

# Internet of things

## What? Why? And How?



By: Eng. Javier Hernández



# About Me



- Computer Engineer
- Developer
- Nerd
- Twitter @soynerdito
- soynerdito@gmail.co  
m
- Interests (no particular order)
  - Programming
  - Making
  - Security
  - Hardware
  - Tech communities
  - Just now - Agriculture



@Soynerdito

# Goals



- What is lot?
- Why is so popular?
- Gain awareness of challenges
- Focus on making our own
- Motivate getting hands dirty into making stuff at hobby or business



# Iot Background

Definition (What is?)



# What is iot? Source: Wikipedia



- The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data,[1][2][3][4] creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions



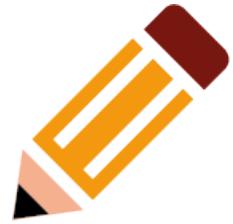
# What is iot? Source: Wikipedia



- network of physical devices
  - vehicles, home appliances, and other items
- embedded with electronics
  - software, sensors, actuators, and connectivity
- enables things to connect and exchange data
- direct integration of the physical world into computer-based systems



# What is a device



- Mobile phones, tablets, laptops
- Transportation: Car, Bus, bikes
- Home appliances: Fridge, TV
- Traffic lights
- Doors
- Clothes
- Furniture
- Anything and everything



# Every device has network connectivity



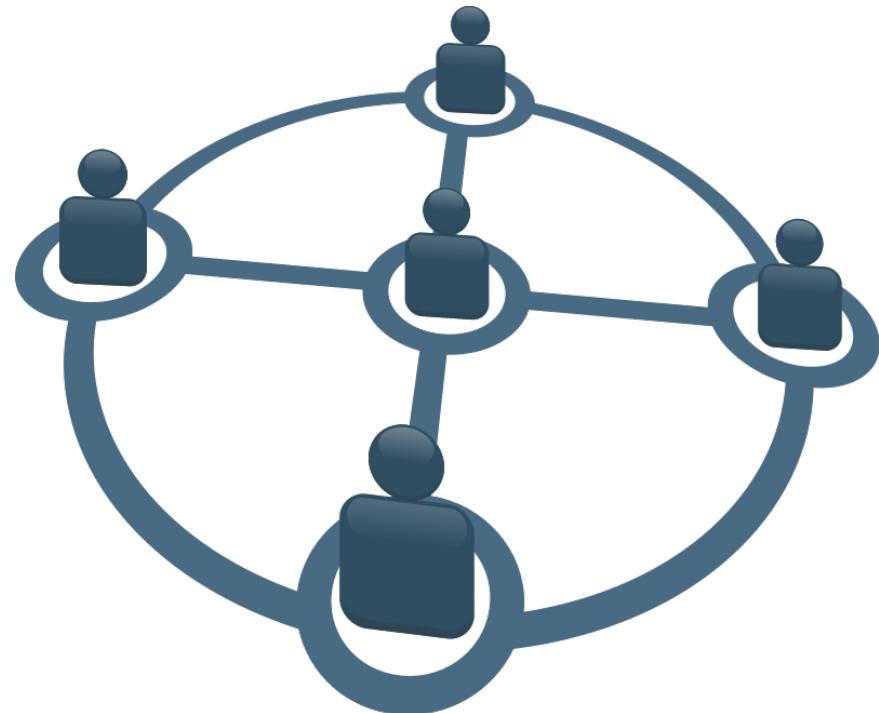
- Some examples may be:

- Wireless

- Bluetooth
    - Wifi
    - RF
    - IRDA
    - LoraWAN

- Wired

- Ethernet
    - RS232/RS485
    - USB



# LoRa (Long Range)



- uses license-free sub-gigahertz radio frequency bands like 169 MHz, 433 MHz, 868 MHz (Europe) and 915 MHz (North America).
- Enables very-long-range transmissions (more than 10 km in rural areas) with low power consumption. The technology is presented in two parts — LoRa, the physical layer and LoRaWAN (Long Range Wide Area Network), the upper layers.

