

# Internet of Things (IoT)



## Introduction to IoT

### Definitions, Characteristics, Applications

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# What is IoT?

- ✓ Internet of Things is the **network of smart physical objects**
  - physical objects (e.g. devices, vehicles, buildings, etc.) **embedded with** sensors, 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

- IoT is the Unifications of technologies:
  - ✓ Embedded Systems
  - ✓ Low Power and Low Rate Network
  - ✓ Internet
  - ✓ Cloud Computing
  - ✓ Data Analytics
  - ✓ Bigdata
  - ✓ Edge Intelligence
  - ✓ Network Security and Data Security
  - ✓ Software Defined Networks
  - ✓ 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 Initial Phase of IoT



- The term "**Internet of Things**" was likely coined by **Kevin Ashton** of Procter & Gamble, later MIT's Auto-ID Center, in 1999.
  - Kevin Ashton said –
    - “In 20<sup>th</sup> century, **computers were brains without senses** – they only knew what we told them.”
    - “Now in 21<sup>st</sup> century, **computers are sensing things for themselves!**”
- **Early 1980s** at the Carnegie Mellon 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.

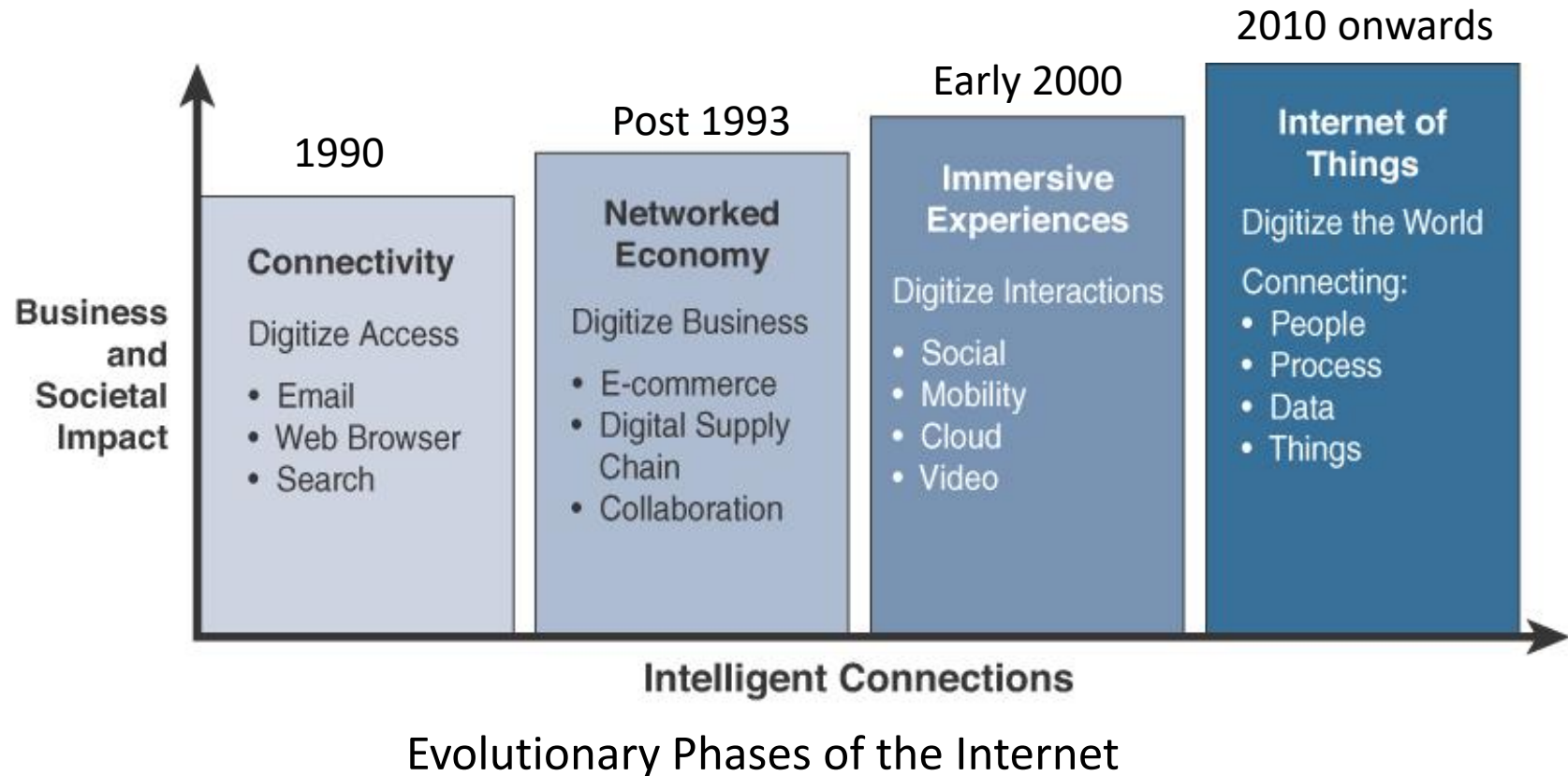
# Brief History of Initial Phase of IoT



- 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 21<sup>st</sup> Century, LG Electronics introduced the world's first refrigerator connected to the internet

# Brief History of Initial Phase of IoT

- The popularity of IoT did not accelerate until 2010/2011 and reached mass market from 2013-14.
- Definition of the IoT has also evolved over time.



# Benefits of IoT



- **Real-Time Monitoring**
  - IoT sensors can **monitor equipment and processes** in real-time, providing valuable sensed data that can be used to streamline operations, reduce waste, and increase output.
- **Automation of Processes**
  - **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
- **Improved Efficiency or Productivity**
  - IoT helps to **enhance productivity by** streamlining processes, automating tasks, and providing real-time data insights.
- **Predictive Maintenance**
  - Continuous monitoring of systems and processes to **identify key indicators of problems** before they result in downtime or system failure

