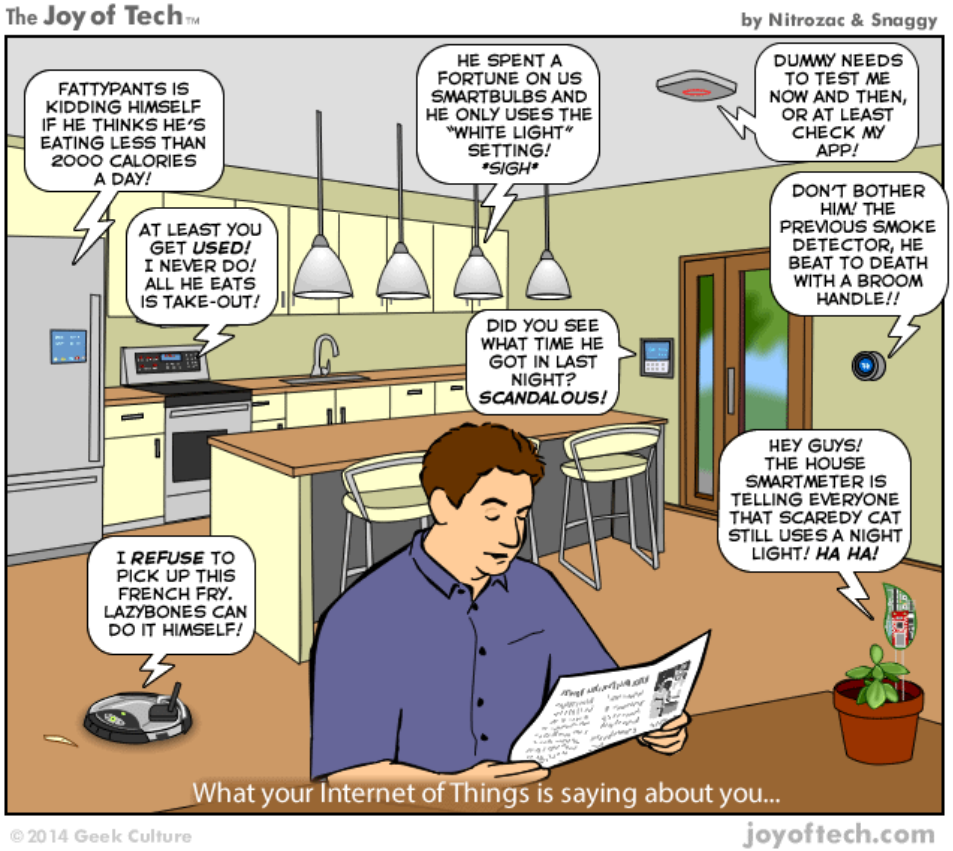
Introduction to the Internet of Things (IoT)

Internet of Things (IoT)

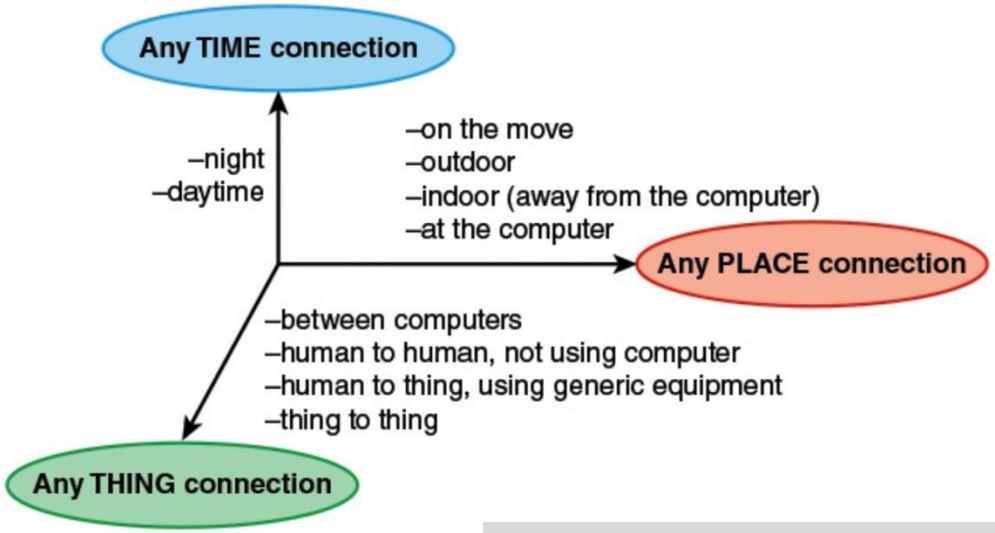
A quick and “physical” definition (https://iot.IEEE.org/definition.html):

“A network of items—each embedded with sensors—which are connected to the Internet.”



Internet of Things (IoT): a more "official" definition

"The IoT can be viewed as a **global infrastructure** for the information society, enabling **advanced services** by **interconnecting (physical and virtual)** things based on existing and evolving interoperable information and communication technologies (ICT)."



