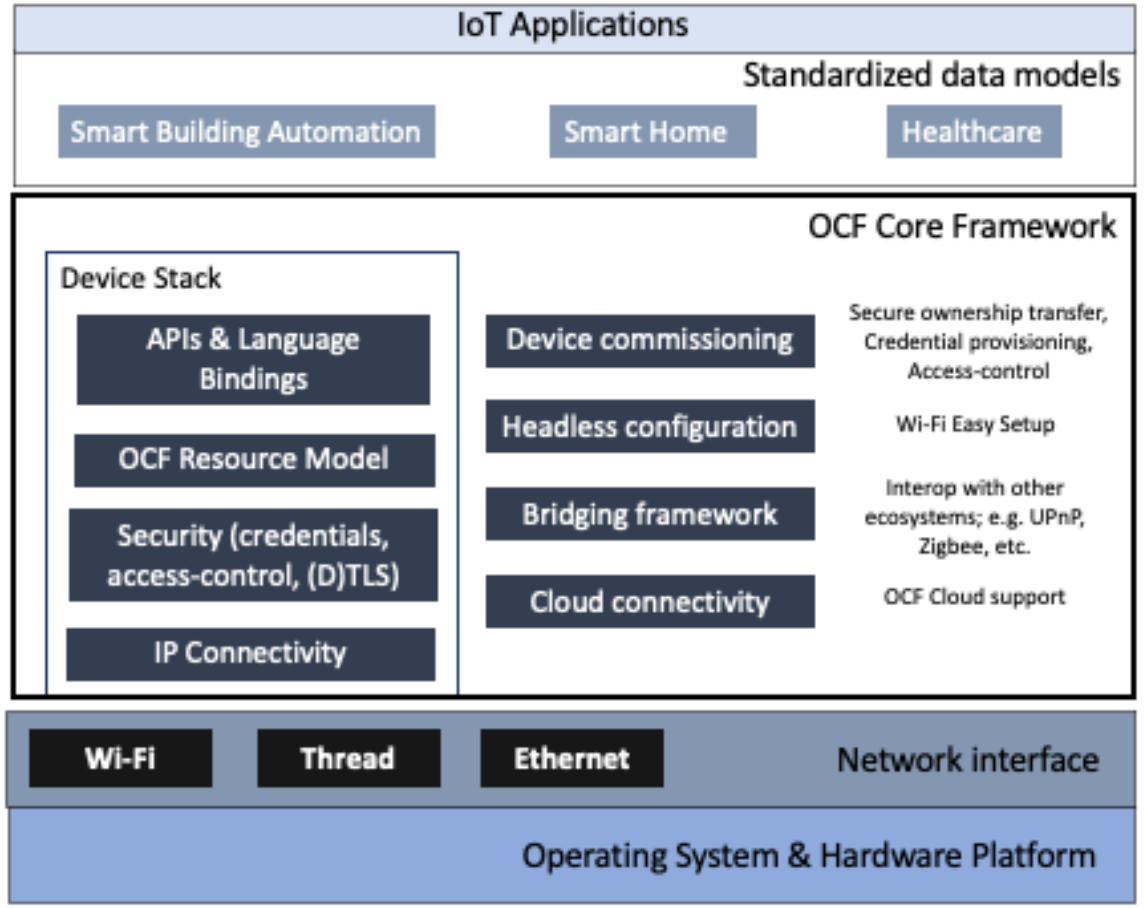
IoTivity constructed to connect that vast amount of smart devices (current and future)

The idea is to assemble the open-source community in order to fasten the development of the services for the devices connection

Open Connectivity Foundation (OCF) funds the project, composed of industry bosses responsible to point out this kind of problems

IoTivity Stack Features

- OS agnostic
- Porting layer
- Optional support for static memory
- C and Java APIs



