
UNIMORE
UNIVERSITÀ DEGLI STUDI DI
MODENA E REGGIO EMILIA

Dipartimento di Scienze Fisiche,
Informatiche e Matematiche

# IoT Systems

## IoT Use cases

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# IoT Use cases

- The IoT can be found in many scenarios
- We will look at some of them
  - Some technologies may be new to you. We will cover them in separate lectures
  - In this lecture we are interested in having an overview of the IoT heterogeneity

# Use cases we cover

- Environmental monitoring
- Autonomous driving
- Smart home
- Smart factory
- e-Health
- Structural monitoring

# Environmental monitoring

- Task:
  - Monitor one or more phenomena in an area of interest
- Example data
  - Temperature, humidity, noise, photos
- How
  - Infrastructure based
  - Crowdsensing (Opportunistic or Participatory)

# The task in detail

- Environmental data (roads, trees, air, …)
  - Helps to understand whether issues are arising
    - Traffic jams, too hot zones, parking spots available
- Many sensors which collect data
  - Data is processed locally or brought back to a central aggregator
  - Data analysis may raise actions to optimize the system

# Example – Singapore LTA

- Green Line Determining (GLIDE) system
- Controls traffic signals
- Adjusts the green time
- Collects data from induction loops, adjacent traffic signals
- Data is processed locally, and adjacent junctions communicate to provide motorist a “green wave”

# Example – Singapore LTA

- Traffic Message Channel (TMC)
- Delivers traffic information
- Uses citizen devices
- Data is collected by sensors
- Decisions are taken by humans

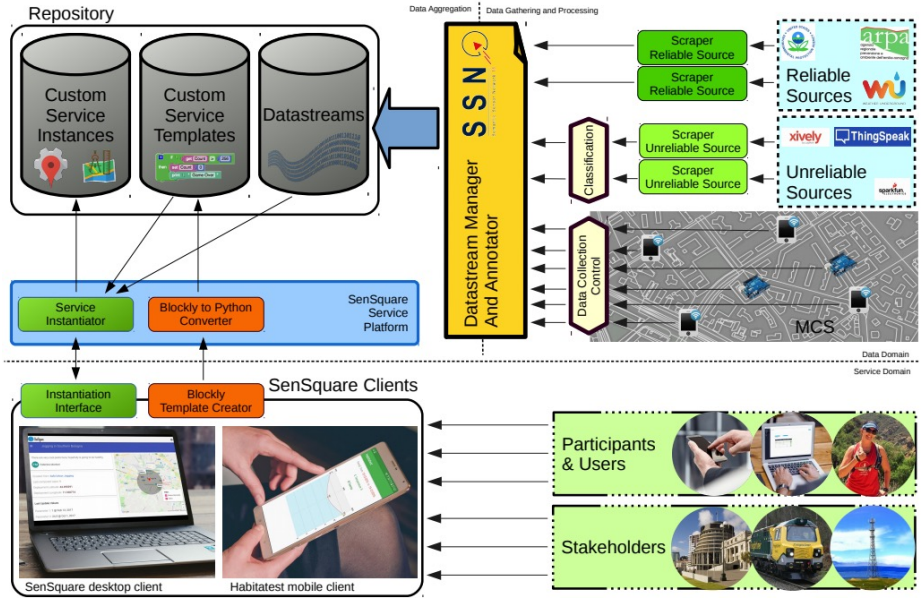
# Takeaways

- The previous example were based on an infrastructure
  - Someone (the municipality, an industry, …) has to design, ubild and deploy such infrastructure
  - Infrastructures have to ba maintained
  - They are also bound to a specific task. If objectives change, the infrastructure may not be suited for the purpose
- Infrastructures have (typically) higher precision
  - It is possible to use more precise sensors
  - Installation is performed by specialized personnal, so errors are limited

