Smart Home

IOT Freshman Seminar
Tue Oct 10, 2023

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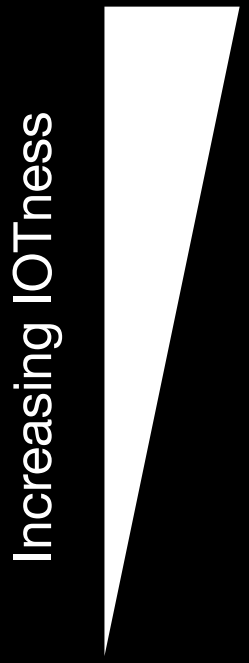
IOT Systems we have covered

What is the “IOTness” of each of these?



- Shared Rideables

  Cloud collects rideable sensor data and can flag for repair or even control its behavior based on speed and location. Can build daskboards to examine usage on a map —>> city planning!

- Ride Share

  Cloud computation to pair rider with driver

- Maps

  Many phones transmitting GPS position to cloud and all info comes back to your App to show crowd behavior

- GPS

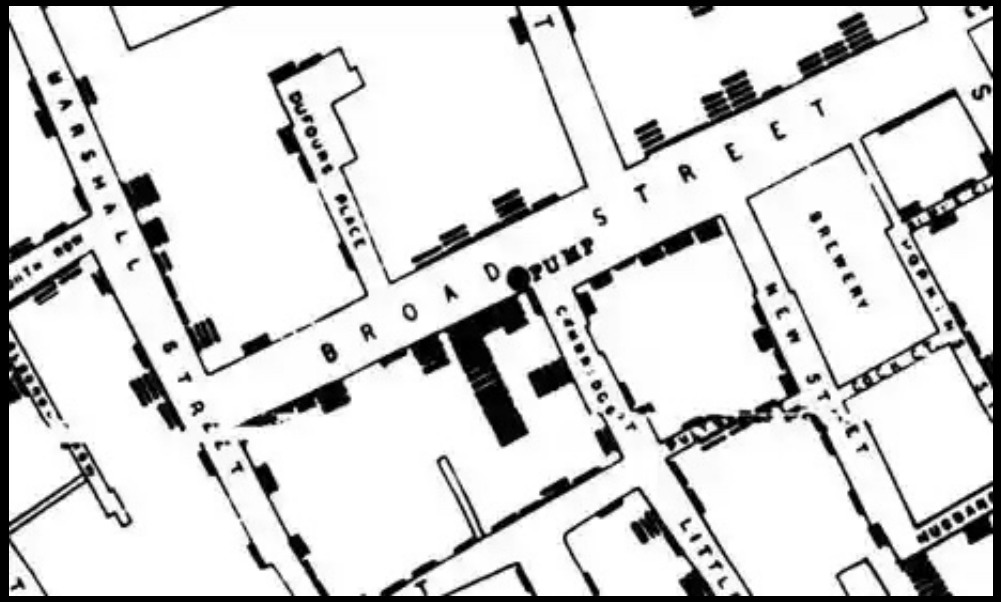
  Phone gets coordinates and can transmit to cloud with selected Apps

Many IOT systems result in aggregated data in a map …

The cholera map that changed the world

John Snow's 1854 London Cholera Outbreak

Mapped Cholera outbreak in London (1854)

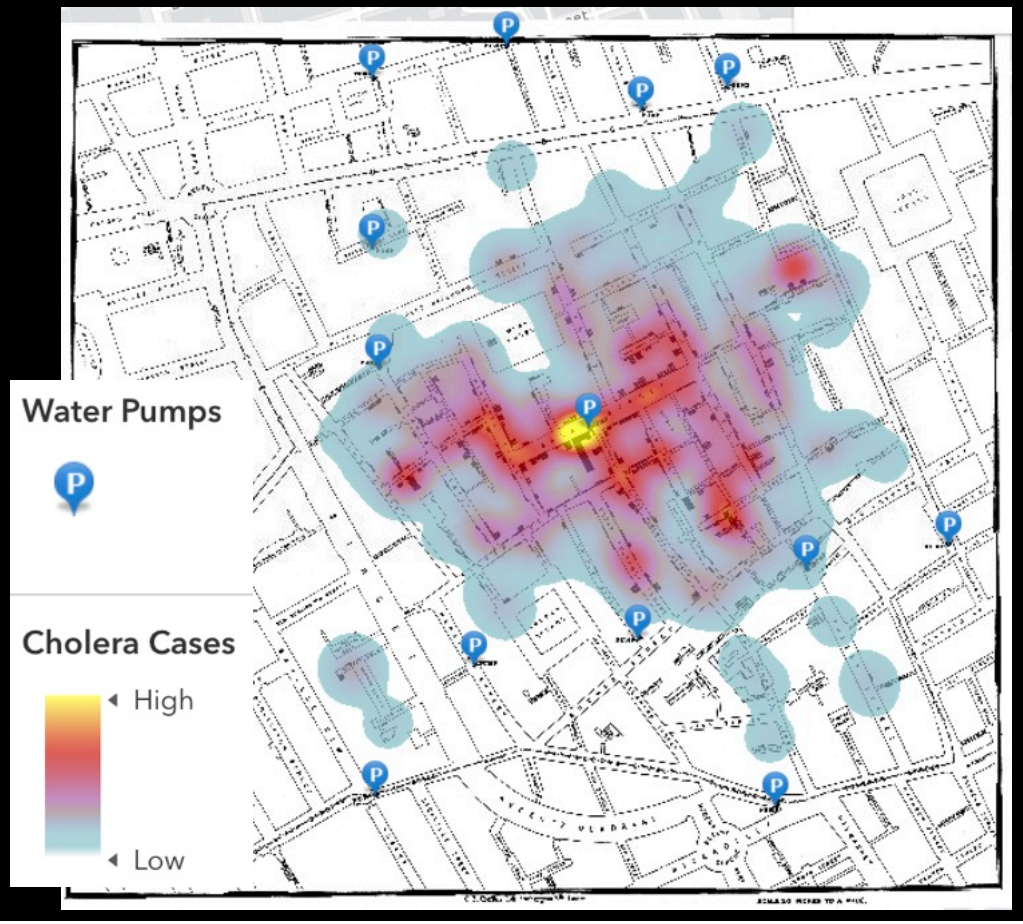


https://learn.arcgis.com/en/projects/map-a-historic-cholera-outbreak/
https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map