Source: <https://en.wikipedia.org/wiki/LoRa>

# LoRa example



## ESP32 LoRa IOT 868MHz-915MHz SX1276 OLED Module Wifi Bluetooth Development Board

Estado: **Nuevo**

Cantidad: **1** Último  
19 vendidos / Ver comentarios

Precio: **15.87 EUR** Aproximadamente US \$18.66

**iCómpralo ahora!**

**Agregar al carro de compras**

**• Agregar a Lista de favoritos**



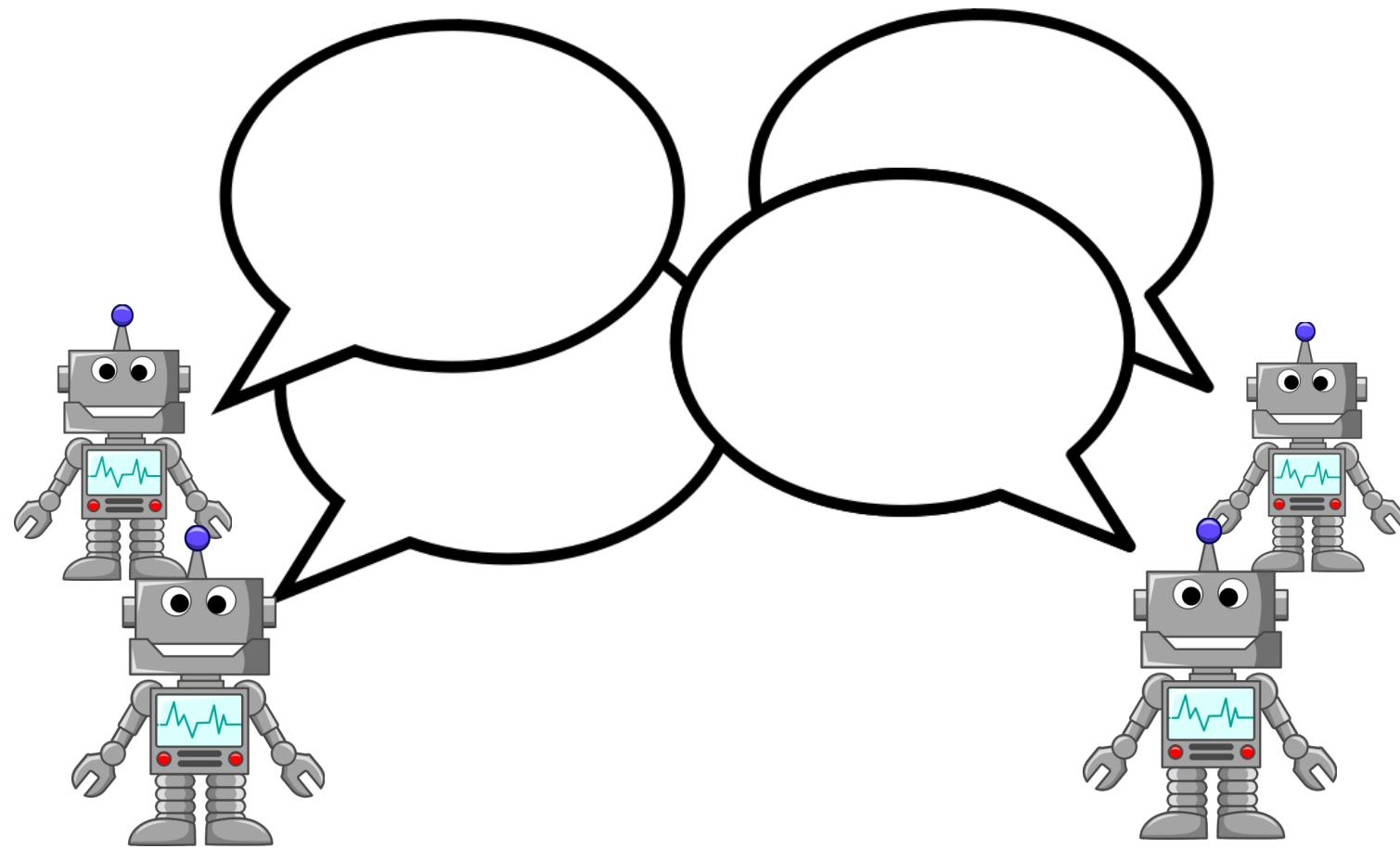
**868-915MHz**

Source: ebay.com

# Send and Receive Data



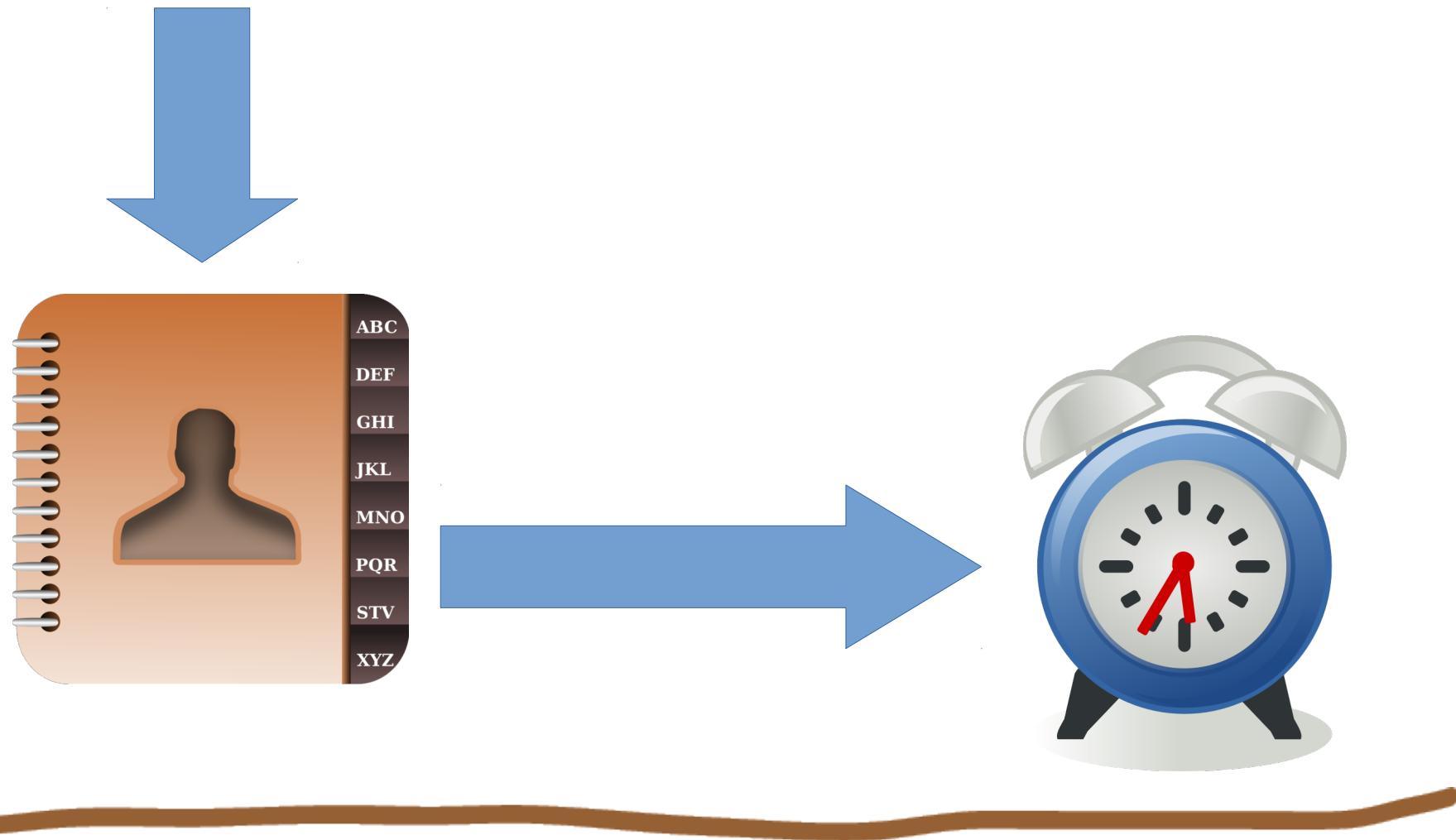
- The devices can talk!



# Example



- Monday 8AM meeting @Office



# Monday



- Morning
  - Wake up on time
  - Automatically make coffee



Make Coffee



Coffe, tea?

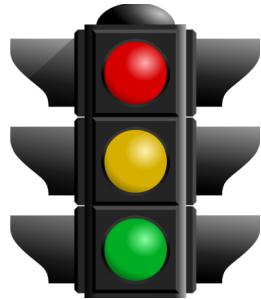
by Marolo Rei



# Monday



- Traffic report
- Estimated morning commute delay 30min



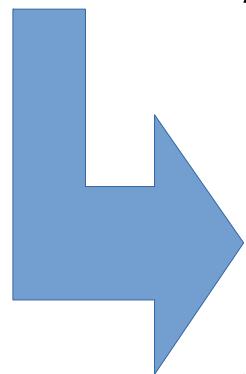
# Monday



- Traffic report
  - Estimated morning commute delay 30min



Adjust alarm -30min



Make Coffee



Coffe, tea?

by Manolo Rei

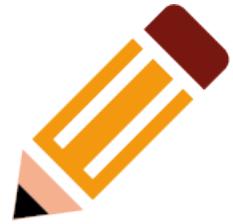


# Traditionally

- Person set water by timer



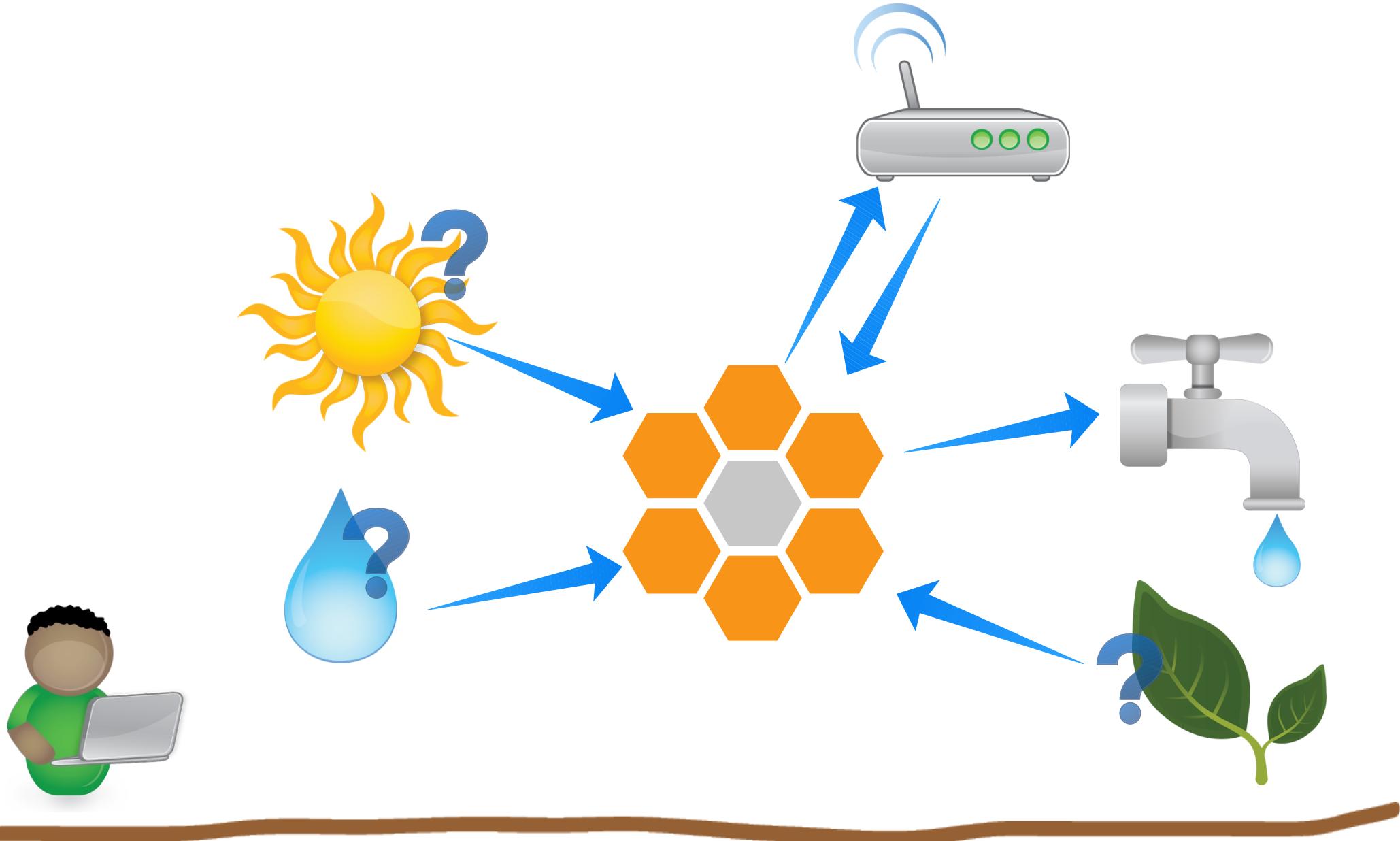
# Traditionally



- Person set water by timer
- Is really needed?
- Was the plant dry?
- Did it rained?
- Will there be rain latter today?
- Feedback, was it activated?



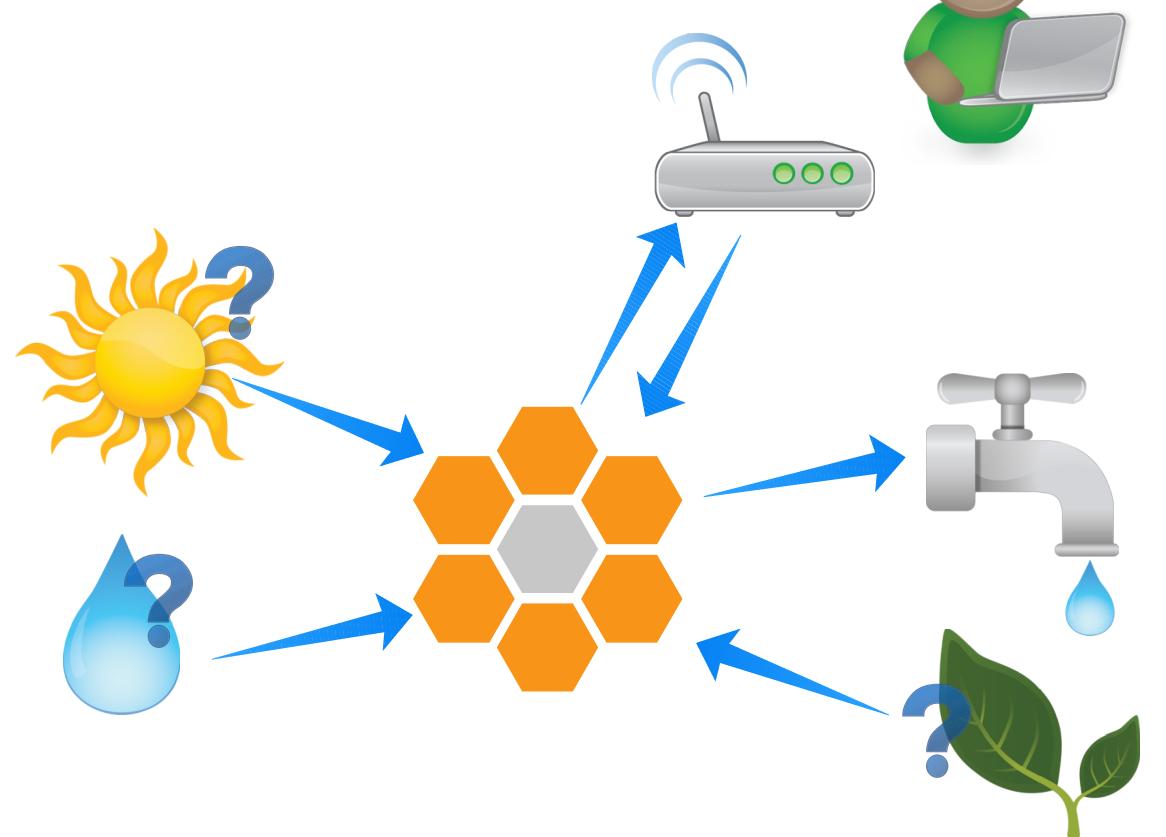
# More integrated with internet



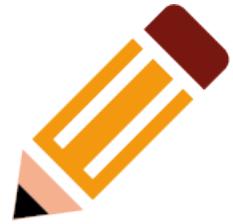
# “IoT” like solution



- Sensors provide information
  - Light
  - Temperature
  - Water
  - Soil moisture
  - Weather forecast
  - Is water available
- User feedback



# Is this new?



- The concept of a network of smart devices was discussed as early as 1982, with a modified Coke machine at Carnegie Mellon University becoming the first internet-connected appliance,[9] able to report its inventory and whether newly loaded drinks were cold.



