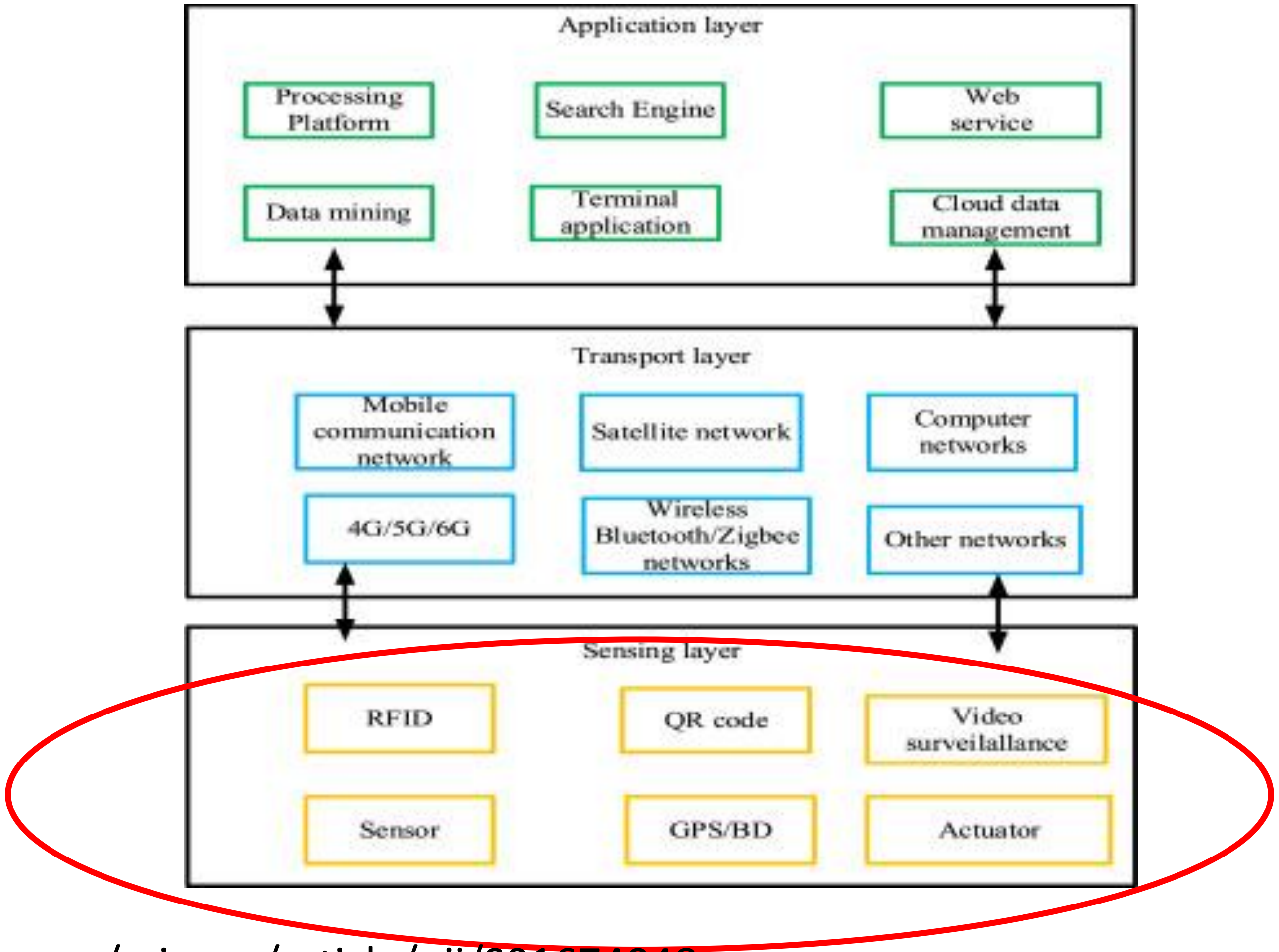
Sensors in IoT

IoT architecture



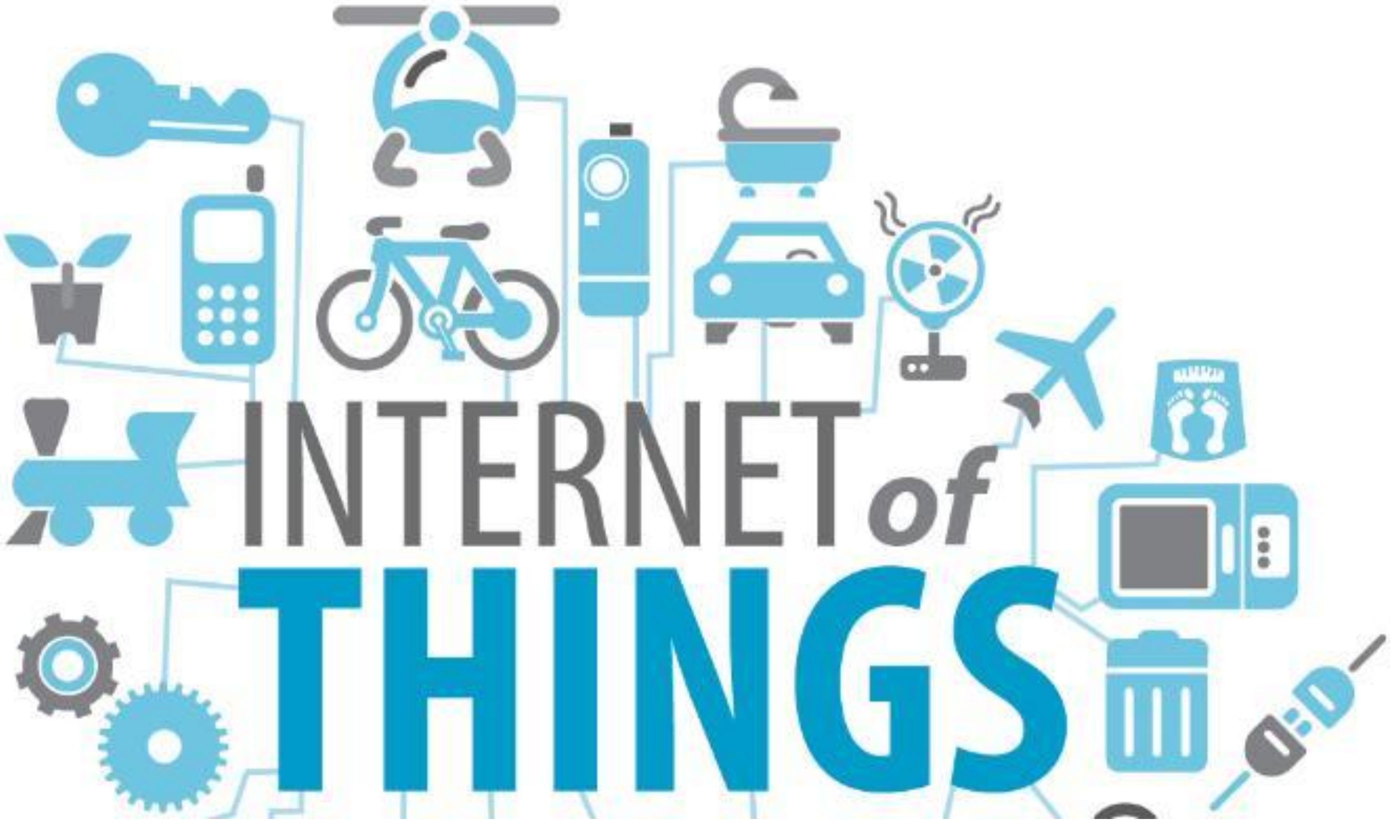
https://www.sciencedirect.com/science/article/pii/S0167404824004024

Reference Material

- Lea, P., 2018. Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security. Packt Publishing Ltd.

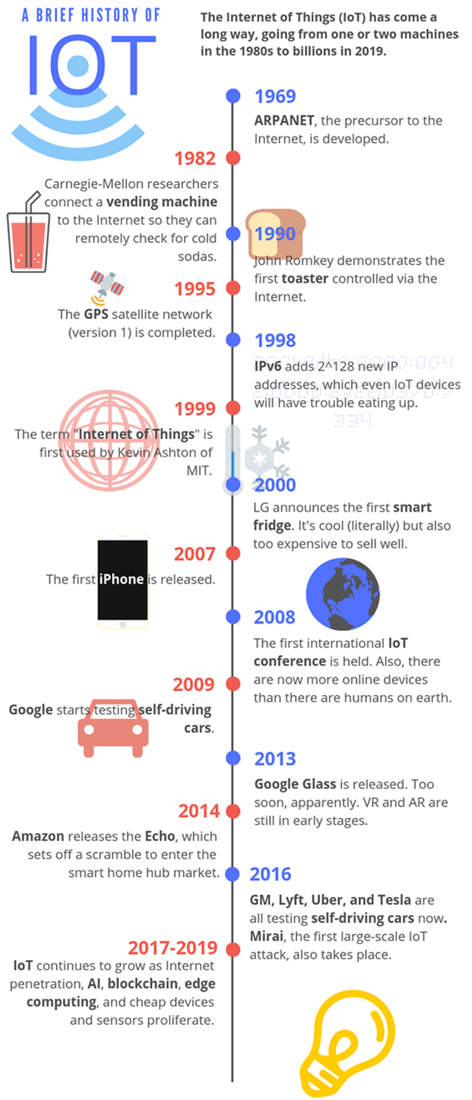
Outline

- History of IoT
- What is IoT?
- IoT Applications
- M2M vs IoT
- Importance of IoT
- Challenges/Impediments
- Case Study



