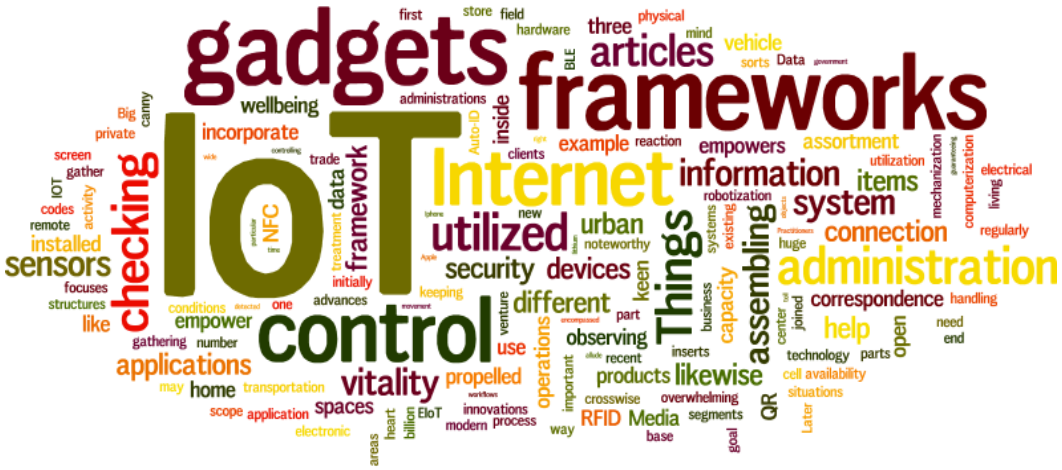
MICT-5306 Internet of Things

Introduction to IoT

Definitions, Characteristics, Applications



"I have no special talent. I am only passionately curious." – **Albert Einstein**

What is IoT?

- ✓ Internet of Things (IoT) is the **network of smart physical objects**
  - physical objects (e.g. devices, vehicles, buildings, etc.) embedded with sensors/actuators, computation unit, memory unit, power source, and network connectivity,
  - which enables the physical object to collect and exchange data,
  - analyze the collected data to extract new insight and respond accordingly.

- ✓ Goal of IoT is to "connect the unconnected"
  - "Things" or "objects" that were not supposed to be connected to the Internet

- ➢ IoT did the technology transition in traditional computer networks

Cont…

- Unifications of technologies:
  - Embedded systems,
  - Low power and low rate network,
  - Internet,
  - Big data,
  - Data analytics,
  - Cloud computing,
  - Edge Intelligence
  - Software defined networks,
  - Network and data security
  - Etc.

- Alternate Definition:

"The Internet of Things (IoT) is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment." – Gartner Research*

* https://www.gartner.com/en/information-technology/glossary/internet-of-things

Brief History of IoT

- The term "Internet of things" was likely coined by Kevin Ashton of Procter & Gamble, later MIT's Auto-ID Center, **in 1999.**
  - "In the 20th century, computers were brains without senses – they only knew what we told them." Now in the 21st century, computers are sensing things for themselves! – Kevin Ashton

- **Early 1980s** at the Carnegie Melon University, a group of students created a way to get their campus Coca-Cola vending machine to report on its contents through a network in order to save them the trek if the machine was out of Coke.

- **In 1990**, John Romkey, developer of the first TCP/IP stack for IBM PC in 1983, connected a toaster to the internet for the first time.

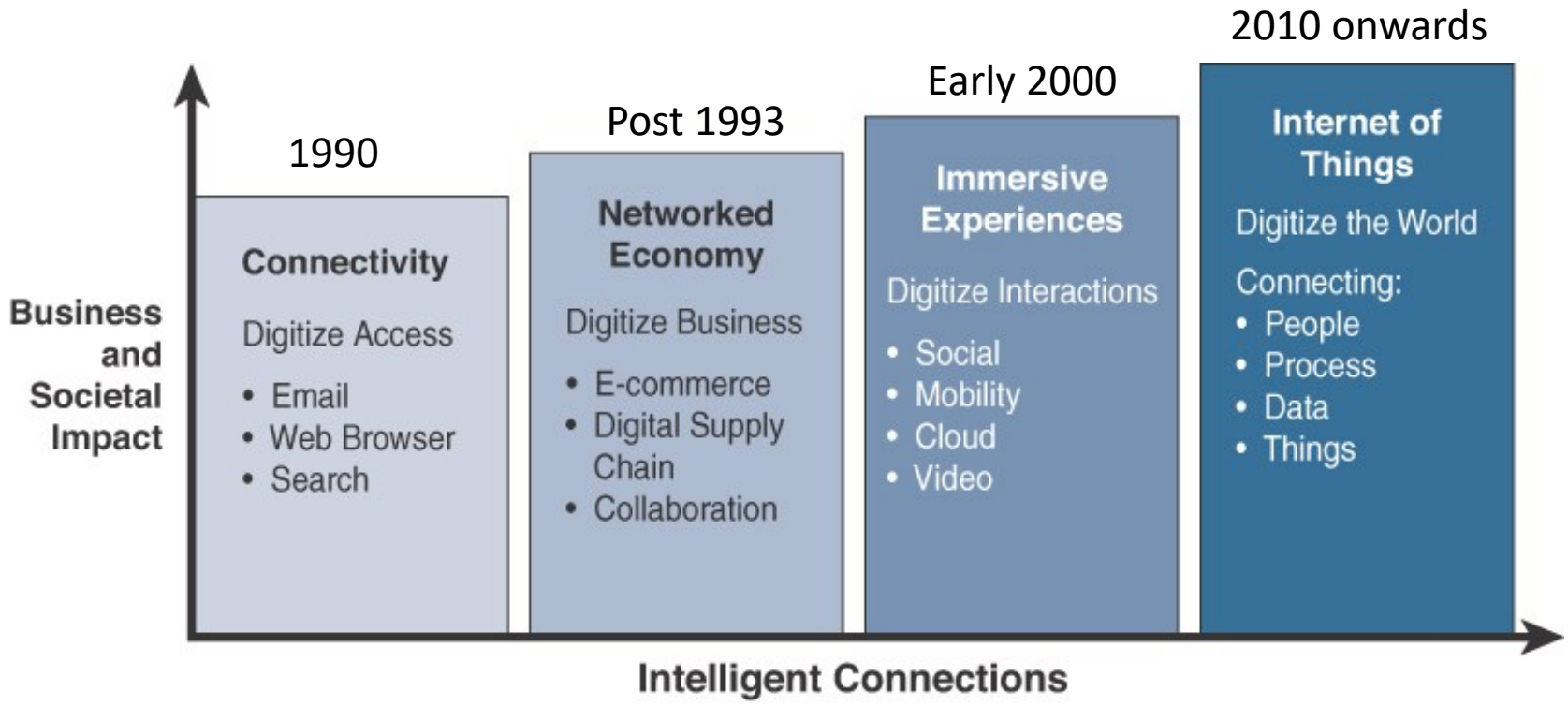
- **In 1991**, a group of students at the University of Cambridge used a web camera to report on coffee available in their computer labs coffee pot.