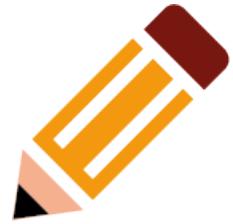
Source: Wikipedia  
[http://en.wikipedia.org/wiki/Internet\\_of\\_Things](http://en.wikipedia.org/wiki/Internet_of_Things)

# 1982?



Also in 1982





# Example: Weather station



- Sensor
  - Wind speed
  - Wind direction
  - Rain
  - Temperature
  - Humidity
  - Barometer
- Connectivity
  - Wifi
- Interaction
  - App
  - Display

Source: Amazon.com

[https://www.amazon.com/Ambient-Weather-Professional-Monitoring-Compatible/dp/B01N5TEHLL/ref=sr\\_1\\_3?ie=UTF8&qid=1535421699&sr=8-3&keywords=weather+station](https://www.amazon.com/Ambient-Weather-Professional-Monitoring-Compatible/dp/B01N5TEHLL/ref=sr_1_3?ie=UTF8&qid=1535421699&sr=8-3&keywords=weather+station)

# Gartner: 26 Billions devices



- 26 billions units installed in 2020
- Almost 30-fold increase from 0.9 billions in 2009

## Gartner Says the Internet of Things Installed Base Will Grow to 26 Billion Units By 2020

The [Internet of Things](#) (IoT), which excludes PCs, tablets and smartphones, will grow to 26 billion units installed in 2020 representing an almost 30-fold increase from 0.9 billion in 2009, according to Gartner, Inc. Gartner said that IoT product and service suppliers will generate incremental revenue exceeding \$300 billion, mostly in services, in 2020. It will result in \$1.9 trillion in global economic value-add through sales into diverse end markets.

Source: <http://www.gartner.com/newsroom/id/2636073>  
Diciembre 2013

# Will there be enough IPs



- IPV6
  - A main advantage of IPv6 is increased address space. The 128-bit length of IPv6 addresses is a significant gain over the 32-bit length of IPv4 addresses, allowing for an almost limitless number of unique IP addresses.

Source:

<http://whatismyipaddress.com/ip-v6>



# Iot Background

Why is so popular?



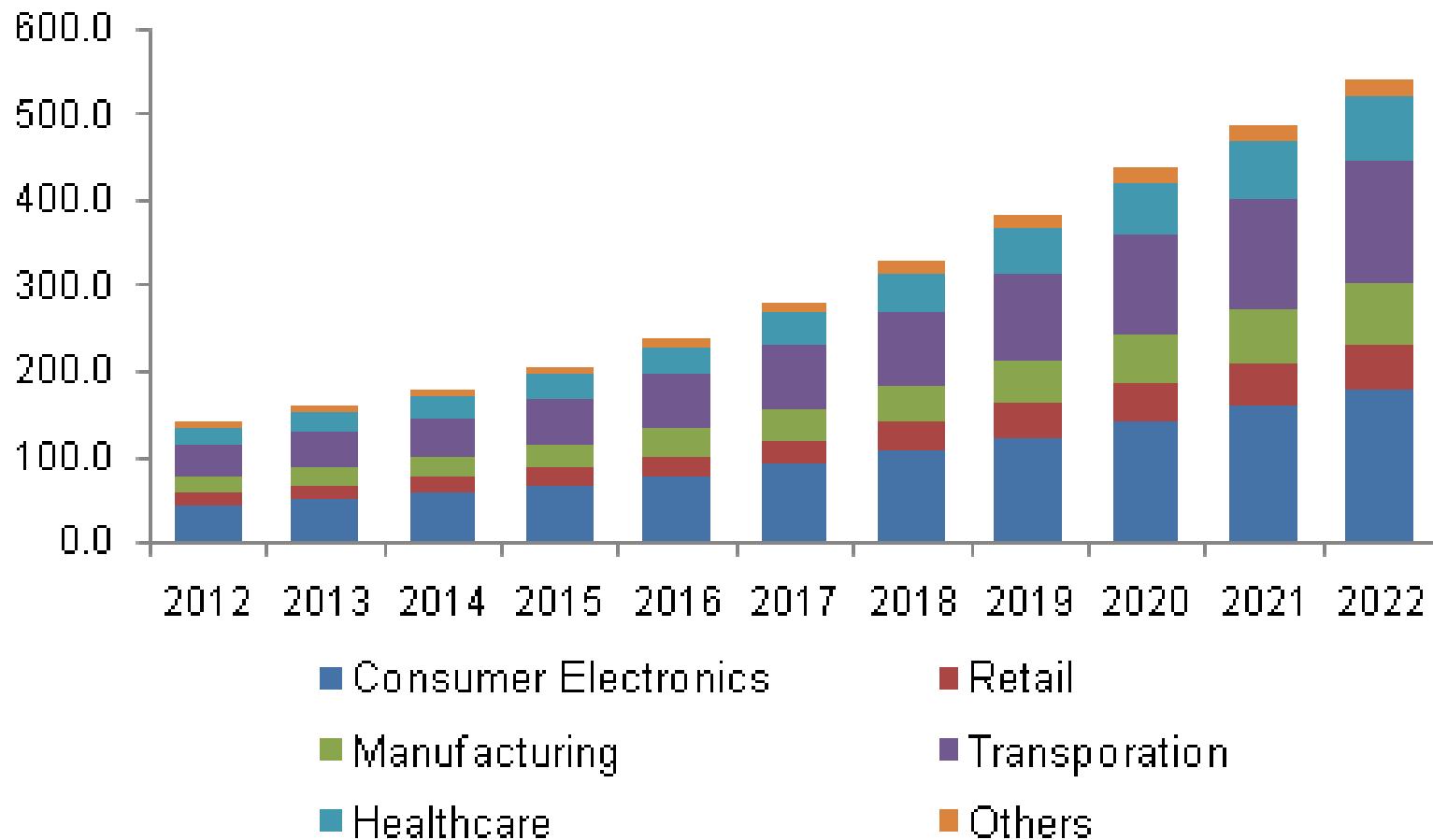
# Industry Insights



- The global Internet of Things (IoT) market size was valued at **USD 605.69 billion in 2014**. Technological proliferation and increasing investments are expected to drive the global market over the next seven years. Significant advances in telecommunication and growing penetration of internet and broadband services have further propelled the growth of Internet of Things (IoT) industry.

Source: <https://www.grandviewresearch.com/industry-analysis/iot-market>

# North America IoT market revenue by application, 2012 - 2022 (USD Billion)



Source: <https://www.grandviewresearch.com/industry-analysis/iot-market>



# Companies & Campaigns





The screenshot shows the ARM website's navigation bar with links for Products, Support, Community, Markets, and About. Below the navigation, there's a search bar and a "Quick Links" sidebar with links to General Resources, IP Graphics, IP Tools, and ARM Patent. The main content area features a large heading "Internet of Things (IoT)" with a sub-section titled "ARM creates sensors, controllers, and other". It includes a brief description of IoT and a call-to-action button labeled "Discover".

[More Details](#)

# ARM



## ARM

**Stock Ticker:** ARMH

**Market Cap:** 22.07B

"ARM's comprehensive product offering includes 32-bit RISC microprocessors, graphics processors, enabling software, cell libraries, embedded memories , high-speed connectivity products, peripherals and development tools."

**IoT Overview:** "ARM creates sensors, controllers, and other embedded intelligence in devices. The Internet of Things (IoT) is the collection of smart, sensor-enabled physical objects, and the networks, servers and services that interact with them. It is a trend and not a single sector or market. However, ARM's technology designs enable the current and future IoT applications and services to become truly ubiquitous and intelligent."

### IoT Projects & Activity:

- [Internet of Things Site](#)
- [UK Technology Strategy Board project](#)
- [Acquired Sensinode](#)
- [Video - ARM CEO on the 'Internet of Things'](#)

# Atmel



**Atmel®**



[More Details](#)

## Atmel

**Stock Ticker:** ATML

**Market Cap:** 3.16B

"Worldwide leader in the design and manufacture of microcontrollers, capacitive touch solutions, advanced logic, mixed-signal, nonvolatile memory and radio frequency (RF) components."

**IoT Overview:** "Today, Atmel is right at the heart of The Internet of Things, a highly intelligent, connected world where Internet-enabled devices will outnumber people. Our technologies are fueling machine-to-machine (M2M) communications and the "industrial Internet."

### IoT Projects & Activity:

- Purchased Ozmo a provider of low power WiFi in 2004
- Embedded Design Blog // IoT Tag

# BOSCH



[More Details](#)

## Bosch

**Stock Ticker:** Private

**Size:** Approximately €52.5 billion in revenue in 2012

"The Bosch Group is a leading global supplier of technology and services, active in the fields of automotive technology, energy and building technology, industrial technology, and consumer goods."

**IoT Tagline:** *The Internet of Things and Services*

**IoT Overview:** "In the near future, more and more devices and systems will be capable of sending and receiving data automatically via the internet. We're already poised on the verge of new developments that offer enormous market potential. According to our estimates, by the year 2015 more than six billion devices and systems will be connected to each other and exchanging data via the internet. The Internet of Things and Services (IoTS) isn't just a distant vision of the future, however – it's already very real and is having an impact on more than just technological developments."