IoTivity device stack and modules

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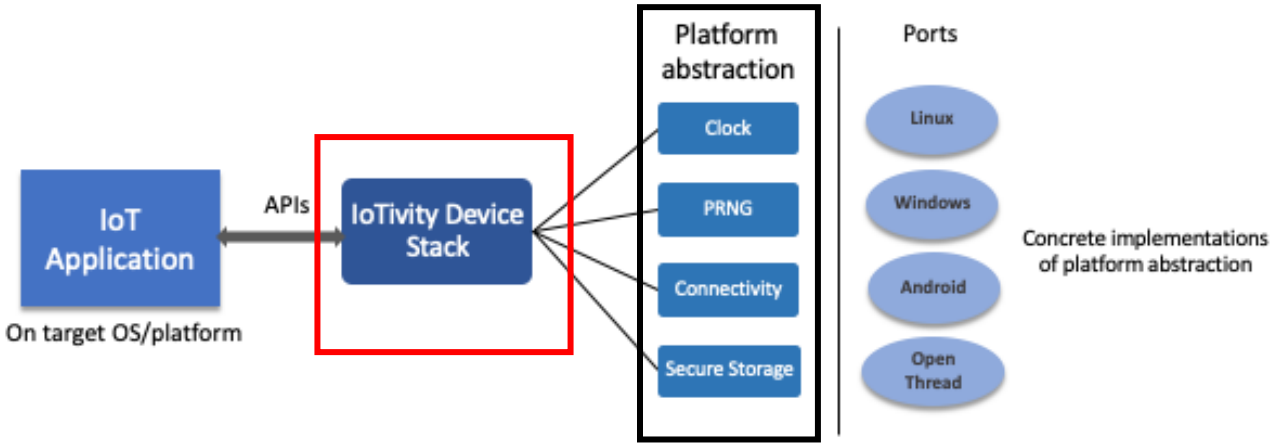
OS Agnostic

Stack and modules of IoTivity operate in cross-platform and perform whenever there is a trigger

Stack operates with the bottom part of hardware platform procedure via a group of **abstract interfaces**



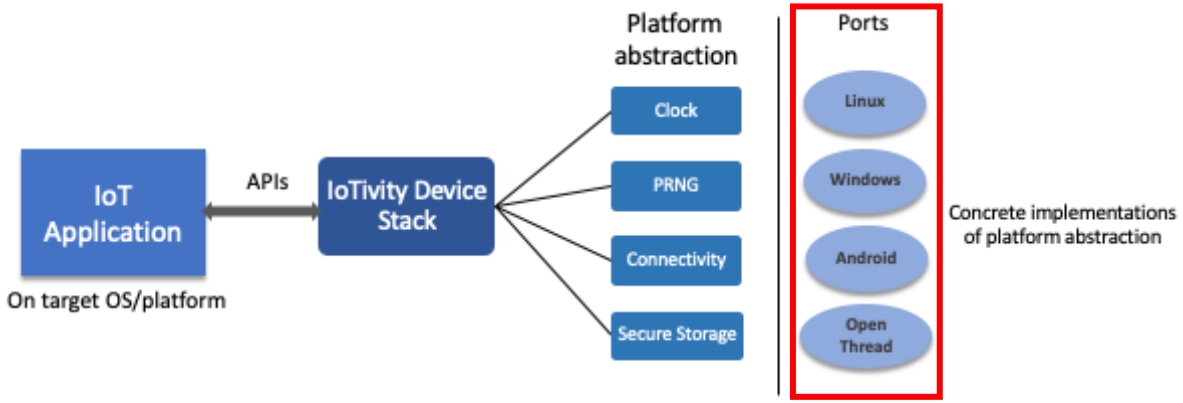
IoTivity was designed for rapid portability to any deployment target

Porting Layer

Platform abstraction is composed of interfaces which stack uses to operate with OS/platform

Those interfaces can executed fast on any OS target since there are simple and limitless

An example of this execution is a '**port**'



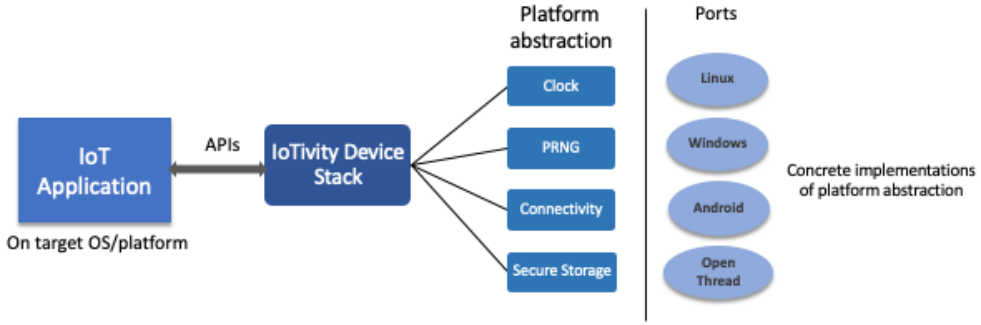
IoTivity was designed for rapid portability to any deployment target

