# *Topic No: 1*
# *The IoT Ecosystem*

### Upon completion of this topic, you will be able to:

1 List the components of an IoT Ecosystem
- Devices
- Gateways
- Platforms

2 Describe and differentiate each component of an IoT Ecosystem

3 List the applications of IoT found in various sectors

4 Discuss Big Data properties

## 1 Components of IoT

### 1.1 Background

The Internet of things is revolutionizing the world we live in. As the name suggests, the idea lies in getting **things** communicating and connected. There is a wide array of things that are connected to the **Internet**. These can range from TVs, aircons, lightings, industrial pumps, heart rate monitors, glucose monitors, vehicles and the list goes on. Every year, there are more and more of these types of devices (things) being connected to the Internet.

Traditionally, the internet was used to connect people. Machines such as computers were used by people to communicate over the Internet.

One of the first mentions of a **thing (device)** communicating over the Internet (previously known as ARPANET) was in 1982 when a coke vending machine in Carnegie Mellon's University was connected to the Internet.

This was during a period when the internet was not highly popular and pervasive yet. The 'IoT' coke machine was able to report its contents over the Internet. This meant that **technicians / suppliers** managing the machine would be able to **remotely know** that the machine was running low on coke bottles.

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Also, the 'IoT' coke machine was able to track how many minutes the new stock was in the machine. Thus, staff and students on campus were able to **roughly guess** the best time to head down and get a nice, cold bottle of coke.

**Remote monitoring** was achieved during a time when computers and the internet were relatively slower and smaller. In 1982, the Internet was very small, consisting of about 300 connected machines.

In our current day, the number of connected devices is increasing rapidly. ARM estimates that by year 2035, there will be a trillion (1000, 000, 000, 000) connected devices. Figure 1 shows the growth estimate chart.

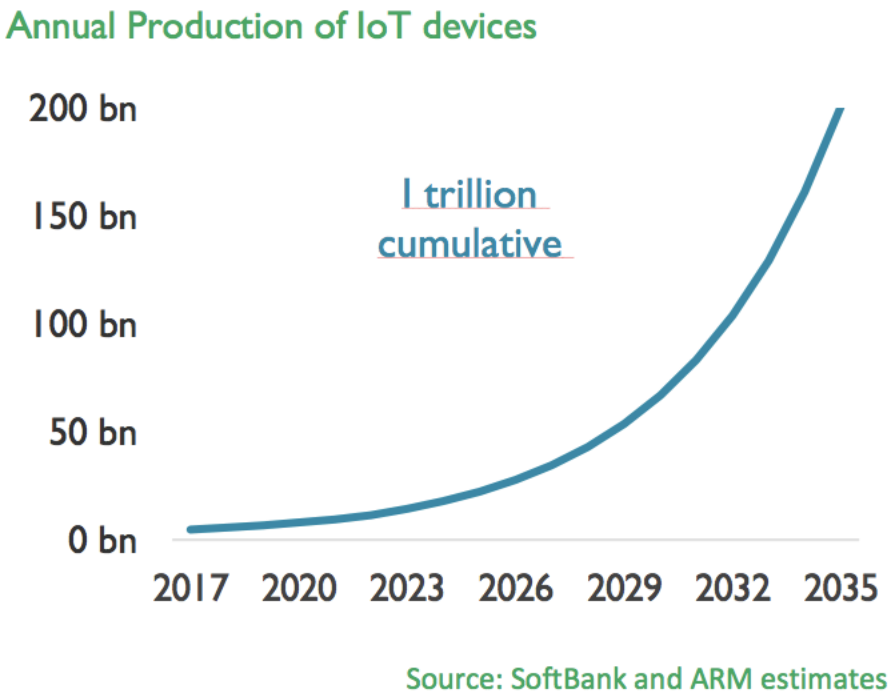


**Figure 1**

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### 1.2 Breakdown

Generally, there are **3 components** that are typically found in an IoT Environment. They are

a. **Devices** (also known as things, objects, machines, nodes, sensors)

b. **Gateways**

c. **Platforms**

Figure 2 illustrates this.