# Crowdsensing

- Leverages citizen devices to collect data
- This avoids the use of an infrastructure
  - Citizens move freely with their devices
  - Data is collected and eventually reported to a central aggregator
- Advantages:
  - No infrastructure needed, can be turned on/off as needed
- Disadvantages
  - Citizens may want to be payed for that, precision and accuracy of the data is lower compared to infrastructure, noise may be higher

# SenSquare

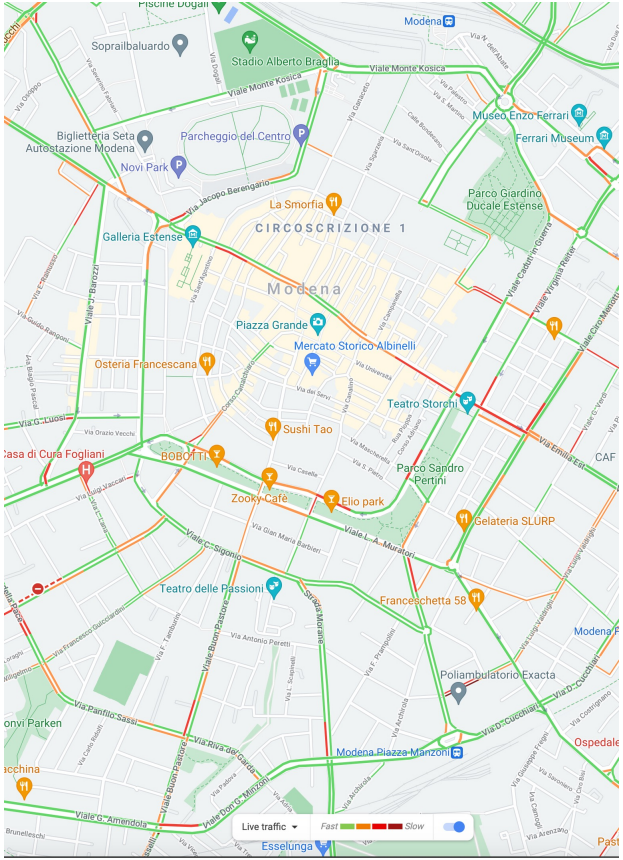



- Environmental monitoring
- Traffic status
- Public transportation conditions
- Cellular connectivity
- Noise pollution
- Leveraging MGRS for hierarchical measurements

F. Montori, L. Bedogni and L. Bononi, “A Collaborative Internet of Things Architecture for Smart Cities and Environmental Monitoring,” in *IEEE Internet of Things Journal*, vol. 5, no. 2, pp. 592-605, April 2018.