Optional Support for Static Memory

In case of missing distribution procedure stack may set to operate

Static distribution of all internal structures by defining a number of parameters at build time

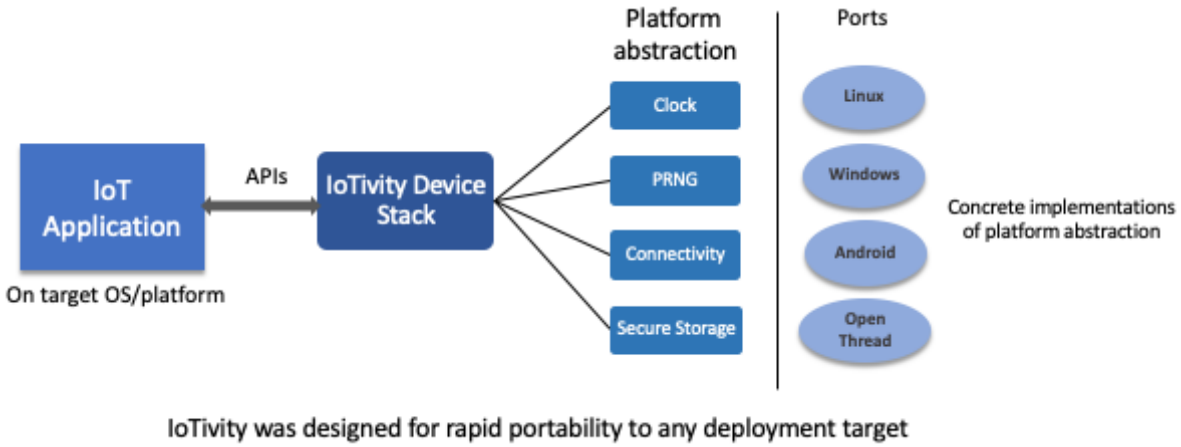
Which consequently limit the allowable workload for an application

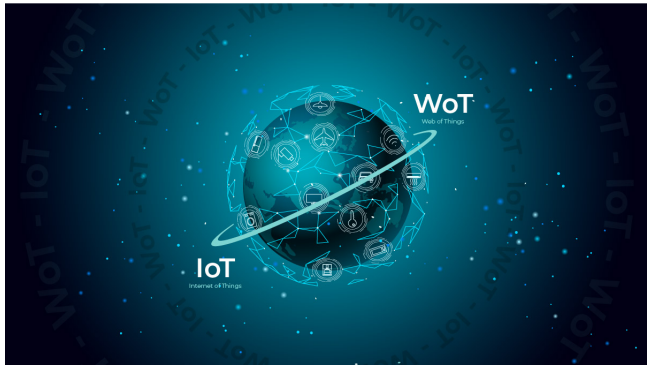


IoTivity was designed for rapid portability to any deployment target

C and Java APIs

Structure and labelling of the API is close to the structures of the OCF specification, making it easier to recognise





Web of Things

Web of Things

Set of standards formed by the world wide web consortium (W3C) to facilitate the interoperability, fragmentation, and usability of the Internet of Things (IoT)

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WoT vs. IoT

- **Easy to program**
- **Faster to integrate**
- **Simpler to prototype and deploy**
- **Easier to maintain large systems**

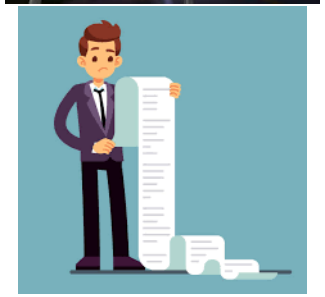
- **More lightweight**
- **Optimised for embedded devices**
- **More bespoke and hard-wired solution**

Aim of both IoT and WoT mainly is to **connect smart devices to the Internet**, although they differ in practise

What if we use a practical example to understand it better?

We can think the **IoT** as the medium connecting food e.g. a **dish** (the object)

Just being the vessel for the mixing of ingredients without having any kind of involvement



Now if we turn to **WoT**, it **includes everything else** for the recipe to be completed e.g. ingredients, stove..

