IoT Engineering
1: Introduction to the Internet of Things

Today

¾ slides,

¼ hands-on.

Slides, code & hands-on: tmb.gr/iot-1

Hands-on, 5': Defining IoT

What does *Internet of Things* mean to you?

Write down your definition on a post-it.

We will check out the result together.

Internet of Things (IoT)

"Internet-connected computers, with sensors and actuators." — @tamberg

"Physical objects with a Web API." — @hansamann

IoT: "Global network of computers, sensors and actuators, connected through Internet protocols."
Web of Things: "RESTful Web services that measure or manipulate physical properties." — @gsiot

Drivers of IoT

Small, inexpensive, low power computers.

Small, inexpensive, low power sensors.

Short and long range connectivity.

Cloud computing and storage.

Standard (IoT) protocols.

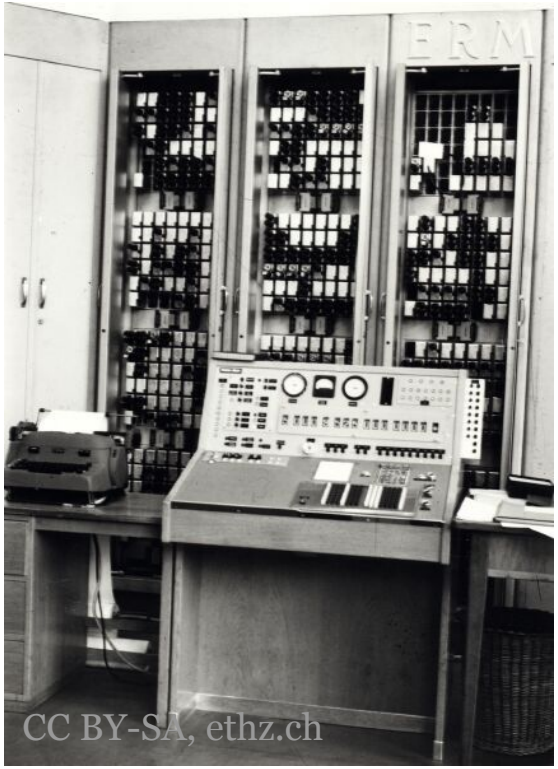
Moore's law

"Moore's law is the observation that the number of transistors in a dense integrated circuit doubles about every two years." — Wikipedia

Gordon Moore, a founder of Intel, noted this in 1965.

=> Computers become more powerful, less expensive.
=> The same power is available in a smaller package.
=> Small computers can be embedded into things.

Moore's law



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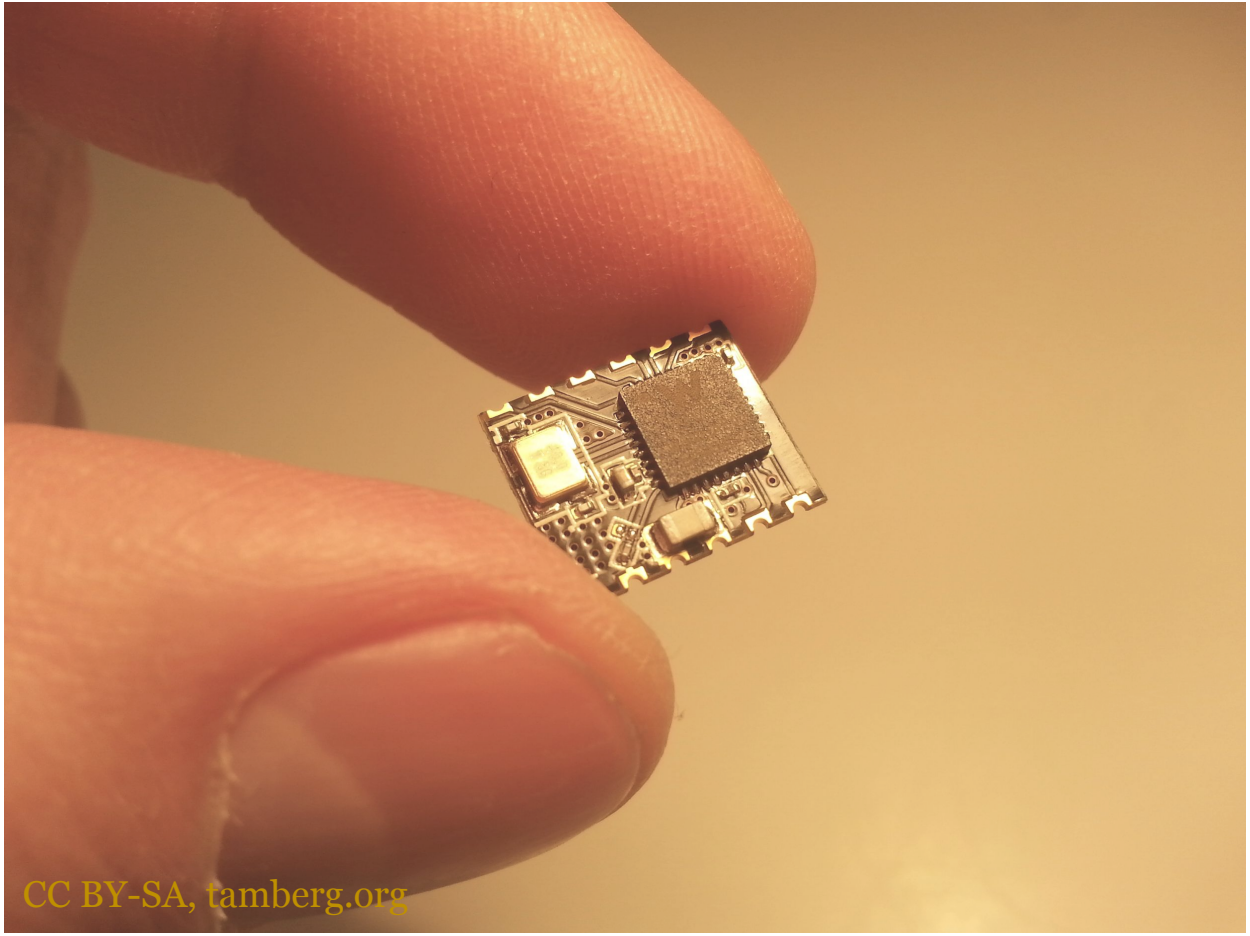