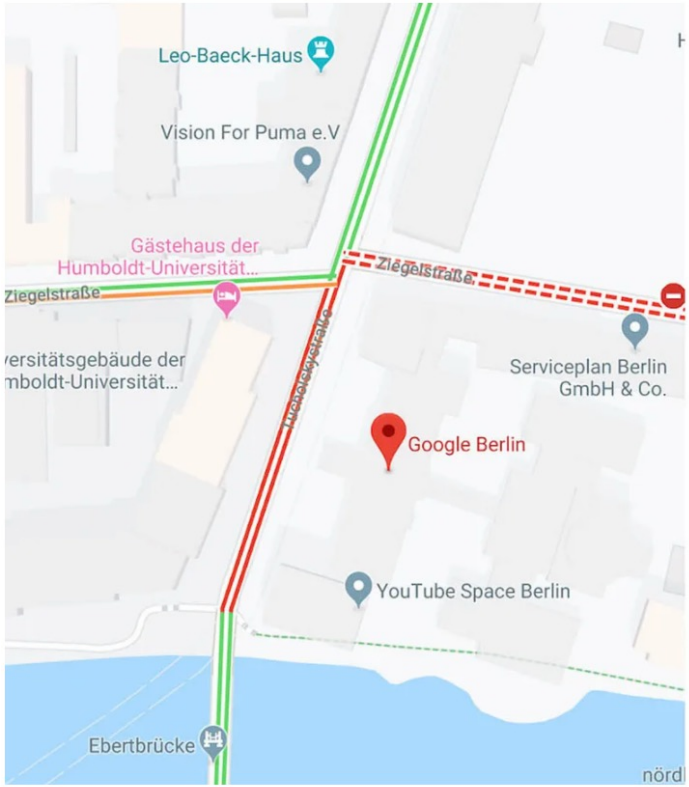
# Crowdsensing example

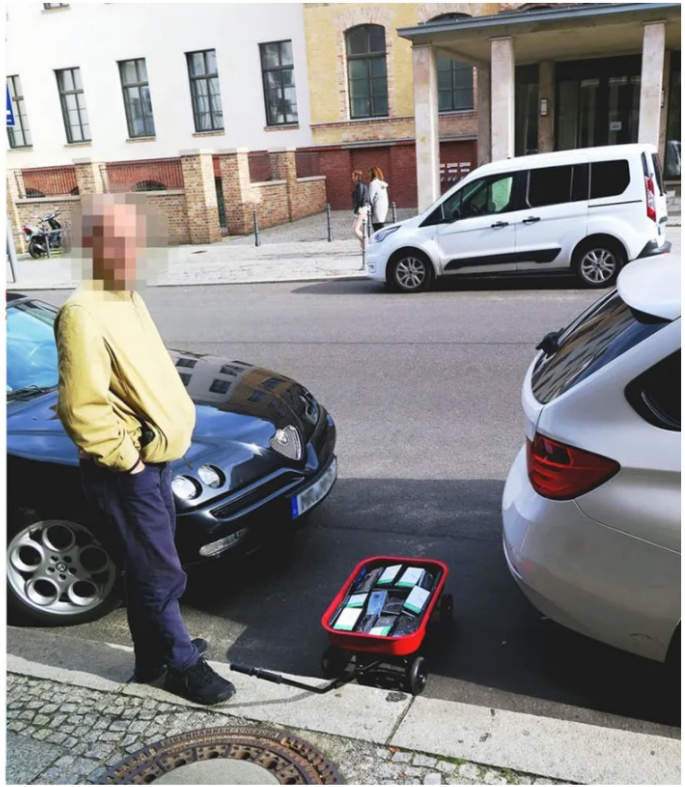
- Probably the most famous one, Google Traffic
- The data is sensed by the smartphones of people driving cars
- Depending on the actual speed vs. the expected speed it is possible to determine traffic conditions



# An Artist Used 99 Phones to Fake a Google Maps Traffic Jam

**With his "Google Maps Hack," artist Simon Weckert draws attention to the systems we take for granted—and how we let them shape us.**



COURTESY OF SIMON WECKERT

https://www.wired.com/story/99-phones-fake-google-maps-traffic-jam/

# Challenges in Crowdsensing

- Reward the users properly
- Data quality
- Privacy of users
- Merging crowdsensed data with other data