- At the **beginning of the 21st Century**, LG Electronics introduced the world's first refrigerator connected to the internet

Cont…

- The popularity of the term IoT did not accelerate until 2010/2011 and reached mass market in 2013-14.

- Definition of the IoT has evolved over time.



Evolutionary Phases of the Internet

Benefits of IoT

- Automation
  - Machines can assemble parts with more precision and speed, resulting in fewer errors during assembly
  - Robots can very rapidly detect faults that may not be detected by the human eye
- Predictive Maintenance
  - Continuous monitoring of systems and processes to identify key indicators of problems before they result in downtime or system failure
- Process / Efficiency Improvement
  - Process improvement affects every aspect of an operation's bottom line
- Cost Reduction
  - When an organization can improve system uptime, automate processes, reduce the risk of failure and gain insights that support better decision making, and reduce resource usage, the result is efficiency and cost savings
- Improved/ New Insights
  - IoT systems often act as the eyes and ears on remote, hard-to-reach, or widely distributed equipment and processes.
- Adaptability
  - The ability to adapt to new business requirements, customer needs, and changing conditions, or scale the deployment in response to business growth or customer requirements

IoT vs. WSN

- Wireless Sensor Network (WSN):
  - WSN refers to a group of specialized dedicated sensors with a communications infrastructure.
  - WSN is primarily used for monitoring and recording the physical environment conditions like temperature, sound, pollution levels, humidity, wind, and so on.
  - It is designed to acquire, process, transfer, and provide data/information extracted from the physical world.
  - In a WSN, there is no direct connection to the internet. Instead, the various sensors connect to some kind of router or central node.
- WSN: Resource constraint sensor nodes + wireless network to connect the nodes + gather some data by sensing the environment.
- IoT: WSN + Internet + App + Cloud computing + Data Analytics + etc…

IoT vs. M2M

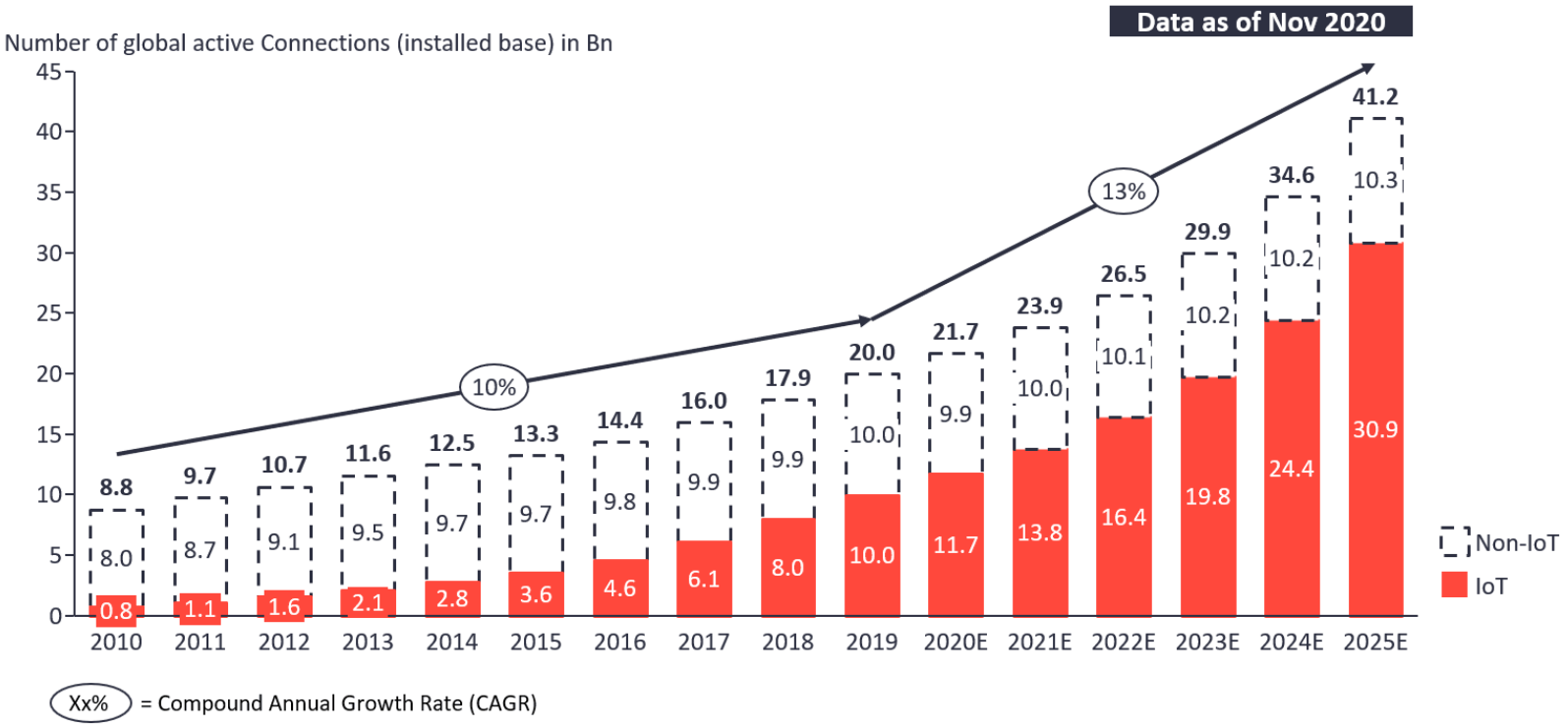
- Machine-to-Machine (M2M): It is a concept where two or more than two machines communicate with each other without human interaction using a wired or wireless mechanism.