# Benefits of IoT



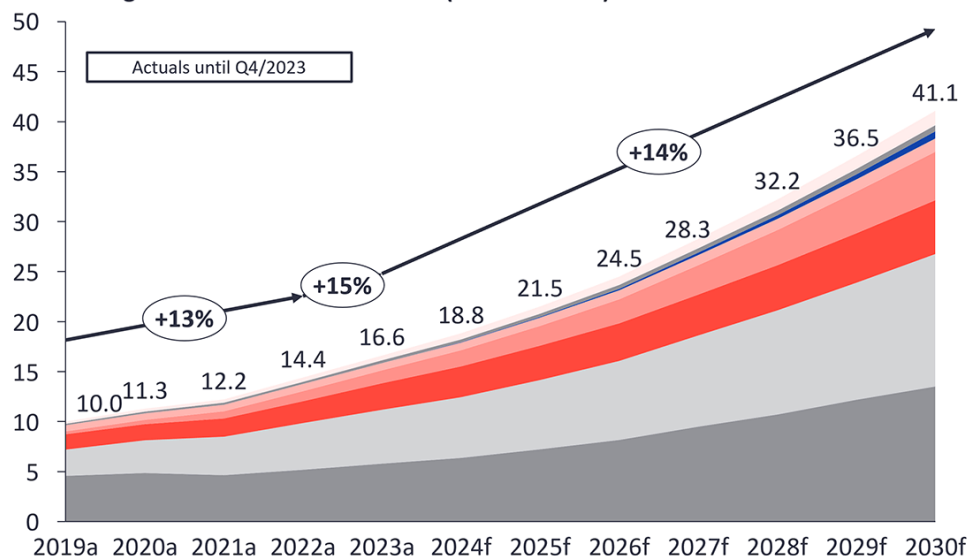
- Improved or New Insights
  - IoT generates vast amounts of data that can be analyzed to identify trends, inefficiencies, and areas for improvement. Organizations can leverage these insights to enhance productivity and operational effectiveness.
- Cost Reduction
  - When an organization can improve 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
- Optimized Work Environments
  - IoT technology can help create more comfortable and efficient workspaces
- 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



# Growth of IoT Devices

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

Number of global active IoT connections (installed base) in billions



Connectivity type	CAGR 21–23	CAGR 23–30
Other	21%	17%
Wireless neighborhood area networks (WNAN)	15%	14%
Cellular 5G IoT	147%	62%
Wired IoT	4%	9%
LPWA	35%	21%
Cellular IoT (excl. 5G, LPWA)	21%	11%
Wireless local area networks (WLAN)	18%	14%
Wireless personal area networks (WPAN)	12%	13%

XX% = CAGR (Compound Annual Growth Rate)

**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 2024-State of IoT Summer 2024. We welcome resharing: Please attribute this image to its original source and include a link back to the original article.

## IoT Analytics' prediction

IoT devices **excluding** PC, Laptop, Smartphone, Tablet, and one directional technology like RFID, NFC

Image Source: <https://iot-analytics.com/number-connected-iot-devices/>

**Wired:** Eth, SCADA network (Modbus, Fieldbus, etc.)

**Cellular:** 2G, 3G, 4G, 5G; **LPWA:** LoRa, HaLow

**WPAN:** BLE, ZigBee, Z-Wave, etc.; **WLAN:** WiFi

**WNAN:** Non-short-range mesh e.g. Wi-SUN

# Global Spending on IoT



IOT ANALYTICS

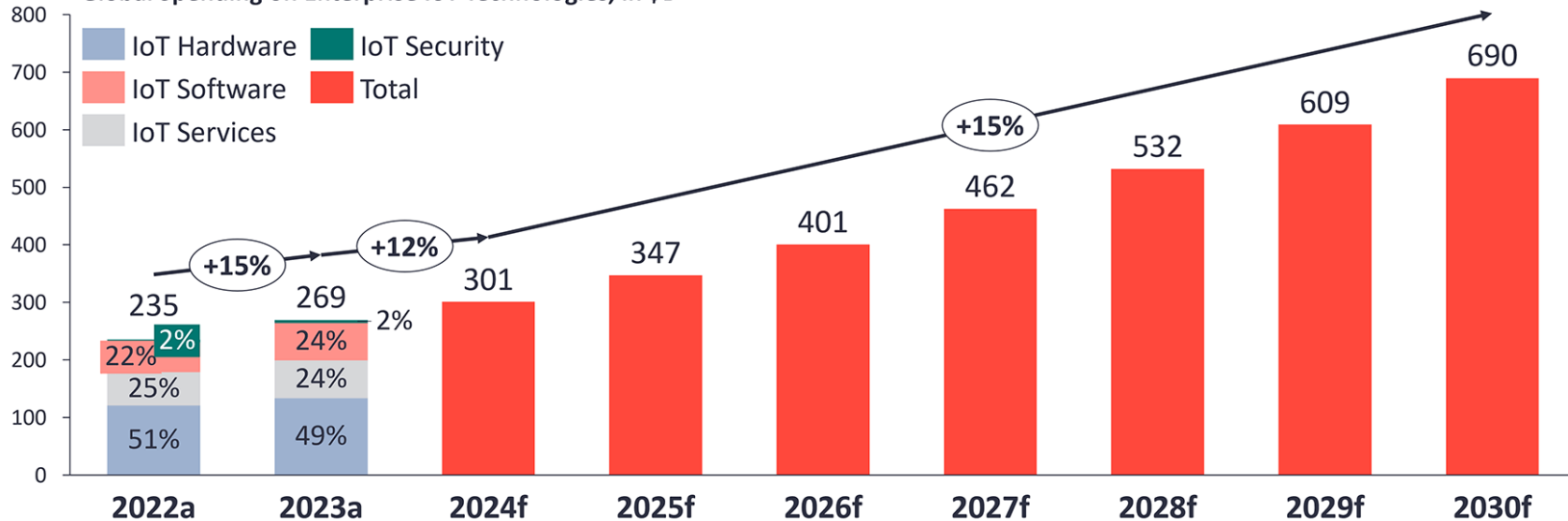
July 2024

Your Global IoT Market Research Partner

## The enterprise IoT market by technology 2023–2030

Data as of June 2024

Global Spending on Enterprise IoT Technologies, in \$B



**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. Since the last update in 2023 our definition of the enterprise IoT tech stack slightly changed.

a: Actuals, f: Forecast

Source: IoT Analytics Research 2024 – Global IoT Enterprise Spending Dashboard (Q2/2024 update). We welcome republishing of images but ask for source citation with a link to the original post or company website.

## IoT Analytics' Report on Global IoT Market as on July 2024

Image source: <https://iotbusinessnews.com/2024/07/10/06205-enterprise-iot-market-size-reached-269-billion-in-2023-with-growth-deceleration-in-2024/>

# Where is IoT?



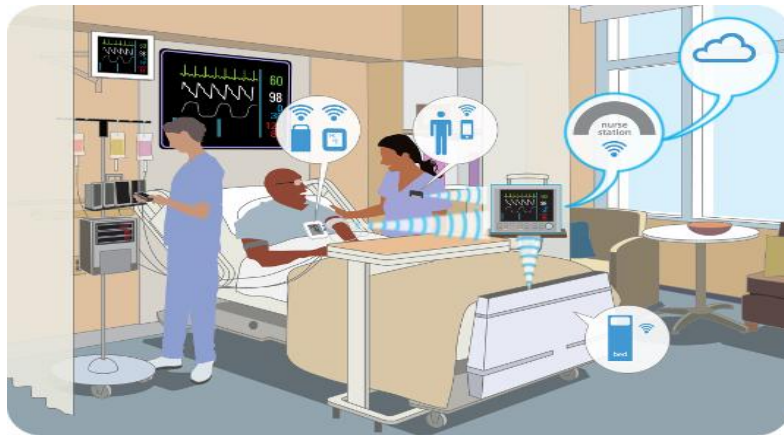
Wearable  
Tech Devices



Smart Appliances



It's everywhere!