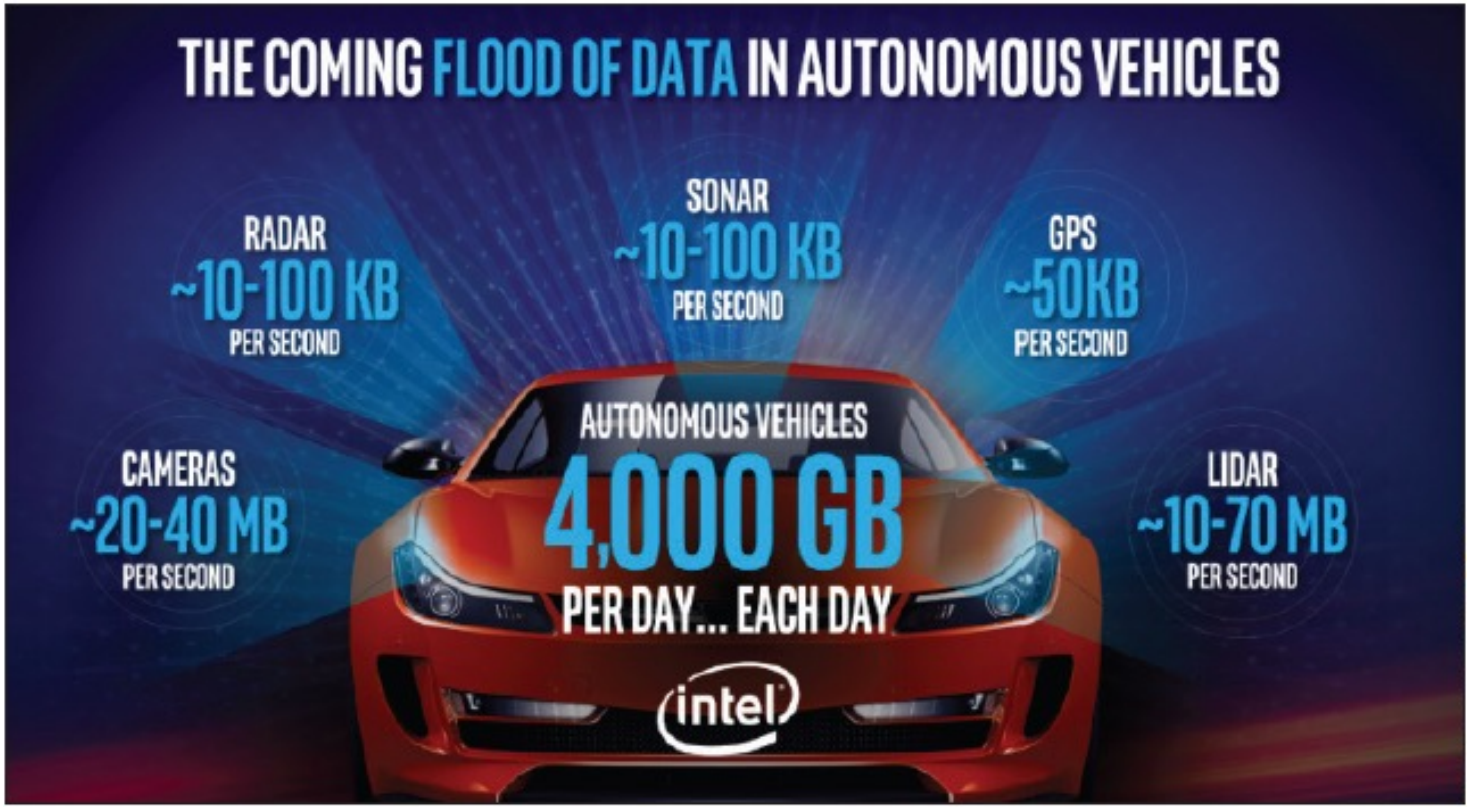
# Autonomous driving

- Cars that run without (or with little) human intervention
- To do so, they are equipped with many (really, **many**) sensors
  - The central "brain" of the car merges them and takes actions

# Autonomous driving

- Cars may also communicate with the road infrastructure
  - To understand whether crossing lights are red or green
  - To check for traffic jams on the road ahead
  - To communicate their actions
- In this scenario, latency is key
  - Data and decision should be shared fast, otherwise actions may be taken too late, or on outdated data

