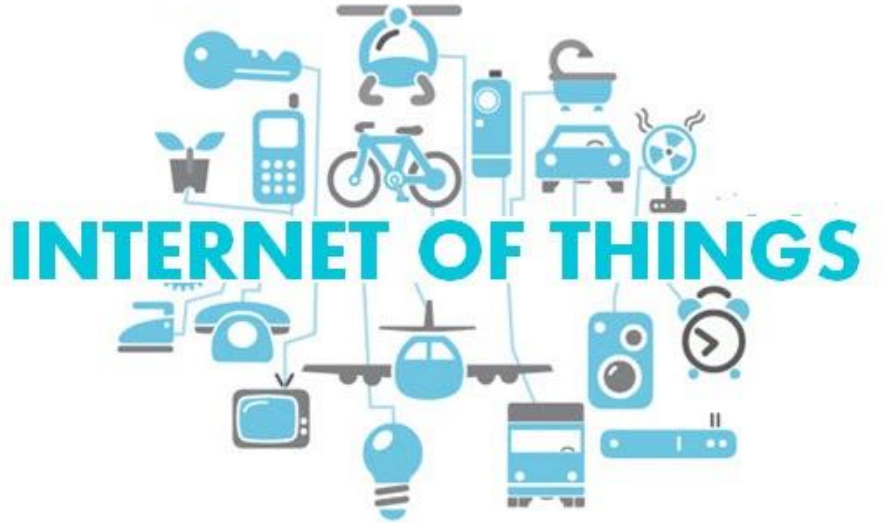
BAIT 2123
INTERNET OF THINGS

Chapter 1: Introduction to IoT

IoT Definitions, Approaches and Models

Overview

- IoT Concepts
- IoT Markets
- IoT Communication Model



The idea of connecting the physical world to the Internet has been around since the 90s.

But the idea didn‘t accelerate twenty – or even ten – years ago.

Slimplilearn - What does IoT mean?

Youtube Video:
https://www.youtube.com/watch?v=6mBO2vqLv38

IoT Things

These objects acting as sensors or actuators are able to interact with each other in order to reach a common goal.

What is out there today ...

Theragun PRO

https://www.therabody.com/us/en-us/pro-red.html

Lavvie Bot

https://www.lavviebot.com/en/design.html

Hydrat Spark

https://hidratespark.com/

Flow by plum lab

https://plumelabs.com/en/flow/

iO Toothbrush

https://www.oralb.co.uk/en-gb/product-collections/electric-toothbrushes/io#3d-teeth-tracking

Welt

https://www.weltcorp.com/

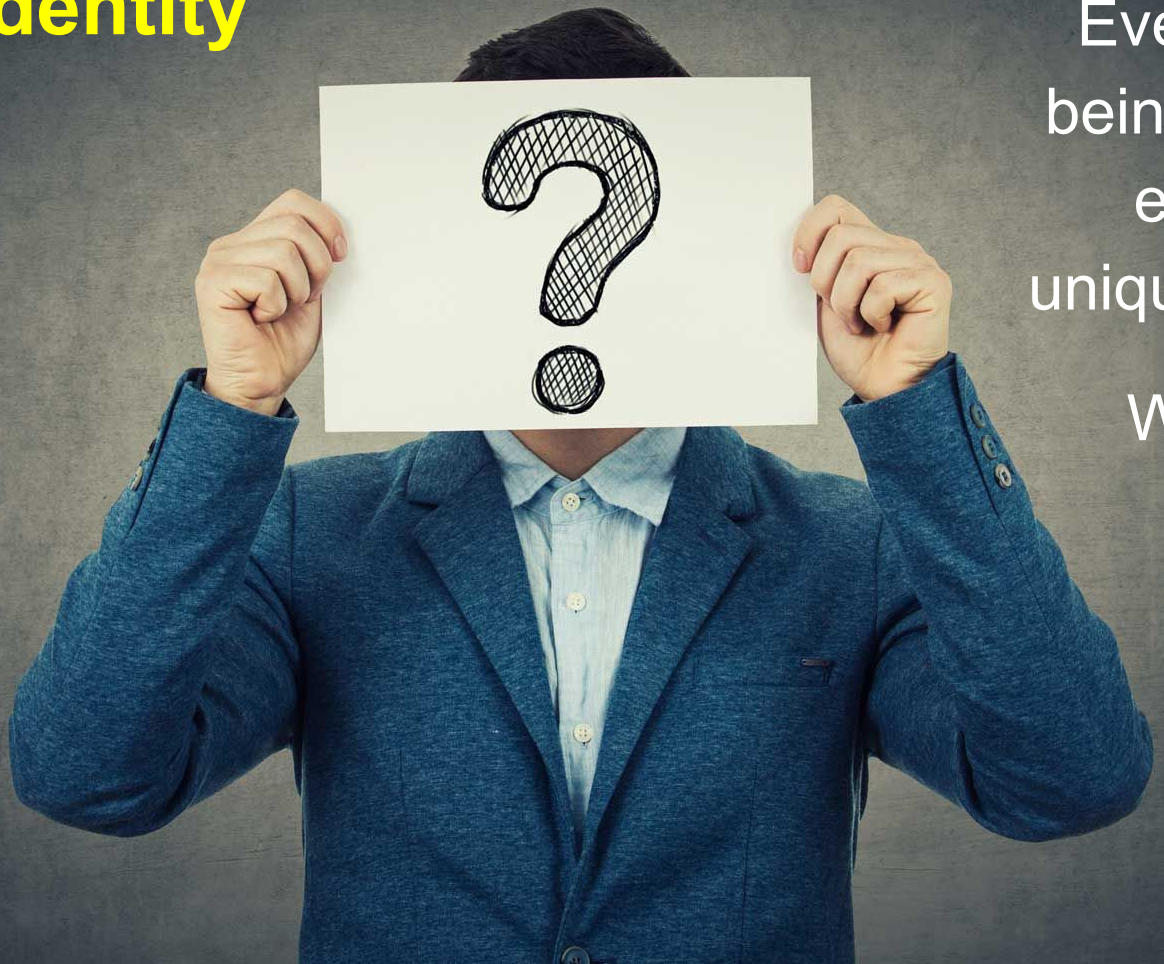
Kisha

https://www.getkisha.com/

What are the things defined
as Internet of Things?