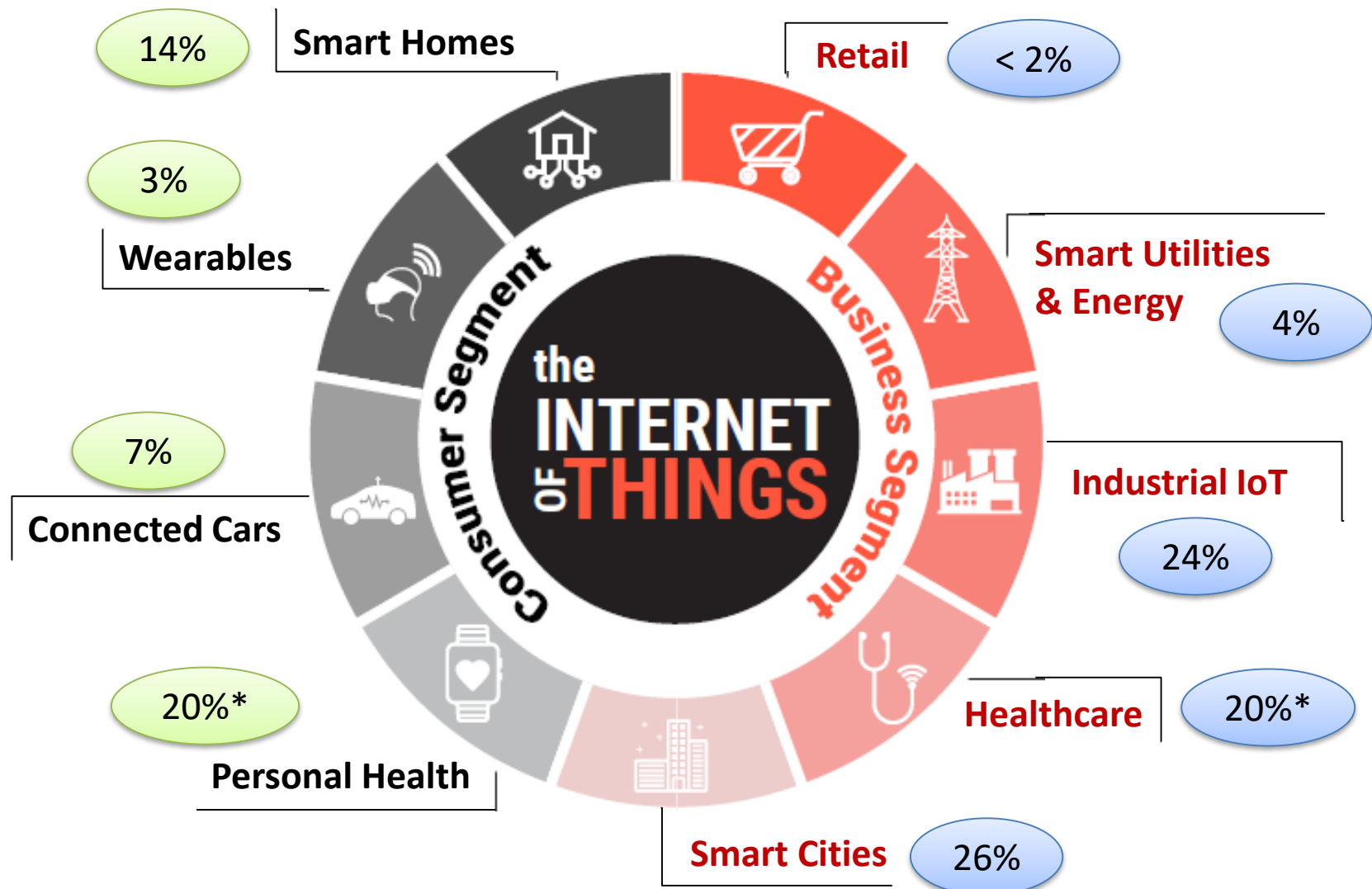


Healthcare



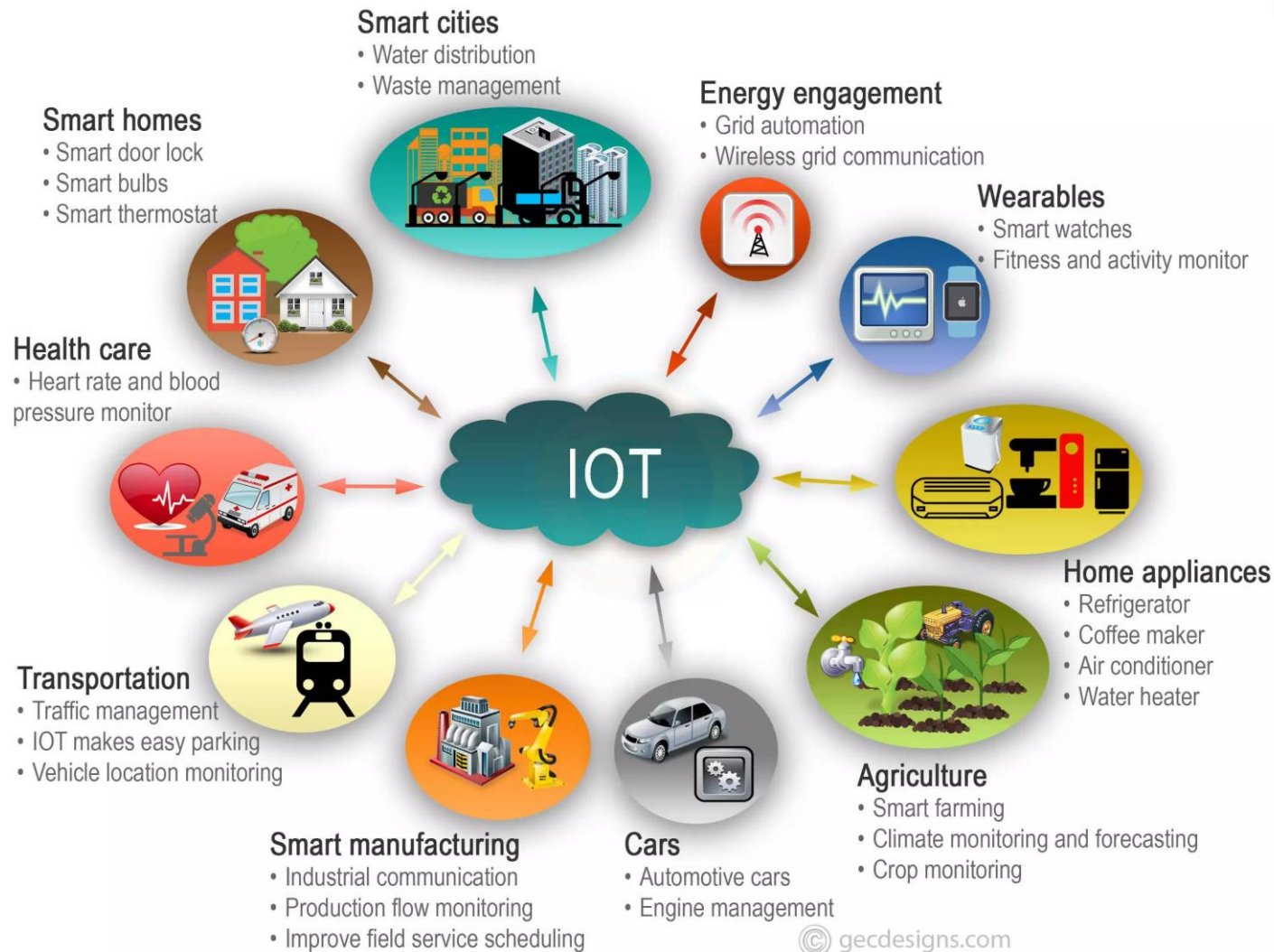
Industry Automation  
and Monitoring

# Global IoT Market Share



