

# Introduction to 4IR, Internet of Things and Embedded Systems

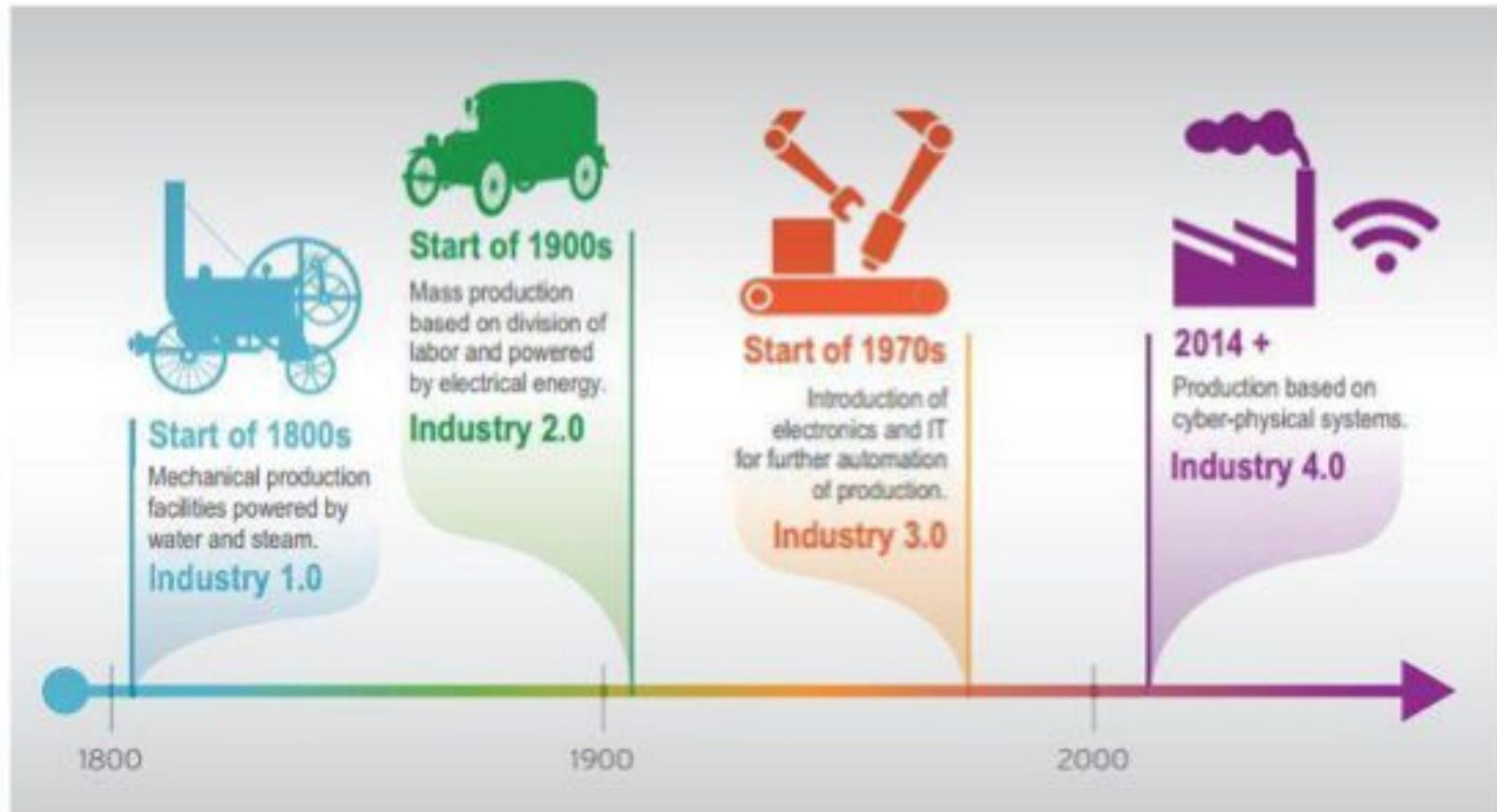
**Learn IoT, Embedded Systems, Cloud and Edge Computing, AI and Blockchain Technologies**  
**Join in the Fourth Industrial Revolution**

CNBC EXPLAINS

# WHAT IS THE FOURTH INDUSTRIAL REVOLUTION?



## Four Stages of the Industrial Revolution



Source: Industry 4.0 (or Zukunftsprojekt Industrie 4.0), a German government high-technology initiative to promote the computerization of traditional industries such as manufacturing.

# What is the Fourth Industrial Revolution?

- Klaus Schwab, founder and executive chairman of the Geneva-based WEF, published a book in **2016** titled "The Fourth Industrial Revolution" and coined the term at the Davos meeting that year.
- Schwab argued a technological revolution is underway "that is blurring the lines between the **physical, digital and biological** spheres."
- Simply put, the Fourth Industrial Revolution refers to how technologies like **artificial intelligence**, autonomous vehicles and the **internet of things** are **merging with humans' physical lives**. Think of voice-activated assistants, facial ID recognition or digital health-care sensors.
- Schwab argued these technological changes are drastically altering how individuals, companies and governments operate, ultimately leading to a **societal transformation** similar to previous industrial revolutions.

# The first three industrial revolutions

- Zvika Krieger, the head of technology policy and partnerships at WEF, told CNBC that there is a common theme among each of the industrial revolutions: **the invention of a specific technology that changed society fundamentally.**
- The First Industrial Revolution started in Britain around 1760. It was powered by a major invention: **the steam engine**. The steam engine enabled new manufacturing processes, leading to the creation of factories.
- The Second Industrial Revolution came roughly one century later and was characterized by **mass production** in new industries like steel, oil and electricity. The light bulb, telephone and internal combustion engine were some of the key inventions of this era.
- The inventions of the semiconductor, personal computer and the internet marked the Third Industrial Revolution starting in the 1960s. This is also referred to as the "**Digital Revolution.**"

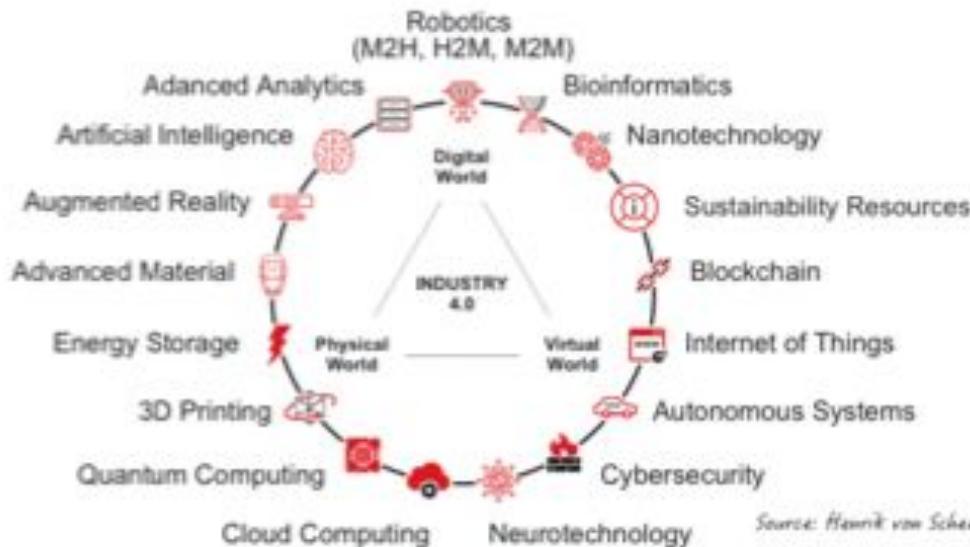
# Difference between Third and Fourth

- Fourth Industrial Revolution is different from the third for two reasons: the gap between the digital, physical and biological worlds is shrinking, and technology is changing faster than ever.
- For evidence of how quickly technological change is spreading, observe the adoption of the telephone. It took 75 years for 100 million people to get access to the telephone; the gaming app "Pokemon Go" hooked that many users in less than one month in 2016.

# The Issues and Concerns

- Some experts warn of a "**winner-take-all economy**," where high-skilled workers are rewarded with high pay, and the rest of workers are left behind.
- A 2018 report by investment firm UBS found **billionaires have driven** almost 80 percent of the 40 **main breakthrough innovations** over the past four decades.
- In 2016, Schwab predicted **inequality** would be the greatest societal concern associated with the Fourth Industrial Revolution.
- "There has never been a **time of greater promise**, or **one of greater potential peril**"

# Next wave of Industry 4.0 unstoppable forces that disrupts everything



1<sup>st</sup> wave 2009 - 2016

2<sup>nd</sup> wave 2016 - 2025

3<sup>rd</sup> wave 2025 ...

- Digitalization
- Internet of Things
- Automation
- M2M Robotics
- Big Data
- Cloud Computing

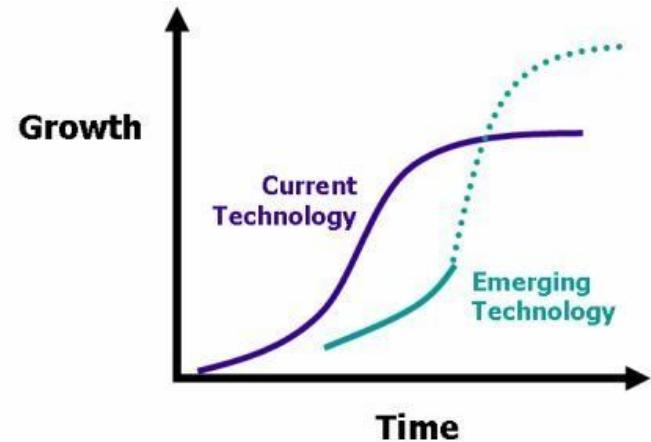
- Artificial Intelligence
- Blockchain
- Quantum Computing
- Sustainable Resources
- H2M Robotics
- Energy Storage

- Energy Storage
- Neuro-technology
- Cybersecurity
- Nanotechnology
- Bioinformatics
- ...

We are Way Behind the Developed  
Countries

# We have Adopted Leapfrog Strategy for Pakistan

- Andrew Ng has proposed a brilliant strategy for **developing countries that have fallen behind in the technology race.**
- The idea is to *skip over the intermediary technologies* and **leapfrog** into the future by adopting 4IR technologies.
- With this approach, it is possible to achieve **exponential growth in a shorter period of time.**



# PIAIC will Focus on these 4IR Technologies

- **Artificial Intelligence (AI)**
- **Internet of Things (IoT)**
- **Cloud Native Computing**
- **Blockchain**

# PIAIC will Apply 4IR Technologies on Pakistani Industry Verticals

To further transform its economy, PIAIC will also adopt Andrew Ng's second strategy which is to develop it's industries by **applying 4IR technologies on industry verticals in they already have a competitive advantage.**

For example, if a developing economy like Pakistan has a strong and thriving cotton spinning industry, then it has an advantage in **applying AI, IoT, Blockchain and Cloud Technologies to cotton spinning industry.**

PIAIC will target the top industries of Pakistan for adoption and implementation of 4IR technologies.

# Fifteen Guiding Principles of PIAIC

**Identify.** Identify key areas where Pakistan can focus.

- a. Cloud Native and Mobile Computing
- b. Data Science and Artificial Intelligence
- c. Blockchain and Decentralized Applications
- d. Internet of Things

**Target Student Body.** The target student body of the PIAIC program includes students, professionals, and under-employed/unemployed individuals with any background.

**Selectivity.** Students are selected into the program after passing an English and Math based aptitude test where they compete with thousands of applicants for a limited number of seats.

# Fifteen Guiding Principles of PIAIC - 2

**Meritocracy.** After selection, students are introduced to a completely merit based system in which any student that does not perform up to the mark is immediately removed from the system.

**Continuous Quality Monitoring.** We have prepared a series of internal exams, which students must attempt every 30-45 days, over the course of the program, that measure the students performance while also simultaneously preparing students for internationally recognized skill based certifications.

**Funnel Management.** Due to a lower quality of early childhood and general education, a wide array of socio-economic issues, and the difficulty of the PIAIC curriculum, it is estimated that about 10% of the students will complete the program successfully.

# Fifteen Guiding Principles of PIAIC - 3

**External Validation.** After successfully completing the PIAIC program and earning the PIAIC certification, each graduating student will also be capable of passing the international certification exams that are required qualifications for PIAIC faculty.

**Homegrown Faculty.** The biggest challenge is in recruiting faculty for these latest state-of-the-art technology programs. There is already an extreme shortage of even the most basic CS subject matter experts. Recruiting international trainers is not feasible because of the difficulty of foreign faculty in communicating with the local students. After earning the international certifications required to become PIAIC Faculty and also familiarity with the PIAIC curriculum, having gone thru it themselves, the best PIAIC graduates who possess both the technical and communication skills required to become instructors are then be offered teaching positions at PIAIC.