Source: https://www.groundreport.com/

History of IoT

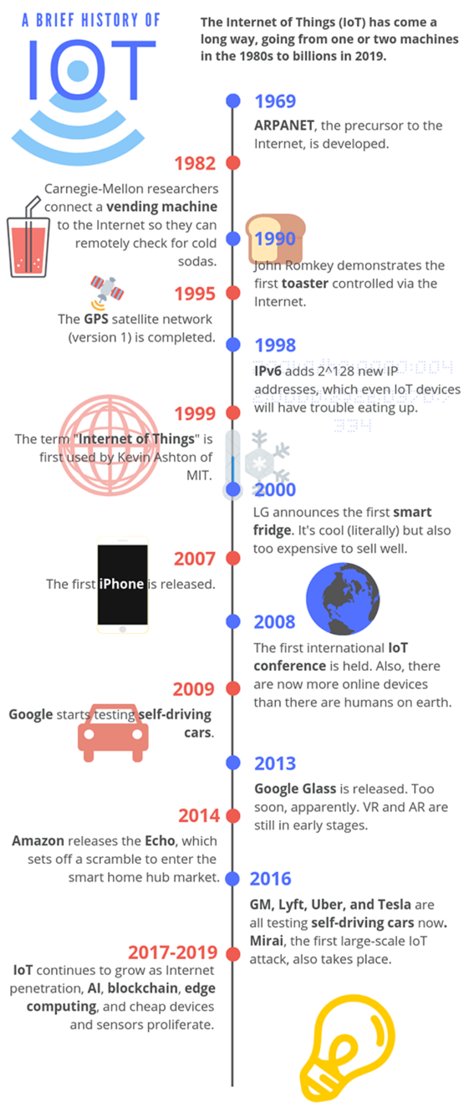


- 1969 – ARPANET was put into service by DARPA, which paved way for the “Internet”
- 1982 – A Coca-Cola vending machine is connected to the Internet by researchers at CMU to check availability of cold sodas. Often cited as one of the first IoT devices.
- 1990 – John Romkey, an Internet pioneer connected a smart toaster to the Internet and controlled it. The birth of communication protocol.
- 1995 – The first GPS satellite program of US government is completed making it possible to get location information required for many IoT devices
- 1998 – 128-bit IPv6 becomes a draft standard allowing more devices to be addressed than IPv4 could (32-bit).
- 1999 – A big year for IoT as the term was used for the first time by Kevin Ashton, a cofounder of Auto-ID center at MIT

Sou… ry-of-iot/

https://romkey.com/

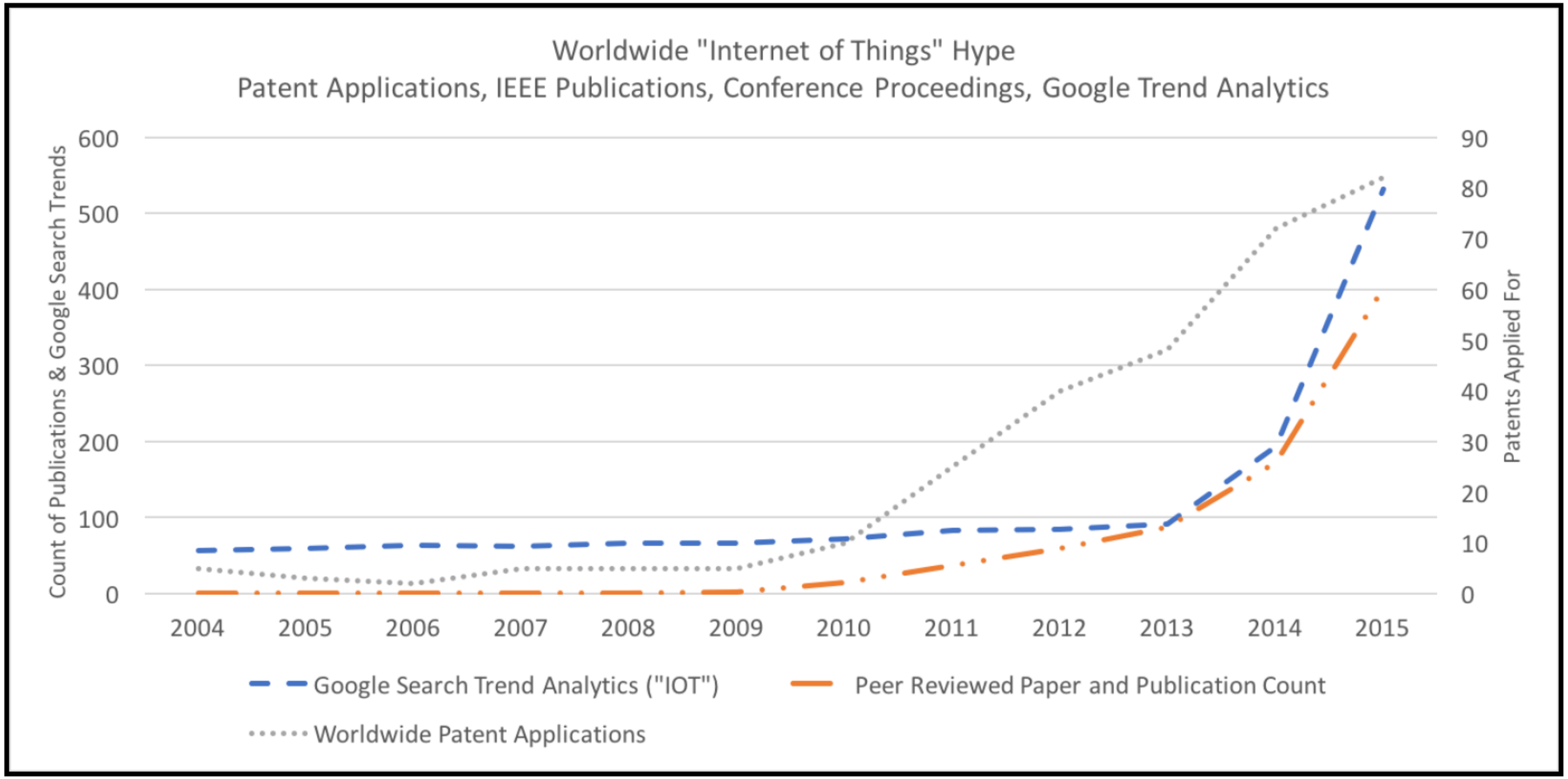
History of IoT (continued)



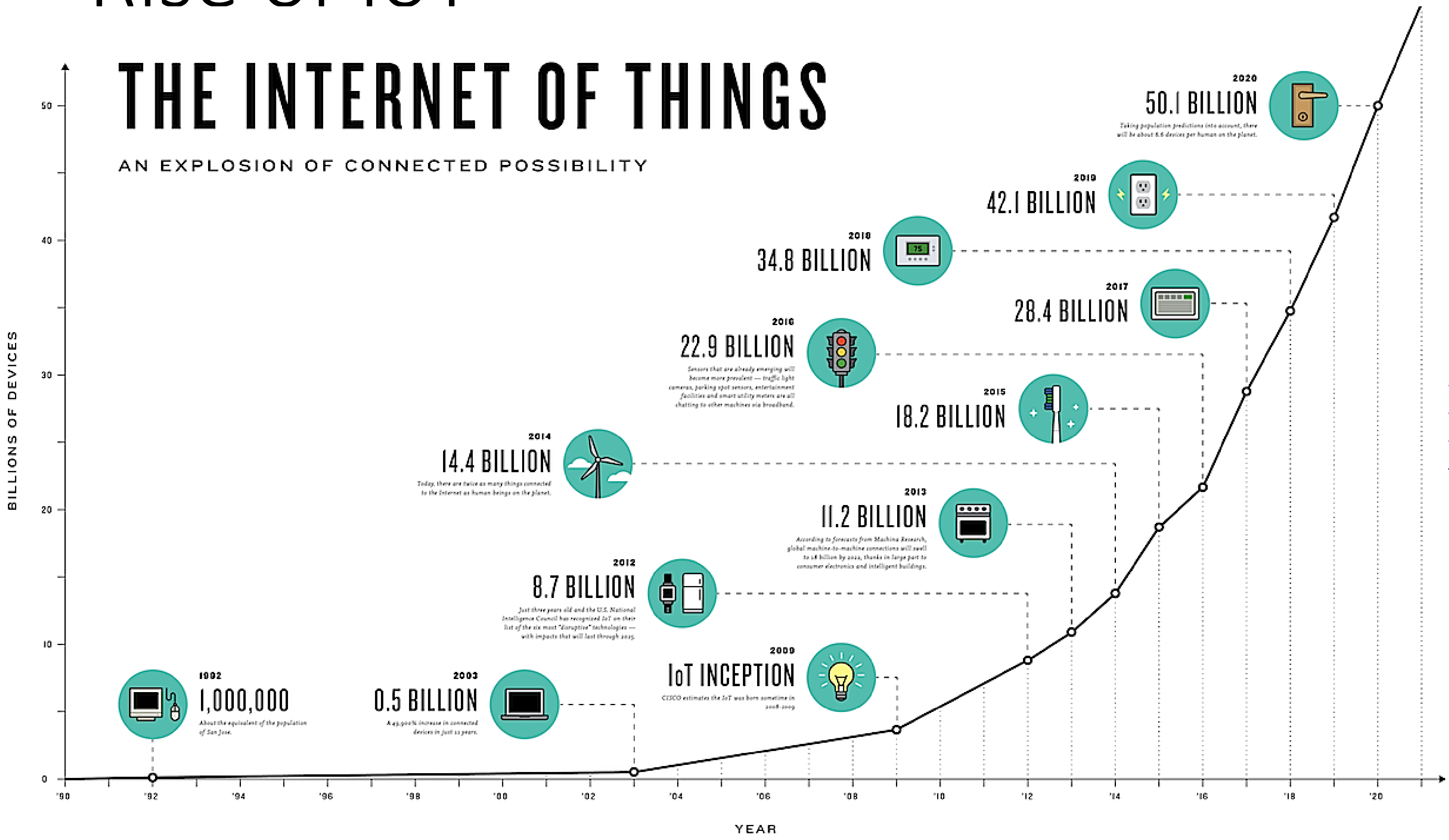
- 2000 – LG introduced the Internet refrigerator with screens and trackers to keep track of the food that was there in the fridge.
  It was expensive.
- 2007 – The first iPhone is released allowing people to interact with the world and internet connected devices in a whole new way.
- 2008 – The first international IoT conference was held in Zurich and also the number of Internet connected devices surpassed the number of humans.
- 2009 – Google starts self-driving car tests
- 2014 – Amazon Echo is released which paves way for the Smart Home Hub market
- 2016 – GM, Lyft, Tesla and Uber all start testing self-driving cars
- -
- -
- -
- 2023: **TomTom and Microsoft unveil generative AI for connected vehicles**
- **Virgin Media develops 5G drone for search and rescue missions**
- **Cybersecurity threats facing medical devices**
- **P2PInfect malware variant targets IoT devices**
- **2024: 5G propelled IoT**
- **Applications: Digital Twin, AI for DM /edge computing.**