CC BY-SA, tamberg.org

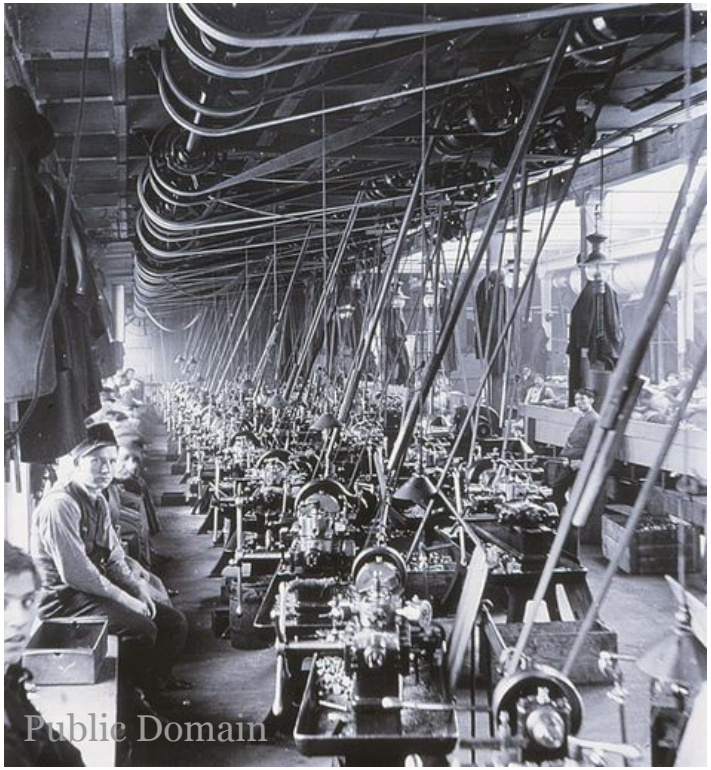
Ubiquitous computing

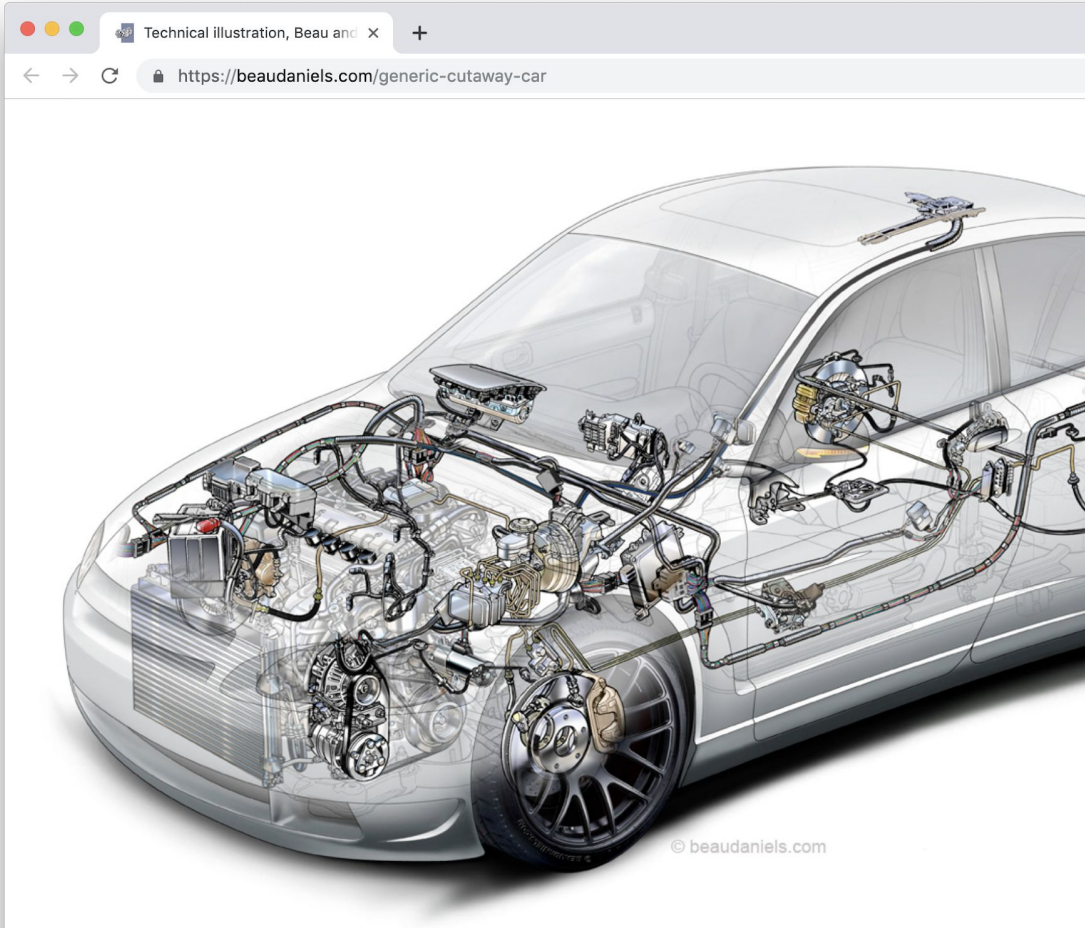
"The idea of integrating computers seamlessly into the world at large [...] *Ubiquitous computing*"

"How do technologies disappear into the background? The vanishing of electric motors may serve as an instructive example"

— Mark Weiser in The Computer for the 21st Century

Motors: 1 vs. n





VEHICLE ELECTRICAL SYSTEM.

Connectivity

Ability to communicate with another computer.

Personal area network (PAN, e.g. BLE, Zigbee).

Local area networks (LAN, e.g. Ethernet, Wi-Fi).

Wide area networks (WAN, e.g. 3/4G, LoRaWAN).

The range grows from "room" to "building" to "city" (e.g. BLE, 30m; Wi-Fi, 100m; LoRaWAN, 2-15km).

IoT high level use cases

IoT enables these core use cases, in different flavors.

Efficiency (e.g. trash bins let you know they are full).

Convenience (e.g. remotely preheat a holiday home).

New insights (e.g. a crowdsourced air quality map).

Sectors include connected consumer products, citizen sensing, industrial IoT and many more.

Connected products

Internet-connected consumer products, e.g.

Nest, a connected, self-learning thermostat.

Philips Hue, connected lights with a Web API.

Withings Scale, logs your weight to a dashboard.

Good Night Lamp, linked lamps to share presence.

Nest Thermostats | Keep You

https://nest.com/thermostats/

It's beautifully designed to keep you comfortable and help save energy.

Proven energy savings.
Can pay for itself in two years or less.[1]

Turns itself down when you're away.

Control it from anywhere.[2]

Remote temp sensing.
Learn more >

Meethue.com | Welcome to the

https://www2.meethue.com/en-us

Smart lights
Smarter controls

Philips Hue is not just a smart bulb, it's a smart lighting system. The smart lights, Hue Bridge, and smart controls will forever change the way you experience light.

Hue lights

These smart and energy-efficient LED lights come in a wide variety of shapes, sizes, and models to suit your space.

Hue Bridge

The heart of your Philips Hue system, the Bridge acts as a smart hub, connecting your devices to your smart lights. You can add up to 50 Philips Hue lights and accessories to one Bridge.