3 elements that
every single human has it

Identity



Every human being living on earth has a unique identity.

What about things in

IOT ?

Intelligence

Each human is born with a brain that can think and process information intelligently.

So do the “things”

Communication

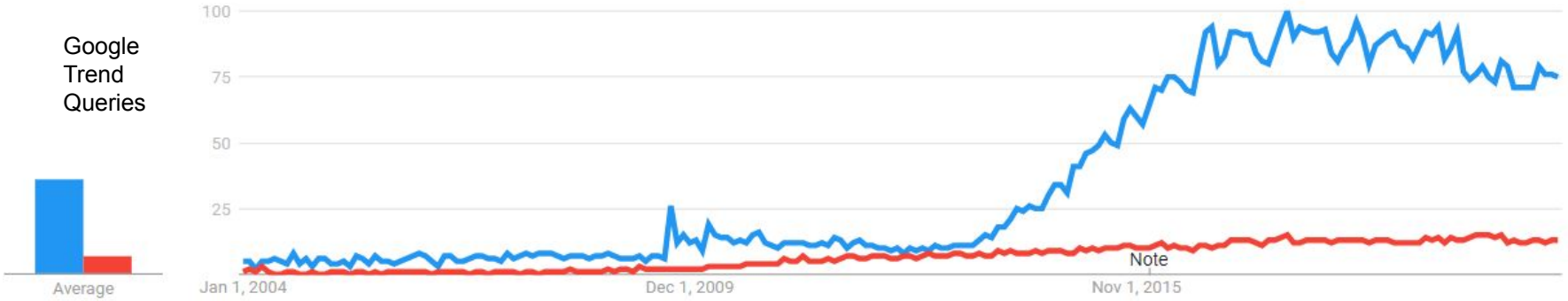
People in the world can communicate via social networks and existing Internet infrastructures.

IoT Concepts

- The Internet of Things (IoT) paradigm is based on **intelligent and self configuring nodes (things)** interconnected in a dynamic and global network infrastructure.
- IoT is generally characterized by real world small things, widely distributed, with limited storage and processing capacity, which involve concerns regarding reliability, performance, security, and privacy.
- IoT refers to a '**world-wide network of interconnected objects** uniquely addressable, based on standard communication protocols whose point of convergence is the Internet.'
- The basic idea behind IoT is the pervasive presence around people of things, able to measure, infer, understand, and even modify the environment.

Figure below indicates the number of research papers dealing with the content of IoT and Cloud. Based on the figure, it does show an increasing trend of Cloud topic discussion and IoT topic of interest among researchers, and industries since the year 2004 until today.

HOW ABOUT NOW?
[LINK]



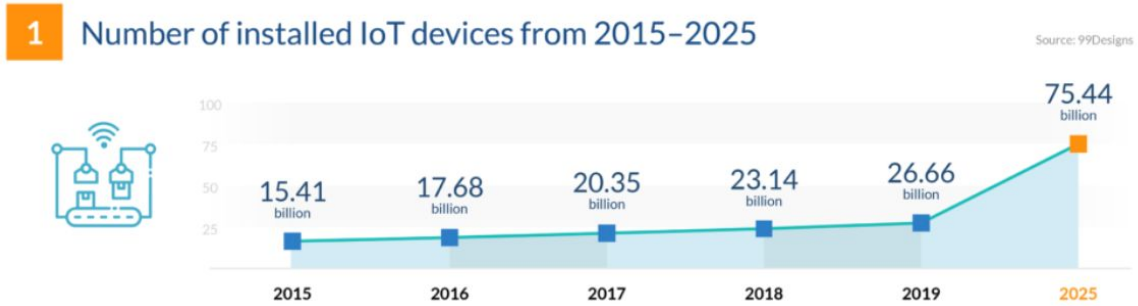
IoT Adoption surged in 2023. 64% of respondents currently deploy IoT solutions and an additional 23% plan to deploy within the next 12 to 24 months.

Source:Eclipse IOT & Edge Commercial Adoption Survey Report (2023):
https://outreach.eclipse.foundation/hubfs/Eclipse%20IoT%20White%20Papers%20and%20Case%20Studies/2023%20IoT%20%26%20Edge%20Commercial%20Adoption%20Survey%20Report%20.pdf

The number of connected devices

How many ?

Year	The number of connected devices
2011	The number of connected devices **overtook the number of people.**
2021	The number of connected devices estimated at **46 billions**. (Juniper Research)
2030	The number of connected devices is expected to reach **125 billions**. (Martech Advisor)



Source:Nick G. (Jan 2024) How Many IoT Devices are there in 2024 [All You Need To Know]
https://techjury.net/blog/how-many-iot-devices-are-there/#gref
https://financesonline.com/iot-statistics/