Sou ry-of-iot/

Rise of IoT

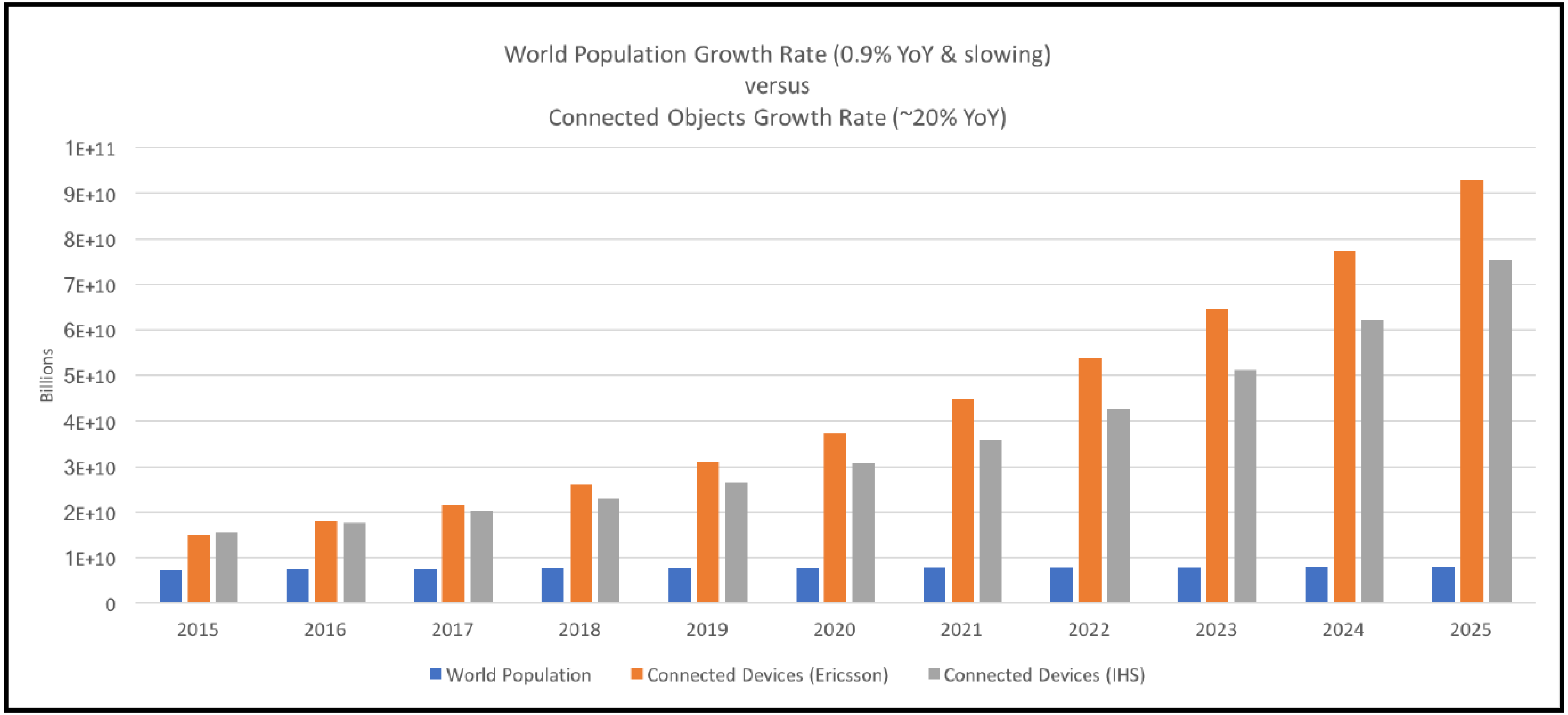

Worldwide "Internet of Things" Hype
Patent Applications, IEEE Publications, Conference Proceedings, Google Trend Analytics
Count of Publications & Google Search Trends
600
500
400
300
200
100
0
Patents Applied For
90
80
70
60
50
40
30
20
10
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Google Search Trend Analytics ("IOT")
Peer Reviewed Paper and Publication Count
Worldwide Patent Applications

Rise of IoT



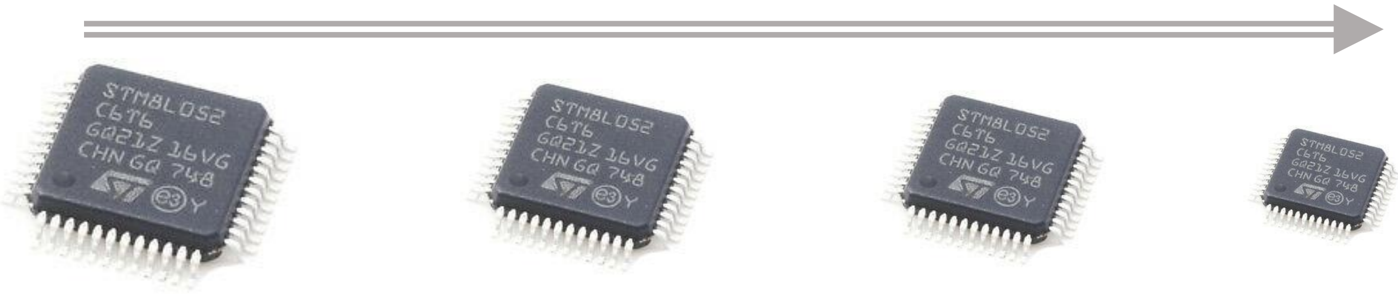
Source: https://www.weforum.org/agenda/2017/06/internet-of-things-will-power-the-fourth-industrial-revolution/

Rise of IoT

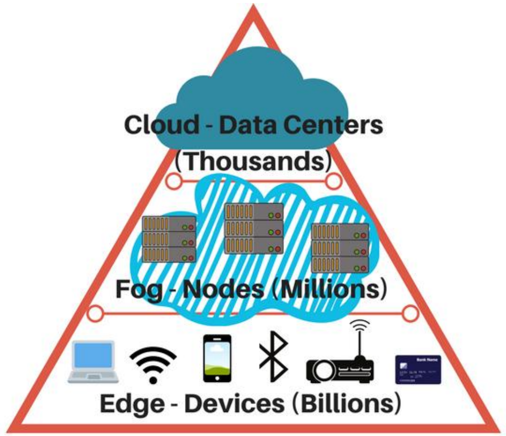

World Population Growth Rate (0.9% YoY & slowing)
versus
Connected Objects Growth Rate (~20% YoY)
Billions
1E+11
9E+10
8E+10
7E+10
6E+10
5E+10
4E+10
3E+10
2E+10
1E+10
0
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
World Population
Connected Devices (Ericsson)
Connected Devices (IHS)

Why is IoT buzz word now?