### IoT Projects & Activity:

- [Internet of Things Blog // RSS](#)
- [Video Introduction](#)
- [Bosch IoT Labs](#)



# Cisco



[More Details](#)

## Cisco

**Stock Ticker:** CSCO

**Market Cap:** 125.08B

"Cisco hardware, software, and service offerings are used to create the Internet solutions that make networks possible-providing easy access to information anywhere, at any time."

**IoT Tagline:** *The Internet of Everything*

**IoT Overview:** "Cisco defines the Internet of Everything (IoE) as bringing together people, process, data, and things to make networked connections more relevant and valuable than ever before-turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunity for businesses, individuals, and countries."

### IoT Projects & Activity:

- Whitepaper
- Video Introduction
- Infographic
- \$150m IoT Fund
- IoT World Forum

# GE



Introducing the Industrial Internet  
The GE Industrial Internet is a new way to do business. It's a way to connect all the assets, people and systems in your business to the Internet, so you can make better decisions faster. And it's a way to connect your business to other businesses, so you can work together to create new products and services.



[More Details](#)

## GE

**Stock Ticker:** GE

**Market Cap:** 248.43B

"We build appliances, lighting, power systems and other products that help millions of homes, offices, factories and retail facilities around the world work better."

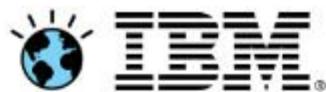
**IoT Tagline:** *Industrial Internet*

**IoT Overview:** "New GE technology merges big iron with big data to create brilliant machines. This convergence of machine and intelligent data is known as the Industrial Internet, and it's changing the way we work."

**IoT Projects & Activity:**

- [IndustrialInternet.com](#)
- [Minds & Machines Conference](#)
- [Whitepaper \(PDF\)](#)
- [Video: Brilliant Machines](#)

# IBM



[More Details](#)

## IBM

**Stock Ticker:** IBM

**Market Cap:** 203.48B

"IBM offers a wide range of technology and consulting services; a broad portfolio of middleware for collaboration, predictive analytics, software development and systems management; and the world's most advanced servers and supercomputers."

**IoT Tagline:** *Smarter Planet*

**IoT Overview:** "Over the past century, we have seen the emergence of a kind of global data field. The planet itself—natural systems, human systems, physical objects—have always generated an enormous amount of data, but until recent decades, we weren't able to hear it, to see it, to capture it. Now we can because all of these things have been instrumented with microchips, UPC codes and other technologies. And they're all interconnected, so now we can actually have access to the data. In effect, the planet has grown a central nervous system and is developing intelligence. It's becoming a much smarter planet."

**IoT Projects & Activity:**

- Video: [IoT Overview](#)
- Whitepaper: [A mandate for change is a mandate for smart](#) (PDF)
- [MQTT Support](#)
- [IBM MessageSight](#)
- [IBM MoteRunner](#)



# And a lot more



Microsoft

Cloud Platform

Overview Solutions Products Try/Buy

## Create the Internet of Things

The Internet of Things (IoT) is here today in the devices, sensors, cloud services, and data your business uses. Begin with us to help your company: the Internet of Your Things.

- Read about Microsoft's vision for IoT
- Get the facts
- Get started with IoT today



ORACLE

Sign In/Register Help Country ▾ C

Products Solutions Dev

## Oracle Internet of Things Platform

Solutions for a Connected World

Overview

Acquire and Manage

Integrate a

Oracle Simplifies Internet of Things

Maximizing Value from Connected Devices

In this connected world, the proliferation of intelligent devices has created a market for entirely new solutions based on Internet of Things (IoT) technology. With the ever-increasing amount of data that is inherent in an IoT world, the key to gaining real business value is effective communication among all elements of the architecture.

More Details

## Microsoft

Stock Ticker: MSFT

Market Cap: 373B

"Microsoft Corporation develops, licenses, markets, and supports software, computers, and related services worldwide."

**IoT Overview:** "The Internet of Things (IoT) is here today in the devices, sensors, cloud

services, and data your business uses. Begin with us to help your company: the Internet of Your Things."

## IoT Project

The Best-Run Businesses Run SAP United States Newsletter Community Free Trial Contact Us

Internet of Things Internet of Things Solutions Internet of Things Technology Community Experts

SAP.com Products Internet of Things

## Make Internet of Things Real: Monitor, Analyze, Automate.

Transform the way you do business with Internet of Things offerings from SAP. Our end-to-end offering for Internet of Things provides everything your business needs to create a System of Things - M2M Connectivity, cloud platform, device management, big data management, event stream processing, predictive analytics, and apps-to make IoT projects real, repeatable and scalable.

Watch: Harnessing the IoT keynote >



**IoT Overview:** "In this connected world, the proliferation of intelligent devices has created a market for entirely new solutions based on Internet of Things (IoT) technology. With the ever-increasing amount of data that is inherent in an IoT world, the key to gaining real business value is effective communication among all elements of the architecture."

Only Oracle's Internet of Things platform delivers an integrated, secure, comprehensive platform for the entire IoT architecture across all vertical markets."