# Self driving cars… How much data?

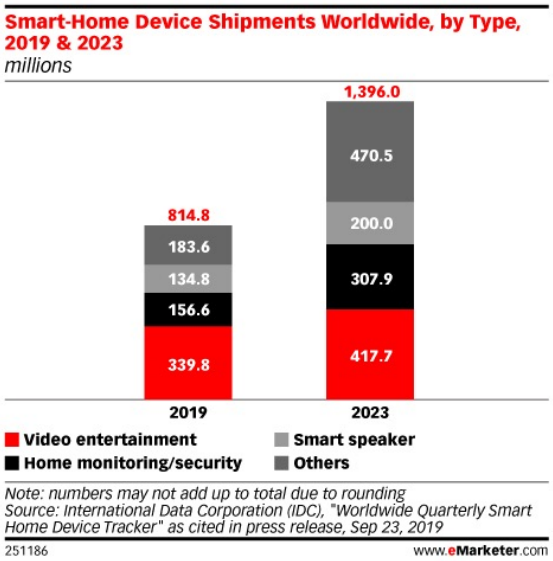


# Challenges in Autonomous driving

- Safety
- Networking
- Data sharing among different platforms
- Performance

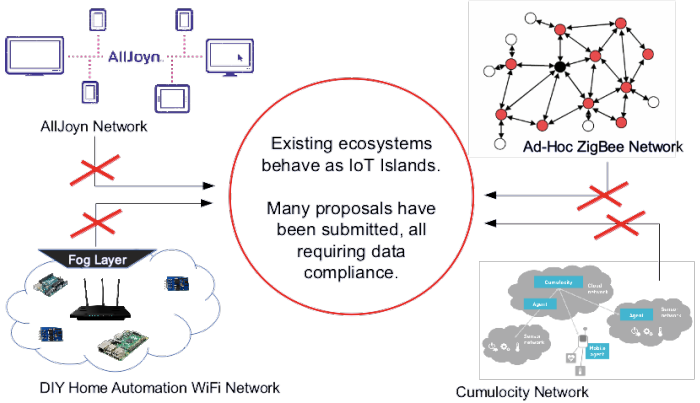
# Smart home

- Also called domotics
- Collection of devices which automate home tasks
  - Switch on the heating systems if its cold
  - Turn on the alarm if no one is at home
- Consumer side, one of the biggest markets

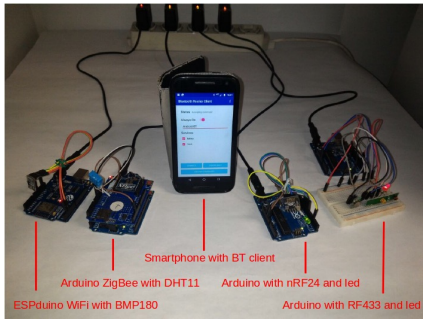


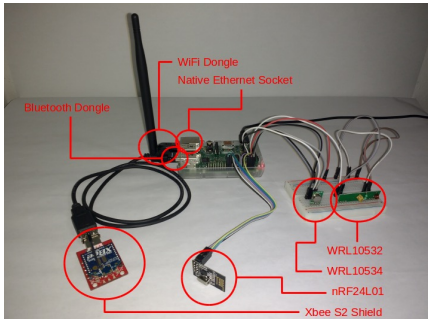
# Intranet or Islands of Things

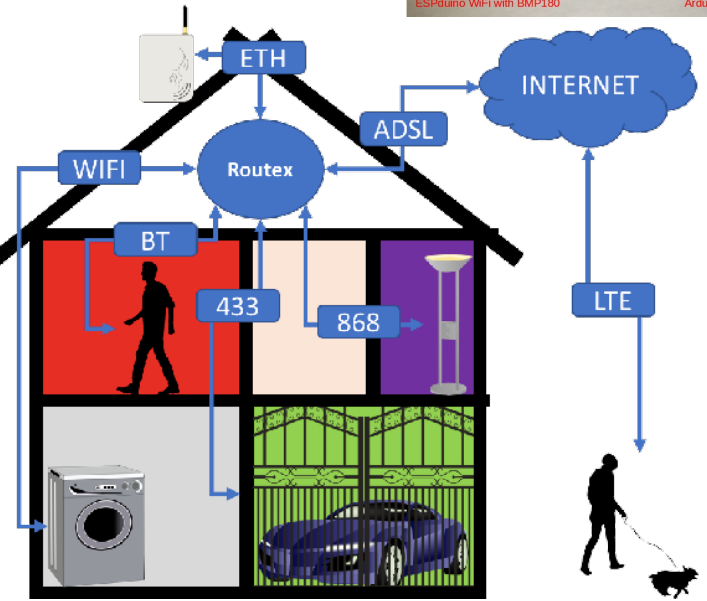
- Problem: easy to share data among the same network, difficult to do it outside of it
- Solutions:
  - Unified multi-technology router
    - Zigbee, LoRa, BLE, WiFi, …
  - Homogenization at the data level
    - Define a common layer through which it is possible to collect heterogeneous data
    - Provide a convenient interface to the end users
    - Something similar to SenSquare

