Internet of Things

Programming

Week-1 Introduction

Unit convenor and Lecturer

Anas Dawod

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Swinburne University of Technology

March 2023

Course Staff

- Prem P. Jayaraman (Moderator)

  pjayaraman@swin.edu.au

  Prem is a Professor and Director of Factory of the Future and Digital Innovation Lab at Swinburne University of Technology. He is a systems and experimental researcher working in the area of Internet of Things (IoT) helping co-create digital solutions solving industries in their digital transformation journey. He has published 100+ articles in IoT.

- Anas Dawod (Unit Convenor and Lecturer)

  adawod@swin.edu.au

  Anas has 2+ years of industry experience and 8+ years of teaching and industrial research experience. He is currently a Research Fellow at Swinburne IoT lab working on an Australian Research Council (ARC) funded project. His research interests focus on the Internet of Things (IoT) and Blockchain technology.

Course Staff

- Hamid Bagha (Tutor)
  hbagha@swin.edu.au

  Hamid is an IoT research graduate who has been involved in multiple IoT-based research projects in different areas including precision agriculture and greenhouse gas emission analysis.

- Hardik Mandani (Tutor)
  pjayaraman@swin.edu.au

  Hardik is an experienced Embedded System Engineer and has 5+ years of industry experience. He is a PhD candidate in Software and Electrical Engineering department at Swinburne University of Technology. His research will focus on developing an IIoT Data-Analytics-based solution to reduce defects in manufacturing systems.

About The Unit

Aims

- Teach fundamentals of developing an IoT-based solution for Smart Homes, Smart Cities etc., using IoT sensors and devices. Students will learn the skills to work with current popular IoT sensor and platforms such as Arduino, Netatmo and will have the opportunity to apply these skills in developing innovative IoT-based system.

Objectives

- To contribute to the development of the following Swinburne Graduate Attributes:
- Communication skills
- Teamwork skills
- Digital literacies

About The Unit

Lectures

- The lectures are offered online and on campus on Tuesdays 6:30pm to 8:30pm.
- Online lectures will be conducted on Week 9, 11, 12, 14, 16, 17, 18, 21 at Collaborate Ultra.
- On campus lectures be conducted on Week 10, 13, 19, 20 at BA201.
- Both online and on campus lectures will be recorded.

Tutorials

- All tutorials will be conducted on campus at BA407
- Expected to work as groups
- Anas Dawod will manage Tutorials on Tue 10:30 and Tue 2:30.
- Hamid Baga will manage Tutorials on Tue 4:30, Wed 12:30, and Wed 2:30.
- Hardik Mandani will manage Tutorials on Wed 8:30, Wed 10:30, Thu 10:30, and Thu 12:30

Course Outline

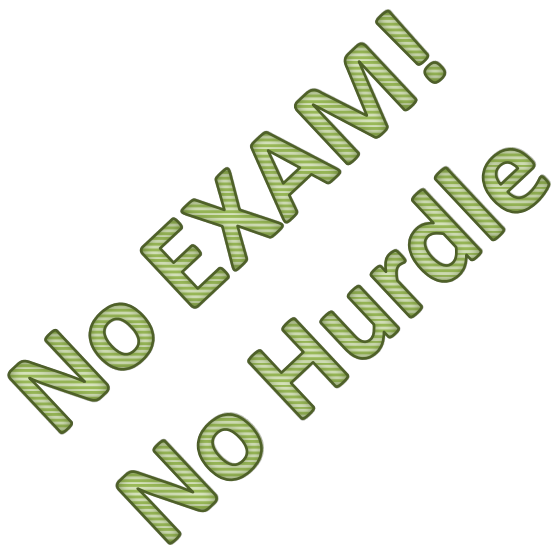
- Week 1 – Introduction
- Week 2 – IoT hardware and Software
- Week 3 – Edge servers
- Week 4 – Communication, Timers and Interrupts
- Week 5 – Data Management
- Week 6 – APIs and Webservers

Semester Break

- Week 7 – Guest Lecture
- Week 8 – IoT Networking
- Week 9 – Cloud computing for IoT applications
- Week 10 – Guest Lecture
- Week 11 – Advanced Topics in IoT 1 (Analytics and Security)
- Week 12 – Advanced Topic in IoT 2 (Analytics and Security)

Assessment

- Survey paper (20%)
- Individual Assignment (25%)
- Group Assignment (35%)
- Quizzes (20%)



Internet of Things

Things? Internet-connected devices?

Internet of Things

What is an IoT

- The term Internet of Things (IoT) was firstly used in the 1990s by MIT when they described the future world of sensors and devices (termed Things) are connected together via the Internet to share their data (Oppitz and Tomsu, 2018).
- The modern IoT research and applications era started ,in mid 2010, due to the technical limitations and the high cost of required IoT elements such as wireless connection modules, sensors, and micro-processors before 2010 (Oppitz and Tomsu, 2018).

What is an IoT

- Though the term “Internet of Things” is relatively new but the system of connecting computers and networks to monitor and control devices has been in use since few decades
- Interestingly, the first known application of IoT was deployed in the 1980s, which was a Coke machine deployed in Carnegie Melon University, and connected to the internet to check the status of the drink machine remotely to decide if the machine needs a fill-up or not (Oppitz and Tomsu, 2018).

What is an IoT

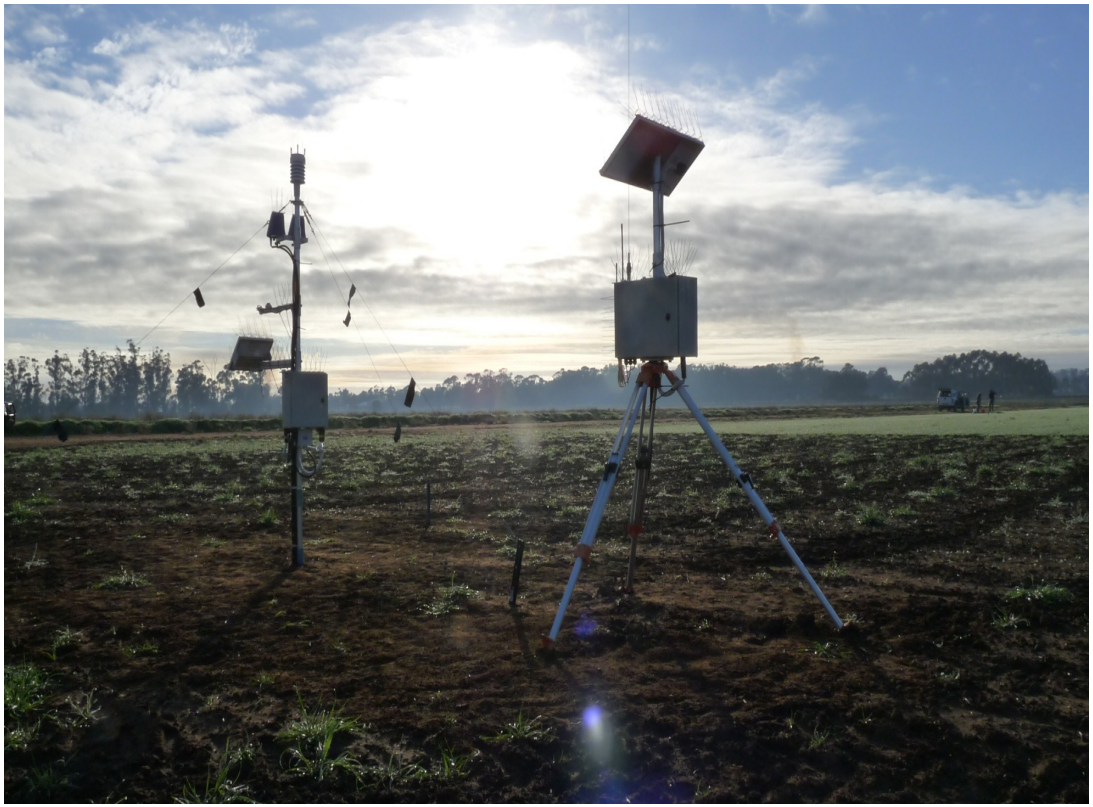
- **Definition:**

  IoT refers to a collection of networked physical devices/physical objects/embedded devices (a.k.a. “things”) capable of sensing and exchanging information with other devices over the internet.

Source: RFC 7452

What is an IoT

Internet of Things is about
learning from a billion of machines that include sensors, cameras, and other smart internet connected objects, a.k.a. Things, as well as people



What is an IoT

- Your alarm clock is informed that you flight is delayed by 1 hour, it lets you sleep later and sets the coffee machine to make coffee when you wake up.
- Your car knows when it needs an oil change, makes an appointment when you have time in the car service location offering the lowest price along the route with less traffic.
- Your fridge knows how long before the milk expires.
- Your iPhone knows the areas with the less pollution and you dynamically adjust your route to reduce the pollution you inhale.

IoT Market

Number of things:

- The number of connected things has grown to reach around 13 billion in 2022 according to Statista.
- CISCO Forecasts that Internet will connect 50 billion things around the world, while Intel estimated 200 billion things to be connected by 2030.
- Huawei: 100 Billion devices by 2025.

IoT Data:

- According to Forbes, IoT will generates 79.4 zettabytes (ZB) by 2030.

IoT Market:

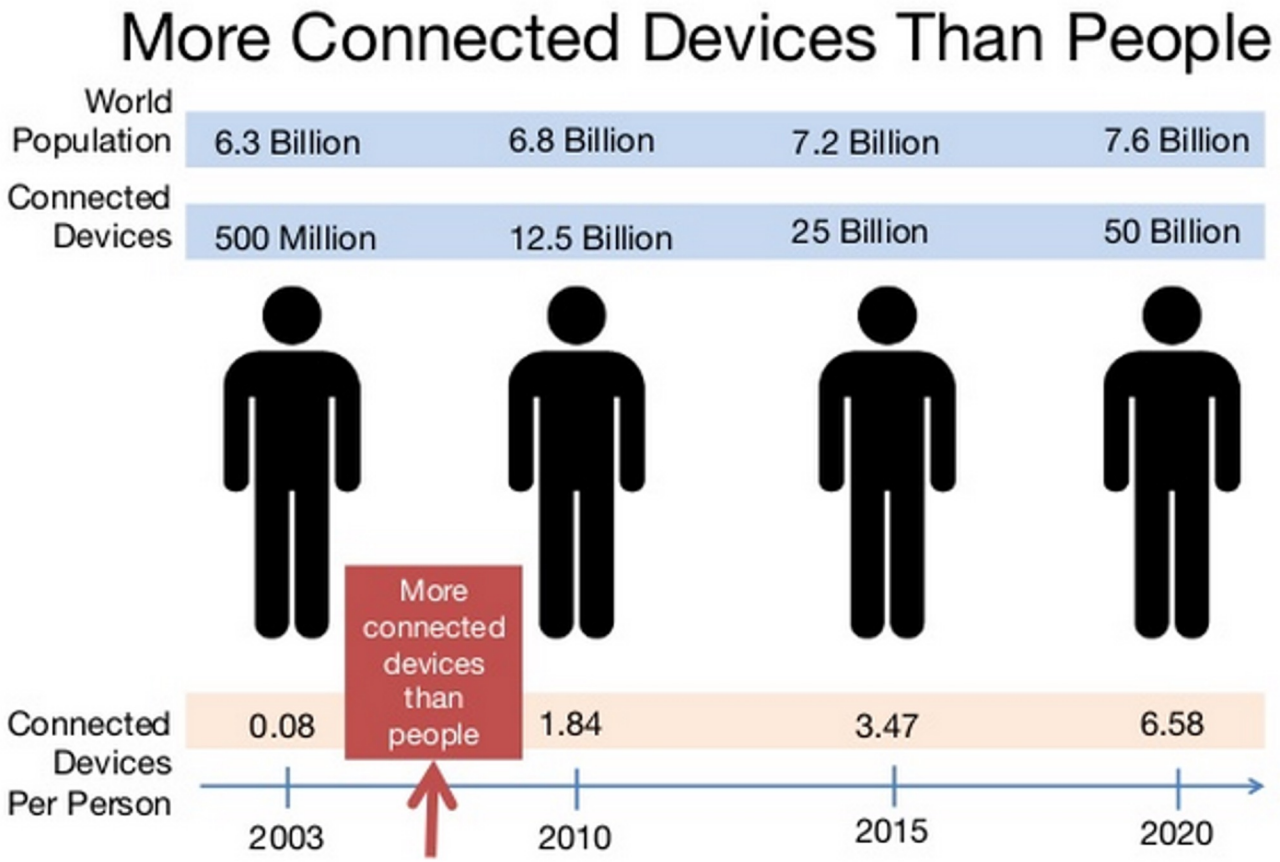
- IoT market will reach $14.7 Trillion by 2022 (Source: CISCO).

