

# The Internet of Things: An Overview

44-440/640-IoT

# Objectives

- Students will be able to:
  - explain what the Internet of Things (IoT) is
  - discuss the history and future of IoT
  - explain the importance of IoT
  - explain how to choose an IoT platform

# Definitions

1. A network (**internet**) of sensor-, actuator- and software-equipped devices (**things**) that share information (**of?**) among themselves and other systems as they scheme to take over the world (we may need to work on this last bit) 😊
2. The gathering of, transfer of, and intelligent use of data

For the record, these definitions are clearly much too dry, and do not even *begin* to convey the excitement and potential of IoT

# IoT @ Work

1.Sydney Harbour Bridge

2.Hayes Dairy Farm

3.Foot Drop Project

4.Smart Monitoring and Asset Management

5.IoT World Forum - Barcelona

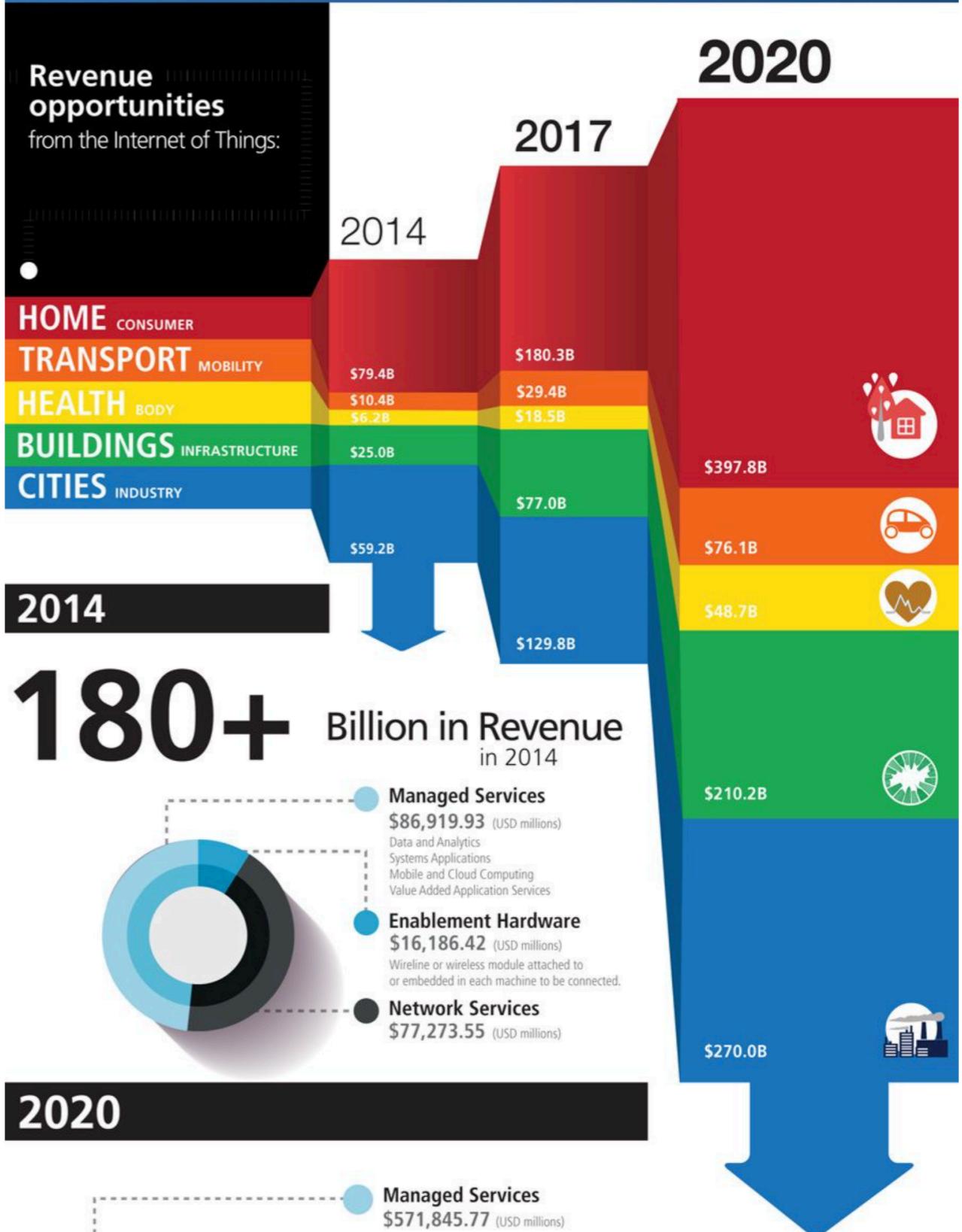
6.Autonomous Vehicles I

7.Autonomous Vehicles II

8.Assistive Technology

# Economic Predictions

The implications of these trends are enormous. Vertically defined, stand-alone products and application markets will increasingly become a part of larger **networked “horizontal” systems**.