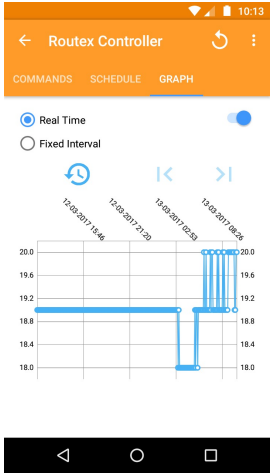


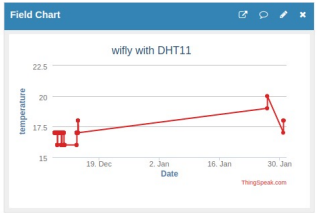
# Routex

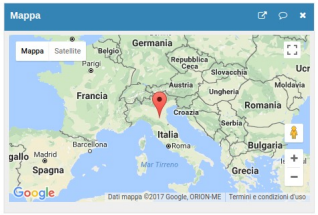

Smartphone with BT client
Arduino ZigBee with DHT11
Arduino with nRF24 and led
ESPduino WiFi with BMP180
Arduino with RF433 and led

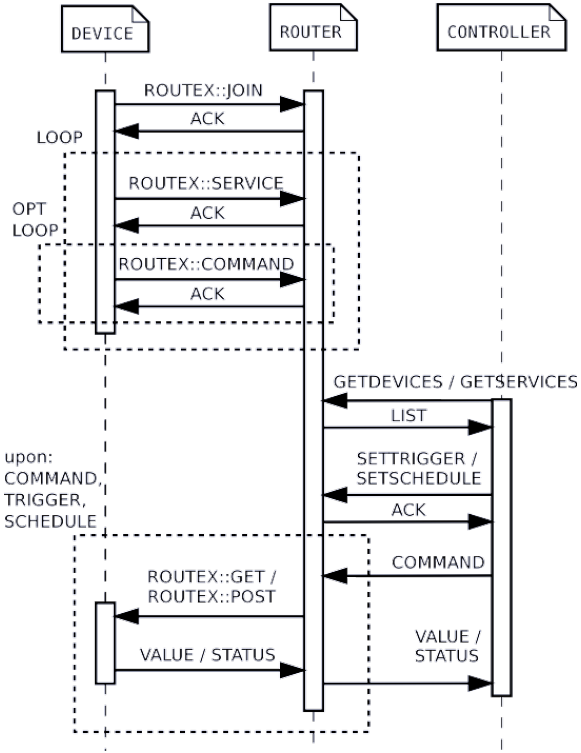

WiFi Dongle
Native Ethernet Socket
Bluetooth Dongle
WRL10532
WRL10534
nRF24L01
Xbee S2 Shield