# Fifteen Guiding Principles of PIAIC - 4

**Hybrid Delivery.** PIAIC classes are offered as a hybrid of both online and onsite programs. Though online delivery of education may deliver significant outcomes in some parts of the world, online education systems have always resulted in failure in Pakistan. Because of low energy and a lack of drive, the majority of students require continuous motivation from faculty and peers to complete the trainings. All students are required to take the proctored exams onsite.

**Large Class Size.** PIAIC classes, like most state run universities in the United States, will have a large number of students. Because of the shortage of quality faculty, large class sizes means the possibility for a maximum number of students to participate in the programs. This also reduces the cost of the program because the cost of teaching is divided among the larger class. To facilitate students, teacher assistants (TA) are assigned to each class and are also available to students during clearly defined office hours.

# Fifteen Guiding Principles of PIAIC - 5

**Affordability & Flexibility.** PIAIC course fees are extremely low. In just 1,000 per month, a student can participate in training programs that cost thousands of dollars in the global market. The fee for online students is Rs 500 per month. Most PIAIC classes are held either on the weekends or in the evenings, allowing almost anyone to participate.

**Lean Startup.** The PIAIC is a lean startup in every essence of the term. Our management follows the principles of the lean startup methodology to its core. Thru a validated learning and a continuous improvement iteration cycle, the PIAIC process delivers results quickly and is also quick to adapt & improve. PIAIC is operating as startups operate in Silicon Valley, USA. The program is totally privately financed.

# Fifteen Guiding Principles of PIAIC - 6

**Freelancing & Services will boast Software Exports.** PIAIC graduates will have the option to join the technology industry as international freelancers or employees in technology services companies. They may also create new startups. This will boost the Pakistan software exports because these developers will be skilled in the latest, most in-demand technologies, earning a hourly rate above \$30 USD.

**Boost Domestic Industry Verticals.** PIAIC will conduct research to determine how to implement 4IR technologies in domestic industry verticals to boost productivity and GDP.

**Entrepreneurship.** The PIAIC programs are geared towards producing graduates that can work in the global markets. Instead of waiting for job offers, students will be trained to create startups and generate revenue in freelancing.

# The Internet of Things (IoT) will power the Fourth Industrial Revolution

- The Fourth Industrial Revolution is changing the very software-defined automation allows manufacturers to link all stages of the value chain, rapidly adapt to changing markets, and create highly personalised products on a mass scale.
- The opportunities presented by this revolution are incredible. According to McKinsey, the economic impact of smart factories could reach up to \$2.3 trillion per year by 2025.
- **At the heart of the Fourth Industrial Revolution is the Internet of Things (IoT), which uses digital technology to connect sensors, actuators, and machines to each other and to factory workers.**

# What is IoT?

- The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, collecting, sharing and analyses of data.
- Thanks to cheap processors and wireless networks, it's possible to turn anything, from a pill to an aeroplane to a self-driving car into part of the IoT

# Definition

The Internet of Things is the network of physical devices that combine IP connectivity with software, sensors, actuators, and other electronics to directly integrate the physical world into our computer-based systems, resulting in efficiency improvements and economic benefits.

Simpler Definition:

The Internet of Things is a network of Internet connected devices that communicate embedded sensor data to the cloud for centralized processing.

# IoT is about Billions of Devices

The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, collecting, sharing and analyses of data.

Thanks to cheap processors and wireless networks, it's possible to turn anything, from a pill to an aeroplane to a self-driving car into part of the IoT

# The Current and Future Impact of IoT

The IEEE has compiled data and makes the following claims about its current and future impact:

- In 2015, the global wearables market had already increased 223% from the previous year (and data on Statista shows it increasing by another 243% between 2015 and 2022)
- By 2020, 250 million vehicles will be connected to the Internet
- IoT will add 15 trillion dollars to the global economy over the next 20 years
- There will be 50 billion Internet-connected devices by the year 2020.

# Benefits of IoT

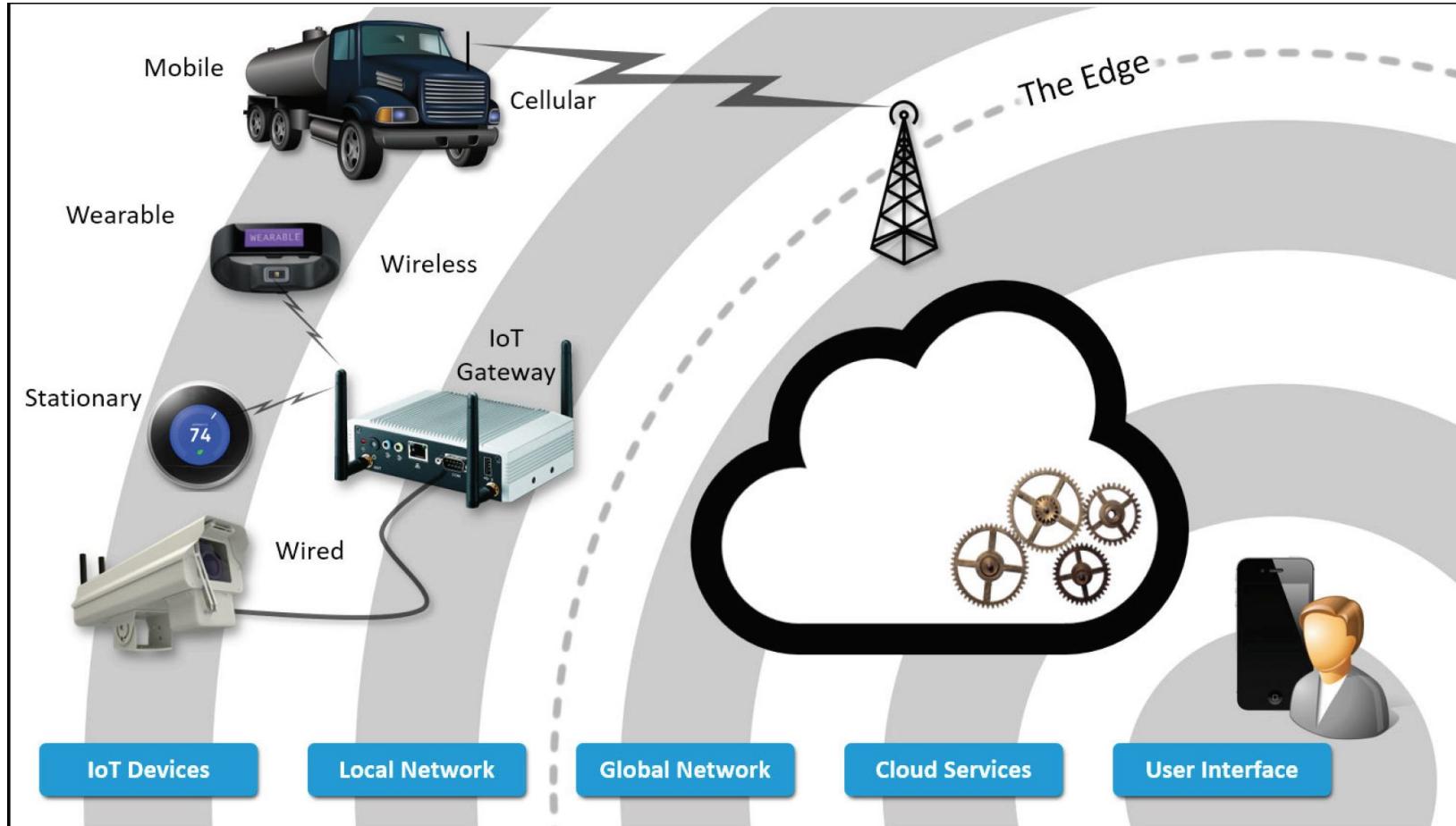
The interconnection of these multiple embedded devices will be resulting in automation in nearly all fields and also enabling advanced applications. This is resulting in improved accuracy, efficiency and economic benefit with reduced human intervention. The major benefits of IoT are:

- Improved Customer Engagement
- Technical Optimization
- Reduced Wastage
- Integrate and Adapt Business Model
- Better Business Decision

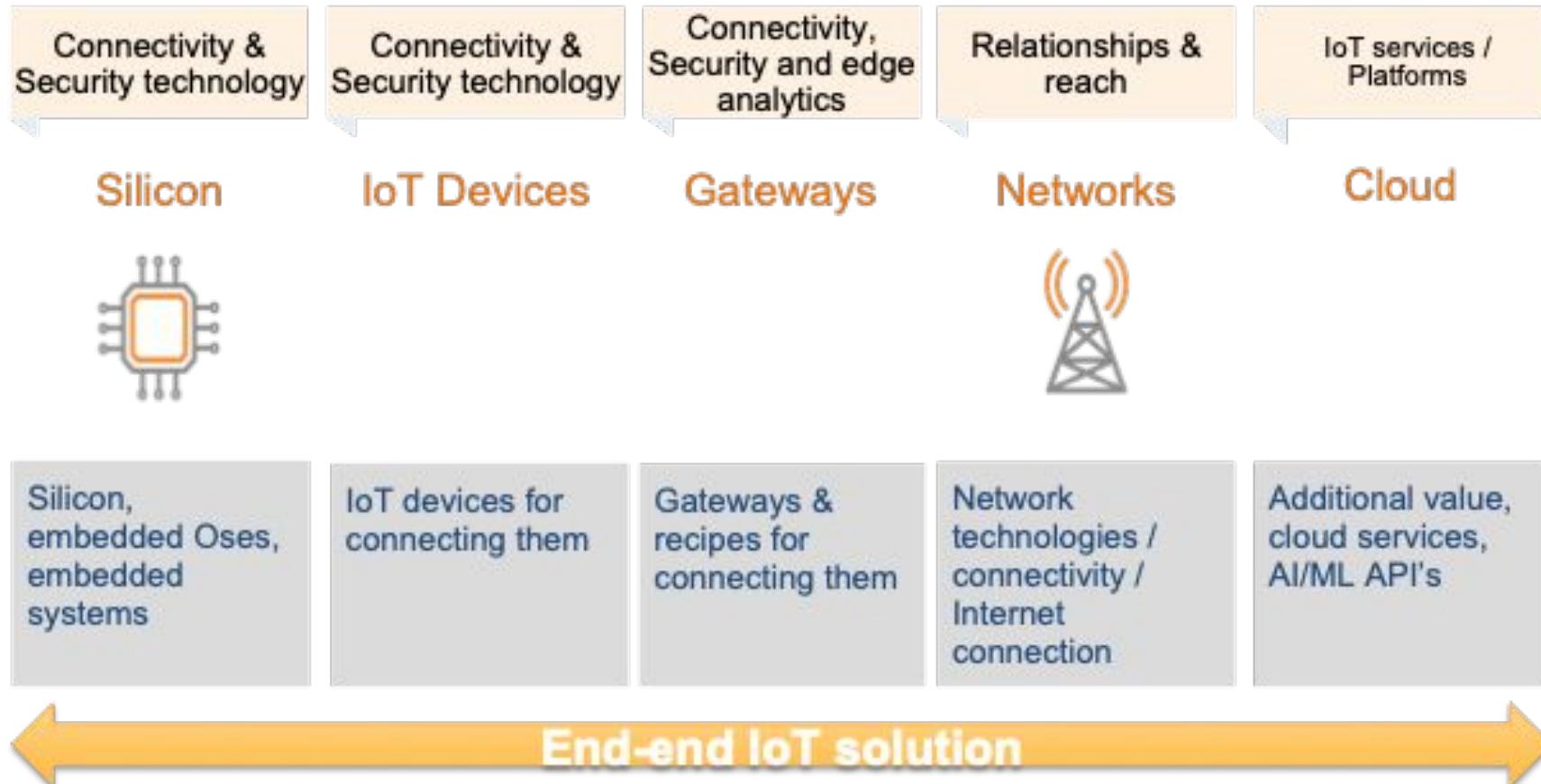
# IoT Enabling Factors

- Miniaturization
- Connectivity
- Advanced power sources and power management
- Inexpensive processors, sensors, and actuators
- Cloud-based processing
- Ubiquitous computing

