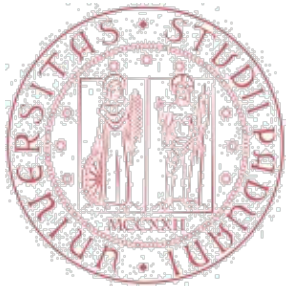

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IoT for Smart Cities: requirements, challenges, and experimental results

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IEEE SPS Italy Chapter Summer School on Signal Processing (S3P)

Outline

- **Part A: vision**
  - Smart City Services
  - Technical requirements
- **Part B: technologies**
  - Cellular
  - Short range
  - Low power wide area
- **Part C: pilots and trials**
  - Padova Smart City
  - Smart Santander

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PART A: Vision

Smart Cities

http://www.keepcalmstudio.com/gallery/poster/L90JKS

Your perspective!

- What's **YOUR** vision of Smart Cities?

Audience says…

(use this white page to take note of what your **smart** classmates say… hopefully that it will not remain empty)

Big players say…

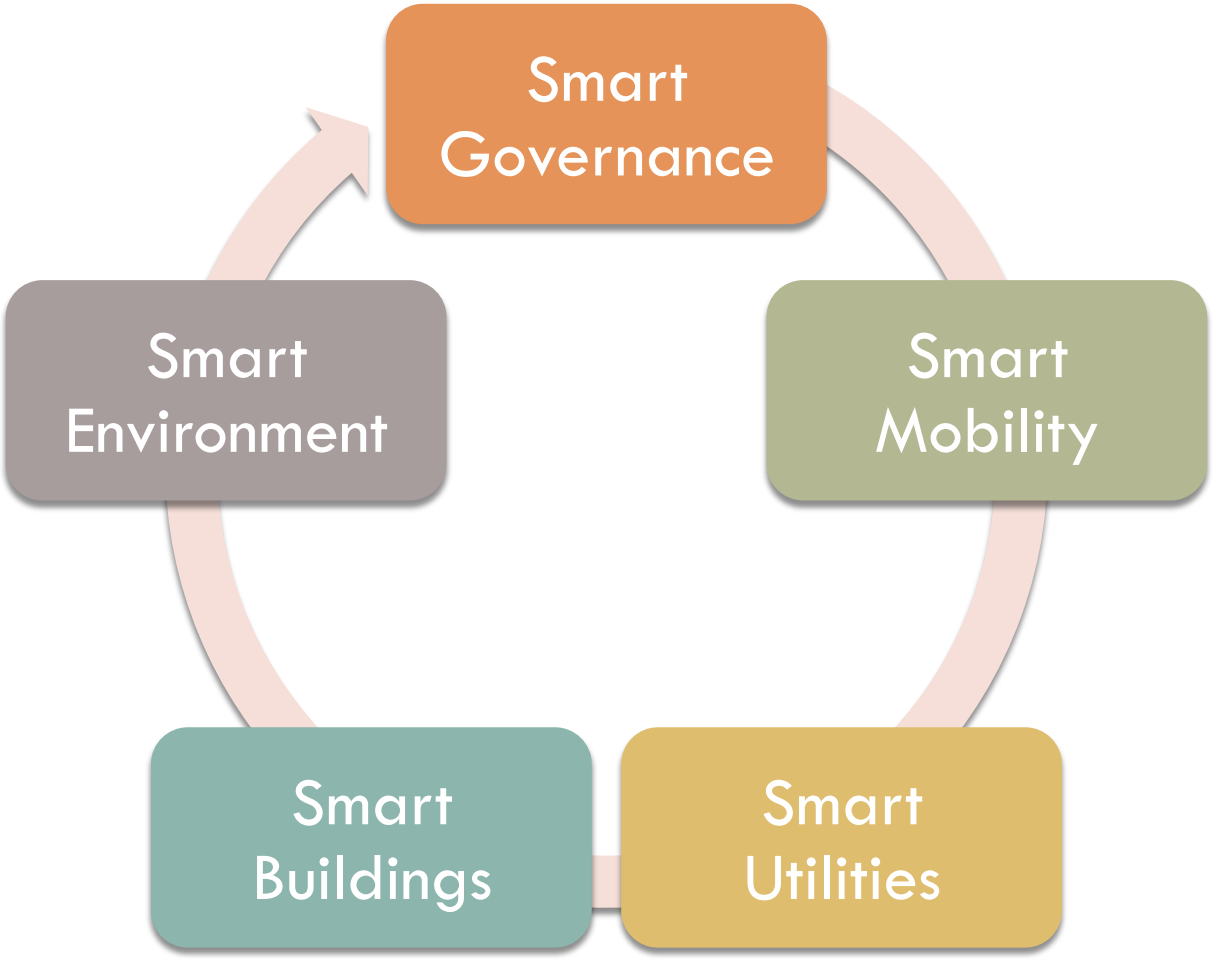
Well… actually,
no one really knows…

but

there's consensus on some points…

Smart Cities concept

Smart city ecosystem



Roadblocks

Political issues

Attribution of decision-making power to different stakeholders

Financial aspects

Lack of clear business model

Technical impairments

Non-interoperability of many heterogeneous enabling technologies

SMART CITY SERVICES

A few examples

Smart buildings

- Monitoring of conditions of (historical) building
  - Polluting levels
  - Humidity/temperature
  - Vibrations
  - Tension sensors in the structure

- Improve energy efficiency