ETH
INTERNET
ADSL
WIFI
Routex
BT
433
868
LTE


10:13
Routex Controller
COMMANDS
SCHEDULE
GRAPH
Real Time
Fixed Interval

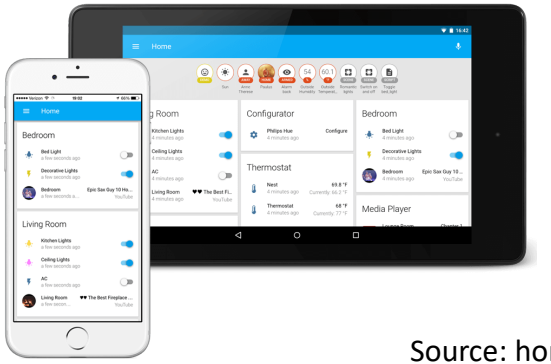

Field Chart
wifly with DHT11
Temperature
Date
ThingSpeak.com


Mappa
Satellite
Germania
Francia
Spagna
Italia
Google

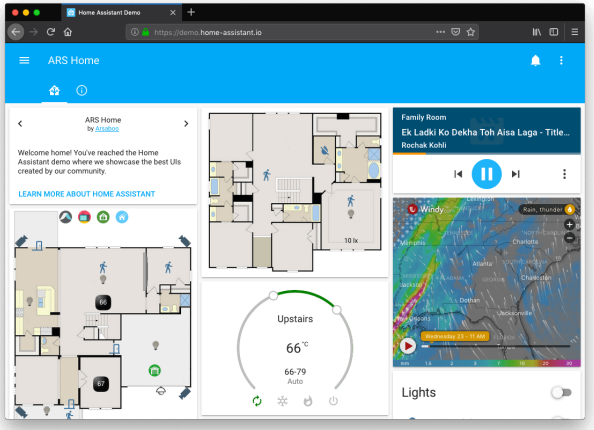

DEVICE
ROUTER
CONTROLLER
ROUTEX::JOIN
ACK
LOOP
ROUTEX::SERVICE
ACK
OPT
LOOP
ROUTEX::COMMAND
ACK
GETDEVICES / GETSERVICES
LIST
SETTRIGGER /
SETSCHEDULE
ACK
upon:
COMMAND,
TRIGGER,
SCHEDULE
COMMAND
ROUTEX::GET /
ROUTEX::POST
VALUE / STATUS
VALUE /
STATUS

# The Home Assistant Project

- Focuses on the smart home
- Easy to interconnect COTS devices
- Also possible to interconnect custom devices
- Central controller, many technologies, many protocols




Source: home-assistant.io



# Challenges in Smart home

- Interoperability
- Costs
- Privacy

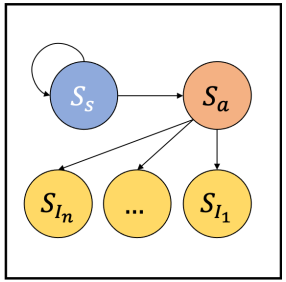
# Smart factory

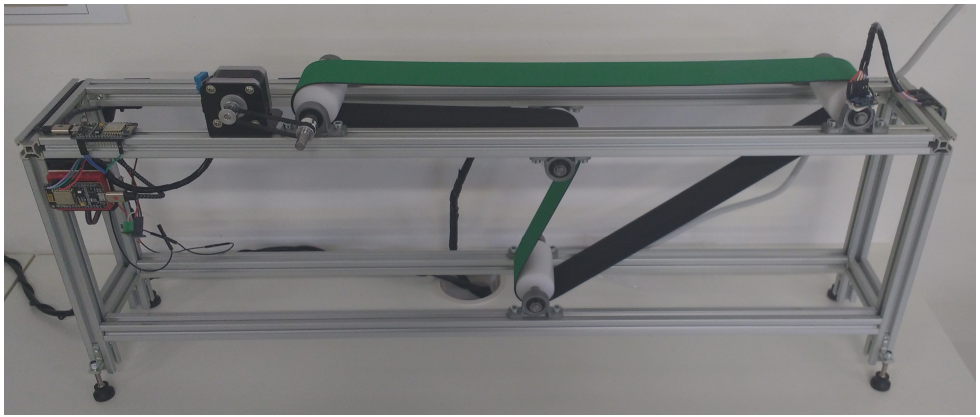
- Bringing the IoT to the industry
- It enconpasses many different technologies
  - IoT
  - AI
  - Robotics
  - Cyber Physical Systems
  - Big Data
  - Cloud