# Components of IoT architecture



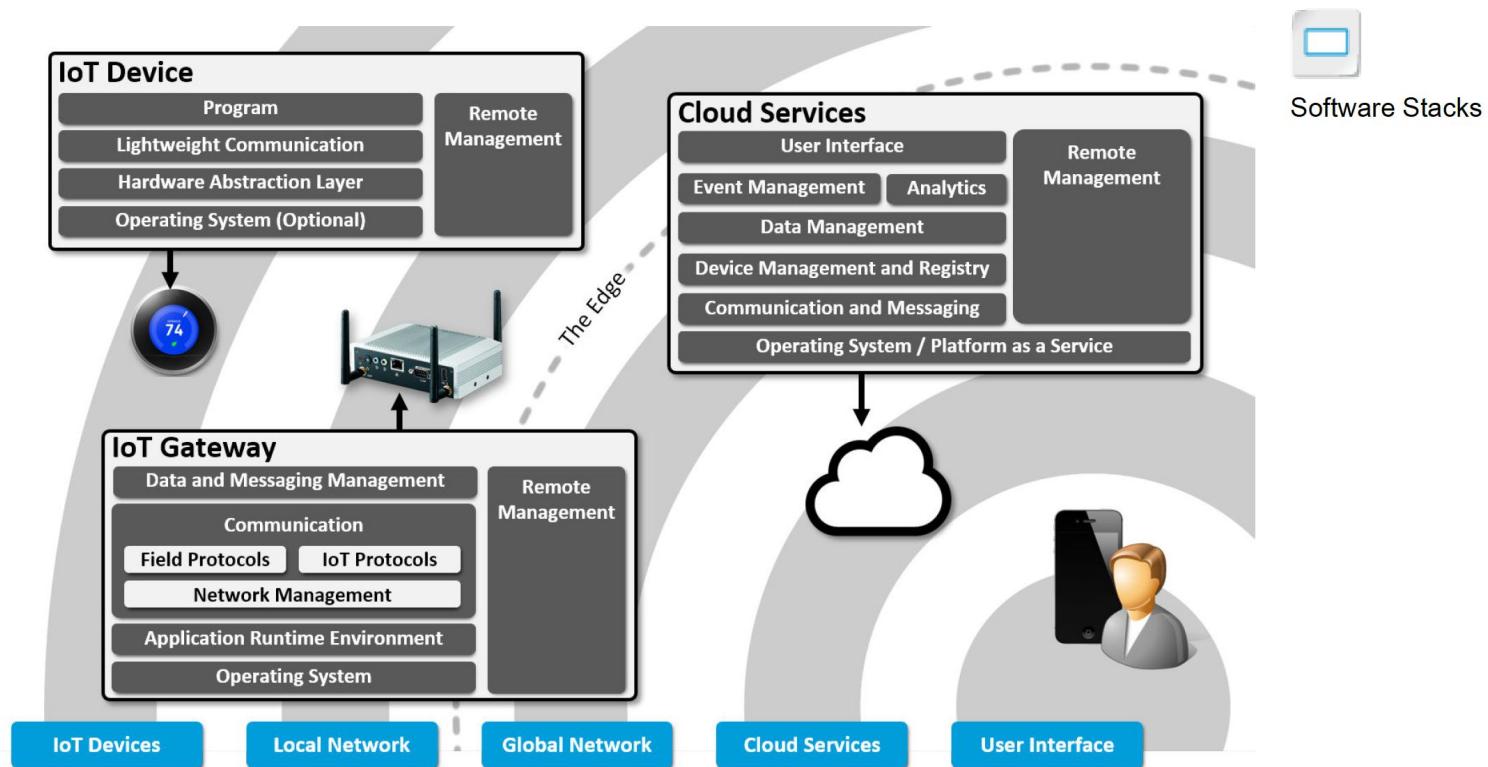
# End-to-end IoT



# Example IoT Devices



# Software Required



# Applications of IoT



# Introduction to IoT

**9 billion** devices around the world are currently connected to the Internet, including computers and smartphones

The number is expected to increase dramatically within the next decade, with estimates ranging from **50 Billion devices** to reaching **1 trillion**

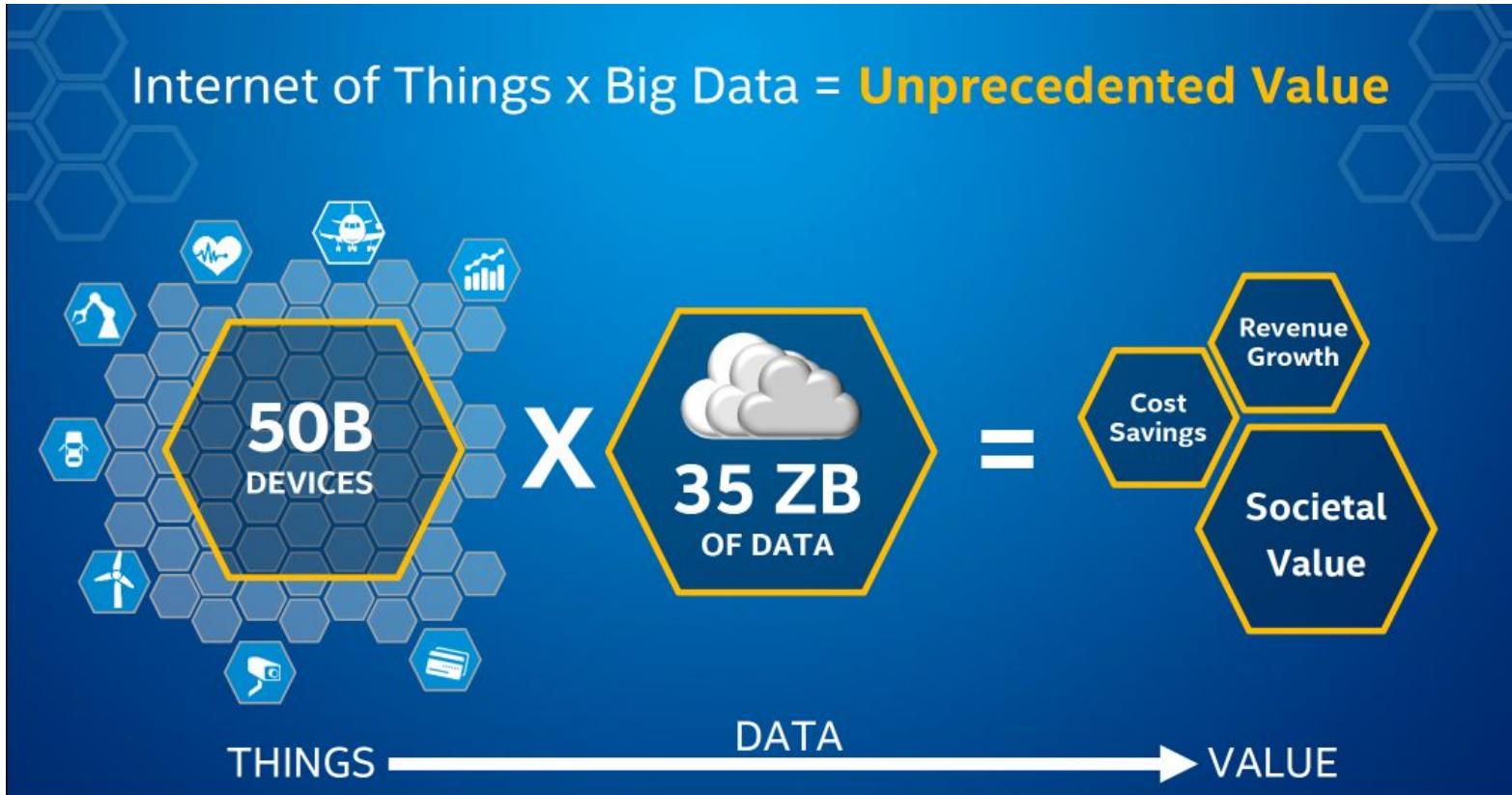


The Internet of Things has the potential to create economic impact **of \$2.7 trillion to \$6.2 trillion** annually by 2025

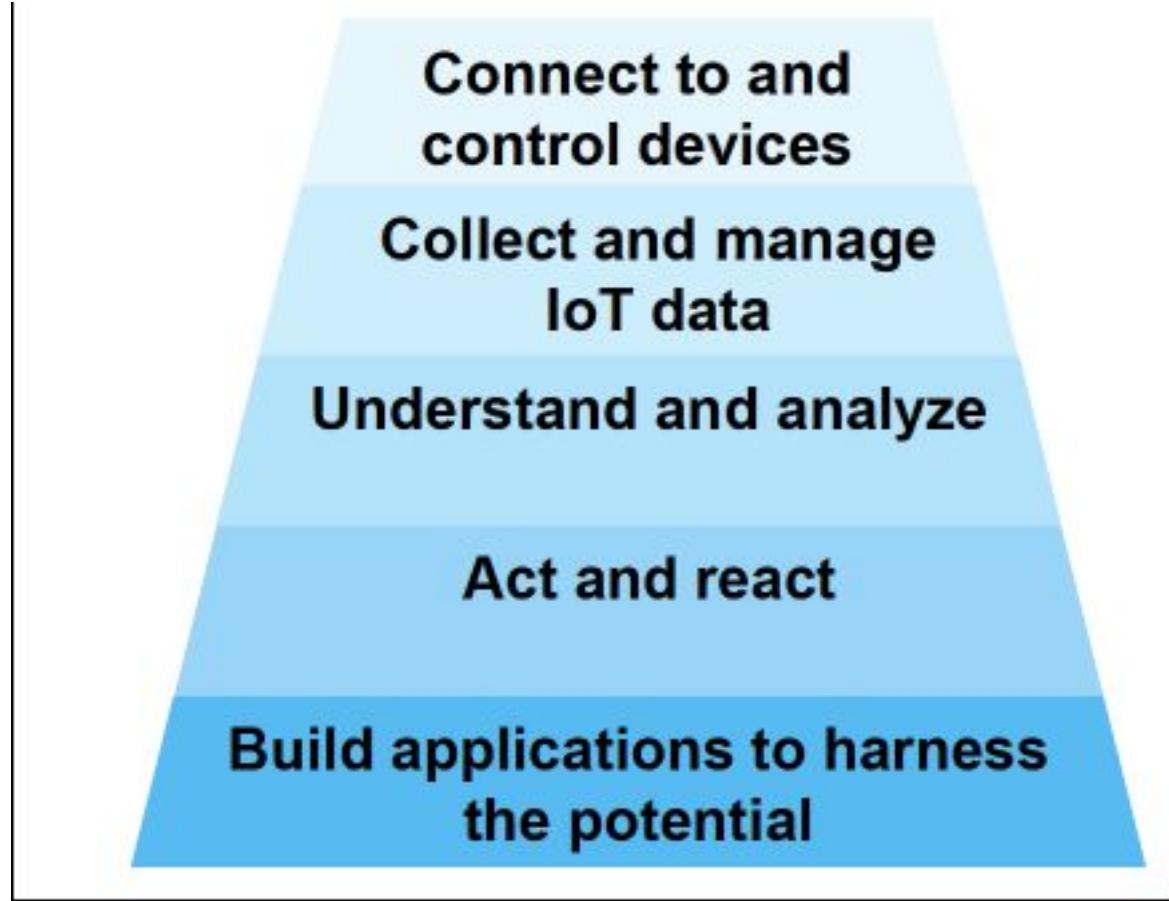
# Where we started



# Value Proposition



# Layers of IoT



# Challenges to IoT

Security, Privacy, Compliance

Market Fragmentation

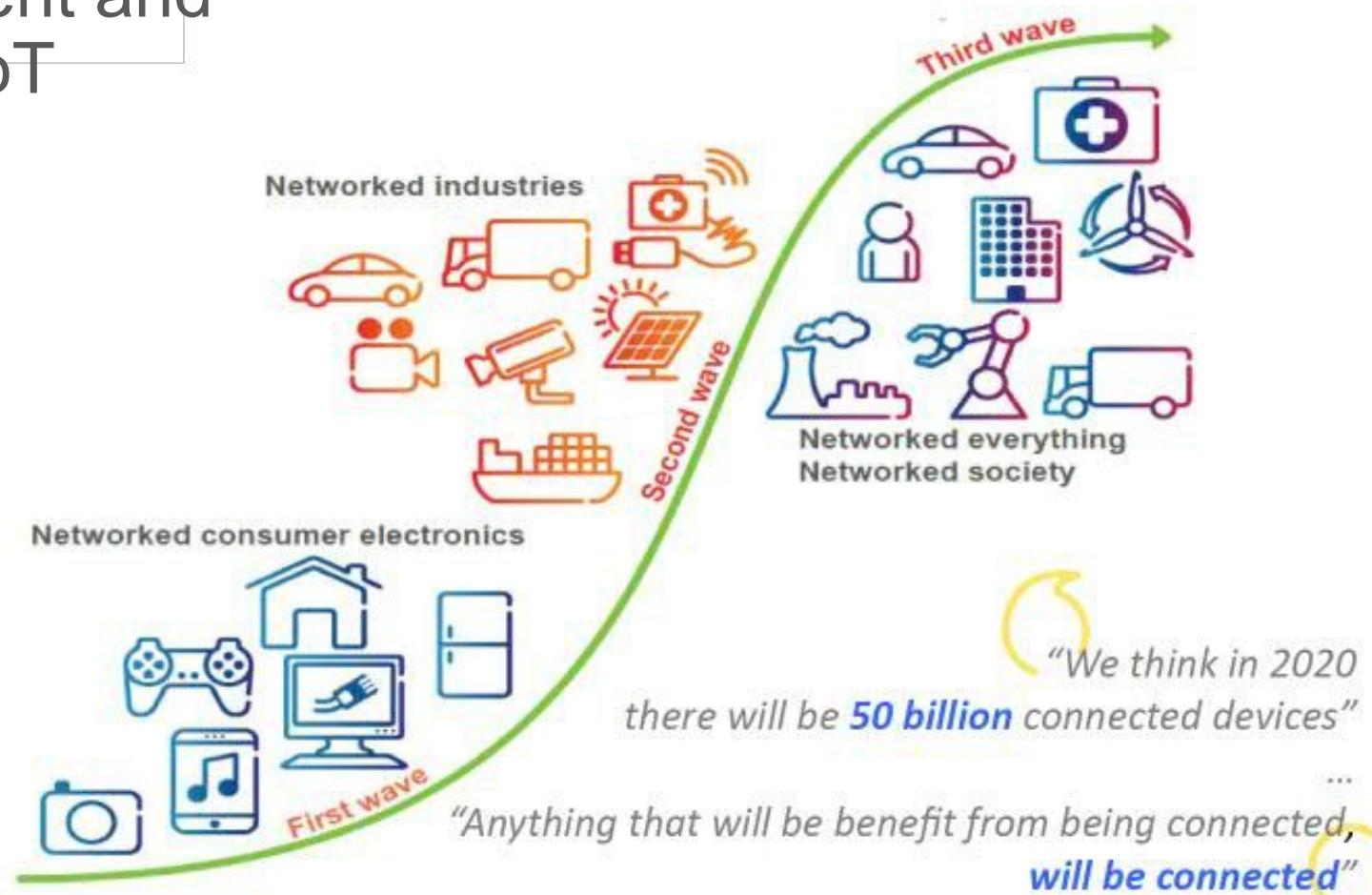
Legacy Infrastructure

LAN/WAN Connectivity

Underutilized Data

Interoperability and Standards

# Past, Present and Future of IoT



# IoT Example: The Refrigerator

A refrigerator is just a thing, so it can be anything besides a computer.