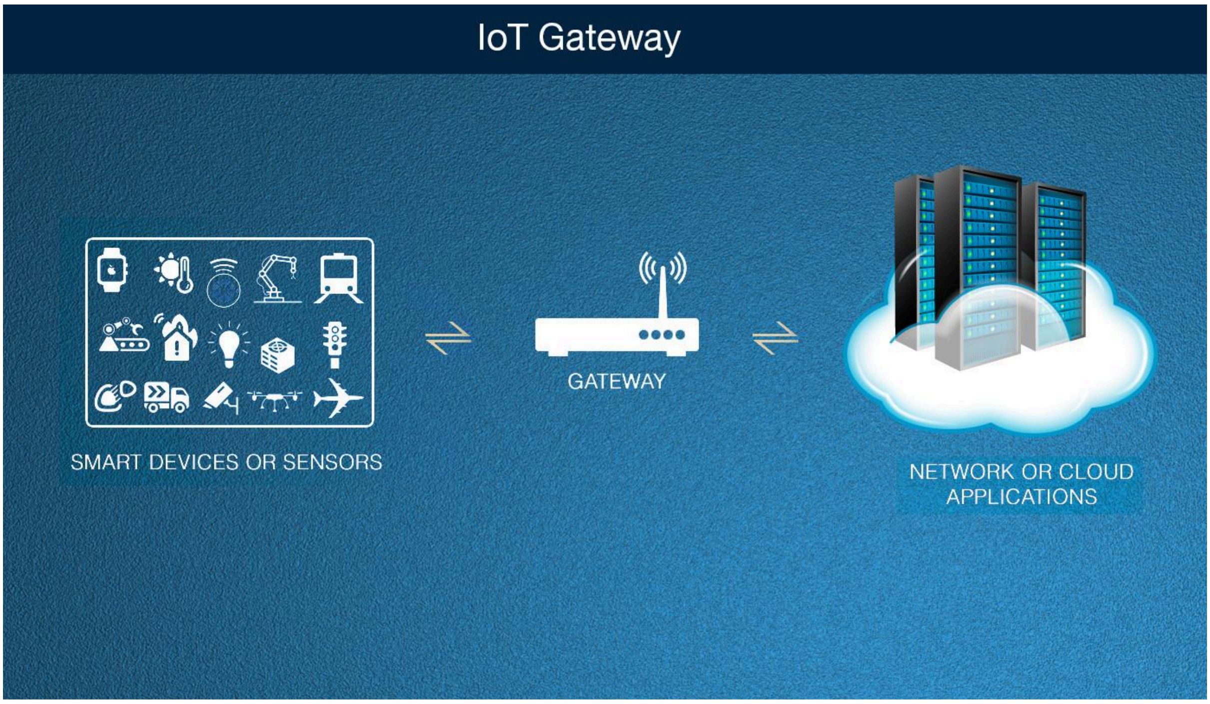


**Figure 2**

Source: https://iot5.net/oracle-iot-architecture-platform/

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# 2 Components of Ecosystem

These components are what enable an IoT solution to work seamlessly end to end.

## 2.1 Devices

There are a wide variety of IoT devices found in various areas such as Healthcare, Retail, Education, Industries and Smart City. All these devices contain some electronics that enable data collection and processing capabilities**. A device can have one or more sensors and/or outputs**.

### 2.1.1 Data Collection

Collection of data is performed by **sensors**. A sensor can collect information about its environment. Some examples of sensors are listed below:

a. A **temperature sensor** can be used to **collect** the temperature of the surrounding environment, the human body, a computer CPU and a variety of others.