The cholera map that changed the world

John Snow's 1854 London Cholera Outbreak

- Cholera is an acute, diarrheal illness caused by infection of the intestine with a toxigenic bacterium (e.g a bacterial infection)
- In the 1800's, we did not know about bacteria!
- This map showed us that the spatial distribution of cholera was correlated with **some** water pumps but not others
- First indication of how it spread (through water contamination)
- This map helped lead the way to water sanitation



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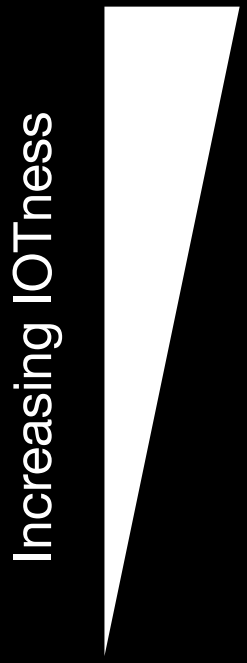

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How does a given IOT fit into this 6-level framework?

IOT LEVEL	FEATURES	EXAMPLES
6	New features not included in levels 1-5	The future of the IOT
5	Remote data is processed and resulting information is sent back to things that take action	Shared Rideables “Smart” Home To Control Devices
4	Remote data is processed and resulting information is sent back to things	Street maps, Uber
3	Thing that transmits data to a remote server on the internet for processing	“Smart” Thermometer to track Covid outbreaks
2	Thing that transmits data to a local server	Agricultural sensor: water, plant health
1	Thing that collects sensor data and stores it locally	Your phone GPS, Wildlife camera, Monitoring a jet engine

Level 6: My prediction is that new and novel big data insights will spawn new applications. Big data is coming from: Ride-share, bike-share, GPS mapping data, and biometric data

When is an IOT the most useful?

“When it semi-automatically optimizes a complex process”

- **Maximize** profit like ride-share and shared rideables
- In the smart home, **optimizing** energy usage
- **Optimize** a manufacturing process
- **Optimize** product delivery
- **Optimize** traffic flow

Smart Home

Network Architecture

- You are at home with an internet connection
- You set up a local area network (LAN) including WiFi
- You connect devices to your Wifi LAN
- Now you can control devices locally (?) and remotely (?)

  Is “Alexa turn on the light” local or does it require the internet?

  1) For Alexa to understand your voice command, it needs to be processed on Amazon cloud servers

  2) Amazon servers send back a **bit** of info to turn on the light (like controlling a shared rideable)

Bottom line: Most/all “things” in the smart home are entirely local but require a round trip to the cloud and back in order to control them. Benefit of this system is you can control your home when you are away.