Hue app

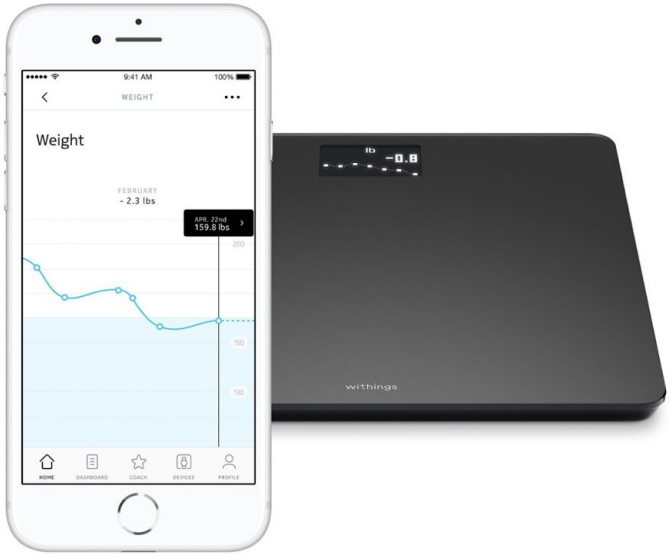
Control your smart lights quickly and conveniently with the Philips Hue app.

Weight & BMI Wi-Fi Scale - Bo

https://www.withings.com/us/en/body

Meet your new accountability partner

Body offers a complete weight tracking experience tailored to individuals seeking easy, effective weight management. Weighing in is just the first step. Each session also provides instant feedback via weight trend and BMI screens, plus automatic sync to a free app on your smartphone, so you can track progress any time, anywhere.



goodnightlamp.com

Not Secure | goodnightlamp.com

Turn a Big Lamp on and Little Lamps which you've given away turn on too. Anywhere in the world.

Use the Good Night Lamp to tell a loved one 'now's a good time for a chat', 'I'm thinking of you' or 'call me when you get home'. You decide. As your family grows or moves away, you can add as many Little Lamps as you want.

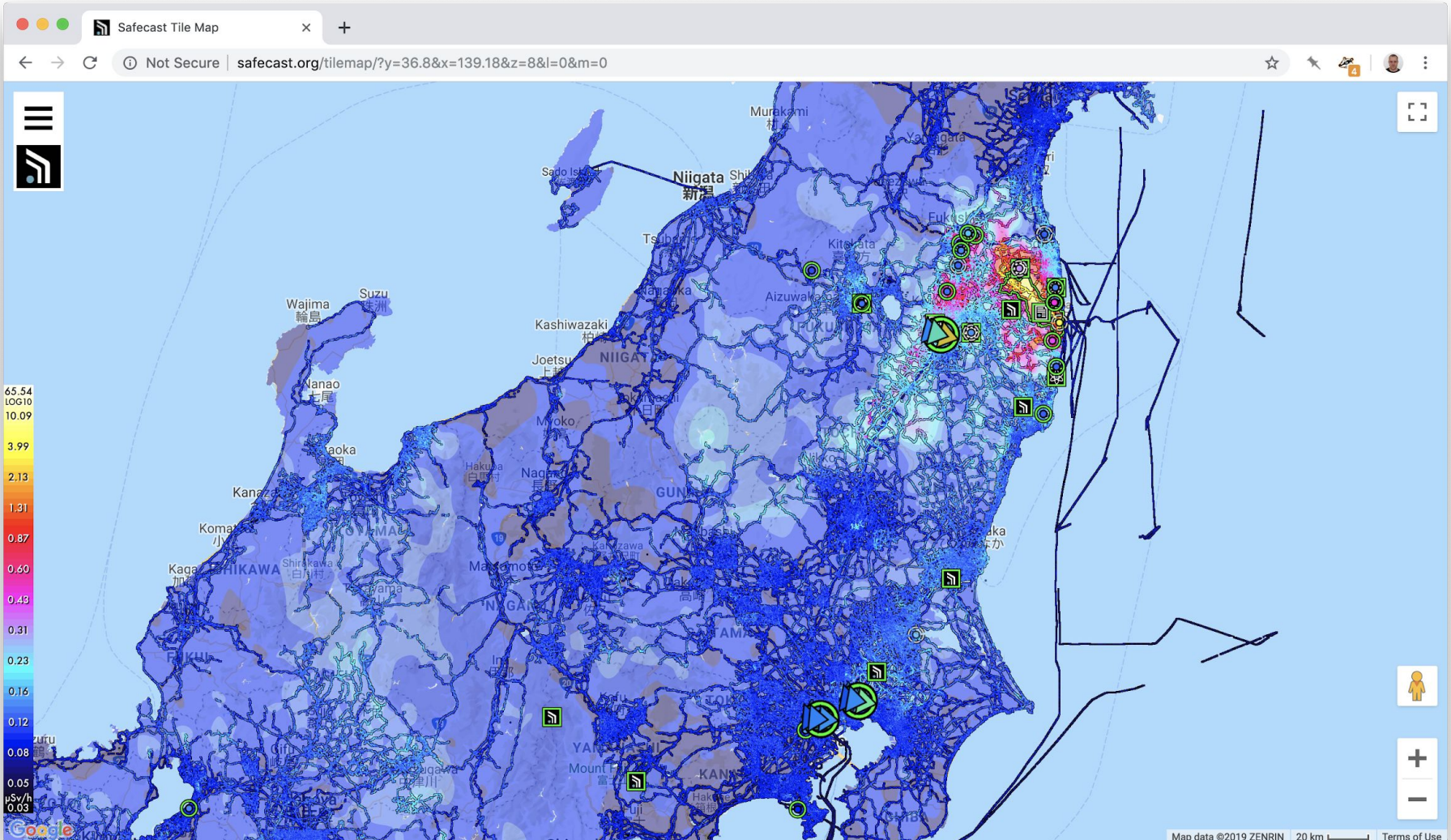
Citizen sensing

Self-built sensors, open data, nonprofit, e.g.

Safecast.org, a crowdsourced radiation map.

Oxford Flood Network, measuring water levels.

Luftdaten.info, particles and nitrogen oxides map.