  - Control temperature, humidity, lighting to enhance comfort whole reducing costs
- Keep an eye on structural health of the building
  - E.g., schools…

Waste management

- Intelligent waste containers
  - Detect level of load
  - Check quality of garbage
  - Communicate with Internet
- Optimize collector trucks route
  - Reduce costs
  - Improve efficiency
  - Reduce pollution

Air quality monitoring

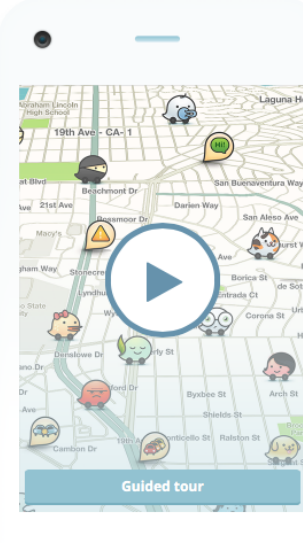
- The 20-20-20 European Union directive targets:
  - 20% reduction of greenhouse gas emissions by 2020
  - 20% cut of energy consumption
  - 20% increase of use of renewable energy sources
- Air quality sensors can be use to
  - Check the quality of the air and trigger prompt intervention when needed
  - Provide feedback to citizens about quality of air
    - eg, suggesting healthier paths for running or strolling

Noise monitoring

- Noise is a form of pollution that is quite annoying for citizens
  - Hospitals, residential areas, …
- Noise sensors can be used to
  - Map the acoustic pollution over the city
  - Improve public security by recognizing alarming sounds
    - House/cars alarms, glass crashes, brawls,…

Traffic monitoring

- Many cities already use traffic monitoring cameras in critical points
- This system may be further empowered by exploiting sensing and localizing capabilities of modern vehicles
  - https://www.waze.com
- Real time accurate traffic monitoring can
  - Help citizens better planning their trip to office
  - Help administration to discipline traffic