- Embedded chips are becoming cheaper, smaller and low power devices
- Emergence of faster communication technologies
- Flexibility of IPv6 to address more IoT devices
- Emergence of fog/edge computing
- Advances in Big Data, Deep Learning and AI understanding

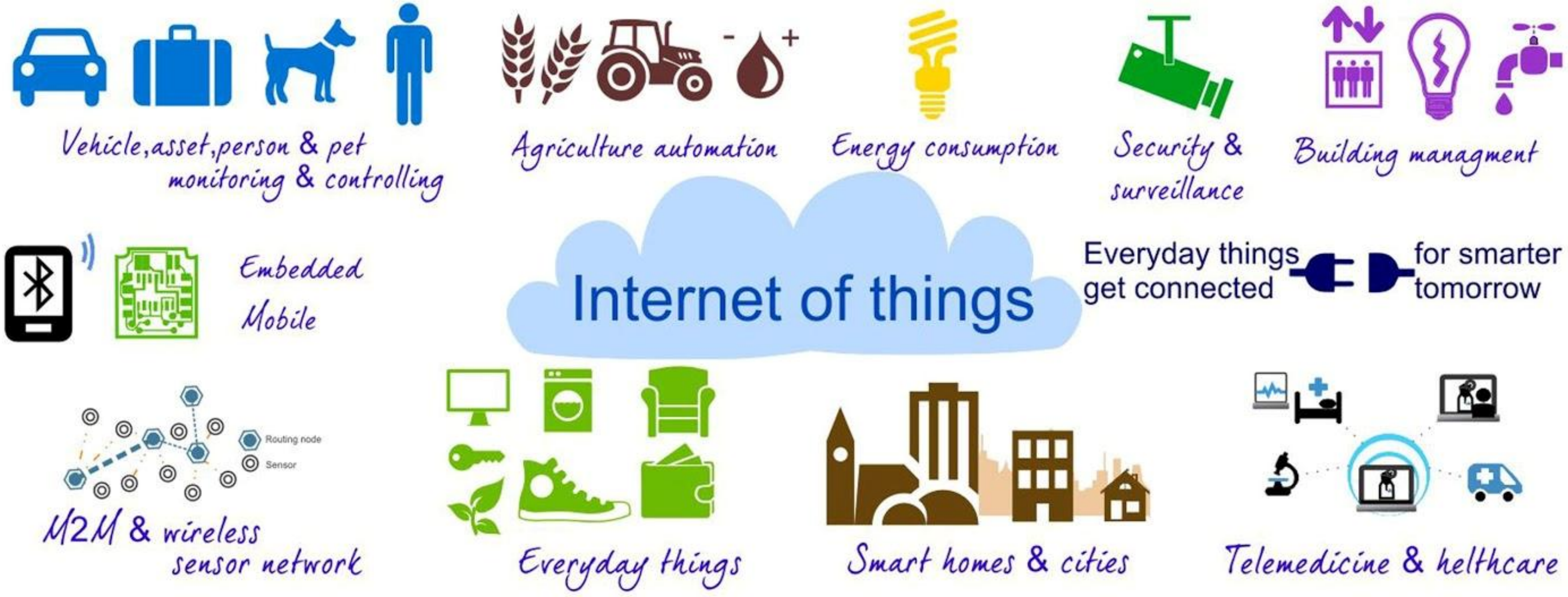


Source: https://timestech.in/gartner-say-worldwide-5g-network-infrastructure-revenue-will-reach-4-billion-in-2020/

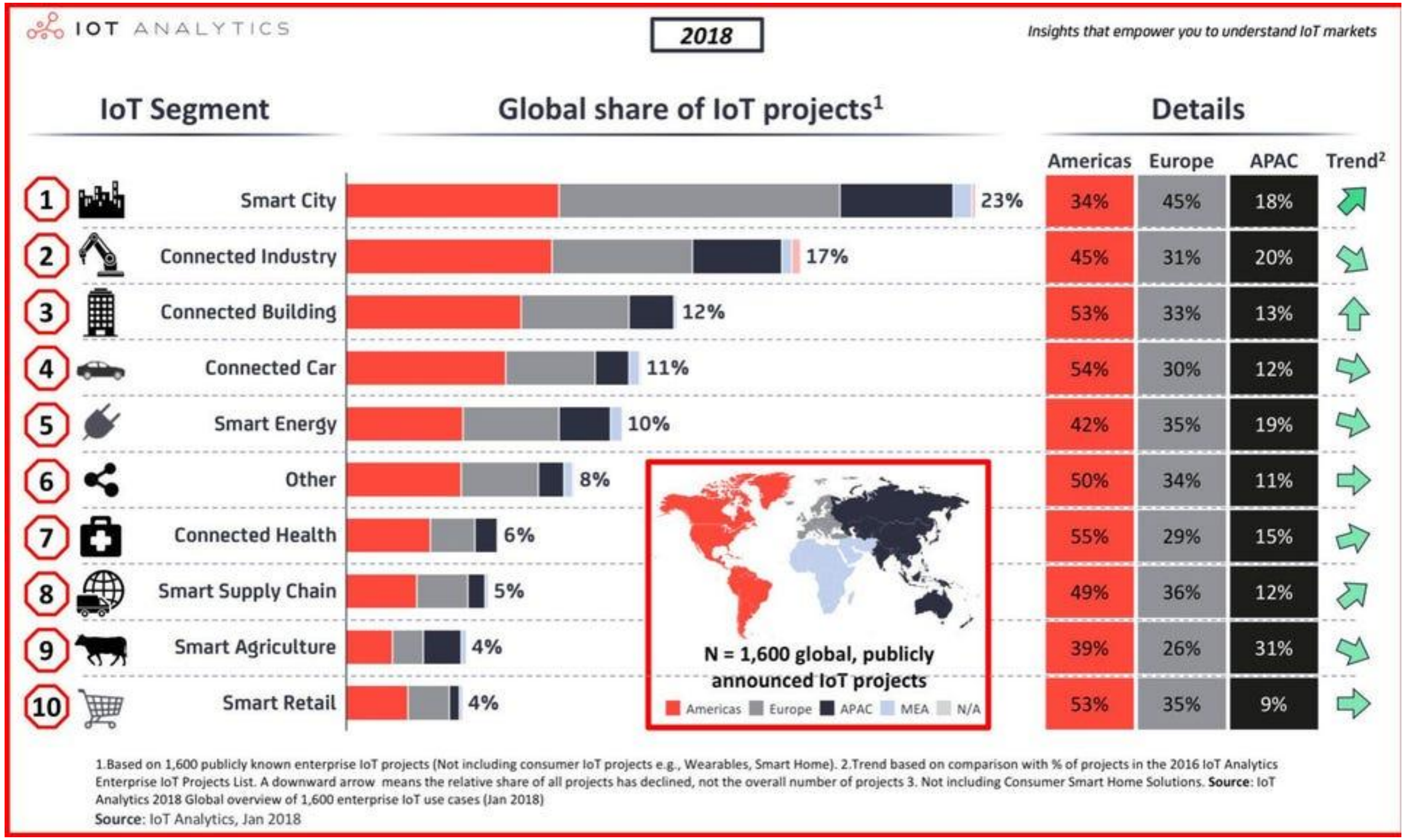


Source: https://www.power-solutions.com/industry-trends-best-practices/industry-trends/fog-computing-and-edge-computing-what-you-need-to-know

IoT Applications



[Source: https://iotworm.com/internet-of-things-applications-area/](https://iotworm.com/internet-of-things-applications-area/)