Source: Recommendation ITU-T Y.2060

All big companies are active in this area

https://www.cisco.com/c/en/us/solutions/internet-of-things/overview.html

https://aiofthings.telefonicatech.com/

https://cloud.google.com/iot-core?hl=es

https://www.ibm.com/cloud/internet-of-things

https://azure.microsoft.com/es-es/solutions/iot/

https://www.intel.com/content/www/us/en/internet-of-things/overview.html

https://www.arm.com/markets/iot

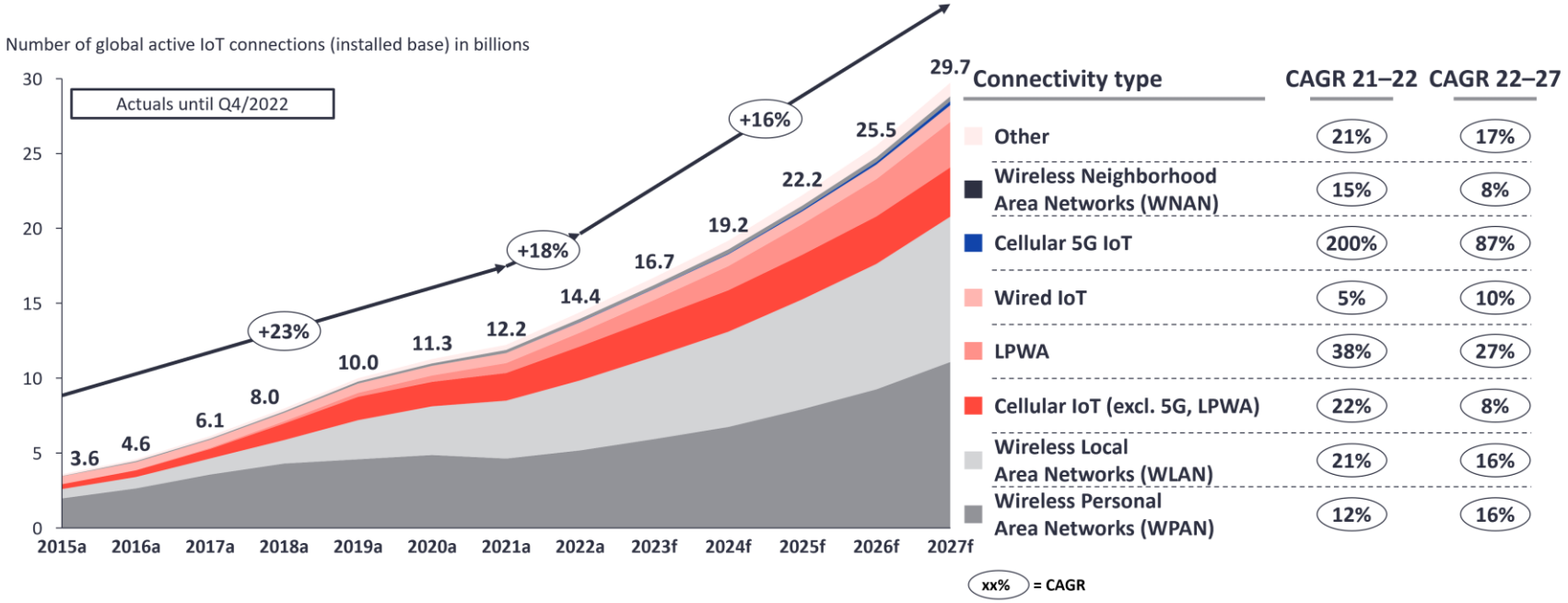
Market Forecast

IOT ANALYTICS

May 2023

Your Global IoT Market Research Partner

Global IoT market forecast (in billions of connected IoT devices)



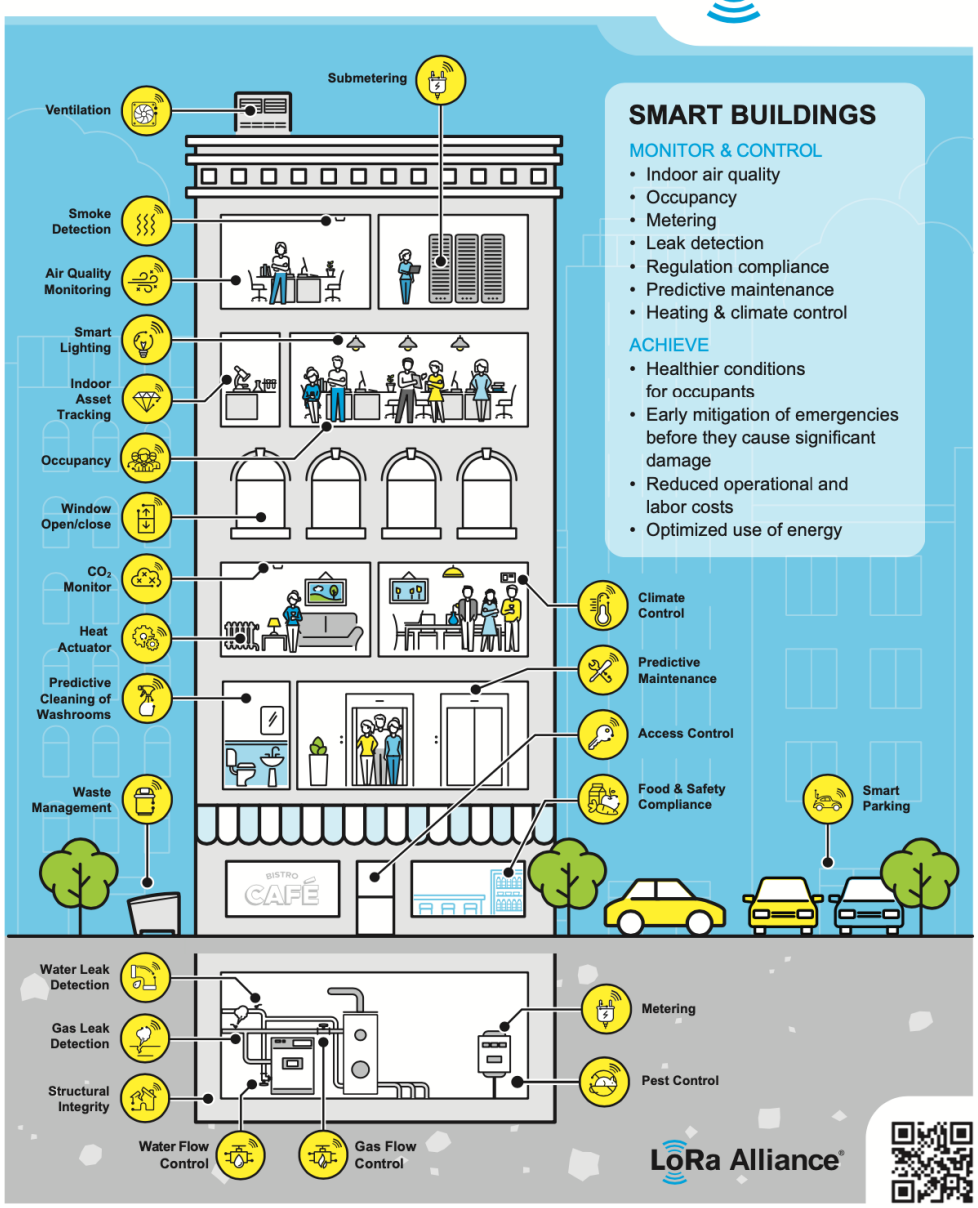
Note: IoT connections do not include any computers, laptops, fixed phones, cellphones, or consumers tablets. Counted are active nodes/devices or gateways that concentrate the end-sensors, not every sensor/actuator. Simple one-directional communications technology not considered (e.g., RFID, NFC). Wired includes ethernet and fieldbuses (e.g., connected industrial PLCs or I/O modules); Cellular includes 2G, 3G, 4G, 5G; LPWA includes unlicensed and licensed low-power networks; WPAN includes Bluetooth, Zigbee, Z-Wave or similar; WLAN includes Wi-Fi and related protocols; WNAN includes non-short-range mesh, such as Wi-SUN; Other includes satellite and unclassified proprietary networks with any range.
Source: IoT Analytics Research 2023. We welcome republishing of images but ask for source citation with a link to the original post and company website.