IoT Market

Driven by increasing urbanization:

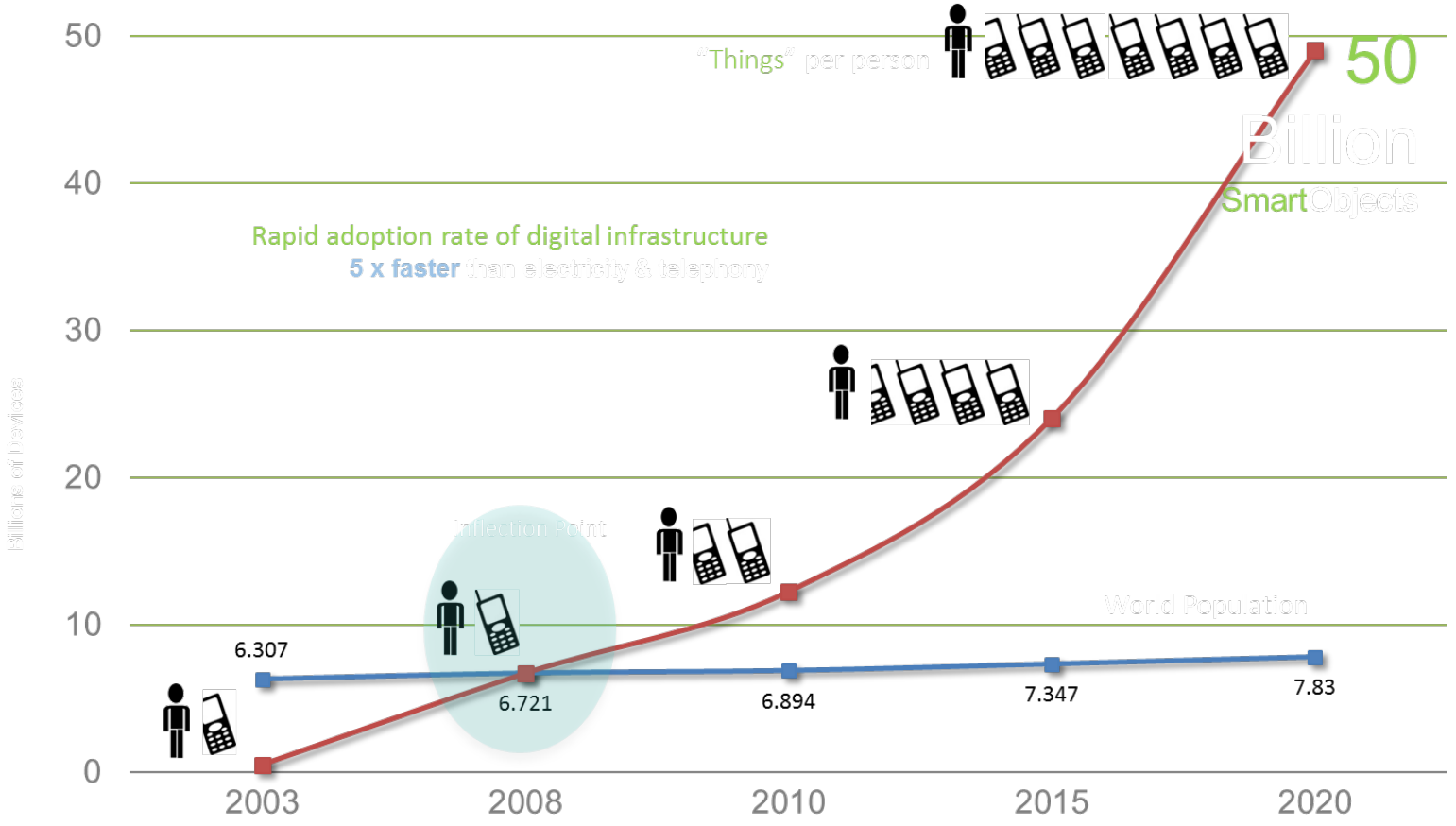
- About 70 percent of the world population will be living in cities by 2050.
- According to CISCO report (2013), people occupying just 2% of the world's land will consume about three-quarter of its resources.

IoT Market


More Connected Devices Than People
World Population
6.3 Billion
6.8 Billion
7.2 Billion
7.6 Billion
Connected Devices
500 Million
12.5 Billion
25 Billion
50 Billion
More connected devices than people
Connected Devices Per Person
0.08
1.84
3.47
6.58
2003
2010
2015
2020

IoT Market

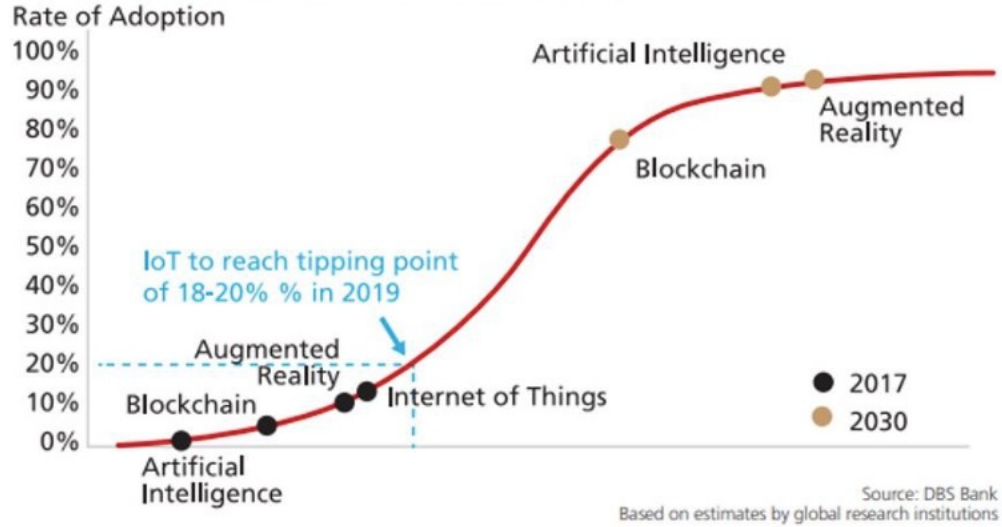
CISCO Forecast: Internet is estimated to connect 50 billion devices around the world by 2020.



Cisco IBSG projections, UN Economic & Social Affairs http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf

IoT Market

IoT adoption to approach 100% over the next 10 years



Source: DBS Bank
Based on estimates by global research institutions

IoT adoption gaining momentum

	2016	2017	2018	2030
IoT units installed base - total (m)	6,382	8,381	11,197	125,000
Consumer devices (m)	3,963	5,244	7,036	75,000
Consumer devices as a % of total devices	62%	63%	63%	60%
Connected devices per person	5	5	5	5
World population (m)	7,400	7,600	7,700	8,500
IoT adoption rate	**11%**	**14%**	**18%**	**176%**

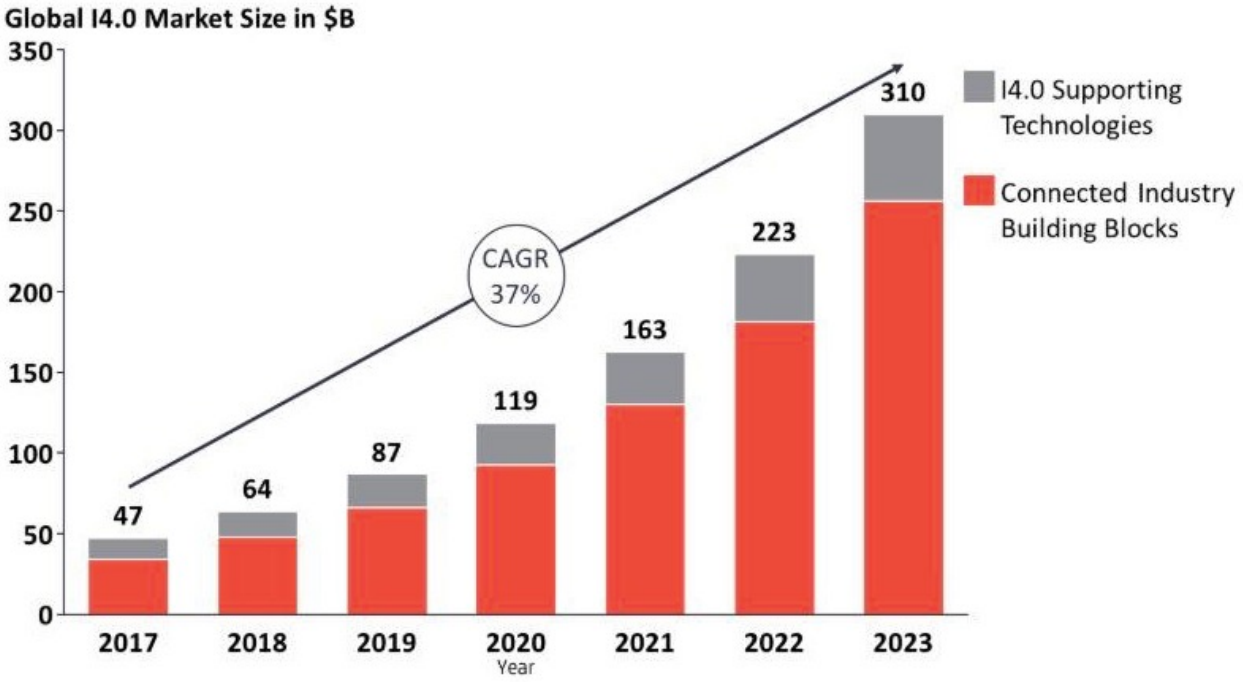
Source: DBS Bank based on estimates by Gartner, United Nations, World Bank

IoT Market

IOT ANALYTICS

Insights that empower you to understand IoT markets

Global Industry 4.0 Market Size 2017-2023



Note: The overall market for I4.0 refers to global spending on the six connected industry building blocks and six I4.0 supporting technologies
Source: IoT Analytics – November 2018

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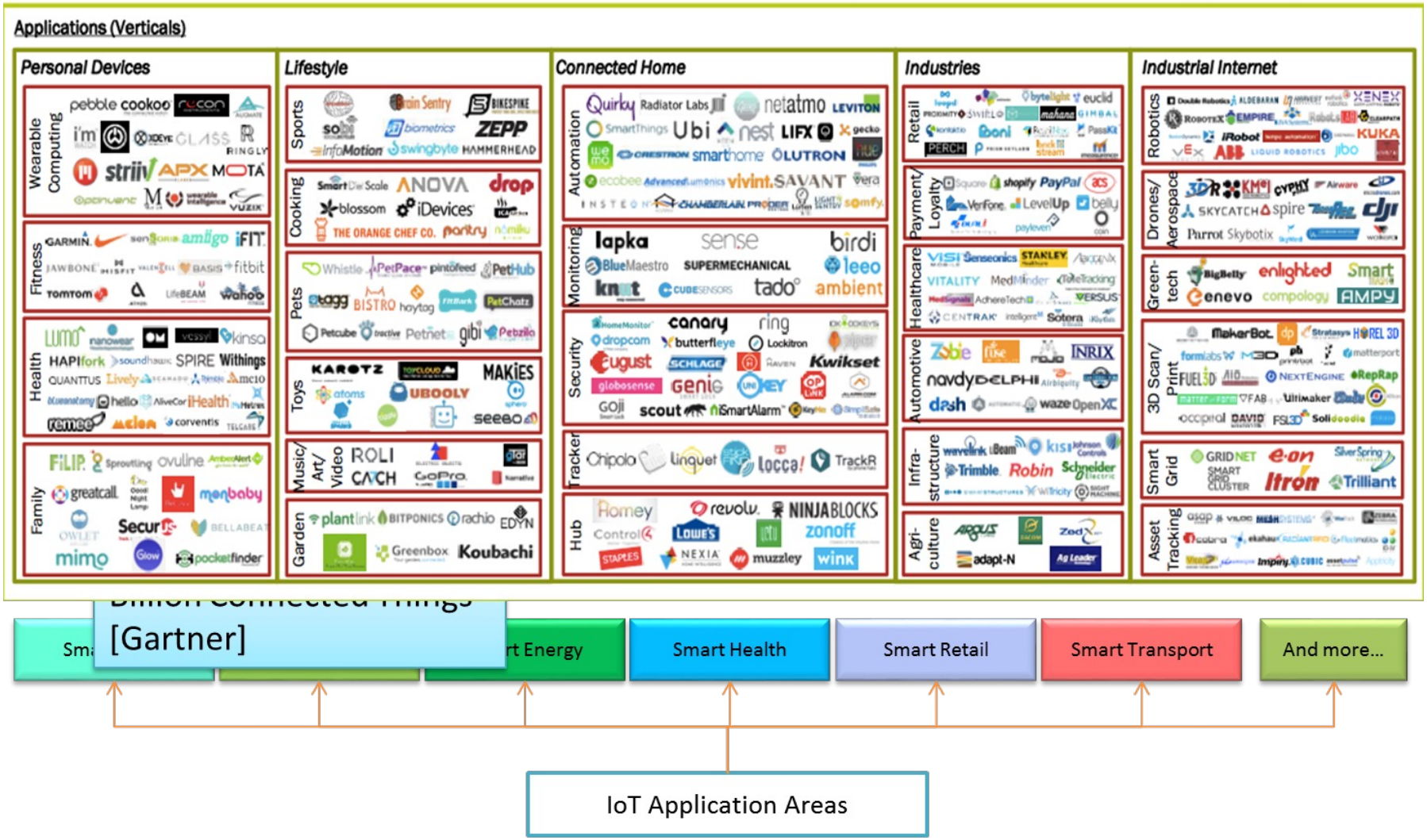
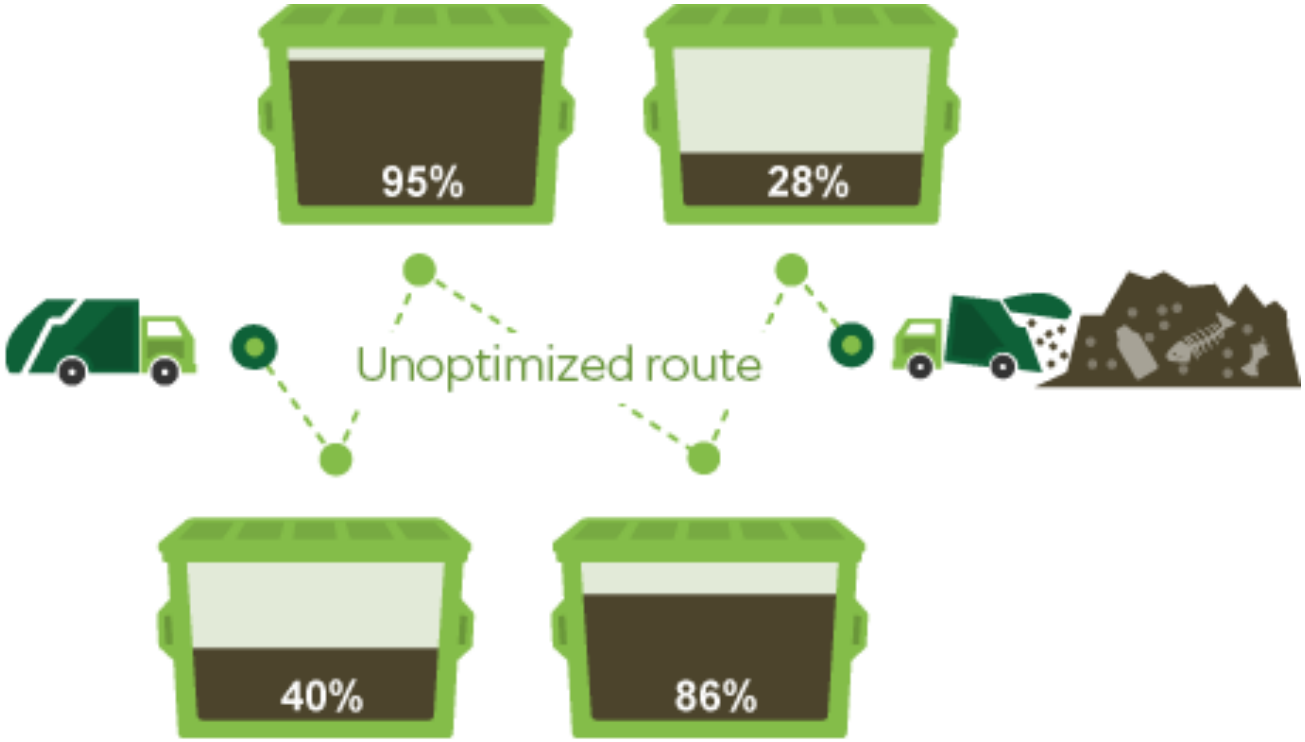
IoT Application



