

Smart Cities, Edge Computing

IOT Freshman Seminar
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Today's Overview

- Smart cities actually using IoT

Chicago IL and Louisville KY (air quality)

- Edge Computing

- IOT Fails

Security Cameras with default password

Smart Cities

Chicago - Array Of Things

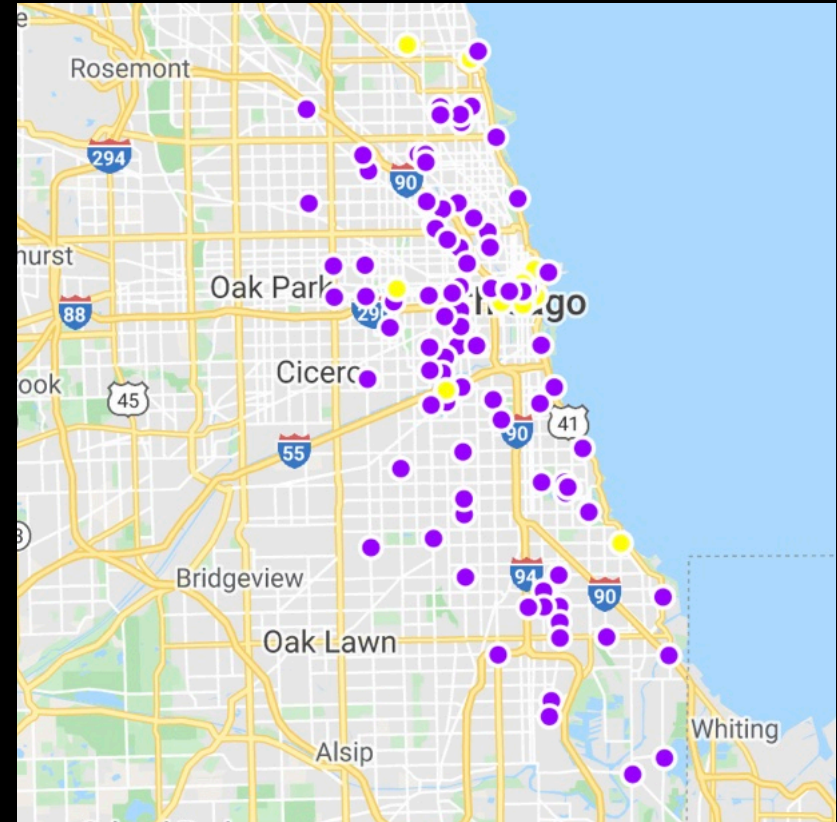
Chicago - Array Of Things

- What if an app told you the most populated route for a late-night walk to the El station by yourself?
- What if you could get weather and air quality information block-by-block, instead of city-by-city?
- What if a light pole told you to watch out for an icy patch of sidewalk ahead?

Smart Cities - Chicago - Array Of Things

Where are the sensors and how many?

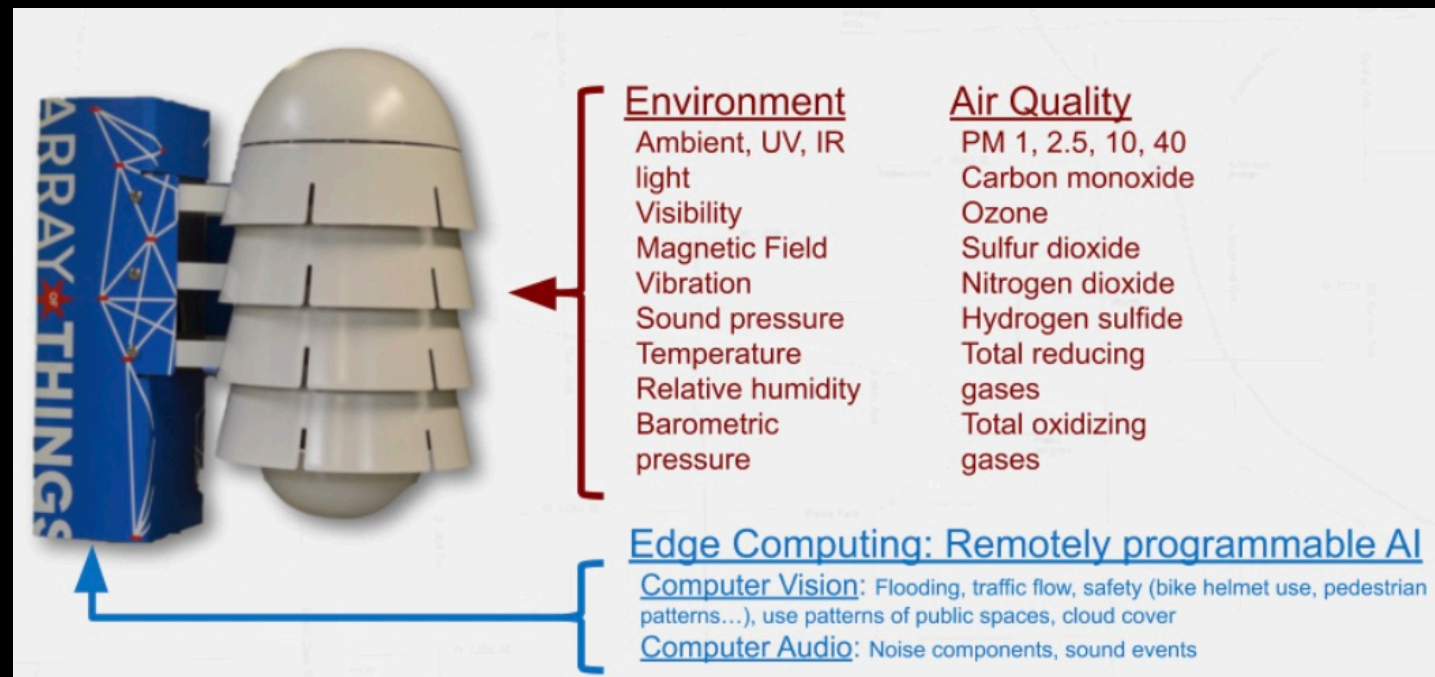
- (2018) Had about 100 sensors



Smart Cities - Chicago - Array Of Things

What Do They Measure?