Basis of	IoT	M2M
Connection type	via (IP) Network and using various communication types.	Mainly point-to-point
Communication protocol	IP based protocol	Proprietary protocols
Internet	Internet connection is required	not dependent on the Internet
Data Sharing	Data is shared with other applications (if required)	Data is shared with only the communicating parties.
Open API	Supports Open API integrations.	There is no support for Open API's
Scalability	More devices, more scalable due to cloud based architecture	Limited devices, less scalable than IoT
App. Example	Smart home, Smart wearables, etc.	Sensor telemetry, ATMs in Bank

Growth of IoT Devices

Total number of device connections (incl. Non-IoT)

20.0Bn in 2019– expected to grow 13% to 41.2Bn in 2025



Note: Non-IoT includes all mobile phones, tablets, PCs, laptops, and fixed line phones. IoT includes all consumer and B2B devices connected – see IoT break-down for further details

Source(s): IoT Analytics - Cellular IoT & LPWA Connectivity Market Tracker 2010-25

IoT Analytics' prediction

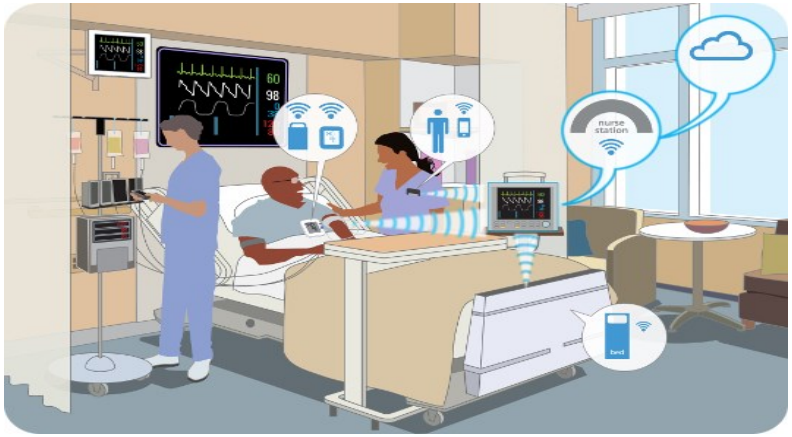
Source: https://iot-analytics.com/state-of-the-iot-2020-12-billion-iot-connections-surpassing-non-iot-for-the-first-time/

Where is IoT?

Wearable
Tech Devices

Smart Appliances

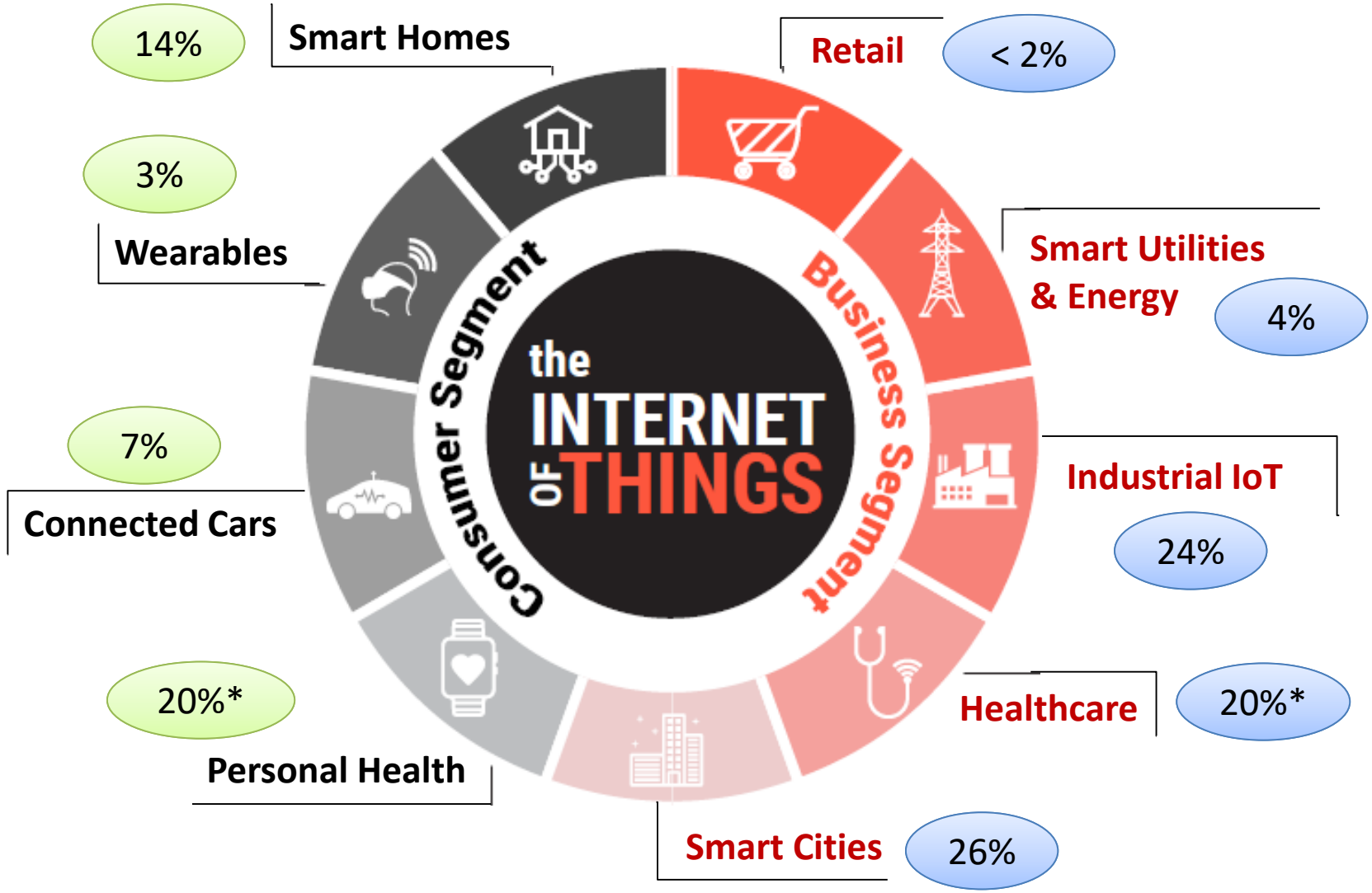
It's everywhere!