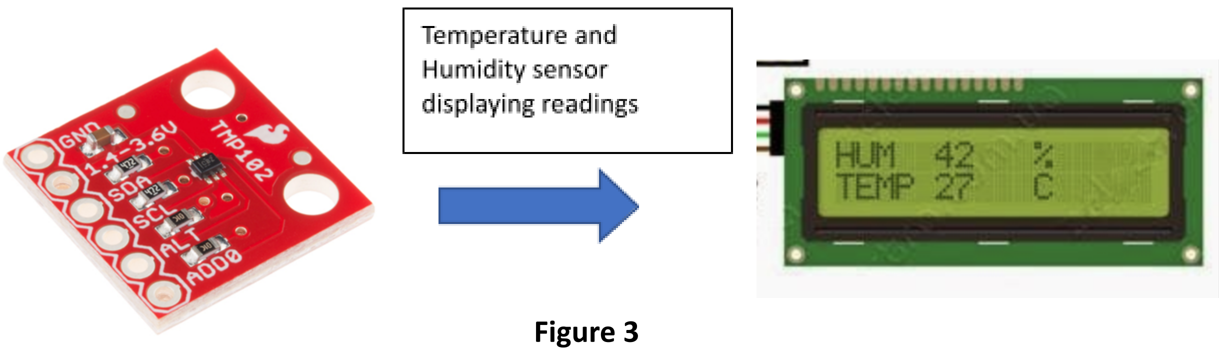


**Figure 3**

b. A **motion sensor** can be used to **collect** information on movement and presence. This is used widely in places such as shopping centers where there are automatic doors, rooms where the lights turn on automatically when people enter and in fitness devices to track motion.

c. An **IP camera** can be used to **collect** image and video feed. This feed then can be used for analytics such as facial recognition, threat detection and law enforcement.

### 2.1.2 Data Processing

After data is collected, the device, depending on its configuration, can perform processing. The following are examples of processing done by an IoT Device.

a. **Aggregation** – this will reduce the data to make it meaningful and reduce network load. If a temperature sensor is sending a reading every 1 millisecond, this might not be meaningful as there might not be significant temperature changes every millisecond and the network will be very busy if information is pushed out every millisecond. This can be aggregated by the device to every second instead.

   Descriptive statistical methods such as average, sum, minimum, maximum, median and mode can be used for aggregation.

b. **Sorting** – this is to ensure sequence and order to the data. For example, temperature reading is always followed by a light intensity reading, if multiple sensors are present.

c. **Validation** – this will ensure that we collect data which is accurate. For example, if the temperature sensor shows a room temperature of 20000 degree Celsius, there must be some error in the data collection depending on the range of the temperature sensor's measuring abilities.

All these sensors have some electronic circuitry that converts the readings, usually in an analog form to a digital value for processing. This value is then transmitted **to a gateway to be sent to the internet, or in some cases, the device can directly connect to the Internet.**

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## 2.2 Gateway

A gateway is used to **manage the traffic between networks that use different protocols**. A gateway sits in between IoT Devices and the cloud. In an IoT Ecosystem, there may be multiple IoT devices sending information using various protocols. Figure 4 shows an example.

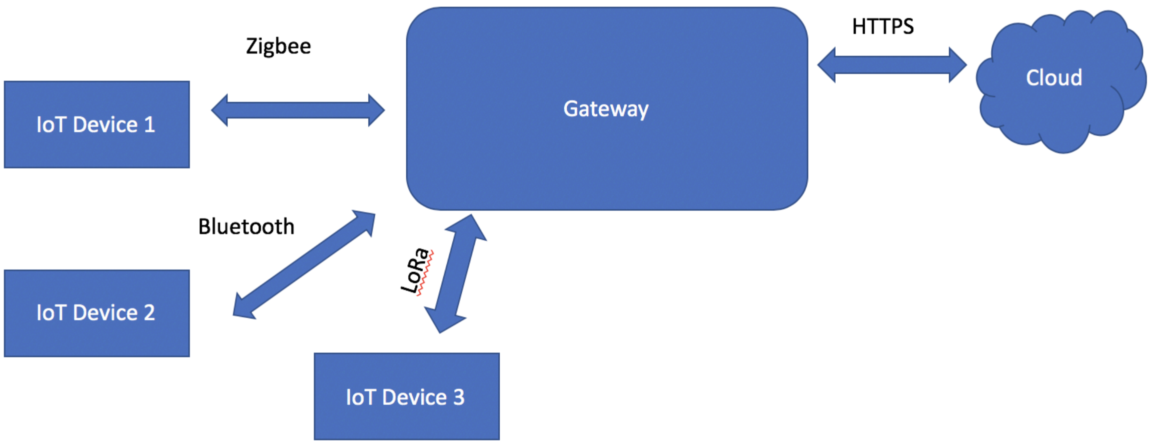


**Figure 4**

The gateway In Figure 4 is used to connect 3 devices using 3 different protocols (Bluetooth, Zigbee and LoRa). We will look at what protocols are in the later chapters. It then sends this information over HTTPS to the platform in the cloud.