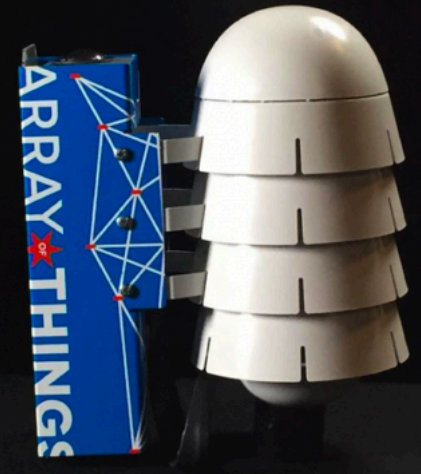
- Environment
- Air Quality
- Video to estimate automobile and pedestrian traffic
- Audio to measure noise levels



Smart Cities - Chicago - Array Of Things

Is it a success?

- ... it seemed to be more of a proof of concept
- They did make their sensors “field programmable” software could be upgraded from the cloud. This is also called “over the air” or OTA.
- Included safety checks to shut down the sensors if too hot, cold, wet
- They did implement an interesting system of “**edge computing**” where video and audio was processed within the “thing” and final analysis was sent to the cloud
 - For example, counting the number of pedestrians, cars, and bikes at an intersection
 - Once analysis was done just **3 numbers were transmitted**
 - Video and audio was immediately deleted
 - This removes any possibility of using video/audio for any other purpose



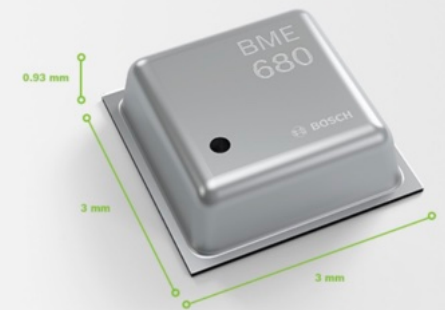
Deleting
personalized data
is really good
practice!

Smart Cities - Chicago - Array Of Things

The data is public and real-time

- Get all the sensor data in the last hour
- <https://github.com/waggle-sensor/waggle-beehive-v2/blob/main/docs/querying-measurements.md#query-api>
- ```
curl -H 'Content-Type: application/json' https://data.sagecontinuum.org/api/v1/query -d '{
 "start": "-1h",
 "filter": {
 "name": "env.*"
 }
}'
```

Gas sensor BME680



- \$20 sensor
- Each Array Of Things “Thing” was ~ \$500



```
{"timestamp":"2023-11-06T17:36:24.36061952Z","name":"env.wind.magnitude","value":0.06,"meta":{"host":"000048b02d3ae327.ws-nxcore","missing":"-9999.0","node":"000048b02d3ae327","plugin":"registry.sagecontinuum.org/gar305/windsonic-2d:0.0.4","sensor":"windsonic60","task":"windsonic-2d","units":"metres/second","vsr":"W04D","zone":"core"}}
```

# Smart Cities

AIR Louisville

# AIR Louisville

## Methods - 2015

- Gave 1,147 residents a sensor that fits on top of their **inhaler**
- Tracks locations of inhaler use with the intention of helping residents manage asthma.
- Collected 5,400 data points over the 13 months of the initial phase and has started identifying hotspots with high inhaler use in order to pinpoint areas with particularly bad air quality.
- AIR Louisville has since expanded to 2,000 residents
- The goal is to not only help residents with asthma, but also of informing city leaders of air quality concerns in order to direct policy.
- With more residents navigating the city with the sensors, the city will get a more complete picture of air quality across Louisville

# AIR Louisville

## Methods

- Bluetooth to connect any inhaler to a smart-phone
- Transmit inhaler use to the cloud (along with GPS coordinates)
- Provide feedback to user on amount of usage
- Where on the map they were using their inhaler
- This feedback could provide a preemptive system so asthma sufferer would have fewer critical event