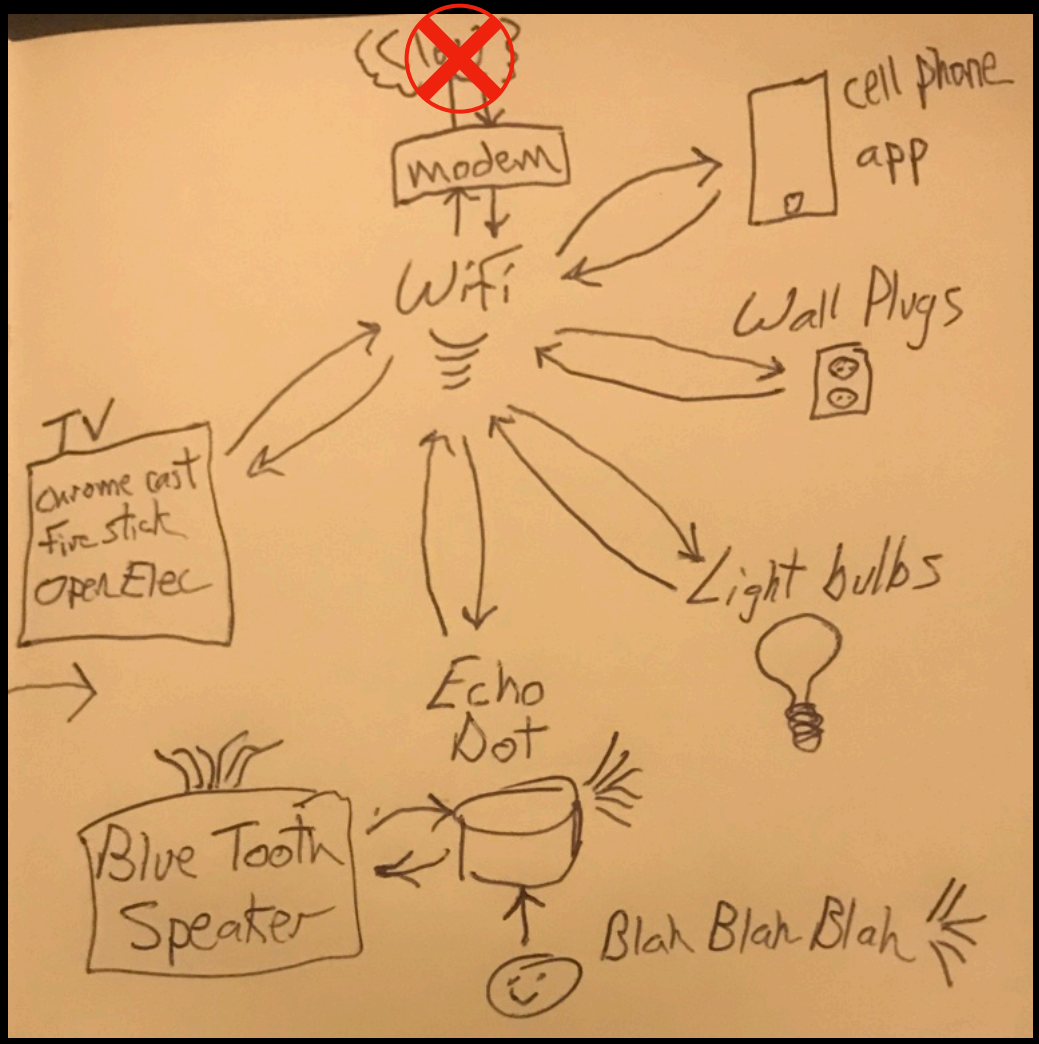
Smart Home

My Network Architecture

- All devices are connected to WiFi router (star topology)
- Sequence for voice command “Alexa, turn on light bulb”
- Echo Dot ➡ Wifi Router ➡ Cloud
- Amazon Cloud interprets my command (AI)
- Amazon Cloud generates signal to turn on light and optional Alexa voice response (AI)
- Cloud ➡ WiFi Router ➡ Light Bulb

What if there is no internet connection to the cloud?
Can I turn on my light with my voice?
Or, can I turn on my light with the Alexa cell phone app?

NOPE !



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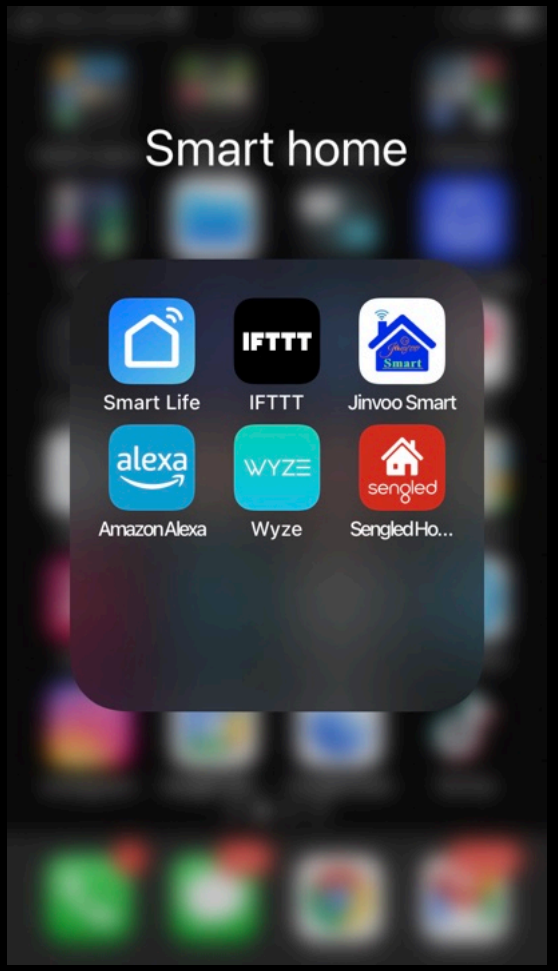
My Devices

- Internet connection with modem
- Router to create ethernet and WiFi local-area-network (LAN)
  - Alexa voice assistant (Alexa Dot), now have 3x
  - Smart plugs controlling: 3x lights, 1x fans
  - Smart Lights (dimmable, RGB so can set color)
  - Smart thermostat with a cell phone app
    - (not IOT) Google Chrome Cast, Amazon FireStick
    - (not IOT) Raspberry Pi running LibreElec (home theatre)
    - (sort of IOT) Raspberry Pi logging temperature, humidity, and air quality. Runs a web server and can check values when not at home (just for fun).
    - Two Arduino Nano ~~Huzzah32~~ microcontrollers: Collecting data and responding to commands via adafruit.io web



What is your favorite smart home thing?

How do you use your smart-home

- Controlling lights?
- Controlling thermostat?
- Asking a voice assistant questions or for information or to play music
- Something else?
- I don’t have any “things”

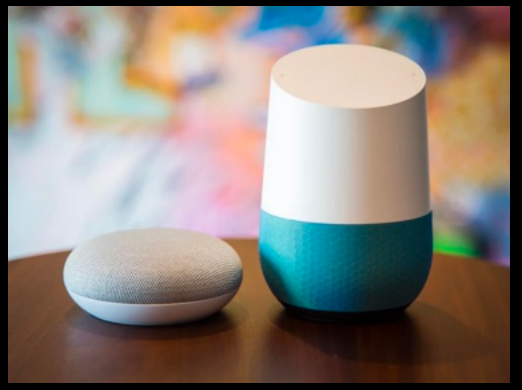
Smart Home

HEY, ALEXA. HEY SIRI. HEY GOOGLE. HEY, CAN ANYBODY HEAR ME??

- Con of voice activated system Alexa (Amazon, Google, Apple)

- Voice commands are require to be interpreted in the cloud (speech to text AI) and then signal sent back down to home network
- Surprisingly, cell phone apps to turn your home “things” on/off also requires the cloud (even if phone is on local wifi)
- If your home loses it’s internet, you can’t control your home with local voice commands or locally/remotely via the cell phone app!
- Especially annoying if (1) you are home and want to turn on the lights, (2) you are away and want to adjust something but the home internet goes out (for various reasons)