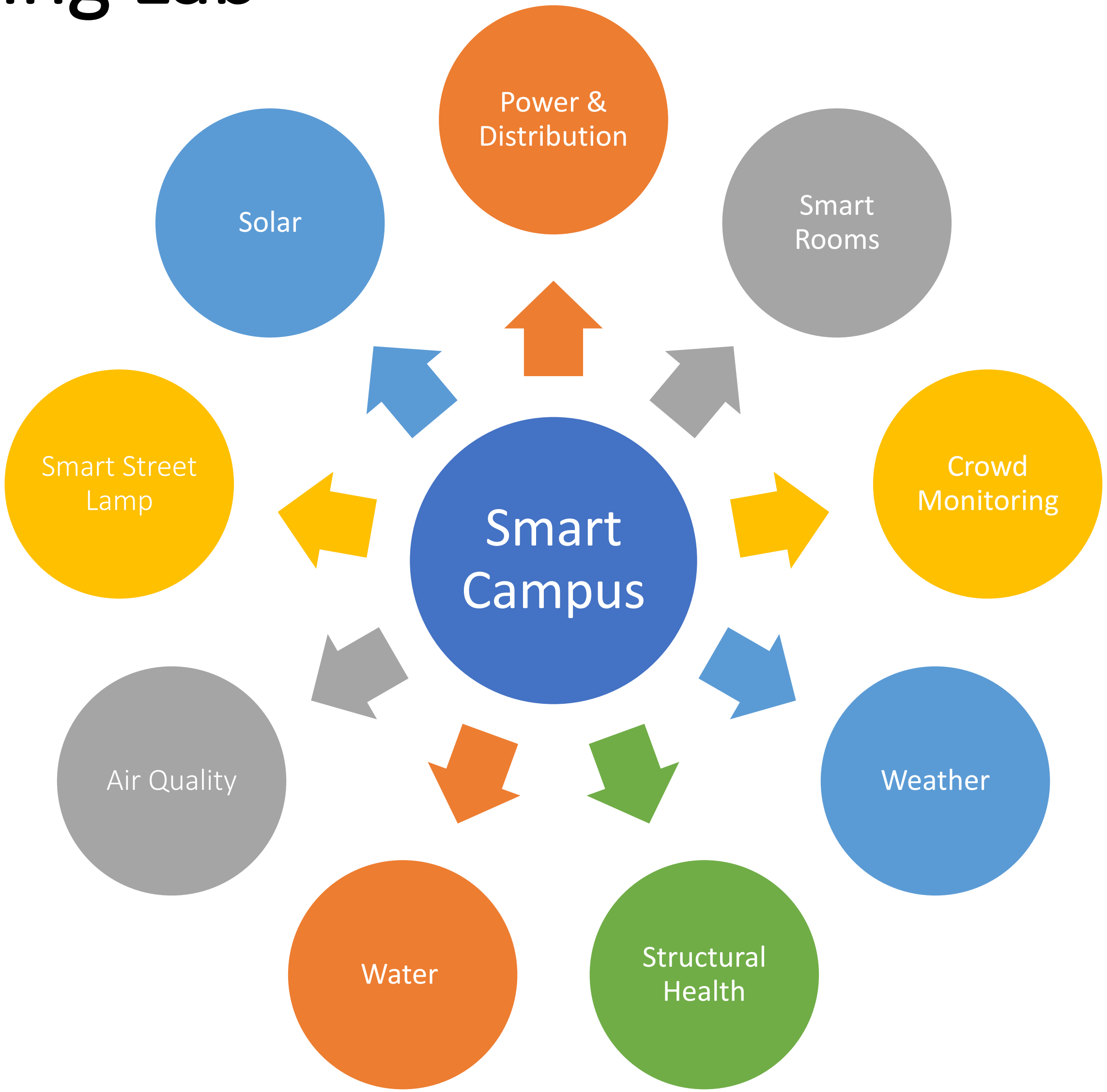


Source: https://www.forbes.com/sites/louiscolumbus/2018/06/06/10-charts-that-will-challenge-your-perspective-of-iots-growth/?sh=42f59eed3ecc

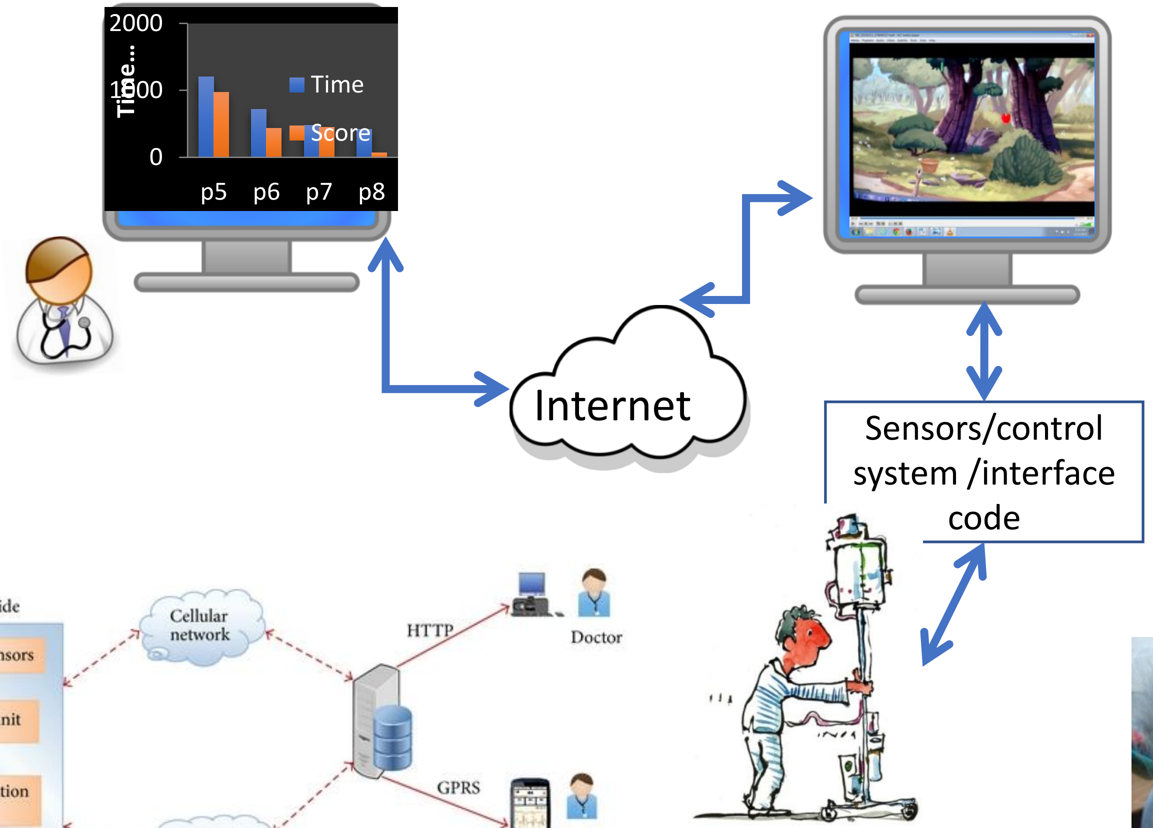
IoT Use Cases

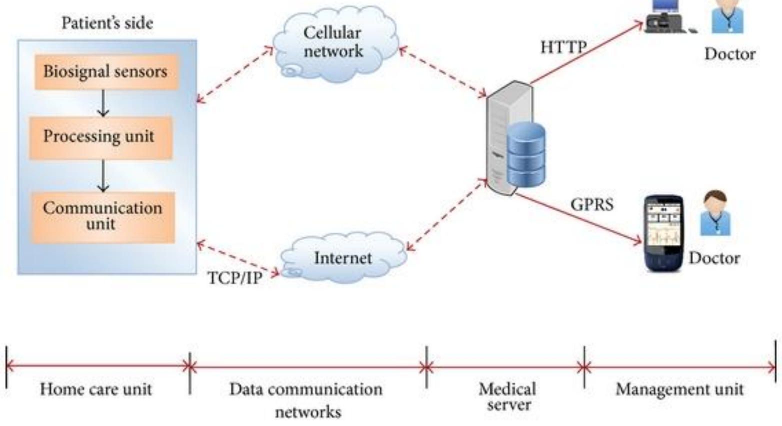
- Industrial and Manufacturing
- Consumer
- Retail
- Healthcare
- Transportation and Logistics
- Agriculture
- Energy
- Smart City