<https://propellerhealth.com/>



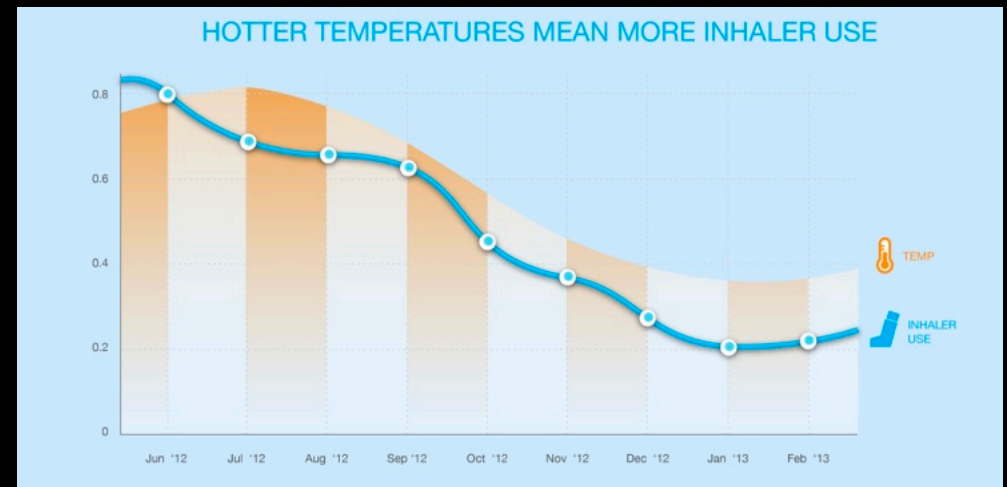
# AIR Louisville

This is similar to tracking Flu and Covid with smart thermometers

# AIR Louisville

## Data Analysis

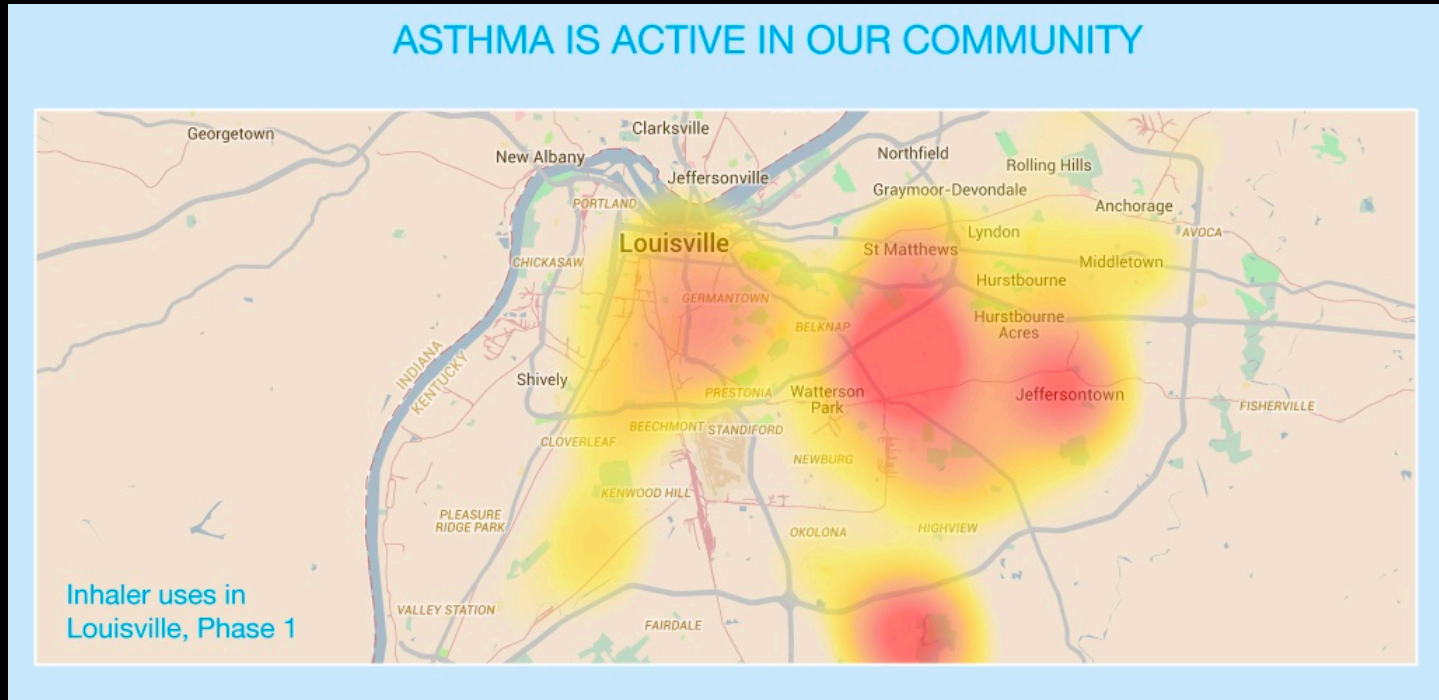
- Again, proof of concept. This data is from 2012-2013



- Like other smart city or community based IoT ... We already know this is true
- But ... This kind of data provides compelling evidence that some action needs to be taken

# AIR Louisville

## Data Analysis

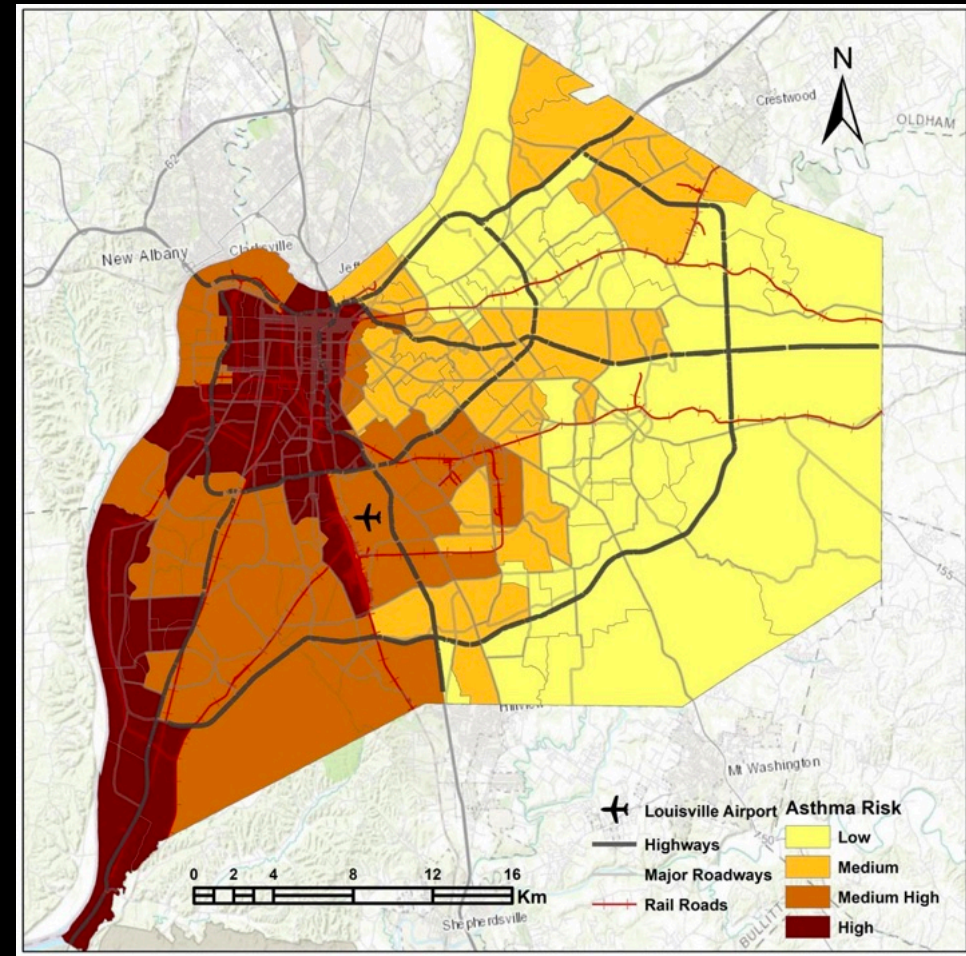


- Mapped Inhaler Use

# AIR Louisville

## Data Analysis

- Create a map of asthma risk for each neighborhood
- Found that rescue medication use happened more often on days with higher temperatures and air pollutant levels, including: Nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>) and sulfur dioxide (SO<sub>2</sub>).
- Calculated the healthcare costs of living in polluted air ...