Healthcare

Industry Automation
and Monitoring

Global IoT Market Share



Source: https://growthenabler.com/flipbook/pdf/IOT%20Report.pdf

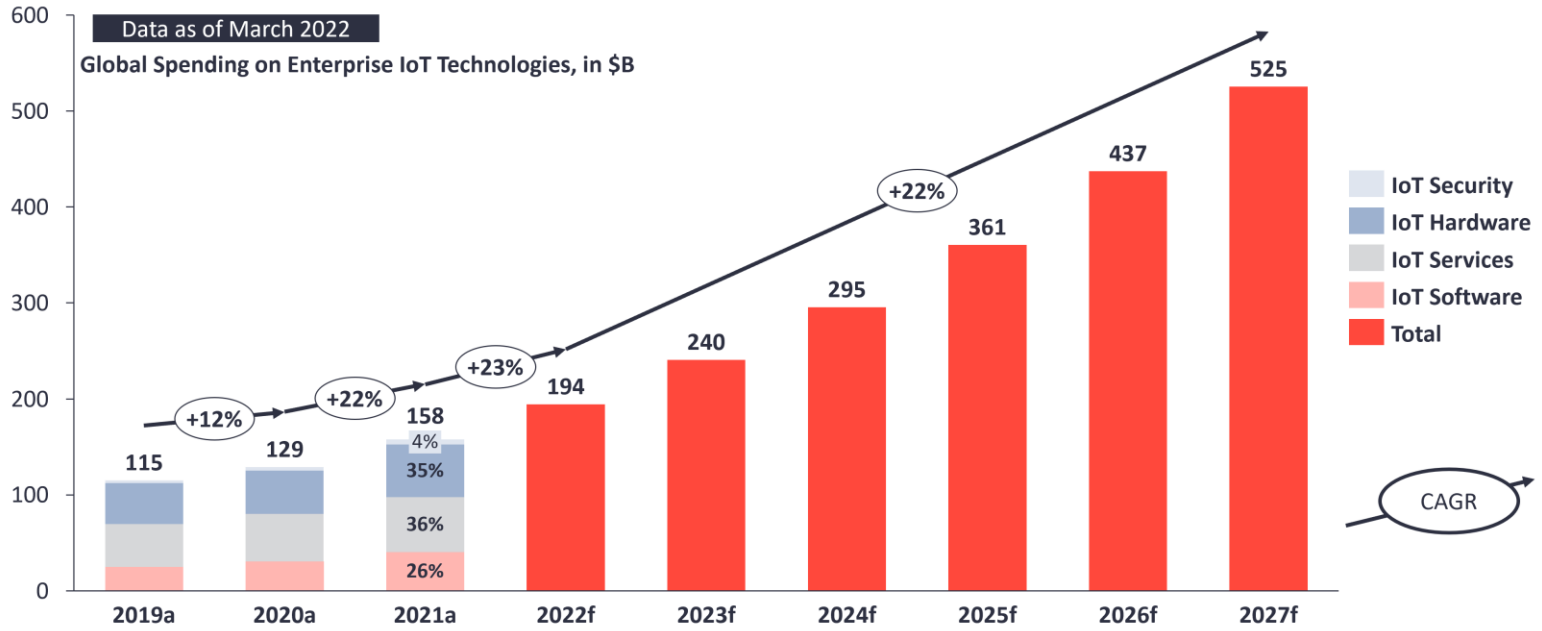
Global Spending on IoT

IOT ANALYTICS

March 2022

Your Global IoT Market Research Partner

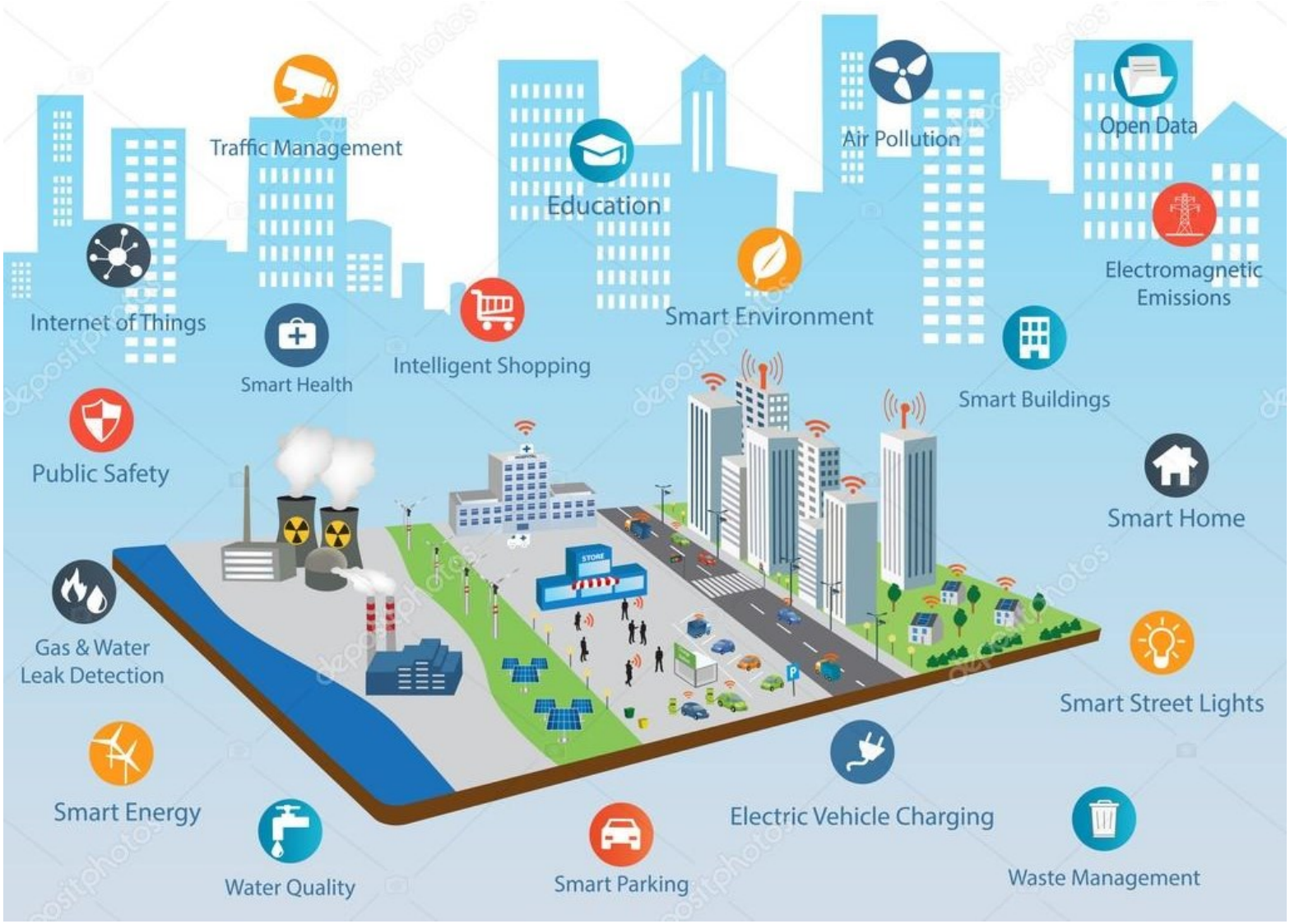
Enterprise IoT market 2019–2027



Note: IoT Analytics defines IoT as a network of internet-enabled physical objects. Objects that become internet-enabled (IoT devices) typically interact via embedded systems, some form of network communication, or a combination of edge and cloud computing. The data from IoT-connected devices is often used to create novel end-user applications. Connected personal computers, tablets, and smartphones are not considered IoT, although these may be part of the solution setup. Devices connected via extremely simple connectivity methods, such as radio frequency identification or quick response codes, are not considered IoT devices. a: Actuals, f: Forecast
Source: IoT Analytics Research 2022. We welcome republishing of images but ask for source citation with a link to the original post or company website.