Smart City Living Lab



IoT and healthcare



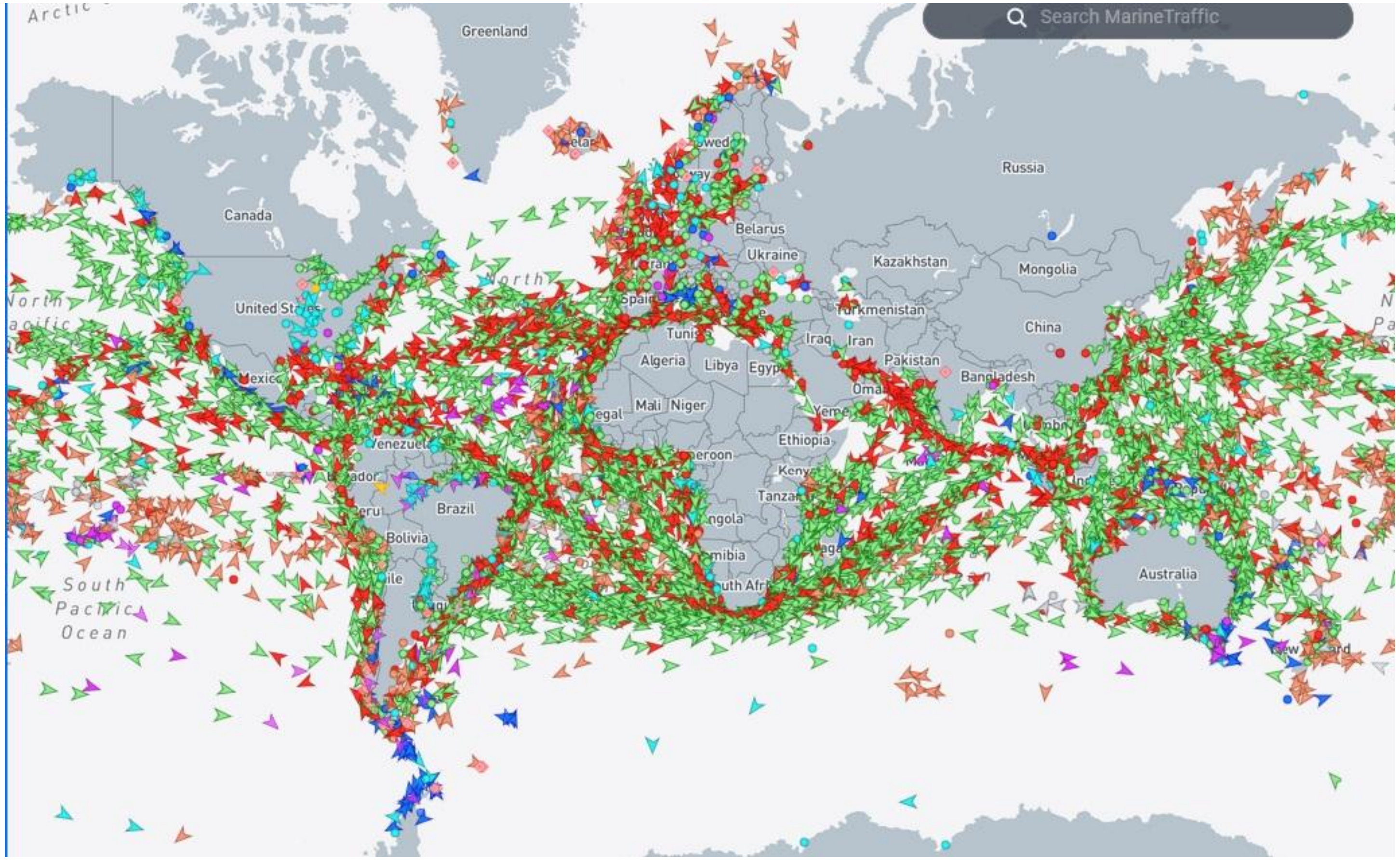


Doc

IoT

IoT Case Study

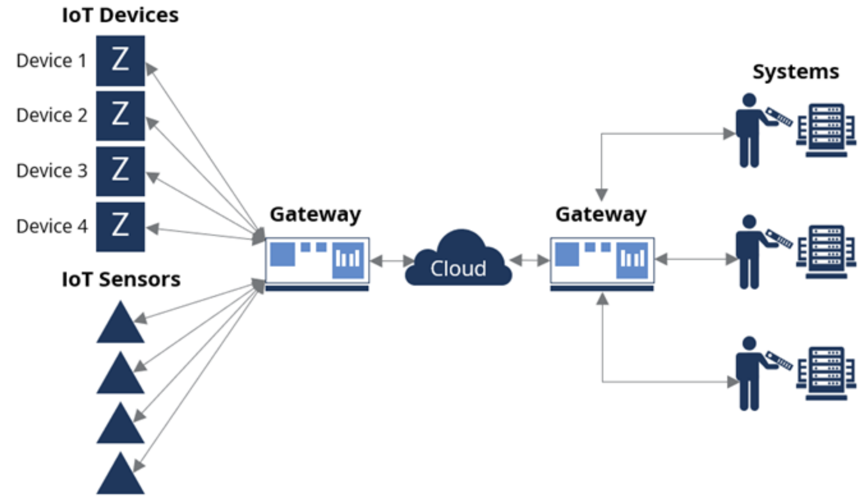
IoT in connected vehicles

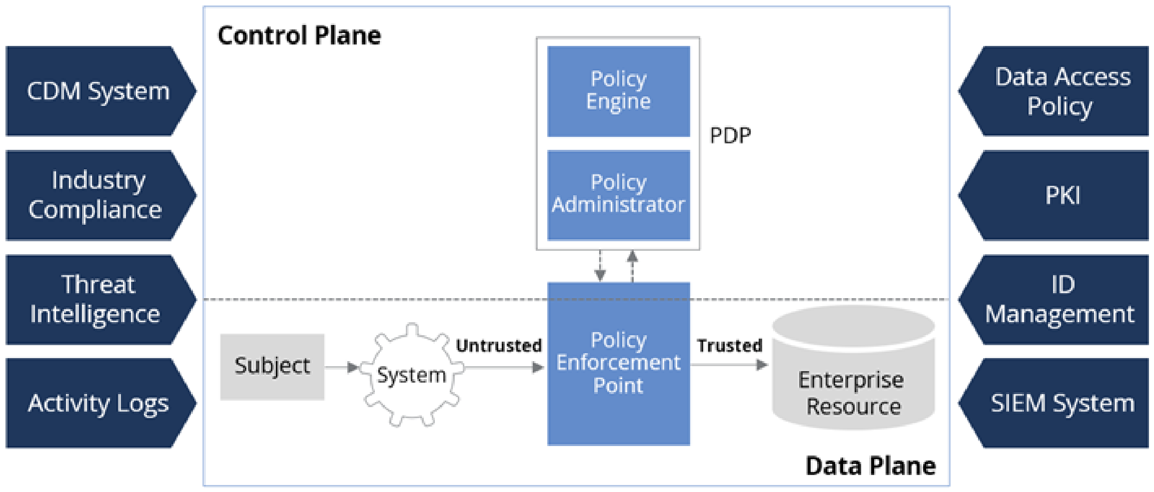


https://www.marinetraffic.com/en/ais/home/centerx:126.9/centery:-9.8/zoom:2

Zero trust Architecture

Typical IoT environment with connections to an internal network

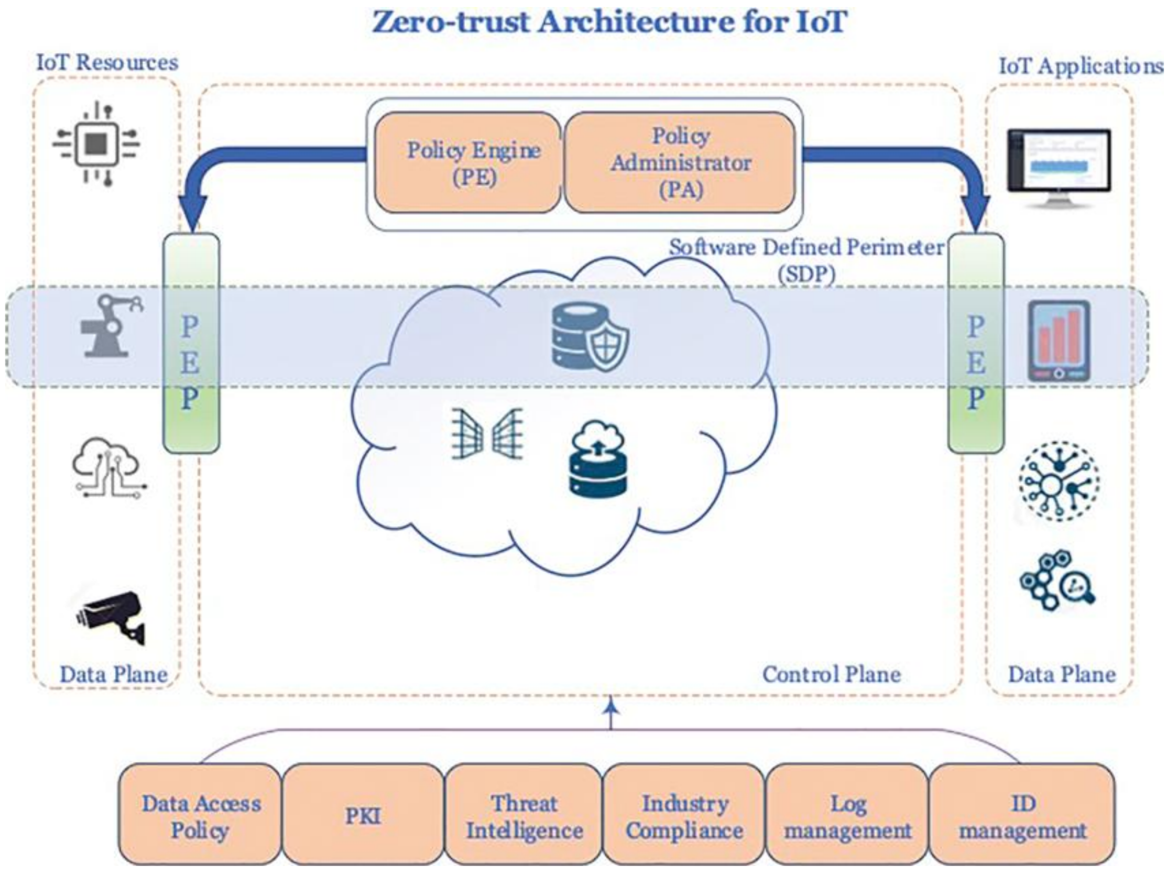




NIST 800-207 Zero Trust Framework