# ICE: What IoT Applications do You Know About?

- In groups of 2-3, put together a list of IoT applications that you are aware of, using the categories below
- We will compare it to the list of > 60 (!) applications that follow
- **Categories:** Cities, Environment, Water, Metering, Security/Emergencies, Retail, Logistics, Industrial Control, Smart Agriculture, Smart Animal Farming, Domestic & Home Automation, eHealth

<https://admin.sli.do/event/ilbgxd8h/polls>

# Smart Cities

## Smart Cities

### 01 Smart Parking

Monitoring of parking spaces availability in the city.

### 02 Structural health

Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.

### 03 Noise Urban Maps

Sound monitoring in bar areas and centric zones in real time.

### 04 Smartphone Detection

Detect iPhone and Android devices and in general any device which works with WiFi or Bluetooth interfaces.

### 05 Electromagnetic Field Levels

Measurement of the energy radiated by cell stations and WiFi routers.

### 06 Traffic Congestion

Monitoring of vehicles and pedestrian levels to optimize driving and walking routes.

### 07 Smart Lighting

Intelligent and weather adaptive lighting in street lights.

### 08 Waste Management

Detection of rubbish levels in containers to optimize the trash collection routes.

### 09 Smart Roads

Intelligent Highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.



# Smart Environment

## Smart Environment

### 10 Forest Fire Detection

Monitoring of combustion gases and preemptive fire conditions to define alert zones.

### 11 Air Pollution

Control of CO<sub>2</sub> emissions of factories, pollution emitted by cars and toxic gases generated in farms.

### 12 Snow Level Monitoring

Snow level measurement to know in real time the quality of ski tracks and allow security corps avalanche prevention.

### 13 Landslide and Avalanche Prevention

Monitoring of soil moisture, vibrations and earth density to detect dangerous patterns in land conditions.

### 14 Earthquake Early Detection

Distributed control in specific places of tremors.



# Smart Water

## Smart Water

### 15 Potable water monitoring

Monitor the quality of tap water in cities.

### 16 Chemical leakage detection in rivers

Detect leakages and wastes of factories in rivers.

### 17 Swimming pool remote measurement

Control remotely the swimming pool conditions.

### 18 Pollution levels in the sea

Control realtime leakages and wastes in the sea.

### 19 Water Leakages

Detection of liquid presence outside tanks and pressure variations along pipes.

### 20 River Floods

Monitoring of water level variations in rivers, dams and reservoirs.



# Smart Metering

## Smart Metering

### 21 Smart Grid

Energy consumption monitoring and management.

### 22 Tank level

Monitoring of water, oil and gas levels in storage tanks and cisterns.

### 23 Photovoltaic Installations

Monitoring and optimization of performance in solar energy plants.

### 24 Water Flow

Measurement of water pressure in water transportation systems.

### 25 Silos Stock Calculation

Measurement of emptiness level and weight of the goods.



# Security and Emergencies

## Security & Emergencies

### 26 Perimeter Access Control

Access control to restricted areas and detection of people in non-authorized areas.

### 27 Liquid Presence

Liquid detection in data centers, warehouses and sensitive building grounds to prevent break downs and corrosion.

### 28 Radiation Levels

Distributed measurement of radiation levels in nuclear power stations surroundings to generate leakage alerts.

### 29 Explosive and Hazardous Gases

Detection of gas levels and leakages in industrial environments, surroundings of chemical factories and inside mines.



# Retail

## Retail

### 30 Supply Chain Control

Monitoring of storage conditions along the supply chain and product tracking for traceability purposes.

### 31 NFC Payment

Payment processing based in location or activity duration for public transport, gyms, theme parks, etc.

### 32 Intelligent Shopping Applications

Getting advices in the point of sale according to customer habits, preferences, presence of allergic components for them or expiring dates.