RMIT University - July 2015

IoT Applications

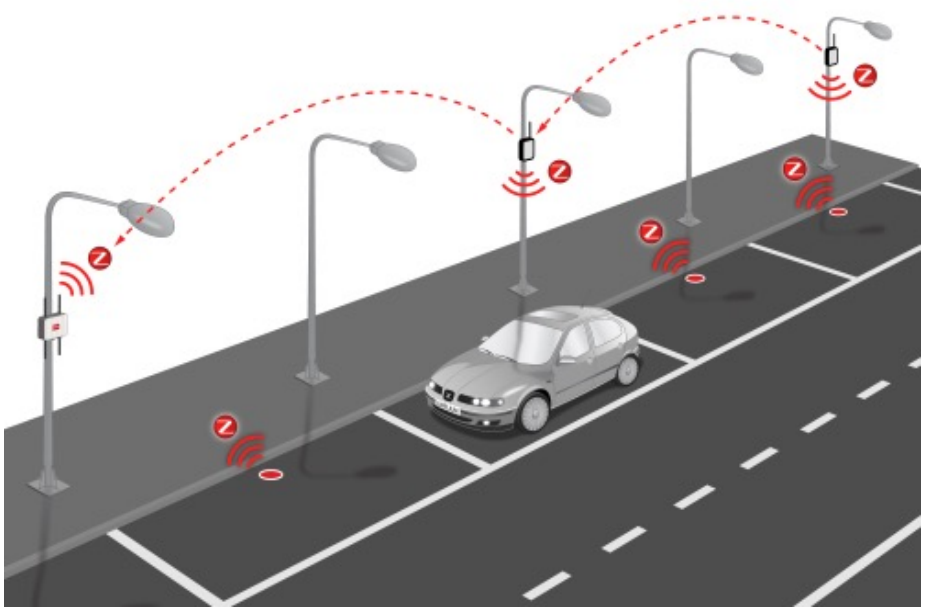
IoT Applications



www.enevo.com

IoT Applications

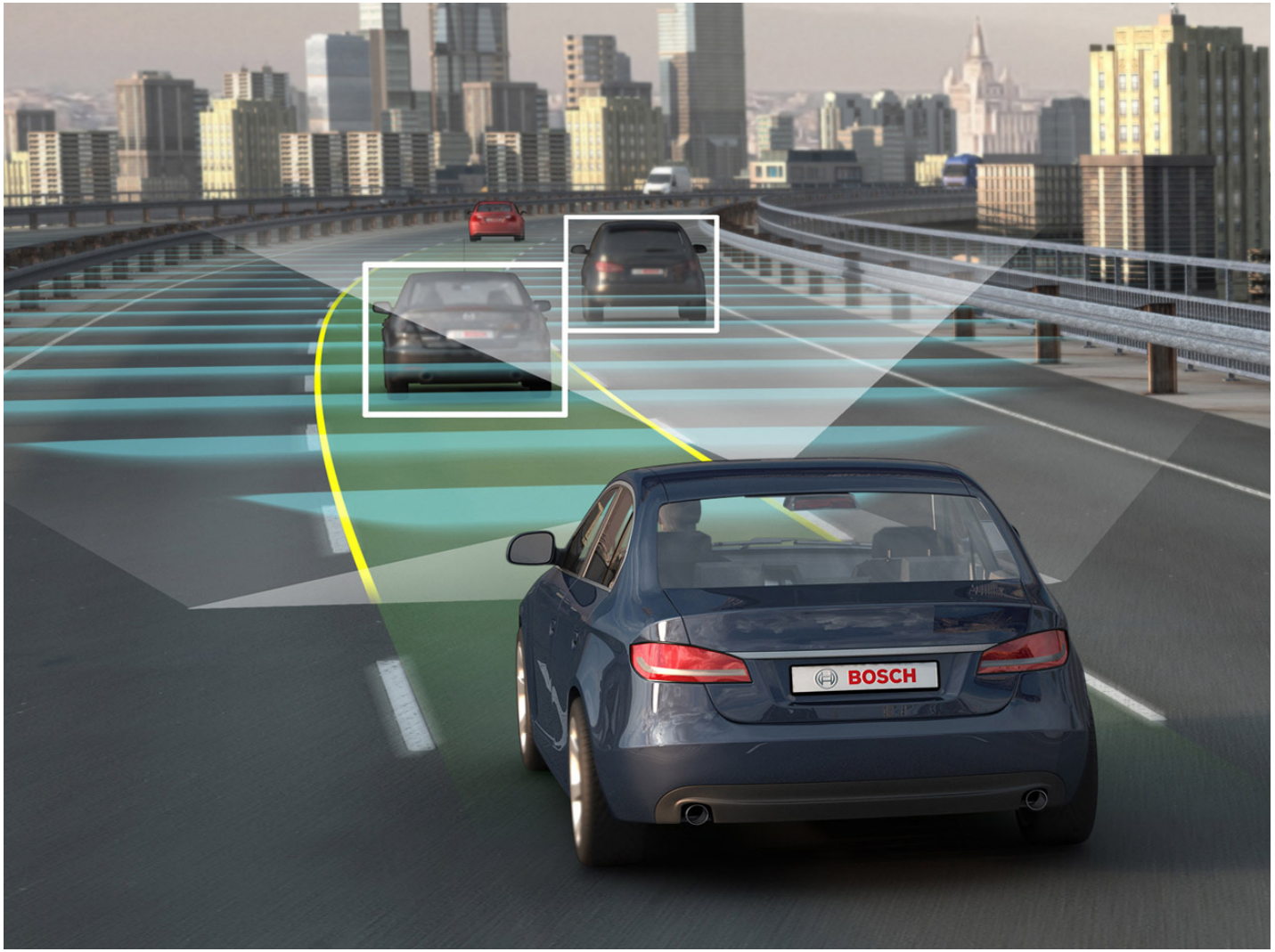
Smart Parking: Make use of ground sensor and infrastructure sensors to monitor parking space in real-time and help traffic management within the city.



www.libelium.com

IoT Applications

IoT Applications



IoT Applications

IoT Applications

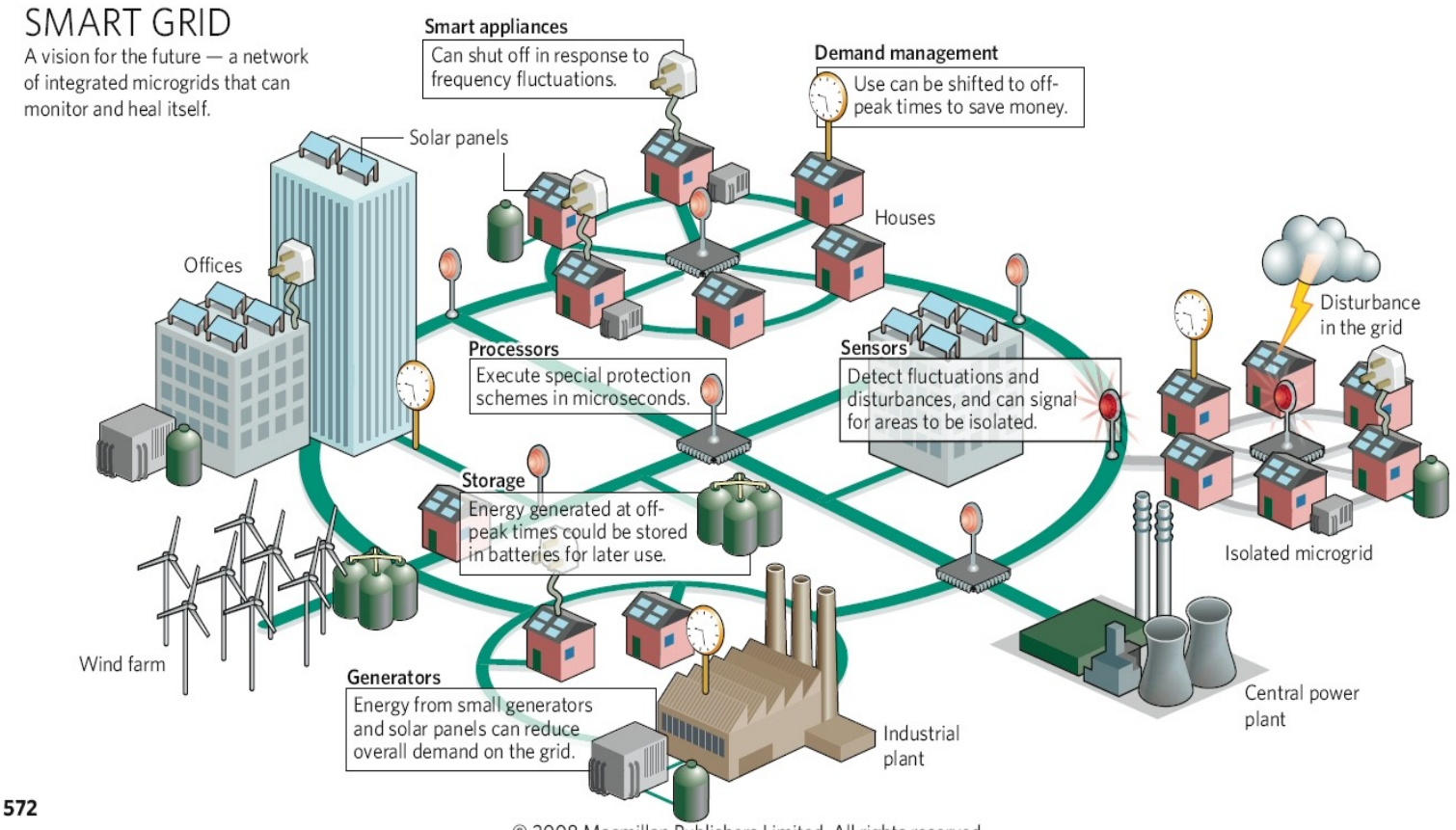
Smart pill brings IoT to digestive health

- Researchers at RMIT University have developed a smart pill that is able to detect intestinal gases, providing data for the development of treatments for gut disorders.
- Consisting of a microprocessor, sensors, a wireless transmitter and a small battery array, the smart pill is enclosed in a liquid-filled capsule which can be ingested by the patient.