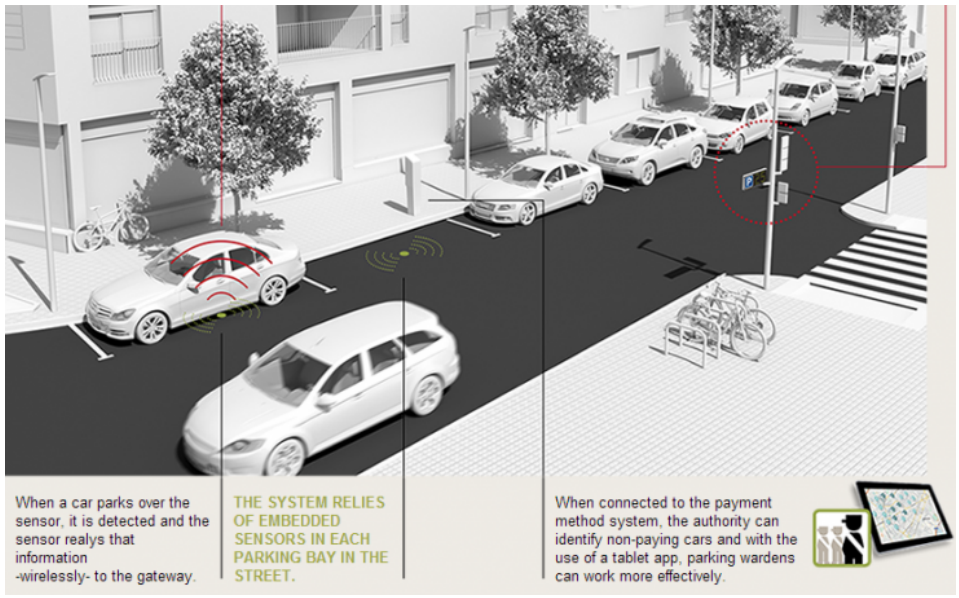


Smart Parking

- Finding a parking place: a modern nightmare!
  - Waste of time → economic loss
  - Source of frustration → health impact
  - Pollution → health/environmental impact

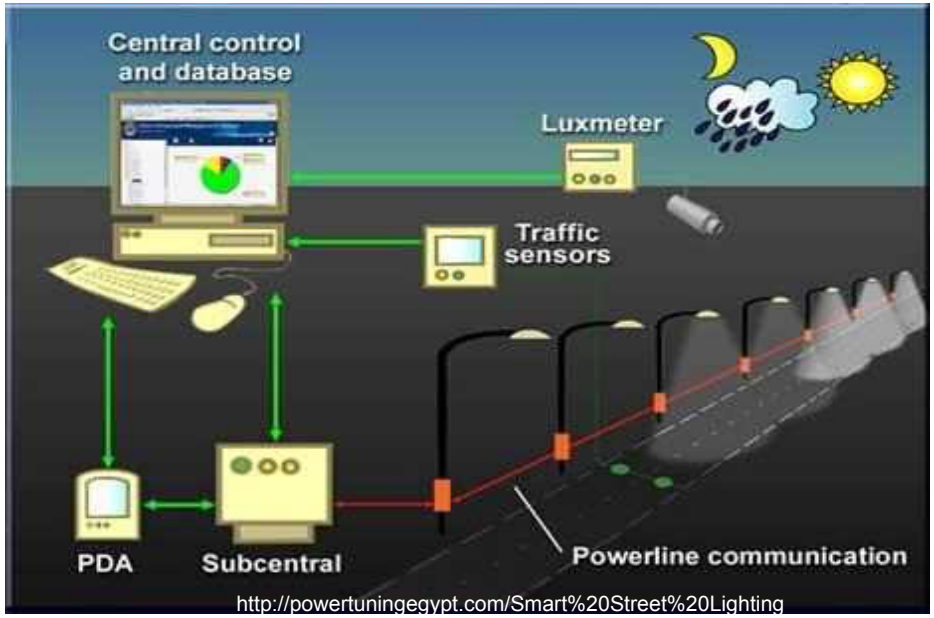
Smart Parking

- Smart parking
  - Place sensors on each parking lot
  - Place intelligent boards along the streets
  - Provide app for smartphones