https://iot-analytics.com/number-connected-iot-devices/

Most popular IoT applications

© https://101blockchains.com/top-iot-applications/

BUILDING INTELLIGENCE WITH LoRaWAN®

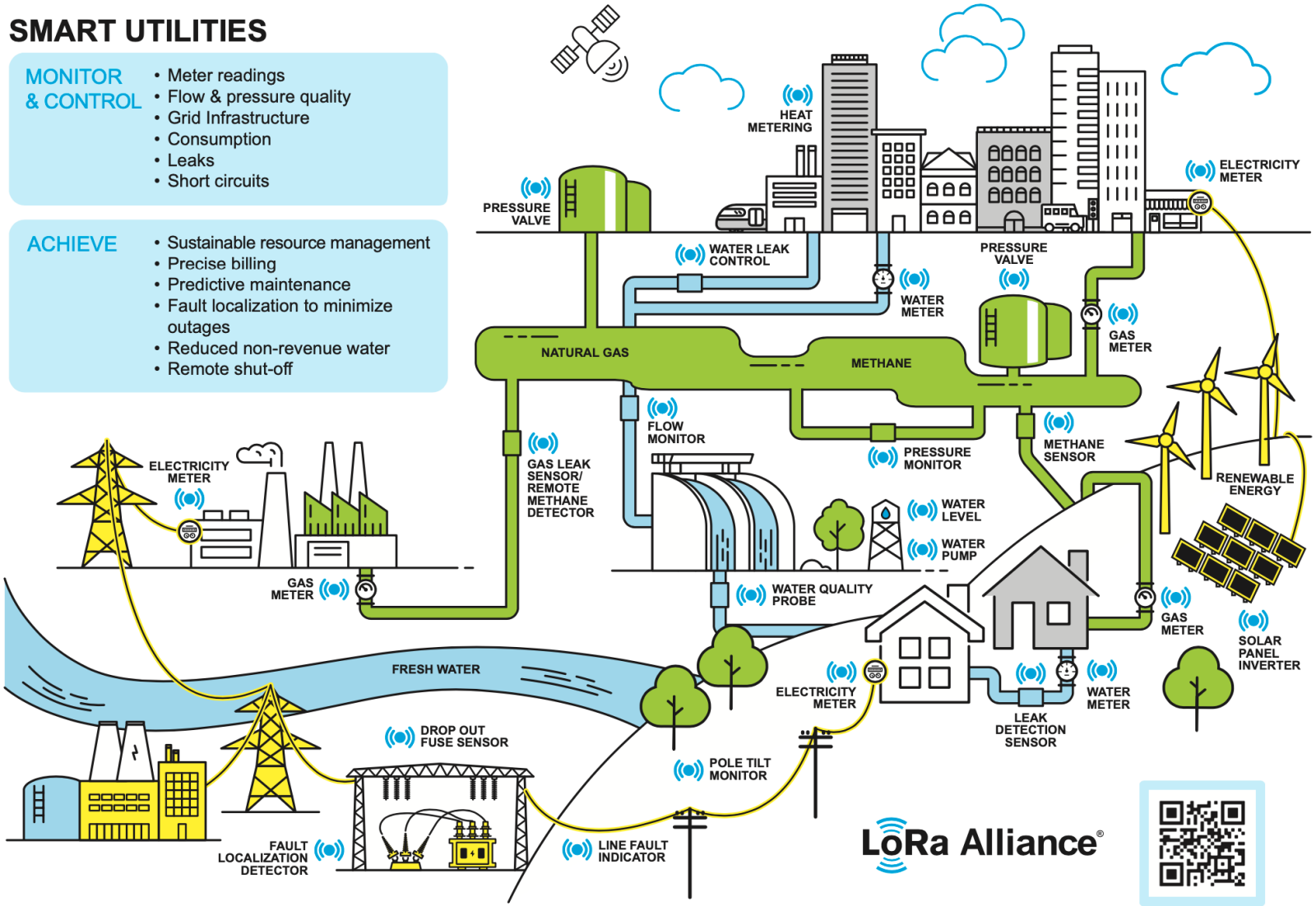


LoRaWAN® FOR PROFITABLE AND EFFICIENT UTILITIES

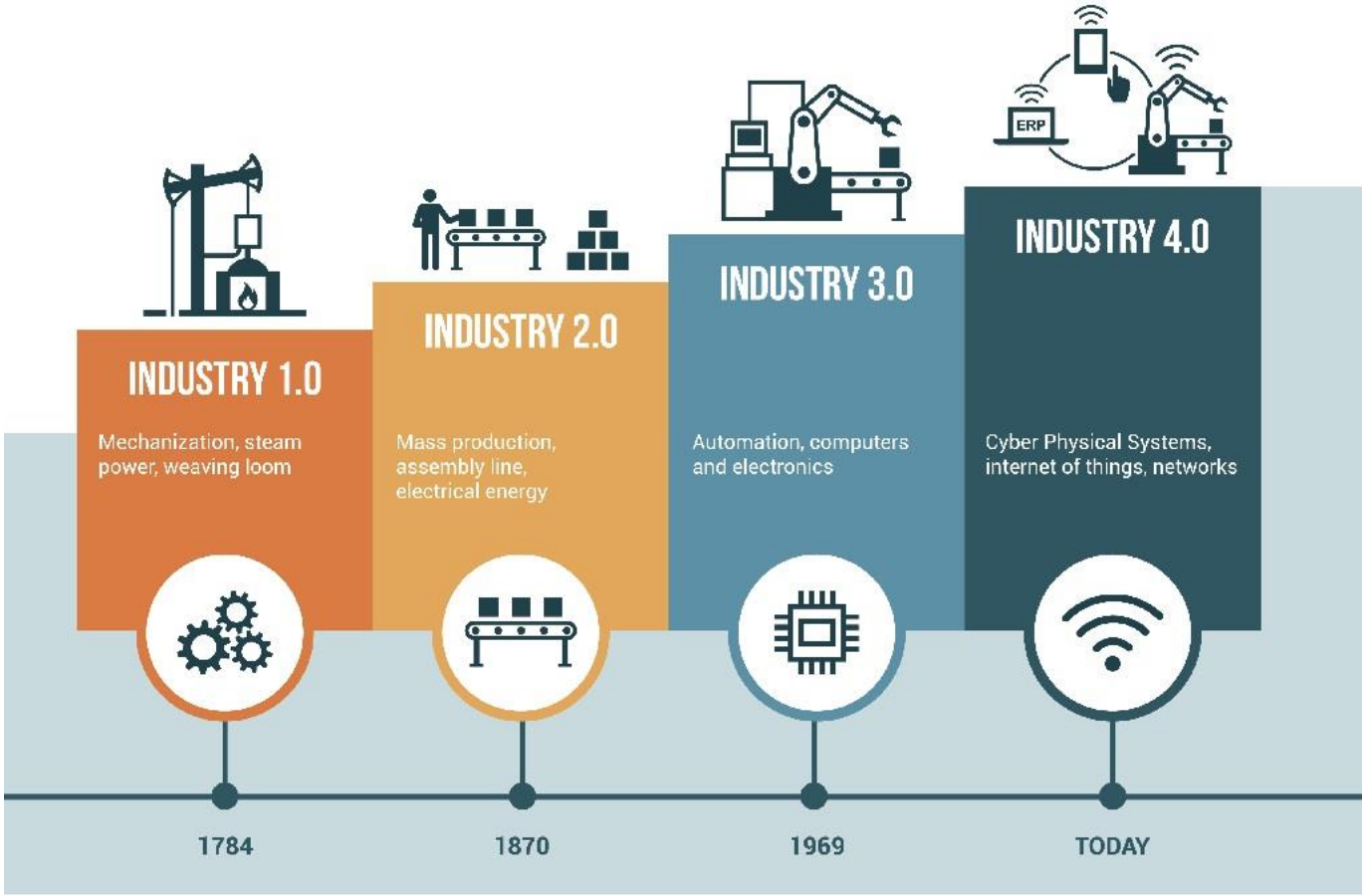
SMART UTILITIES

MONITOR & CONTROL
- Meter readings
- Flow & pressure quality
- Grid Infrastructure
- Consumption
- Leaks
- Short circuits

ACHIEVE
- Sustainable resource management
- Precise billing
- Predictive maintenance
- Fault localization to minimize outages
- Reduced non-revenue water
- Remote shut-off