If it's a computer, we're not calling that a thing, but anything besides a computer.

Now the next thing you do is you add to that some type of computational intelligence (Micro controller).

So that's intelligent refrigerator. But maybe you wouldn't call that Internet of Things, cuz it's not actually networked yet. Then, to top it off, you add Internet connectivity.

It's got some kind of computation inside and it's got a network connection which means it can use all sorts of other resources that are not local.

# IoT Example: What the IoT Refrigerator can do

You can have IoT fridge detect that you are low on butter and then just order that, and then the next morning, butter will appear on your doorstep.

You can search for low food prices.

Give you a good idea for food for you tomorrow is this type of meal that you've had in the past.

IoT device should have a simple interface, have computational intelligence and be connected to the internet.

# IoT Devices vs Computers

IoT Device has a main function separate from Computation

- Cars drive, Phone make calls, TVs displays shows
- Computation is a means to an end

Computers main function is to compute, they are general purpose machines

IoT Devices are Special Purpose Devices, software and hardware are efficient for the task - but inefficient for other tasks

# Technological Trends that lead to IoT

- Cost of hardware has decreased allowing to be added to devices
- Smaller size and lesser weight needed to incorporate computation into devices
- Computation ability has increased tremendously
- Internet is available everywhere
- Wireless Access (4G, Wi-Fi) has become cheap and ubiquitous, 5G on the way (No physical cables required)
- Data transmission cost is fairly low, internet bandwidth is high
- Cloud computing is being used extensively (IoT devices are a window to these cloud services)
- Rise of Open Source Software (Rust, Web Assembly, Docker, Kubernetes, etc.)

# What are Embedded Systems?

- IoT devices are embedded systems
- Computer based Systems that do not appear to be computers - complexity is hidden from the users
- The complexity is embedded inside the device (that is where the name came from)
- IoT devices are always connected to the internet
- Embedded systems may have computational complexity but may or may not be connected to a network
- Things are moving from Embedded to IoT, a lot of thing were Embedded but are now IoT
- Sometime an Embedded System does not interact with the user but with another system, invisible to the user (Disk drive, anti lock braking system)

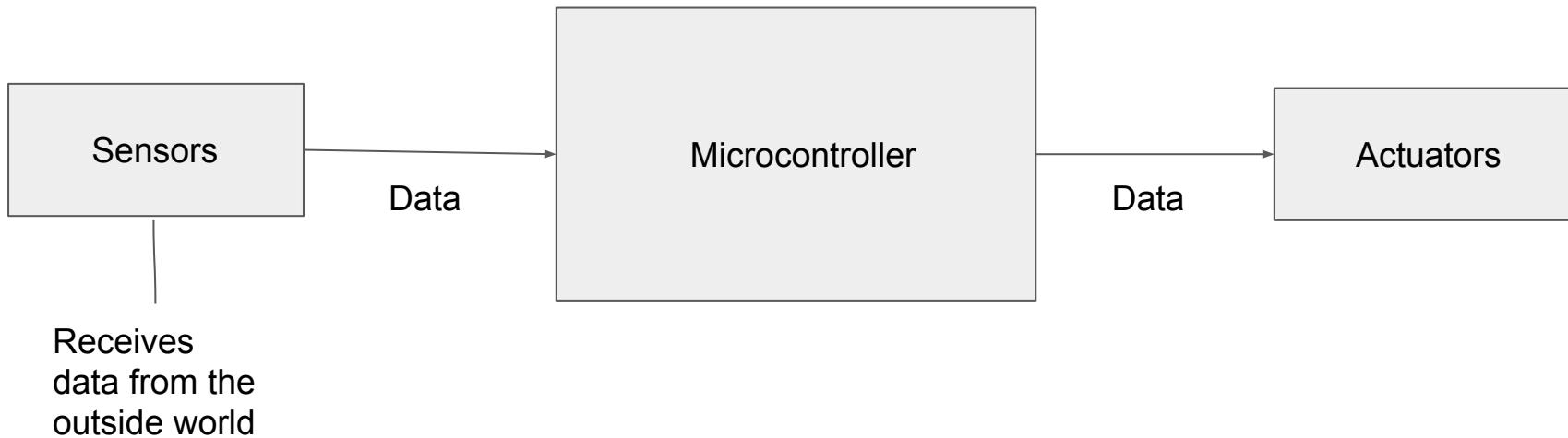
# Efficiency Rules in Embedded Systems

- Most embedded systems are in cost-critical markets (e.g. consumer products)
- Other Applications are in performance or power critical markets (e.g. military, medical)
- It not that we just want it to work but we want it to work under tight constraints
- Cannot depend on Moore's Law to save you in the long run, it has to perform from day one

# Embedded Systems vs Regular Platform Design

- Embedded devices are generally application specific. Embedded systems are made to do one thing or one related set of things.
- Unlike desktop, laptop computers which can run any type of program or pretty good doing any type of program.
- When you know that the device is gonna do one thing, you design it for the one thing, you don't design it for everything.
- A general purpose machine is overpowered.
- But embedded systems are designed specifically and they let you change the way you do design, you can just put in the things that you need to put in. Spend money on what you need to put in. So, higher design efficiency is possible in Embedded System.
- In embedded system you have understand both the software and hardware, which makes it more difficult.

# Embedded Systems Structure



# Microcontrollers

Integrated circuits that executes a program

Microcontrollers vs Microprocessors

Slower, 16 MHz - 500 MHz

Less memory, fewer features

Much cheaper

You write your program on computer, compile it and upload it to the flash memory of the microcontroller. As soon as there is power it runs the program.

We will use Rust and C to program microcontrollers

# Sensors

Sensors just receive information from the environment.

Thermistor: Receives temperature information.

Photoresistor: It reports light intensity.

CMOS camera (digital camera): It captures images

# Actuators

Actuators cause events to occur in the environment.

LEDs (light emitting diodes): they turn lights off and on

LCDs (liquid crystal displays): like what's on my digital watch

Servo motor: motors

# Analog to Digital Conversion

- Converts Analog Data to Digital Data
- Used to interface with analog sensors
- Analog to digital is the same as the difference between real numbers and integers
- So the universe. The world in general to the perception of humans is analog.
- Digital phenomena is something that's either off or on, or at least has some discrete number of states.
- In order for our program on our microcontroller to be able to use information from sensors, that analog signal has to be converted to a digital value.
- Now on the output end, you usually need digital to analog conversion. So let's say I have a microcontroller and it's outputting some sound to some speakers. These speakers are analog devices, they need analog signal.

# Microcontroller Characteristics

Architecture (ARM, ESP32)

Datapath bitwidth (4 - 128 bits)

- Number of bits in each registry
- Determine accuracy and data throughput

Input/Output pins

- Need enough pins to support the application

Performance

- The clock rates are slower than desktops

# Other Microcontroller Characteristics

## Timers

- Needed for real-time applications

## Analog to Digital Convertors

- Used to read input from analog sensors

## Low power modes

- Power saving is key

## Communication protocol support

- Interface with other IC's
- UART, I2C, SPI, etc.

# IoT Devices are a Window to Cloud Services

Google Assistant and Alexa (processing is done on the cloud)

Netflix (Movie is not sitting on your phone but are in the cloud)

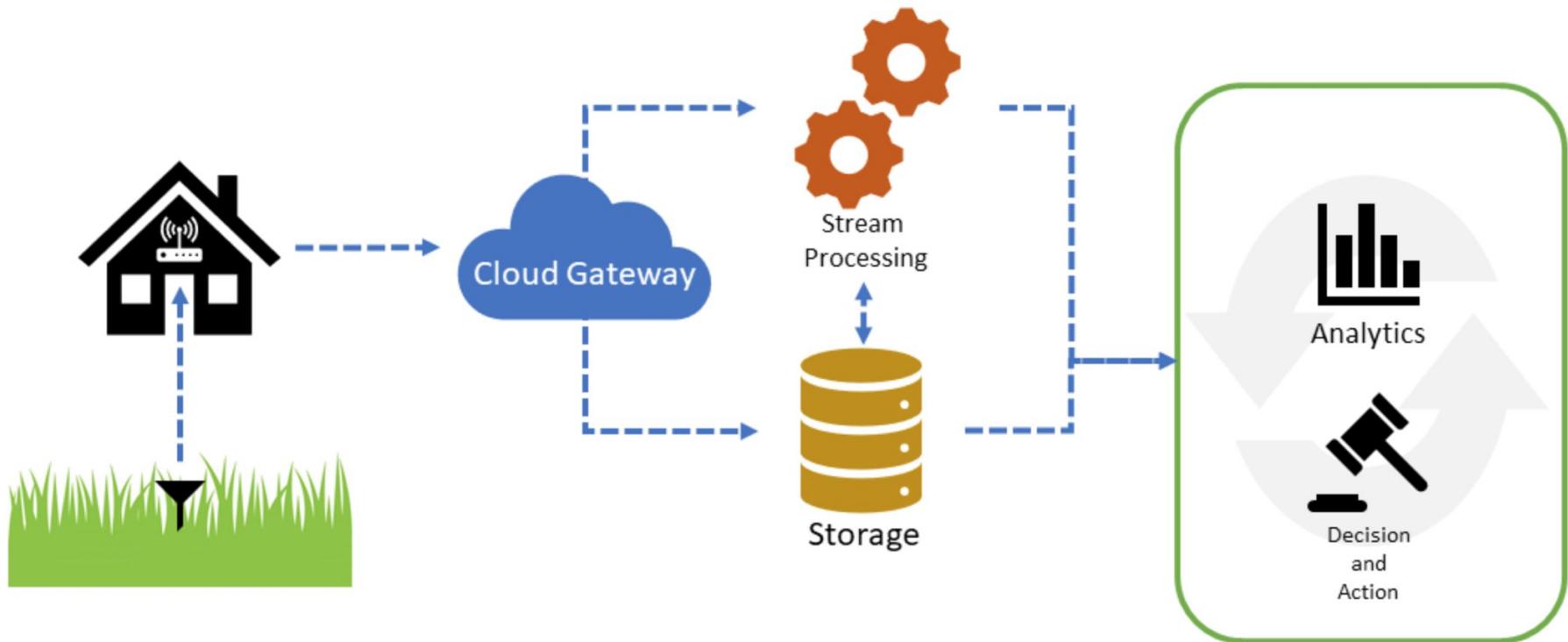
IoT devices give access to huge databases and computation resources on the cloud

# IoT involves two essential components

A device-side (made up of individual devices) that acts as a data source

A cloud-side that gathers data and provides resources for analyzing it

# Example: Water Pricing During Summer



# Categories of IoT devices and services: Maker IoT

The term "maker" has come to be equated with "hobbyist" and refers to those who like to build things to experiment or for personal use out of electronic components. When it comes to IoT, the idea of building unpolished but functional devices that collect data, using cloud services to gather and store that data, and maybe even doing analytics on the data collected all is a part of what is included in this category. But a commercial business may employ a maker's approach to experiment with ideas, create proof-of-concept devices, do costing, and other planning exercises. So "maker" need not be limited to hobbyists but describes an approach to development.

# Consumer IOT

It largely consists of commercial devices and associated services that are geared towards home or personal use such as connected thermostats or appliances. While the basic IoT concepts apply, the scope of what the devices collect, how they manage and store data, and how the data is used may be much more limited than what you'd find in an enterprise environment.