Other than managing traffic, a gateway can also add value by performing some data processing on the traffic sent by multiple IoT devices. One example of data processing is Edge Computing.

### 2.2.1 Edge Computing

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This is to bring the computing **capabilities of the IoT Platform closer to where the data is sourced**. It provides connection, computing, storage, control and application functions on a network edge node close to IoT devices to meet user requirements for real-time services, intelligence, security and data aggregation. Leveraging mature communication technologies, edge computing distributes the computing, storage and communication loads from a central node (iot platforms) to edge nodes (gateways) with weaker computing capabilities. This minimizes latency and cost, and improves reliability of services, while protecting user privacy at the edge. Figure 5 shows this.

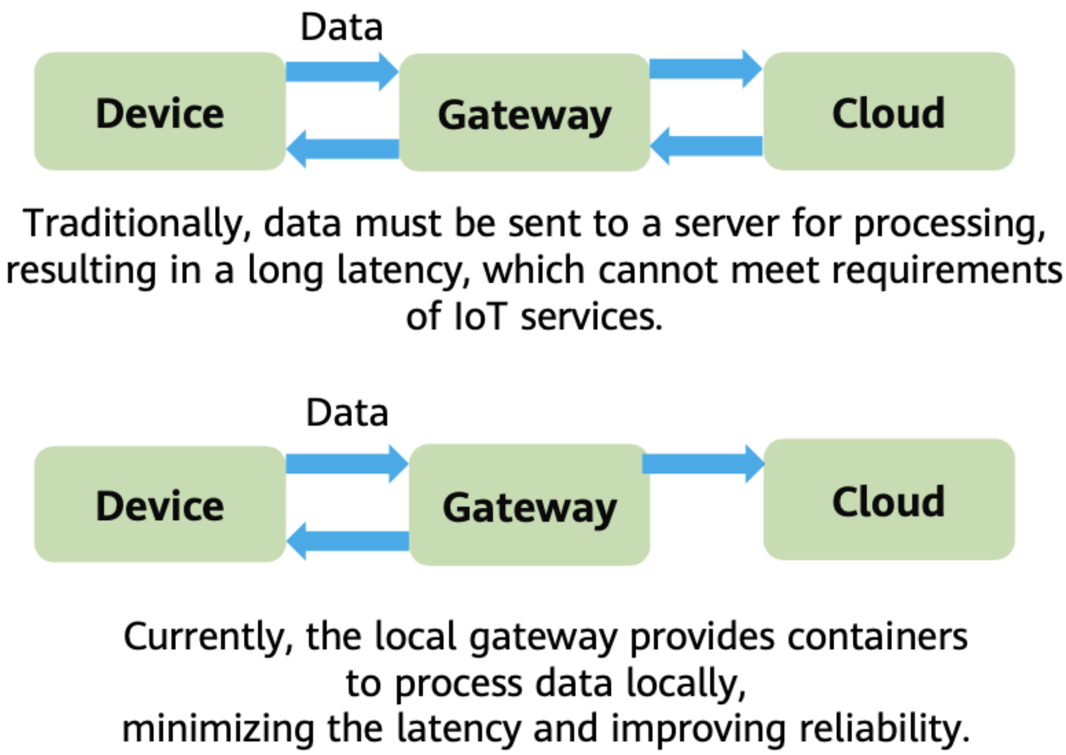


**Figure 5**

**Source: Huawei IoT Certification Materials v2.5**

**2.2.1.1 Core Benefits of Edge Computing**

- **Real Time services:** Dynamic path adjustment, real-time data analysis, and event response in milliseconds are supported