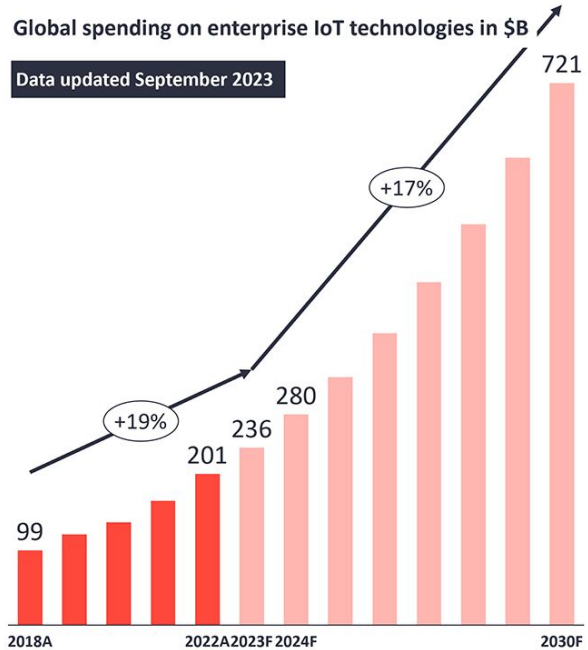
IOT ANALYTICS

March 2024

Your Global IoT Market Research Partner

Market snapshot: Internet of Things

Market size



Market players (selection*)

Microsoft, TE connectivity, cisco, IBM, aws, vodafone, Alphabet, QUECTEL, BELDEN, software AG, Qualcomm, ST, ABB, ptc, intel, NXP, Rockwell Automation, SEMTECH, paloalto NETWORKS, SIEMENS, zscaler, ADVANTECH, FORTINET, Schneider Electric, accenture, signify, TCS TATA CONSULTANCY SERVICES, Honeywell, cognizant

Market trends 2024 (selection*)

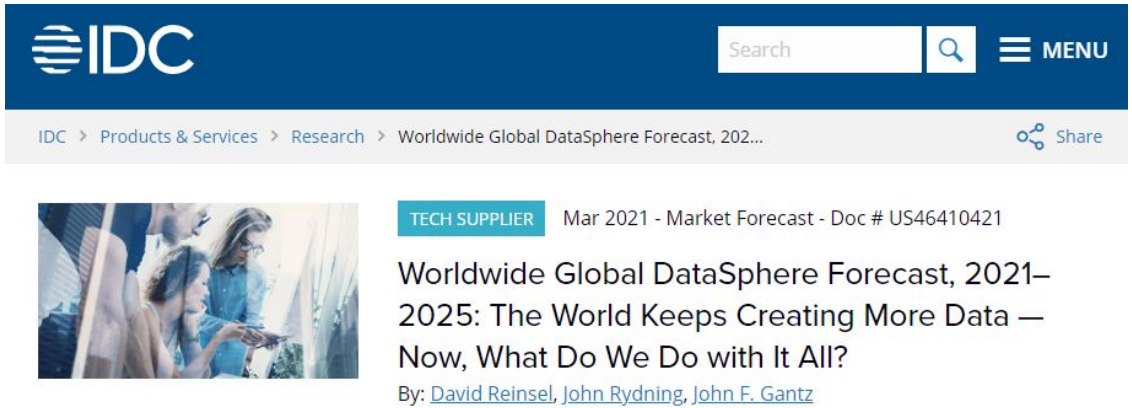
1	Semiconductor companies invest in embedded chipset security
2	Industrial automation hardware becoming more intelligent with integration of AI chipsets
3	The race for generative AI solutions in manufacturing had begun
4	Generative AI has a positive (not negative!) impact on the manufacturing workforce
5	Companies are in danger of neglecting tech adoption basics in the rush to generative AI
6	Marketplaces are gaining in importance for technology procurement
7	Data fabric is emerging as an advanced evolution of data lakes
8	Hyperscalers pivot their edge strategies to innovate and secure their IIoT market position
9	Industrial vendors are strongly investing in DataOps solutions
10	Robots charged per hour are starting to replace manual labor due to labor shortage

Source: IoT Analytics Research 2024-State of IoT – Spring 2024. * = Just selected IoT market leaders shown-list is not exhaustive; Just those trends shown that we discuss in the accompanying blog post. We track hundreds of IoT companies and related trends. We welcome the republishing of images but ask for source citation with a link to the original post and company website.

Source: Knud Lasse Lueth, 14 March 2024, https://iot-analytics.com/state-of-iot-10-emerging-iot-trends-driving-market-growth/

The volume of connected data

International Data Corporation (IDC) estimates that the amount of data in the world will more than quadruple in the next five years to reach 175 zettabytes in 2025.