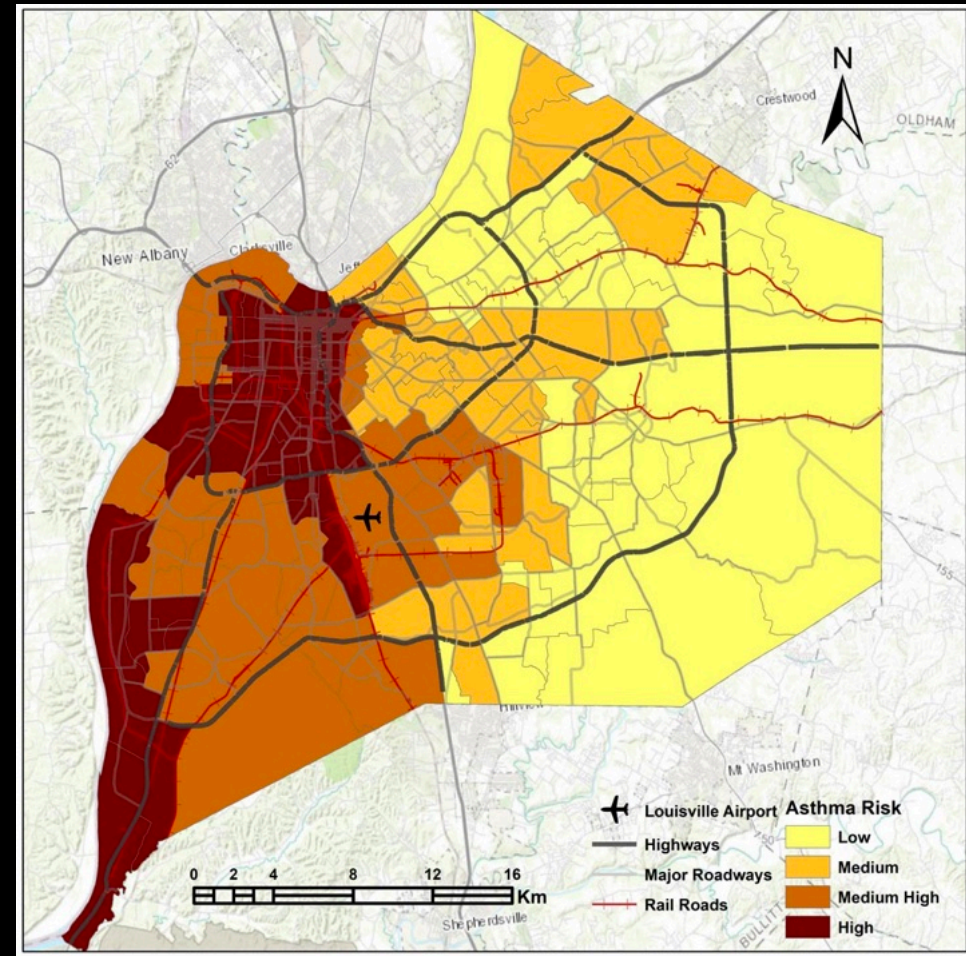




# AIR Louisville

## Health Care Costs

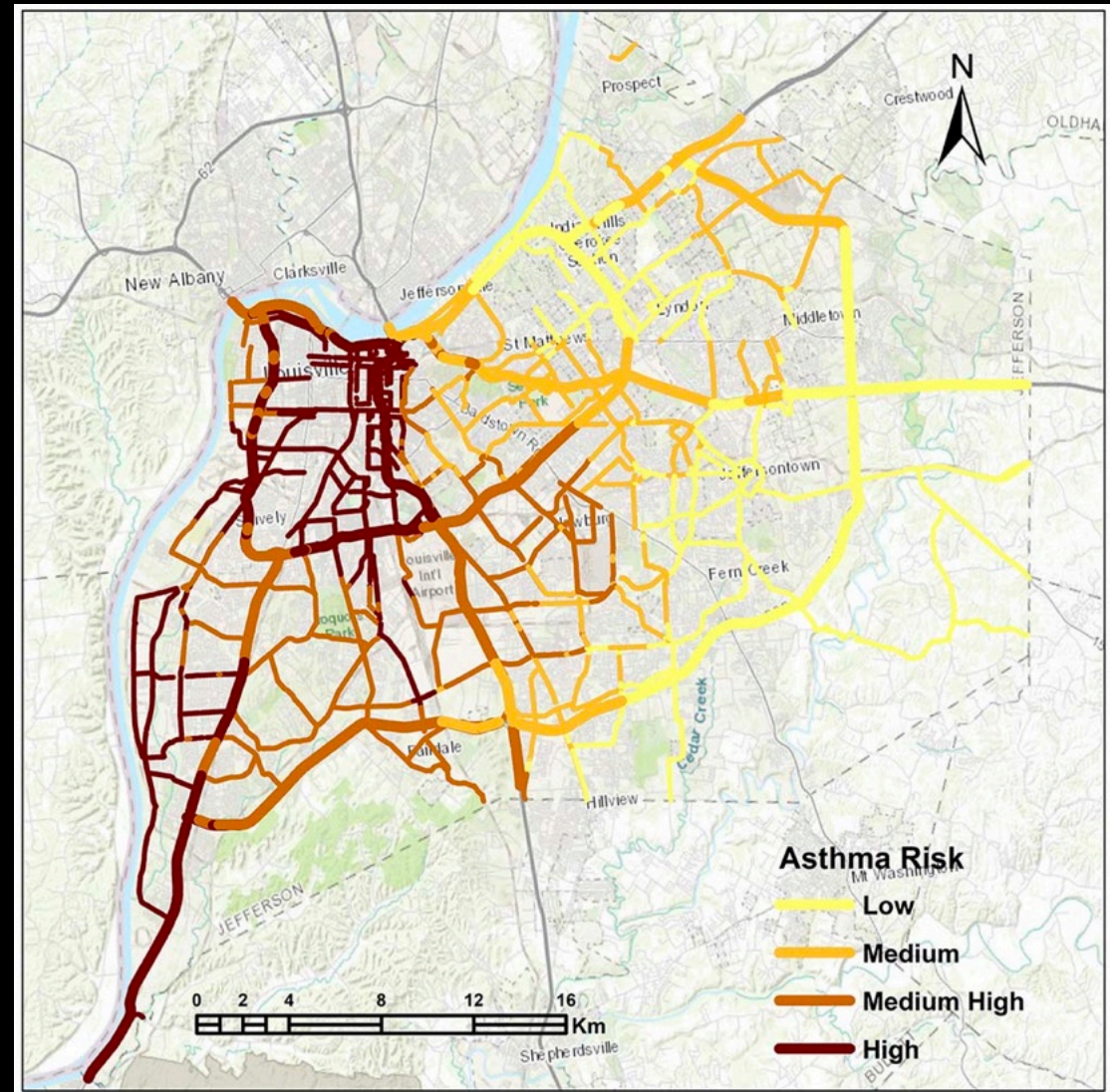
- When ozone exceeds the EPA limit of 70 parts per (ppb), the community could expect to see more than 65,000 asthma rescue inhaler uses.
- Adds up to healthcare costs of up to \$129,000 on just that day.
- In 2016, ozone exceeded the 70 ppb limit on 19 days