Safecast Tile Map
Not Secure
safecast.org/tilemap/?y=36.8&x=139.18&z=8&l=0&m=0
Niigata
新潟
Sado Island
Murakami
Yamagata
Fukushima
Kitakata
Aizuwakamatsu
Tsuchiya
Nagaoka
Kashiwazaki
Joetsu
NIIGATA
Wajima
輪島
Suzu
珠洲
Nanao
七尾
Myoko
Hakuba
白馬村
Nagano
長野
GUNMA
Kanazawa
Komatsu
小松
TOYAMA
Kaga
ISHIKAWA
Shirakawa
白川村
Matsumoto
Takasaki
高崎
Fukui
福井
Gifu
岐阜
Mount Fuji
富士山
YAMANASHI
KANAGAWA
TOKYO
Hakone
箱根
SHIZUOKA
65.54
LOG10
10.09
3.99
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1.31
0.87
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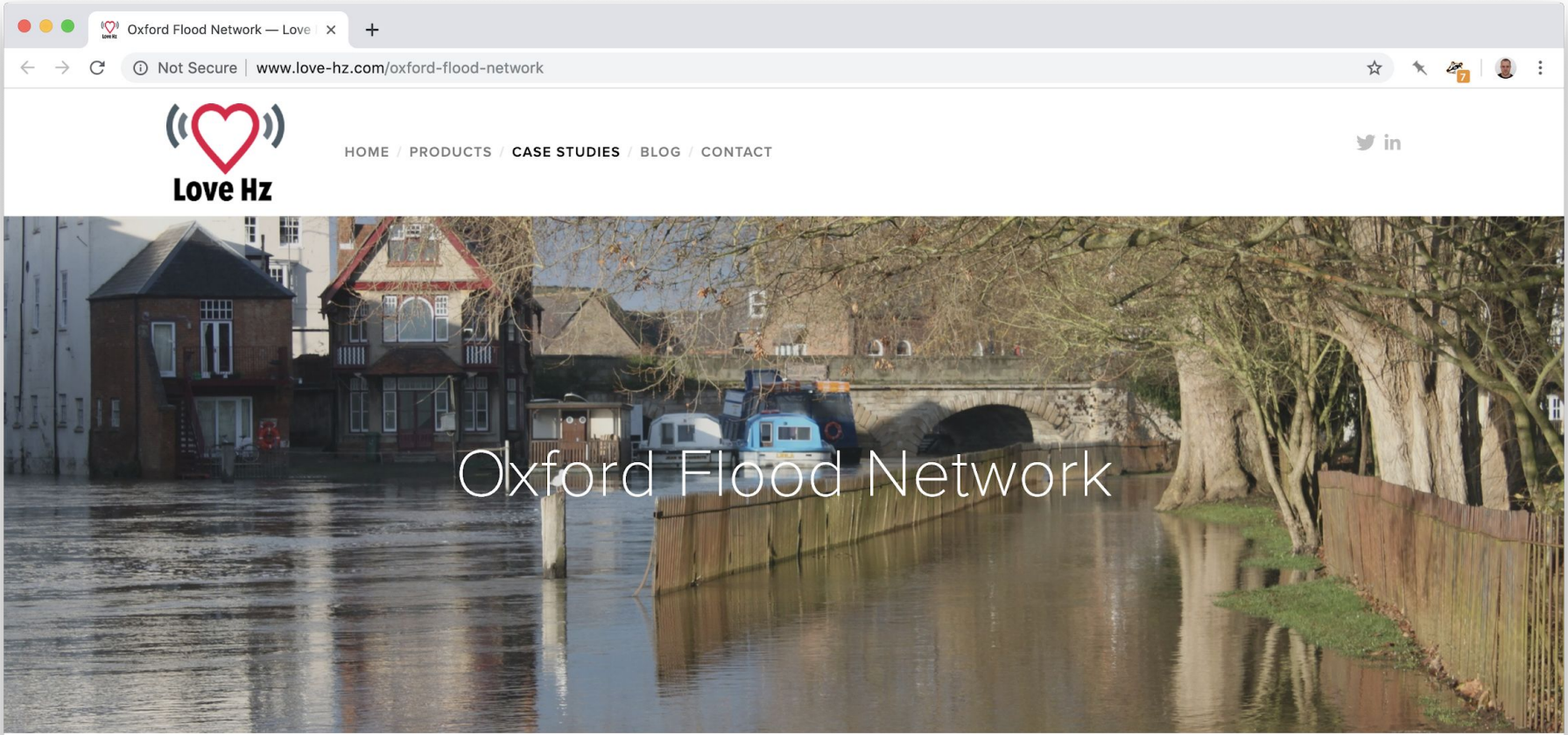
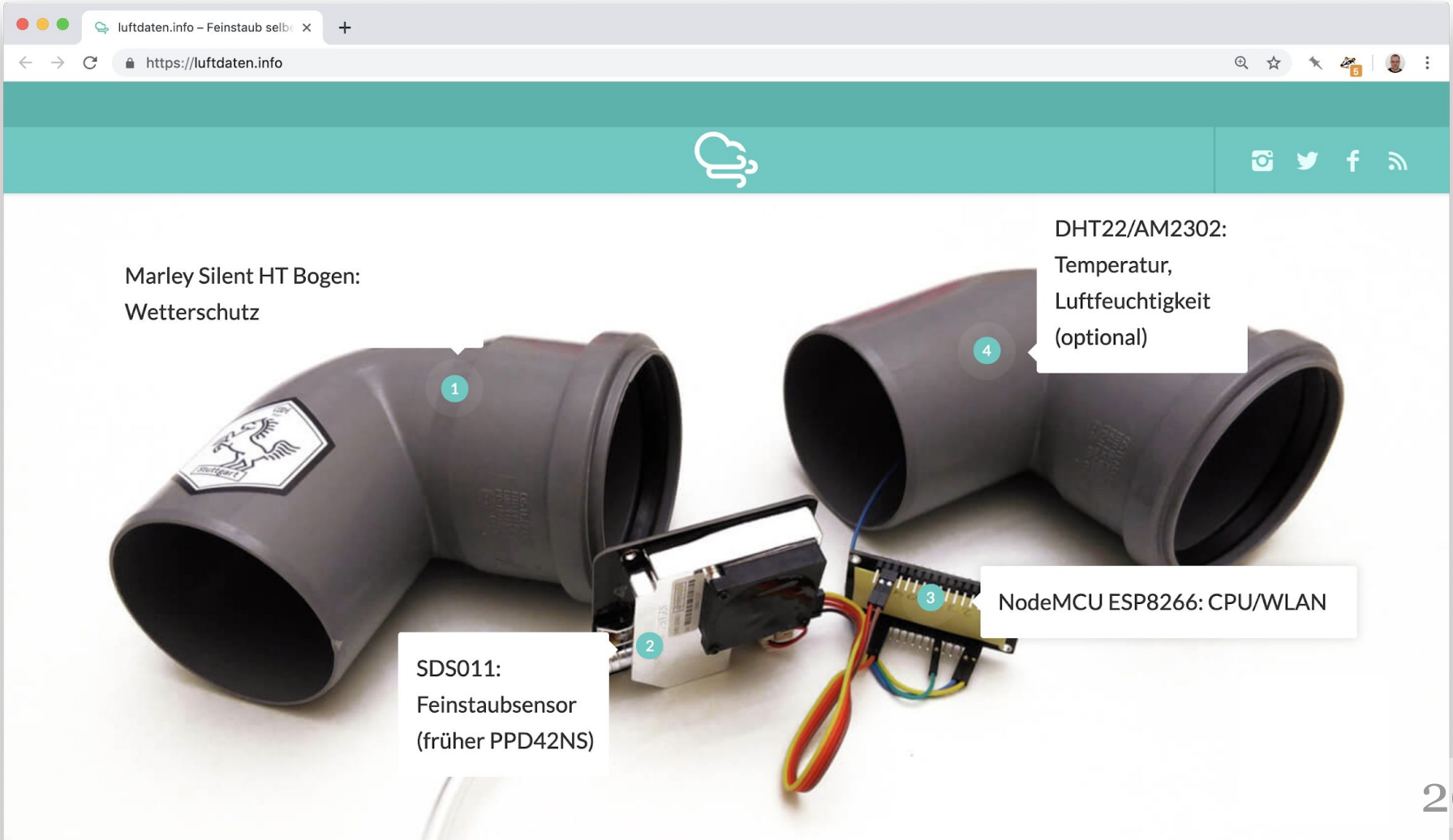
Map data ©2019 ZENRIN
20 km
Terms of Use