In other words, **IoT** is the **medium** helping **communicate all devices** between them to transfer information (**network layer**)

BUT the **non-involvement** of **IoT** on what kind of data are or how they transfer and even the reason of moving is **important**

That is where the **role of WoT** comes quite handy!!

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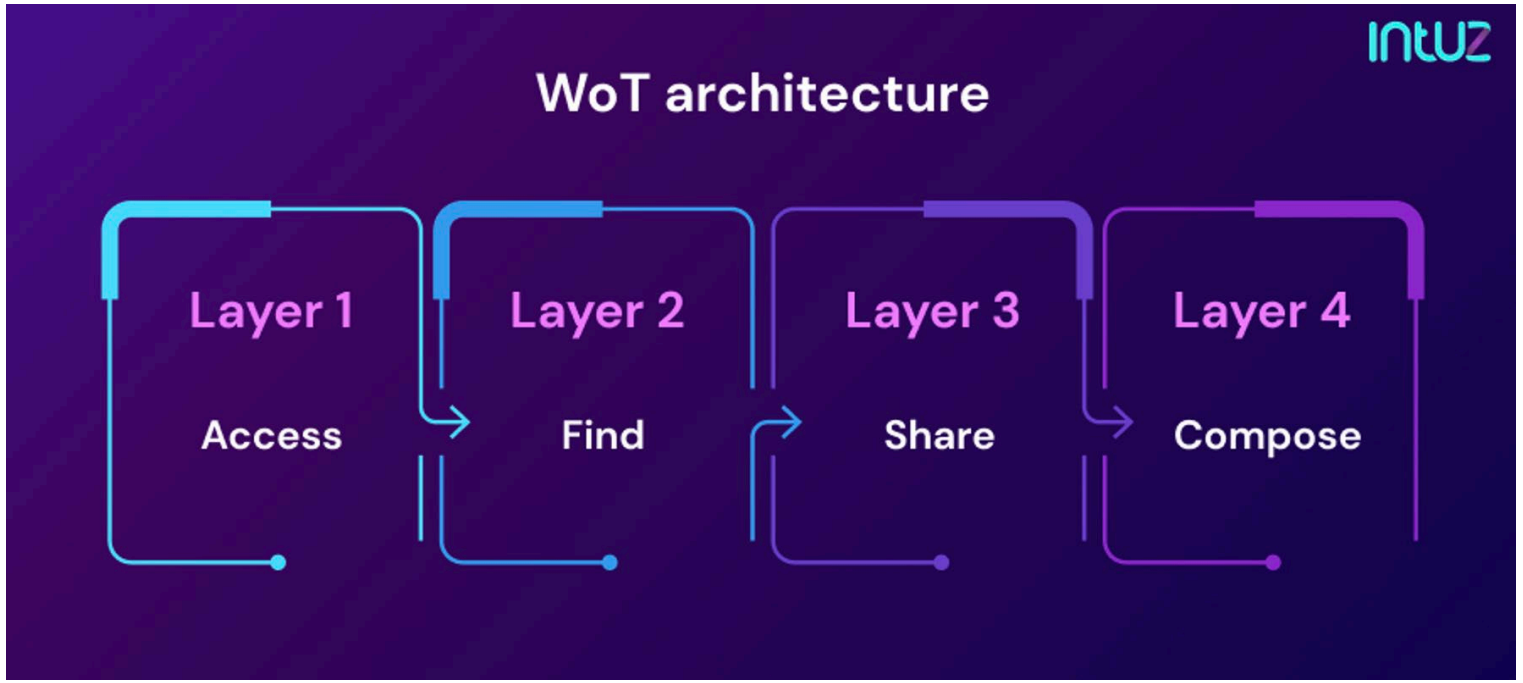
WoT acts as **application layer** and fills the holes that IoT left behind, by setting the rules for the path of data

WoT add group of paths for the data transfer between points and making sure of transceiver-receiver compatibility

WoT could be seen as a **subset of IoT** with **purpose** to **empower** the **IoT characteristics**

WoT Architecture



Layer 1 - Accessibility

WoT consists of various evolving architectural standards, which bring us to the following blocks:

In this layer transform anything to a web thing

In that manner, we have the opportunity to interact with the transforming web thing with HTTP demands

In other words, web thing can be an API which allow us to interact with anything in the real world

Layer 2 - Findability

This layer is there to help applications understand what a data is or the purpose of its existence

Helps internet users operate your device by making it easy to find & work in various WoT applications