- **Intelligent analysis and processing at the edge:** Services can be deployed at the edge and flexibly adjusted.
- **Data Aggregation:** Data fragmentation is eliminated, invalid noise is shielded and data is uploaded on demand.
- **Private Security Domains:** Data, Node and Network Security Domains

### 2.3 Platforms

Internet of Things (IoT) strives to connect devices remotely for seamless functioning and ease of operations. An IoT platform bridges the gap between applications and networks. Figure 7 shows this. An IoT platform is a set of components that allows developers to **spread out the applications, remotely collect data, secure connectivity, and execute sensor management.**

An IoT platform manages connectivity of the devices and allows developers to build new software applications. It facilitates the collection of data from devices and enables business transformation. It connects different components, ensuring uninterrupted flow of communication between the devices.

*"By the end of 2019, there were 620 publicly known Internet of Things (IoT) platforms, which was more than twice as many as in 2015."*

*Source: https://www.statista.com/statistics/1101483/global-number-iot-platform/*

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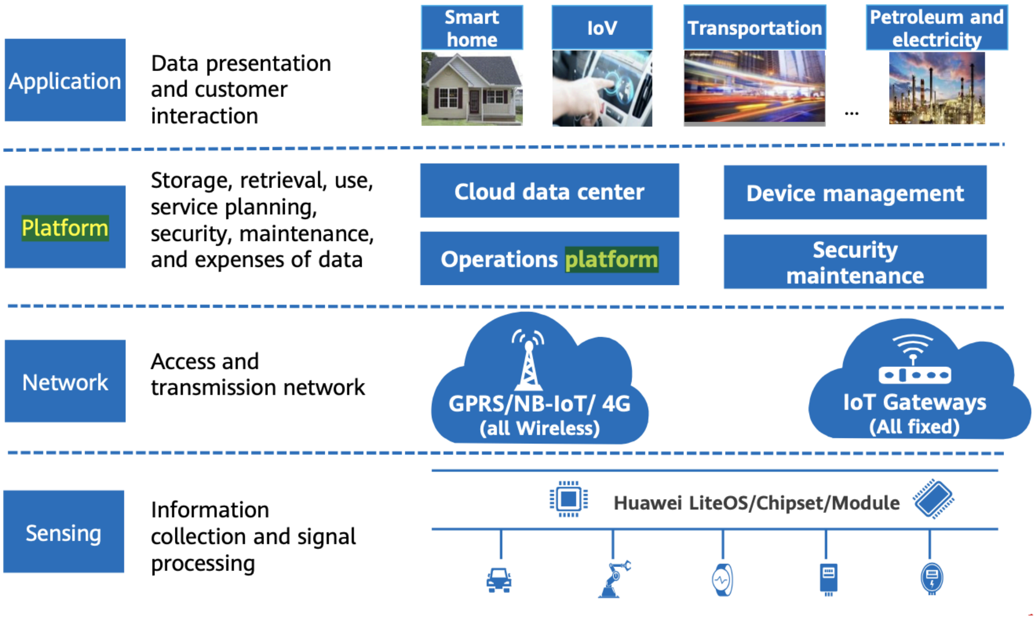


**Figure 7**

**Source: Huawei IoT Certification Materials v2.5**

## 3 IoT Applications

Organizations best suited for IoT are those that **would benefit from using sensing devices** in their business processes. Some of the **applications** can be **:**

a. Proactive maintenance
b. Asset performance management.
c. Detect impending equipment failure

The following section covers the sectors where these applications can be found.

### 3.1 Manufacturing

Manufacturers can gain a competitive advantage by using production-line monitoring to enable **proactive maintenance** on equipment when sensors detect an impending failure. Sensors can actually measure when production output is compromised. With the help of sensor alerts, manufacturers can quickly check equipment for accuracy or remove it from production until it is repaired. This allows companies to reduce operating costs, get better uptime, and **improve asset performance management.**

### 3.2 Automotive

The automotive industry stands to realize significant advantages from the use of IoT applications. In addition to the benefits of applying IoT to production lines, sensors can **detect impending equipment failure** in vehicles already on the road and can alert the driver with details and recommendations. Thanks to aggregated information gathered by IoT-based applications, automotive manufacturers and suppliers can learn more about how to keep cars running and car owners informed.