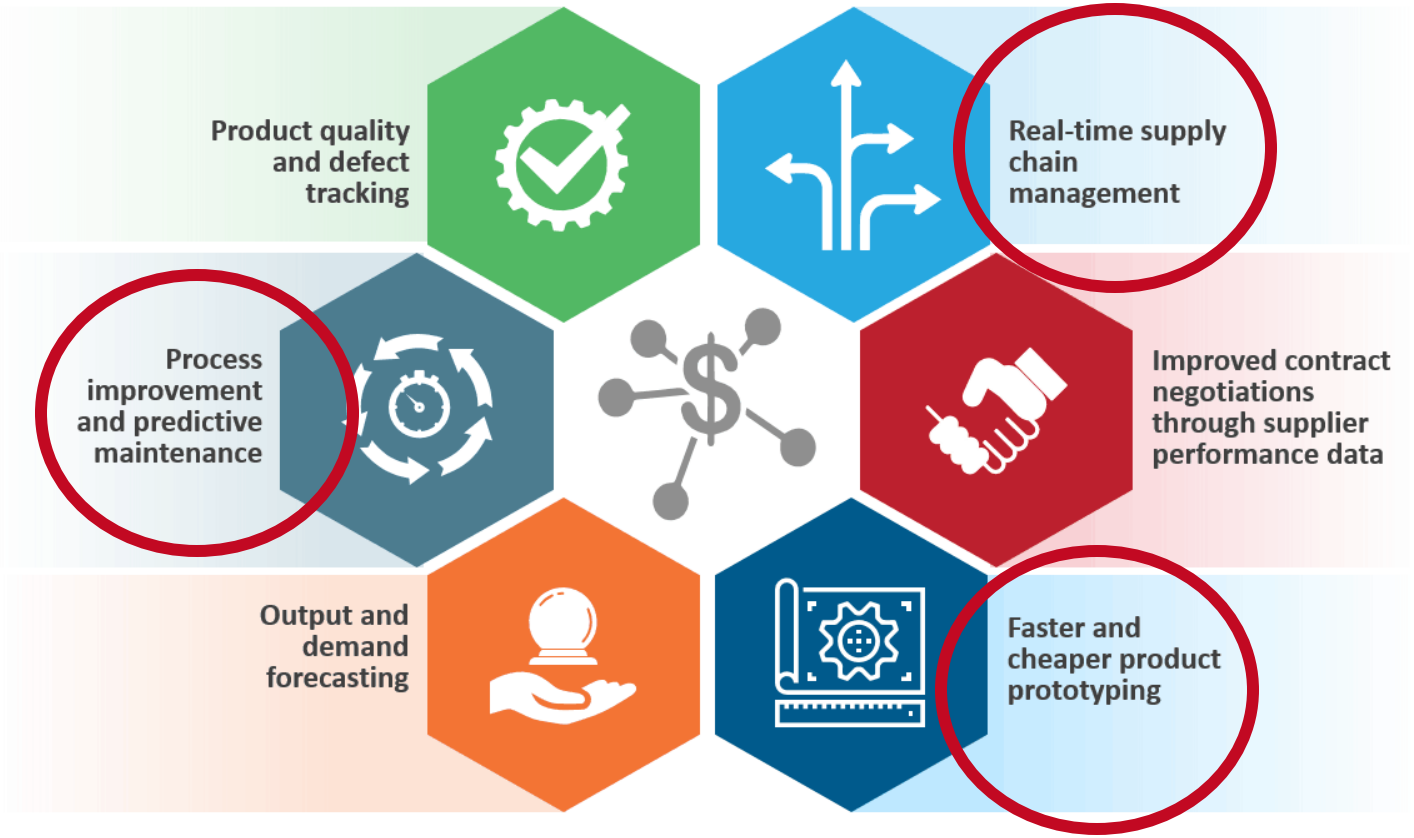


Industry 4.0 and Industrial IoT (IIoT)



How Industry 4.0 is Helping Manufacturers

Industry 4.0 – automation and data exchange in manufacturing technologies – is helping manufacturers to achieve their goals of reducing cost and increasing profitability through improvements and optimization across the value chain



Everest Group® Enterprise Digital Adoption in Manufacturing | Pinnacle Model™ Assessment 2018

Predictive maintenance

IOT ANALYTICS

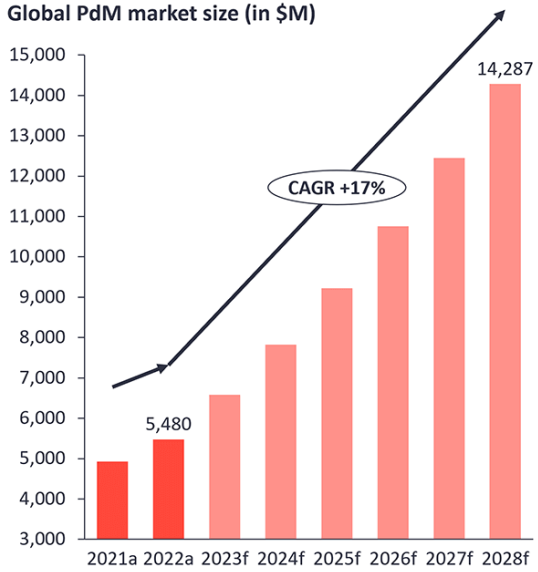
November 2023

Your Global IoT Market Research Partner

Market snapshot: Predictive maintenance 2024

Market size

Global PdM market size (in $M)



20 selected vendors

MathWorks · ARUNDO · AVEVA · machinemetrics · sas · aspentech · I-care · aws · Rockwell Automation · novity · IBM · boon logic · COGNITE · falkonry · SKF · ABB · Microsoft · AUGURY · Baker Hughes · SIEMENS