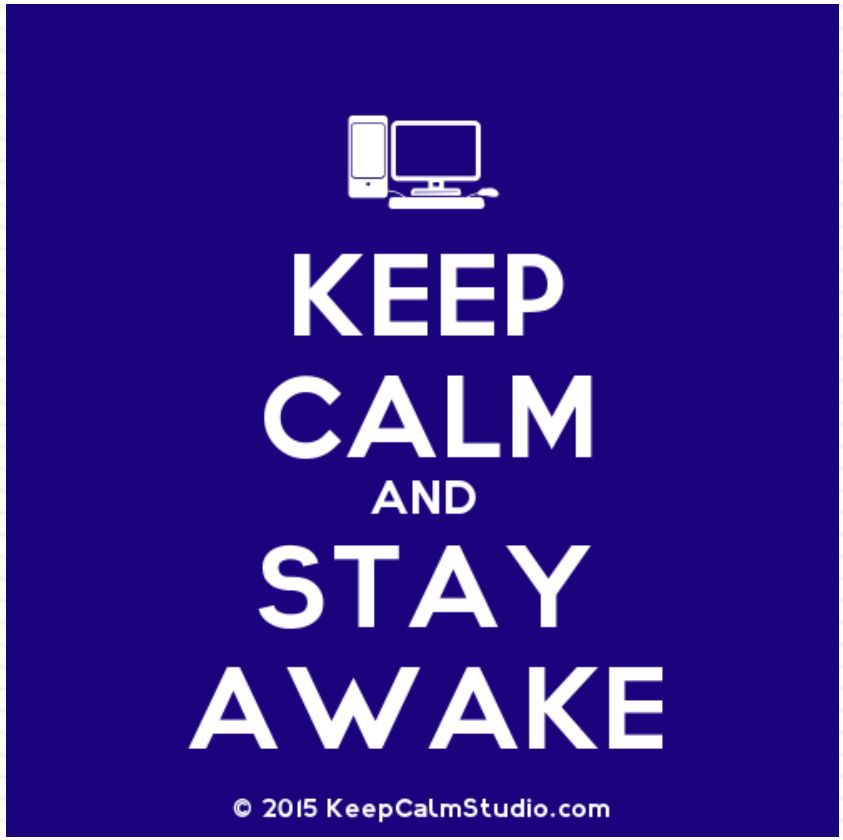
Smart lighting

- Place sensors on street lamps along the road
- Optimize the light intensity according to
  - Time of the day
  - weather conditions
  - presence of people
- Automatically find burned bulbs
  - Reduce replacement time
  - Reduce costs
- Provide WiFi access



Smart City Service Requirements

- **Place-&-Play**
  - Ubiquitous coverage
  - Zero-configuration
- **Low Cost**
  - Simple Hardware
  - Massive production
- **Little maintenance**
  - Very long battery life
  - Very low fault rate
  - Remote control/ reprogramming



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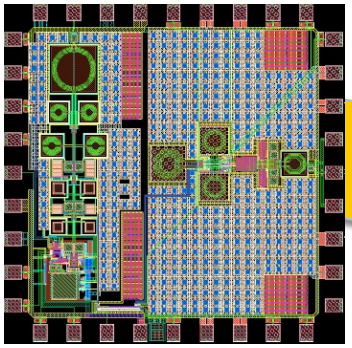
PART B: Technologies

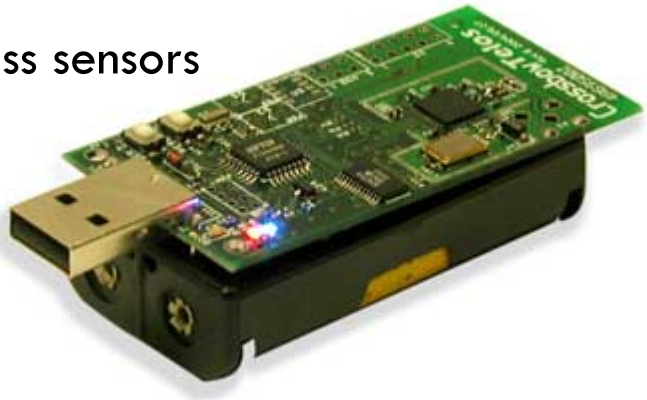
http://www.keepcalmstudio.com/gallery/poster/L90JKS