# Cool examples





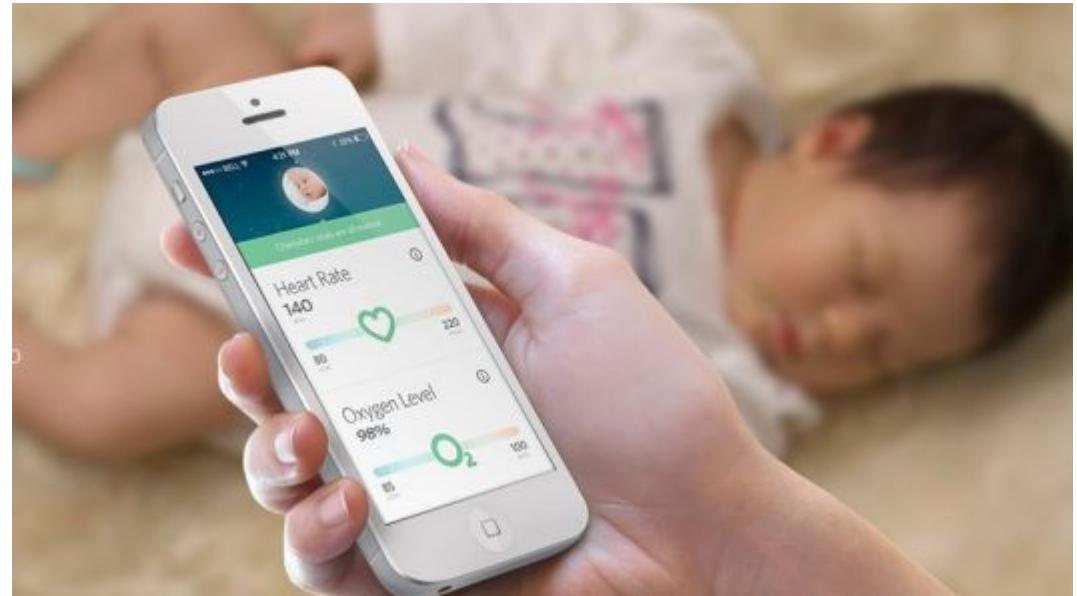
# Baby monitor



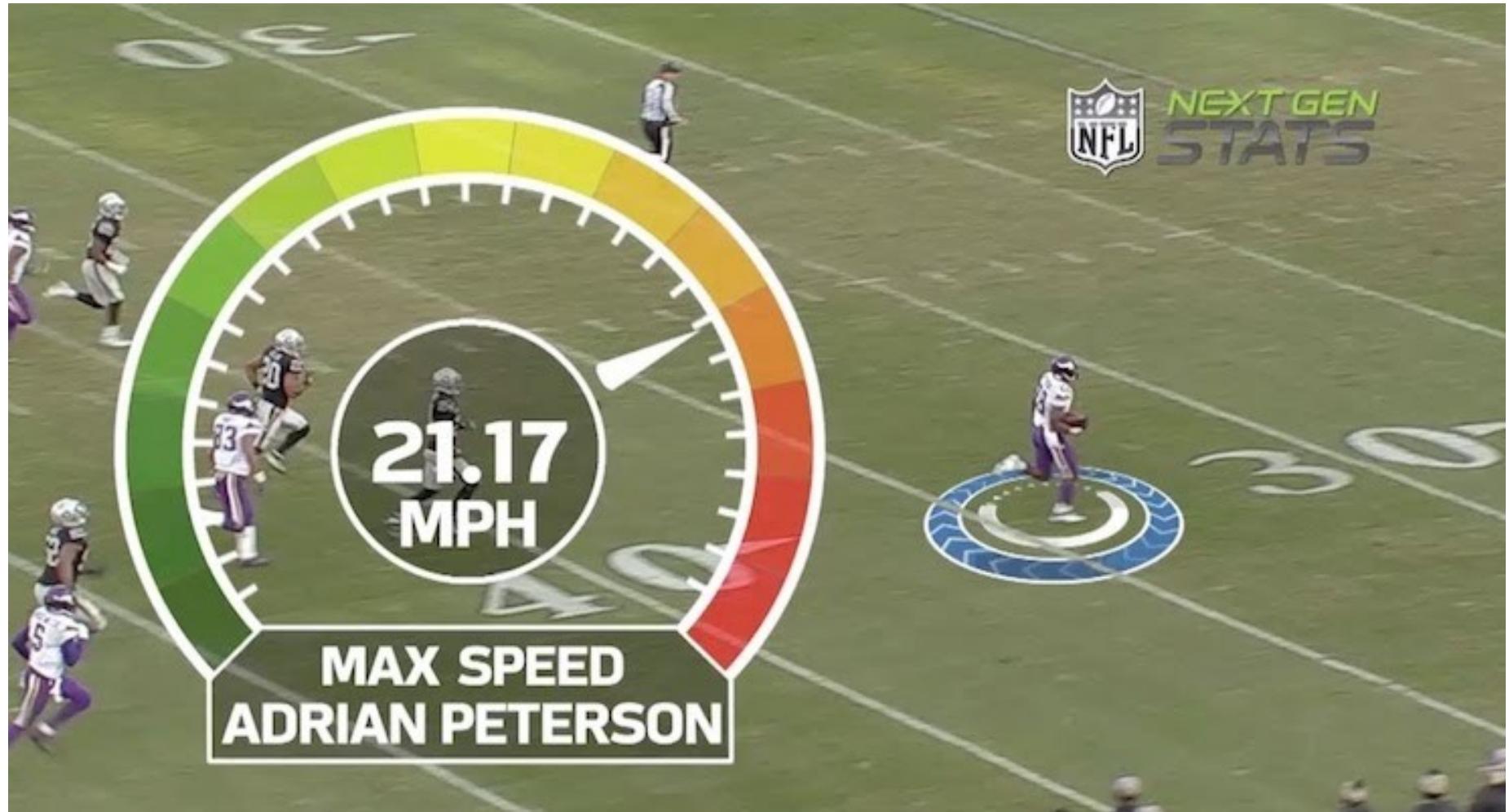
# Creepy baby monitoring



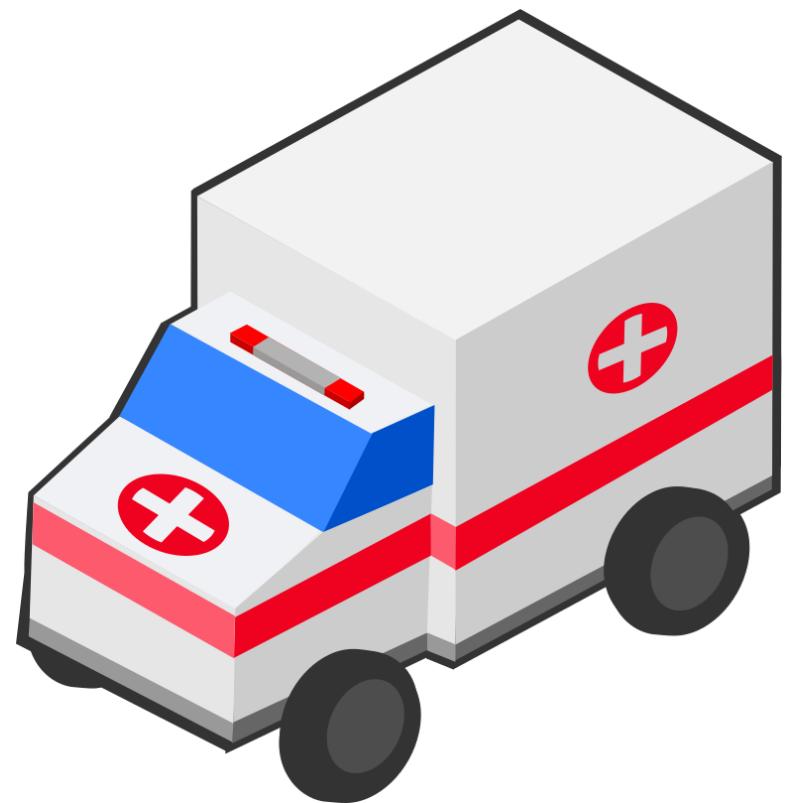
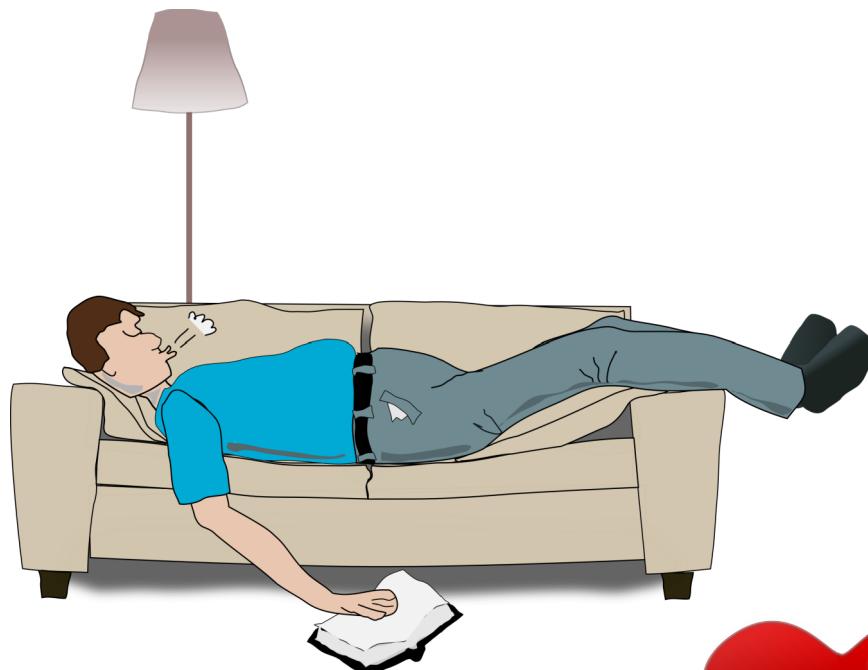
- Heart rate
- Temperature
- Awake?



# Sports



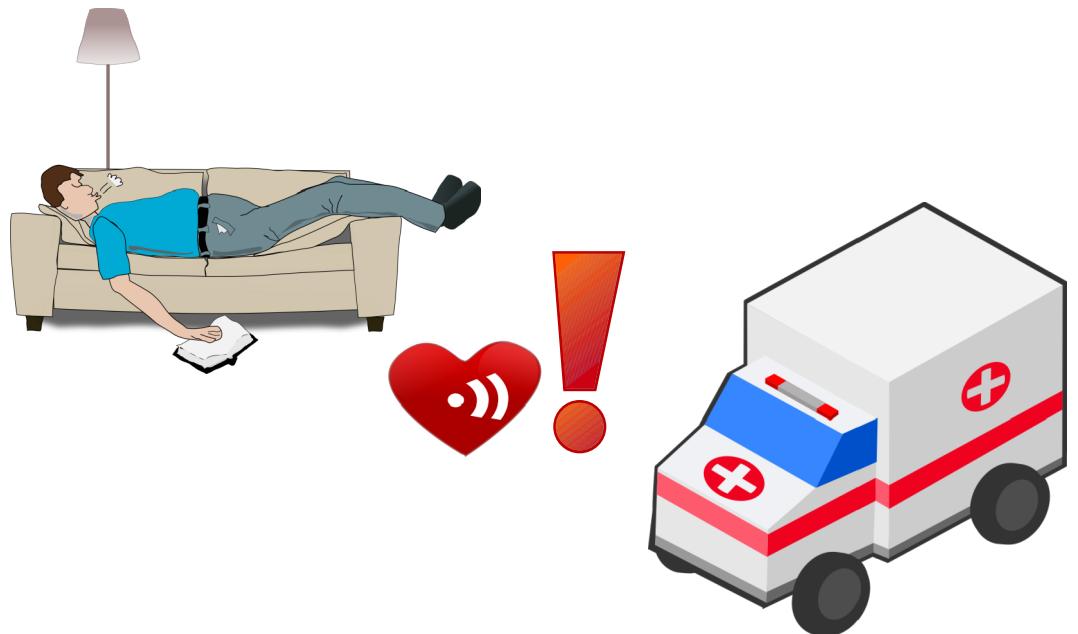
# Health



# Health



- Heart attack
- Call ambulance before it happens
- Patient with doctor while the attack



# Industrial examples



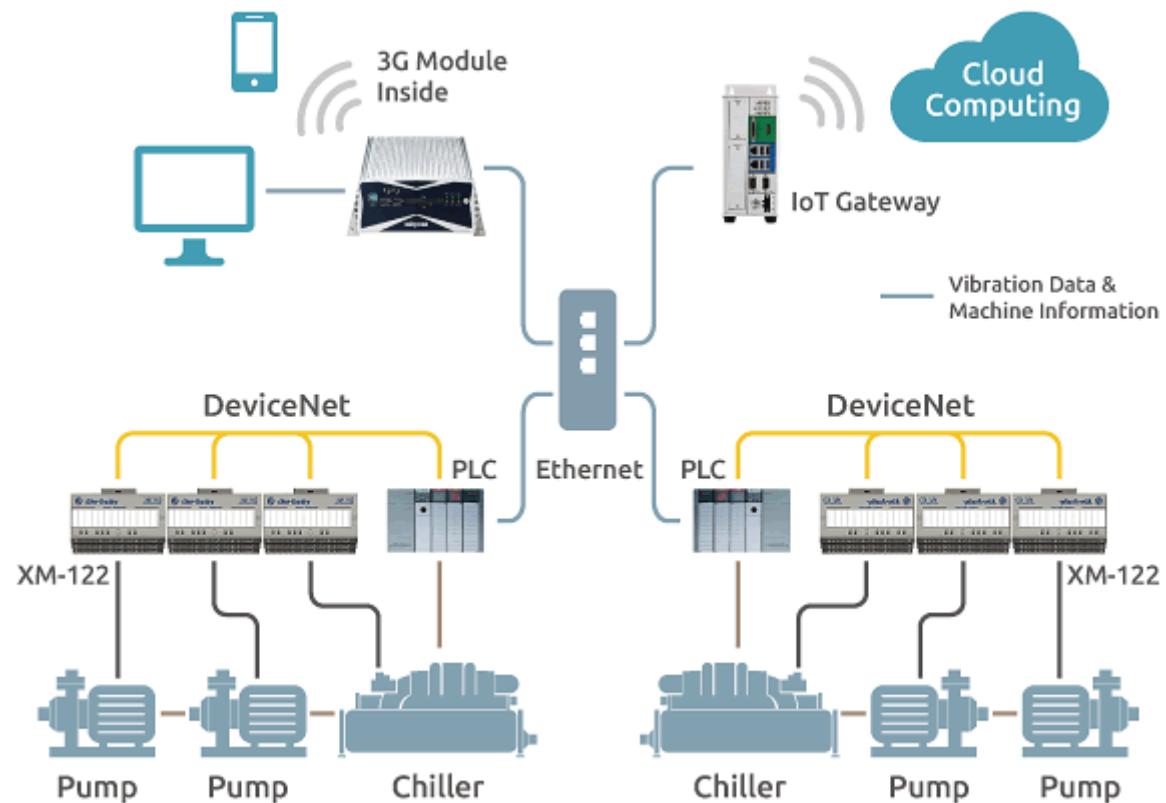
Automation  
Quality control



# PLC connected



- PLC
  - Traditionally dedicated network
  - Link to Ethernet
  - Link to internet (optional)
  - External controls/reporting



# Industrial key features



- Regulation
- **Efficiency**
- Quality and safety
  - Reduce human error
  - Reduce costs
  - Monitoring
  - Measure processes
  - Etc.