- Translates to more than \$2.4 million in healthcare costs.



# AIR Louisville

## Asthma Risk

- Correlate asthma risk with other environmental measures

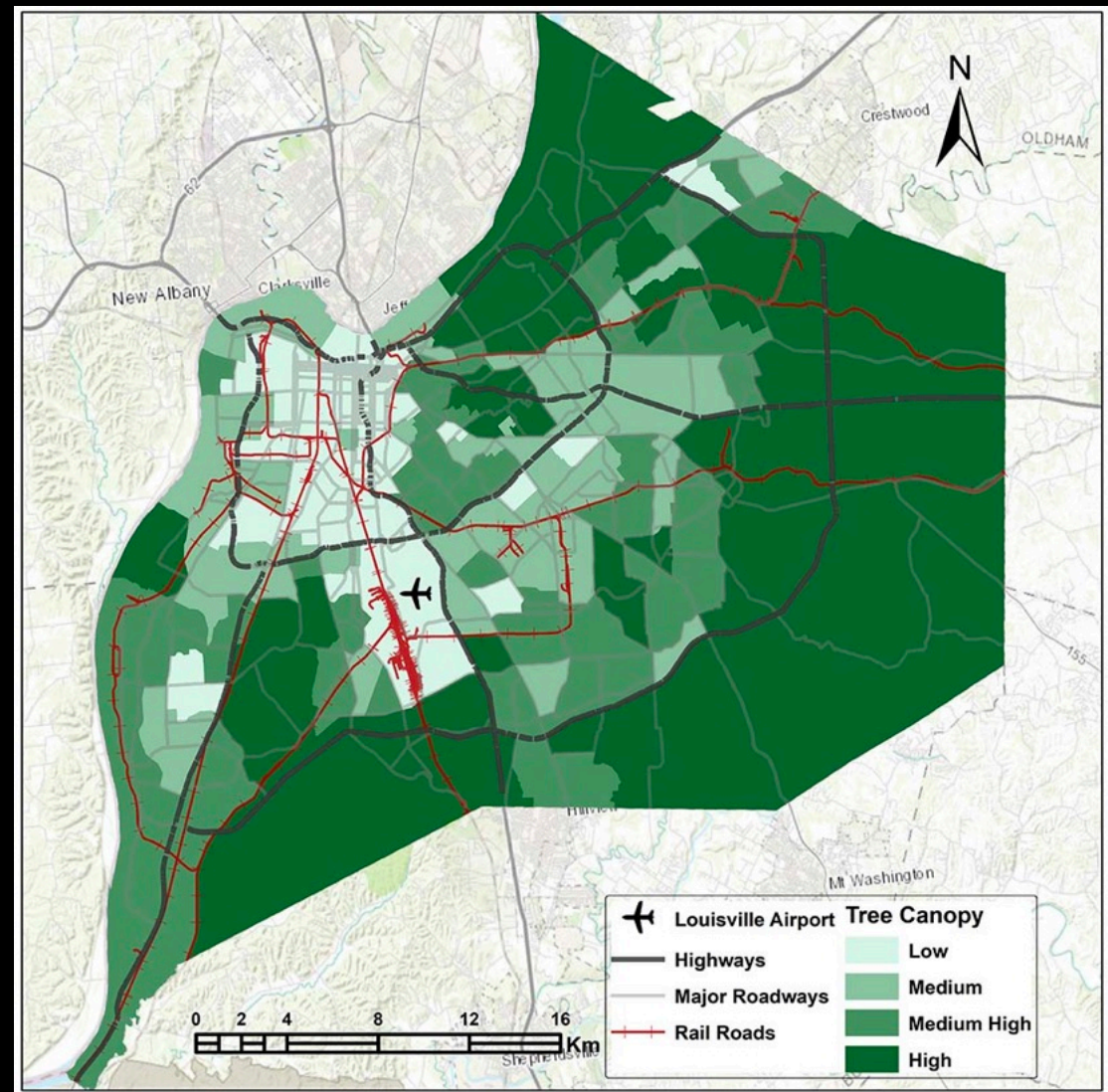




# AIR Louisville

## Tree Canopy

- Correlate asthma risk with other environmental measures
- Lack of trees are often at the root of low quality of life