It happens by **using web standards** to explain the purpose of **data** & the **things**

Layer 3 - Sharing

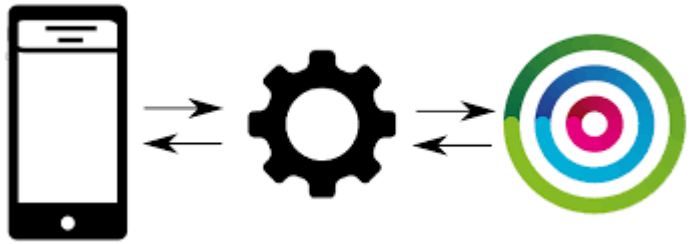
Purpose: Discover a safe manner to move data through services securely

This is achieved with various protocols like TLS, Oauth, etc

Layer 4 - Composition

Purpose: Discover how to create an application for WoT with the appropriate tools

Tools in this layer can be found from **web toolkits** such as JavaScript SDKs



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WoT Example Application

If we want to create a smart house and purchase a lot of IoT devices like:

- Smart TV
- Door
- CCTV cameras
- ..

The way to connect all these together and easy manage them even through our smartphone is the WoT

WoT sets up communication protocols and standards and builds a **web of things**

E.g. In case of burglary cameras send a signal to alarm and to your smartphone

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2 Web Pillars

- **Search Engine Optimization** (SEO) and **Usability** Important Pillars of A Successful Web Design
- **SEO** attracts online users to your website by putting the site in the first page of the search engines or queries.
- **Usability** is all about user's behavior or reactions after they arrive on the site

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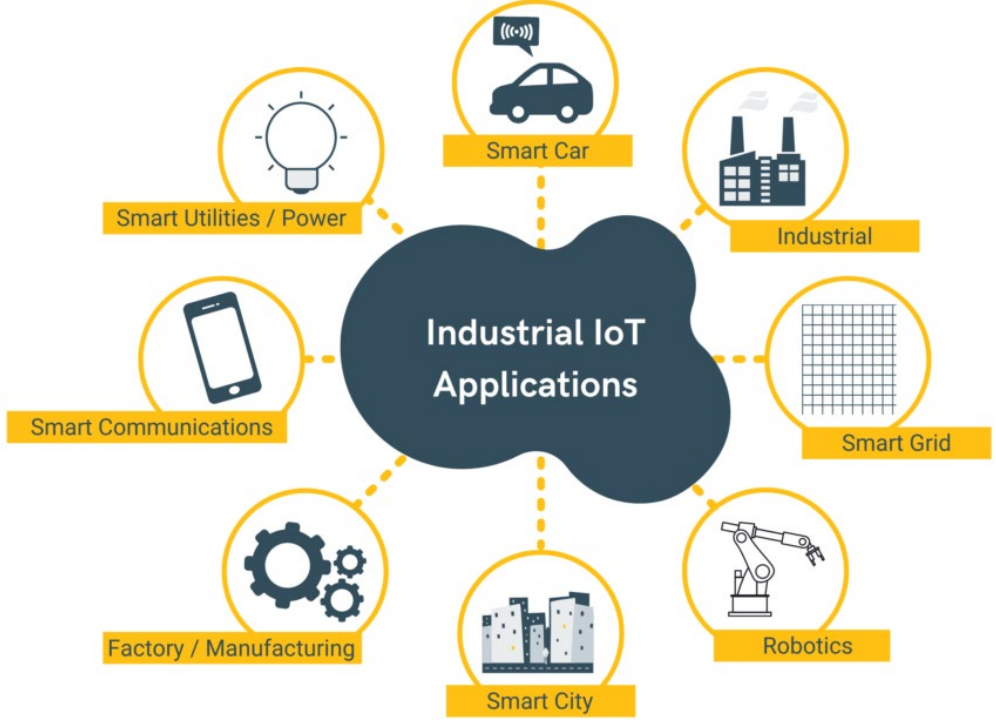
IoT Applications



