# The Internet of Things (IoT)

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## What is the IoT?

The **Internet of things** (**IoT**) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data.

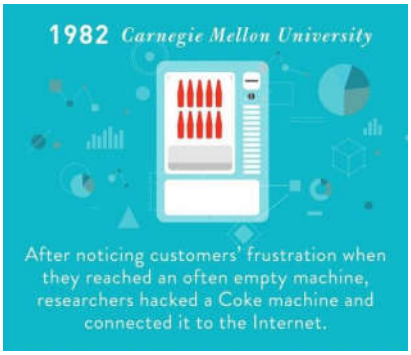
## What is the IoT platform?

- The **IoT platform** is a suite of components that enable:
  - Deployment of applications that monitor, manage, and control connected devices.
  - Remote data collection from connected devices.
  - Independent and secure connectivity between devices.
  - Device/sensor management.

## IoE?

The **Internet of Things** (IoT), also sometimes referred to as the **Internet** of Everything (IoE), consists of all the web-enabled devices that collect, send and act on data they acquire from their surrounding environments using embedded sensors, processors and communication hardware.

## How New Is The IoT?



## 1982???

- Students used Arpanet
  - Replaced by WWW protocols in mid '90s
- Switches in the coke machine communicated with a PDP-11 (DEC Computer)
- Students could tell
  - How much coke was in each of the 6 columns in the machine
  - How long it'd been there, so they knew how cold the Coke was

## Another Early Example

- 1st use of webcam
  - Trojan room coffee pot
  - Early 90s
  - Allowed remote view of a coffeepot, eliminating the need to walk to the Trojan room to see how much coffee was left
  - Done by professors at Cambridge University in England

## Still More Early Examples

- So connected devices are not a new idea
  - 1990 – A toaster that could be turned on and off using the internet
  - 1994 – The wearcam
    - Inspired by the Trojan Room Coffee Pot
    - Done by Steve Mann, MIT
    - He had a camera mounted backward on his head
      - He said it was for safety purposes so he could see what was coming up on him
    - He designed and built a video capture and transmission system to webcast his experience

## What, Exactly, Are We Talking About?

| S-E-N-S-E | What the Internet of Things does | How it differs from the Internet |
|---|---|---|
| **S**ensing | Leverages sensors attached to things (e.g. temperature, pressure, acceleration) | More data is generated by things with sensors than by people |
| **E**fficient | Adds intelligence to manual processes (e.g. reduce power usage on hot days) | Extends the Internet's productivity gains to things, not just people |
| **N**etworked | Connects objects to the network (e.g. thermostats, cars, watches) | Some of the intelligence shifts from the cloud to the network's edge ("fog" computing) |
| **S**pecialized | Customizes technology and process to specific verticals (e.g. healthcare, retail, oil) | Unlike the broad horizontal reach of PCs and smartphones, the IoT is very fragmented |
| **E**verywhere | Deployed pervasively (e.g. on the human body, in cars, homes, cities, factories) | Ubiquitous presence, resulting in an order of magnitude more devices and even greater security concerns |

## What Has Enabled This Explosion?

- ***Cheap sensors*** – Sensor prices have dropped to an average 60 cents from $1.30 in the past 10 years.
- ***Cheap bandwidth*** – The cost of bandwidth has also declined precipitously, by a factor of nearly 40X over the past 10 years.
- ***Cheap processing*** – Similarly, processing costs have declined by nearly 60X over the past 10 years, enabling more devices to be not just connected, but smart enough to know what to do with all the new data they are generating or receiving.
- ***Smartphones*** – Smartphones are now becoming the personal gateway to the IoT, serving as a remote control or hub for the connected home, connected car, or the health and fitness devices consumers are increasingly starting to wear.

## What Has Enabled This Explosion?

- ***Ubiquitous wireless coverage*** – With Wi-Fi coverage now ubiquitous, wireless connectivity is available for free or at a very low cost, given Wi-Fi utilizes unlicensed spectrum and thus does not require monthly access fees to a carrier.
- ***Big data*** – As the IoT will by definition generate voluminous amounts of unstructured data, the availability of big data analytics is a key enabler.
- ***IPv6*** – Most networking equipment now supports IPv6, the newest version of the Internet Protocol (IP) standard that is intended to replace IPv4. IPv4 supports 32-bit addresses, which translates to about 4.3 billion addresses – a number that has become largely exhausted by all the connected devices globally. In contrast, IPv6 can support 128-bit addresses, translating to approximately 3.4 x $10^{38}$ addresses – an almost limitless number that can amply handle all conceivable IoT devices. (34 Undecillion – that's the number 34 followed by 39 zeros) (The "c" is pronounced like an "s")

## Popular Devices In Use Today

- Alexa
  - Amazon Personal Assistant
  - Works with Amazon devices – i.e. Echo, Echo Dot
  - Controversial
    - Is it spying on us?
    - It's always on
    - Stores snippets of what it hears
    - A kindergartner ordered a dollhouse and cookies
    - Was witness to a murder
      - This case is still in the courts
      - Amazon framing it as a 1st amendment issue

## Smart Thermostats

- Nest is best known
  - Works with Alexa
  - Learns your preferences
  - Can be programmed from your phone
- Ecobee, Honeywell, Sensi
  - All work with Alexa
  - All can be programmed with your phone

## And Speaking Of Nest

From the S.F. Chronicle last week


**New Nest device can spot family, intruders**

Security camera uses facial recognition to ID, announce friends, pets

… algorithms that recognize familiar faces.