### 33 Smart Product Management

Control of rotation of products in shelves and warehouses to automate restocking processes.



# Logistics

## Logistics

### 34 Quality of Shipment Conditions

Monitoring of vibrations, strokes, container openings or cold chain maintenance for insurance purposes.

### 35 Item Location

Search of individual items in big surfaces like warehouses or harbours.

### 36 Storage Incompatibility Detection

Warning emission on containers storing inflammable goods closed to others containing explosive material.

### 37 Fleet Tracking

Control of routes followed for delicate goods like medical drugs, jewels or dangerous merchandises.

# Industrial Control

## Industrial Control

### 38 M2M Applications

Machine auto-diagnosis and assets control.

### 39 Indoor Air Quality

Monitoring of toxic gas and oxygen levels inside chemical plants to ensure workers and goods safety.

### 40 Temperature Monitoring

Control of temperature inside industrial and medical fridges with sensitive merchandise.

### 41 Ozone Presence

Monitoring of ozone levels during the drying meat process in food factories.

### 42 Indoor Location

Asset indoor location by using active (ZigBee) and passive tags (RFID/NFC).

### 43 Vehicle Auto-diagnosis

Information collection from CanBus to send real time alarms to emergencies or provide advice to drivers.

# Smart Agriculture

## Smart Agriculture

### 44 Wine Quality Enhancing

Monitoring soil moisture and trunk diameter in vineyards to control the amount of sugar in grapes and grapevine health.

### 45 Green Houses

Control micro-climate conditions to maximize the production of fruits and vegetables and its quality.

### 46 Golf Courses

Selective irrigation in dry zones to reduce the water resources required in the green.

### 47 Meteorological Station Network

Study of weather conditions in fields to forecast ice formation, rain, drought, snow or wind changes.

### 48 Compost

Control of humidity and temperature levels in alfalfa, hay, straw, etc. to prevent fungus and other microbial contaminants.



# Smart Animal Farming

## Smart Animal Farming

### 49 Hydroponics

Control the exact conditions of plants grown in water to get the highest efficiency crops.

### 50 Offspring Care

Control of growing conditions of the offspring in animal farms to ensure its survival and health.

### 51 Animal Tracking

Location and identification of animals grazing in open pastures or location in big stables.

### 52 Toxic Gas Levels

Study of ventilation and air quality in farms and detection of harmful gases from excrements.

# Domestic & Home Automation

## Domotic & Home Automation

### 53 Energy and Water Use

Energy and water supply consumption monitoring to obtain advice on how to save cost and resources.

### 54 Remote Control Appliances

Switching on and off remotely appliances to avoid accidents and save energy.

### 55 Intrusion Detection Systems

Detection of windows and doors openings and violations to prevent intruders.

### 56 Art and Goods Preservation

Monitoring of conditions inside museums and art warehouses.

# eHealth

## eHealth

### **57 Fall Detection**

Assistance for elderly or disabled people living independent.

### **58 Medical Fridges**

Control of conditions inside freezers storing vaccines, medicines and organic elements.

### **59 Sportsmen Care**

Vital signs monitoring in high performance centers and fields.