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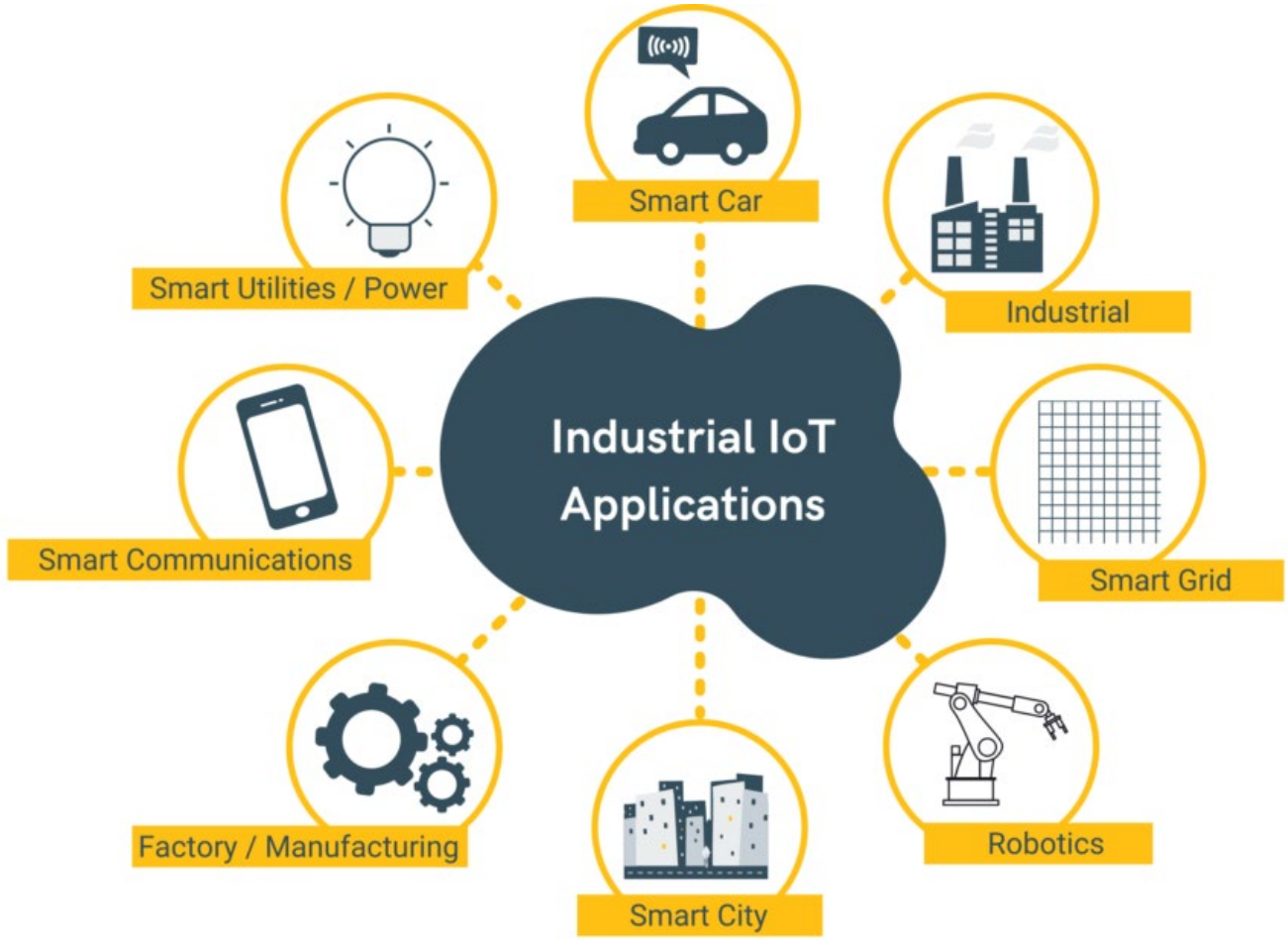
IoT Applications

- IoT Intelligent Applications are prebuilt software applications that can analyze and present captured IoT sensor data to business users via dashboards

- IoT applications use machine learning algorithms to analyze massive amounts of connected sensor data in the cloud



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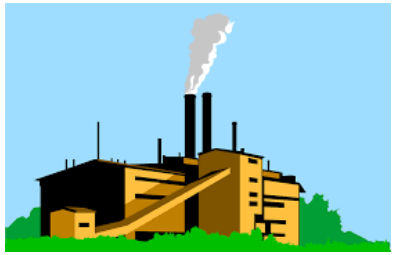
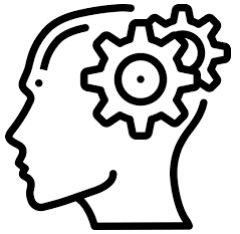
As it is well known industrial applications need huge amount of energy