Components

- ✓ Low-power wireless transmitters



- ✓ Wireless sensors



- ✓ Algorithms and communication protocols

- ✓ Management systems

- ✓ Services

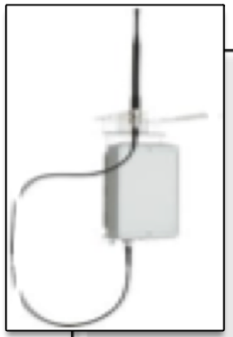
Three main approaches

Short-range multihop

- ZigBee
- WiFi low energy
- RFID

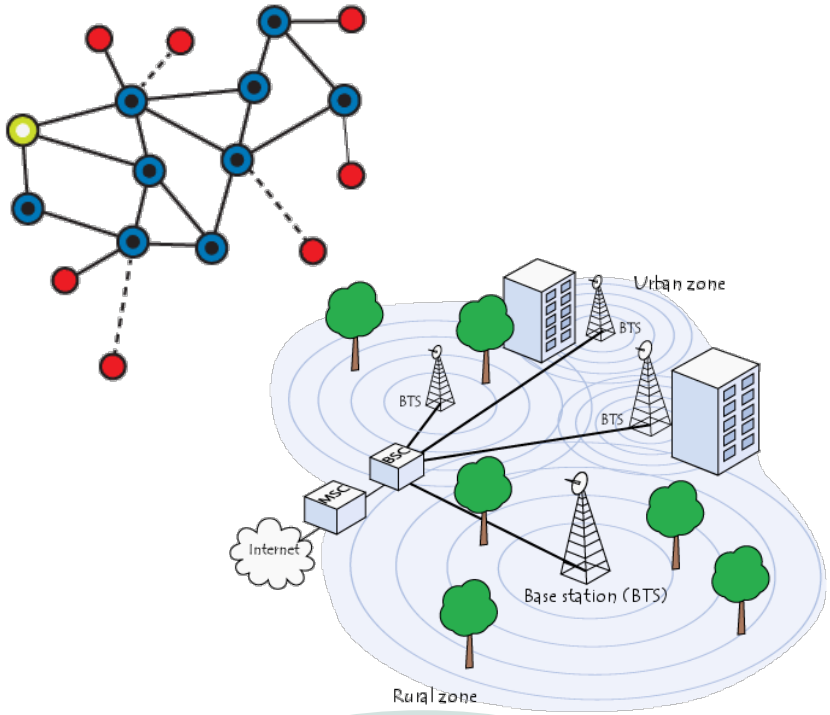
Cellular

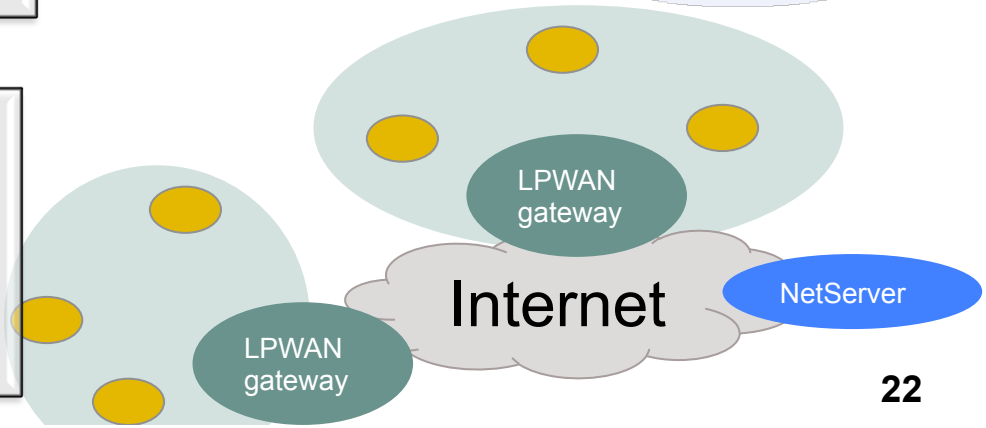
- GSM
- LTE-A
- 5G



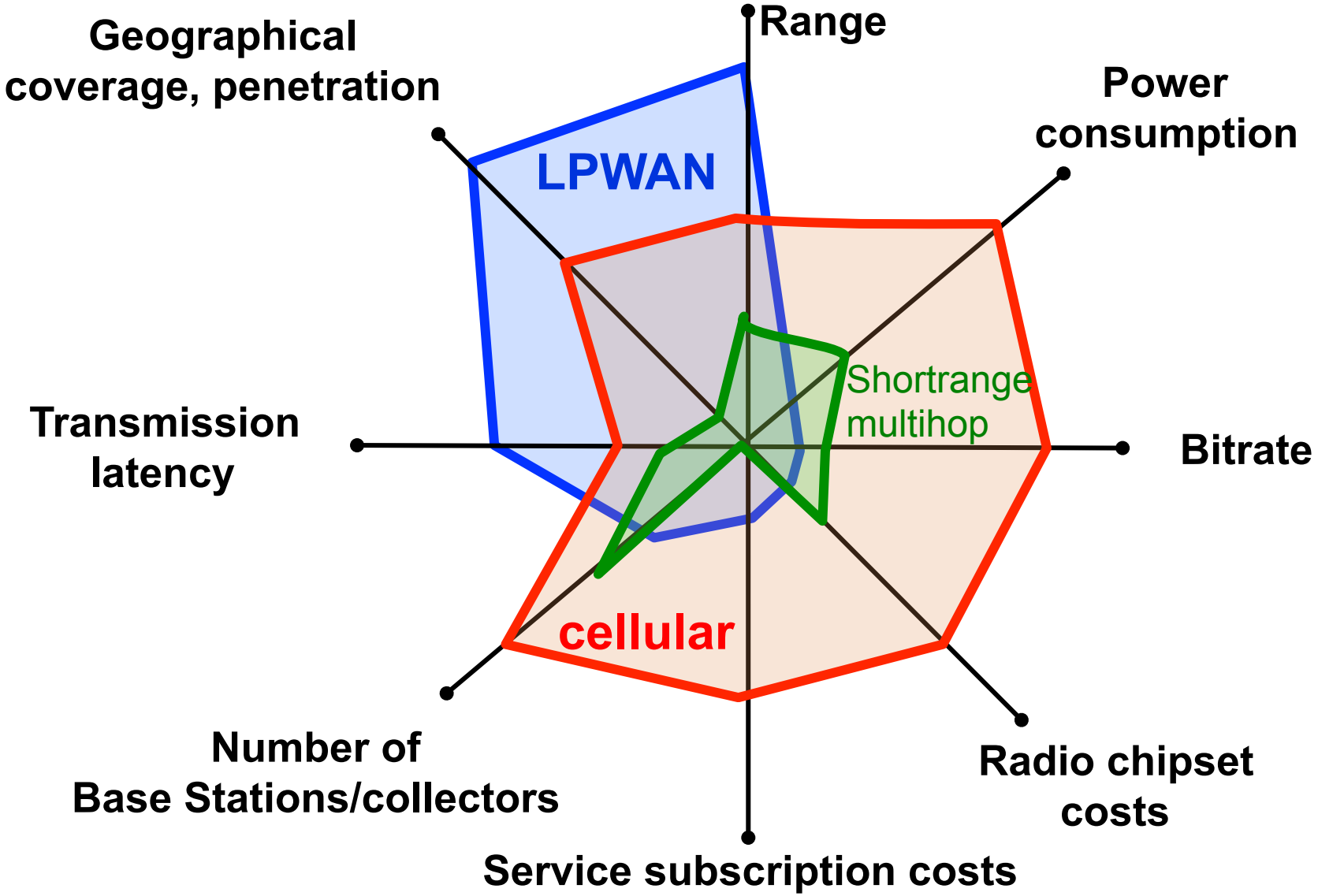
Low Power Wide Area Networks (LPWAN)