# AIR Louisville

## Results

- AIR Louisville helped participants improve their asthma and COPD
- Over 12 months
- This was by providing IoT feedback about the spatial location of pollutants



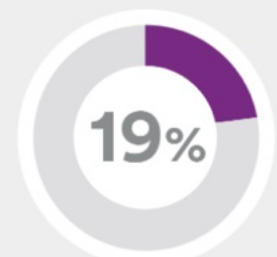
An average of 82% reduction in asthma rescue inhaler use



29% of uncontrolled participants gained control of their asthma



On average, AIR Louisville participants more than doubled their symptom-free days



AIR Louisville participants slept better, with an average 19% increase in symptom-free nights

<https://www.airlouisville.com/results.html>

# AIR Louisville

## What actions were taken based on this IoT data?

- Taking a number of steps to reduce asthma and COPD triggers, and make the City better for people with respiratory disease.
- Increasing tree coverage in high risk asthma areas.
- Identifying alternative truck routes that would route trucks away from high risk neighborhoods, thereby reducing diesel emissions in these areas
- Providing Propeller's Asthma Forecast Card to all citizens of Louisville via their Smart Louisville automated alert system
- **Considering** changes to city-wide zoning policies to address the health impacts of highways and industrial emissions.
- <https://propellerhealth.com/>

# Smart Cities

## Common Themes

- To date, no city (I know of) have installed a permanent IoT to measure things like localized ground temperature or air quality
- These IoT systems do exist at the macro scale (NOAA, USGS, NWS), weather and air quality maps we use every day
- Most results lead to “suggestions” for how to change the city. Are there examples where cities have actually taken action?
- Why are cities not routinely implementing these systems?

# Smart Cities

## Common Themes: Barcelona, Chicago, Louisville

- Why have cities not set up permanent and real-time IoT?
- High cost of sensors (air quality sensors are expensive)
- High cost of maintaining sensors
- High cost of maintaining networks for data transfer
- Yet, this is what originally created the IoT: **low cost** sensors, computing and networks
- What other high costs are involved ???

# Smart Cities

## What are the common goals?

- Inform citizens
- Allow data to be analyzed by researchers
- Inform city planning

- When do they work?

I would say they work when the community is involved with data collection

Noise pollution in Barcelona Spain and Asthma inhalers in Louisville KY



# Edge Computing

# Edge Computing

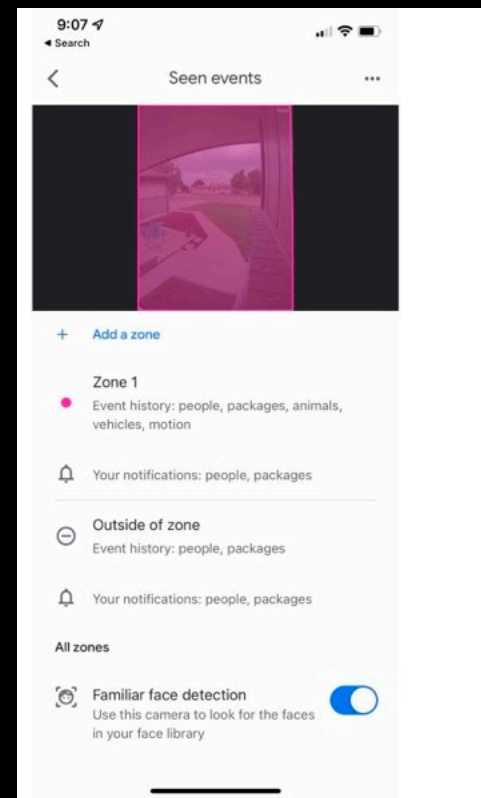
**Problem with current IoT architecture**

**... Too much data goes into the cloud for processing and storage**

# Edge Computing

## Extreme Example - Video/Audio doorbells

- Imagine if everybody's smart porch video and microphone sent everything to the cloud
- 24/7
- Or if you had a business with 10-15 cameras transmitting all their video/audio data to the cloud
- This would be an absurd amount of data



# Edge Computing

## Extreme Example - Video/Audio doorbells

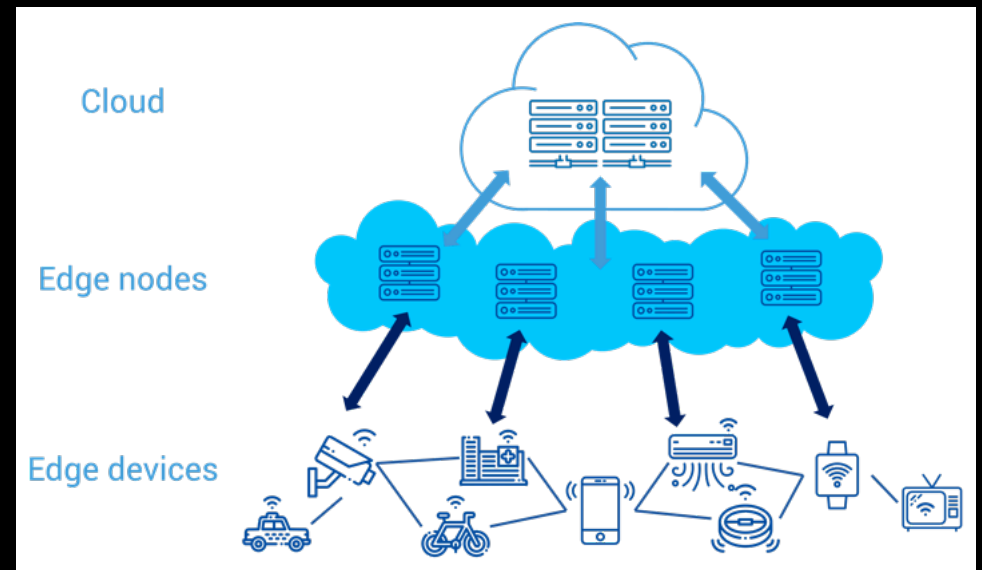
- Simple solution
- Have the door-bell do some pre-processing (edge computing)
- For example, only send video when motion is detected, only send audio when sound is detected
- Additional edge computing would do object detection (car, person, animal) and even face detection