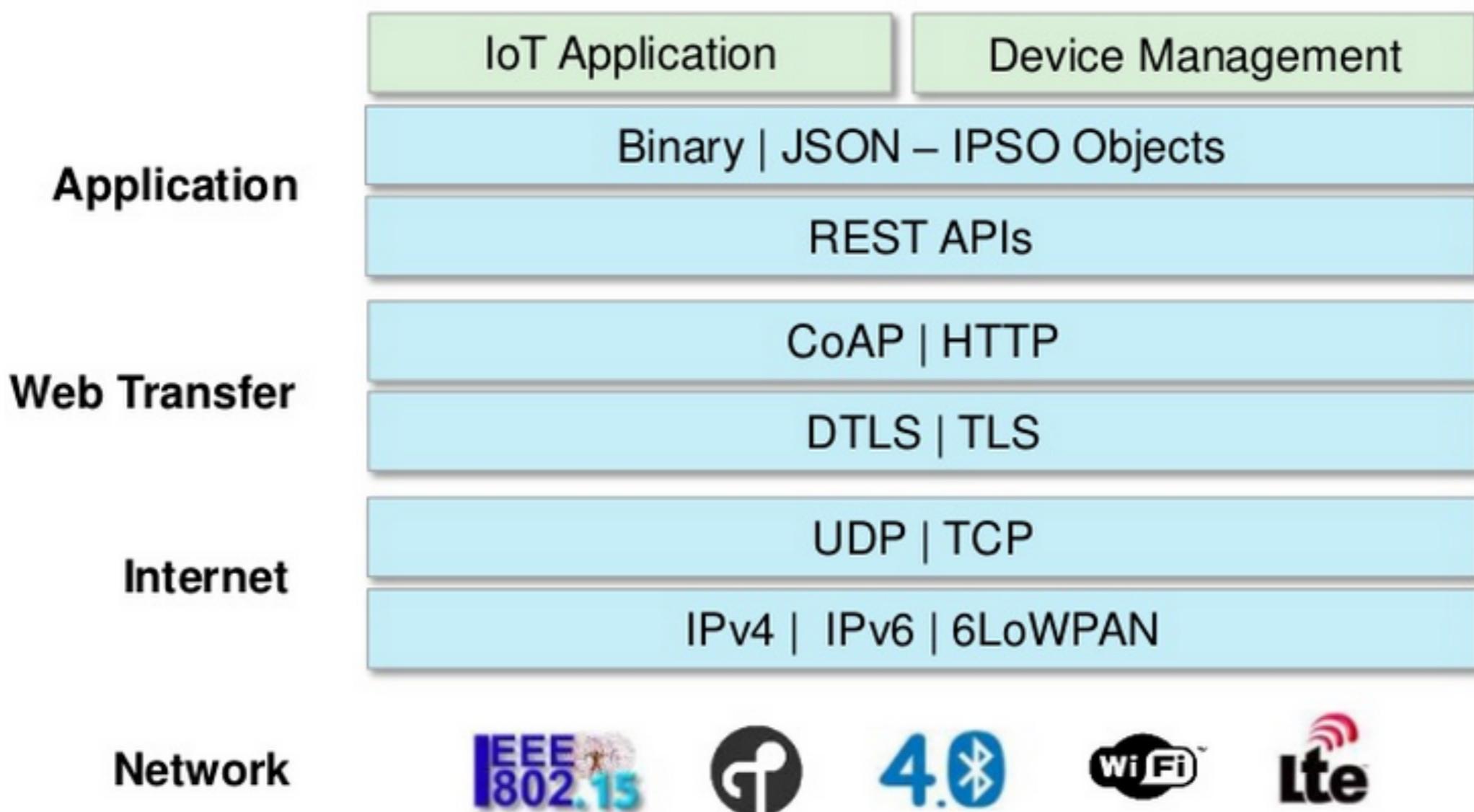
### **60 Patients Surveillance**

Monitoring of conditions of patients inside hospitals and in old people's home.

### **61 Ultraviolet Radiation**

Measurement of UV sun rays to warn people not to be exposed in certain hours.