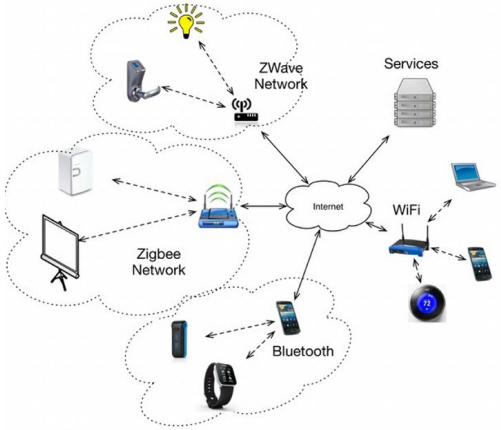
Until now the ability to reach energy data, was limited in monitoring the summation of the consumption, for the entire facility



The **lack** of a real-time view of **energy efficiency,** in different parts of the facility, is **crucial**



Here is where the **I**nternet **o**f **T**hings (**IoT**) steps in



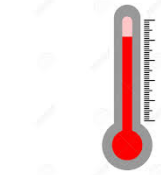
Internet **o**f **T**hings (**IoT**) can provide detailed data regarding energy consumption

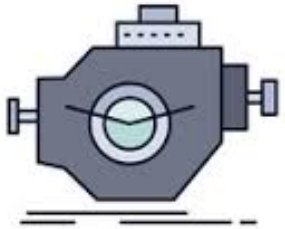
These analytic data can reveal **abnormal energy consumption** and spot **energy efficiency gaps**

In a plant, IoT application can be used to check the energy performance of machines and collect useful data

Data from a machine could be power consumption & operating parameters such as:

- Temperature
- Pressure
- Speed
- ..





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IoT Applications for Industry

- This part explains how to apply Internet of Things technologies in manufacturing

- Sensors, processors, systems and platforms used by manufacturing businesses to create greater efficiencies in operations

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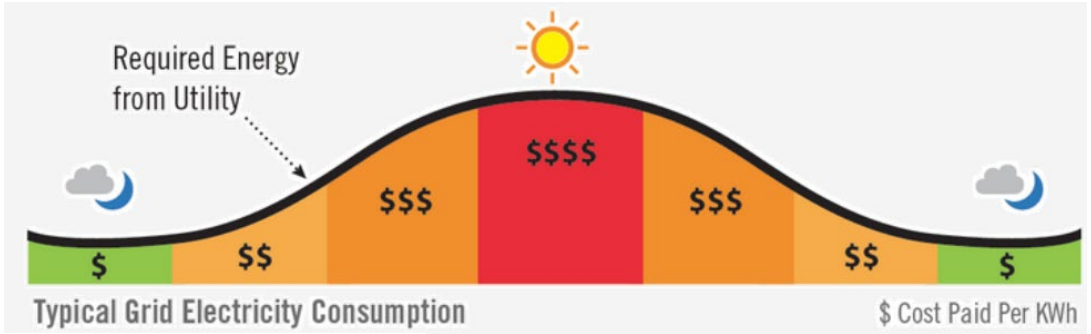
Example 1 - Why using IoT in Industry

The collected data (with usage patterns), may point out older parts of equipment, dissipating more energy than new models

Therefor a replacement of components may take place to improve the efficiency of the model

Example 2 - Why using IoT in Industry

Change time-shift of machines that have high consumption in energy, **NOT** operating during peak energy times **(High cost)**



Example 3 - Why using IoT in Industry

Smart Water Management assist its clients (consumers) to check their water consumption and bring forth useful information

In order to do so, recruits several sensors to check different factors regarding the water such as temperature, quality..