# Enterprise IoT

Whereas Consumer IoT is focused on “turnkey” device solutions that solve specific problems or enable new scenarios for individuals or homes, enterprise-class IoT is focused on solving specific business problems like efficiency, reducing waste, increasing speed to market or of production, and providing intelligence on how business systems are running. A single enterprise may deploy dozens of devices that work in concert to give a business a single view of a factory or fleet of planes or gas pipeline. Enterprises also may require real-time data and real-time analysis of those data in order to make just-in-time adjustments or prevent disastrous consequences from a failed system. Consumer-grade IoT products rarely require this so the type of architecture needed in an enterprise will be more involved and require more services than a consumer solution requires.

# IoT for Manufacturing

Microsoft highlights the following benefits for implementing IoT solutions in a manufacturing scenario:

- Improved visibility across your manufacturing operations—make more informed decisions with a real-time picture of operational status
- Improved utilization—maximize asset performance and uptime with the visibility required for central monitoring and management
- Reduced waste—take faster action to reduce or prevent certain forms of waste, thanks to insight on key production metrics
- Targeted cost savings—benchmark resource usage and identify inefficiencies to support operational improvements
- Improved quality—detect and prevent quality problems by finding and addressing equipment issues sooner

# IoT enabled Smart City

Telecom company AT&T describes the following benefits of a city fitted with smart devices that provide real-time data on things like parking, traffic, violent activities, and air quality:

- Enhanced citizen safety
- Optimized public services
- Economic growth
- Improved traffic flow
- Improved environment
- Empowered civic engagement

# IoT enabled Retail

Analytics company SAS reports that IoT is starting to find its way into the retail experience. Using devices like RFID tags, mobile devices, and even digital signs, retail is embracing the advantages IoT can provide. The SAS report highlights five places where retail is using IoT to enhance their business and customer's experience:

- Predictive Equipment Maintenance.
- Smart Transportation.
- Data-aware Warehouses.
- Connected Consumer.
- Smart Store.

# IoT Adoption

- In a 2018 blog post, Microsoft gave an overview of companies that are starting to use IoT solutions in what they call “Smart Buildings.” These companies are using IoT technology to help people navigate buildings, trigger maintenance requests, help engineers design better buildings and help property managers oversee their properties in a more efficient and effective way.
- Technology company Intel is working with many companies to enable IoT solutions. Intel describes solutions that range from building smarter trains to smarter roads. They've helped a plastics company determine inefficiencies in their control system as well as improve their product cycle and reduce inventory risks. Intel's “wearables” solutions "improve worker efficiency and safety, including hands-free operations of industrial equipment."

# IoBT, Software and Combat Clouds

**Internet of battlefield things (IoBT)** - Military planners envision a future battlefield defined by the internet of things, one in which smart devices, soldier-worn sensors and unmanned aircraft produce a nonstop torrent of actionable data.

**Software defined aircraft** - All revealed fifth-generation fighters use commercial off-the-shelf main processors to directly control all sensors to form a consolidated view of the battlespace with both onboard and networked sensors.

**Combat clouds** - Fifth-generation jet fighters will operate together in a "combat cloud" along with future unmanned combat aircraft.

# An IoT Device

1. Connected to the Internet
2. Secure
3. Smart Features
4. Communication Capabilities with other devices
5. Remotely Configurable
6. Programmable
7. Replaceable (Optional)
8. Environmentally Flexible (Optional)

# Consumer versus Business Goals for IoT

Individual consumers implement cloud connected devices (such as doorbells, thermostats, and even refrigerators) in order to make their life easier, more comfortable, or more secure. Consumer devices in the home are not typically being used for the same purpose as an IoT device implemented in a business scenario.

In a way, business goals for IoT are simple compared with consumer goals. Businesses tend to implement IoT solutions in order to be more profitable, to increase safety for their work force, and to more easily comply with government regulations in order to create a better business environment. Profitability can be realized either directly through cost reductions or indirectly through competitive advantage. A business could use IoT to provide customers with improved service, resulting in increased market share (and overall profits). In most cases both the business and their customer benefit.

# IoT Consumer Space Examples

- Connected Refrigerators
- Connected Doorbells and Cameras
- Connected Thermostats

# Business goals for IoT, improving:

- Product Quality and Extended Product Lifetime
- Service Reliability and Uptime
- Operating Efficiency
- Workforce safety
- Governmental compliance

# IoT Verticals

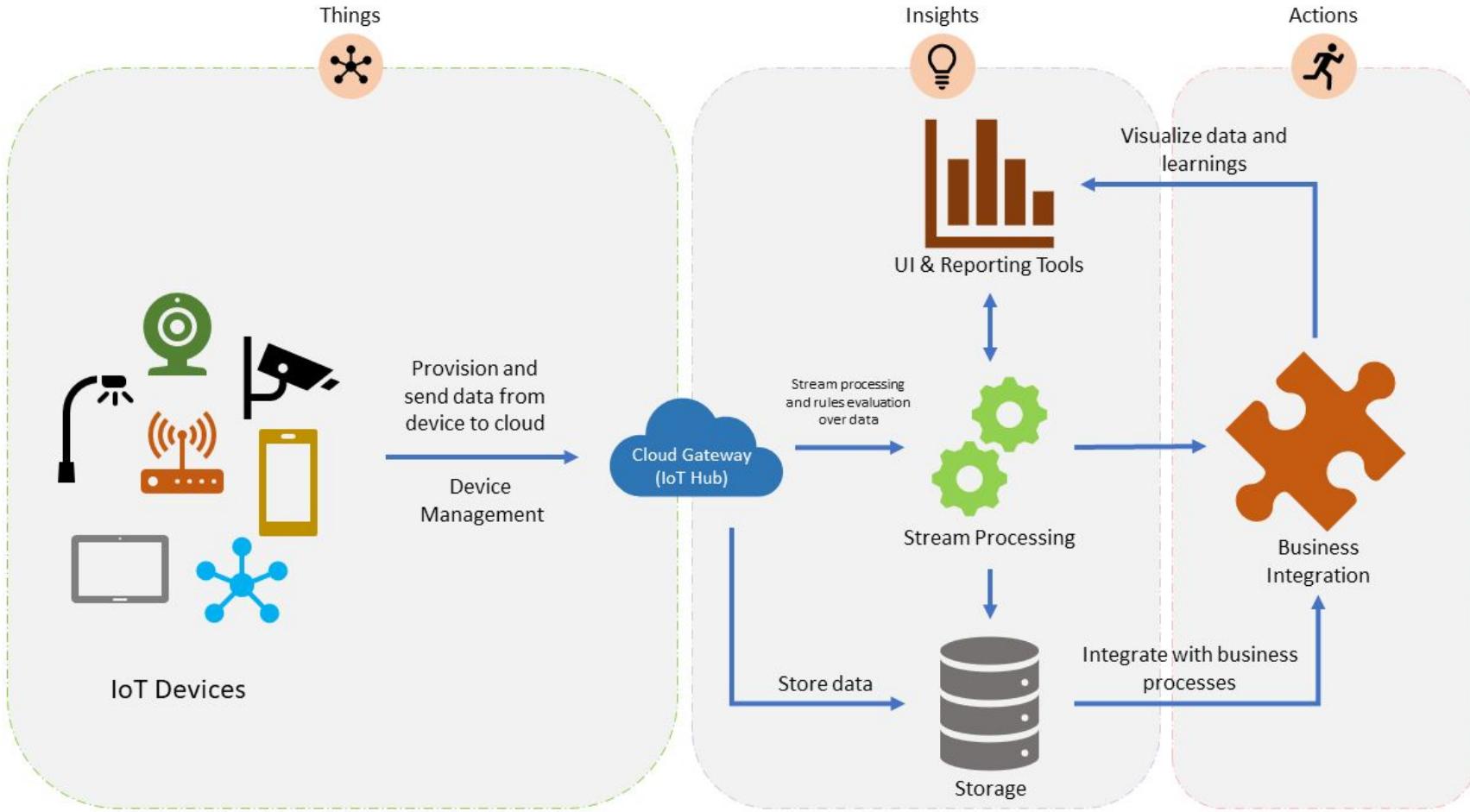
- Manufacturing
- Smart City
- Smart Building
- Healthcare
- Energy
- Transportation and Smart Vehicles
- Logistics and Inventory Management
- Retail
- Agriculture
- Military

# Core Subsystems of an IoT Architecture

1. devices (and/or on premise edge gateways) that have the ability to securely register with the cloud, and connectivity options for sending and receiving data with the cloud,
2. a cloud gateway service, or hub, to securely accept that data and provide device management capabilities,
3. stream processors that consume that data, integrate with business processes, and place the data into storage, and
4. a user interface to visualize telemetry data and facilitate device management.

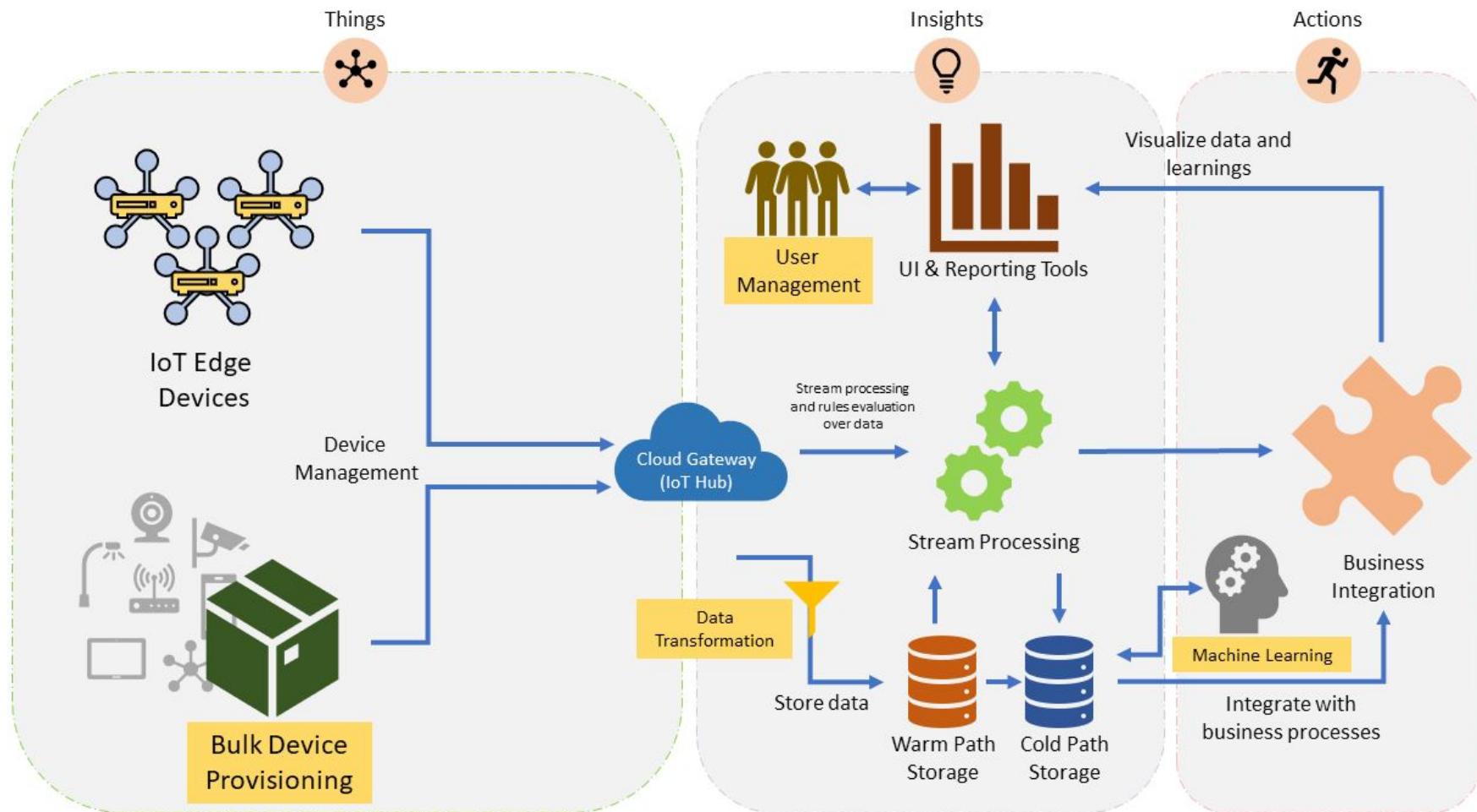
# IoT Sub-systems Description

1. **Cloud Gateway:** The Cloud Gateway provides a cloud hub for secure connectivity, telemetry and event ingestion and device management (including command and control) capabilities.
2. **Stream Processing:** Processes large streams of data records and evaluates rules for those streams.
3. **Business Process Integration:** Facilitates executing actions based on insights garnered from device telemetry data during stream processing. Integration could include storage of informational messages, alarms, sending email or SMS, integration with CRM, and more.
4. **Storage:** Storage can be divided into warm path (data that is required to be available for reporting and visualization immediately from devices), and cold path (data that is stored longer term and used for batch processing).
5. **User Interface:** The user interface for an IoT application can be delivered on a wide array of device types, in native applications, and browsers.