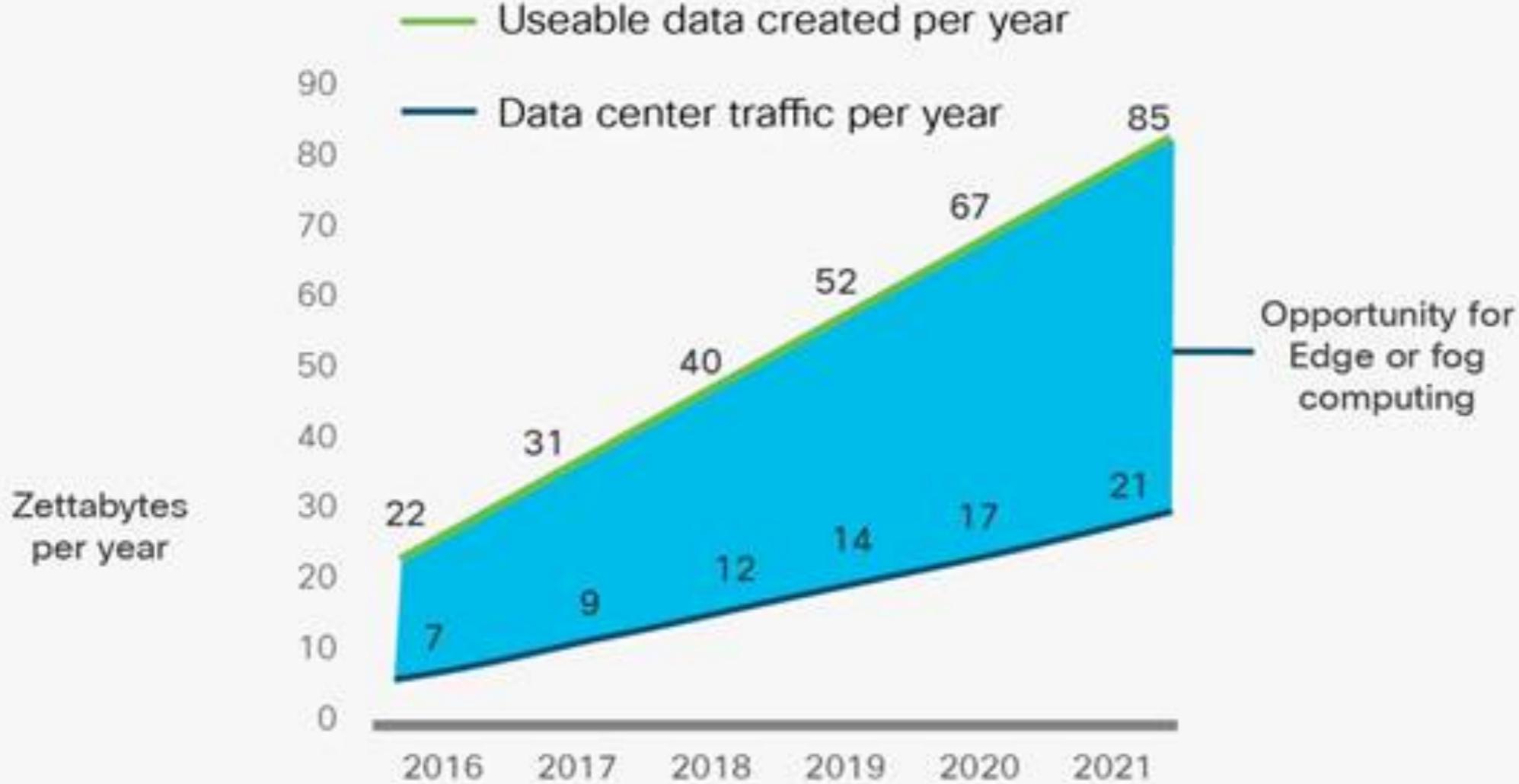
# Communication Protocols



# Prototyping Platforms

- Arduino, Arduino Yun
- Photon, Electron, Argon
- Raspberry Pi
- BeagleBone
- ESP8266
- Tessel (JavaScript based)

# That's a Yotta Data



By 2021, 850 ZB/year will be generated by people and things - mainly things. Of that, ~10% will be worth storing. This is 4x the capacity of existing data centers. This is a job for fog computing!

ZB =  $10^{21}$  bytes = 1 billion TB; 1 YB = 1000 ZB

# Cloud Computing

- A suite of services (software + hardware made available over the internet)
- The big 3 providers (Amazon, Google, Microsoft) provide a vast array of services, such as:
  - storage, computing, networking, data analytics, app development, machine learning, etc.

# Cloud Computing Advantages

- Obviates the need to:
  - purchase infrastructure
  - configure it: let experts concentrate on security, performance and reliability
  - performance: working on a problem, requires more storage, or more CPUs? A good cloud provider can just spin up more hardware often automatically (all you need is   - install software locally

# Cloud Computing Advantages

- The amount of data that is produced by IoT devices is *staggering*.
- Analyzing terabytes or petabytes of data requires industrial-strength facilities
- Keeping that data secure also requires significant resources and expertise