3 different types

1. Indirect failure prediction
2. Anomaly detection
3. Remaining useful life

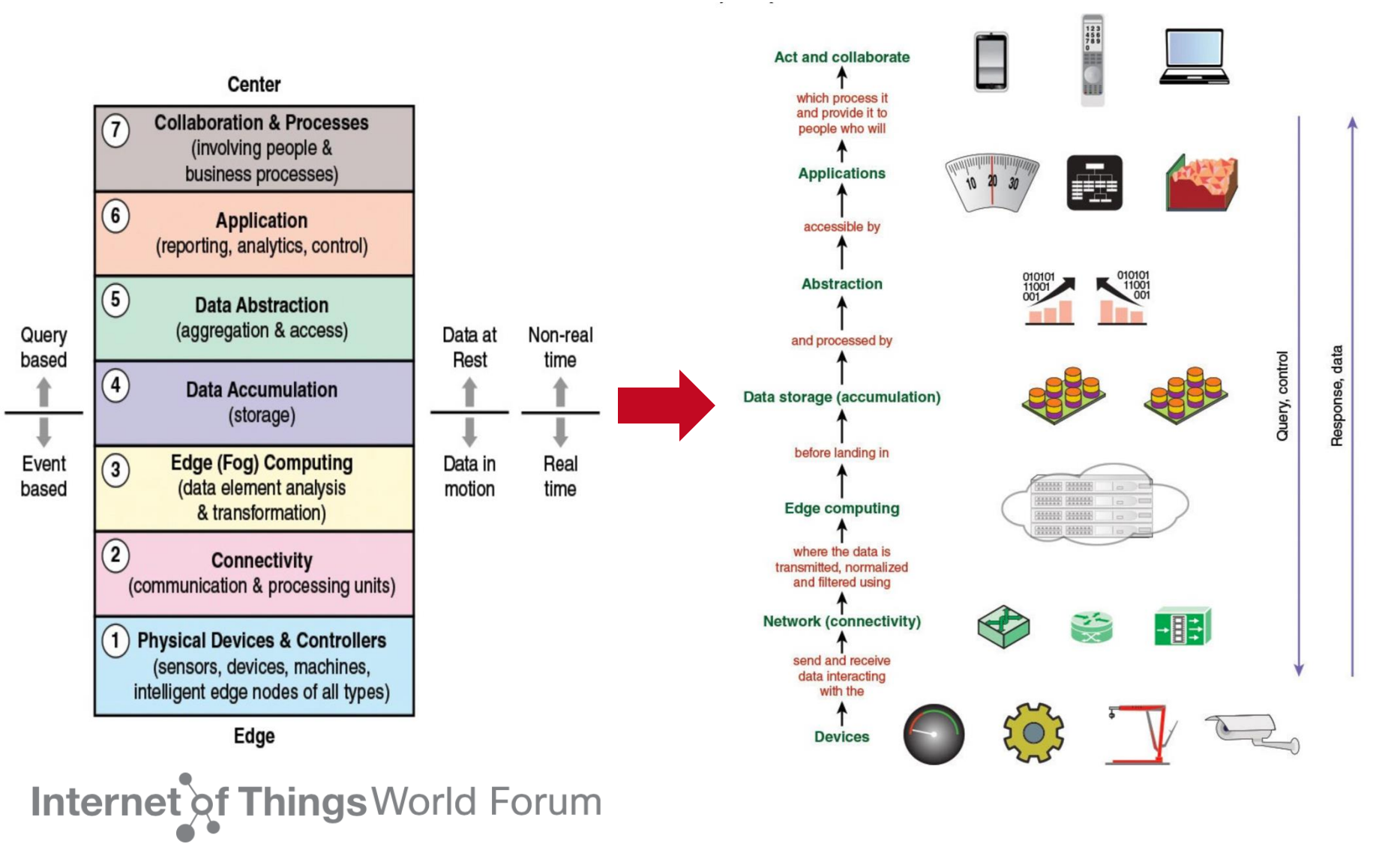
3 selected trends

- Complete solutions that offer pre-trained models and prescriptions
- Integration into the maintenance workflow
- Specialized solutions for specific industries or assets

Source: IoT Analytics Research 2023-Predictive Maintenance Market Report 2023-2028. Please cite the source and link to the original post and our website if you republish our images.

https://iot-analytics.com/predictive-maintenance-market/

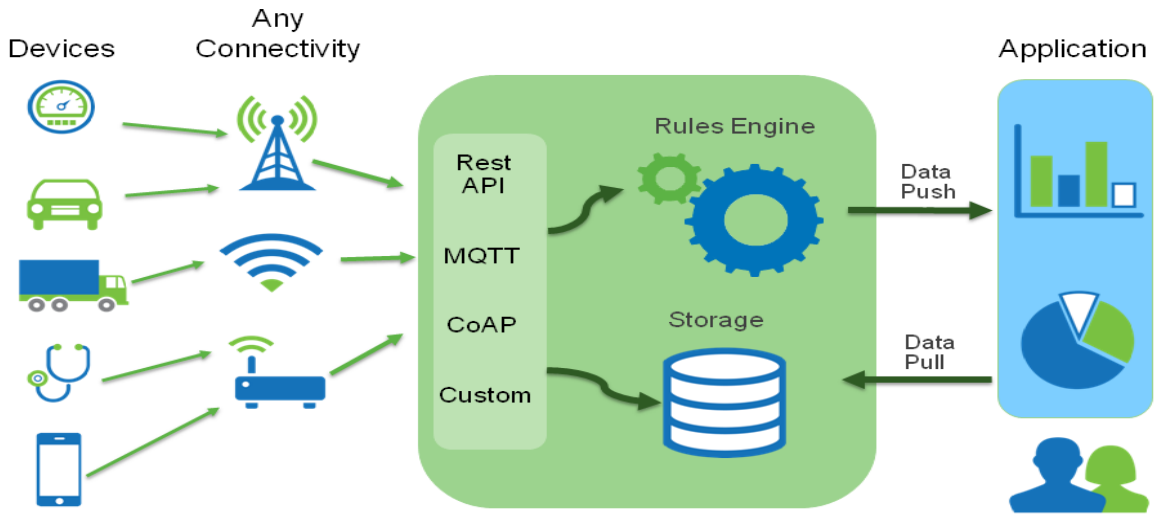
Reference Model



Internet of Things World Forum

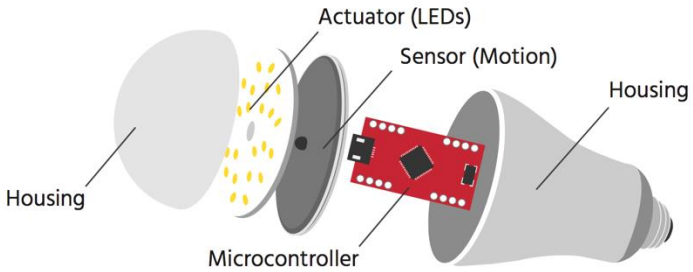
IoT simplified model

- Devices ("things")
  - These could be sensors, actuators, robots, cars, whatever can be connected.
  - A lot of inheritance from the world of "sensors networks"
- Connectivity
  - To connect things reliably to Internet.
  - Wireless connectivity is central to this task
- Platform
  - the collected data needs to be stored and processed somewhere.
  - Typically cloud-based infrastructures… but the edge is growing

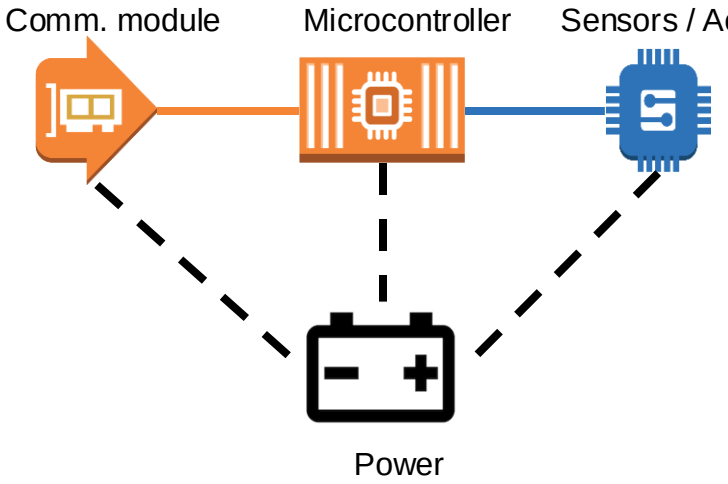


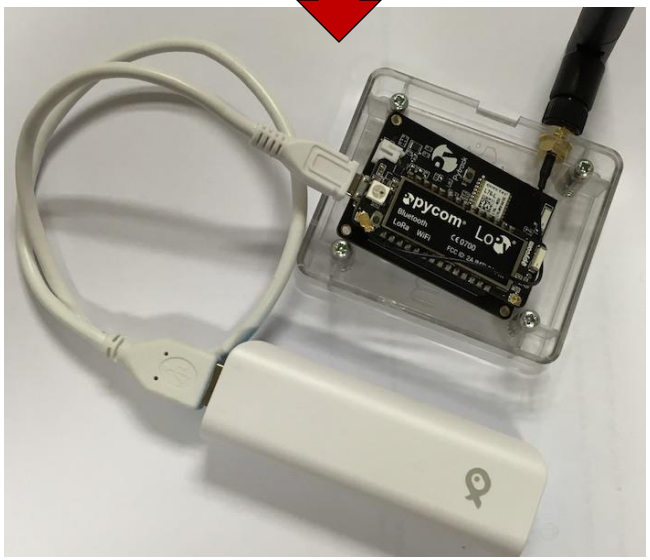
Things

- A "thing" generally consists of **four main parts:**
  - Sensors & actuators
  - Microcontroller
  - Communication unit
  - Power supply
- A "thing" has the **following properties**:
  - It's usually powered by battery. This implies limited source of energy.
  - It's generally small in size and low in cost. This limits their computing capability.