Citizens, Building a Smart City


luftdaten.info – Feinstaub selb
https://luftdaten.info
Marley Silent HT Bogen:
Wetterschutz
1
DHT22/AM2302:
Temperatur,
Luftfeuchtigkeit
(optional)
4
3
NodeMCU ESP8266: CPU/WLAN
2
SDS011:
Feinstaubsensor
(früher PPD42NS)

Industrial IoT

"Industrie 4.0" in German, cyber-physical systems.

E.g. Rolls-Royce TotalCare, "engine as a service".

Predictive maintenance (know what *will* break).

Anomaly detection (find *unknown* issues).

Live feedback (from *deployed* engines).

Civil Aerospace – Rolls-Royce

https://www.rolls-royce.com/products-and-services/civil-aerospace.aspx

971.40 GBX +22.60 GLOBAL

ROLLS ROYCE

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Home > Products & Services > Civil Aerospace

Latest updates on our Trent engine family

IoT reference model

Device, ~~thing~~, ~~product~~ (with sensors & actuators).

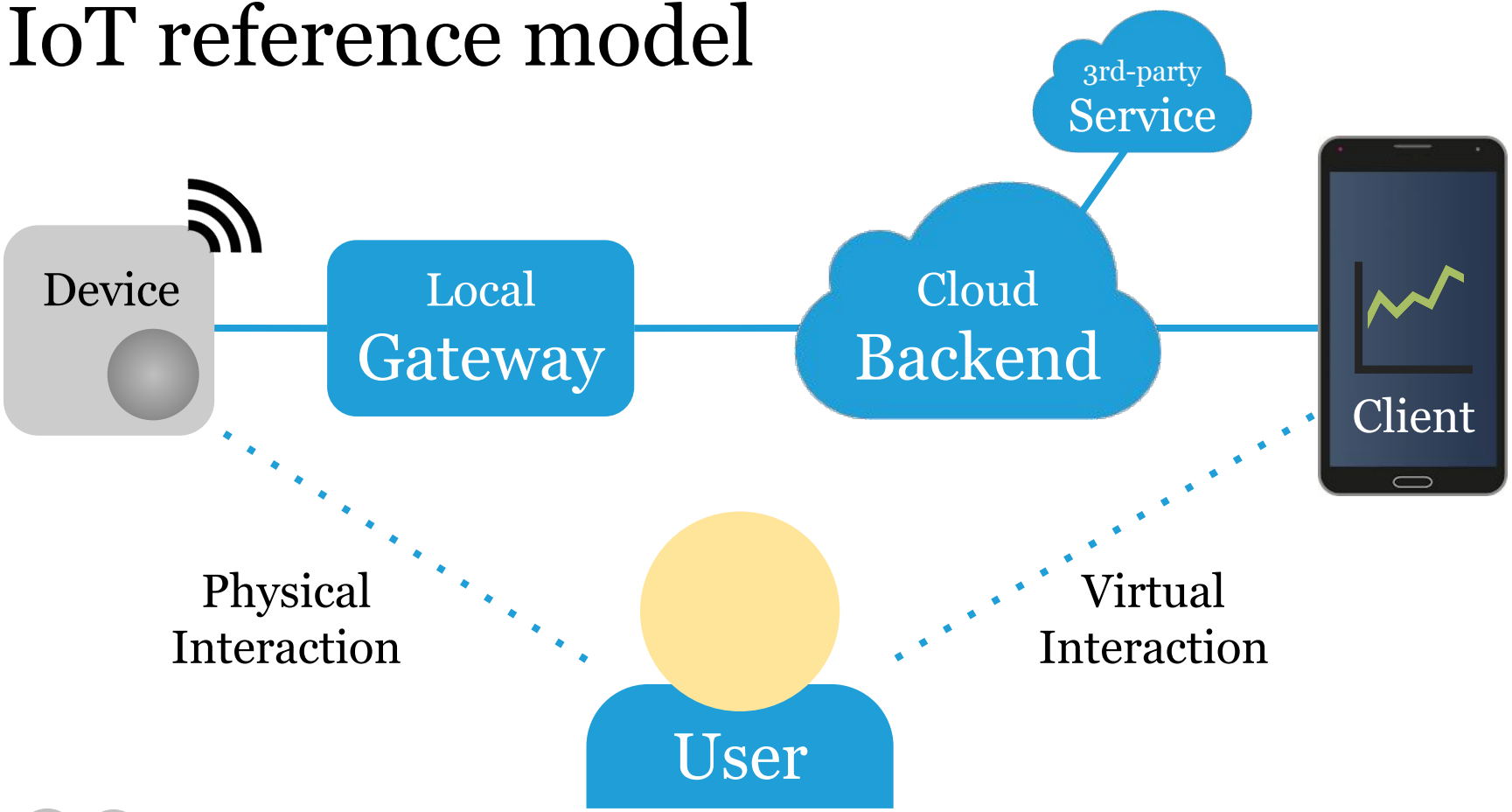
Gateway, ~~hub~~, ~~bridge~~ (in the local network).

Backend (IoT platform, "in the cloud").

Client (app or 3rd-party service).

User (local or remote).

IoT reference model



Device

Embedded computer with sensors and actuators.

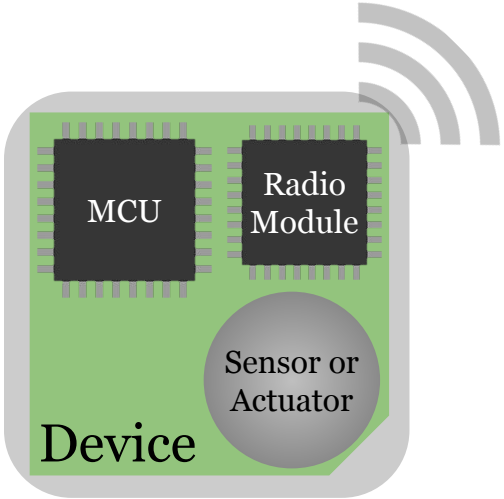
Connectivity on the chip or as an external module.

Microcontroller (MCU) with constrained resources.

Small, slow processor, limited memory, low power.

Often battery powered or harvesting energy.

Device



Sensors

Convert physical properties to electrical signals.

E.g. temperature, sound, light, distance, flow.

Actuators

Convert electrical signals to physical properties.

E.g. light, movement, sound, heat, current.