# A Bite-Sized Guide to Byte Multiples

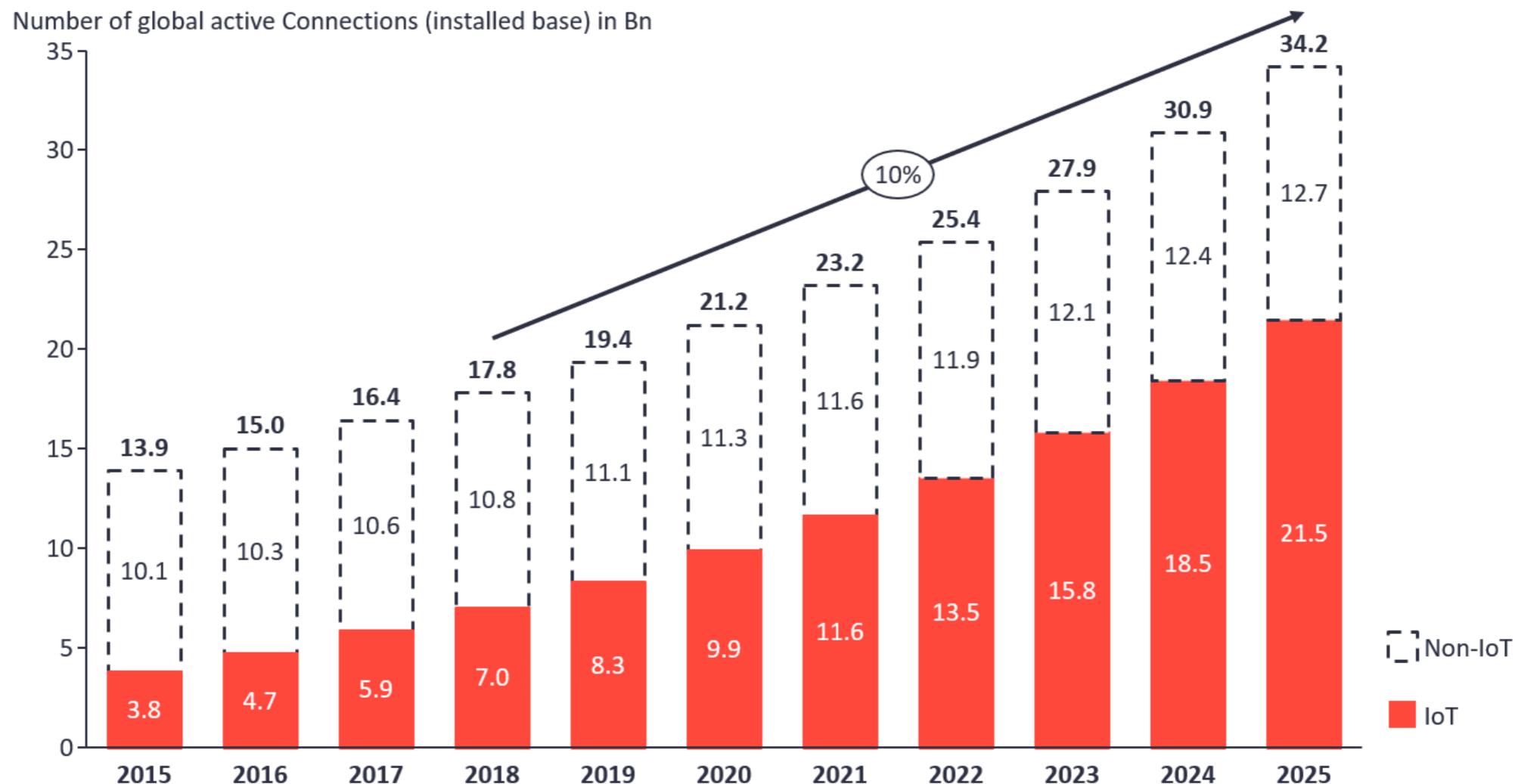
Multiples of bytes			V · T · E	
Decimal		Binary		
Value	Metric	Value	IEC	JEDEC
1000	kB kilobyte	1024	KiB kibibyte	KB kilobyte
$1000^2$	MB megabyte	$1024^2$	MiB mebibyte	MB megabyte
$1000^3$	GB gigabyte	$1024^3$	GiB gibibyte	GB gigabyte
$1000^4$	TB terabyte	$1024^4$	TiB tebibyte	–
$1000^5$	PB petabyte	$1024^5$	PiB pebibyte	–
$1000^6$	EB exabyte	$1024^6$	EiB exbibyte	–
$1000^7$	ZB zettabyte	$1024^7$	ZiB zebibyte	–
$1000^8$	YB yottabyte	$1024^8$	YiB yobibyte	–
Orders of magnitude of data				