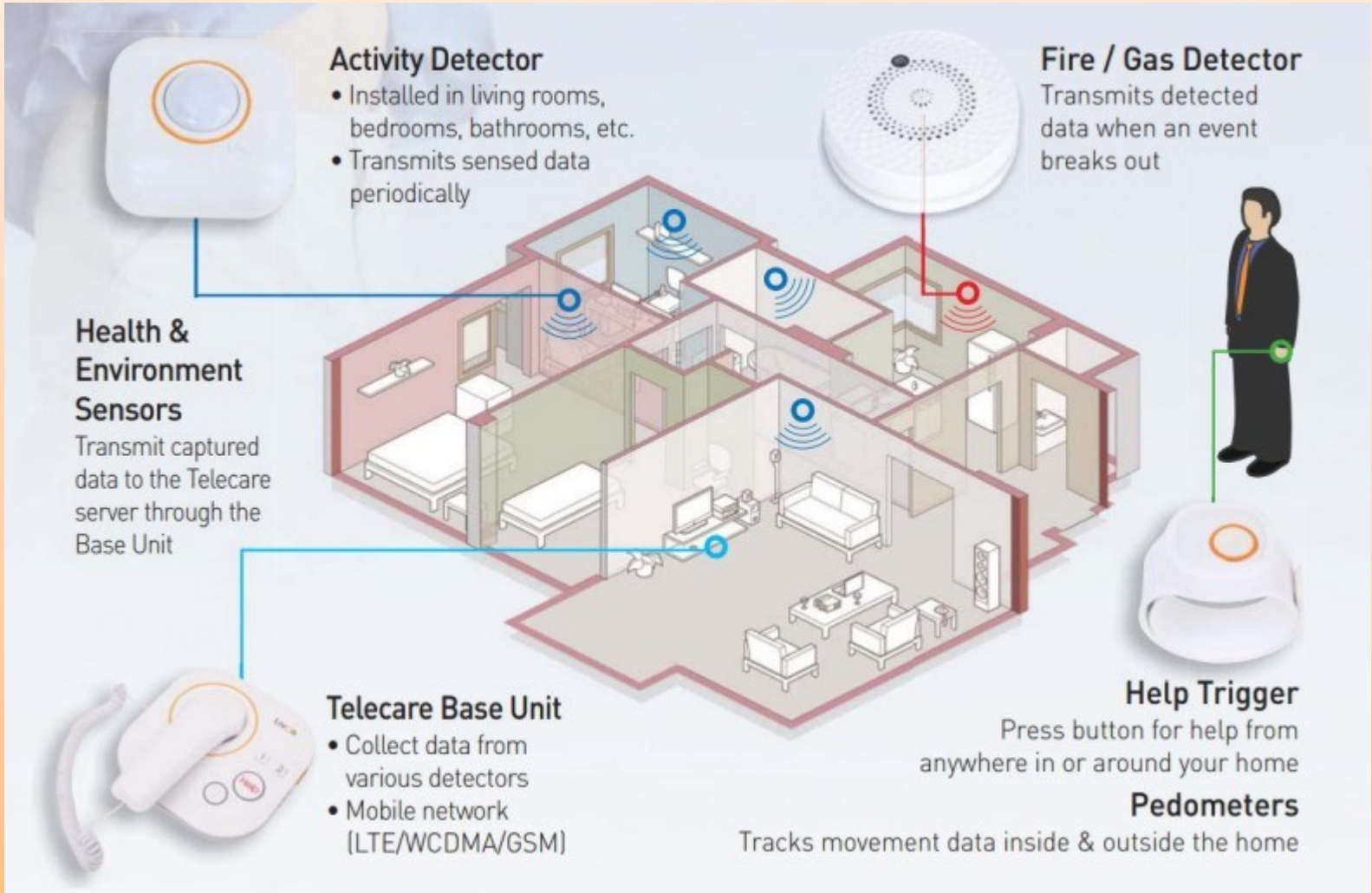
Source: https://iot-analytics.com/iot-market-size/