# Edge Computing

## Definition

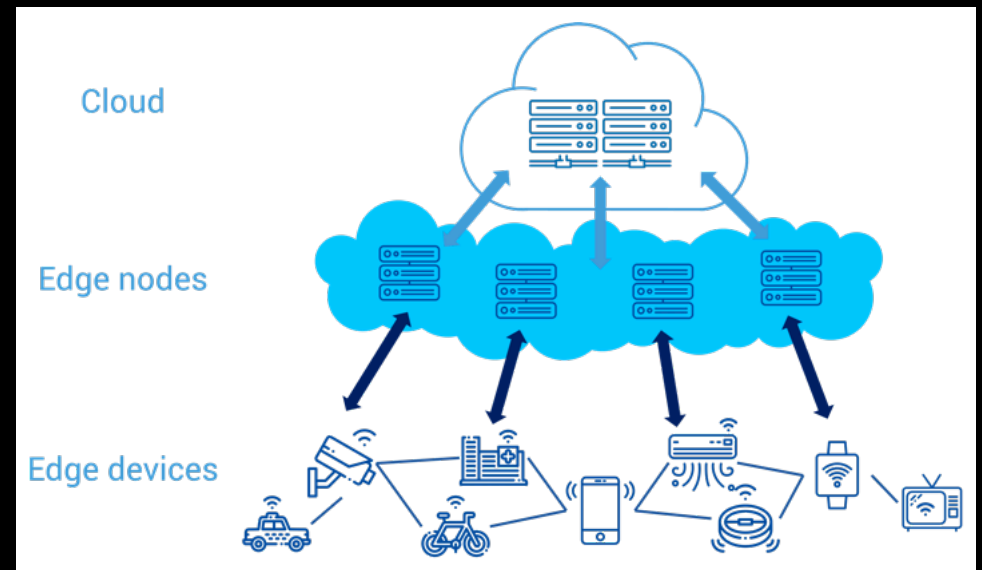
- When data is processed closer to the “thing” rather than in the cloud
- Put another way - A network architecture in which client data is processed at the periphery of the network, as close to the originating source as possible.



# Edge Computing

## Advantages

- **Reduce upload bandwidth.** 10 billion things transmitting large amounts of data would make the internet get real slow
- **Improve privacy.** Ensure you are only transmitting required information
- **Reduce latency.** When round trip to the cloud is not necessary, can get results faster

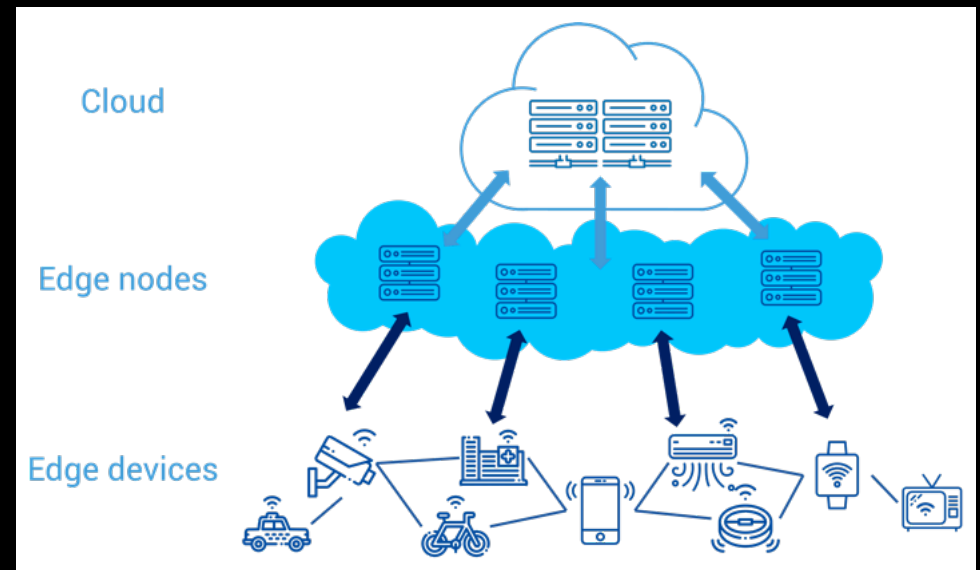


In addition to computing at the edge, “things” can **communicate** at the edge.

# Edge Computing

## Use cases

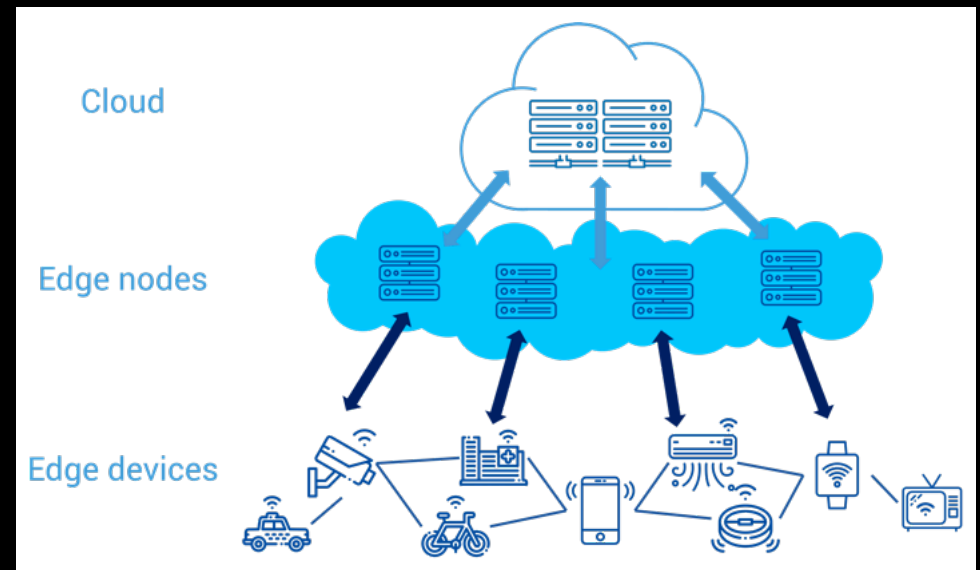
- If you play **online video games**, you are using edge computing. Your gaming computer/phone does a lot of the processing
- **Autonomous vehicles**. Sensor data on the vehicle is MASSIVE and you need low latency for safe operation. No way to send all the data to the cloud and get a response within a reasonably fast time.
- Video/Audio doorbells only transmitting when there is movement or sound
- What are some others use cases?