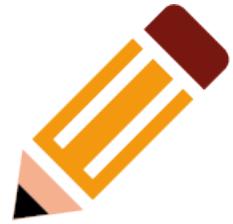


# Stuxnet



- **Stuxnet** is a malicious **computer worm**, first uncovered in 2010. Thought to have been in development since at least 2005, Stuxnet **targets SCADA systems** and is **believed** to be **responsible** for causing substantial **damage** to **Iran's nuclear program**. Although neither country has openly admitted responsibility, the worm is believed to be a **jointly built American/Israeli cyberweapon**.

Source: Wikipedia <https://en.wikipedia.org/wiki/Stuxnet>



Nuclear plant?  
Who cares?



# HP Printer hack



## Printers Can Be Hacked to Catch Fire

These devices are completely open and available to be exploited, a researcher says

---

By Paul Wagenseil, SecurityNewsDaily on November 29, 2011



# Security



- Communication protocols
  - Encrypted, vulnerable?
- Who can decide what?
  - Users and user validation
  - Data storage
- Is it accessible from the network?
  - What network?
  - By whom?
- Worst case scenario what could happen



# Some considerations



- Keep up to date
  - Security patches
  - Devices end of life, support
- Fail over plans
  - What if the system is down
- Integration with other systems
- Constant validation, testing
  - False alarms (system integrity)
- Expected service life





# Reference



European Union Agency for  
Network and Information Security



TOPICS

NEWS

PUBLICATIONS

EVENTS



11

About ENISA

## Topic

- ^ IoT and Smart Infrastructures
- > Internet of Things (IoT)

## Keywords

Internet of things

## Baseline Security Recommendations for IoT

The study which is titled 'Baseline Security Recommendations for Internet of Things in the context of critical information infrastructures', aims to set the scene for IoT security in Europe. It serves as a reference point in this field and as a foundation for relevant forthcoming initiatives and developments.

Published November 20, 2017  
Language English



Download

PDF document, 4.05 MB

<https://www.enisa.europa.eu/publications/baseline-security-recommendations-for-iot>

# Home examples



Products in the market  
Home made



# Exercise



- Fitbit





Data Security

# FITBIT REVEALS TROOP LOCATIONS IN GLOBAL HOTSPOTS

By Adam Levin - January 30, 2018



Share on Facebook



Tweet on Twitter



# US Bases identifiable and mappable



**Nathan Ruser**  
@Nrg8000

Follow

Strava released their global heatmap. 13 trillion GPS points from their users (turning off data sharing is an option). [medium.com/strava-engineer... It looks very pretty, but not amazing for Op-Sec. US Bases are clearly identifiable and mappable](https://medium.com/strava-engineering/strava-global-heatmap-13-trillion-gps-points-1000x1000)

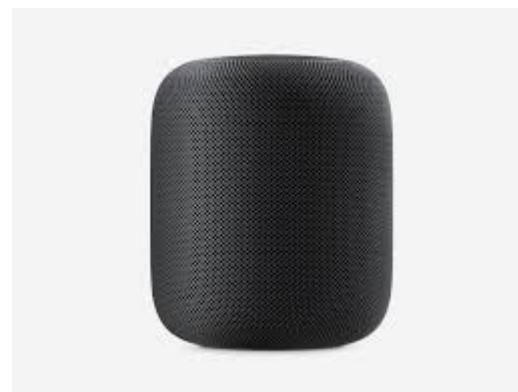


10:24 AM - 27 Jan 2018

# Digital Assistants



- News
  - Traffic, weather
- Agenda
- Entertainment
- Control other stuff



Google Home

# Microwave



# Traditional Internet



# Internet Now...



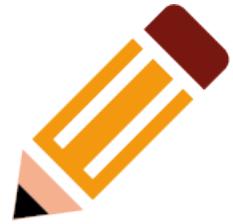
# Internet of things everything



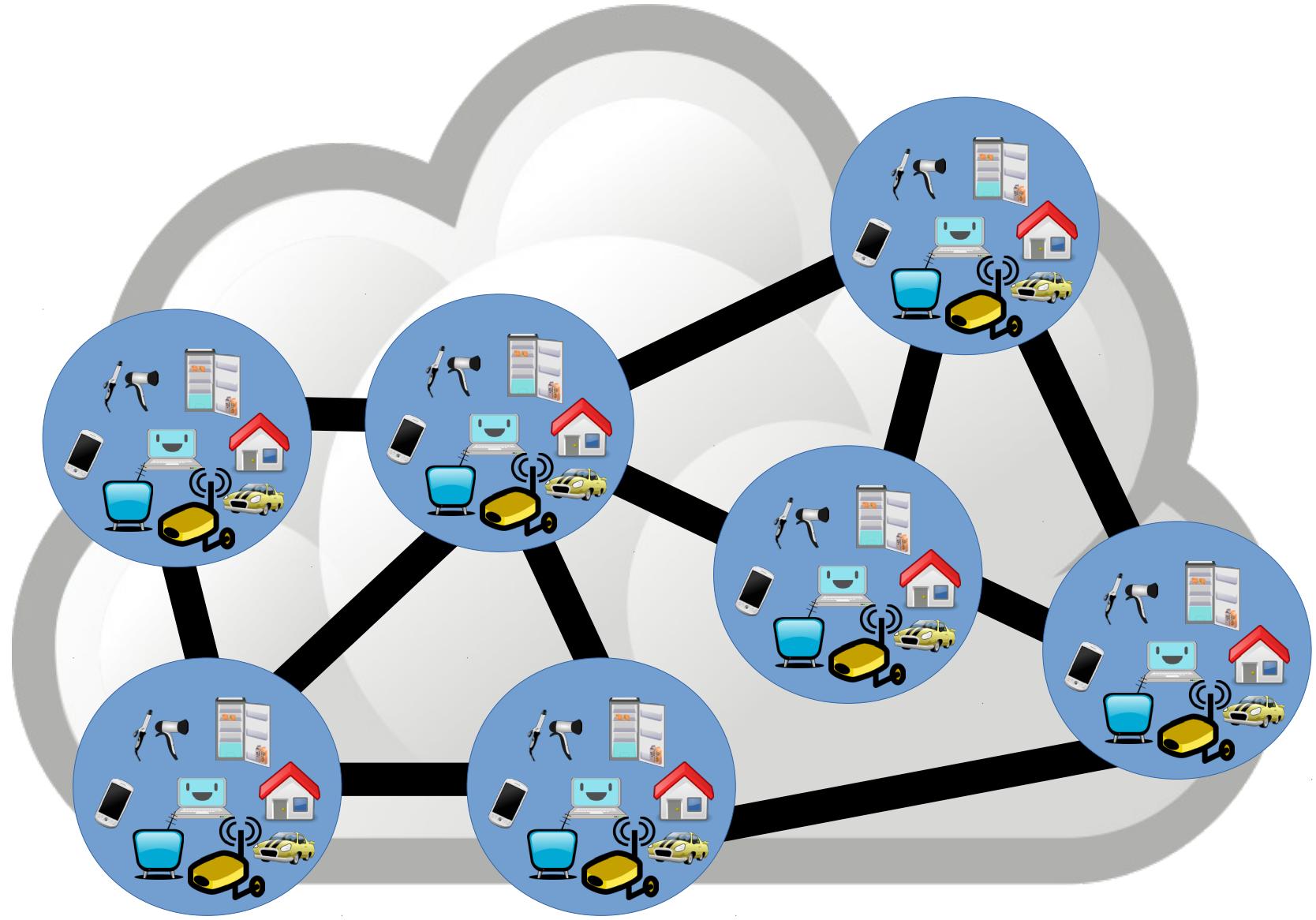
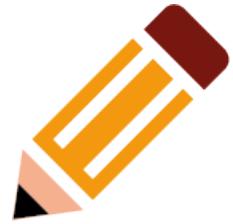
# Everything is a part of a System



# Small systems all over



# Interconnected systems





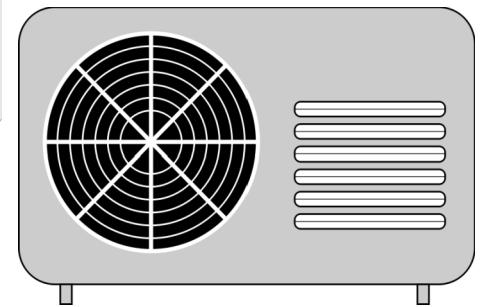
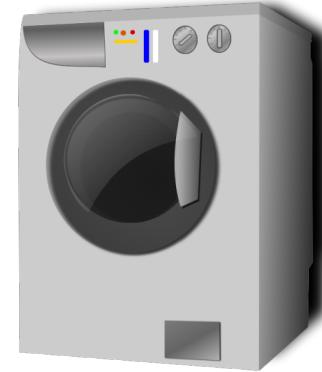
# How to Connect things?



# Machine to machine



- Protocols
- Data access
- Compatibility
- Brands
- Device type
- Security
- Open or proprietary
- Bandwidth



# Eclipse <http://iot.eclipse.org/>



## Open Source for IoT

IoT needs open source to be successful.  
Eclipse IoT simplifies IoT development.



### Standards

Implementation of IoT standards like MQTT, CoAP, LWM2M and OneM2M



### Getting Started

Step-by-step guide to getting started on IoT development



### Services & Frameworks

Building blocks to accelerate IoT development



### All projects

Check out all our IoT open source projects

## Technology

Eclipse IoT provides open source implementations of the standards, services and frameworks that enable an Open Internet of Things.

# Standards



- OMA LightweightM2M
- LightweightM2M is principally a device management protocol, but it should be designed to be able to extend to meet the requirements of applications. LightweightM2M is not restricted to device management, it should be able transfer service / application data.
- OMA LightweightM2M (LWM2M) is an industry standard for device management of M2M/IoT devices. It heavily relies on CoAP and therefore is optimized for communications over sensor or cellular networks.
- OMA LWM2M provides an extensible object model that allows to enable application data exchanges in addition to the core device management features (firmware upgrade, connectivity monitoring, ...)