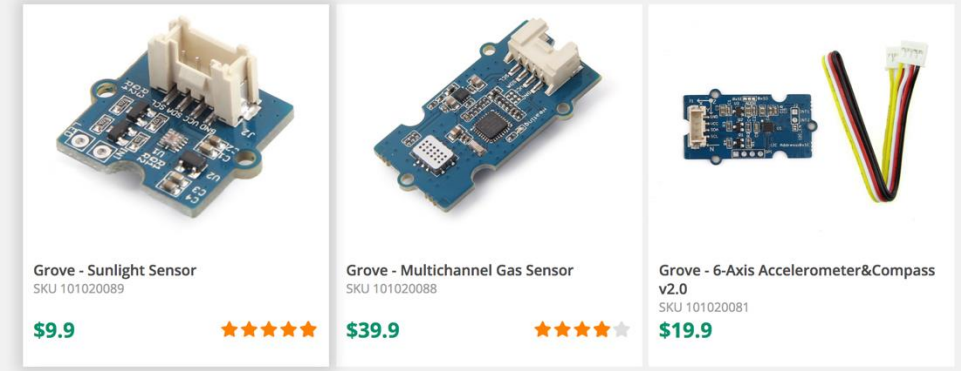
A Reference Guide to the Internet of Things Copyright © 2017 Bridgera LLC, RIoT