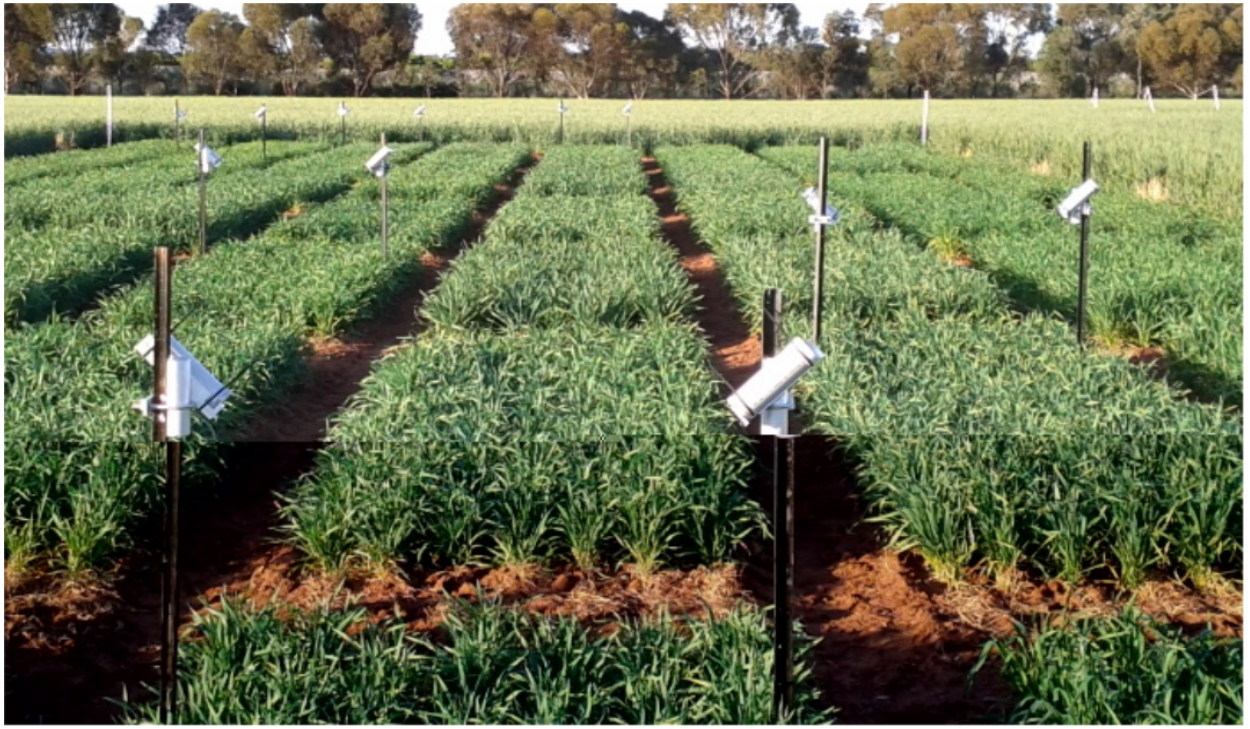
Source: https://www.iothub.com.au/news/smart-pill-brings-iot-to-digestive-health-413887