Gateway

Computer in the local network, with more resources.

Connects local devices/network to the Internet, e.g.

LoRaWAN to Wi-Fi gateway (TTN indoor gateway).

Zigbee to Ethernet gateway (Philips Hue bridge).

Or the Wi-Fi router itself (for Wi-Fi devices).

Transparent, depending on the perspective.

Backend

Backend server(s), service endpoint "in the cloud".

Provides data to clients, receives commands.

High availability, scalability, bandwidth.

Can provide storage or data analysis.

Can call 3rd-party (Web) services.

Client

Client app, e.g. dashboard or 3rd-party service client.

Reads measurement data from devices via backend.

Writes control data to the device via backend.

Multiple client apps can share a backend.

Decentlab Data Access - Indoo

https://demo.decentlab.com/dashboard/db/indoor-air-quality-demo?refresh=15m&orgId=3

Indoor Air Quality Demo

Zoom Out | Last 3 days | Refresh every 15m | Sign in

LoRa WAN demo project by

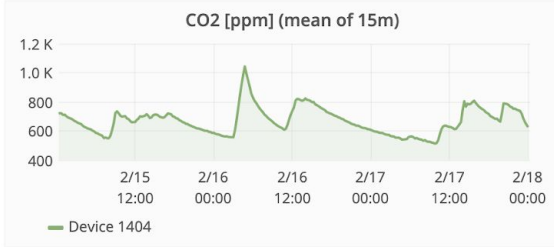
decentlab

CO2, temperature, and humidity sensor

Node 1404 (CO2)

LoRa infrastructure provided by

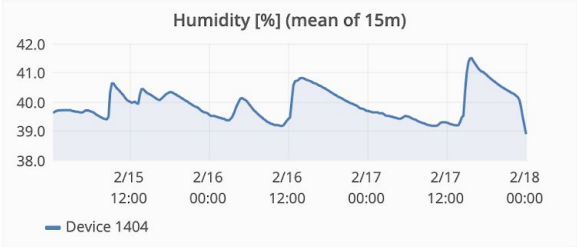
THE THINGS NETWORK



Current

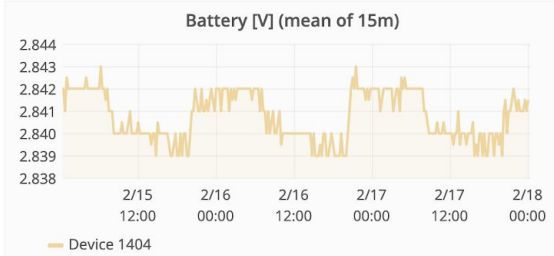
625.5

ppm



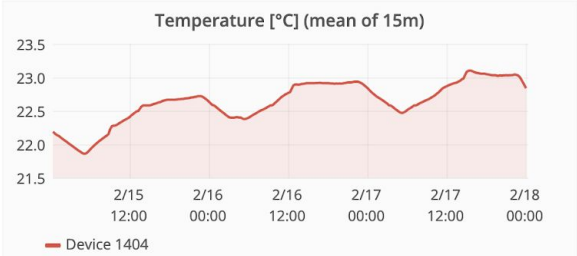
Current

38.9 %



Current

2.84 V



Current

22.84 °C

Hands-on, 15': Deconstructing IoT

Click here to pick one of the above products/projects.

Nest[1], Hue[2], Withings[3], Good Night Lamp[4], Safecast[5], Luftdaten[6], Oxford Flood Network[7], Rolls-Royce[8].

Draw a reference model of how it works.

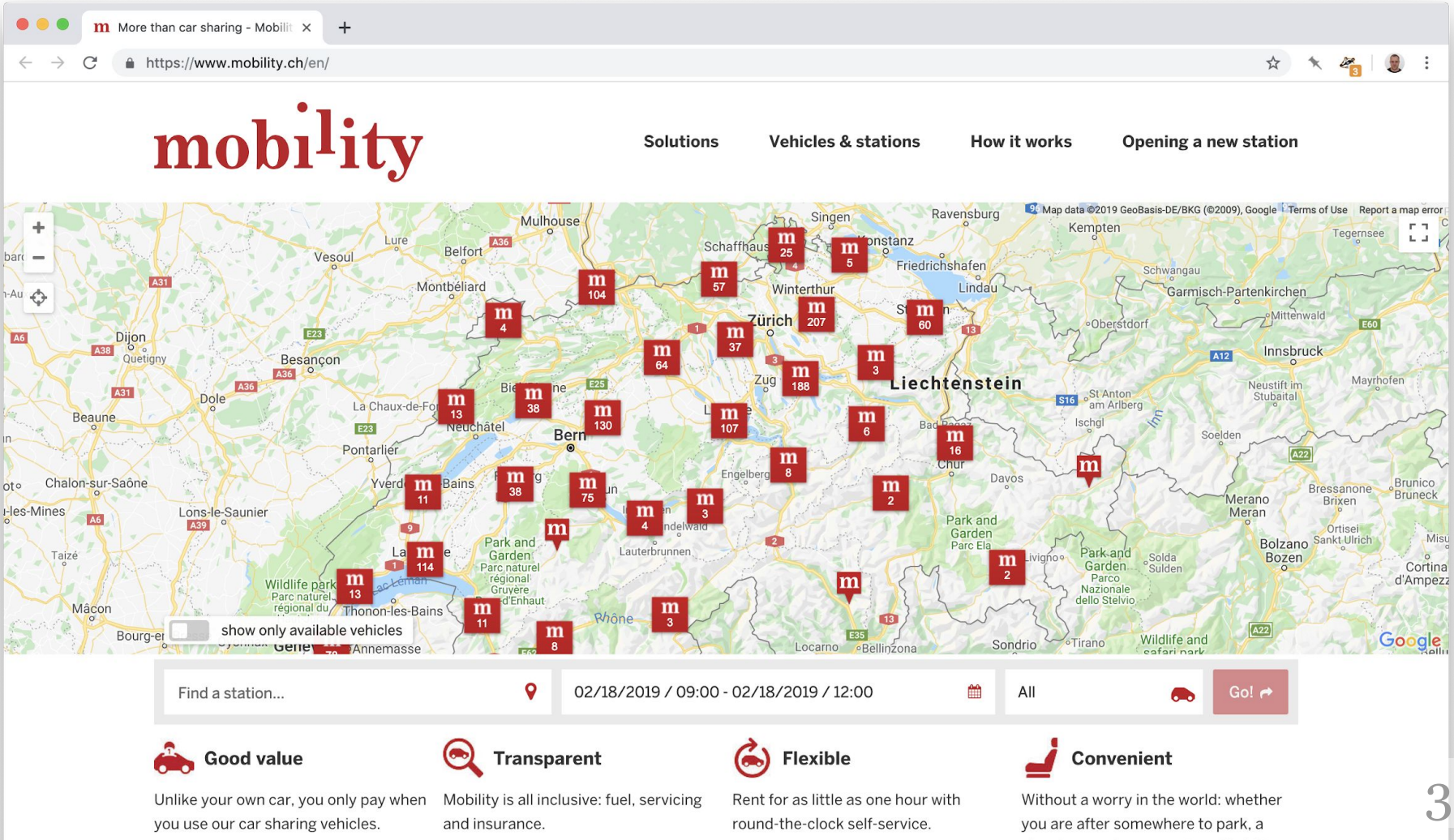
Here is a connected door example.