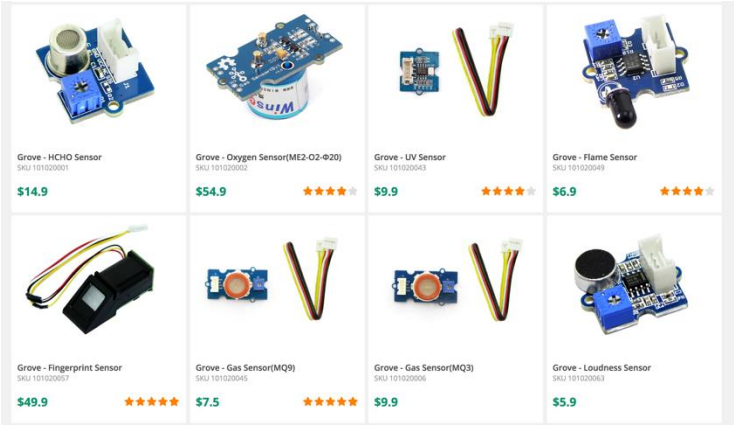




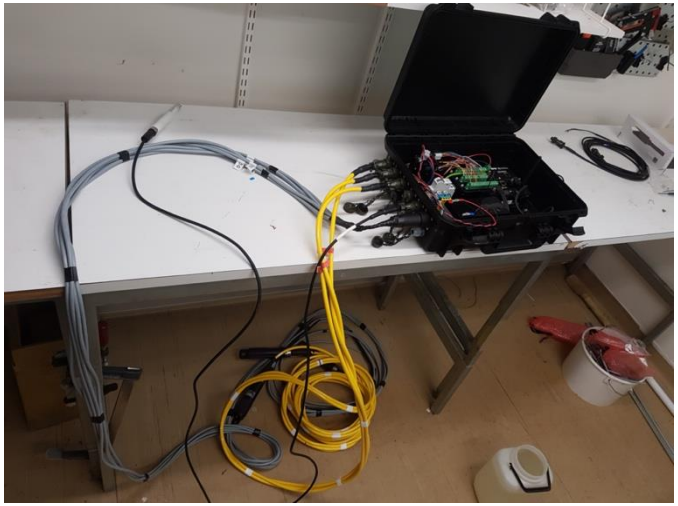
Classic things

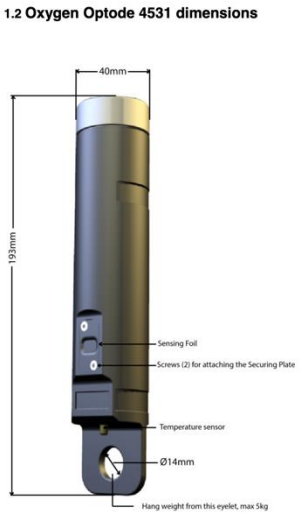
cheap…





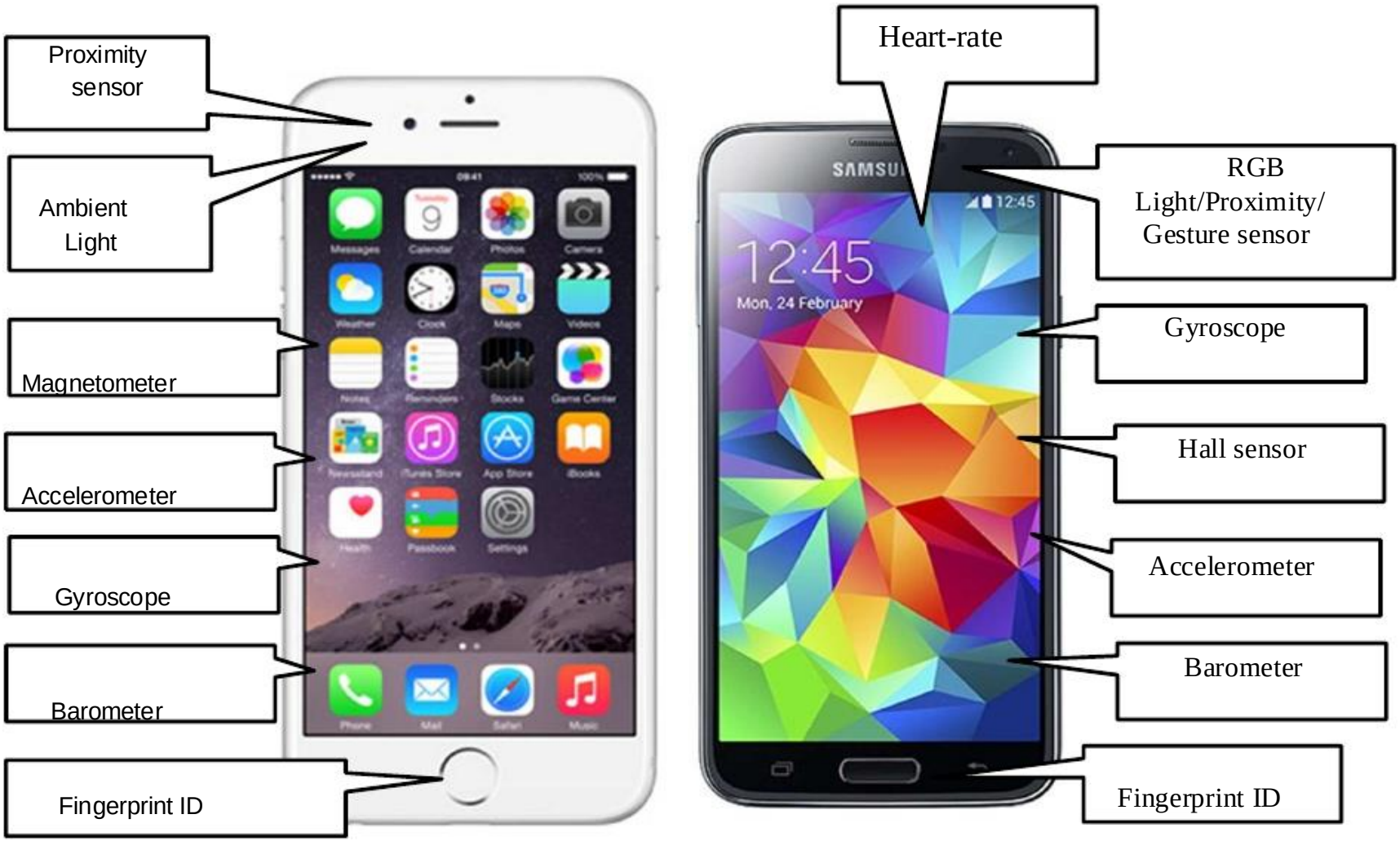
expensive…





Parameter	Output	Default range[2)]	Calibrated range	Accuracy	Resolution
Oxygen Concentration	0 - 5V	0 to 800µM	0 to 500µM	<8µM or 5% whichever is greater	< 1µM
	4 - 20mA	0 to 800µM	0 to 500µM	<9µM or 5.2% whichever is greater	< 1µM
Oxygen Saturation	0 - 5V	0 – 200%	0 - 120%	<5 %	<0.4%
	4 - 20mA	0 – 200%	0 - 120%	<5.2 %	<0.4%
Temperature	0 - 5V	-5 to + 35°C	0 - 36°C	±0.1°C	±0.01°C
	4 - 20mA	-5 to + 35°C	0 - 36°C	±0.15°C	±0.02°C

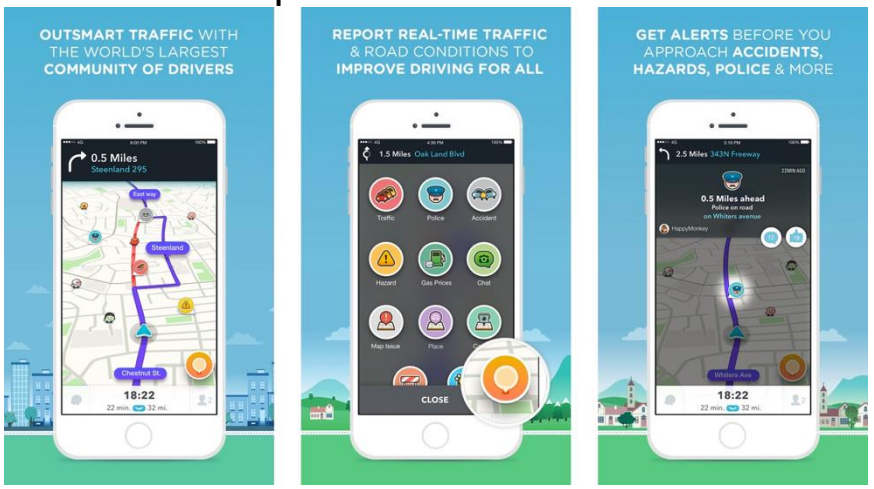
Sensors in Modern Smart Phones

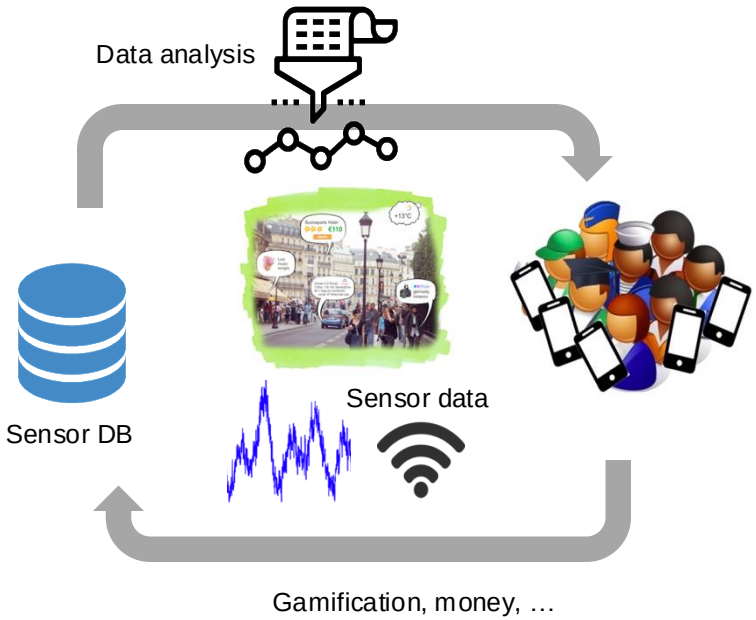


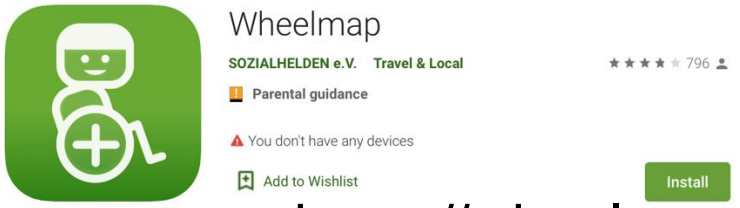
Beyond conventional things

- Humans as a sensor
  - Crowdsensing
  - social sensors: E.g., tweeting real-world data and/or events

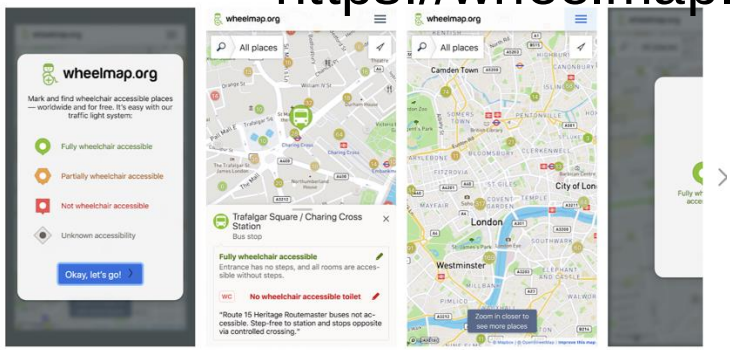
https://www.waze.com



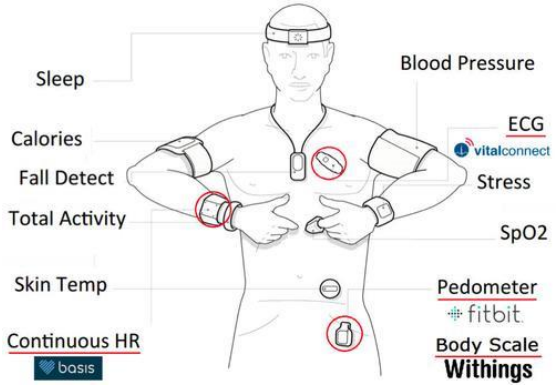




https://wheelmap.org/



Things++ → with a "Tiny" help



Connectivity simplified

HTTP (REST, CoAP), MQTT, …

TCP, UDP

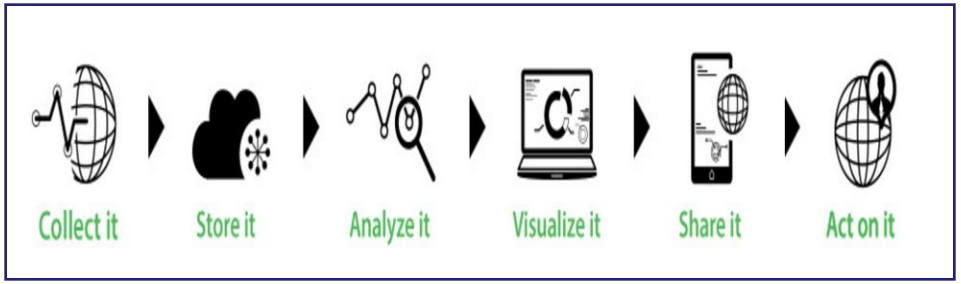
IPv4, IPv6, 6LoWPAN

Ethernet	WiFi	ZigBee, Bluetooth LE, UWB, RFID, …	2G: GPRS; 4G:LTE Cat M1 (eMTC) LTE Cat NB1 (NB-IoT)	LoRaWAN, SIGFOX