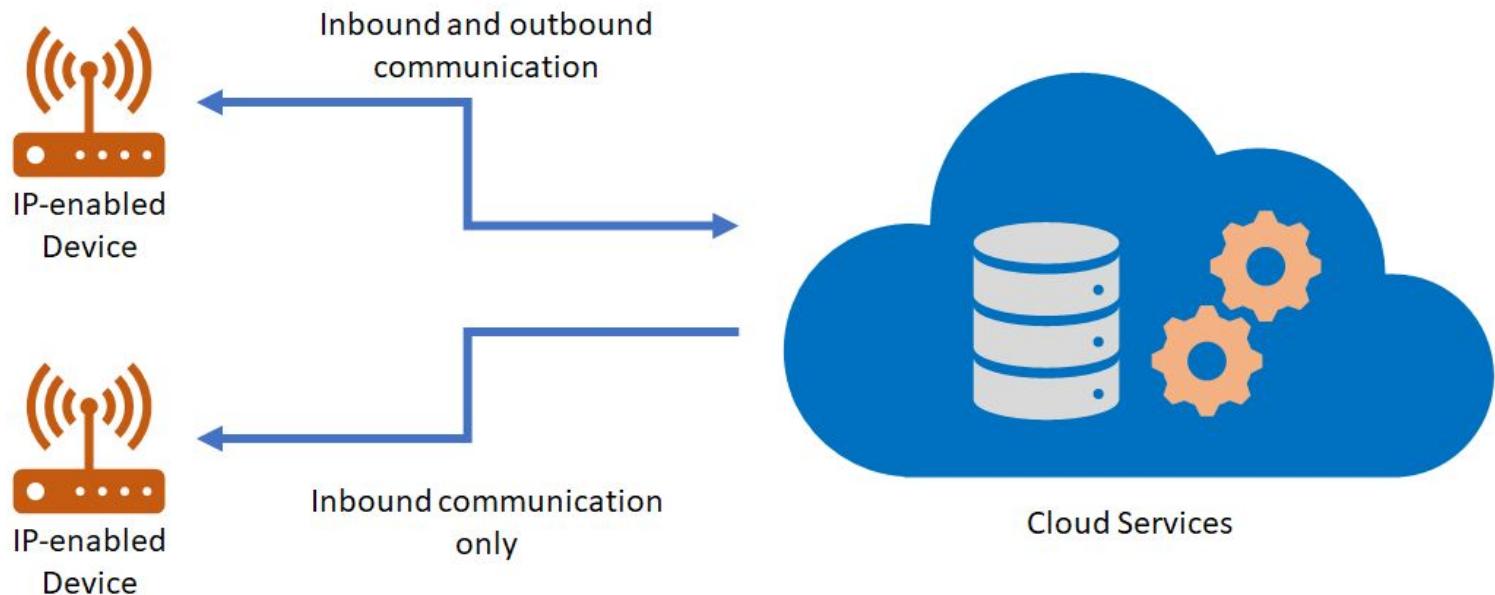


# Optional Subsystems of an IoT Architecture

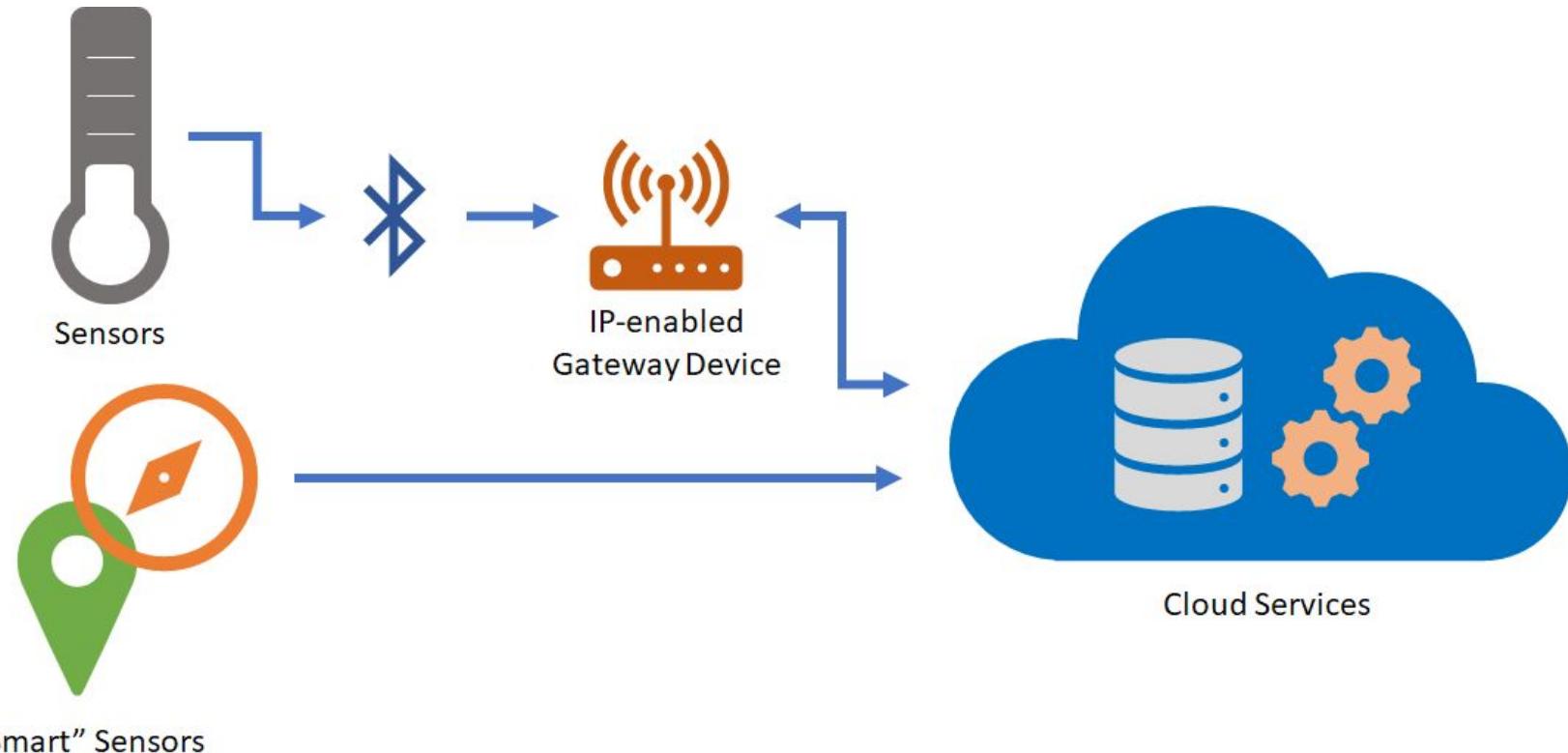
5. telemetry data transformation which allows restructuring, combination, or transformation of telemetry data sent from devices
6. machine learning which allows predictive algorithms to be executed over historical telemetry data, enabling scenarios such as predictive maintenance, and
7. user management which allows splitting of functionality amongst different roles and users.



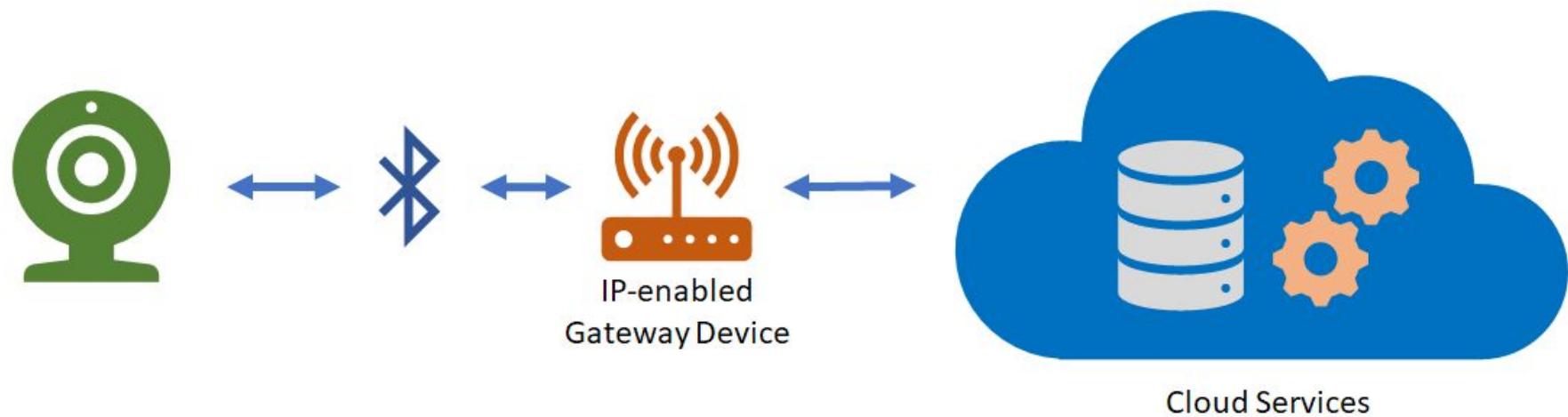
# IoT Hardware: IP Enabled Devices



# IoT Hardware: Sensors and Smart Sensors



# IoT Hardware: Non-IP Enabled Devices



# Example of Sensors Available

- Temperature
- Humidity
- Energy
- Compass
- Pressure
- Sonar
- Light and UV

# Edge Devices and Field Gateways

A field gateway (edge) is a specialized device-appliance or general-purpose software that acts as a communication enabler and, potentially, as a local device control system and device data processing hub. A field gateway can perform local processing and control functions toward the devices; on the other side it can filter or aggregate the device telemetry and thus reduce the amount of data being transferred to the cloud backend.

Gateways in this context may assist in device provisioning, data filtering, batching and aggregation, buffering of data, protocol translation, and event rules processing.

# Edge Computing

- Edge computing is a distributed computing paradigm which brings computer data processing and storage closer to the location where it is needed. So, instead of having a centralized, remote cloud to do all the work, the data is handled and stored locally, i.e. on the IoT device itself or at the nearest network node.
- Computation is largely or completely performed on distributed device nodes.
- Edge computing pushes applications, data and computing power (services) away from centralized points to locations closer to the user.
- Edge computing does not need contact with any centralized cloud, although it may interact with one.
- Edge application services reduce the volumes of data that must be moved, the consequent traffic, and the distance the data must travel. That provides lower latency and reduces transmission costs.

# Why pure cloud computing isn't the best option for IoT

Traditional cloud computing has a number of drawbacks when it comes to IoT:

- Data security threats. Data is constantly being transmitted back and forth between the cloud and a device, and as such, the risk of privacy violation is heightened.
- Performance issues. IoT applications rely heavily on real-time actions. Yet, the processing speed of your cloud-based app often depends on the actual distance between the device itself and the server location.
- Operational costs coincidentally grow as the amount of data produced and shared increases.

On top of that, most data sourced to the cloud often bears no practical value and is never used.

# How does edge computing work?

- Every IoT sensor produces tons of data every second. In the case of cloud computing, the data is instantly transferred to the central, unified cloud database where it's processed and stored.
- If there's any action required, the central server will send its response back to the device upon receiving and analyzing the acquired data.
- While the whole process typically takes less than a second to complete, there might be situations when the response may be delayed or interrupted. This can happen due to a network glitch, weak internet connection, or simply because the data center is located too far from the device.
- Now, in case of edge computing, you don't need to send the data acquired by the IoT sensors anywhere. The device itself or the nearest network node (e.g. the router) is responsible for data processing and can respond in a proper manner if action is required.

Edge Computing makes it possible that the IoT device is no longer dependent on the internet connection and can function as a standalone network node.

# The benefits for edge computing in IoT

1. Increased data security
2. Better app performance
3. Reduced operational costs
4. Improved business efficiency and reliability
5. Unlimited scalability

# Edge Computing Use Cases

McKinsey finds that the industries with the most edge computing use cases are:

- travel, transportation, and logistics
- energy
- retail
- healthcare
- utilities

# Voice Revolution



Voice control is most suitable in the following IoT use cases

- Home automation
- Automobiles
- Health Care
- Entertainment

# Voice Assistants Are Taking Over Consumer IoT

No industry felt the heat of the voice assistant battle more than Consumer IoT (CIoT), in which voice assistant integrations became the primary focus for any CIoT product-centric company.

Imagine a future in which every command is at the tip of your tongue. When you wake up, your bathroom mirror can report your schedule for the day. During breakfast, you can ask the coffee machine for a latte, extra foam. On the train, your watch will tell you just how late you'll be to work. In the office, your printer will pipe up, asking for more ink, please.

# Entry point into the IoT's has been Amazon and Google's smart speakers

For many consumers, the entry point into the Internet of Things has been Amazon and Google's smart speakers.

Voice control is one of the primary drivers of smart home market growth with the number of home voice devices projected to reach 275 million by 2023 in USA alone.