# Public Cloud Providers

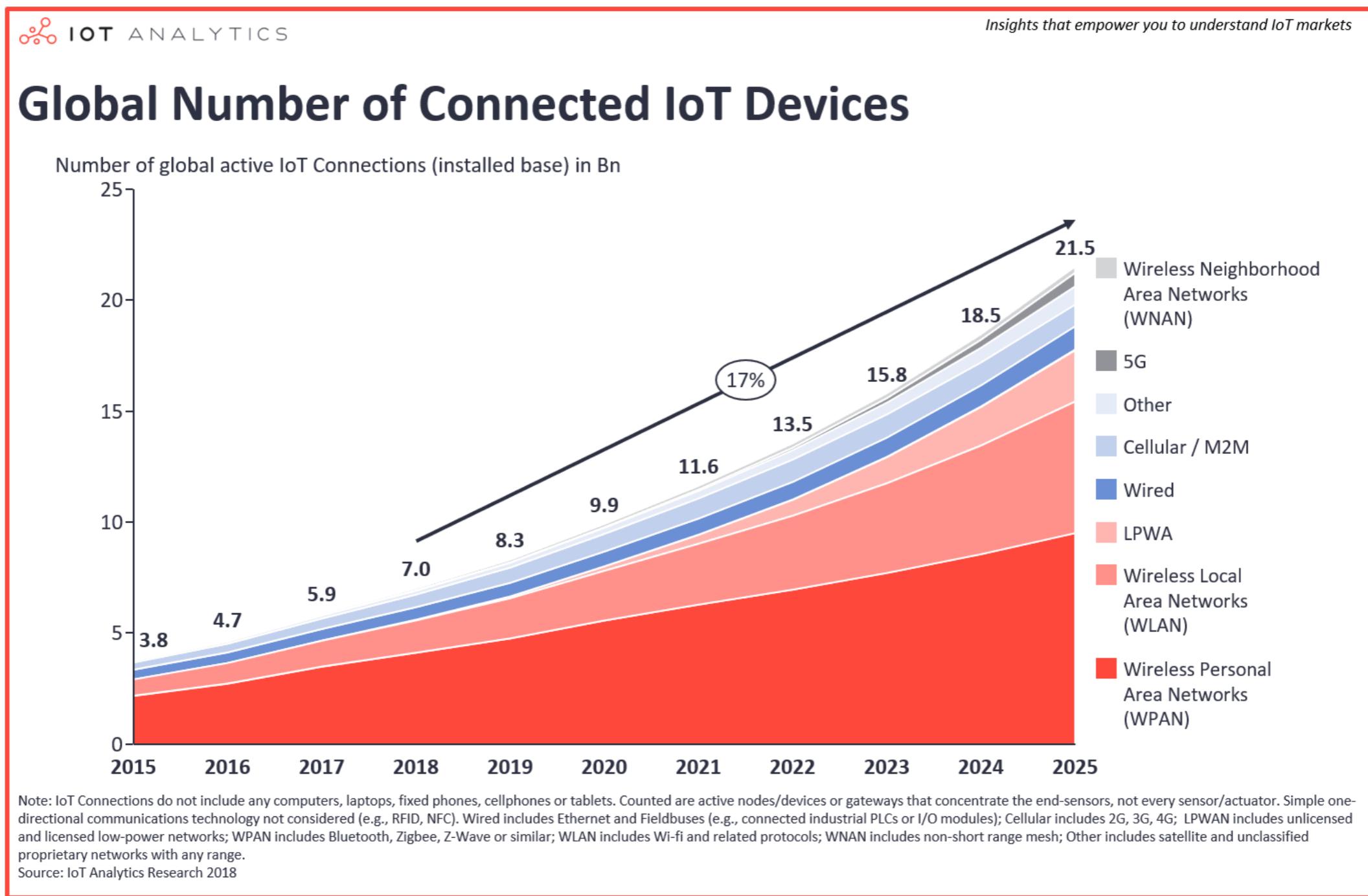
- Amazon Web Services
- Google Cloud Platform
- IBM Cloud
- IFTTT.com
- Microsoft Azure
- data.sparkfun.com
- Ubidots
- and many, many more!