Platforms

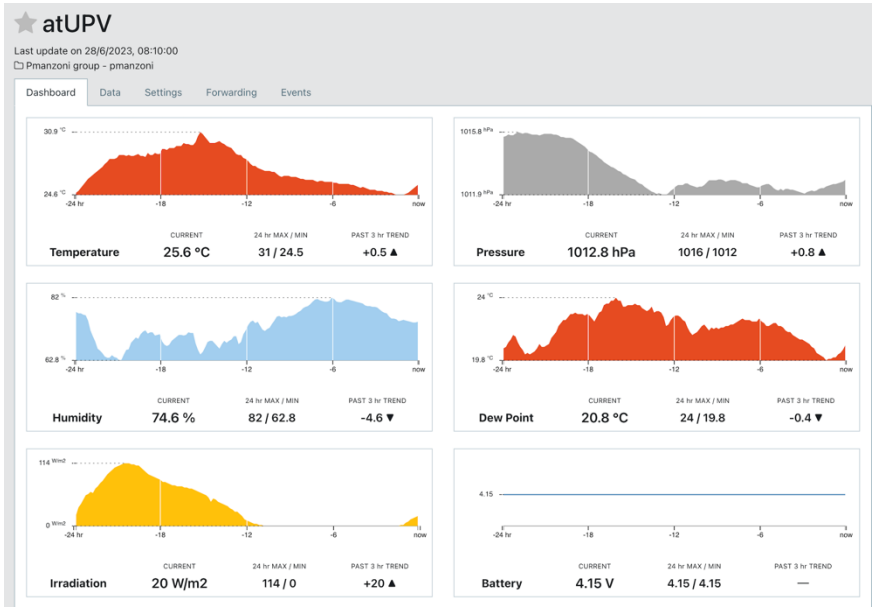
- Microsoft Azure IoT Hub
  - https://azure.microsoft.com/es-es/products/iot-hub
- Amazon AWS IoT
  - https://aws.amazon.com/es/iot/
- ~~Google Cloud IoT Core~~

→ **https://firebase.google.com/**



- Ubidots
  - https://ubidots.com/
- ThingsBoard
  - Open-source
  - https://thingsboard.io/
- TIG stack
  - Telegraf/InfluxDB/Grafana
- FIWARE
  - https://www.fiware.org/
- ThingSpeak
  - Based on MATLAB
  - https://thingspeak.com/

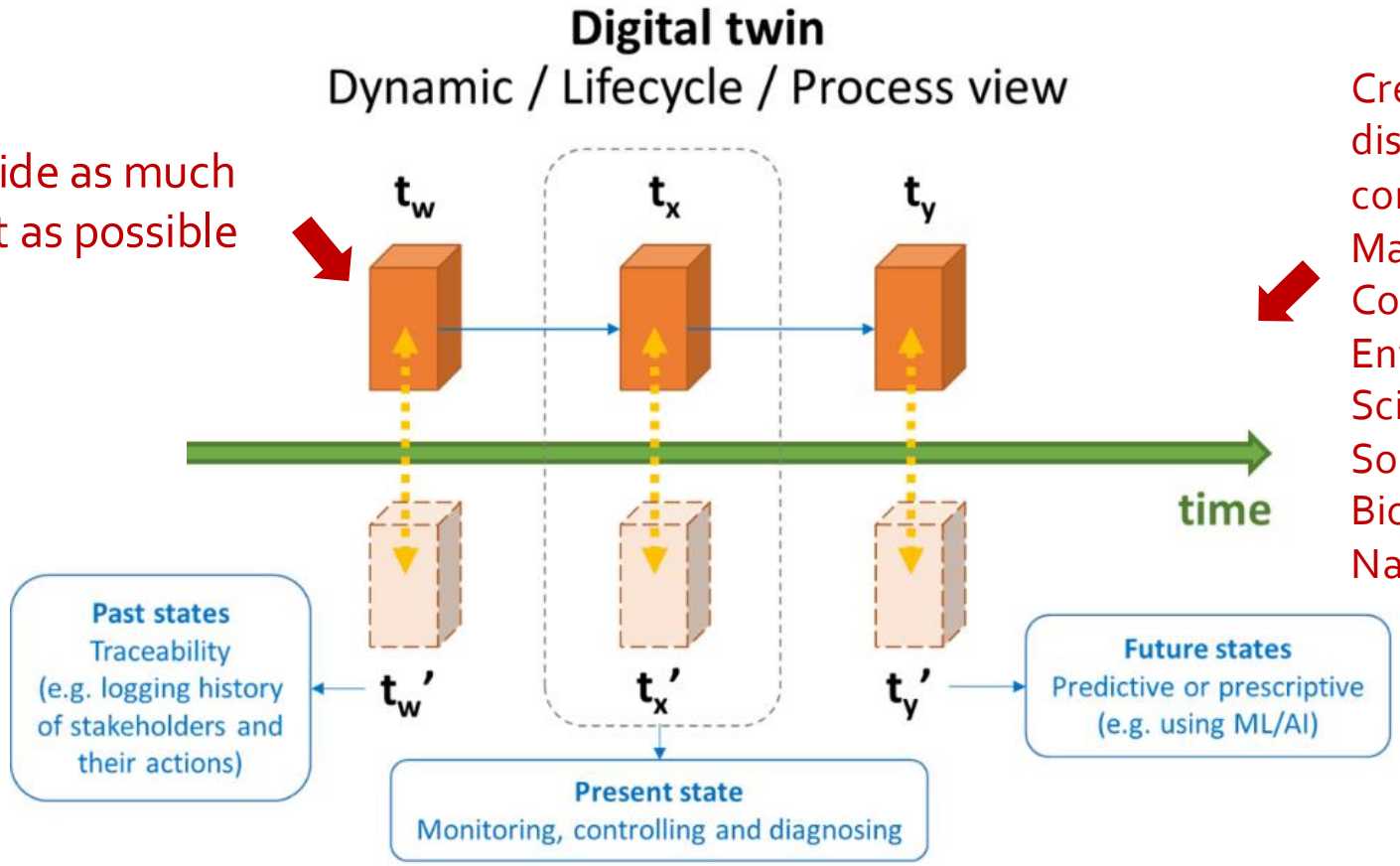
Platforms: data visualization & analysis



Digital Twins

The Industrial Internet Consortium's (IIC) vocabulary defines a digital twin as a "digital representation of an entity, including attributes and behaviors, sufficient to meet the requirements of a set of use cases."
In this context, the entity in the definition of digital representation is typically an asset, process or system.

https://www.iiconsortium.org/



J. C. Camposano, K. Smolander and T. Ruippo, "Seven Metaphors to Understand Digital Twins of Built Assets," in IEEE Access, vol. 9, pp. 27167-27181, 2021, doi: 10.1109/ACCESS.2021.3058009.