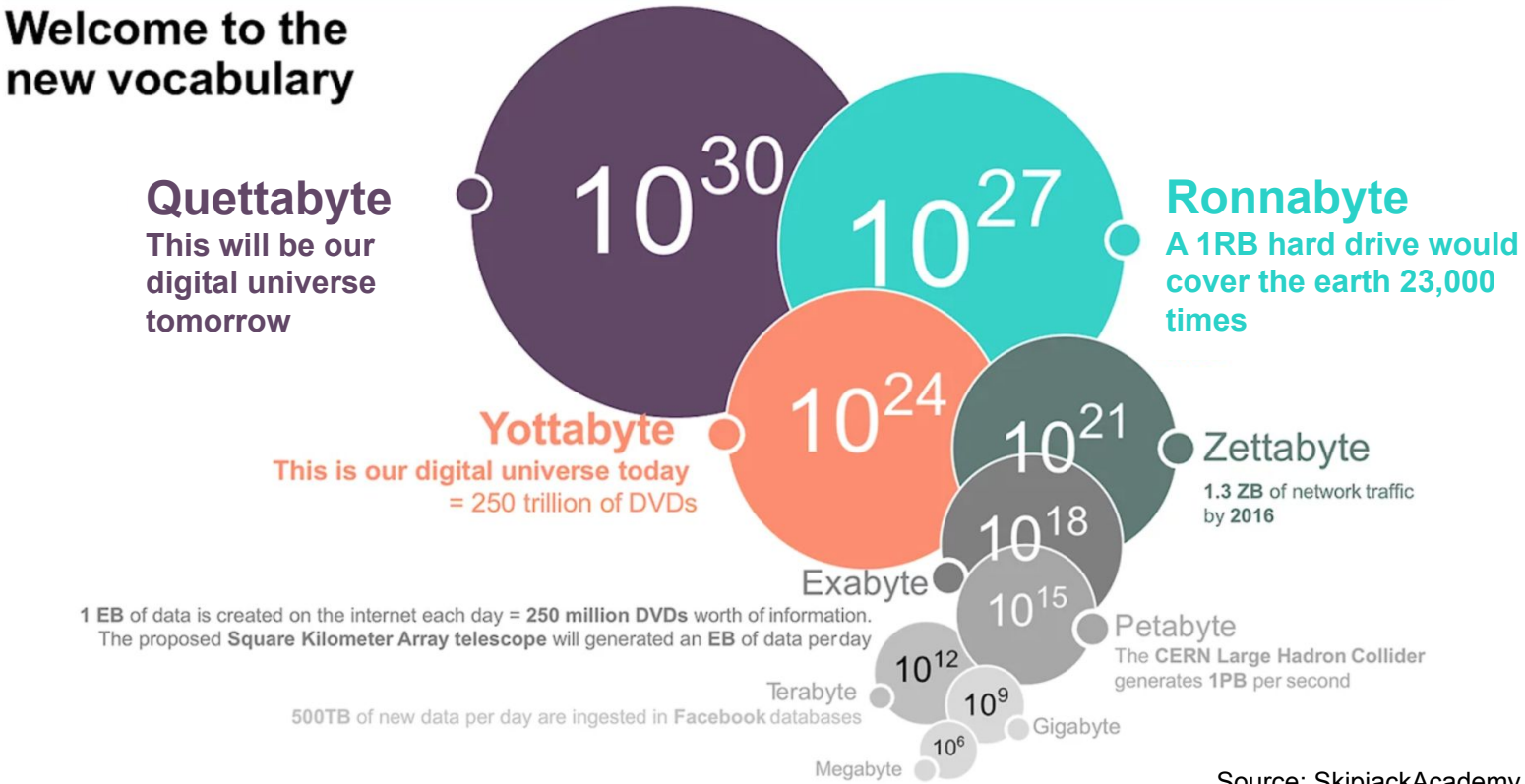


More Info

From Statista

Sources: Datacenternews.asia (Mar 2021) The world generated 64.2 zettabytes of data last year- but where did it all go?
https://datacenternews.asia/story/the-world-generated-64-2-zettabytes-of-data-last-year-but-where-did-it-all-go

IDC predicts that the Global Datasphere will reach 175 Zettabytes by 2025, by *Seagate Whitepaper*



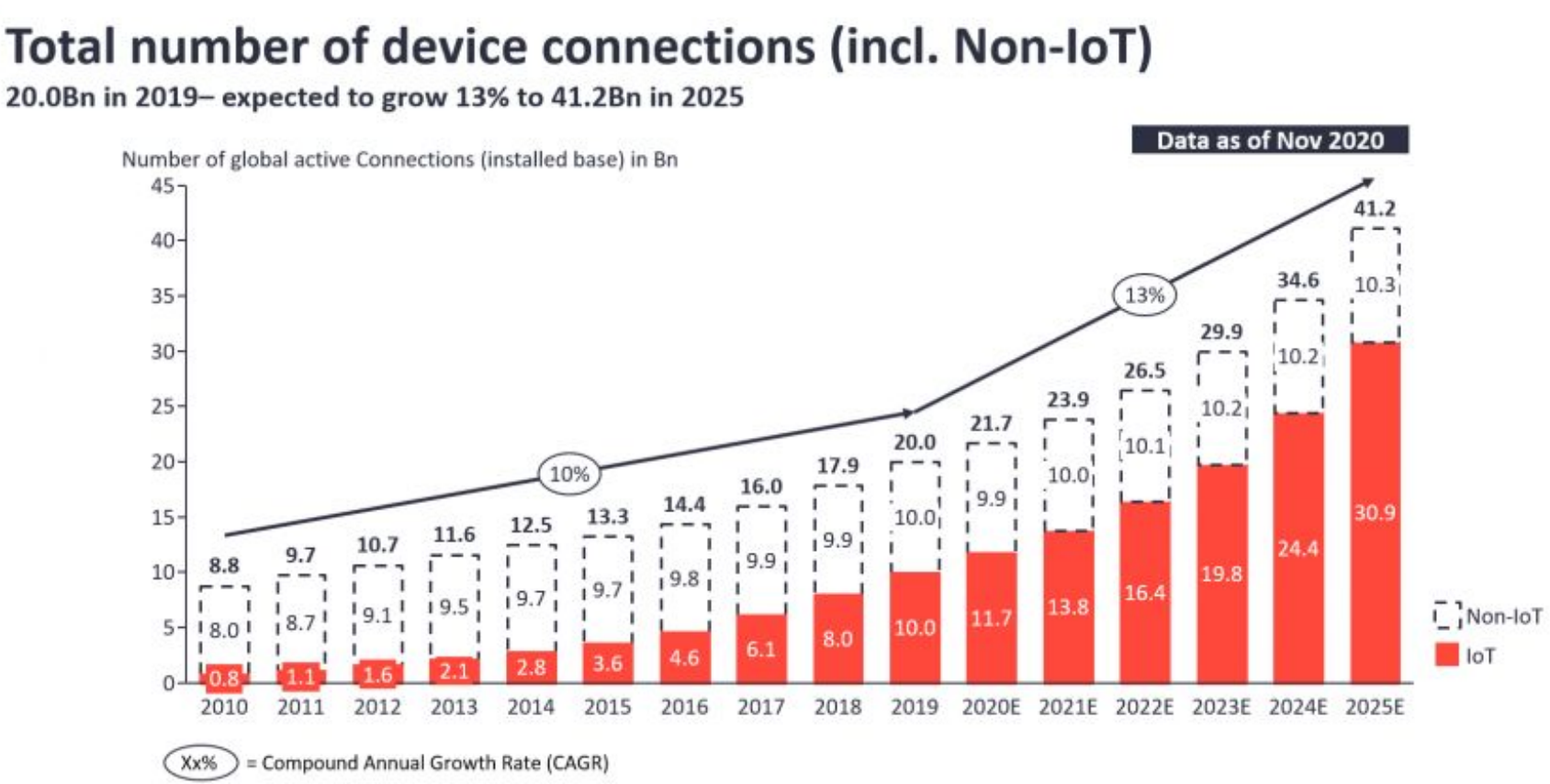
Source: SkipjackAcademy
Amended based on CGPM 2022