https://isg-one.com/articles/iot-in-a-zero-trust-world

Zero Trust Architecture



https://link.springer.com/article/10.1007/s10796-021-10199-5

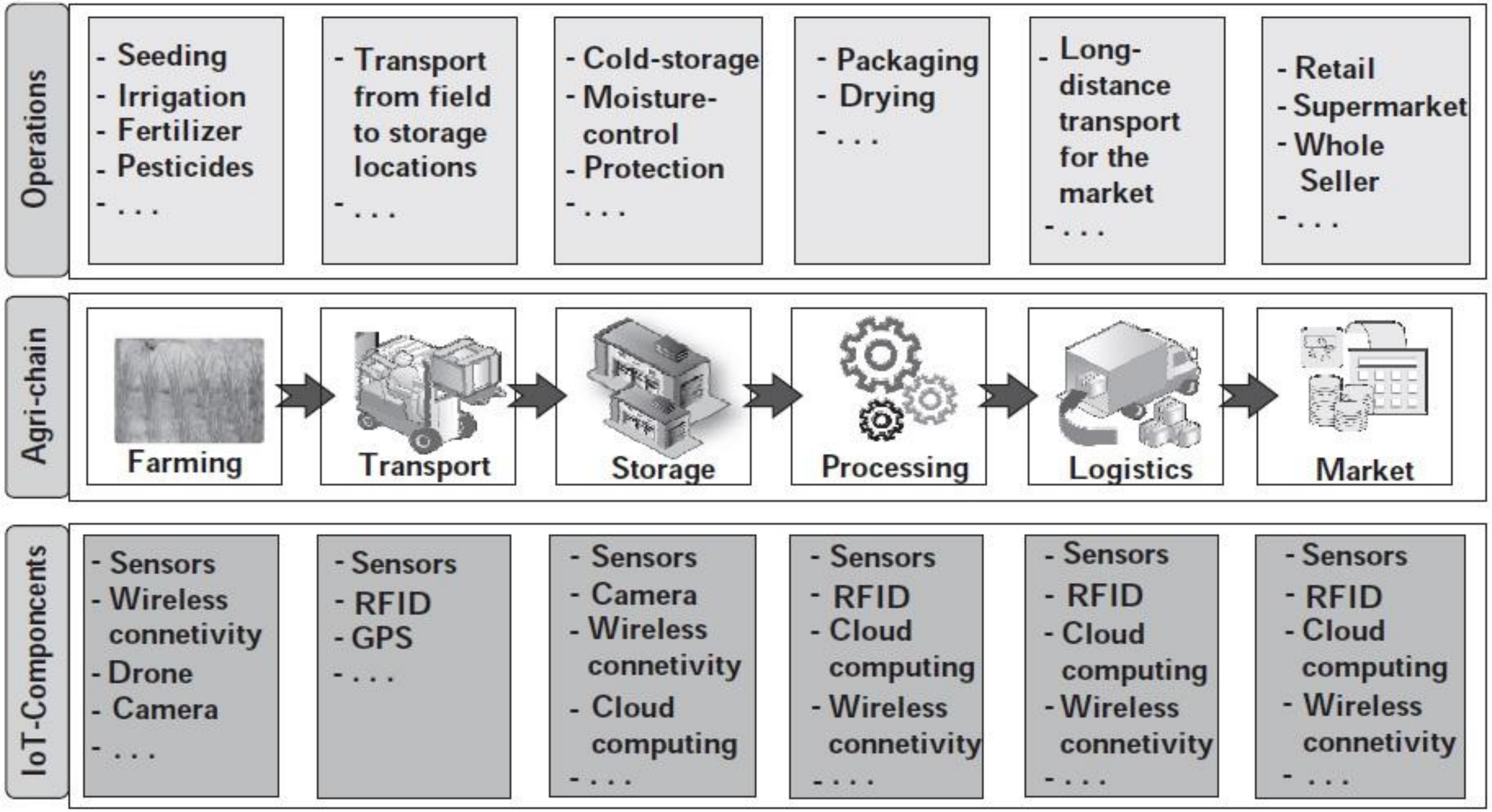
Case study – sensors in agriculture (IoT)

- Increase crop productivity
- Surveillance
- Cropping planning

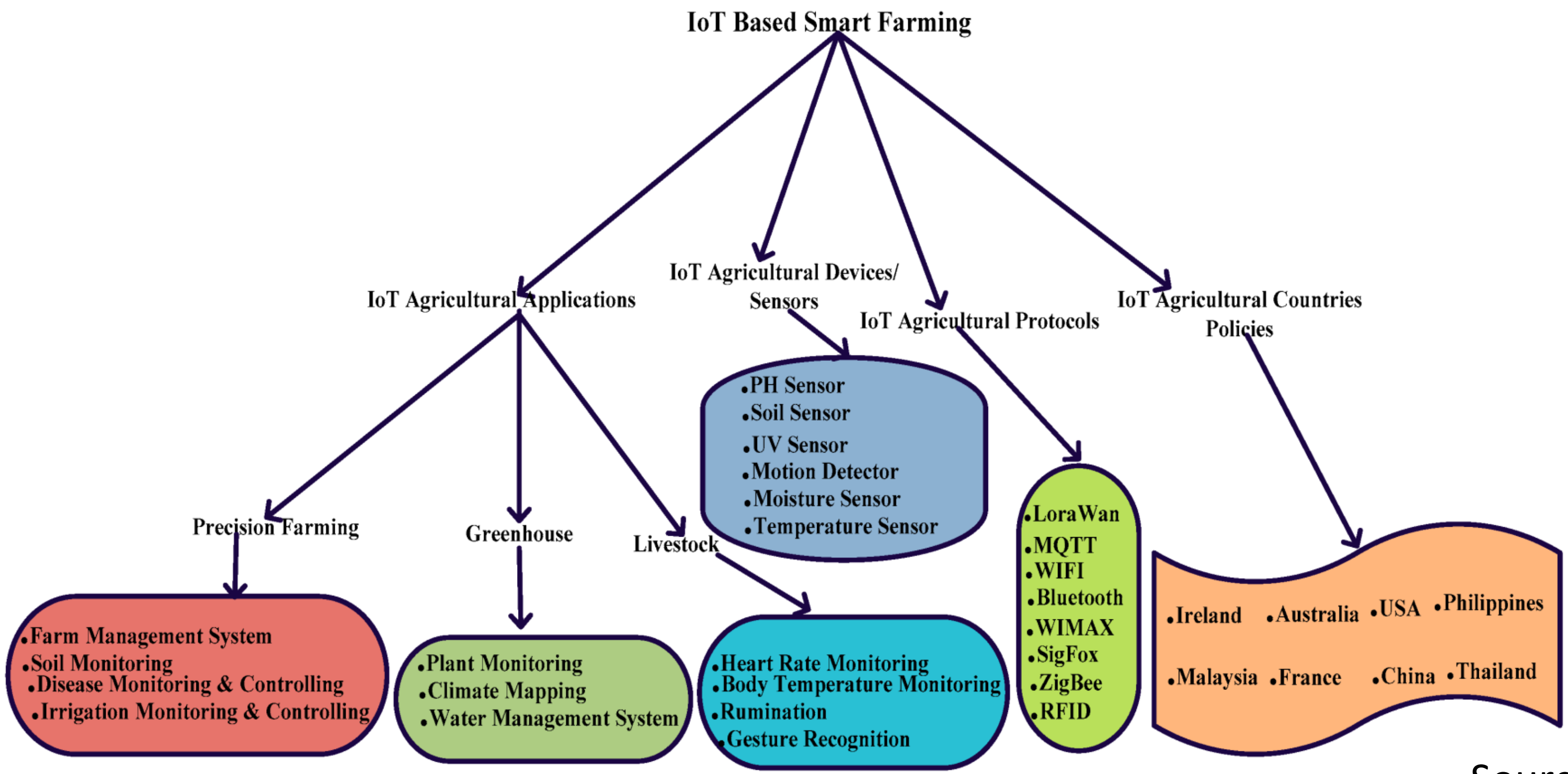
Agricultural sensors
Farming drones
Smart Greenhouses
Monitoring climate conditions
Crop management - Crop rotation
Water management
Cattle monitoring and management