- Amazon



- Google

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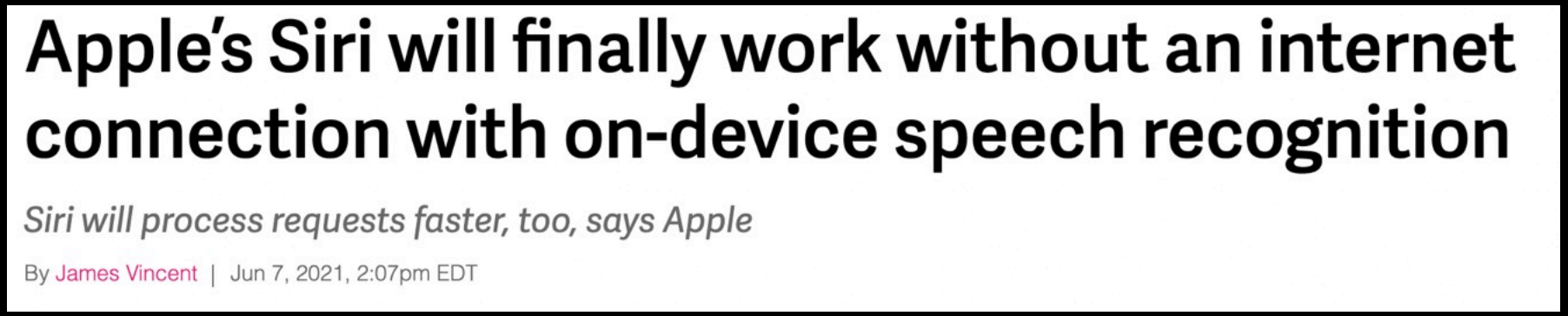
Controlling your home with no internet



Apple's Siri will finally work without an internet connection with on-device speech recognition

Siri will process requests faster, too, says Apple

By James Vincent | Jun 7, 2021, 2:07pm EDT

- Siri now works on newer iPhone/iPad models with no internet (assume a connection to local WiFi). As of iOS 15.
- Possible because Apple is interpreting voice commands (AI) on the mobile device (no cloud)
- "This addresses one of the biggest privacy concerns for voice assistants, which is unwanted audio recording"

https://www.theverge.com/2021/6/7/22522993/apple-siri-on-device-speech-recognition-no-internet-wwdc

Smart Home

Controlling your home with no internet - “Edge Computing”

- Hey Chat GPT, “What is edge computing”

Edge computing is a distributed computing paradigm that brings computation and data storage closer to the location where it is needed, **rather than relying solely on centralized cloud servers**. In edge computing, data processing and analysis are **performed locally on devices** or at edge servers, which are typically **located close to the data source or end-users**. This approach has gained popularity in recent years due to its ability to address some of the limitations of traditional cloud computing, especially in scenarios where low latency, real-time processing, and data privacy are critical.

- https://chat.openai.com/c/7cef5125-c749-451f-8e70-4e66af598b8e

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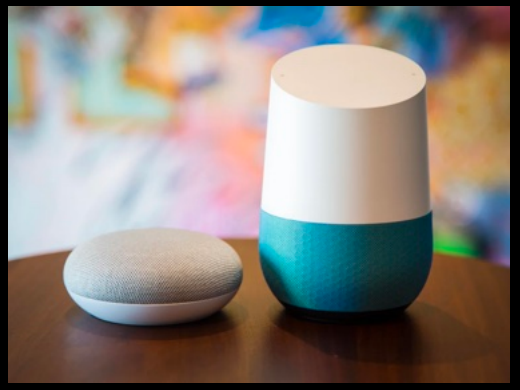
Controlling your home with no internet - “Edge Computing”

Why don’t amazon and google home devices do the same kind of edge computing?

Cost, iPhone is > $700 and Alexa dot is ~ $35

- Amazon



- Google

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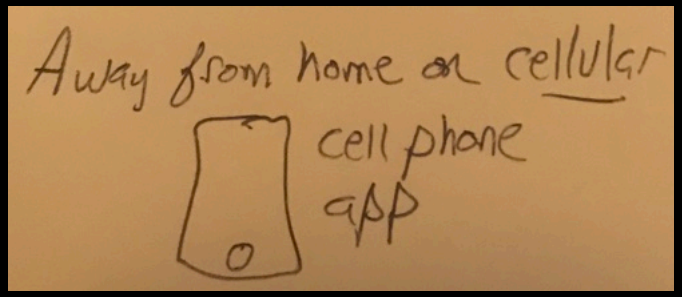
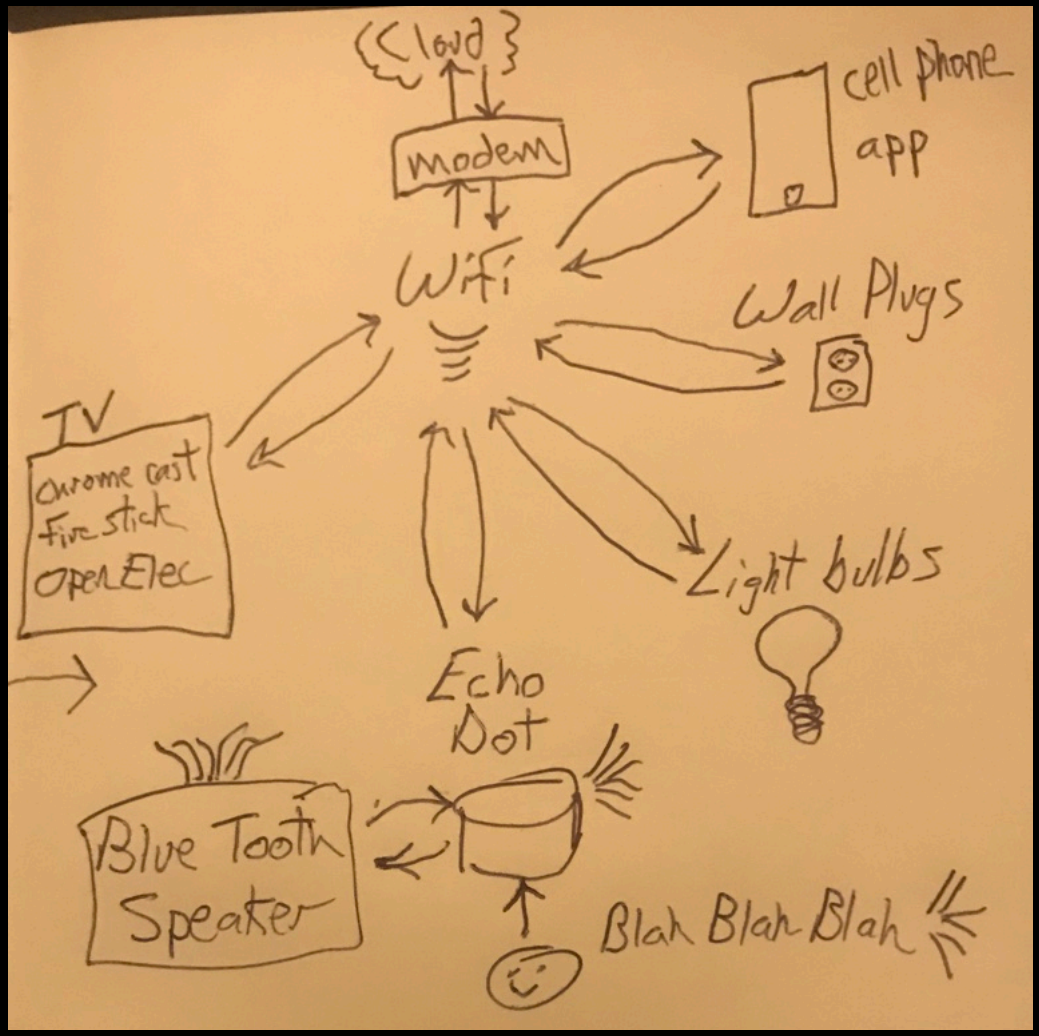
Benefits of requiring the cloud