IoT Applications

A Smart Grid IoT for Demand Side Management

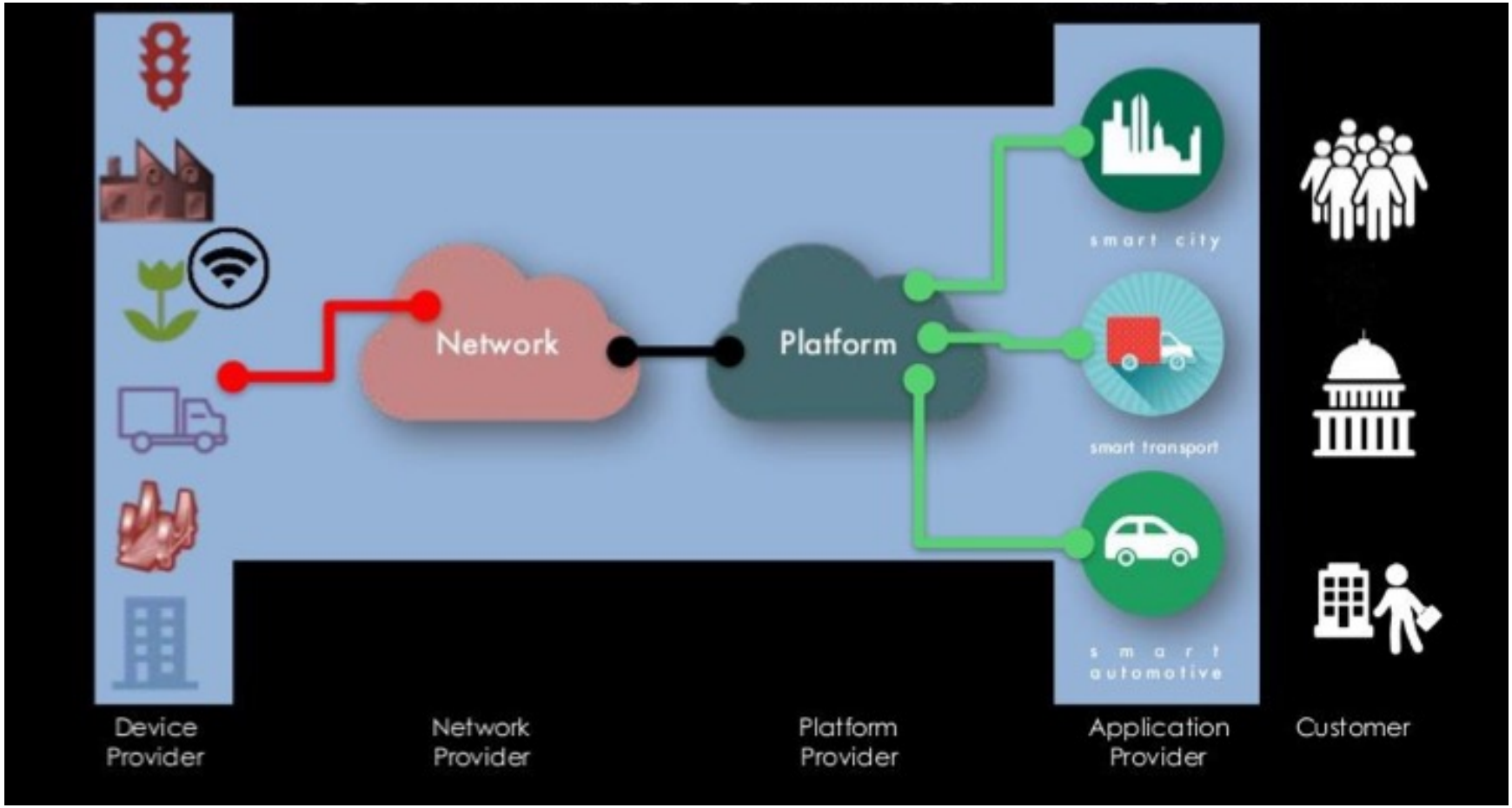


IoT Applications



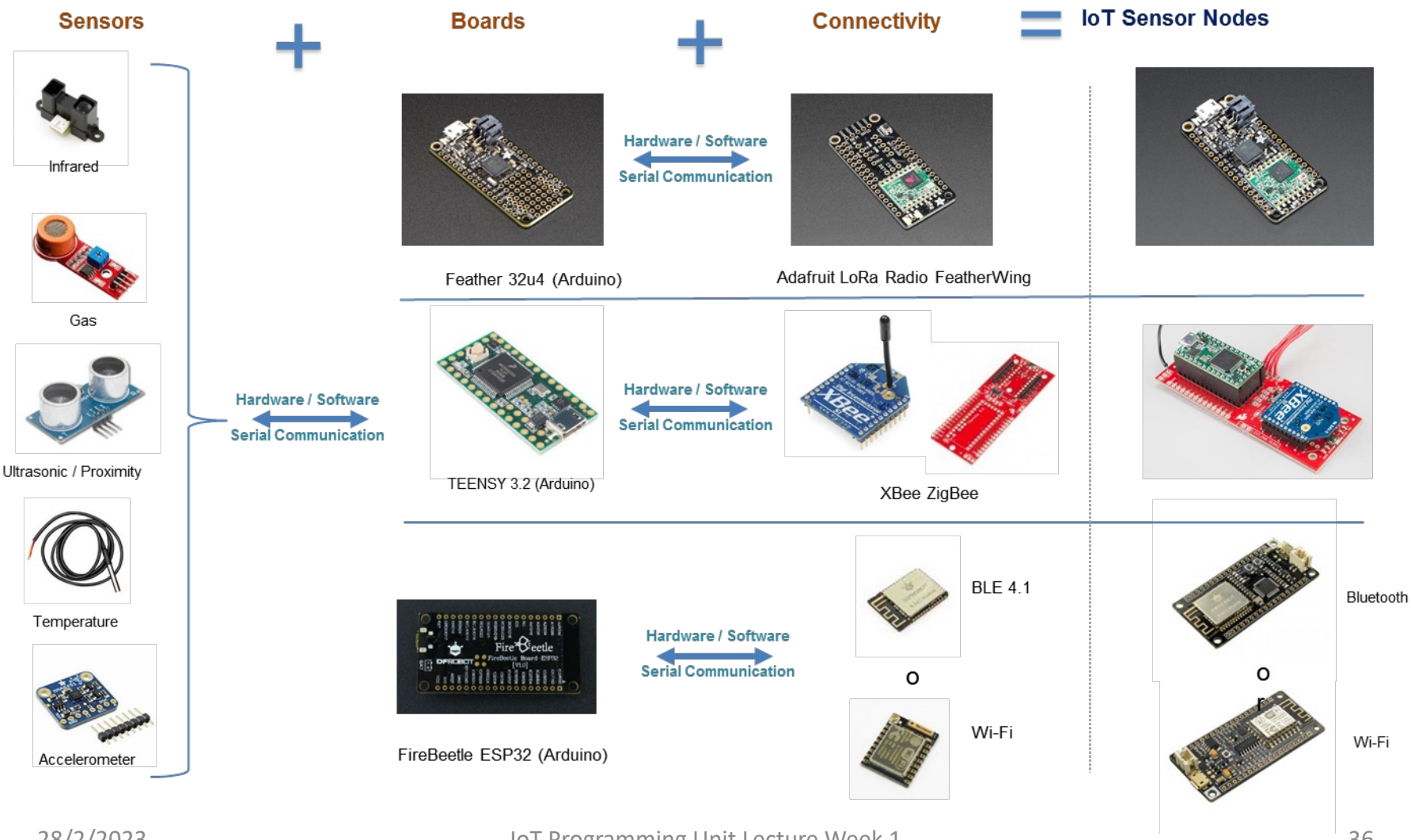
IoT Challenges

IoT Architecture



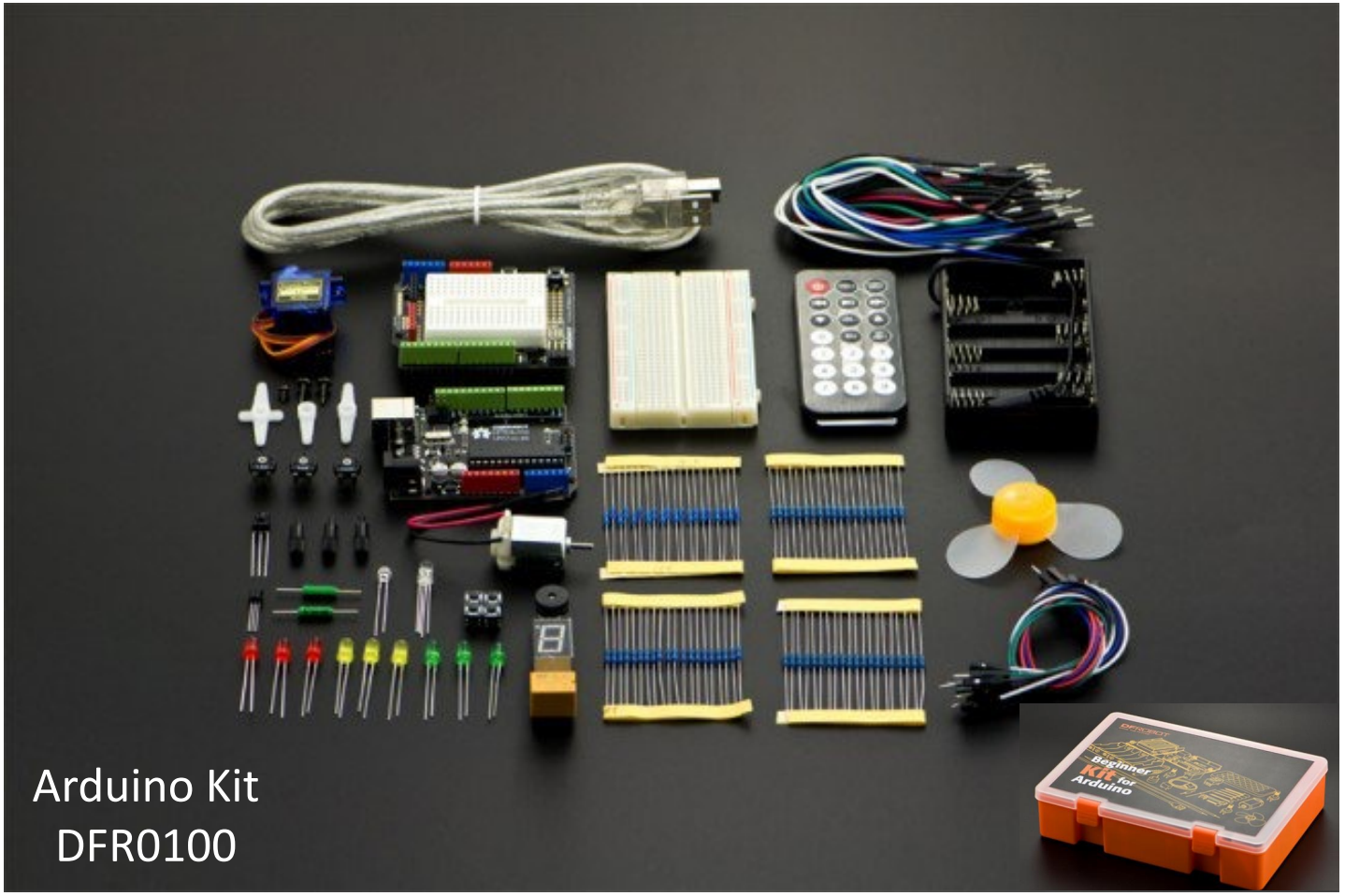
IoT Architecture

IoT Hardware



IoT Architecture

IoT Hardware



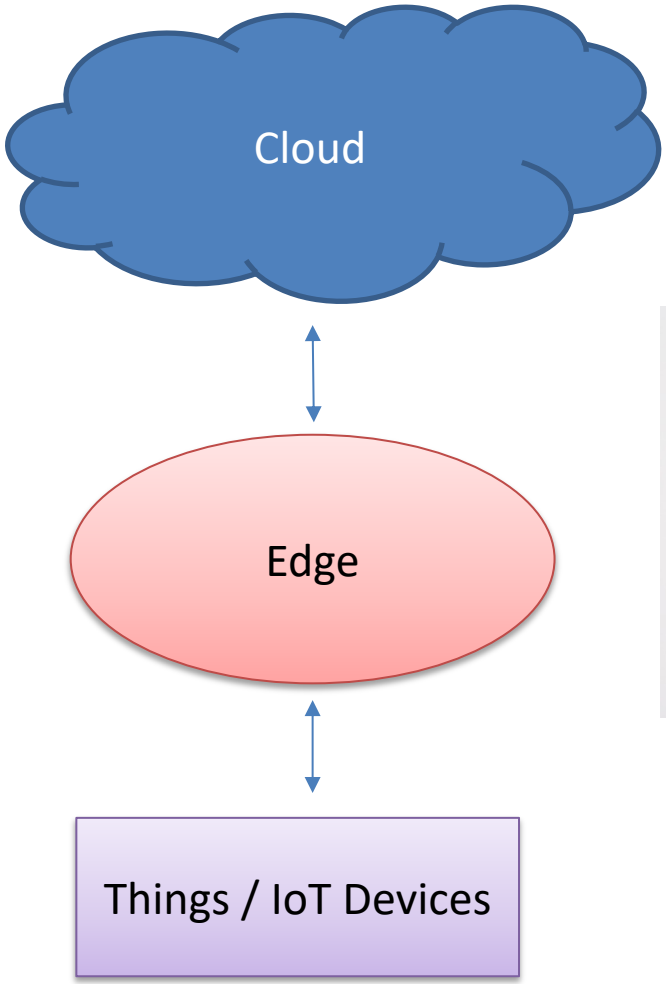
Arduino Kit
DFR0100

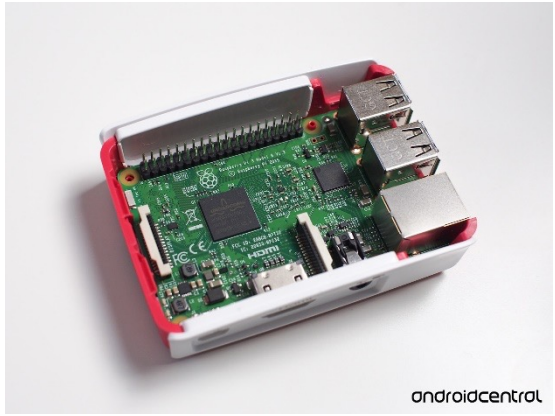
IoT Architecture

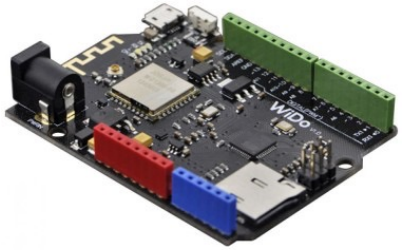
IoT programing

IoT Architecture

IoT programing







IoT Architecture

Data Management

1.1 Billion

Data points generated by sensors **daily**

500 Gigabytes

Data generated by an offshore oil rig **weekly**

1000 Gigabytes

Data generated by an oil refinery **daily**

10,000 Gigabytes

Data generated by a jet engine every **30 minutes**

2.5 Billion Gigabytes

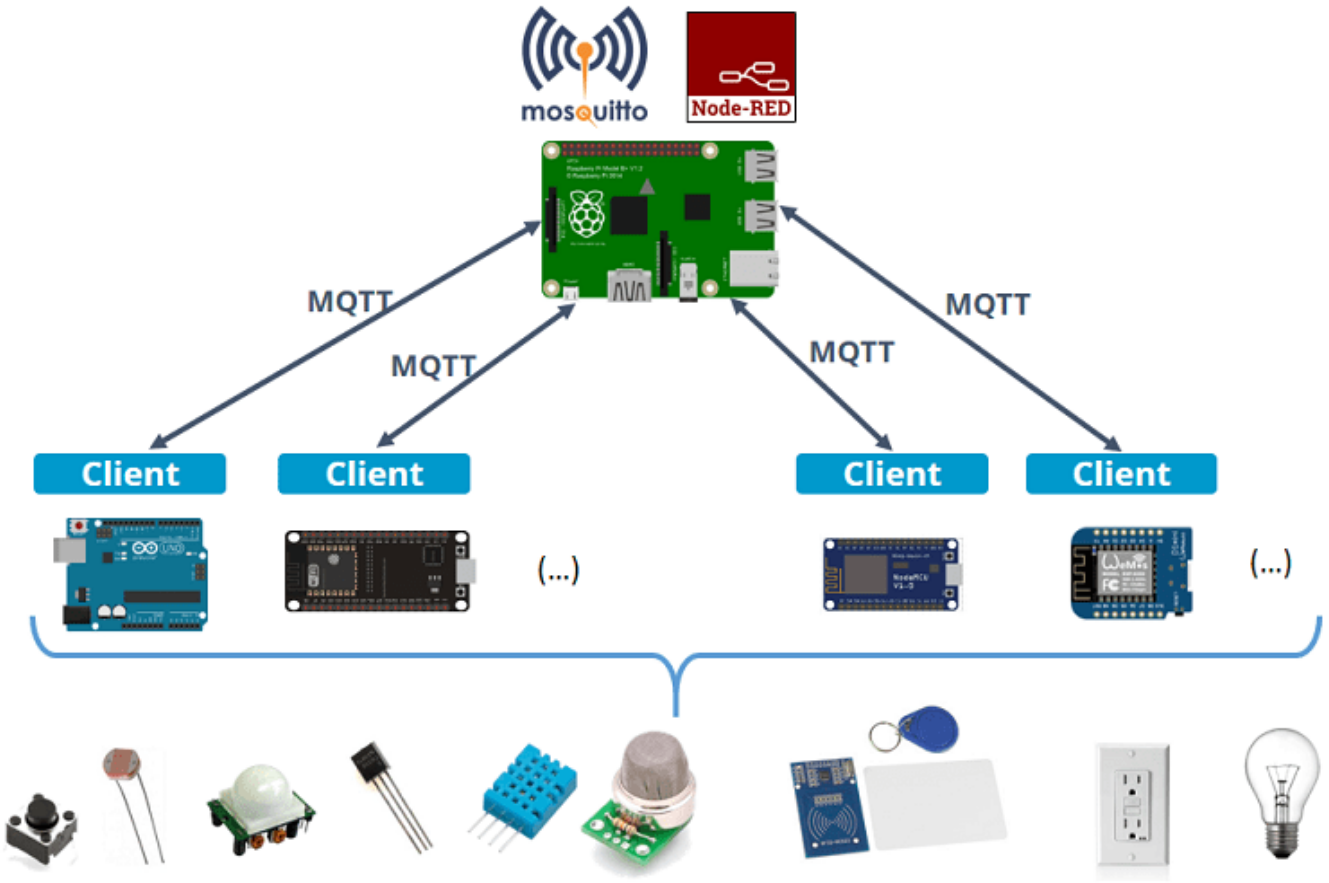
Data generated worldwide **daily**

90% of the world's data

Has been created in the last **2 years!**

IoT Architecture

Protocols



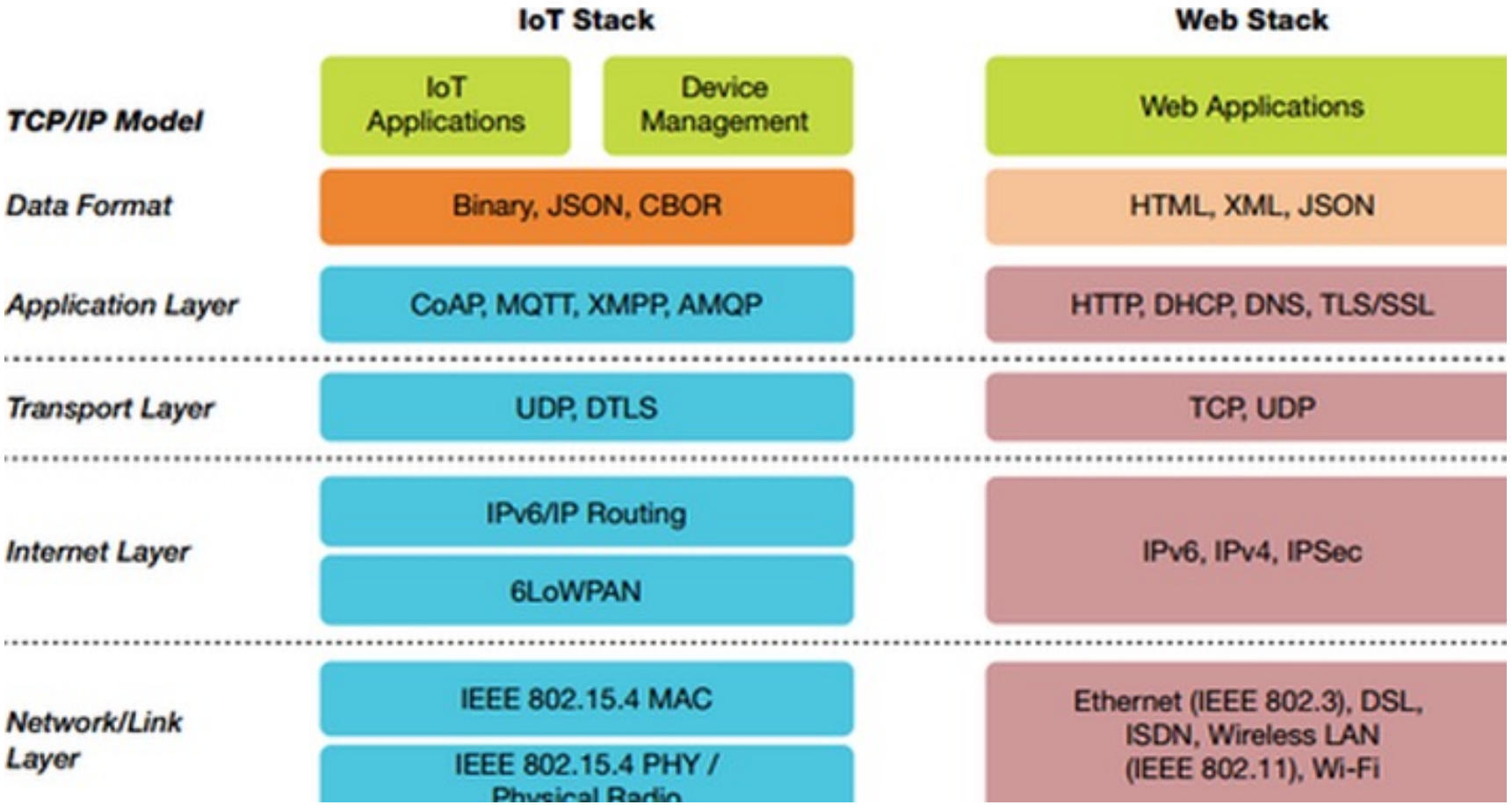
https://randomnerdtutorials.com/what-is-mqtt-and-how-it-works/