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

# Applications of IoT

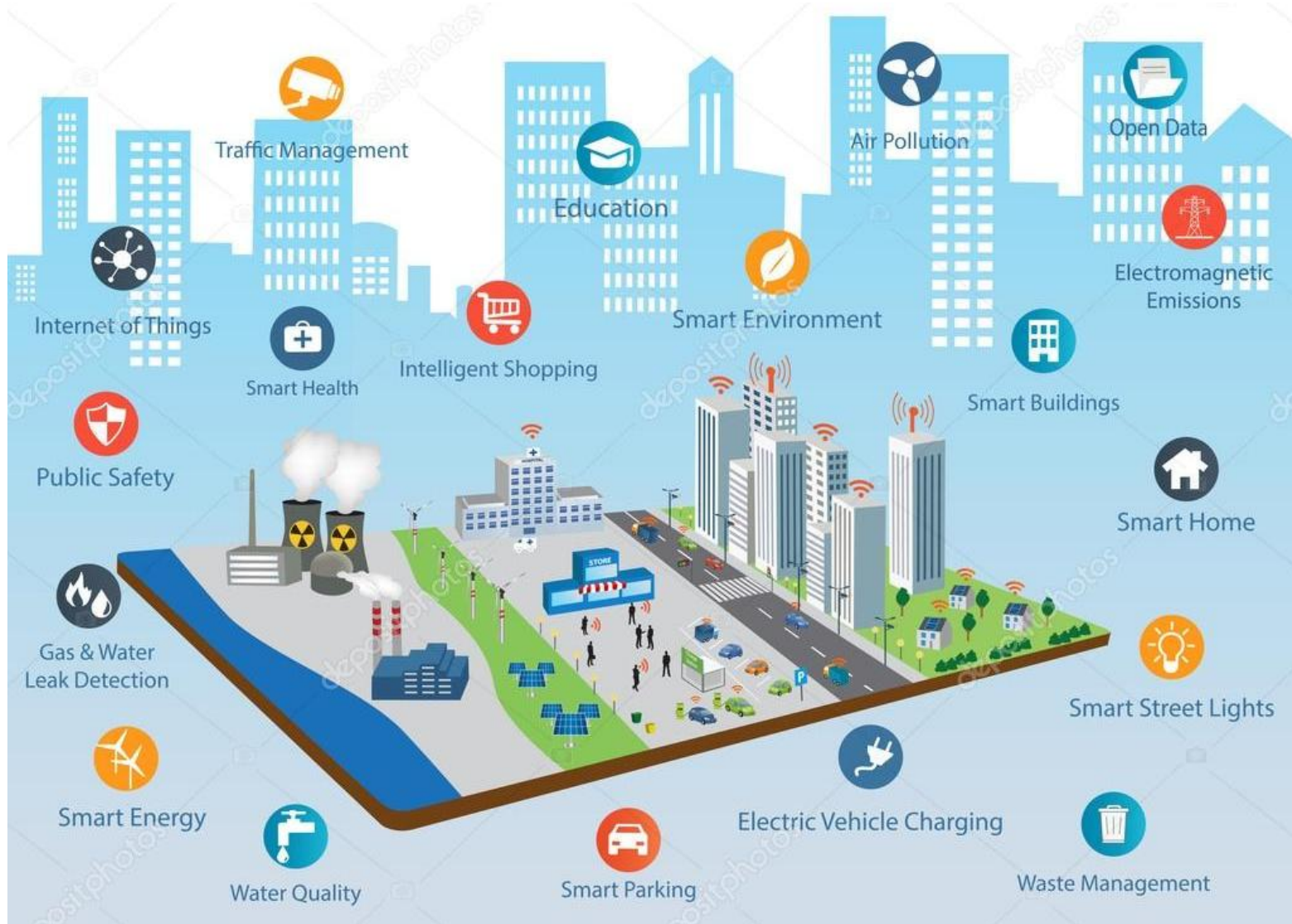


© gecdesigns.com

Source: <https://sl.bing.net/jncHHWGAj36>