# IoT: Big and Bigger

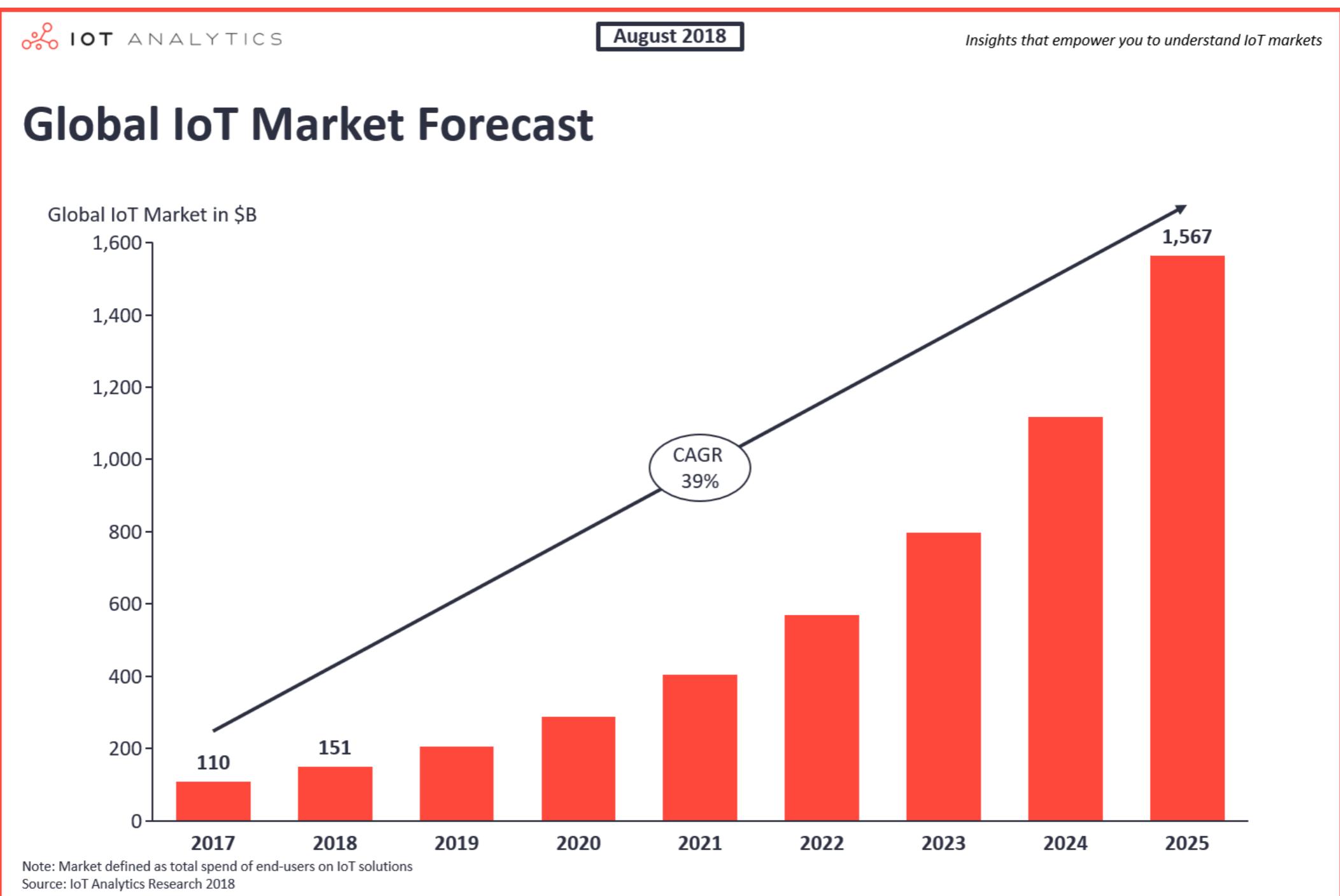
## Total number of active device connections worldwide



# 8B and Counting



# The IoT Market



# Resources

- [http://www.economist.com/blogs/babbage/2010/08/internet\\_things](http://www.economist.com/blogs/babbage/2010/08/internet_things) [read]
- [http://www.nytimes.com/2011/12/18/sunday-review/the-internet-gets-physical.html?\\_r=2&pagewanted=all](http://www.nytimes.com/2011/12/18/sunday-review/the-internet-gets-physical.html?_r=2&pagewanted=all)
- <http://postscapes.com/what-exactly-is-the-internet-of-things-infographic>
- <http://iotlist.co> [lots of IoT examples]
- [http://www.libelium.com/resources/top\\_50\\_iot\\_sensor\\_applications\\_ranking/](http://www.libelium.com/resources/top_50_iot_sensor_applications_ranking/)
- [https://www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.html#\\_Toc503317525](https://www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.html#_Toc503317525)