Smart City



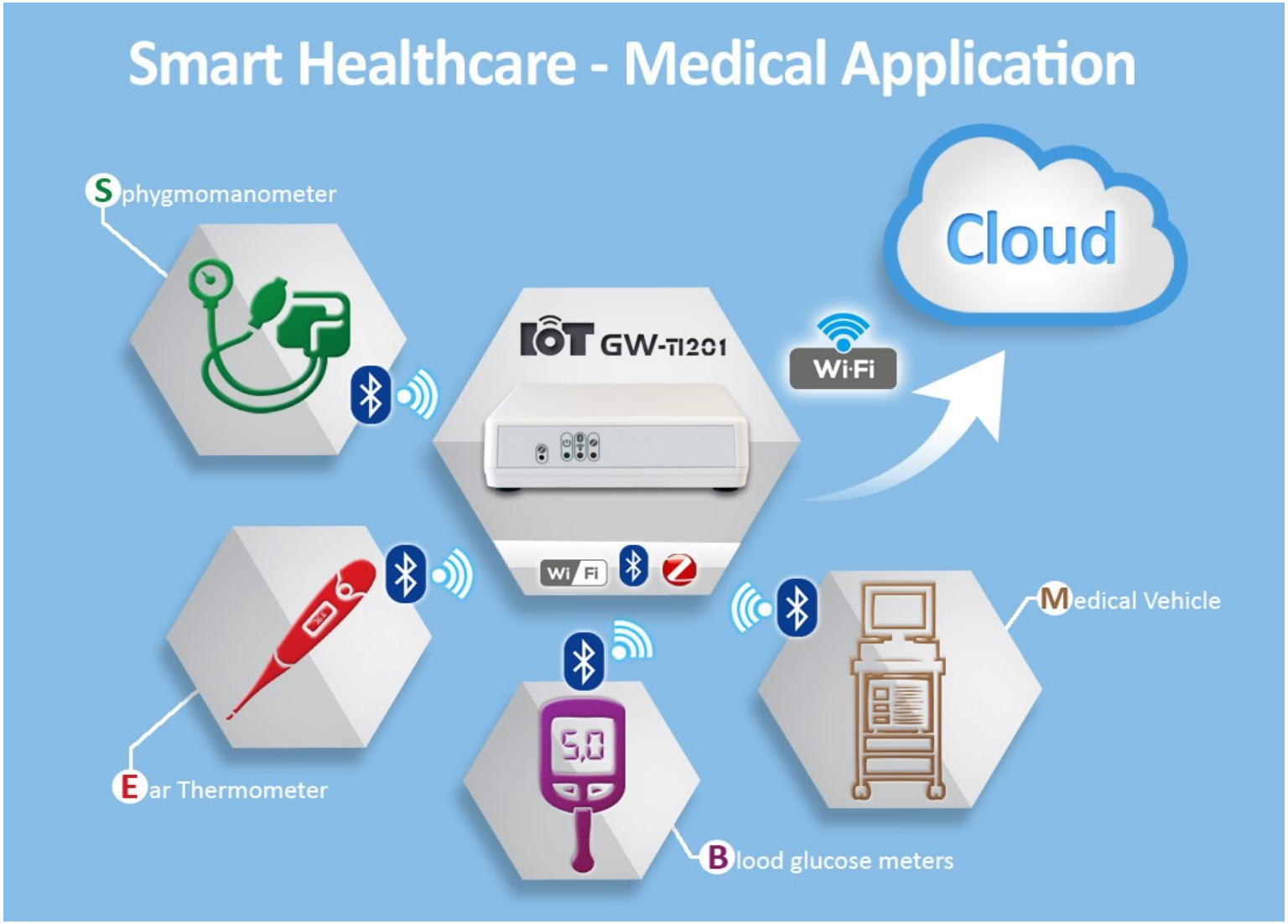
Source: https://depositphotos.com/126025652/stock-illustration-smart-city-concept-and-internet.html

Smart Home



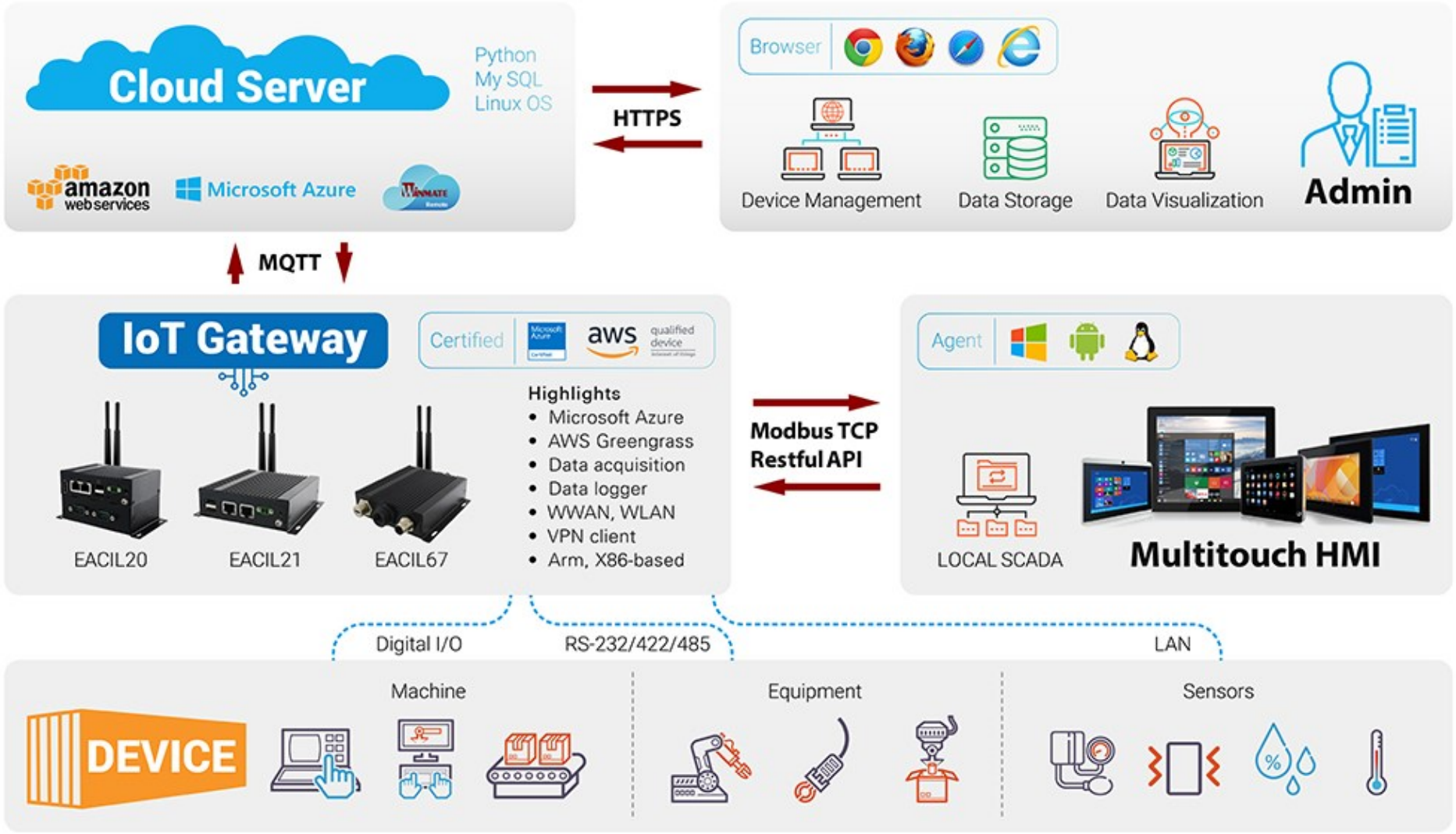
Source: https://medium.com/@globalindnews/north-america-accounted-for-major-share-in-the-global-smart-home-healthcare-market-in-2015-cc9cc1974ac5