# Visions of dialogue from science fiction

- Hal “2001: A Space Odyssey” (1968)
  - Naturally conversing computer
- Star Trek (original 1966)
  - Natural language command and control
- Her (2013)
  - A virtual partner with natural dialogue capabilities

# A NEW KIND OF UI: VUI

## A.I. Assistants/**Platform shift**



*"From mobile first to AI-first"*

Sundar Pichai

October 4th, 2016



Dyn Says Cyberattack Has Ended, Investigation Continues



Visa Taps Blockchain for Cross-Border Payment Plan



Airbnb Revises New York Rules Amid Possible Legislation

DIGITS

## Speech Recognition Gets Conversational

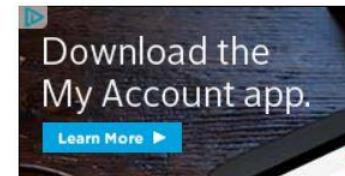
# Five Ways Conversational Bots Will Change The Way We Do Business



**Forbes Technology Council**

Elite CIOs, CTOs & execs offer firsthand insights on tech & business. [FULL BIO ▾](#)

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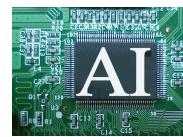
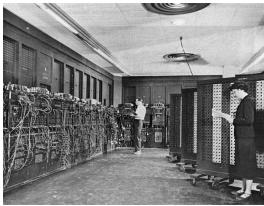
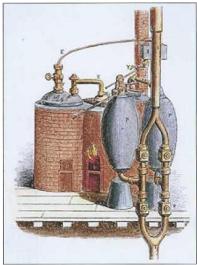
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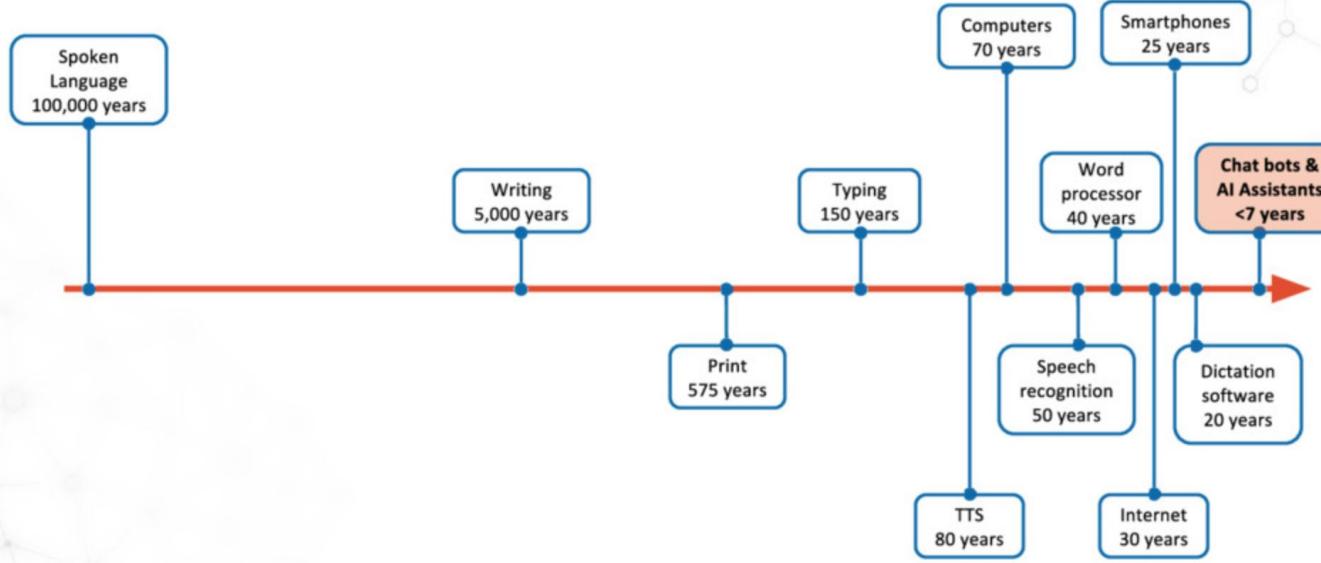
GOOGLE'S NEW CHATBOT  
WON'T SHUT UP—AND THAT'S A  
GOOD THING

**WIRED**

# Technology revolutions



## VUI/Human to human vs. Human to computer



# Digital Assistants are so Hot

- The market for AI-driven personal assistants and bots will almost double in 2018, reaching more than \$12 billion by 2020 with 1.6 billion active users, according to Statista.
- Today, pretty much every tech giant is making digital agents for their customers. Amazon's Alexa, Microsoft's, Apple's Siri and Google's Assistant.

# Reasons for being so Hot

- Natural language is more intuitive than web or mobile interfaces, which usually entail some degree of a learning curve
- Enhanced productivity
- Personalization, goes far beyond voice recognition. They employ machine learning to refine their responses and deliver only relevant options based on consumer preferences
- Personal assistants can access a large spectrum of data
- AI-enabled assistants and innovations in the Internet of Things bring a whole new level of communication between devices, people, and companies

## A.I. Assistants/**Some examples**



Apple's  
Siri

2011



Microsoft's  
Cortana

2014



Amazon's  
Alexa

2014



Google's  
Assistant

2016



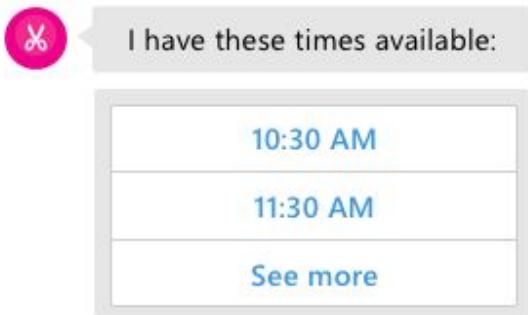
Samsung's  
Bixby

2017

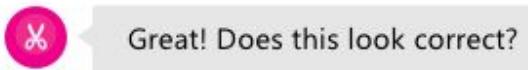


# What is a Bot?

- A Bot is a conversation based UI
- Conversation is based on language
- Conversation takes place on a general canvas
- Canvas can be:
  - Chat Client: Skype, Team, Slack, Messenger
  - Voice: Echo, Cortana Skills, Siri, Google Now
  - App: Website, App



10:30 AM



Haircut at Salon Contoso

Sat, May 13 at 10:30 AM

1 Microsoft Way,  
Redmond, WA 98052

Book now

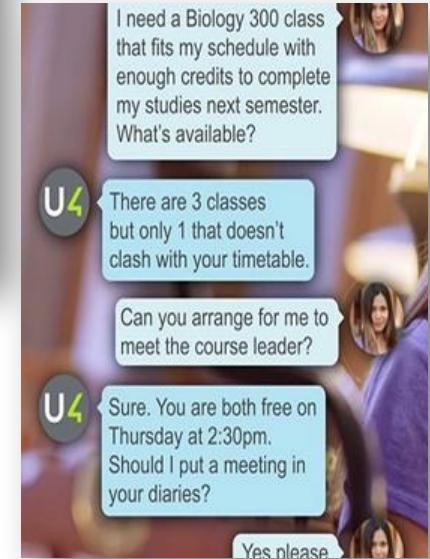
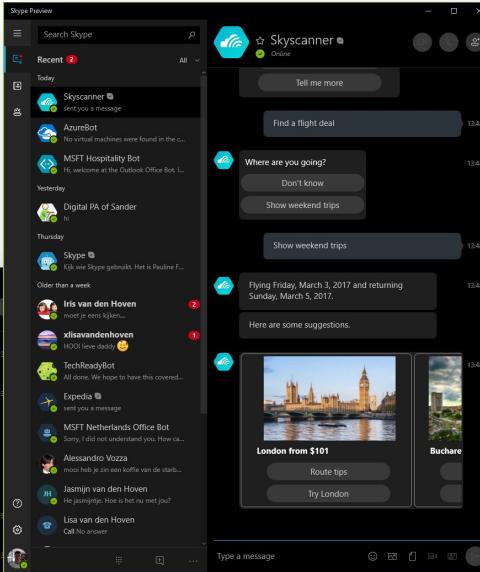
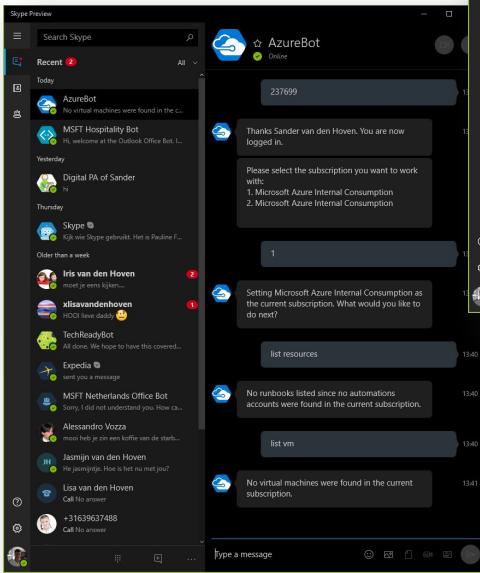
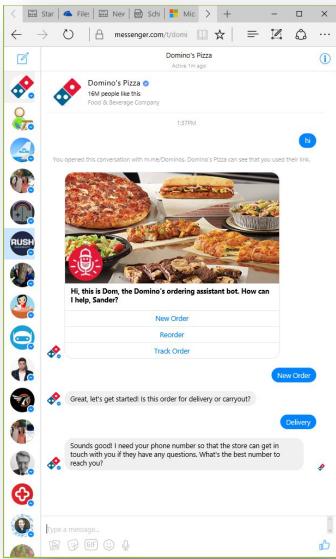


## Scenario's for Bots

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1. Question and Answers
2. Automate Helpdesk, Handoff to human if too complex
3. Product selection and ordering
4. Task Automation
5. Proactive Assistance & Monitoring
6. Expert Systems

# Bot Examples



# Embedded devices with dialogue capabilities

- Amazon Echo (2014) – home assistant device
  - Plays music
    - With voice commands
  - Question answering
    - Get weather, news
    - More complex questions, like
      - “how many spoons are in a cup?”
  - Setting timer
  - Manages TODO lists



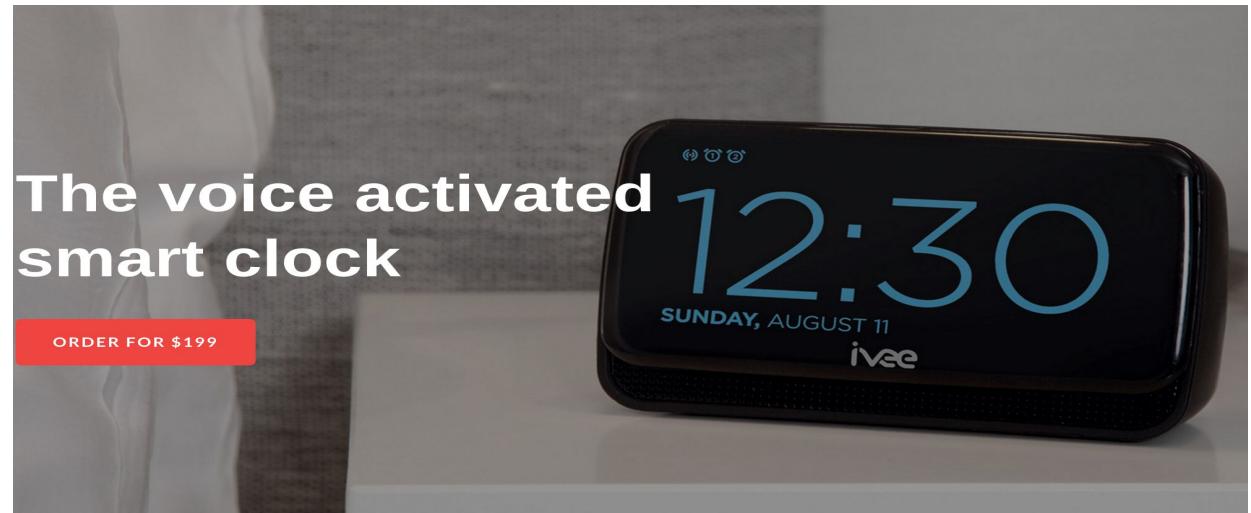
# Embedded devices with dialogue capabilities