### 3.3 Transportation and Logistics

Transportation and logistical systems benefit from a variety of IoT applications. Fleets of cars, trucks, ships, and trains that carry inventory can be rerouted based on weather conditions, vehicle availability, or driver availability, thanks to IoT sensor data. The inventory itself could also be equipped with sensors for **track-and-trace and temperature-control monitoring.** The food and beverage, flower, and pharmaceutical industries often carry temperature-sensitive inventory that would benefit greatly from IoT monitoring applications that send alerts when temperatures rise or fall to a level that threatens the product.

Further details on IoT and its Applications can be found here:
https://www.oracle.com/sg/internet-of-things/what-is-iot/

## 4 Big Data

With the advent of the Internet of Things (IoT), more objects and devices are connected to the internet, gathering data on customer usage patterns and product performance. The emergence of machine learning has also produced more data.

Big data "size" is a constantly moving target; as of 2012 ranging from a few dozen **terabytes** to many **exabytes** and **zettabytes** of data. Big data requires a set of techniques and technologies with new forms of integration to reveal insights from data-sets that are diverse, complex, and of a massive scale.

Figure 5 shows the engineering suffixes. It is important to note that exabytes is $10^{18}$ and zettabytes is $10^{21}$. That is a massive amount.

| SI prefixes | | | | |
|---|---|---|---|---|
| Prefix | | Representations | | |
| Name | Symbol | Base 1000 | Base 10 | Value |
| yotta | Y | $1000^{8}$ | $10^{24}$ | 1 000 000 000 000 000 000 000 000 |
| zetta | Z | $1000^{7}$ | $10^{21}$ | 1 000 000 000 000 000 000 000 |
| exa | E | $1000^{6}$ | $10^{18}$ | 1 000 000 000 000 000 000 |
| peta | P | $1000^{5}$ | $10^{15}$ | 1 000 000 000 000 000 |
| tera | T | $1000^{4}$ | $10^{12}$ | 1 000 000 000 000 |
| giga | G | $1000^{3}$ | $10^{9}$ | 1 000 000 000 |
| mega | M | $1000^{2}$ | $10^{6}$ | 1 000 000 |
| kilo | k | $1000^{1}$ | $10^{3}$ | 1 000 |
| | | $1000^{0}$ | $10^{0}$ | 1 |
| milli | m | $1000^{-1}$ | $10^{-3}$ | 0.001 |
| micro | μ | $1000^{-2}$ | $10^{-6}$ | 0.000 001 |
| nano | n | $1000^{-3}$ | $10^{-9}$ | 0.000 000 001 |
| pico | p | $1000^{-4}$ | $10^{-12}$ | 0.000 000 000 001 |
| femto | f | $1000^{-5}$ | $10^{-15}$ | 0.000 000 000 000 001 |
| atto | a | $1000^{-6}$ | $10^{-18}$ | 0.000 000 000 000 000 001 |
| zepto | z | $1000^{-7}$ | $10^{-21}$ | 0.000 000 000 000 000 000 001 |
| yocto | y | $1000^{-8}$ | $10^{-24}$ | 0.000 000 000 000 000 000 000 001 |

**Figure 5**

**Source:** **https://en.wikipedia.org/wiki/Engineering_notation**

### 4.1 Big Data Properties

The general consensus of the day is that there are specific attributes that define big data. In most big data circles, these are called the four V's. Figure 6 illustrates this.

- Volume -> Scale of Data
- Variety -> Different forms of Data
- Velocity -> Streaming Data
- Veracity -> Uncertainty of Data