Factors that drives the hype of IoT, an emerging technology

- Hal Varian, Chief Economist at Google, believes that Moore's Law has something to do with the newfound interest in the IoT: "The price of sensors, processors, and networking has come way down. Since WiFi is now widely deployed, it is relatively easy to add networked devices to the community."
- Janus Bryzek, known as "the father of sensors" thinks that the new version of the Internet Protocol, IPv6, "enabling almost unlimited number of devices connected to networks."
- Another factor is that four major network providers: Cisco, IBM, GE and Amazon, have decided "to support IoT with network modification, adding Fog layer and planning to add Swarm layer, facilitating dramatic simplification and cost reduction for network connectivity."

Source: Gil Press. (2014). Internet of Things by the numbers: Market Estimates and Forecasts. Forbes. Available at: https://www.forbes.com/sites/gilpress/2014/08/22/internet-of-things-by-the-numbers-market-estimates-and-forecasts/

Moore's Law has something to do with the newfound interest in the IoT



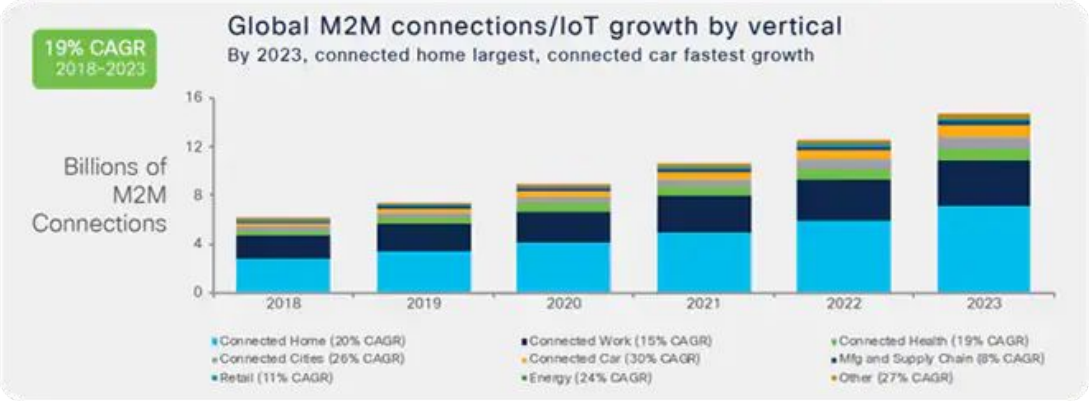
Source: Knud Lasse Lueth (Nov 2020), IoT-Analytics.com, State of the IoT 2020, https://iot-analytics.com/state-of-the-iot-2020-12-billion-iot-connections-surpassing-non-iot-for-the-first-time/

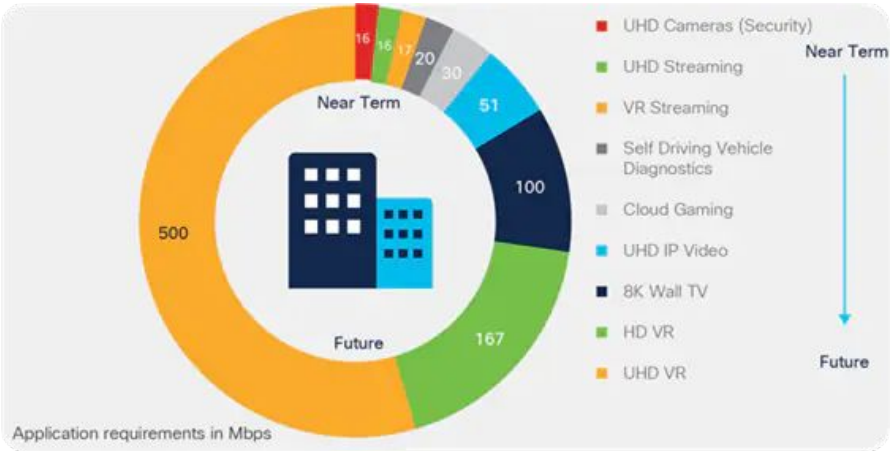
Internet of Things Markets to reach $1,100B by 2026

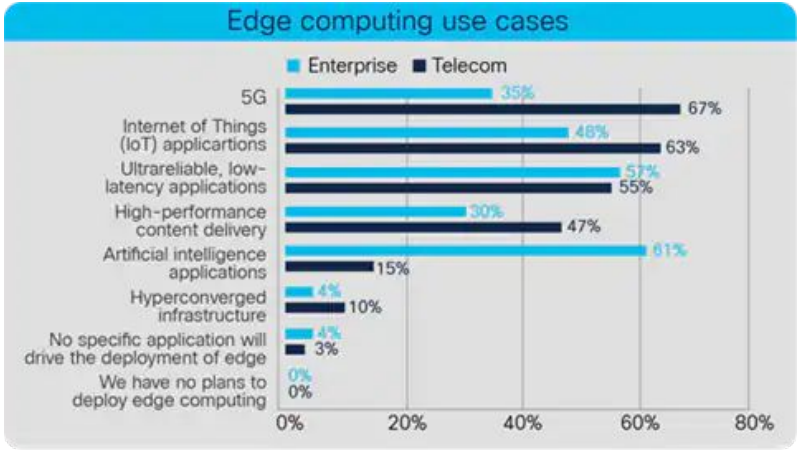
- Mordorintelligence reported that IoT market is projected to reach US$ 2.37 Trillion by 2029, exhibiting a CAGR of 15.12% in the forecast period.
- Statista.com reported that IoT market is anticipated to grow with 10.49%(CAGR 2024 - 2029) , resulting in US$1.56 trillion by 2029.