IoT Architecture

Protocols

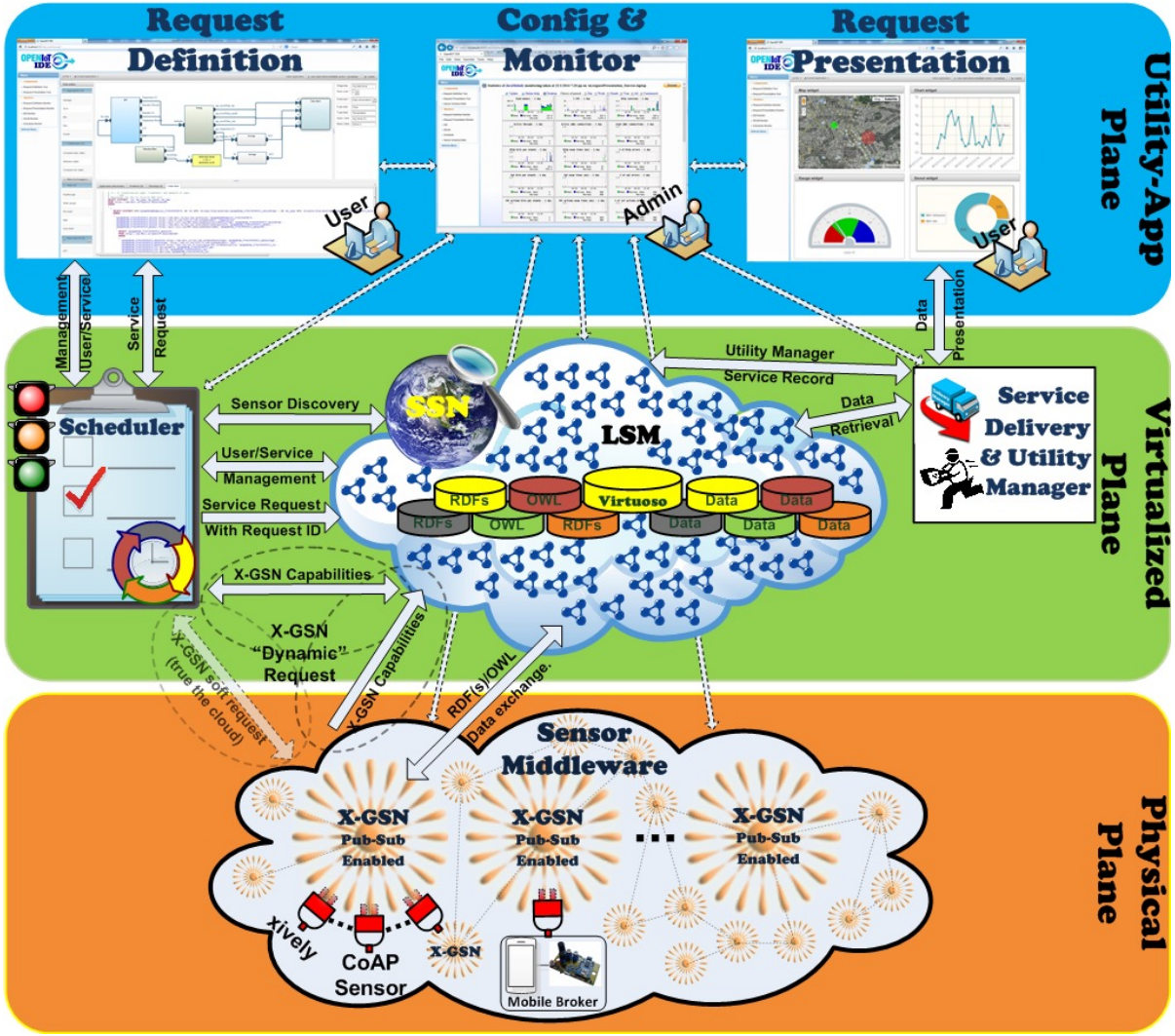
IoT Architecture

Protocols



Source: https://www.iotone.com/files/img/emerging-open-and-standard-protocol-stack-for-iot_1.png

IoT Architecture



IoT Platforms

IoT Software Platform	Device management?	Integration	Security	Protocols for data collection	Types of analytics	Support for visualizations?
2lemetry - IoT Analytics Platform**	Yes	Salesforce, Heroku, ThingWorx APIs	Link Encryption (SSL), Standards (ISO 27001, SAS70 Type II audit)	MQTT, CoAP, STOMP,M3DA	Real-time analytics (Apache Storm)	No
Appcelerator	No	REST API	Link Encryption (SSL, IPsec, AES-256)	MQTT, HTTP	Real-time analytics (Titanium [1])	Yes (Titanium UI Dashboard)
AWS IoT platform	Yes	REST API	Link Encryption (TLS), Authentication (SigV4, X.509)	MQTT, HTTP1.1	Real-time analytics (Rules Engine, Amazon Kinesis, AWS Lambda)	Yes (AWS IoT Dashboard)
Bosch IoT Suite - MDM IoT Platform	Yes	REST API	*Unknown	MQTT, CoAP, AMQP,STOMP	*Unknown	Yes (User Interface Integrator)
Ericsson Device Connection Platform (DCP) - MDM IoT Platform	Yes	REST API	Link Encryption (SSL/TSL),Authentication (SIM based)	CoAP	*Unknown	No
EVRYTHNG - IoT Smart Products Platform	No	REST API	Link Encryption (SSL)	MQTT,CoAP, WebSockets	Real-time analytics (Rules Engine)	Yes (EVRYTHNG IoT Dashboard)
IBM IoT Foundation Device Cloud	Yes	REST and Real-time APIs	Link Encryption (TLS), Authentication (IBM Cloud SSO), Identity management (LDAP)	MQTT, HTTPS	Real-time analytics (IBM IoT Real-Time Insights)	Yes (Web portal)
ParStream - IoT Analytics Platform***	No	R, UDX API	*Unknown	MQTT	Real-time analytics, Batch analytics (ParStream DB)	Yes (ParStream Management Console)
PLAT.ONE - end-to-end IoT and M2M application platform	Yes	REST API	Link Encryption (SSL), Identity Management (LDAP)	MQTT, SNMP	*Unknown	Yes (Management Console for application enablement, data management, and device management)
ThingWorx - MDM IoT Platform	Yes	REST API	Standards (ISO 27001), Identity Management (LDAP)	MQTT, AMQP, XMPP, CoAP, DDS, WebSockets	Predictive analytics(ThingWorx Machine Learning), Real-time analytics (ParStream DB)	Yes (ThingWorx SQUEAL)
Xively- PaaS enterprise IoT platform	No	REST API	Link Encryption (SSL/TSL)	HTTP, HTTPS, Sockets/ Websocket, MQTT	*Unknown	Yes (Management console)

Cloud Computing and IoT

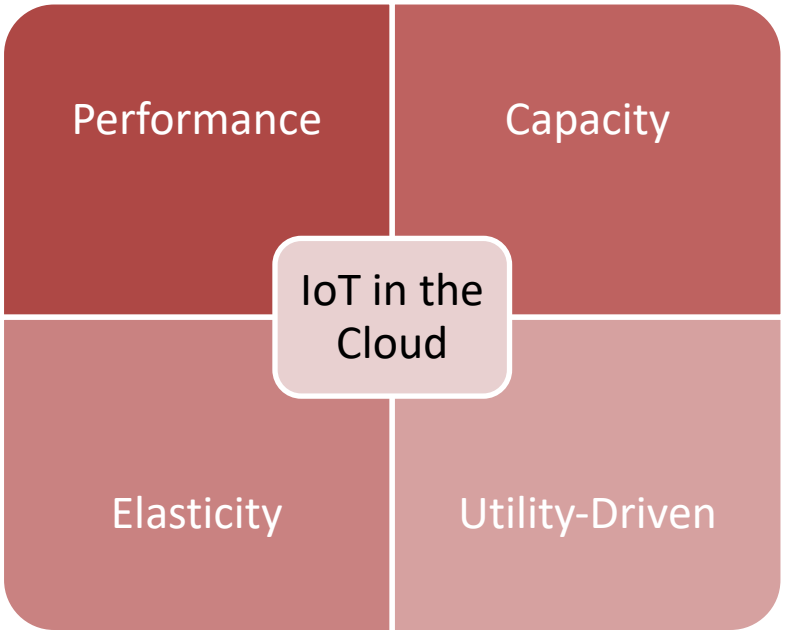
IoT/Cloud convergence

Benefit:

- Allows IoT applications to leverage the benefits of the Cloud

Challenge:

- Conflicting properties of IoT (e.g., WSN) and Cloud



IoT/Sensors	Cloud Computing
• Location specific • Resource constrained, • Expensive (development/ deployment cost) • Generally inflexible (resource access and availability)	• Location independent • Wealth of inexpensive resources • Rapid elasticity • Flexibility

IoT Description

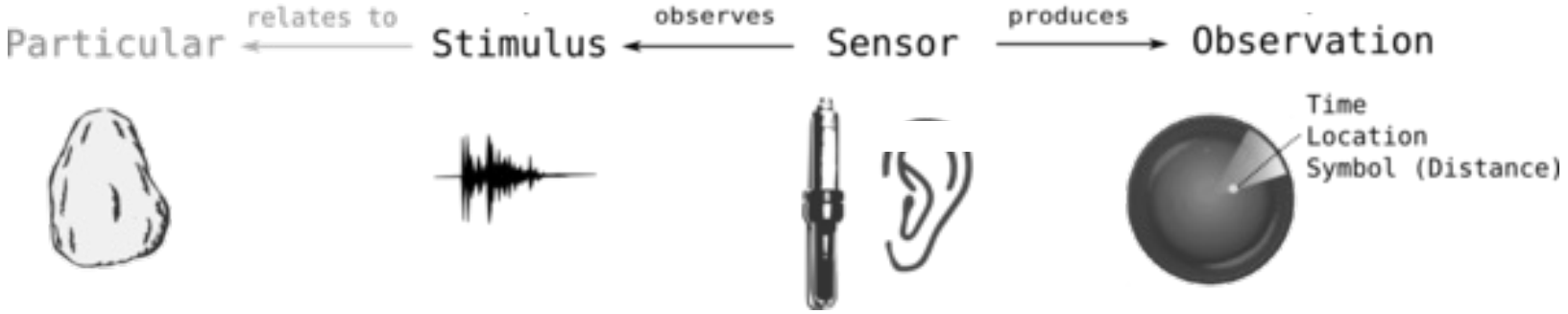
How are machines supposed to integrate and interpret sensor data?

W3C

Semantic Sensor Networks (SSN)

IoT Description

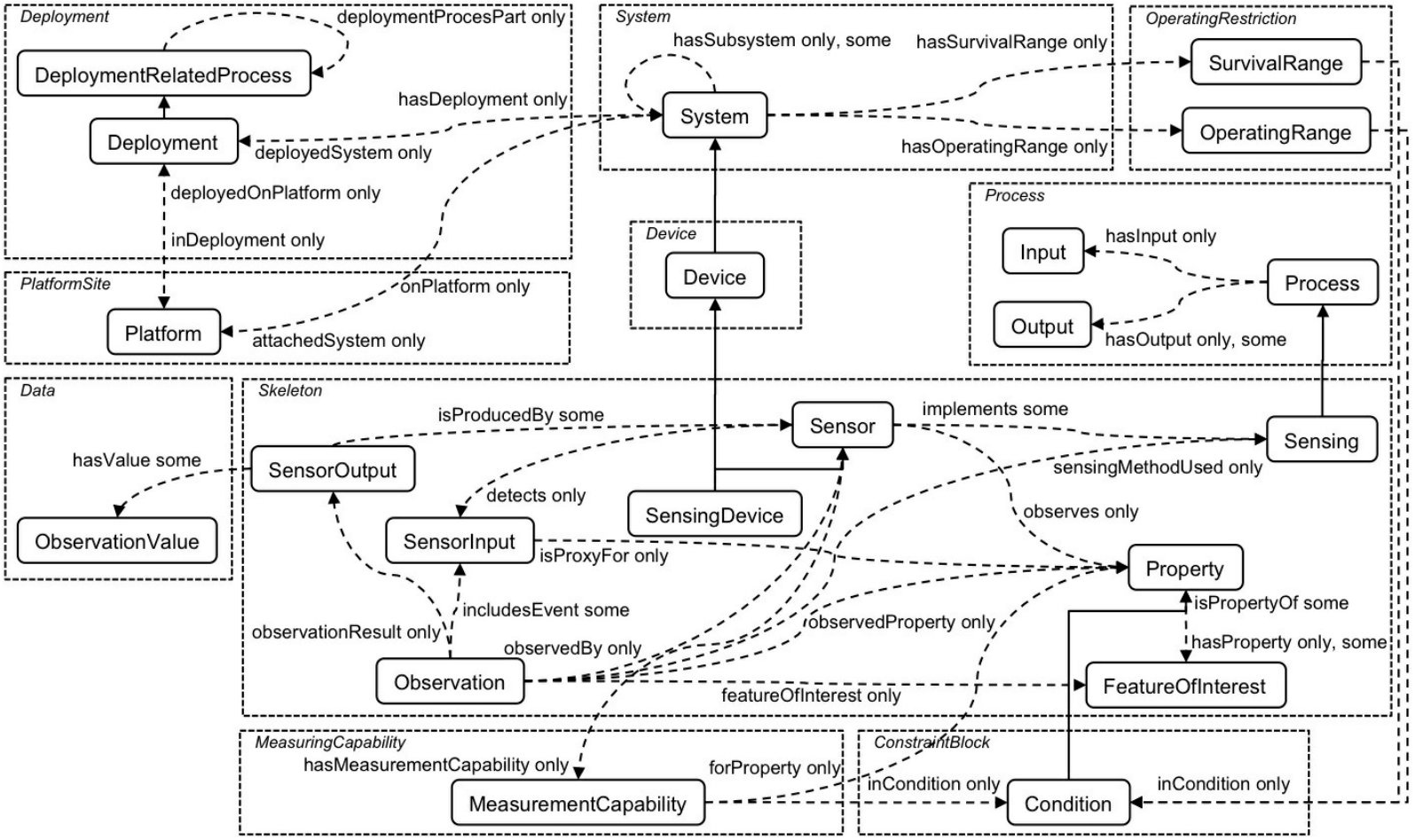
W3C Semantic Sensor Network Ontology



Lefort, L., Henson, C., Taylor, K., Barnaghi, P., Compton, M., Corcho, O., Garcia-Castro, R., Graybeal, J., Herzog, A., Janowicz, K., Neuhaus, H., Nikolov, A., and Page, K.: Semantic Sensor Network XG Final Report, W3C Incubator Group Report (2011).