# Standards



- CoAP
  - CoAP (Constrained Application Protocol) is a protocol specialized for use with constrained nodes and networks.
  - It implements the REST architectural style, it can be transparently mapped to HTTP. However, CoAP also provides features that go beyond HTTP such as native push notifications and group communication.



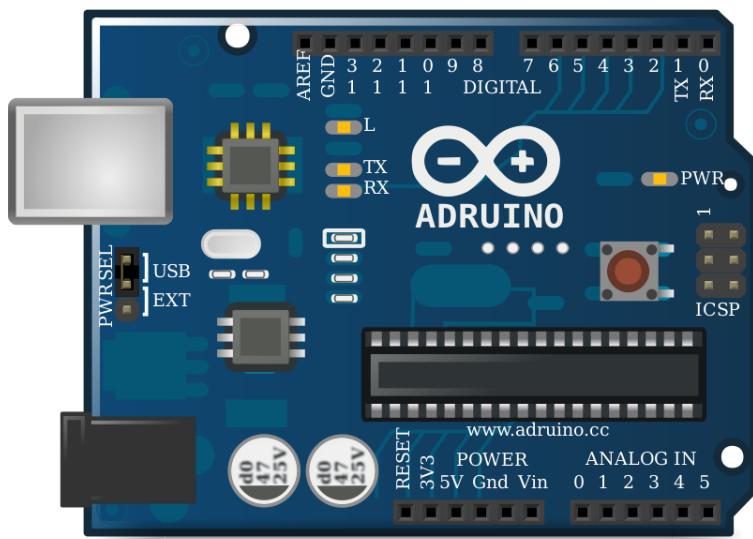
# Standards



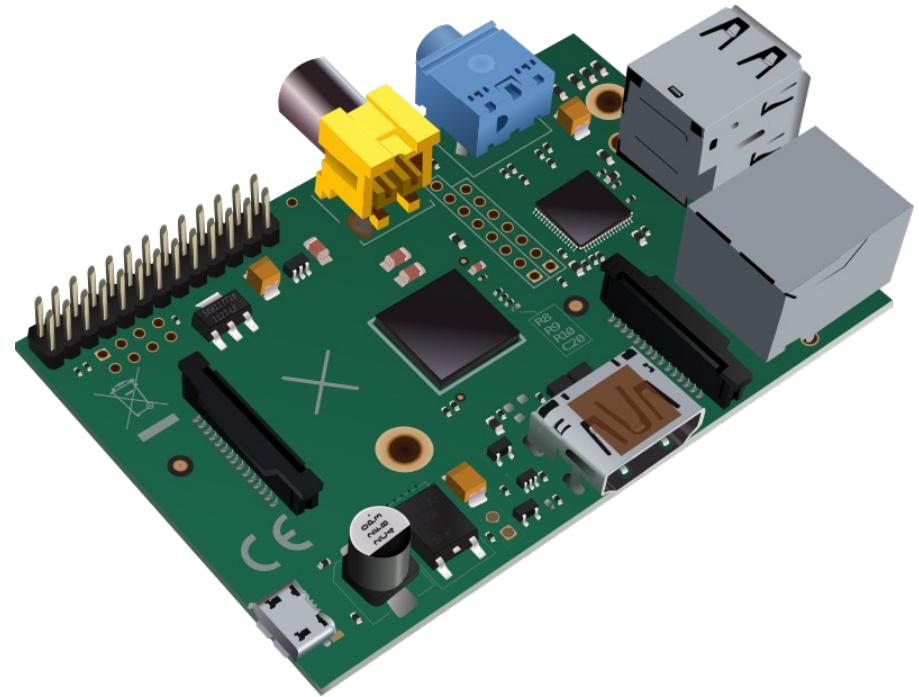
- Message Queuing Telemetry Transport (MQTT)
  - Protocol designed to connect the physical world devices and networks, with applications and middleware used in IT and Web development.
  - Lightweight
  - Publish/Subscribe
  - Wired/Wireless
  - Protocol used by Facebook chat!



# Common hardware

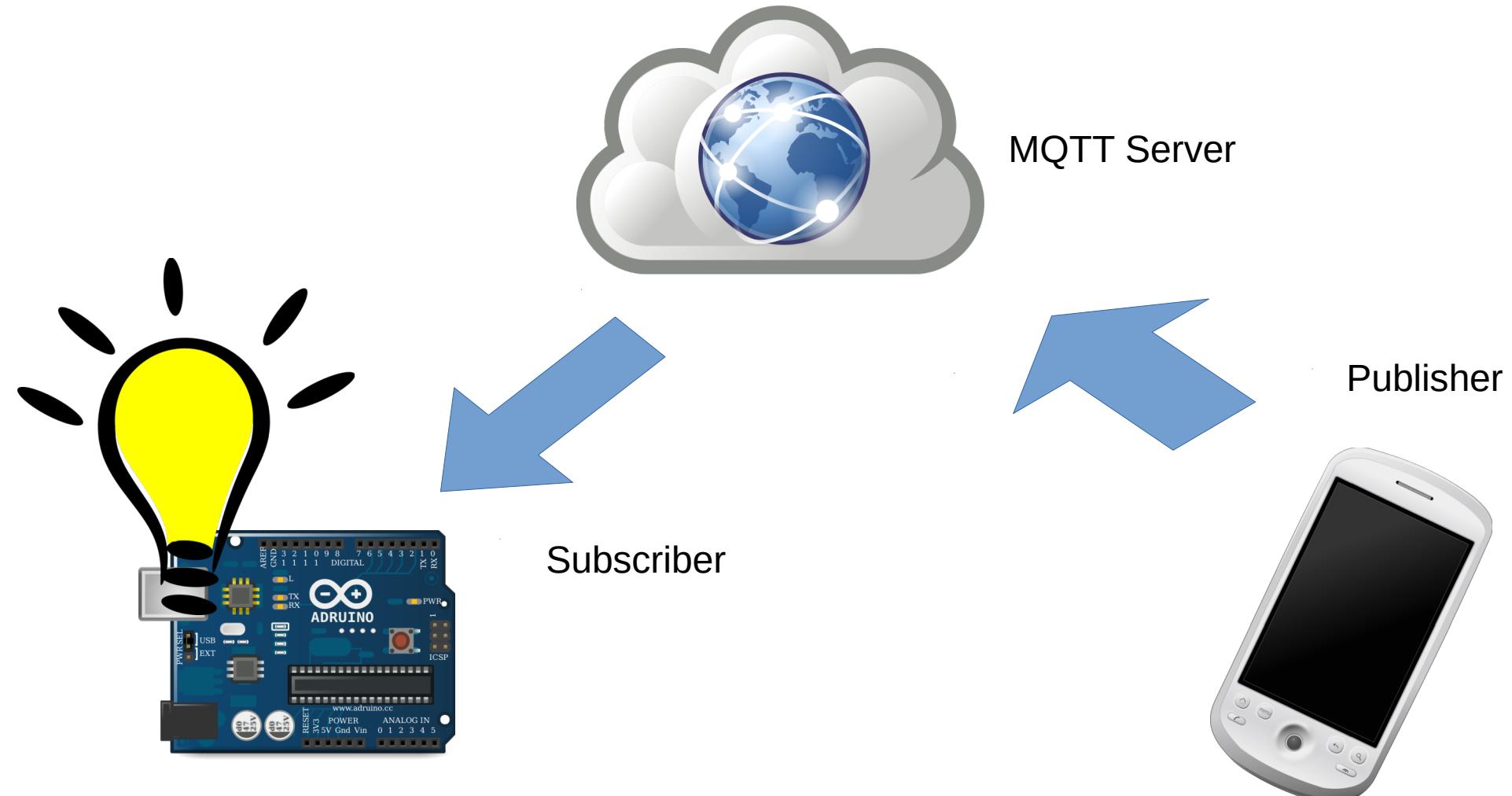


Arduino



Raspberry Pi

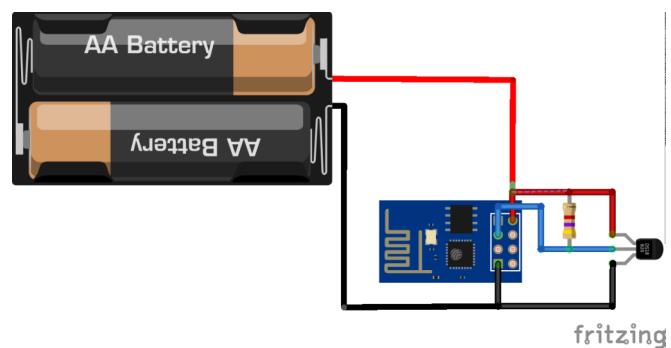
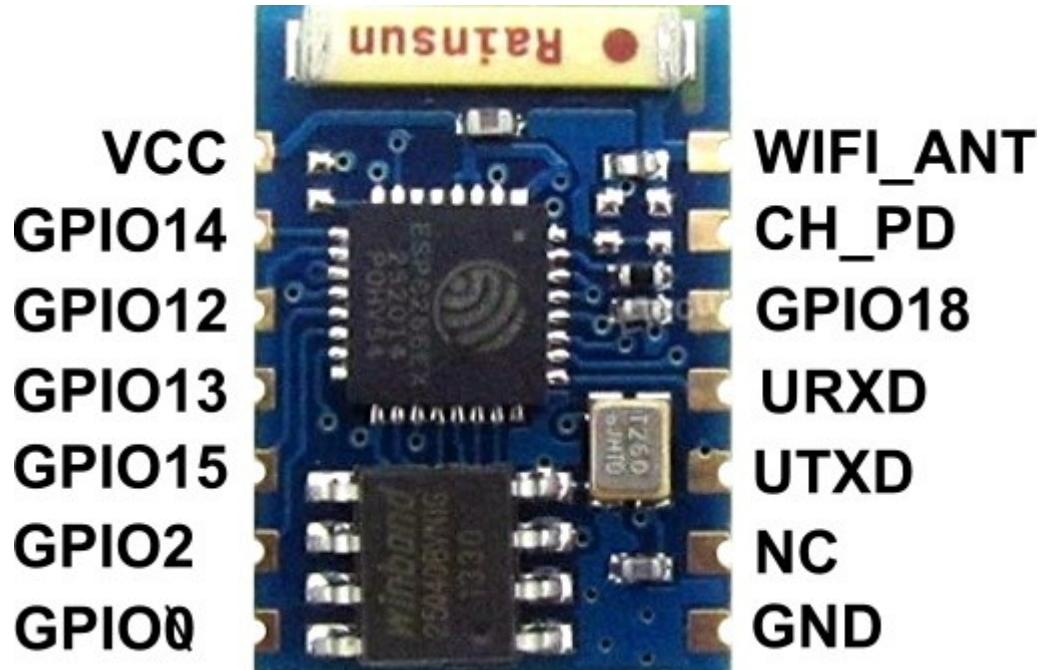
# MQTT Implementation