Smart Healthcare



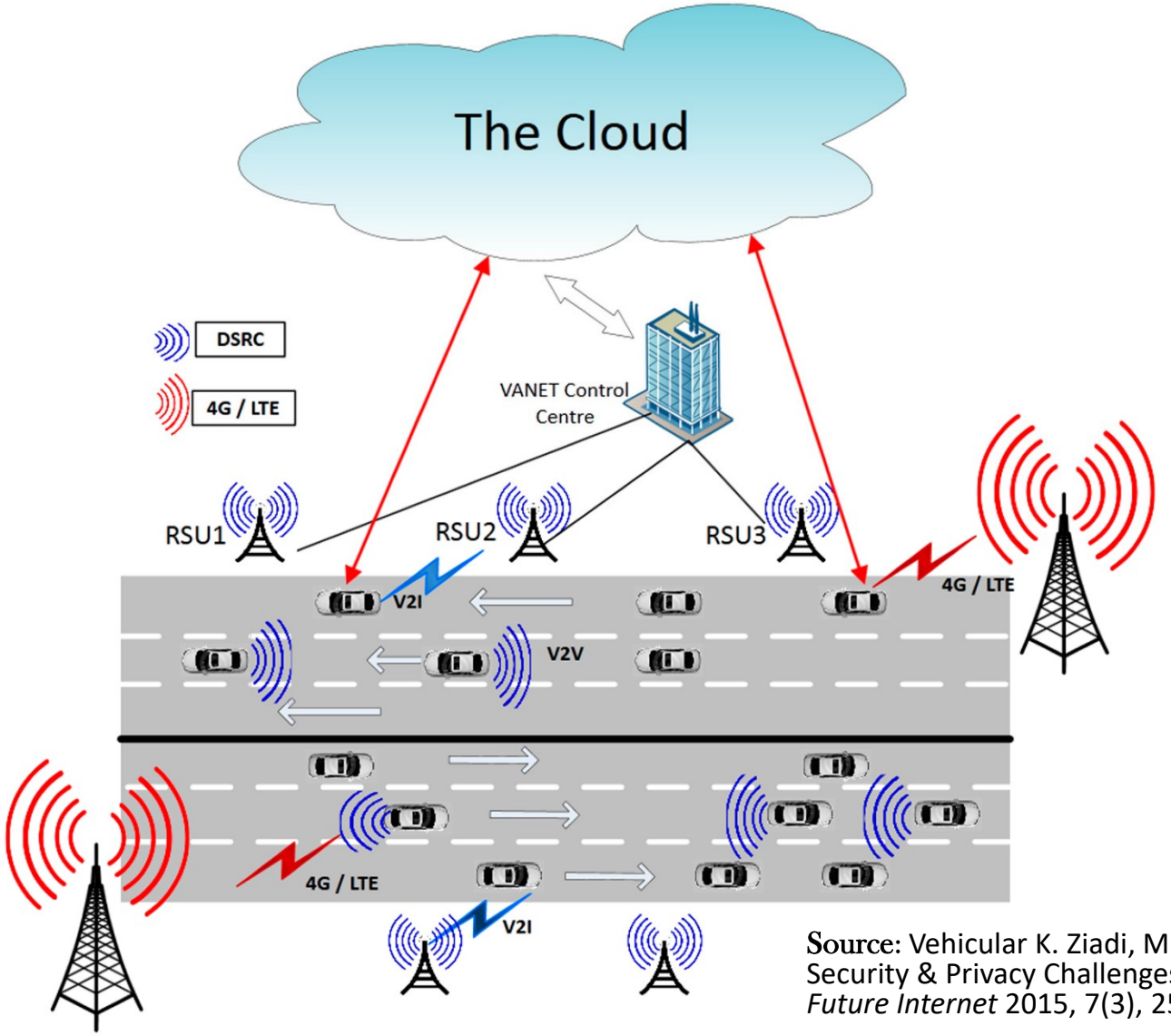
Source: http://iot.fit-foxconn.com/

Industrial IoT



Source: https://www.winmate.com/Solutions/Solutions_IoT.asp

Connected Cars



Source: Vehicular K. Ziadi, M. Rajarajan, "Internet: Security & Privacy Challenges and Opportunities", *Future Internet* 2015, 7(3), 257-275.