… for a $10-a-month subscription, a smartphone alert will notify you the next time a person who's been identified, appears on the camera.

## Smart TVs

- LG
- Samsung
- Sony
- Most major brands
- Are they listening?
  - Probably
  - You can turn these features off, but they typically don't tell you about this

## And Speaking of TVs

Have you heard about ATSC 3.0?


## This Means Smarter TVs

- Surveys indicate that people are fearful of Smart TVs listening
- ATSC 3.0 has some compelling reasons to get us to change our minds
- The ATSC 3.0 standard supports 4K resolution with high dynamic range.
  - Features include:

## ATSC 3.0 Features

- Being able to start programs at the beginning even after they have already started
- Personalized on-screen guide with recommendations
- Custom home screens based on viewer preferences
- On-screen search of video on demand, streaming, and over-the-air TV programs

## ATSC 3.0 Features

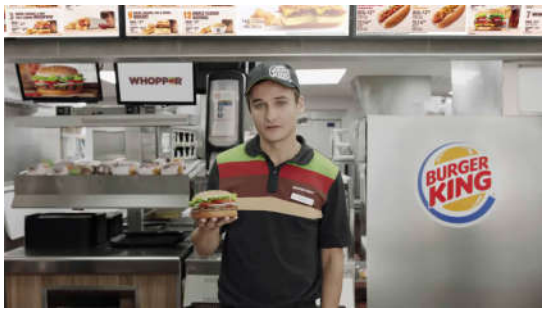
- Fast-forward and rewind to any scene on TV shows and sporting event
- Ability to zoom in and choose camera angles when watching sports
- Alerts when favorite shows, sporting events, or weather reports are airing
- Advanced emergency alerts based on location

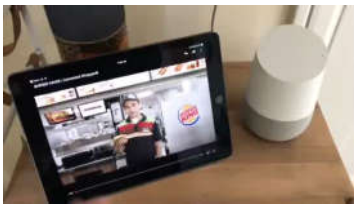
## TV Remotes

- Comcast X1 remote as an example
  - Talk to it
    - Watch channel XXX
    - Find such and such program
  - What happens to the data they collect?

## And, of course, smart phones

- Apple's Siri
- Google Home
- Both services listen and answer
  - What happens to the data?
  - Is it stored?
  - Is it sold?
- How about the latest Burger King commercial fiasco?



## Others

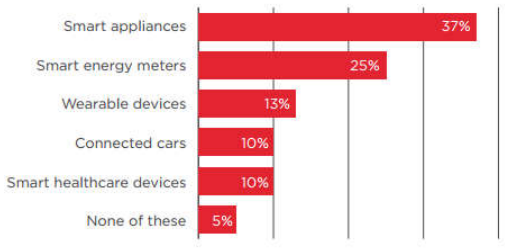
- Smart watches
- Fitbits
- Refrigerators
- Coffee makers
- Door locks
- Doorbells
- Light bulbs
- Baby monitors
- Crock pots
- Smoke Detectors
- Light switches
- Etc., etc., etc.

## How Large Is the IoT

| YEAR | NUMBER OF CONNECTED DEVICES |
|---|---|
| 1990 | 0.3 million |
| 1999 | 90.0 million |
| 2010 | 5.0 billion |
| 2013 | 9.0 billion |
| 2025 | 1.0 trillion |

**Estimate By Analytics Vidhya**

## What Are The Likely Uses?




**GSMA Report**

## Future IoT Uses

- Smart Cities
- Smart Environment
- Smart Water
- Smart Metering
- Security & Emergencies
- Retail
- Logistics
- Industrial Control
- Smart Agriculture
- Smart Animal Farming
- Domestic & Home Automation
- eHealth

## Smart Cities

- **Smart Parking -** Monitoring of parking spaces availability in the city.
- **Structural health -** Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.
- **Noise Urban Maps -** Sound monitoring in bar areas and centric zones in real time.
- **Smartphone Detection -** Detect iPhone and Android devices and in general any device which works with WiFi or Bluetooth interfaces.
- **Electromagnetic Field Levels -** Measurement of the energy radiated by cell stations and and WiFi routers.
- **Traffic Congestion -** Monitoring of vehicles and pedestrian levels to optimize driving and walking routes.
- **Smart Lighting -** Intelligent and weather adaptive lighting in street lights.
- **Waste Management -** Detection of rubbish levels in containers to optimize the trash collection routes.
- **Smart Roads -** Intelligent Highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.