# How to get started

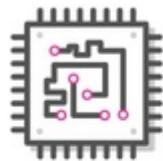


- Wifi is cheap
- Multiple options
- ESP8266 < \$5



fritzing

# CHIP \$9 Computer



**1GHz + 512MB + 4GB**

processor



ram

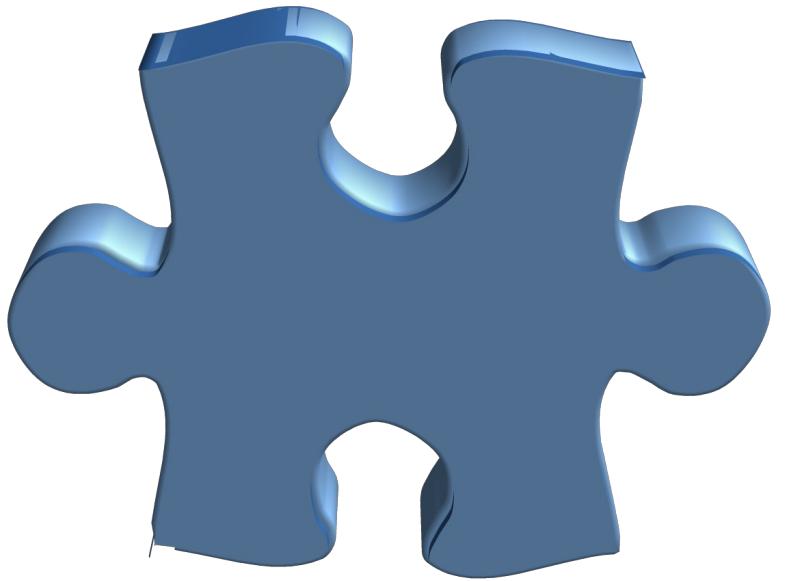


storage

# IOT opportunities



- Hardware electronic
- Products, data collection
  - Data Storage
- Clothes
- Analysis
  - Processing power
- Security



# Some Challenges



- Connecting Existing hardware
  - Cost
- People
  - Privacy
- Inter-connectivity of devices
  - Brands
  - protocols
- Connectivity
  - Around 40% of the world population has an internet connection today
  - Wikipedia says 51% of PR internet
- Security

# Internet Users by Country



- In 2014, nearly 75% (2.1 billion) of all internet users in the world (2.8 billion) live in the top 20 countries.
- The remaining 25% (0.7 billion) is distributed among the other 178 countries, each representing less than 1% of total users.



# E-waste



- “according to United Nations University estimates reported by ITU, 67 million metric tons of electrical and electronic equipment were put on the market in 2013. In the same year, 53 million metric tons of e-waste (waste electrical and electronic equipment) were disposed of worldwide. ”



Source:

<https://itunews.itu.int/En/4850-E-waste-and-the-Internet-of-Things.note.aspx>

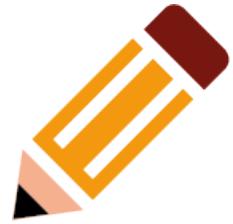
# Live demos



Build demo  
Making it blink



# Wemos D1 mini



- ESP8266
- Programming with arduino
- Led Connected to pin D0



# Dotnet new console



```
· using System;
· using System.Text;
· using System.Threading;
· using MQTTnet;
· using MQTTnet.Client;
· using MQTTnet.Implementations;
·
· namespace mqttConsole
· {
·     class Program
·     {
·         static async System.Threading.Tasks.Task Main(string[] args)
·         {
·             Console.WriteLine("Hello World!");
·             // Use TCP connection.
·             var options = new MqttClientOptionsBuilder()
·               .WithTcpServer("broker.hivemq.com", 1883) // Port is optional
·               .WithTcpServer("iot.eclipse.org", 1883) // Port is optional
·               .WithTcpServer("test.mosquitto.org", 1883) // Port is optional
·               .Build();
·
·             // Create a new MQTT client.
·             var factory = new MqttFactory();
·             var mqttClient = factory.CreateMqttClient();
·
·
·             mqttClient.ApplicationMessageReceived += (s, e) =>
·             {
·                 Console.WriteLine("### RECEIVED APPLICATION MESSAGE ###");
·                 Console.WriteLine($" Topic = {e.ApplicationMessage.Topic}");
·                 Console.WriteLine($" Payload = {(Encoding.UTF8.GetString(e.ApplicationMessage.Payload))}");
·                 Console.WriteLine($" QoS = {e.ApplicationMessage.QualityOfServiceLevel}");
·                 Console.WriteLine($" Retain = {e.ApplicationMessage.Retain}");
·                 Console.WriteLine();
·             };
·
·             mqttClient.Connected += async (s, e) =>
·             {
·                 Console.WriteLine("### CONNECTED WITH SERVER ###");
·
·                 // Subscribe to a topic
·                 await mqttClient.SubscribeAsync(new TopicFilterBuilder().WithTopic("outTopic").Build());
·
·                 Console.WriteLine("### SUBSCRIBED ###");
·             };
·             await mqttClient.ConnectAsync(options);
·
·
·             string inputLine = "";
·             do
·             {
·                 inputLine = Console.ReadLine();
·                 if (inputLine?.Length > 0)
·                 {
·                     await mqttClient.PublishAsync(
·                         new MqttApplicationMessageBuilder()
·                           .WithTopic("inTopic")
·                           .WithPayload(inputLine)
·                           .Build());
·                 }
·             }
·             while (inputLine?.Length > 0);
·         }
·     }
· }
```

# Project file



- <Project Sdk="Microsoft.NET.Sdk">
- <PropertyGroup>
- <LangVersion>latest</LangVersion>
- <OutputType>Exe</OutputType>
- <TargetFramework>netcoreapp2.1</TargetFramework>
- </PropertyGroup>
- <ItemGroup>
- <PackageReference Include="MQTTnet" Version="2.8.4"/>
- </ItemGroup>
- 
- </Project>

# Arduino example



```
/*
 * Basic ESP8266 MQTT example
 *
 * This sketch demonstrates the capabilities of the pubsub library in combination
 * with the CSPI266 WiFi module.
 *
 * - It uses the MQTT function:
 *   - publishes "Hello World" to the topic "outTopic", every two seconds
 *   - subscribes to the topic "inTopic", printing out any messages
 *     received. If the message is binary, it will be printed as hex.
 *   - If the first character of the topic "inTopic" is an 'L', switch On the D5 LED.
 *
 * - It will reconnection to the server if the connection is lost using a blocking
 *   reconnect function. See the "mqtt_reconnect" example for how to
 *   implement the same result without blocking the loop.
 *
 * To run this sketch:
 * - Add the following 3rd party library under "File > Preferences > Additional Boards Manager URLs":
 *   http://dmantra.org/package_dmantra_index.json
 * - Select "ESP8266" under "Tools > Board"
 * - Select your ESP8266 in "Tools > Board"
 *
 */
#include <CSPI266WiFi.h>
#include <PubSubClient.h>

// Update these with values suitable for your network.
const char* ssid = "..."; // Your WiFi SSID
const char* password = "..."; // Your WiFi password
const char* mqtt_server = "test.mosquitto.org";
WiFiClient espClient;
PubSubClient client(espClient);
long lastMsg = 0;
char msg[50];
char msgQ[50];

void setup() {
    Serial.begin(115200);
    client.setServer(mqtt_server, 1883);
    client.setCallback(callback);
}

void setup_wifi() {
    WiFi.begin(ssid, password);
    while (WiFi.status() != WL_CONNECTED) {
        Serial.print(".");
        Serial.print("Connecting to WiFi...");
        Serial.print(".");
        Serial.print(".");
        Serial.print(".");
        Serial.print(".");
        delay(1000);
    }
    Serial.println("Connected to WiFi!");
    Serial.print("IP Address: ");
    Serial.println(WiFi.localIP());
}

void callback(char* topic, byte payload, unsigned int length) {
    Serial.print("Message arrived [");
    Serial.print(topic);
    Serial.print("] ");
    for (int i = 0; i < length; i++) {
        Serial.print((char)payload[i]);
    }
    Serial.println();
    if ((topic[0] == 'L') && (topic[1] == 'D')) { // If the LED is on (topic is LOW)
        digitalWrite(D5, HIGH); // Turn the LED off by making the voltage HIGH
    } else { // If the LED is off (topic is HIGH)
        digitalWrite(D5, LOW); // Turn the LED on by making the voltage LOW
    }
}

void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...\n");
        // If connecting successfully, publish an acknowledgement.
        if (client.connect("ESP8266Client")) {
            Serial.print("Connected\n");
            // Once connected, publish an acknowledgement.
            client.publish("inTopic", "Hello World");
            // And reschedule the next publish
            client.reschedule();
        } else {
            Serial.print("Connection failed!\n");
            Serial.print("Reason: ");
            Serial.println(client.error());
            // Wait 5 seconds before trying
            delay(5000);
        }
    }
}

void loop() {
    if (!client.connected()) {
        reconnect();
    }
    client.loop();
    long now = millis();
    if (now - lastMsg > 2000) {
        lastMsg = now;
        // Publish a message to the topic "outTopic"
        client.publish("outTopic", "Hello World");
        // Print the last message received
        if (client.available()) {
            String msg = client.readStringUntil('\n');
            Serial.print("Received [");
            Serial.print(msg);
            Serial.print("]\n");
        }
    }
}
```

# Arduino source wifiManager