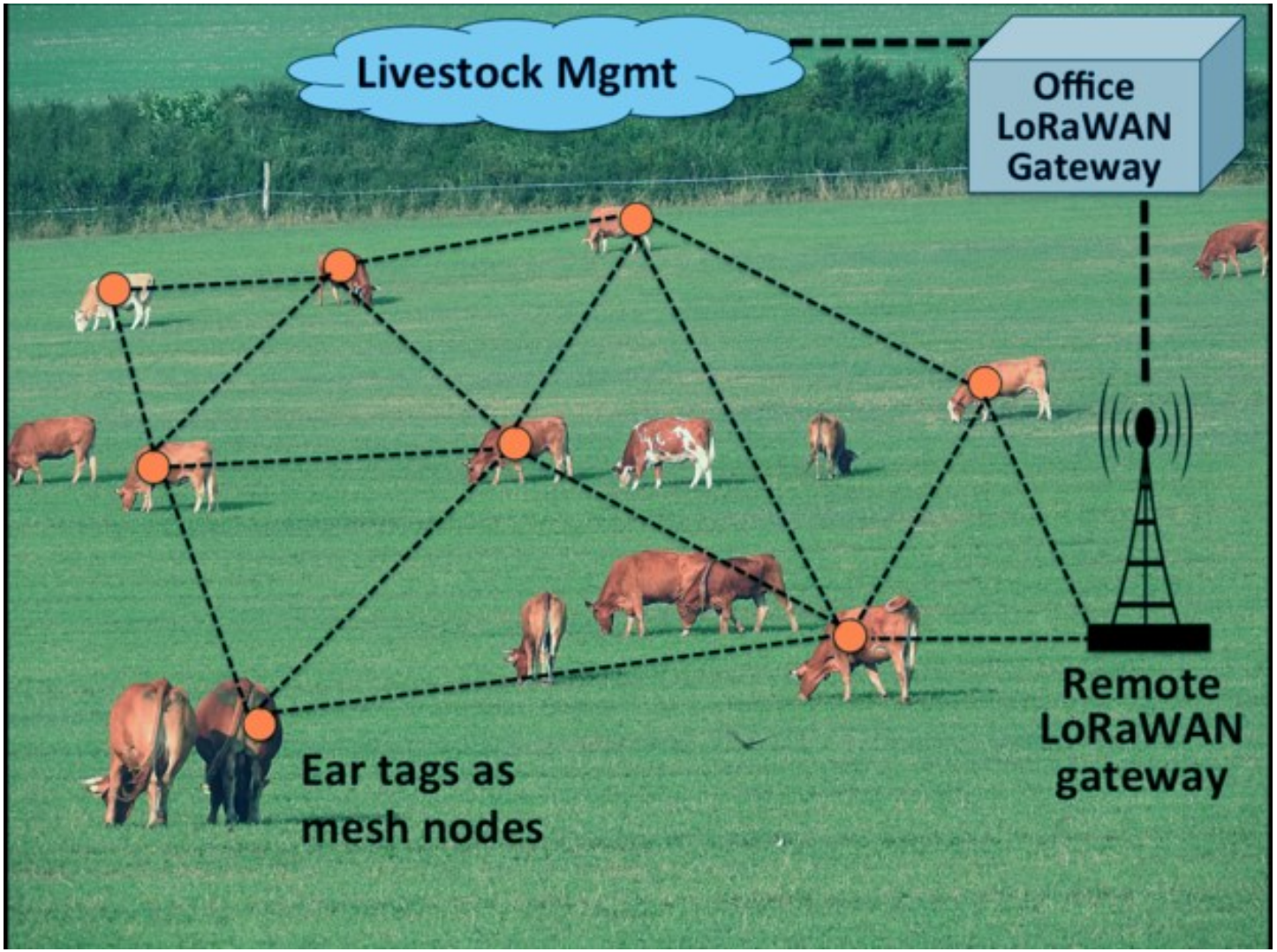
Google's Self-Driving Car

Source: https://www.google.com/

Smart Agriculture

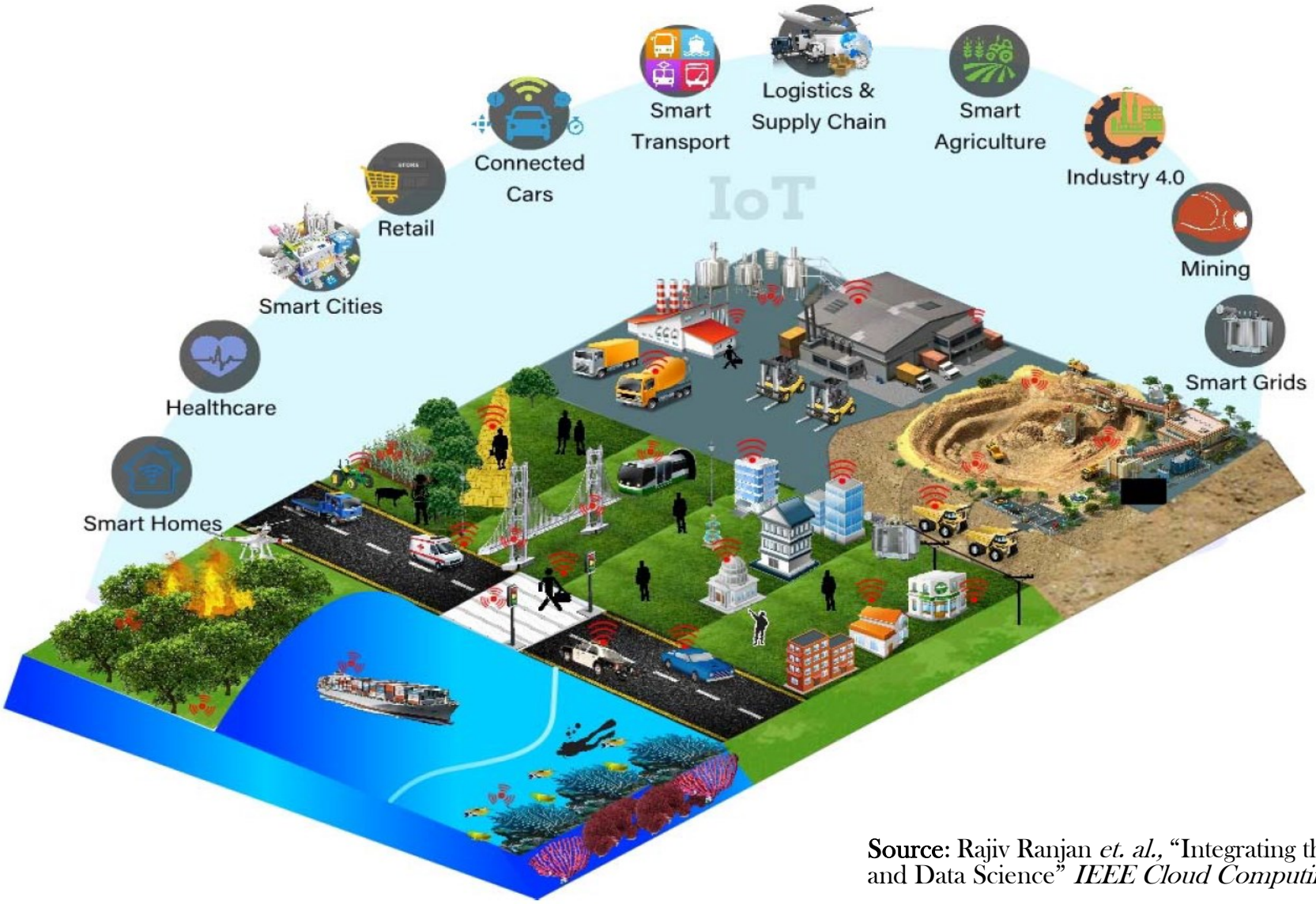
Source: https://in.pinterest.com/pin/515380751093603767/?lp=true

Livestock Management



Source: https://data-flair.training/blogs/iot-applications-in-agriculture/

Many More ….



Source: Rajiv Ranjan *et. al.,* "Integrating the IoT and Data Science" *IEEE Cloud Computing*, 2018

Main Challenges in IoT

Sensors

- Limited resources
- Limited types of sensors

Scale

- millions of devices are connected to form IoT

Privacy

- which personal data to share with whom
- how to control

Security

- "things" becomes connected, so security becomes complex

Low Power Network

- Devices should remain connected to the Internet for years
- High network latency

Big data and Data analytics

- massive amount of sensor data
- different sources and various forms
- extract intelligence form the heaps of data

Interoperability

- various protocol, various architecture
- unavailability of standardized platform
- different technology leads to interoperability issue
- Recent IoT standards are minimizing this problem

Lessons Learned

- ✓ Learned about what is IoT
- ✓ Learned the genesis of IoT
- ✓ Understand the benefits of IoT
- ✓ Learned about the market share of IoT
- ✓ Understand the real world applications of IoT
- ✓ Understand various challenges IoT implementation is facing

Thanks!

Figures and slide materials are taken from the following Books:

1. David Hanes *et al.*, "**IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things**", 1st Edition, 2018, Pearson India.

2. Mayur Ramgir, "**Internet of Things: Architecture, Implementation and Security**", 1st Edition, 2020, Pearson India.