Example 3 - Why using IoT in Industry

Smart meters transmit information with the water company,

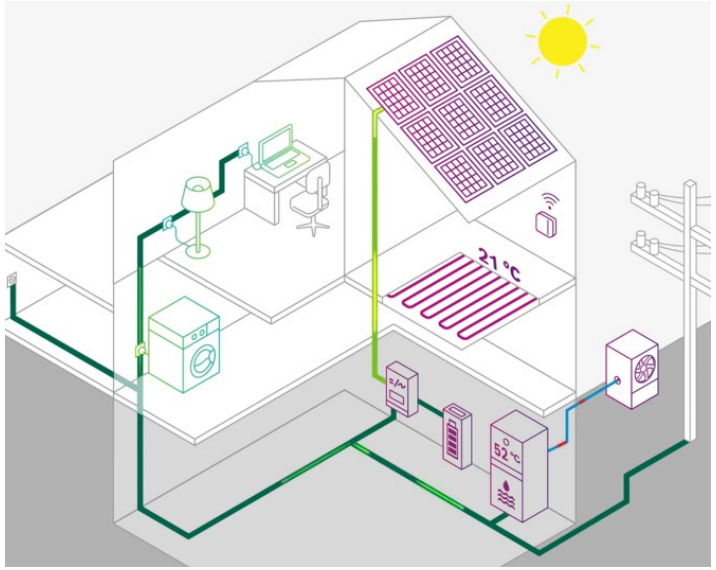
Analyze the data with a software and

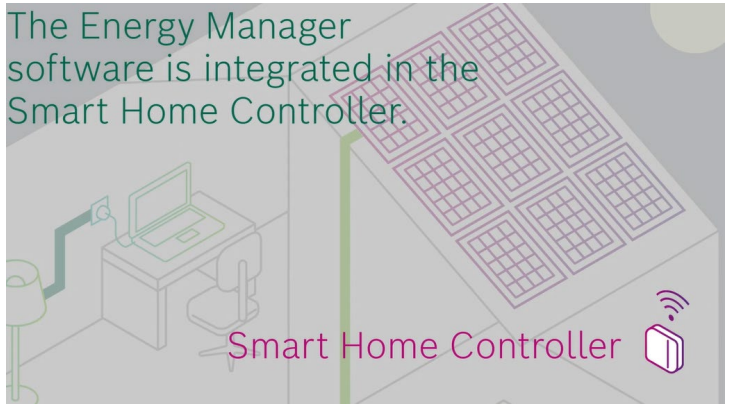
Return the data to consumer in a simple form

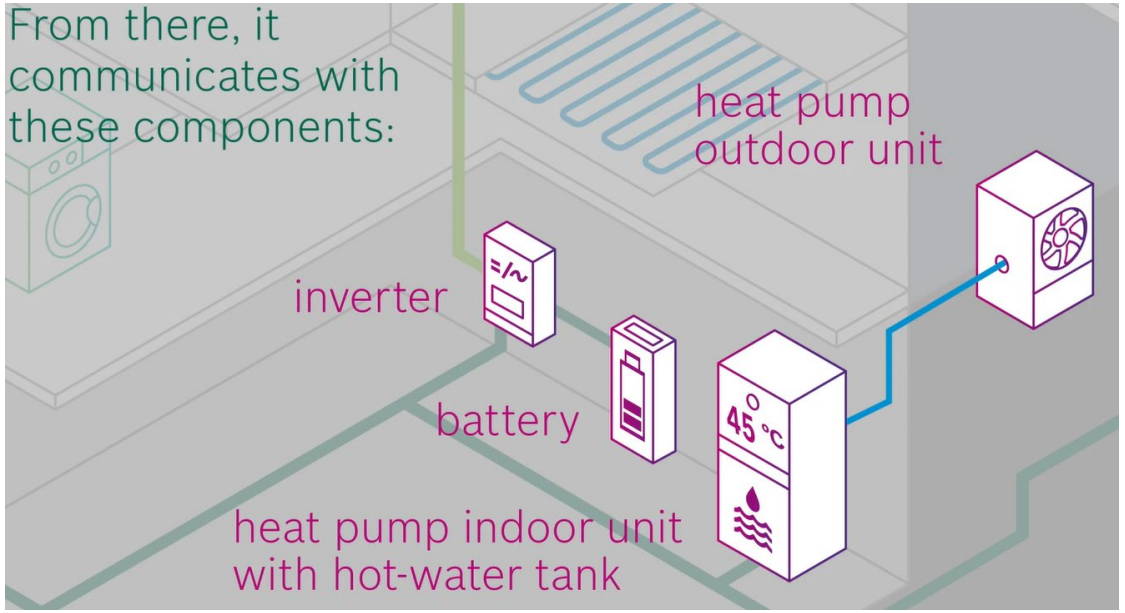
How do smart meter help on the water utilities to act in advance:

- Monitor and inspect for corroding pipes
- Look on real-time data to check for leaks
- Give the advantage to consumers checking their water consuming through software

Example 4 - A household







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