# Edge Computing

## Use cases

- Autonomous Vehicles: All this data needs to be processed locally
  - Multiple video cameras
  - Multiple Radar/Lidar
  - Fast communication with smart city like traffic lights, stop signs (geofencing)
- Will self driving cars be able to do it on a traditional road?
- Or will they require a “smart road” to make it work?





# Edge Computing

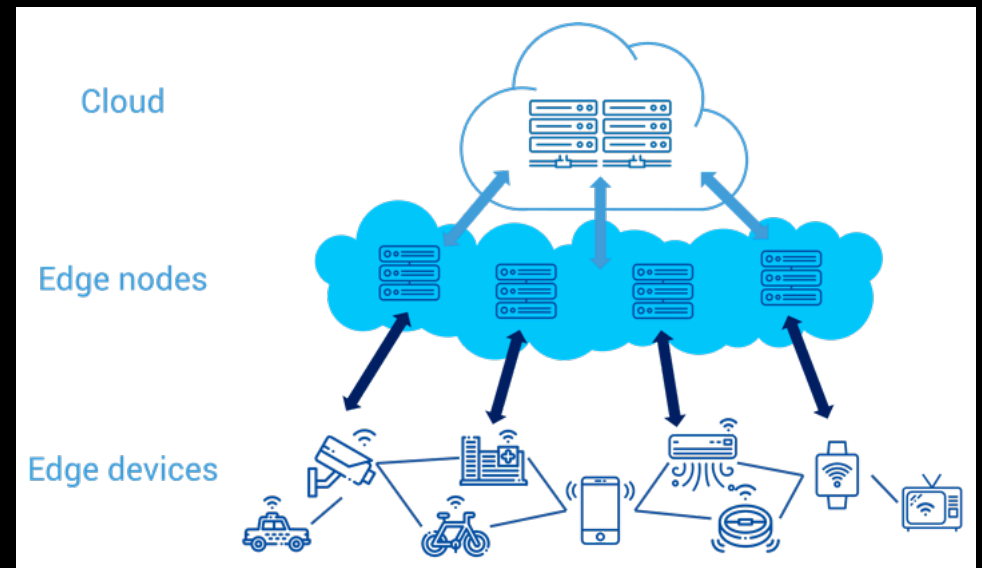
## Use cases

- Apple has announced Siri will process your voice commands directly on the phone
- This solves all the major problems of IoT including:

Reducing Network Bandwidth

Increases Privacy

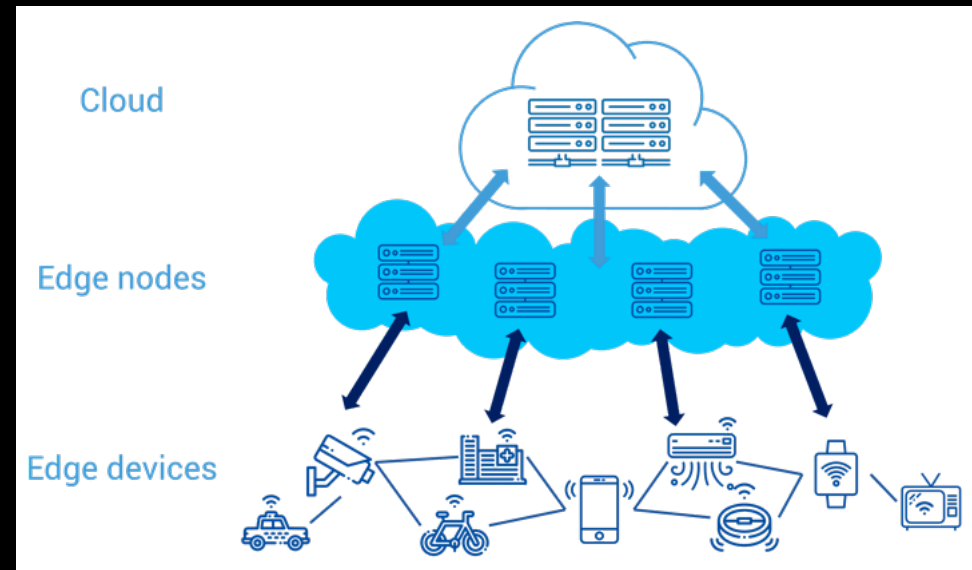
Reduces Latency



# Edge Computing

## Use cases

- Original IoT architecture with everything going to the cloud is overly complex, high band-width, insecure, and slow
- Hopefully our smart home can act both in **local** and **remote** modes
- If your home on your WiFi your commands to turn a “thing” on/off would remain local
- Important: Local “things” can communicate directly with each other



# IoT Fail

# IoT Fail

## Security Cameras With Default Password

- (2014) A site linked to 73,011 unsecured security camera locations in 256 countries to illustrate the dangers of using default passwords

This project is still going ... but the creators actively remove camera in homes and apartment ... they try to just provide “public” cameras

Go To Link: <http://www.insecam.org/>