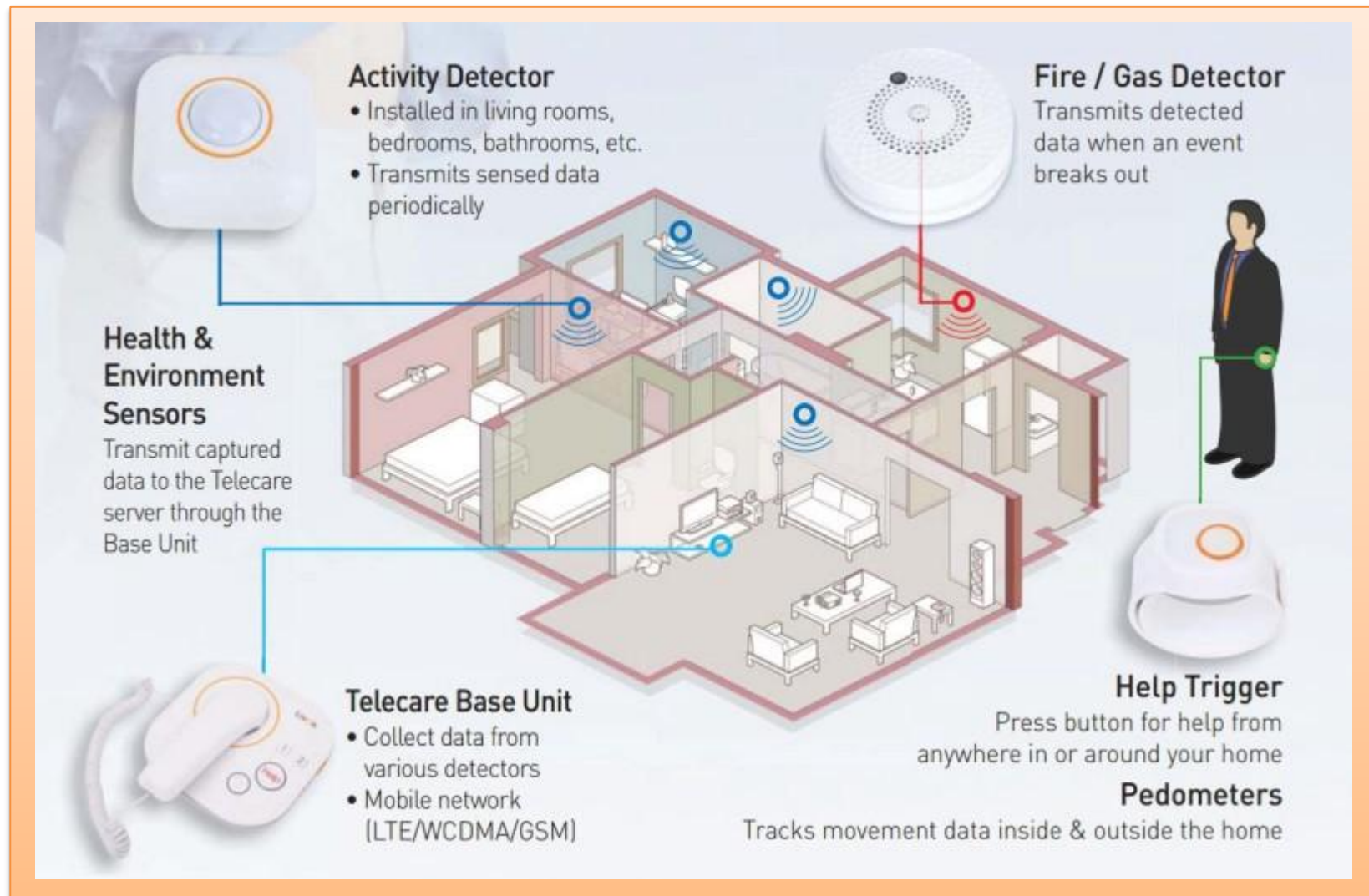


# Smart City



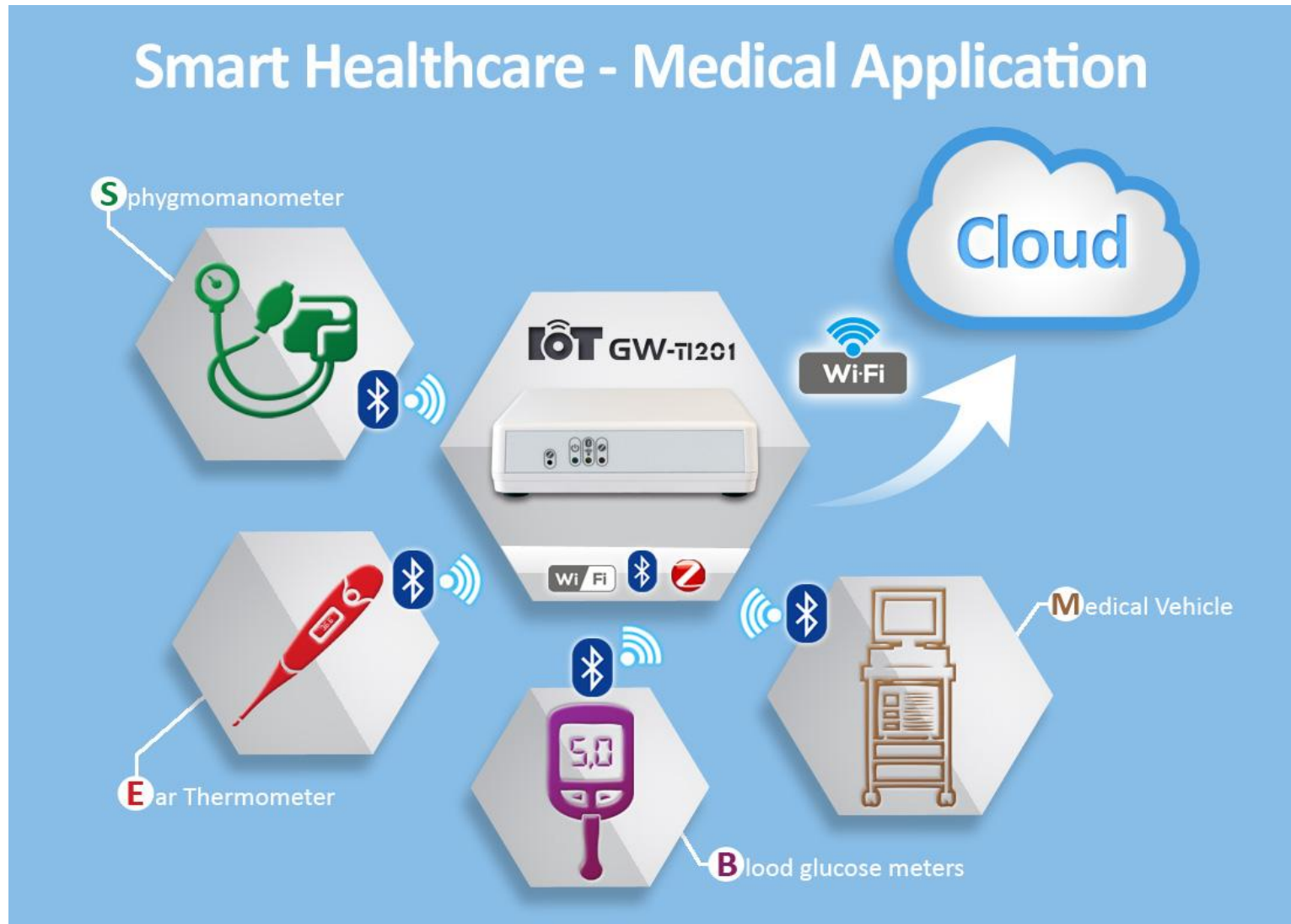
Source: <https://depositphotos.com/126025652/stock-illustration-smart-city-concept-and-internet.html>