IoT Description

W3C Semantic Sensor Network Ontology



Lefort, L., Henson, C., Taylor, K., Barnaghi, P., Compton, M., Corcho, O., Garcia-Castro, R., Graybeal, J., Herzog, A., Janowicz, K., Neuhaus, H., Nikolov, A., and Page, K.: Semantic Sensor Network XG Final Report, W3C Incubator Group Report (2011).

Advance topics

- Security and Privacy
- Analytics

IoT Security and Privacy

Device security

- Attackers are shifting their targets from servers to IoT devices.
- Reasons: IoT devices are less protected, close to users, and far more in numbers than users.

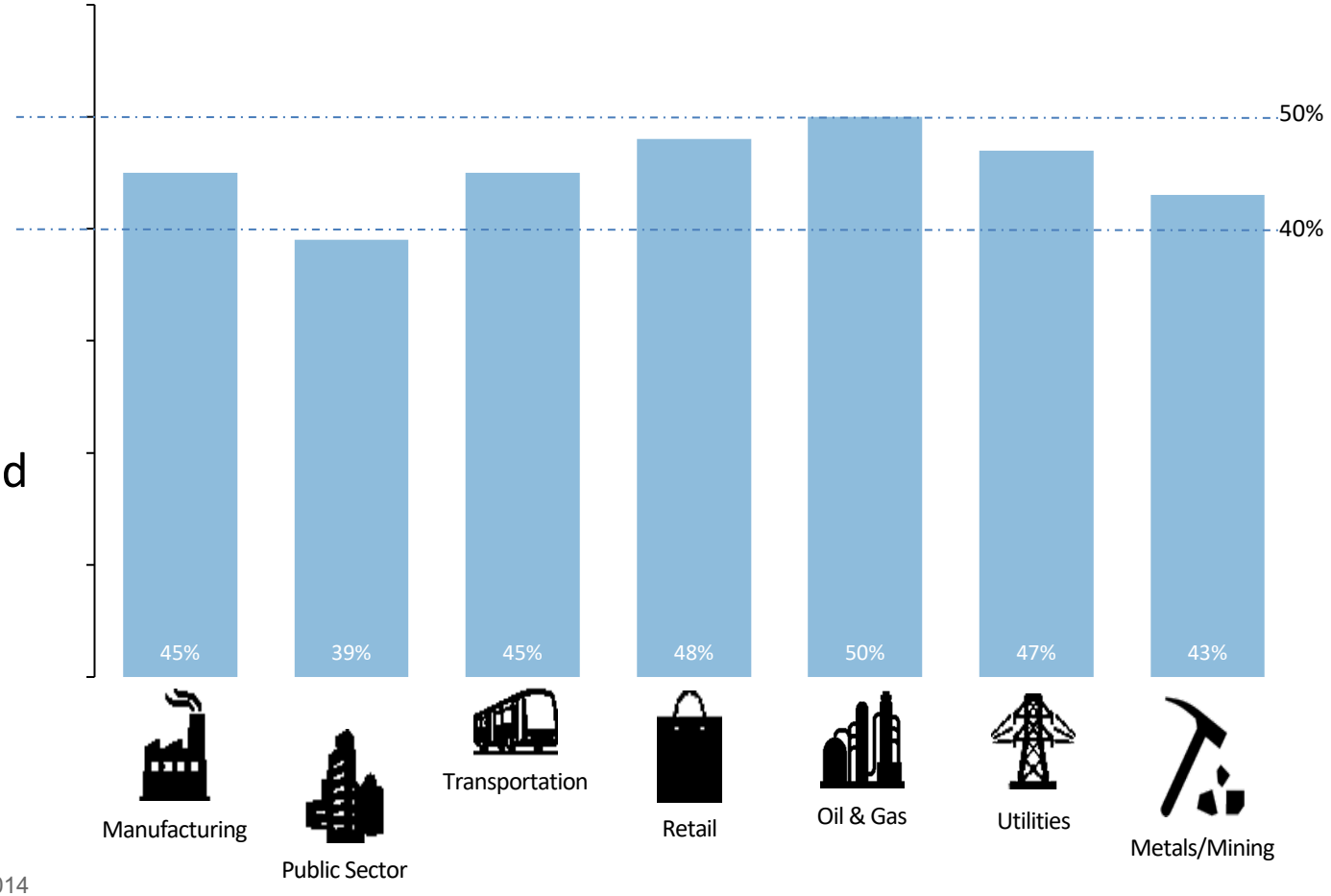
Privacy

IoT Analytics

What percentage of your manual operational processes could be automated through use of IoT solutions?

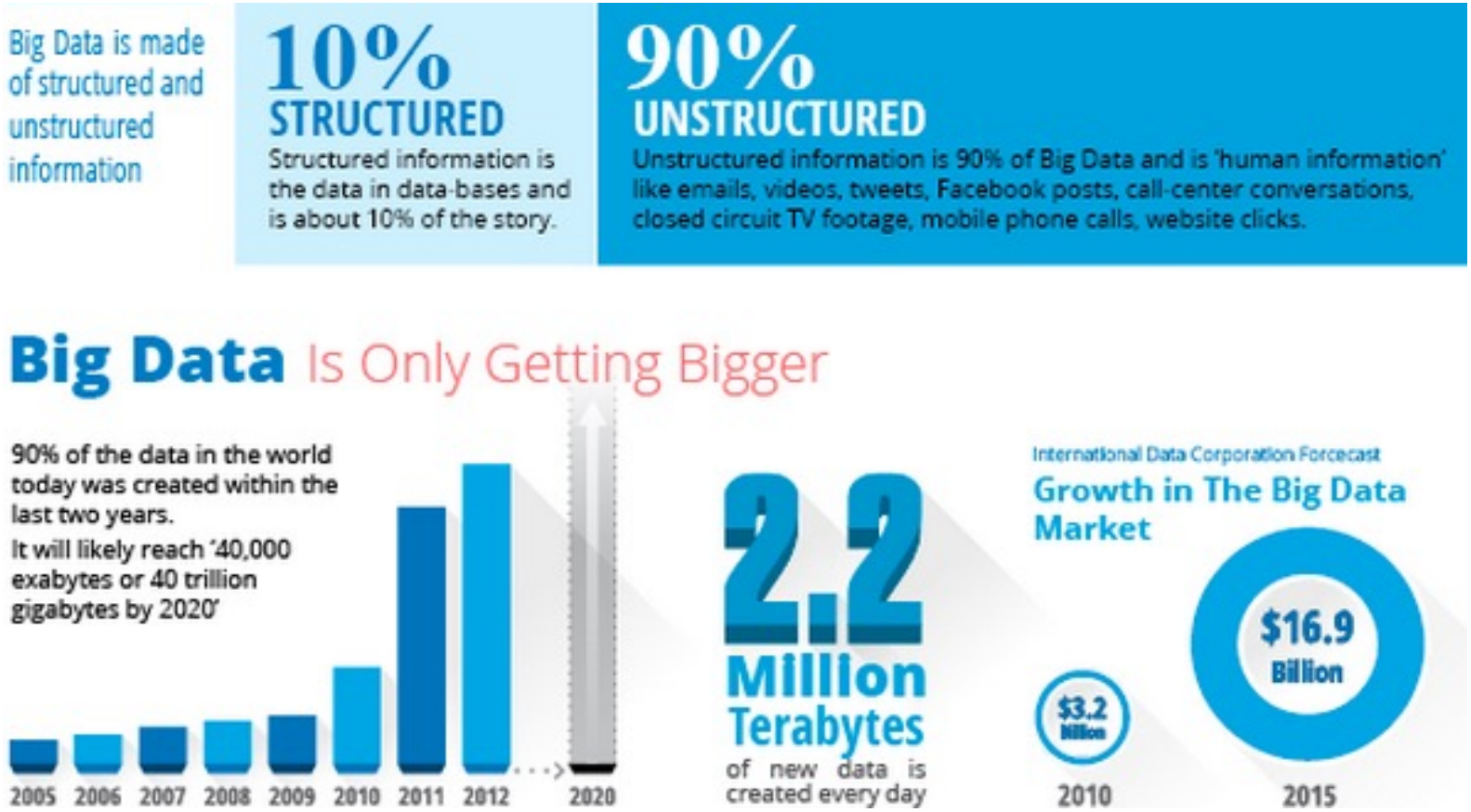
Nearly ½ of

manual processes could be automated with IoT



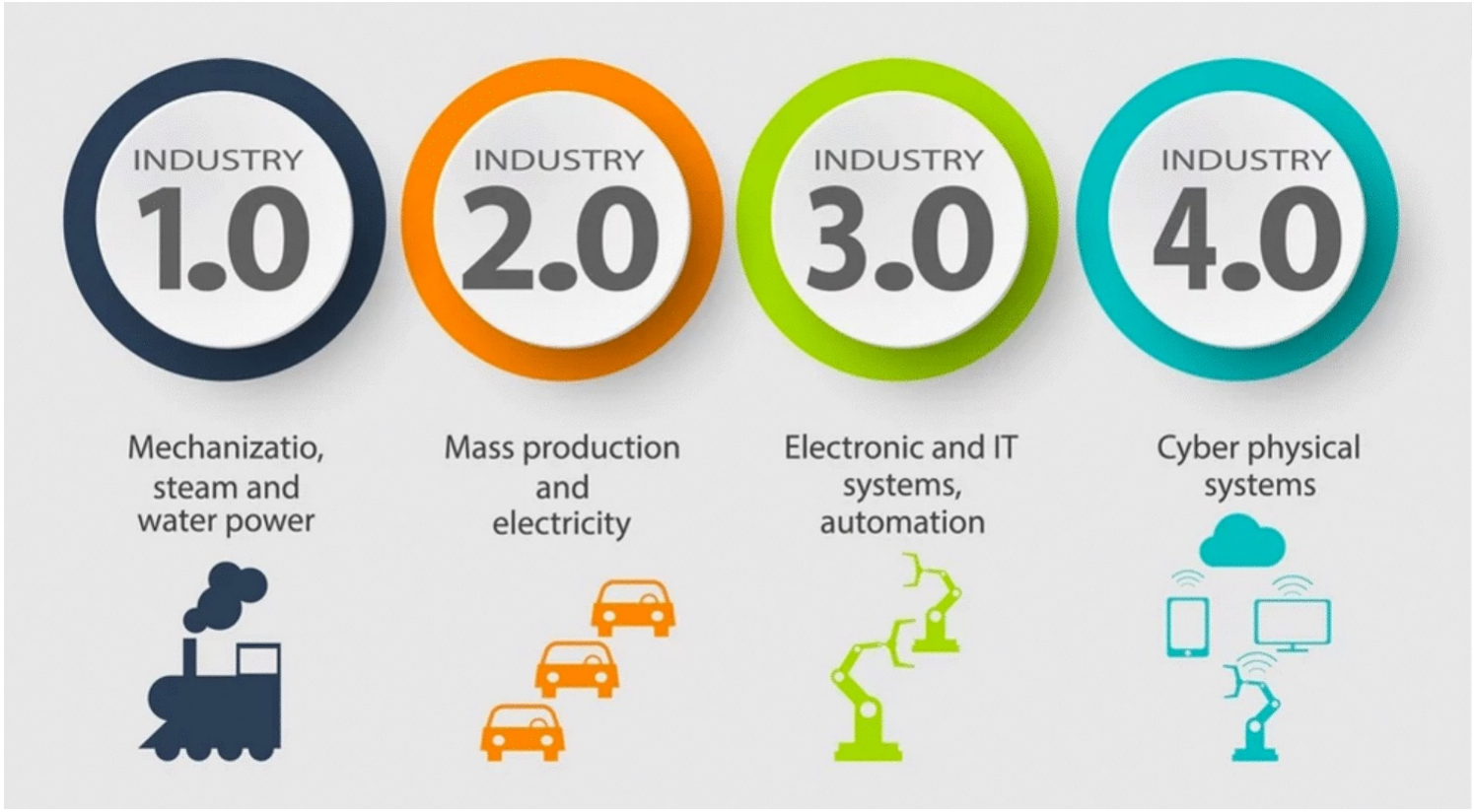
Source: Cisco Consulting Services "Internet of Things" Global Study, 2014