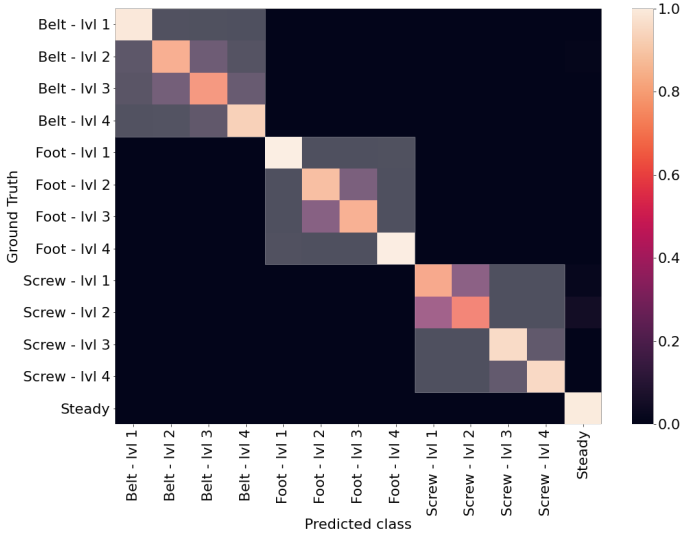
**In a nutshell:** it is the digitization of the industry, with advanced IT technolgies which enable automatic decisions and monitoring of the whole production chain.

# Predictive maintenance

- Classifying issues when no training data is available
- Leveraged one class SVM to detect base state and anomalies
- Ask to the operator about the specific anomaly



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# Example

# Challenges in Smart factory

- Performance
- Latency
- Interoperability

# e-Health

- As the miniaturization of devices advances, it is possible to fit more sensors in less space
- Some ilnesses require constant monitoring, such as hearth issues or dementia
- Wearable devices are of paramount importance

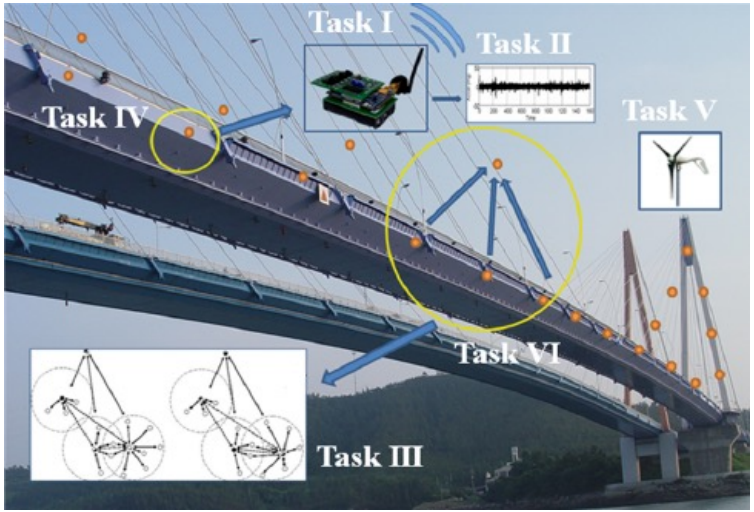
Source: eias.org

# Challenges in e-Health

- Privacy
- Battery efficiency
- Communicatoin efficiency
- Resilience and trust

# Structural monitoring

- Key to monitor long term health of buildings
- Vibrations, humidity, earthquake resilience
- May have both fixed sensors as well as mobile ones such as drones




Mechitov, Agha, “Building portable middleware services for heterogeneous cyber-physical systems”

# Challenges in structural monitoring

- Resilience and trust
- Battery efficiency
- Mobile/Static nodes interoperations