# Smart Home



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

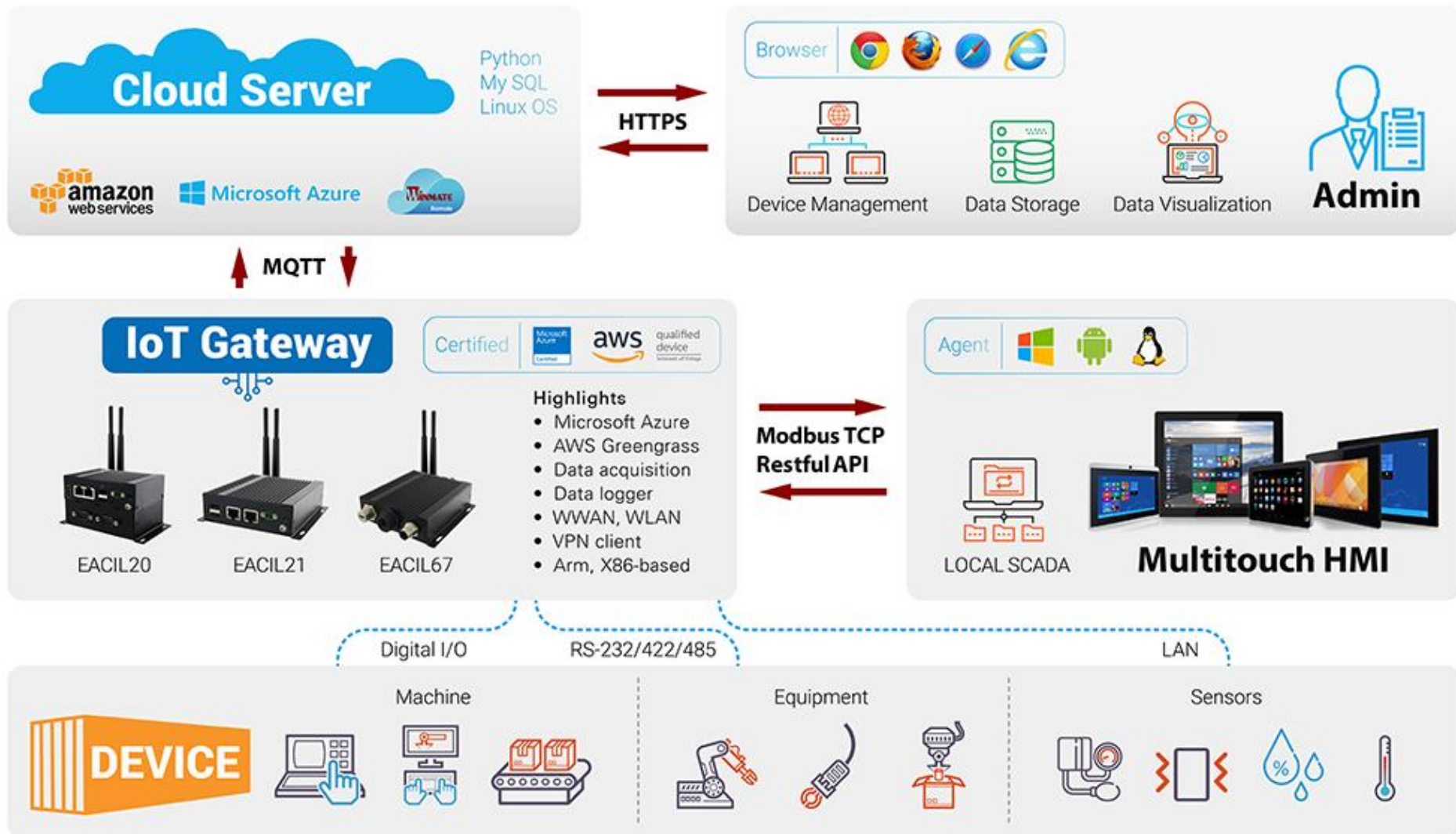
# Smart Healthcare



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

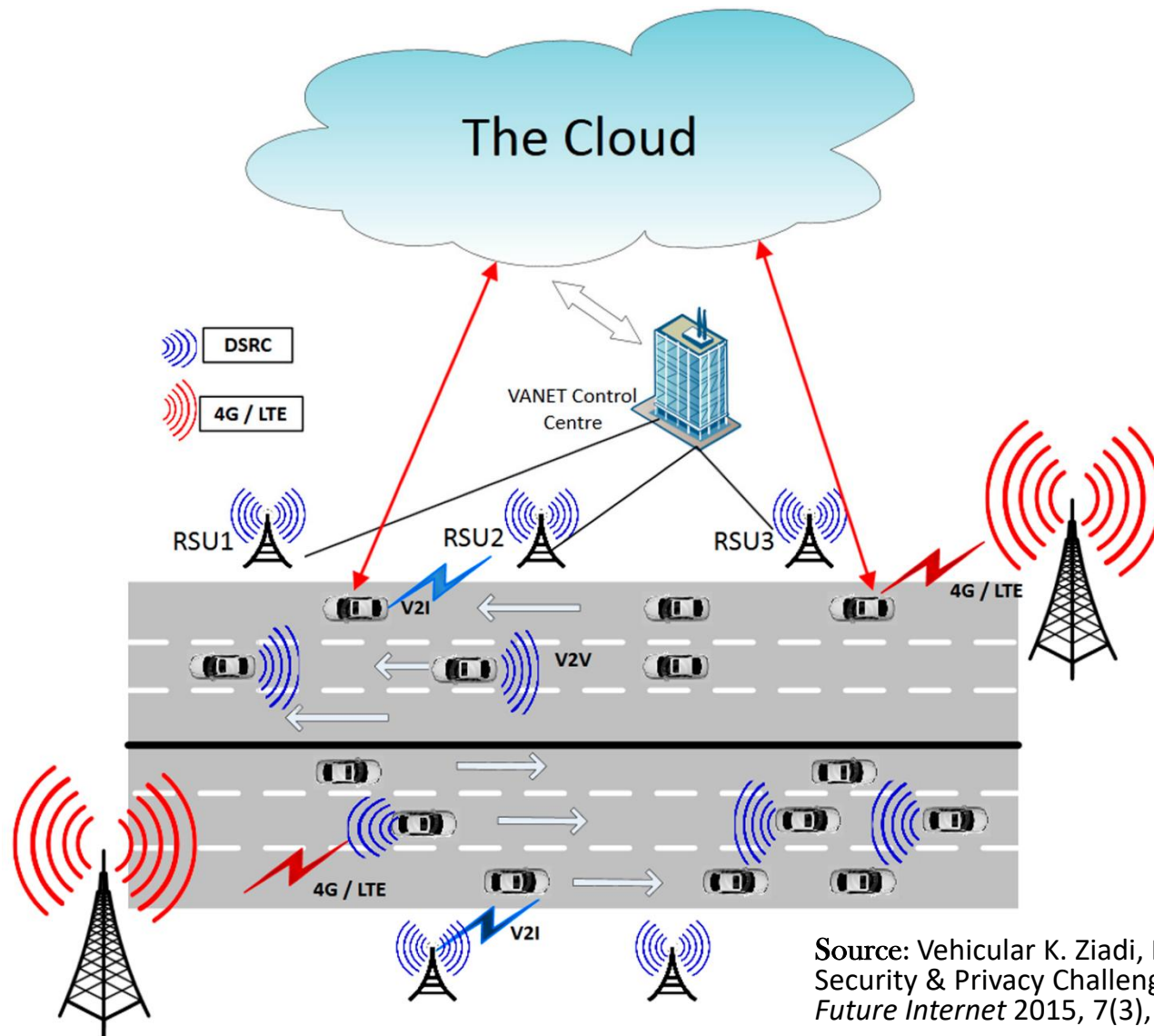


# Industrial IoT



Source: [https://www.winmate.com/Solutions/Solutions\\_IoT.asp](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/>