- When home internet connection is on (cross your fingers)
- Can control your home through a cell phone app
- Even **<u>when far away</u>**, as long as your home and phone are on the internet.





Smart Home

My Smart home

08-02-21 | CONNECTED WORLD

The smart home is flailing as a concept—because it sucks

The smart home was supposed to be the next big computing platform. Now it seems lost in a fog of frustration.

- Is it really smart?
- Is there AI, in particular does it “learn”

  Will it tell me interesting things based on my previous interactions? Not really
- Is it simple to configure?

  No
- Is it robust and fault tolerant? Will it adapt to changes in connectivity?

  No
- When everything is working, is it pretty useful?

  Yes

https://www.fastcompany.com/90660570/the-smart-home-is-flailing-as-a-concept-because-it-sucks

Smart Home

Is all this “Artificial Intelligence”

- Sort of. A pet-peeve of mine is the overuse of the phrase “artificial intelligence” (AI)
- Lets use **“machine learning” (ML)**
- Interpreting your voice is ML and the algorithms are owned by the company (Amazon, Apple, Google)
- Generating speech is ML and again is proprietary
- Beyond that, not much more ML (in my opinion)
- If alexa/siri suggest something, it is clearly just **if-this-then-that**

  You asked to play “punk rock” music tons a ton of times, siri then asks “do you like these songs”

  This is based on a database of listening preferences. In my opinion it is not AI

  Alexa/Siri are not “learning” your behaviors, they are not adapting based on their history/ experience
- This bummed me out when I got an Alexa

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If This Then That (IFTTT)

- A cloud service that allow you to connect anything to everything
- Particularly useful because you can connect physical events to web based interfaces

  Text me at sunrise and sunset

  Send me a text when I receive email

  Log the day/time when I arrive at home and at work (phone is on a local wifi)

https://ifttt.com/explore/widgets-collection

Smart Home

Open Source (free) solutions

Home Assistant

- Home Assistant (https://www.home-assistant.io/)
- Open Hab (https://www.openhab.org/)
- Pros
  - Free to use
  - Open Source community are constantly making improvements, adding features, and improving security
  - You own and control your data
  - To control devices from your LAN, no round trip to cloud required. **Everything is local**
- Cons
  - Voice activation is basic, a set of pre-defined commands
  - Steep learning curve to set up simple devices

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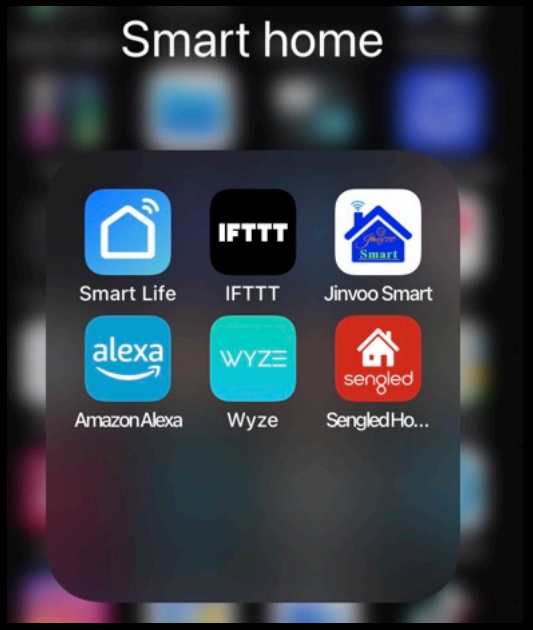
Maintaining all your home devices can be a pain

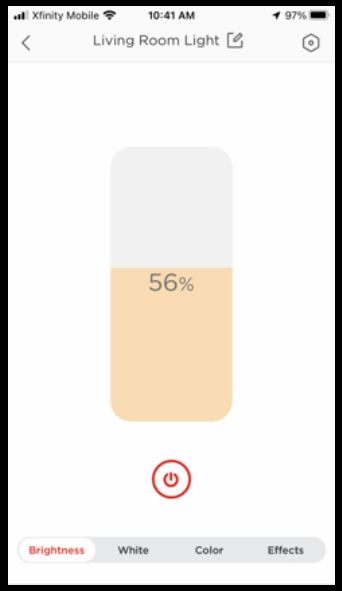


- Each device may communicate by different protocols

  Alexa does not control all smart plugs, lights, etc. etc

  You end up having to install a lot of different cell phone apps

Smart Home



- Two Smart Plugs
- One smart light
- Alexa seems to control all of them (requiring the cloud)
- They each have their own app (also requiring the cloud)

Another problem with the smart home is it lacks an agreed upon standard

What are some existing agreed upon standards?

Smart Home, 281 trillion things

Have you seen 281,474,976,710,656 things?