Answers questions

Sets time

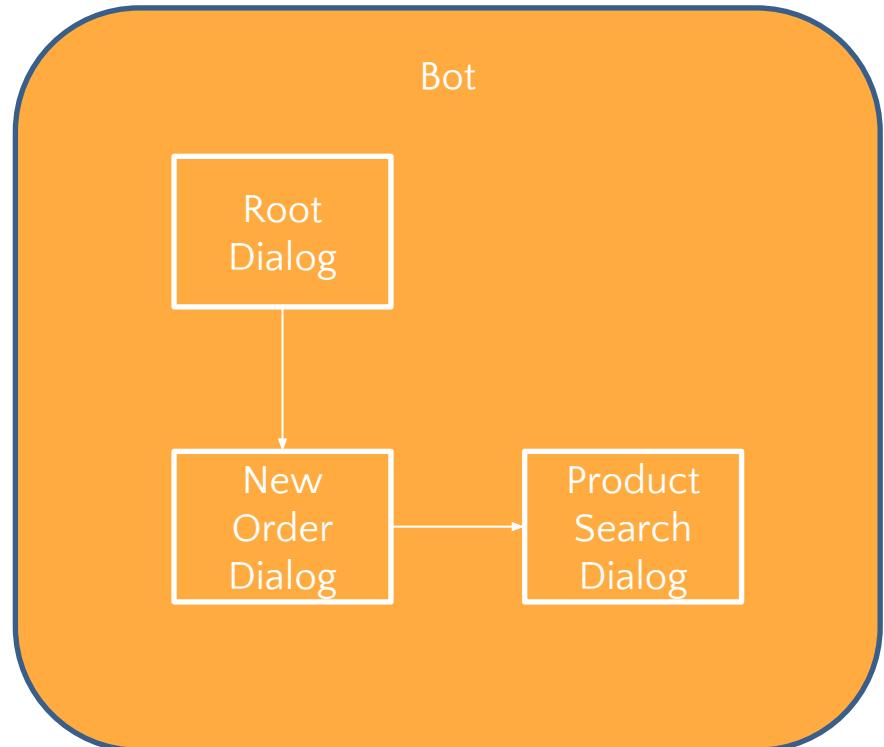
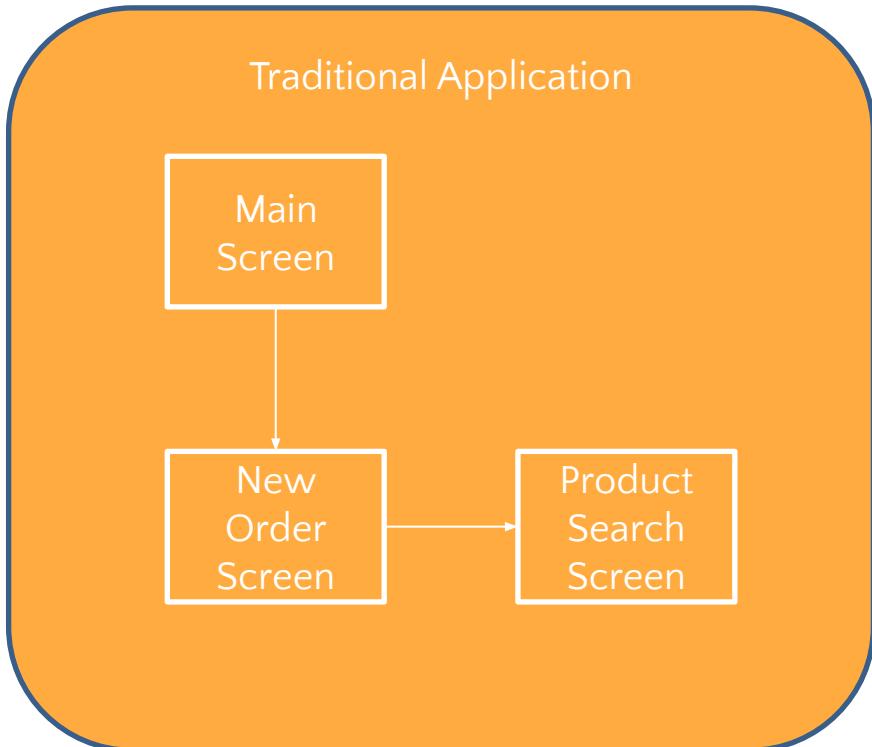
Device control and queries.

Thermostat Etc.



# Dialogs are for bots like screens are for apps

They separate concerns and organize flows, exactly the same way:



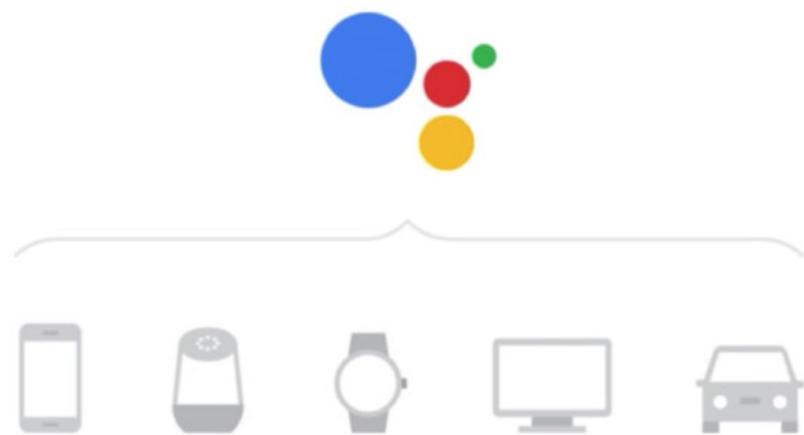
# Google



## ASSISTANT

Hi, how can I help?

## G. Home & G. Assistant/**Device compatibility**



# Google Assistant coming soon to more speakers, appliances and other devices

- Google is putting its Assistant on a wide range of third-party hardware.  
Google has announced that it's going to be putting the Assistant on partner speakers, appliances, connected cameras, and much more.
- It is already on the iPhone.

# Google wants to ‘see’ as well as ‘hear’ your surroundings



Google Lens

# How to develop for the Google Assistant platform

# Actions on Google

<https://developers.google.com/actions/>

Actions on Google is a developer platform that lets you create software to extend the functionality of the Google Assistant, Google's virtual personal assistant, across more than 500 million devices, including smart speakers, phones, cars, TVs, headphones, watches, and more.

You can build smart home Actions that let users control Internet of Things (IoT) devices through the Google Assistant. Building smart home Actions lets you connect, query, and control devices through your existing cloud infrastructure.

## VUI/**Some design principles**



Character  
Tone

Energy level  
Pace



Where is the user?  
Which device?

What are they doing?



"Sorry, try Command 1"  
"You can say A, B or C"

# Our Voice Platform

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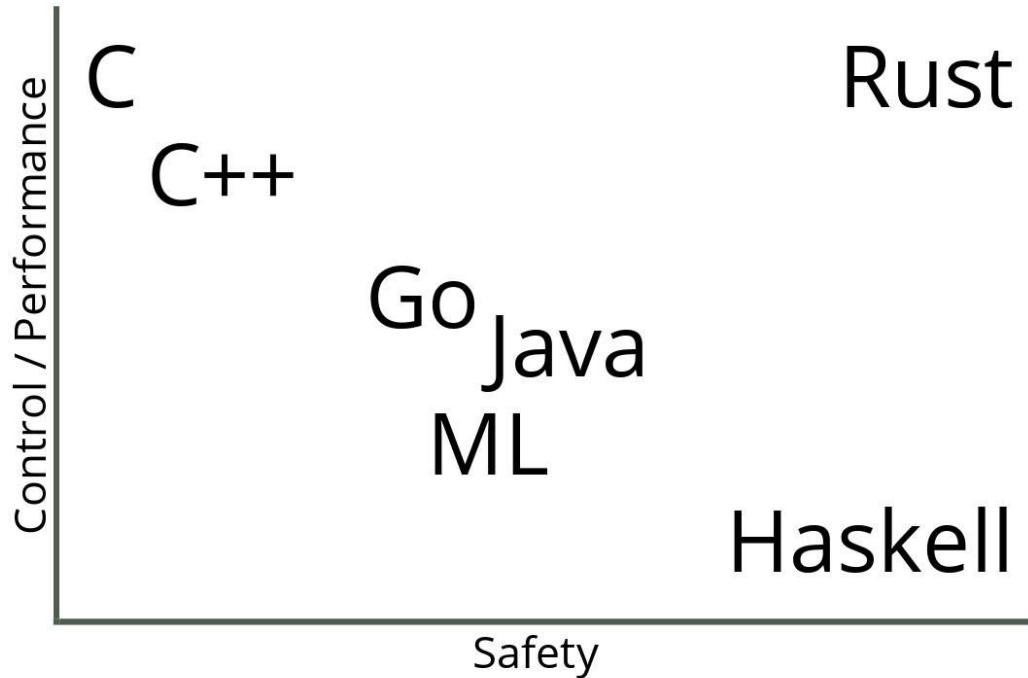
# IoT Open Source Software which we will use

**MCU:** Bare Metal Programming with Embedded Rust

**Edge/Gateway:** Rust, JavaScript (Node.js) and WebAssembly Microservices running on Linux Raspbian, Docker, Kubernetes, MQTT and KubeEdge

**Cloud:** Rust, JavaScript (Node.js), and WebAssembly Microservices running on Linux Ubuntu, Docker, Kubernetes, Serverless and Kafka

# Rust: Performance with Safety



# Our Messaging Protocols: Kafka and MQTT

- MQTT is a publish/subscribe protocol particularly suited to IoT applications thanks to its small footprint, real-time guarantees, and suitability for use in high-latency, low-throughput, and unreliable networks. It is designed for connections with remote locations where a "small code footprint" is required or the network bandwidth is limited. The publish-subscribe messaging pattern requires a message broker.
- Based on a publish/subscribe model, Kafka is one of the most widely used platforms to process and distribute real-time data streams. It is used for building real-time data pipelines and streaming apps. It is horizontally scalable, fault-tolerant, wicked fast, and runs in production in thousands of companies.
- Both, MQTT and Apache Kafka have great benefits for their own use cases. But, none of them are the single allrounder for everything. The combination of both makes them very powerful and a great solution to build IoT end-to-end scenarios from the edge to data center and back.

# Our Orchestrator: Why the IoT needs Kubernetes

Kubernetes has become the de-facto standard container orchestration framework for cloud-native deployments. Kubernetes addresses many of the complexity challenges that development teams see when building and deploying IoT solutions.

- Enabling DevOps for IoT
- Scalability
- High availability
- Efficient use of cloud resources
- Deployment to the IoT edge

Kubernetes IoT Edge Working Group

<https://www.youtube.com/watch?v=OeuOzMvGDM0>

# Hardware which we will use: Microcontroller



The STM32F3DISCOVERY allows users to easily develop applications with the STM32F3 Series based on ARM® Cortex®-M4 mixed-signal MCU. It includes everything required for beginners and experienced users to get started quickly.

It includes an ST-LINK/V2 or ST-LINK/V2-B embedded debug tool, accelerometer, gyroscope and e-compass ST MEMS, USB connection, LEDs and push-buttons. Price \$16 in USA, and \$24 on Ali Express.

# Hardware which we will use: Field Gateway/Edge



## Raspberry Pi 3 Model B+

1.4GHz 64-bit quad-core processor, dual-band wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and Power-over-Ethernet support (with separate PoE HAT)

Price in USA \$35

# Our Programming Languages



# The future of IoT is AI

As IoT devices will generate vast amounts of data, then AI will be functionally necessary to deal with these huge volumes if we're to have any chance of making sense of the data.

Data is only useful if it creates an action. To make data actionable, it needs to be supplemented with context and creativity. IoT and AI together is this context, i.e. 'connected intelligence' and not just connected devices.

Traditional methods of analysing structured data and creating action are not designed to efficiently process the vast amounts of real-time data that stream from IoT devices. This is where AI-based analysis and response becomes critical for extracting optimal value from that data.

# Blockchain in the Internet of Things?

- Traditional IoT systems are dependent on a centralized architecture. Information is sent from the device to the cloud where the data is processed using analytics and then sent back to the IoT devices.
- With billions of devices set to join IoT networks in the coming years, this type of centralized system has very limited scalability, exposes billions of weak points that compromise network security and will become incredibly expensive and slow if third-parties have to constantly check and authenticate each and every micro-transaction between devices.
- **Smart contracts** in blockchain networks will allow devices to function securely and autonomously by creating agreements that are only executed upon completion of specific requirements. It not only allows for greater automation, scalability and cheaper transfers (no third-party needed to oversee transactions).
- With traditional centralized networks, the risk of a single point of failure disabling an entire network is a very real possibility. A **decentralized blockchain** network mitigates this risk with millions of individual nodes that transfer data on a peer-to-peer (p2p) basis to keep the rest of the IoT network running smoothly.

# IoT and Blockchain Complement Each Other

Blockchain technology can be used in tracking billions of connected devices, enable the processing of transactions and coordination between devices; allow for significant savings to IoT industry manufacturers. ... In an IoT network, the blockchain can keep an immutable record of the history of smart devices.

# IoT + Cloud and Edge Computing + AI + Blockchain: The Fourth Industrial Revolution has Begun

The combination of IoT, Cloud and Edge Computing, AI and Blockchain technologies allow machines in the Internet of Things to be able to lease themselves out, schedule and pay for their own maintenance, purchase their own replacement parts and keep their own transactional records, using blockchain.

Let's take a MCQ covering this Presentation:  
Total Questions: 46, Total Time: 60 minutes

Let Us Do Some Rust and IoT Coding



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