IoT Analytics



http://hrboss.com/hiringboss/articles/big-data-infographic

Industry 4.0



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Industry 4.0

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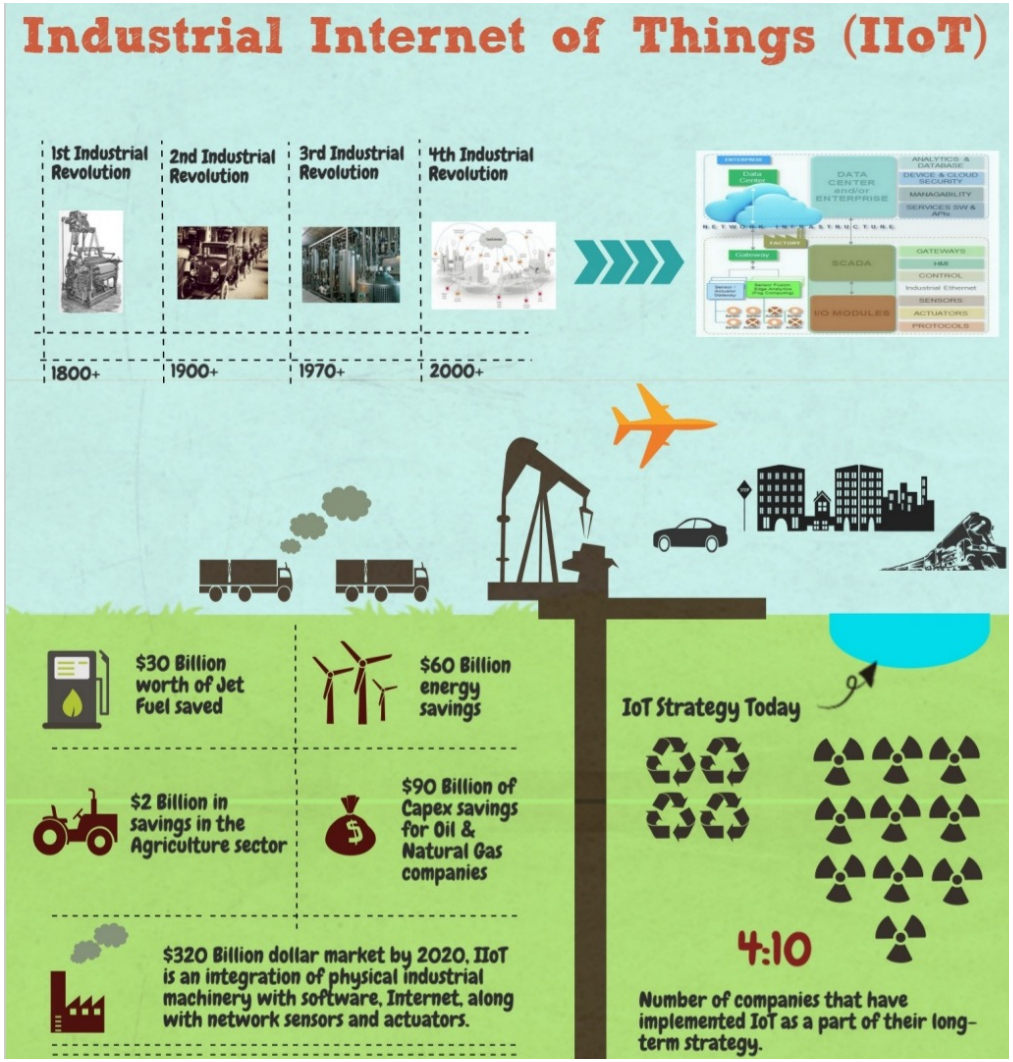
Industrial IoT (IIoT)



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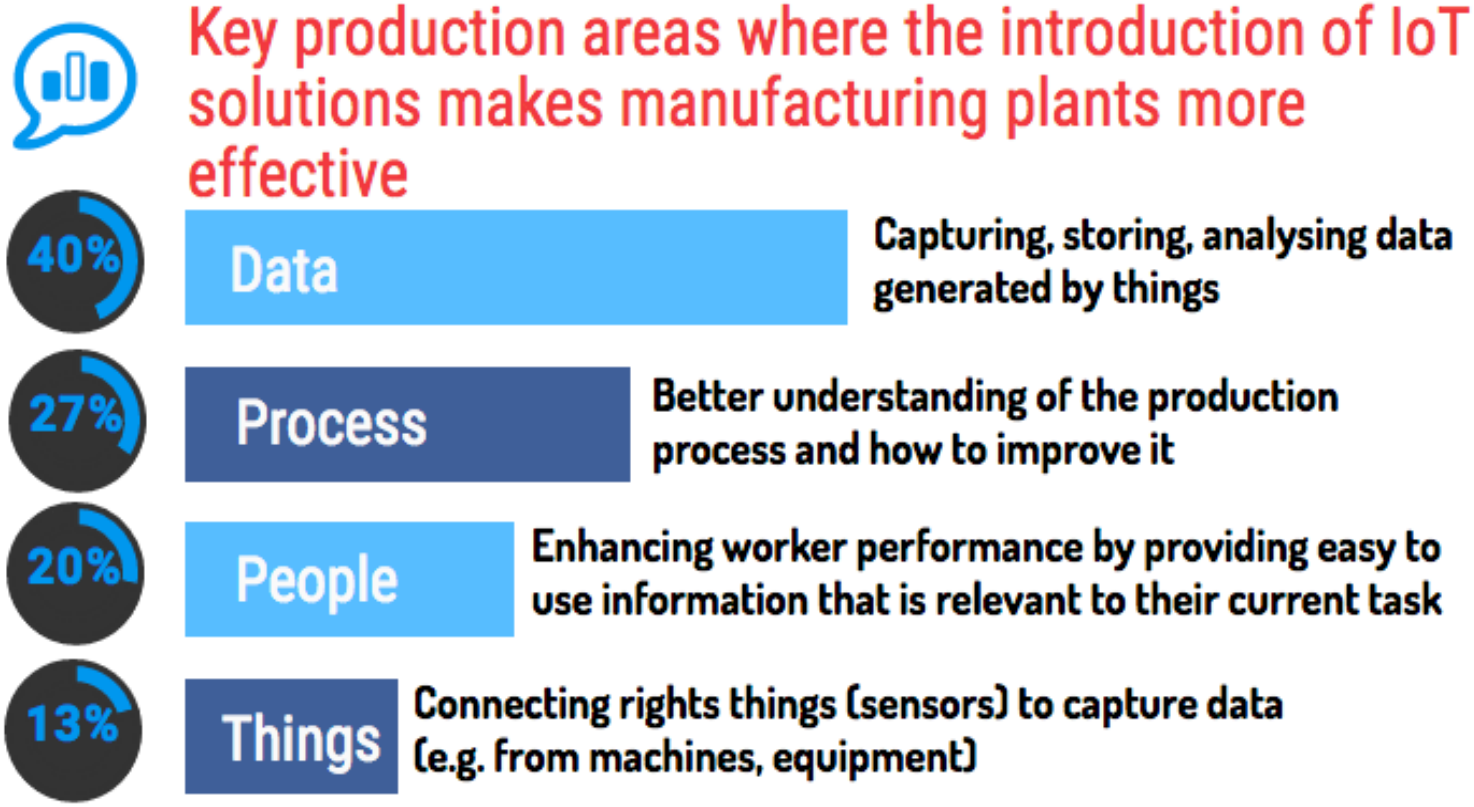
Industrial IoT (IIoT)

What are the key areas of IoT that makes the manufacturing plants more effective?

Industrial IoT (IIoT)



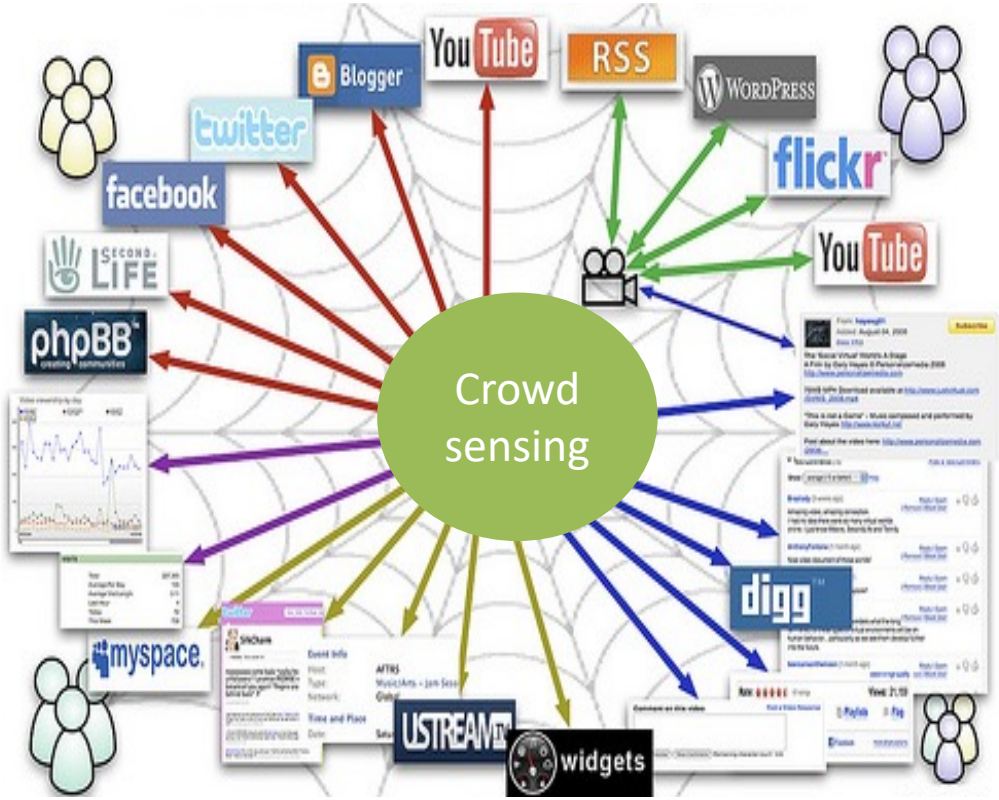
CISCO, 2016, http://www.cisco.com/c/dam/en_us/solutions/trends/iot/docs/iot-data-analytics-white-paper.PDF (2016)

Research Problems in IoT

Research problems in social media mining and social network analysis

Where/When-
Region-of-interest is defined around a place, event, and/or time

Who –
Who's connected to who & how

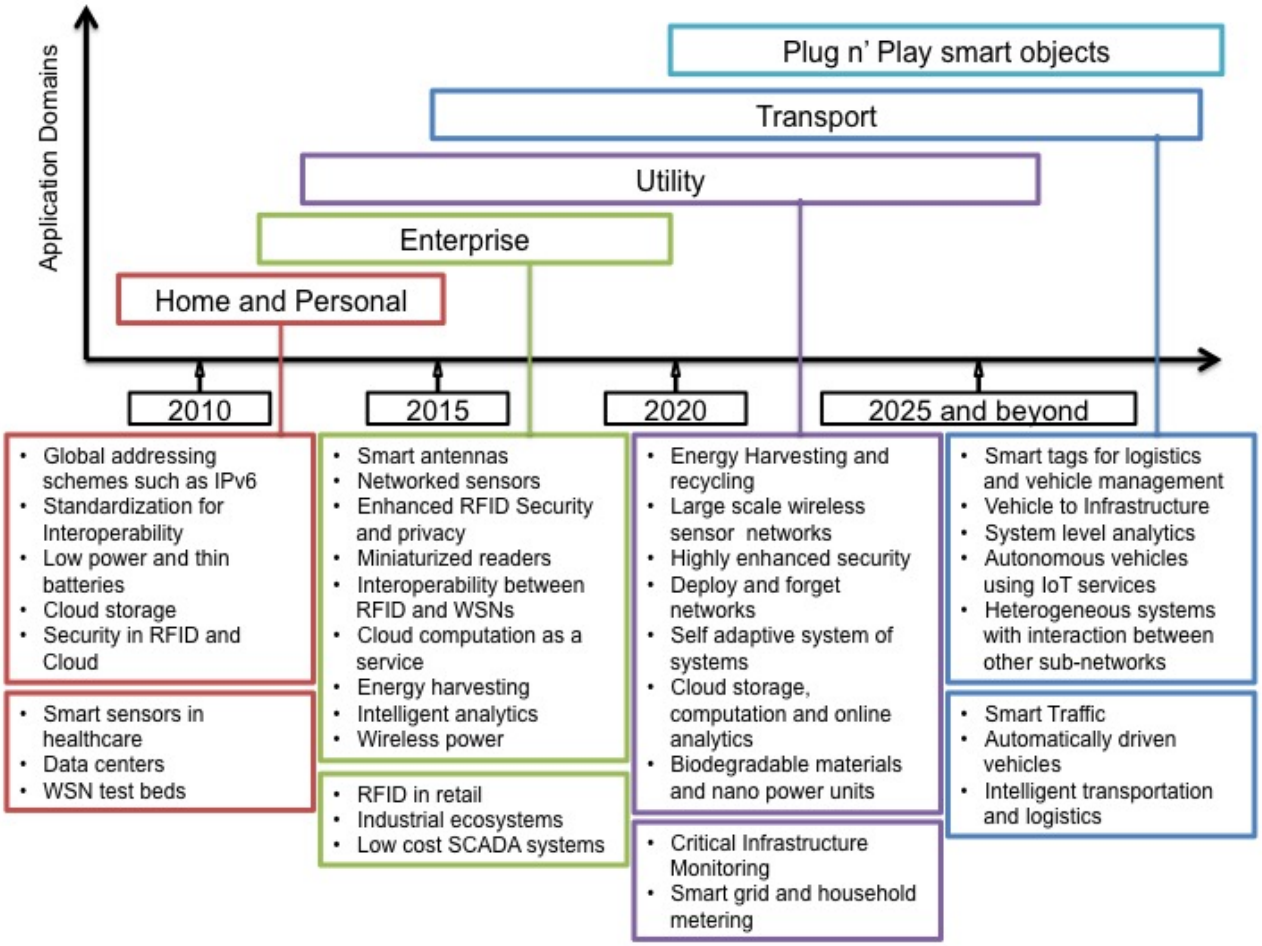


What -
Analysis of content (e.g. places, names, events)

Why -
Building the story or evidence trail

Rapid - Greater resolution and depth of analysis in real-time

IoT
Key Technological Development



Source: Jayavardhana Gubbi, Rajkumar Buyya, Slaven Marusik and Marimuthu Palaniswami, Internet of Things: A vision, Architectural elements and future directions.

Lecture Summary

- Unit Introduction
- Basics of IoT
- IoT architecture
- IoT applications

Remember to enroll for a tutorial session and borrow your kit in first week.

Lecture Summary

- Unit Introduction
- Basics of IoT
- IoT architecture
- IoT applications