IEEE
Advancing Technology for Humanity

- MAC address: Media Access Control Address
- Used as a unique identifier assigned to a network interface controller (NIC). Like every house has a unique postal address
- Used in most IEEE 802 networking technologies, including Ethernet, Wi-Fi, and Bluetooth
- Yes, every device that has a local network connection has one of these! Even a light bulb. A unique identifier
- This 48-bit address space contains potentially 2^{48} (over 281 trillion) possible MAC addresses
- Address assignment is managed by the IEEE

2C:54:91:88:C9:E3

"Turn on kitchen light" works because kitchen light has a unique address

Smart Home

Two steps in standardizing and making the user experience simple

- ZigBee
- Matter

Smart Home

Zigbee Devices

- Wireless communication standard (not WiFi)

  IEEE 802.15.4 physical radio specification and operates in unlicensed bands including 2.4 GHz, 900 MHz and 868 MHz
- Requires a ZigBee chip (As compared to Wifi chip)
- Requires a ZigBee hub (As compared to WiFi router)
- Lower power (**devices can last 2+ years on battery**)
- Longer range
- Lower bandwith (can’t stream Netflix over ZiBee like you can WiFi)
- Zigbee devices can function without an internet connection ***
- Zigbee can be a mesh network ***

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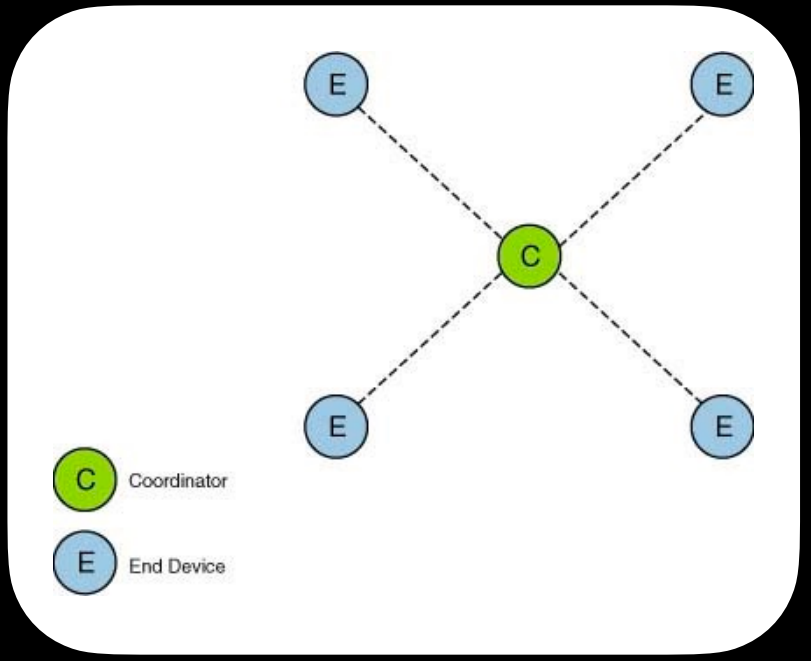
Zigbee Devices - Star Topology

- It is the simplest and most limited one in the Zigbee (similar to WiFi).
- A ***coordinator*** and a few ***end devices***.
- Devices are all connect to single coordinator node and all communication goes via this coordinator.
- The disadvantage of this topology is it may become hindrance and there is no optional path from the source to the end devices.
- If the coordinator goes out, nobody can talk to anyone else



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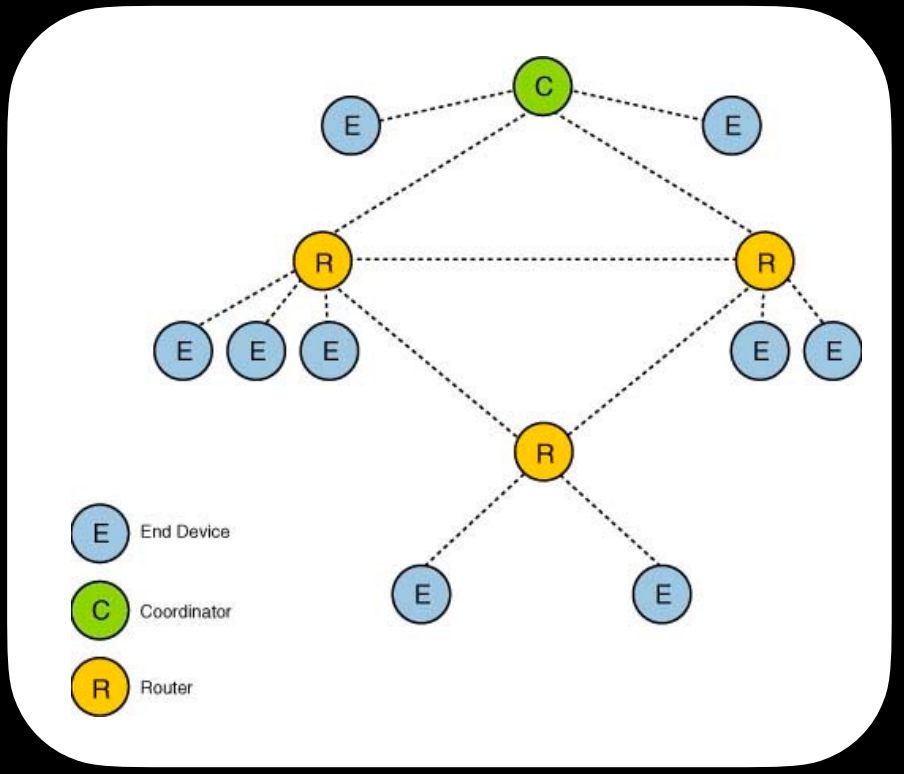
Zigbee Devices - Mesh Topology (aka peer-to-peer)

- One coordinator, a few routers and end devices.
- You can expand the network range by adding more **routers** into the network.
- Routers are interconnected with other routers so that multiple pathways connect each router.
- **Routers** can be normal plugged in devices like a smart-plug or a smart light-bulb.
- If one of the paths fail, the node will find an alternate path to reach to the destination therefore eliminating dead zones.
- Using this mesh topology it is easier to add or remove the device because they can communicate with any destination device in the network.