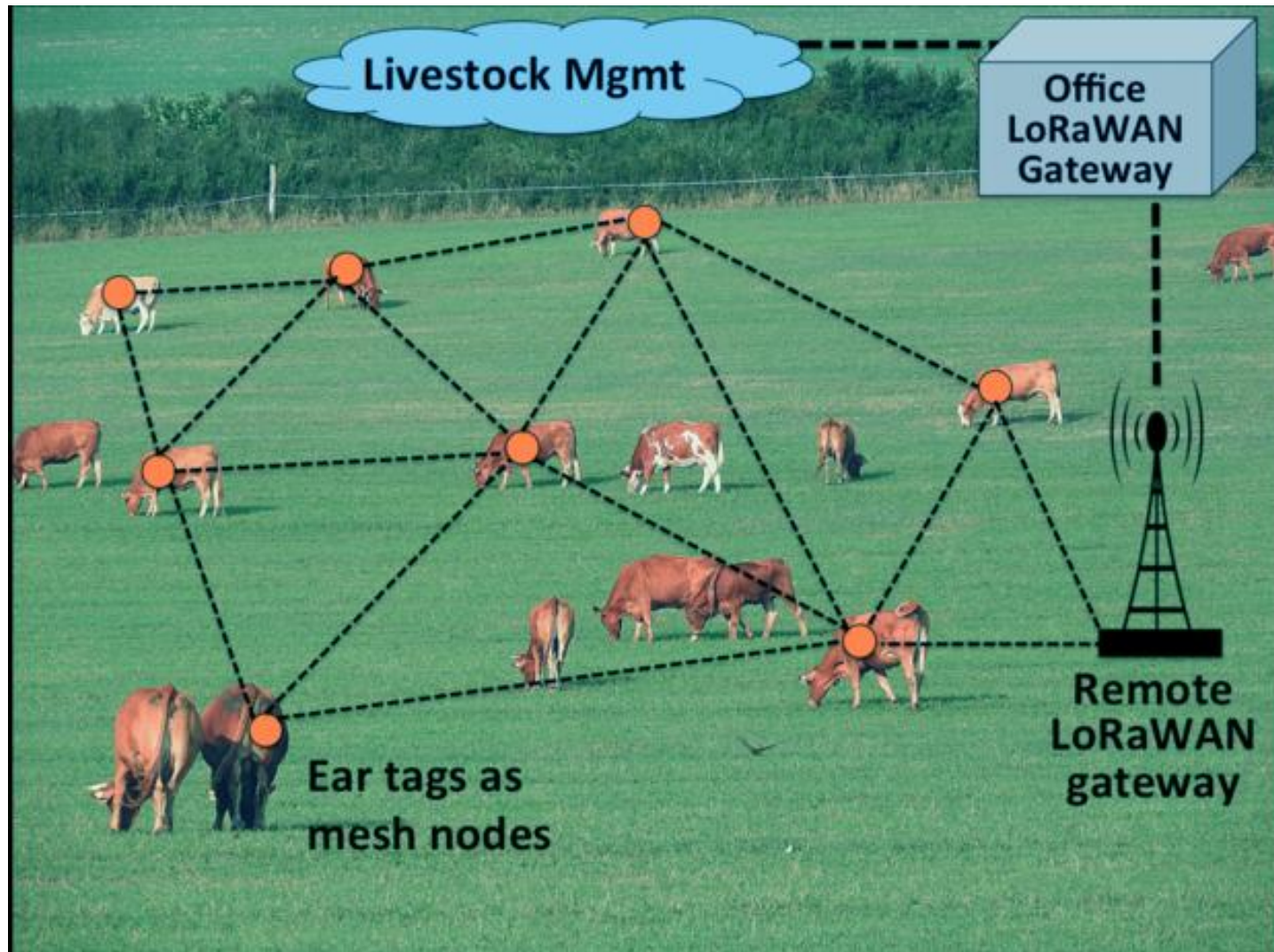


# Smart Agriculture



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

# Livestock Management



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



# Main Challenges in IoT Implementation

## Sensors

- limited resources
- limited types of sensors

## Scale

- millions of devices are connected to form IoT

## Low Power Network

- devices should remain connected to the network for years
- high network latency
- can't use traditional communication protocols

## Interoperability

- various protocol, various architecture
- unavailability of standardized platform
- different technology leads to interoperability issue

## Bigdata & Data analytics

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

## Privacy

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

## Security

- “things” becomes connected, so security becomes complex

# 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 in IoT implementation

# Thanks!



Figures and slide materials are taken from the following Books:

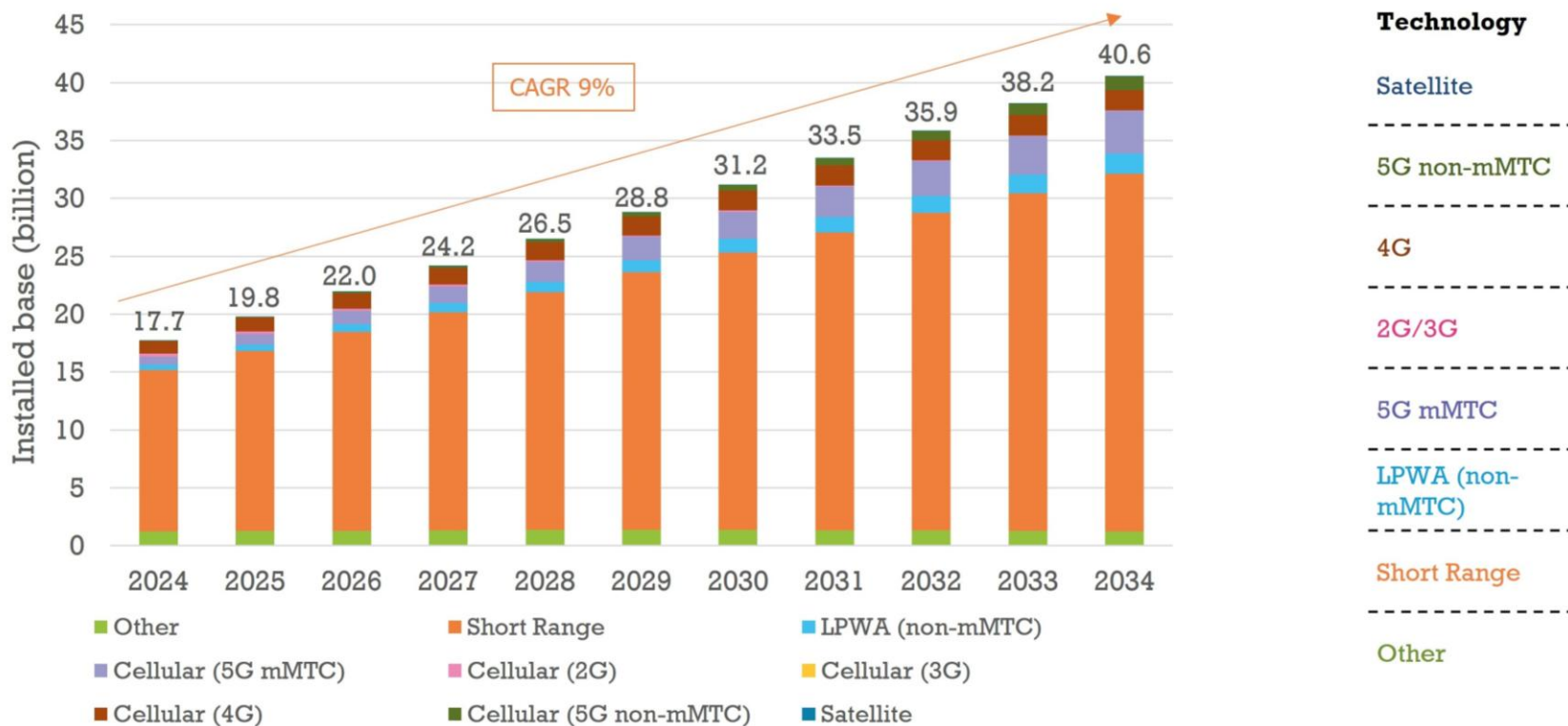
1. David Hanes *et al.*, “**IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things**”, 1<sup>st</sup> Edition, 2018, Pearson India.
2. Mayur Ramgir, “**Internet of Things: Architecture, Implementation and Security**”, 1<sup>st</sup> Edition, 2020, Pearson India.



# Growth of IoT Devices

## Global IoT connections forecast, 2024-34

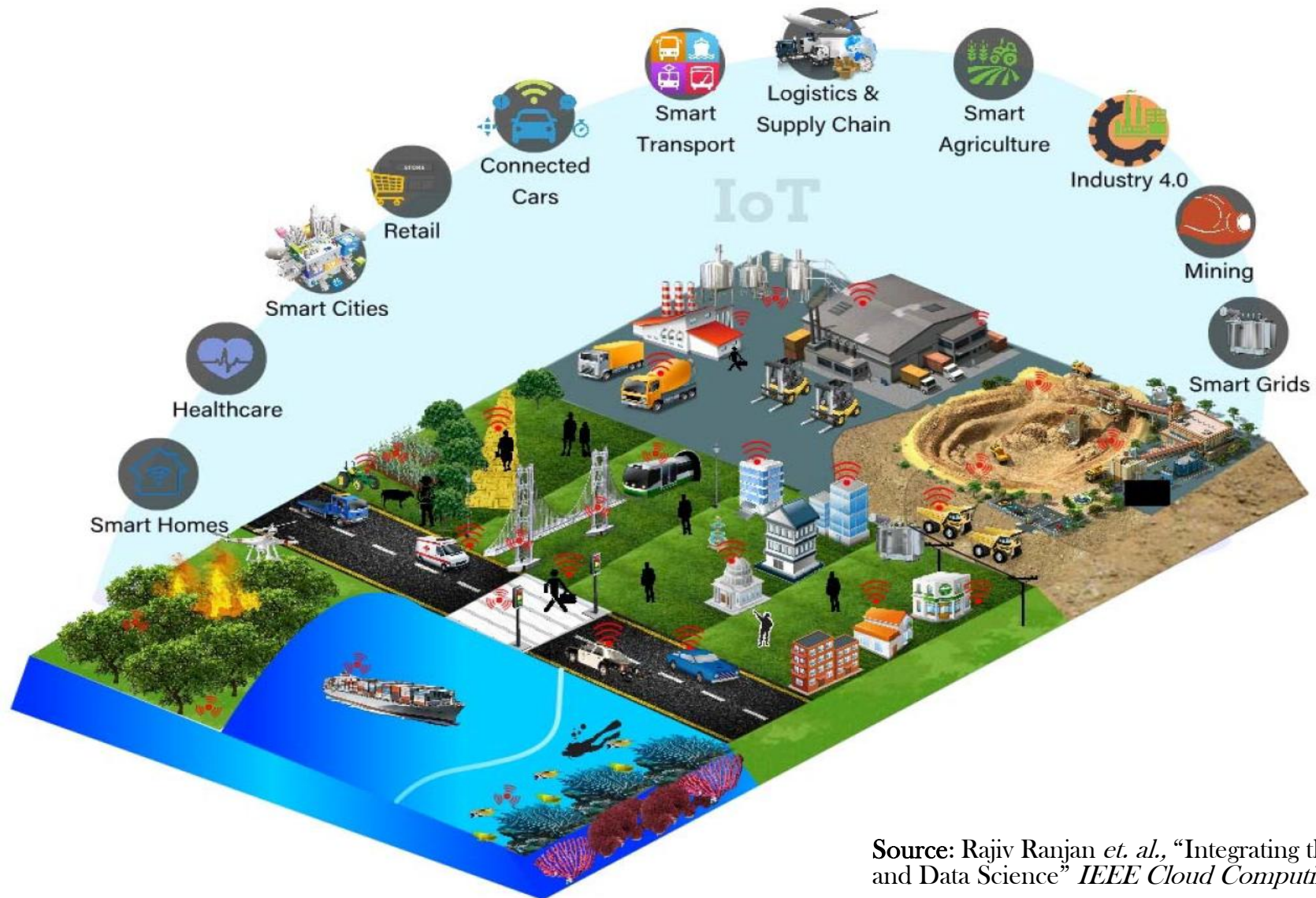
[Source: Transforma Insights IoT Forecast Database, 2025]



## Transforma Insights's Prediction

Image Source: <https://transformainsights.com/research/reports/global-iot-forecast-report-2024-2034>

# Many More ....



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