What is CAGR ?

More resources: IDC. (2023). Asia/Pacific IoT Spending to reach $435 billion in 2027, European $227 billion in 2023 https://www.idc.com/getdoc.jsp?containerId=prAP51105223, https://www.idc.com/getdoc.jsp?containerId=prEUR250941023

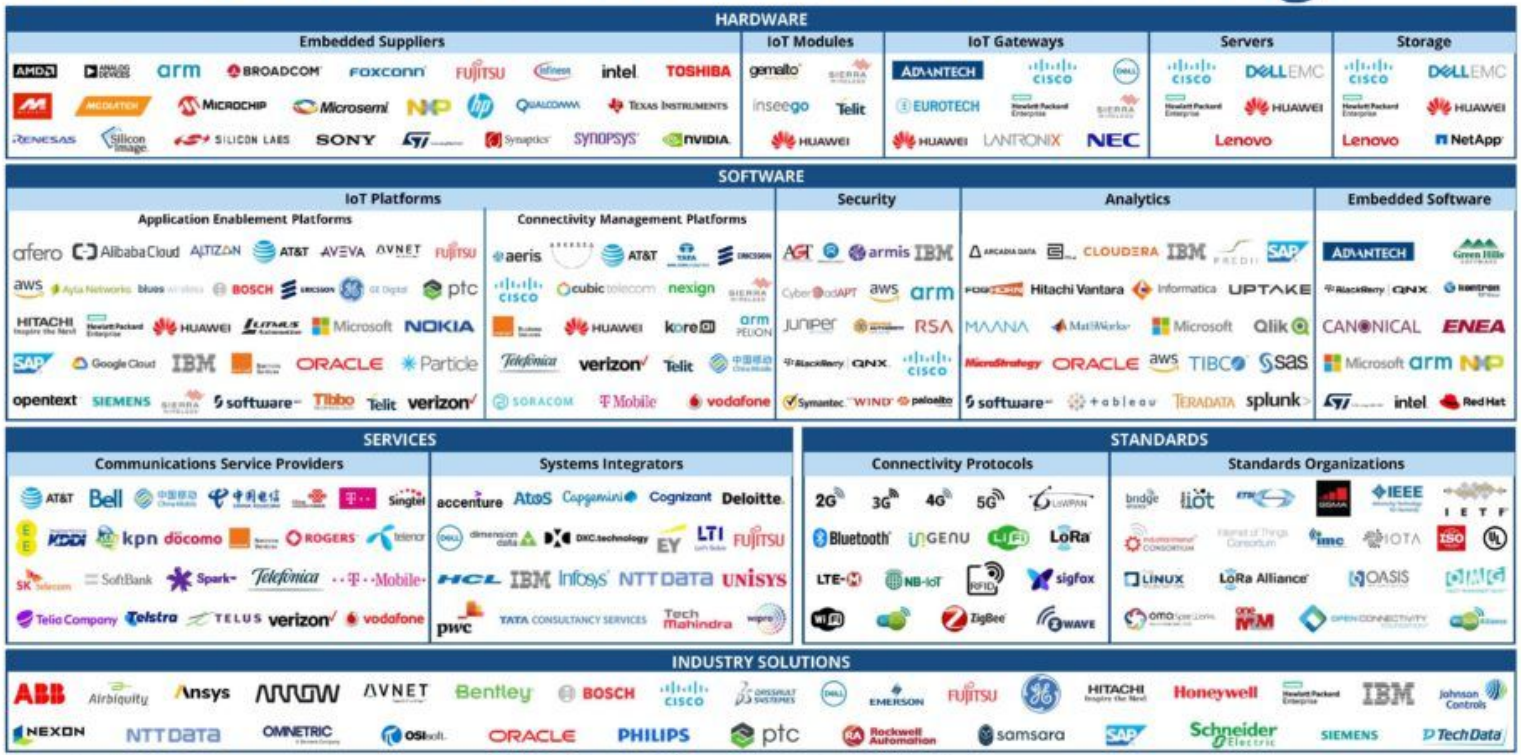






Source: CISCO.com (Mar 2020), Cisco Annual Internet Report (2018–2023) White Paper, https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html

IDC Market Glance: Internet of Things



Source: IDC, 1Q21

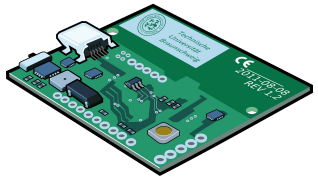
For areas on which IDC publishes market share data, the top 3–5 market share leaders are represented.
For areas on which IDC does not publish market share data, vendor selection is up to analyst discretion.

IDC ANALYZE THE FUTURE

For more information on IDC Market Glance: Internet of Things 1Q21 (Doc #US47329721), contact permissions@idc.com.

Source: IDC (Feb 2021) https://blogs.idc.com/wp-content/uploads/2021/02/02.08.21_SC_Image-1-1024x578.jpg

How does IoT communicate to each other ?