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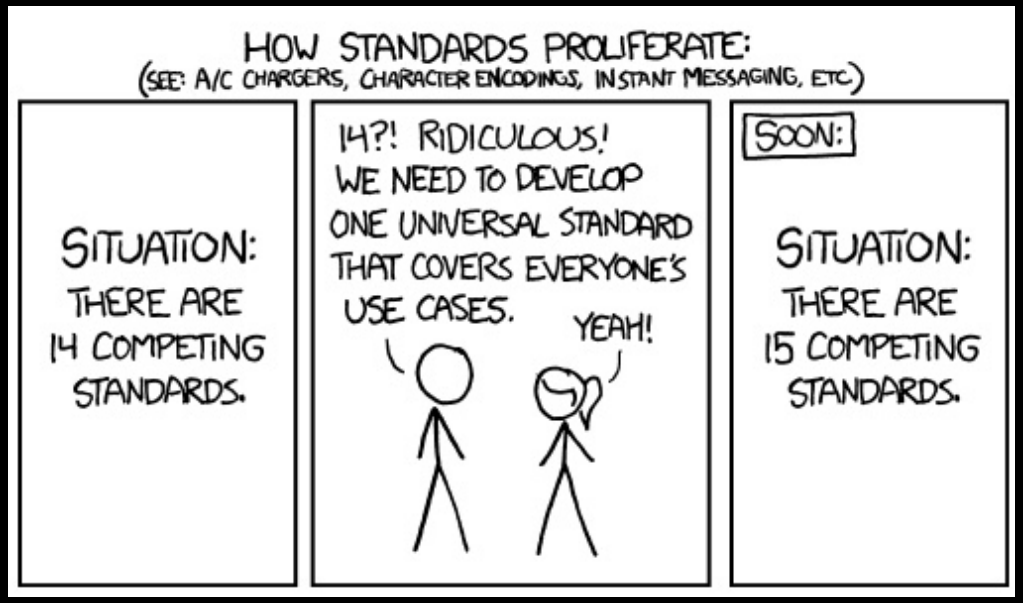
Standardized Protocols - We use these every day without thinking much about it

- WiFi (your laptop, phone, TV, and all things connecting to it)
- USB (plugging in a mouse, keyboard, or hard-drive) More than 14 different connectors :(
- BlueTooth (connecting a mouse, speaker, or your AirPods)
- HDMI (plugging in a monitor)
- Power Outlet Plugs (plugging an appliance into the wall, different in different regions of the world)
- Celcius and Fahrenheit
- Meters and Yards, centimeters and meters, …

Smart Home

Too Many Standards

- Big frustration right now is there is not one standard all devices use to communicate
- Image if all your USB plugs worked slightly different
- As it is a young technology, each company came up with their own way of doing things
- Problem is that some devices can’t talk to others
- Zigbee partially solved this dilemma but requires specialized hardware



Matter

Matter is the USB for home automation

- Matter is a home automation connectivity standard (Announced in 2022)
- Matter aims to reduce fragmentation across different vendors, and achieve interoperability among smart home devices and Internet of things (IoT) platforms from different providers
- Matter is a unified connectivity technology for the smart home. It is not a smart home platform like Apple HomeKit, Google Home, and Amazon’s Alexa.
- Matter doesn’t automate or control your home; it simply provides the pipes and language for devices to communicate.
- Developed as a collaboration between Amazon, Apple, Google, Comcast, and Zigbee (10’s more in the collaboration)

Matter

Matter is the USB for home automation

- We will see
- Lots of products introduced at CES 2022 (https://www.ces.tech/)
- As usual for IOT, lots of speculation

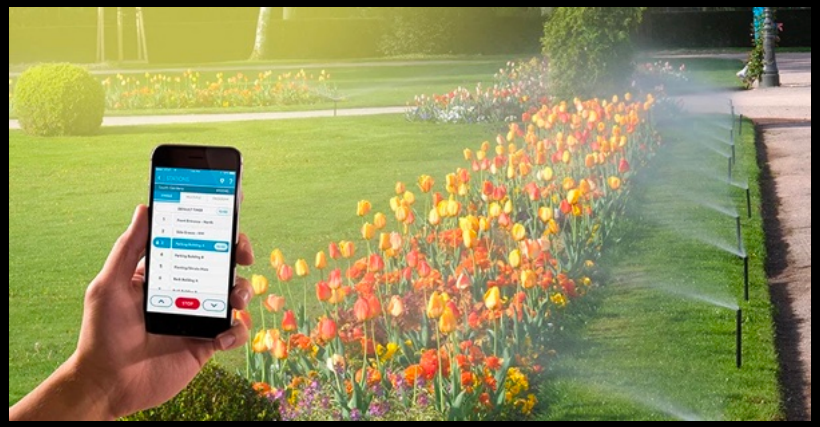
Smart Home

Useful “things”

- Irrigation (watering your lawn)
- Security:
  - Door bell with video camera
  - Video camera surveillance (exterior and interior)
  - Door locks
- Lights on/off
- Smart energy: Thermostat
- Smart energy: Energy hungry appliances (washers and dryers)

Smart Home

Watering Your Lawn (or crops)



- Self contained IOT
- Sensors can measure the moisture of dirt to signal when the lawn needs water
- If there is a distributed network of sprinklers, one part of lawn but not others can be watered
- Can **scrape** weather forecast to determine if water is necessary (is it going to rain later today)
- Control the timing, in NoCal you need to water in the morning and the evening

Smart Home
Security

- Both at the door and around the home
    - Video/Audio doorbell
    - Distributed Video/Audio surveillance
- Text/Email/App notification with a video clip when there is movement
- You can bring up the video/audio on your phone/browser whenever/wherever you want
- Popular use case is monitoring your kids in particular when there is a baby-sitter
- Another use case is for elder care (Alzheimers)
- New technology to alert when it detects glass breaking (announced at CES 2022)
- BlueTooth door locks: Used by AirBnB