## Domestic & Home Automation

- **Energy and Water Use -** Energy and water supply consumption monitoring to obtain advice on how to save cost and resources.
- **Remote Control Appliances –** Remotely switching appliances on and off to avoid accidents and save energy.
- **Intrusion Detection Systems -** Detection of windows and doors openings and violations to prevent intruders.
- **Art and Goods Preservation -** Monitoring of conditions inside museums and art warehouses.

## eHealth

- **Fall Detection -** Assistance for elderly or disabled people living independently.
- **Medical Refrigerators -** Control of conditions inside freezers storing vaccines, medicines and organic elements.
- **Sportsmen Care -** Vital signs monitoring in high performance centers and fields.
- **Patients Surveillance -** Monitoring of conditions of patients inside hospitals and in old people's home.
- **Ultraviolet Radiation -** Measurement of UV sun rays to warn people not to be exposed in certain hours.

## Interesting Example

**Do you hear what Bose hears?**

An Illinois lawsuit claims that **Bose** is selling information about users' listening habits without permission. Kyle Zak, who bought a $350 pair of wireless Bose headphones, said he downloaded the **Bose Connect** app, which the company said would add functions. But according to his complaint, it also gave Bose and a data-mining company access to his listening data, which the suit says might include podcasts or other audio files that could yield information about a user's political preferences, health or other interests. Bose did not comment on the suit.

## Interesting Example

### Ring Wi-Fi Enabled Doorbell

- See, hear and speak to anyone at your door from your smartphone, tablet or PC.
- Get instant alerts when visitors press your Doorbell or trigger the built-in motion sensors.
- Watch over your home in crystal-clear HD video.
- Protect your home – day or night – with infrared night vision.
- Communicate with visitors via two-way audio with noise cancellation.
- Check-in on your property at any time, and get streaming video and audio with Live View.
- Set up your Doorbell in minutes with the included tool kit and installation guide.
- Dual-powered: Runs off the internal battery or can be connected to existing Doorbell wiring.
- Lifetime purchase protection: If your Ring Doorbell gets stolen, we'll replace it for free!
- Compatible with iOS, Android, Mac and Windows 10 devices.

## Interesting Example


Ring Wi-Fi Enabled Video Doorbell

## Mark Zuckerberg's Webcam

## What To Do?

**Tech support...**
How to keep your gadgets honest

- **Blind your webcams.** Now that we've all heard the CIA can spy on us through certain smart TVs, it's time to reassess what data your internet-connected devices are collecting. Hackers can hijack a computer's webcam, for example, so use tape or a webcam cover to block the lens when you don't need it.
- **Limit tracking.** Many apps, including Facebook, ask to use your location or your phone's microphone. In your phone's settings, you can choose which apps have access to which data. While you're at it, consider turning off your phone's voice-recognition functions—better known as Hey Siri (iOS) or OK Google (Android). Some smart TVs log information on your viewing habits, too, so search the menu to disable data collecting.
- **Strengthen your passwords.** You probably know strong passwords are a must to keep hackers at bay. But whenever possible, establish two-factor authentication as well.

*Source:* Time.com

## Are We At Risk?

- Is that connected tea kettle really a problem?
  - No, but ….
  - What if a hacker used it to get control of our home network?

## Breach Possibilities

- Recent security breaches
  - Target
  - Yahoo (at least twice)
  - Sony
  - Etc., etc., etc.
- Security experts predict that a major IoT breach will occur within 2 years.
  - It will be traced back to an unsecured IoT device

## Breach Possibilities

- Why hasn't it happened yet?
  - Hackers currently have little interest
  - The devices are easily hacked, as they aren't very secure, but …
  - They are not ubiquitous yet
- It's predicted that within the next 2 year period there will be some shiny new product that we get enamored with that is adopted quickly (think iPhone) and then watch out!!

## How About Automobiles?

- How could cars be a problem?
  - Remote entry systems use a short distance radio transmitter
  - There are various kinds of systems
    - Just lock and unlock the car
    - Start and stop the engine
    - Both of these function without a physical key
  - These systems can be hacked from afar
  - There are many documented cases already

## Other Auto Breach Possibilities

- Carrying our surveillance on you
- Remote disabling of brakes
- Risk of ransomware
- Even terrorism
  - Taking over automobile steering would be disastrous

## Summary

- Why isn't more being done?
  - IoT in the internet age is so new that no standards exist (yet)
  - Device vendors have not had sufficient reason to push for standards (yet)
- What kinds of standards?
  - Encryption
  - Firewall configuration
  - Device authentication

**Questions ?**