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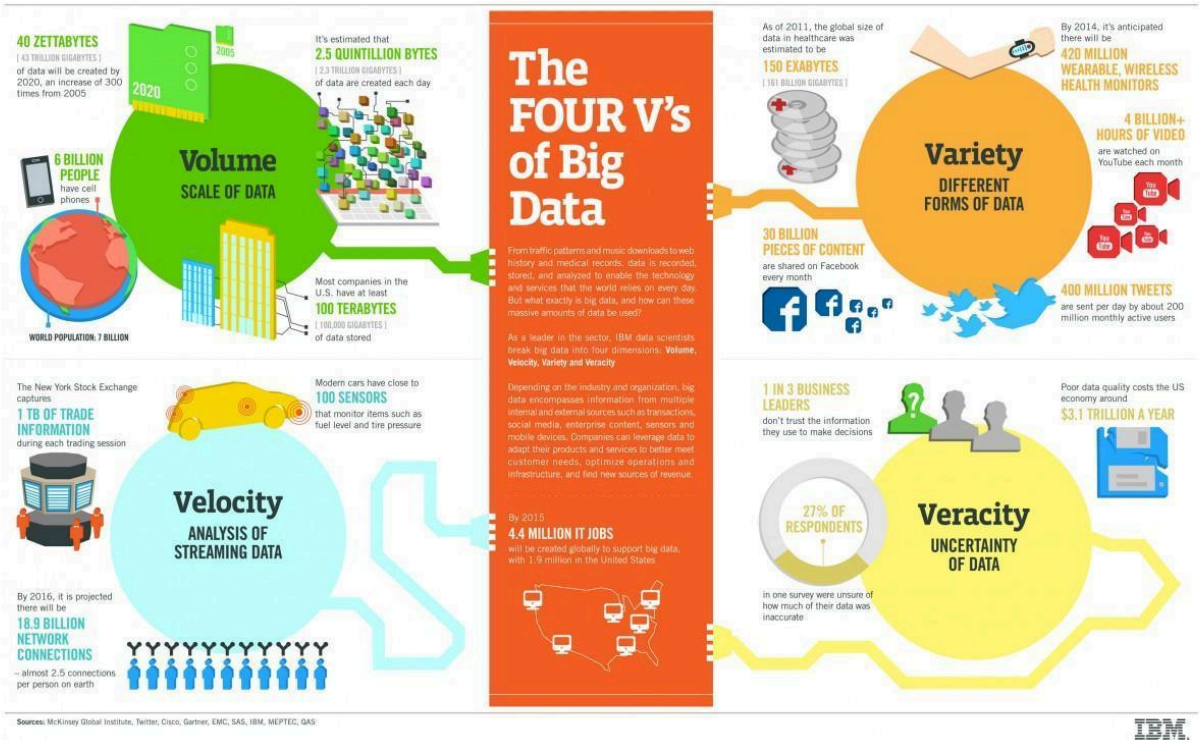


**Figure 6**

**Source:[https://www.ibmbigdatahub.com/infographic/four-vs-big-data](https://www.ibmbigdatahub.com/infographic/four-vs-big-data)**

**4.1 Volume**

The main characteristic that makes data "big" is the sheer ***volume***. It makes no sense to focus on minimum storage units because the total amount of information is growing exponentially every year. In 2010, Thomson Reuters estimated in its annual report that it believed the world was "awash with over **800 exabytes of data and growing**

**4.2 Variety**

*Variety* is one the most interesting developments in technology as more and more information is digitized. Traditional data types (structured data) include things on a bank statement like date, amount, and time. These are things that fit neatly in a database.

**Unstructured data is a fundamental concept in big data**. The best way to understand unstructured data is by comparing it to structured data. Think of *structured data* as data that is well defined in a set of rules. For example, money will always be numbers and have at least two decimal points; names are expressed as text; and dates follow a specific pattern.

With *unstructured data,* on the other hand, there are no rules. A picture, a voice recording, a tweet — they all can be different but express ideas and thoughts based on human understanding. One of the goals of big data is to use technology to take this unstructured data and make sense of it.

**4.3 Veracity**

*Veracity* refers to the **trustworthiness or uncertainty of the data.** Can a person studying a dataset rely on the fact that the data is representative of only a certain part of the population. Also, there can be inherent discrepancies in all data collected.

**4.4 Velocity**

*Velocity* is the frequency of incoming data that needs to be processed. Think about how many SMS messages, Facebook status updates, or credit card swipes are being sent on a particular telecom carrier every minute of every day, and you'll have a good appreciation of velocity. A streaming application like Amazon Web Services Kinesis is an example of an application that handles the velocity of data.