Smart Home

smart energy : thermostat

- Thermostat to control heating/cooling when you are around and reduce energy/cost when you are not around
- **Thermostat can sense when you are around by looking for your phone on the local WiFi**
- It is useful to turn off heating/cooling remotely when you forget if you turned it off
- Compared to other “convenient” home IOT, this has potential to really reduce our overall energy consumption
- Can save you money

Smart Home

smart energy: energy hungry appliances

- Only run energy demanding appliances during off peak hours
- Will save you money
- Compared to most “smart home” devices, this could have a large impact
- If all washing machines would only run during off peak house, could reduce burning non-renewable resources
- California’s electricity grid reaches its peak level of usage between the late afternoon and early evening – a time frame in which electricity produced by renewable resources is less available and thus costs more to produce.

https://www.intuz.com/blog/iot-application-in-smart-washing-machine

Smart Home

smart energy: energy hungry appliances

- Lets have a look at a **smart washing machine** advertisement

  https://www.intuz.com/blog/iot-application-in-smart-washing-machine

- Lets make it better

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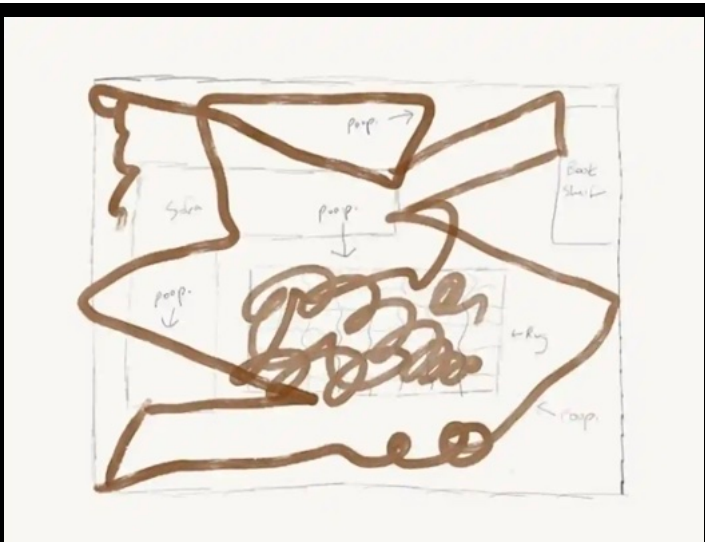
IOT Fail: poopocalypse



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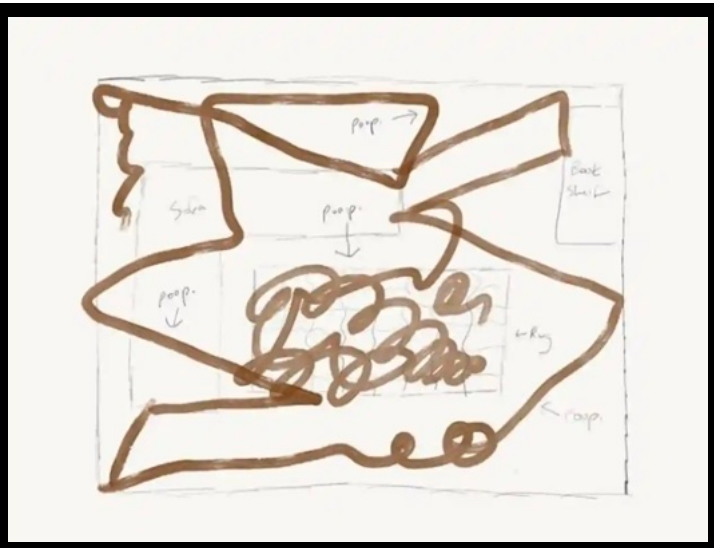
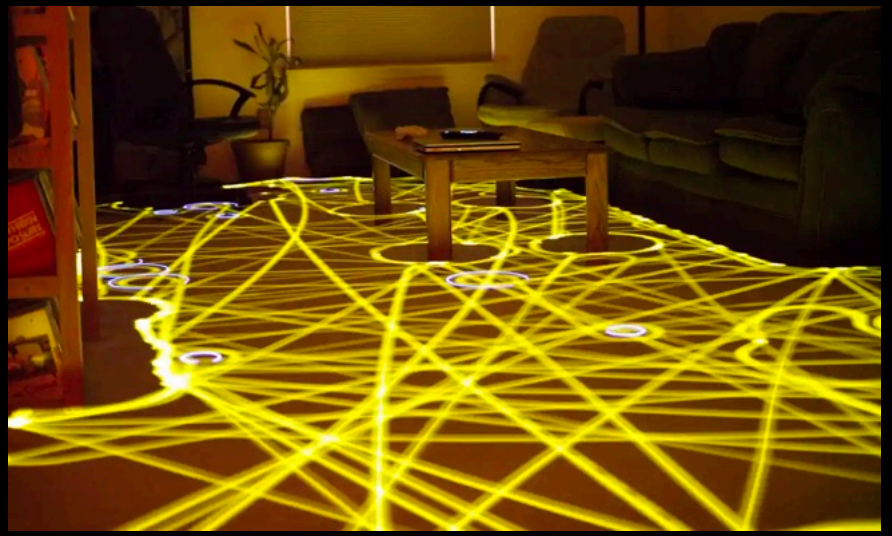
IOT Fail: poopocalypse

- Roomba robot often spreads dog poop all over a house.
- “It will be on your floorboards. It will be on your furniture legs. It will be on your carpets. It will be on your rugs. It will be in your kids’ toy boxes. If it’s near the floor, it will have poop on it. Those awesome wheels, which have a checkered surface for better traction, left 25ft poop trails all over the house,”
- Roomba is now mapping your home and looking for “changes” or new things on the floor and can avoid them
- People are wary because this is done in the cloud, Roomba has the layout of your house.





https://www.theguardian.com/technology/2016/aug/15/roomba-robot-vacuum-poopocalypse-facebook-post

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- In the smart home, **optimizing** energy usage
- **Optimize** a manufacturing process
- **Optimize** product delivery
- **Optimize** traffic flow

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