IoT Communication Model (An operational perspective)

- In March 2015, the Internet Architecture Board (IAB) released a guiding architectural document for networking of smart objects (RFC 7452), which outlines a framework of **FOUR (4) common communication models** used by IoT devices.
  - Device-to-Device Communication
  - Device-to-Cloud Communication
  - Device-to-Gateway Communication
  - Back-End Data-Sharing Model

Source: Internet Society. (2015). The Internet of Things: An Overview. Understanding the Issues and Challenges of the Connected World. www.internetsociety.org

Device-to-Device Communication Model

- This model represents **two or more devices** that **directly connect** and communicate between one another, rather than through an intermediary application server.
- These devices communicate over networks, including **IP networks** or the Internet. Often, however these devices use protocols like **Bluetooth**, **Z-Wave**, or **ZigBee** to establish direct device-to-device communications, as shown in the figure below.

Resource: Tschofenig, H., et. al., Architectural Consideration in Smart Object Networking. Tech. no. RFC 7452. Internet Architecture Board, Mar. 2015. https://www.rfc-editor.org/rfc/rfc7452.txt

- This communication model is commonly used in applications like **home automation systems**, which typically **use small data packets** of information to communicate between devices with relatively **low data rate** requirements.
- Residential IoT devices like **light bulbs**, **light switches**, **thermostats**, and **door locks** normally send small amounts of information to each other (e.g. a door lock status message or turn on light command) in a home automation scenario.

Example : Toilet Light, Entrance Doorbell

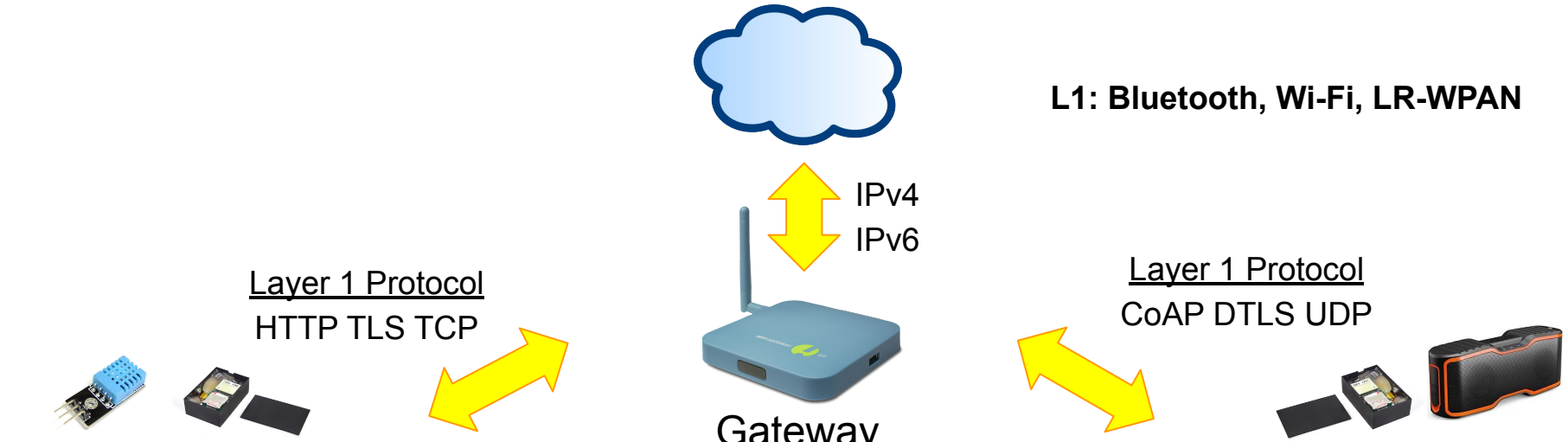
Device-to-Cloud Communication Model

- In this model, the **IoT devices connect directly to an Internet cloud service** like an application service provider to exchange data and control message traffic.
- This approach frequently takes advantage of existing communications mechanisms like traditional wired **Ethernet or Wi-Fi** connections to establish a connection between the device and the IP network, which ultimately connects to the cloud service.

- Device-to-Cloud communication model is employed by the popular consumer IoT devices like the **Samsung SmartTV**.
- The Samsung SmartTV technology, the television uses an **Internet connection** to transmit **user viewing information** to Samsung for analysis and to enable the interactive voice recognition features of the TV.

Device-to-Gateway Communication Model

- Commonly named as **device-to-application-layer gateway (ALG) model**, the IoT device connects through an ALG service as a conduit to reach a cloud service.
- Typically, there is application software operating on a local gateway device, which acts as an intermediary between device - cloud service, and provides security and other functionality such as **data or protocol translation**.