Be ready to present your result.

Connected product

The entirety of one or more devices, gateways, backends, apps and the services they represent.

E.g. ATM, "money, now".
Philips Hue, "smart lighting".
Kindle, "never be without a book".
Good Night Lamp, "share your presence".
Echo, "control your home, using just your voice".


More than car sharing - Mobilit
https://www.mobility.ch/en/
mobility
Solutions
Vehicles & stations
How it works
Opening a new station
Map data ©2019 GeoBasis-DE/BKG (©2009), Google
Terms of Use
Report a map error
Zürich
Winterthur
Liechtenstein
Bern
Basel
Lucerne
Lausanne
Geneva
show only available vehicles
Find a station...
02/18/2019 / 09:00 - 02/18/2019 / 12:00
All
Go!
Good value
Unlike your own car, you only pay when you use our car sharing vehicles.
Transparent
Mobility is all inclusive: fuel, servicing and insurance.
Flexible
Rent for as little as one hour with round-the-clock self-service.
Convenient
Without a worry in the world: whether you are after somewhere to park, a

Architectural Patterns

Systems with various degrees of connectedness.

Physical computing (on device).

App + accessory (local/personal network).

Remote sensing (device via gateway to cloud).

Remote control (cloud via gateway to device).

Edge computing (on edge device/gateway).

Physical computing

On device sensing/control, no connectivity.

Sensor → Device, e.g. logging temperature.

Device → Actuator, e.g. time-triggered buzzer.

Sensor → Device → Actuator, e.g. RFID door lock.

A → B: measurement or control data flow.

App + accessory

Local sensing/control, local connectivity.

Sensor → Device → Client app

E.g. blood sugar measurements.

Actuator ← Device ← Client app

E.g. insulin pump control data.

A → B: measurement or control data flow.

Remote sensing

Sensor → Device → Gateway → Backend → Client

E.g. air quality data via LoRaWAN to shared map.
(LoRaWAN would introduce an additional backend.)

Or machine telemetry via 3/4G to analysis tool client.
(3/4G gateway would be transparent, it's TCP/IP.)

A → B: measurement or control data flow.

Remote control

Client → Backend → Gateway → Device → Actuator

E.g. app sends command via backend to dim a light.

Or a stormy weather service triggers a blind to go up.

Remote sensing and control can be combined.

This is sometimes called "physical mashup".

A → B: control data flow.

Edge computing

Sensor → Device → Edge GW → Device → Actuator.

Variant: Sensor → Edge Device → Actuator.

Use cases: Low latency or big amounts of data.

E.g. cloudless voice recognition unlocks a door.

Or FFT over local machine data, trigger alerts.

A → B: measurement or control data flow.

Important IoT System Qualities

Security, to keep devices, network & backend secure.

Privacy, to keep people in control of their own data.

Interoperability, to become part of an ecosystem.

Openness, standards & open source build trust.

See, e.g. betteriot.org principles for guidance.

Your WiFi-connected thermost

The Washington Post (WP Company LLC) [US] | https://www.washingtonpost.com/posteverything/wp/2016/11/03/your-wifi-connected-thermostat-can-take-down-t...

Sections

The Washington Post
Democracy Dies in Darkness

Your WiFi-connected thermostat can take down the whole Internet. We need new regulations.

The government has to get involved in the “Internet of Things."

By **Bruce Schneier**
Bruce Schneier is a security technologist and a lecturer at the Kennedy Sch
Harvard University. His new book, "Click Here to Kill Everybody," will be pub
November 3, 2016

Late last month, popular websites like Twitter, Pinterest, Reddit and P
most of a day. The distributed denial-of-service attack that caused the
vulnerabilities that made the attack possible, was as much a failure of
it was of technology. If we want to secure our increasingly computerize
world, we need more government involvement in the security of the “I
and increased regulation of what are now critical and life-threatening
longer a question of if, it’s a question of when.

First, the facts. Those websites went down because their domain name

Jeremiah Grossman on Twitter

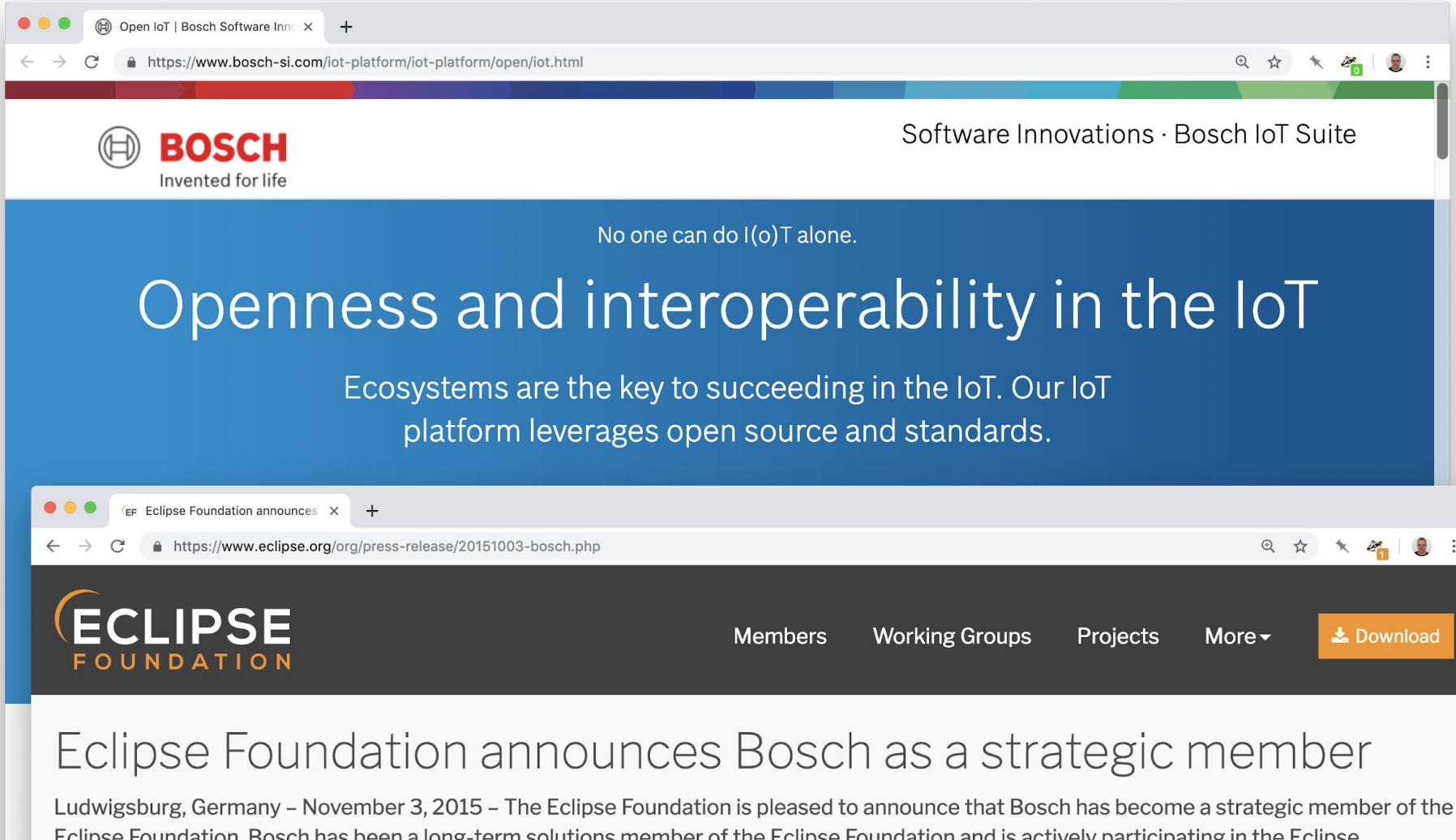
https://twitter.com/jeremiahg/status/78957408345313...