Marut (https://www.marutdrones.com/

IoT components in the agricultural chain

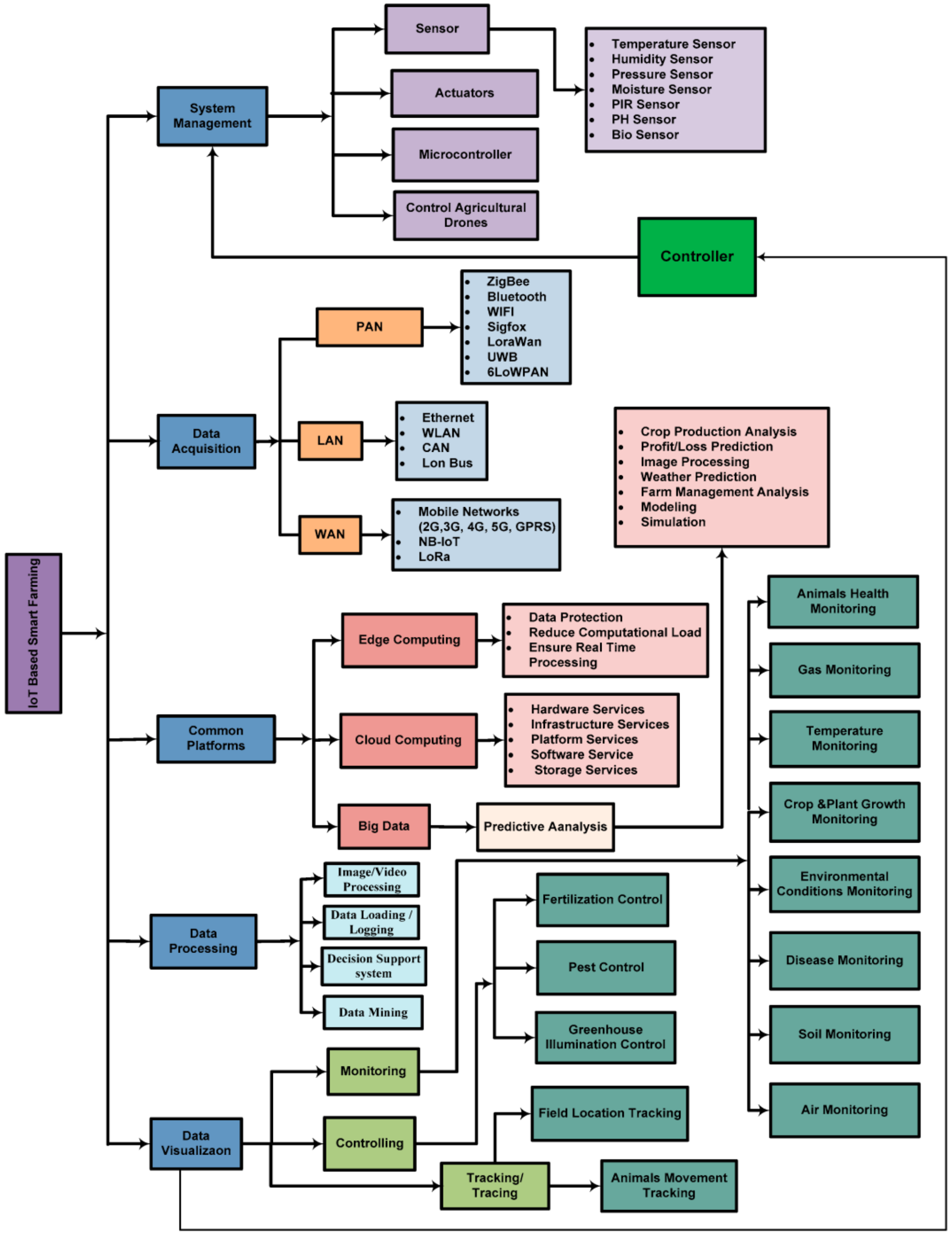


IoT in Agriculture



Source: Farooq et al.,2020

Role of IoT Technology in Agriculture: A Systematic Literature Review



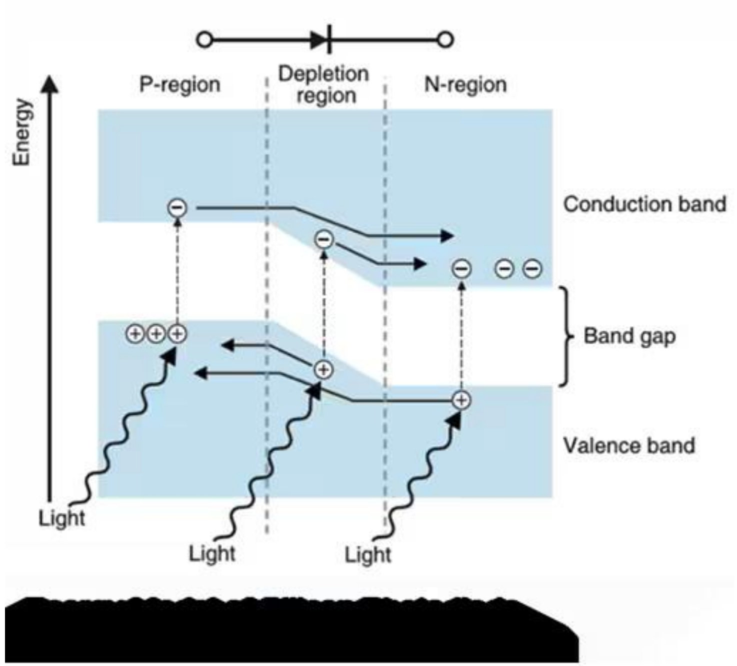
Source: Farooq et al.,2020

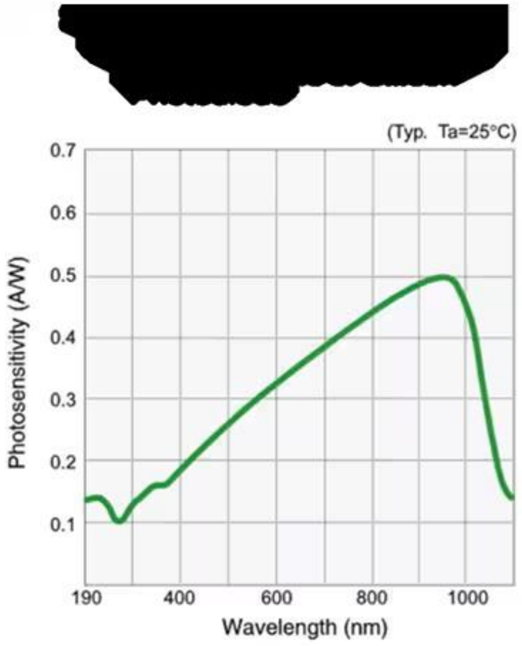
Role of IoT Technology in Agriculture: A Systematic Literature Review

In-situ assessment of leaf area index using IoT-based agricultural system

- The PAR (Photosynthetically Active Radiation) Sensor measures photosynthetic light levels in both air and water.

The PAR (Photosynthetically Active Radiation) Sensor reports the Photosynthetic Photon Flux Density (PPFD), which corresponds to micromoles of photons per meter squared per second (µmol m^{-2} s^{-1}).



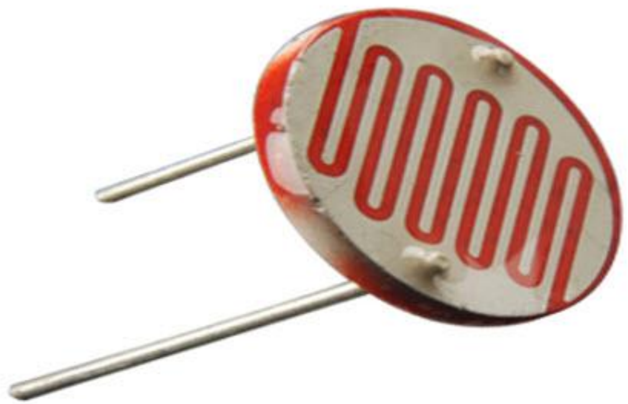


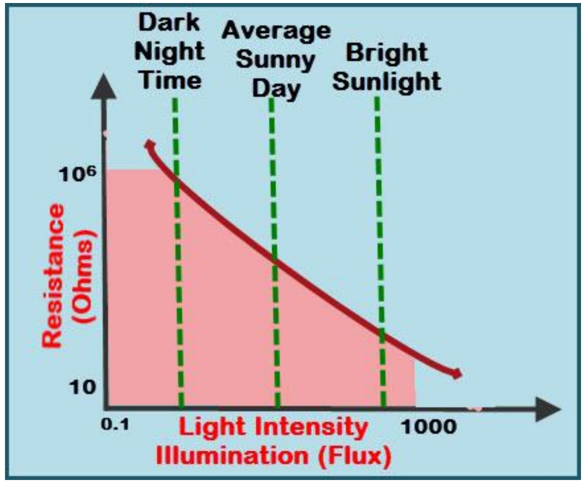
Source: Shimadzu

LDR sensors

LDR sensor

- A Light Dependent Resistor (LDR) or a photoresistor is a device made up of high resistance semiconductor material (cadmium sulfide (CdS) being a popular choice for these photoresistors. Lead sulfide (PbS) and indium antimonide (InSb))
- Passive sensor
- Resistance changes with the change in light intensity
- Cadmium Sulfide used as the semiconductor material
- Preferred for outdoor lighting and automatic street lighting circuits

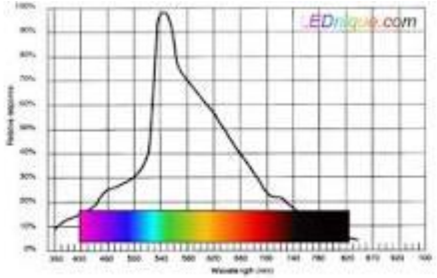


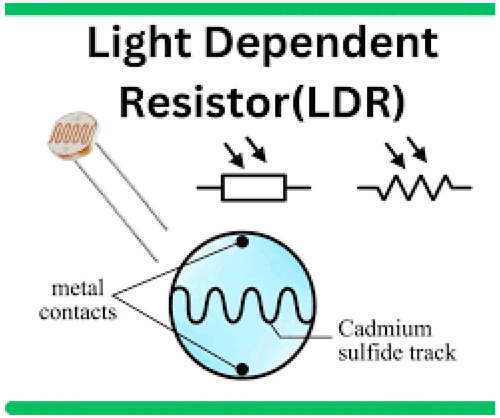


Source: https://www.elprocus.com/ldr-light-dependent-resistor-circuit-and-working/

LDR Working Principle

- Based on the principle of photoconductivity → conductivity of a material enhances when light falls on it
- Electrons in the valence band of the material jump to the conduction band provided the photons have energy required to excite the electrons across the bandgap of the material
- Sensitivity of LDR varies with wavelength of the light incident on device
- Latency of LDR → Time taken to respond to changes by the component
- Significant time from light changes to LDR getting its last value → Not used for scenarios with quick changes of light values
- Few tens of milliseconds when light is given after complete darkness, but can take upto a second when light is removed





Privacy Label -

https://www.iotsecurityprivacy.org/downloads/Emami-Naeni_USENIX23_ConsumerWillingnesstoPay.pdf

https://ieeexplore.ieee.org/document/9664750