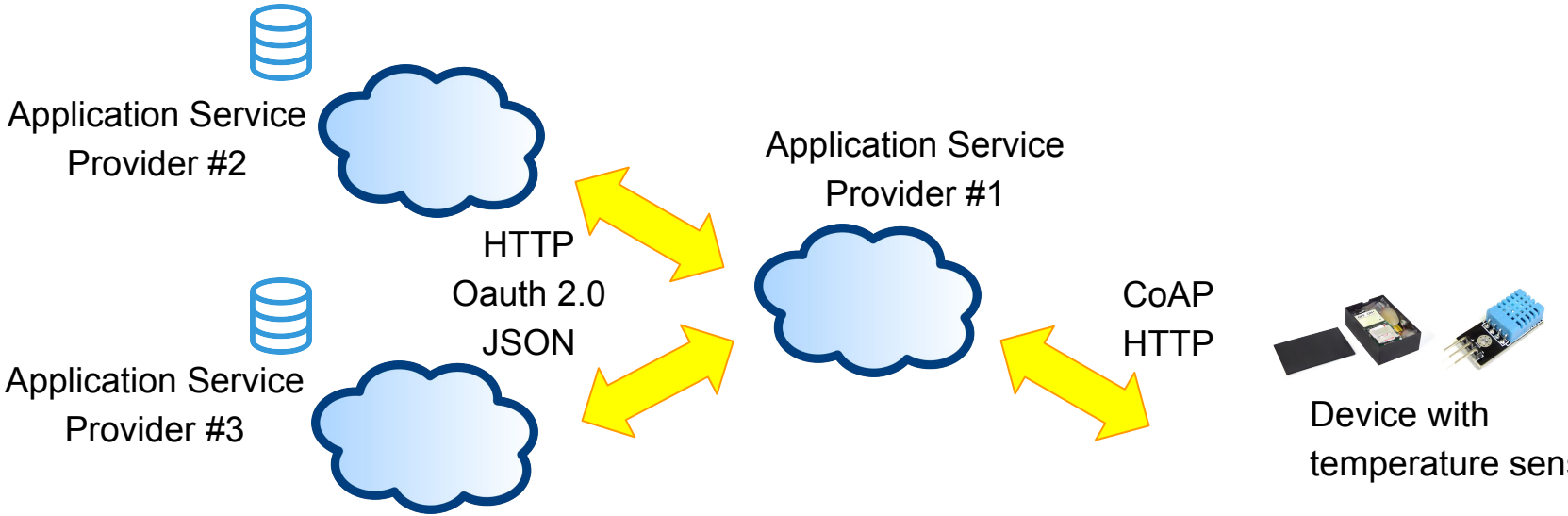


- Several forms of this model are found in consumer devices. In many cases, the local gateway device is a **smartphone running an app** to communicate with a device and **relay data to a cloud service**.

- E.g., **Personal fitness trackers**.
  - These devices ***do not have the native ability*** to connect directly to a cloud service, so they frequently ***rely on*** smartphone app to serve as an intermediary ***gateway*** to connect the fitness device to the cloud.

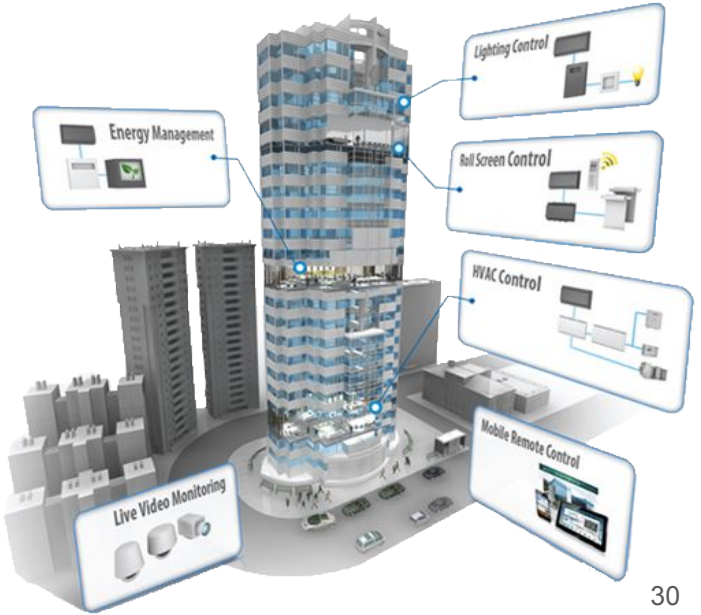
Back-End Data Sharing Model

- The back-end data-sharing model refers to a communication architecture that enables users to **export and analyze smart object data from a cloud service in combination with data from other sources.**
- This allows the data collected from single IoT device data streams to be aggregated and analyzed.



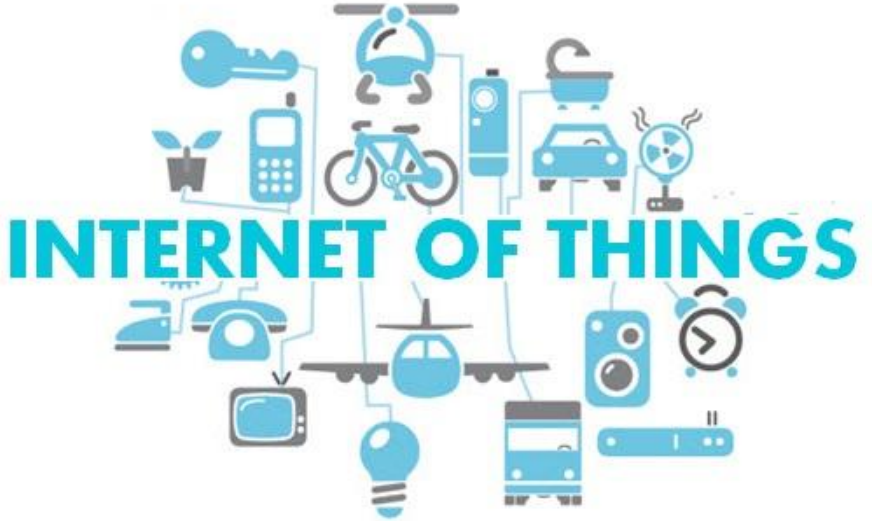
- The back-end data-sharing model suggests a federated cloud services approach or **cloud applications programmer interfaces (APIs)** are needed to achieve interoperability of smart device data hosted in the cloud.

- E.g., An office complex - consolidating, analyzing the **energy consumption** and utilities **data** produced by all the **IoT sensors and Internet-enabled utility systems**.
- An effective back-end data sharing architecture would allow the company to easily **access and analyze the data** in the cloud produced by the whole spectrum of devices in the building.
- It facilitates **data portability** needs: allows users to move their data when they switch between IoT services, breaking down traditional data silo barriers.



Summary

- IoT Concepts
- IoT Markets
- IoT Communication Model



More ideas about Internet of Things ?

https://www.youtube.com/watch?v=1GcMAiIMQYU

Joke of the day