Jeremiah Grossman
@jeremiahg

Follow

As Bruce Schneier recently explained about IoT-device security, "The market can't fix this because neither the buyer nor the seller cares."

11:08 PM - 21 Oct 2016


Open IoT | Bosch Software Inn
https://www.bosch-si.com/iot-platform/iot-platform/open/iot.html
BOSCH
Invented for life
Software Innovations · Bosch IoT Suite
No one can do I(o)T alone.
Openness and interoperability in the IoT
Ecosystems are the key to succeeding in the IoT. Our IoT platform leverages open source and standards.
Eclipse Foundation announces
https://www.eclipse.org/org/press-release/20151003-bosch.php
ECLIPSE FOUNDATION
Members
Working Groups
Projects
More
Download
Eclipse Foundation announces Bosch as a strategic member
Ludwigsburg, Germany – November 3, 2015 – The Eclipse Foundation is pleased to announce that Bosch has become a strategic member of the

Summary

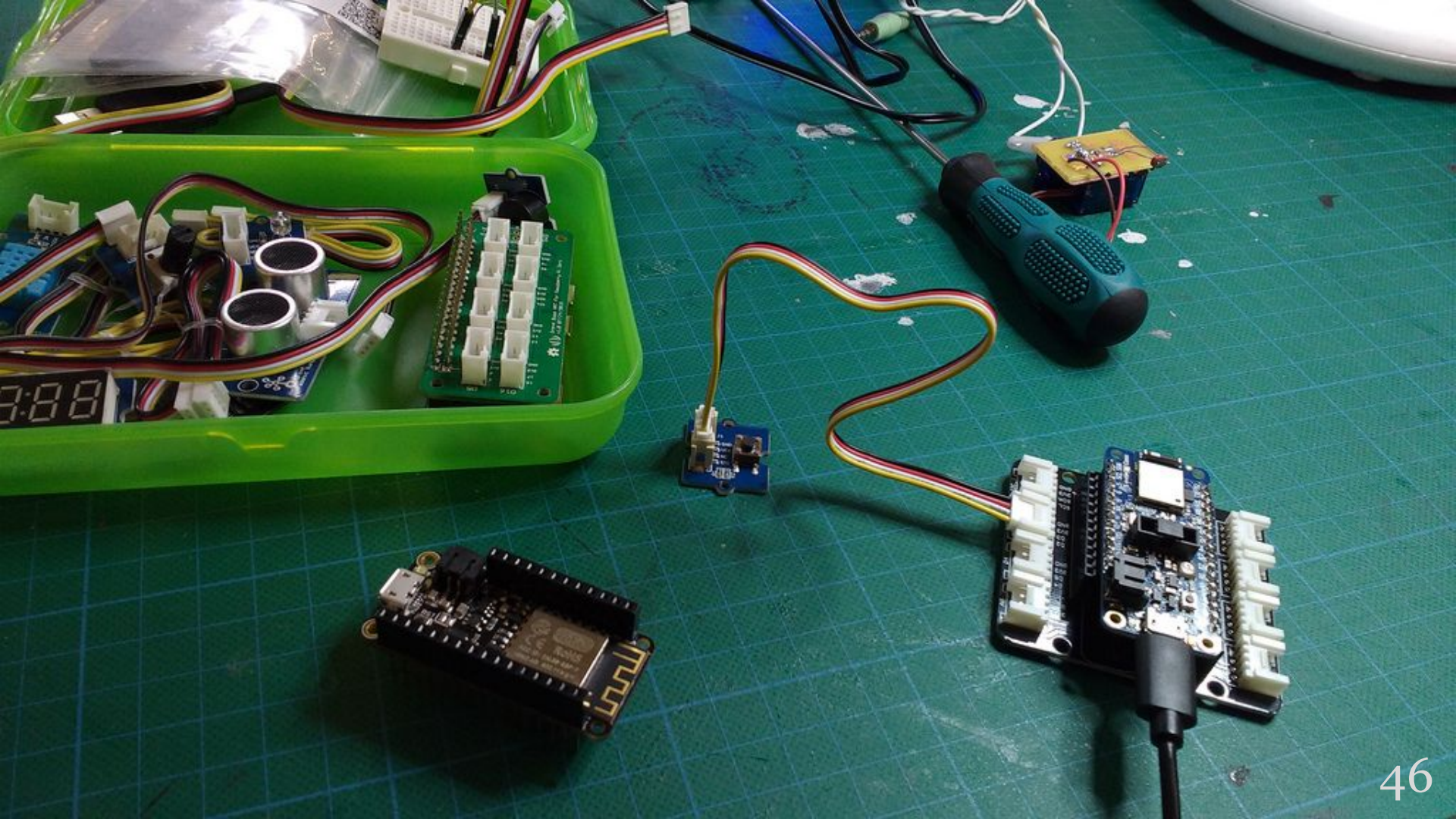
We defined IoT, understood the drivers behind it.

We looked at connected products in three sectors.

We know a simple reference model for IoT systems.

We've seen some patterns with varying connectivity.

Next: Microcontrollers, Sensors & Actuators.



Homework, max. 3h

Install the Arduino IDE and set up microcontrollers:

Check the Wiki entry on Installing the Arduino IDE.

Set up the Feather nRF52840 Express for Arduino.

Set up the Feather Huzzah ESP8266 for Arduino.

And take a first look at the IoT Engineering Wiki.

Feedback?

Find me on https://fhnw-iot.slack.com/

Or email thomas.amberg@fhnw.ch

Slides, code & hands-on: tmb.gr/iot-1