- SIGFOX
- Neul
- LoRa

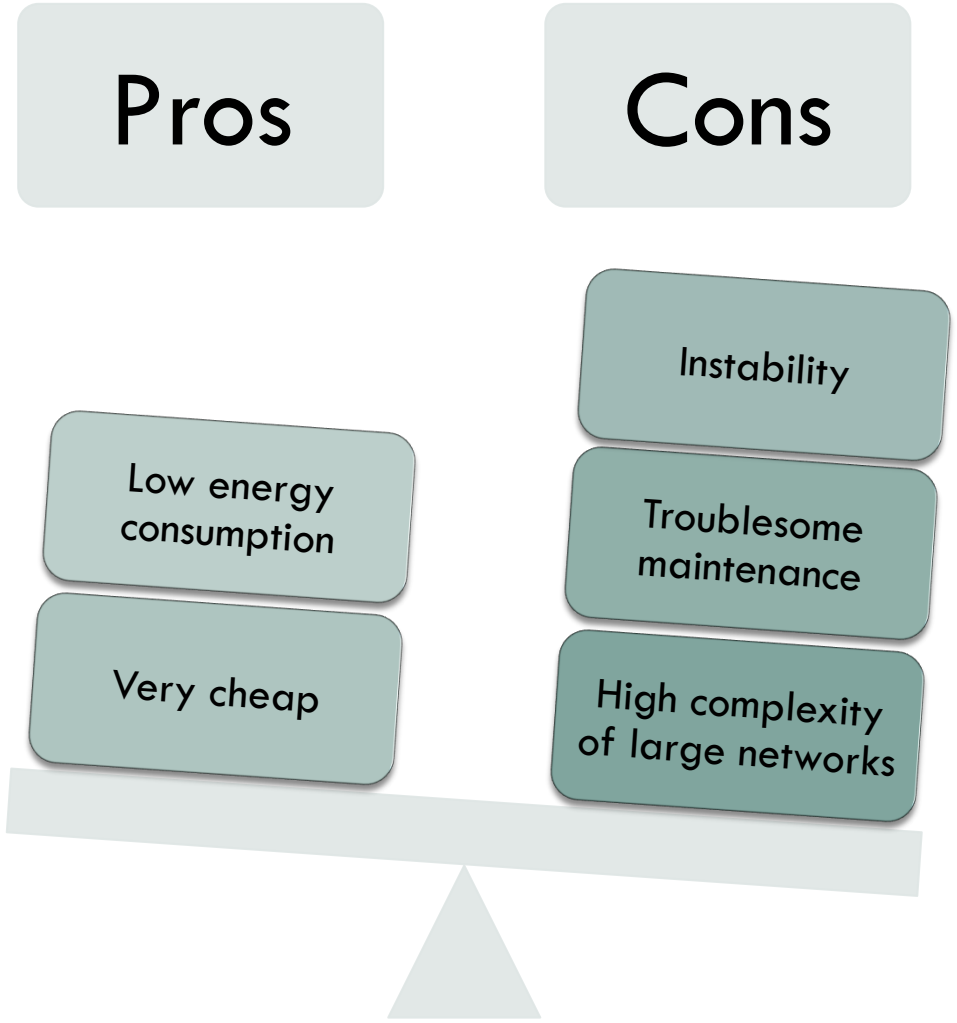




Quick comparison

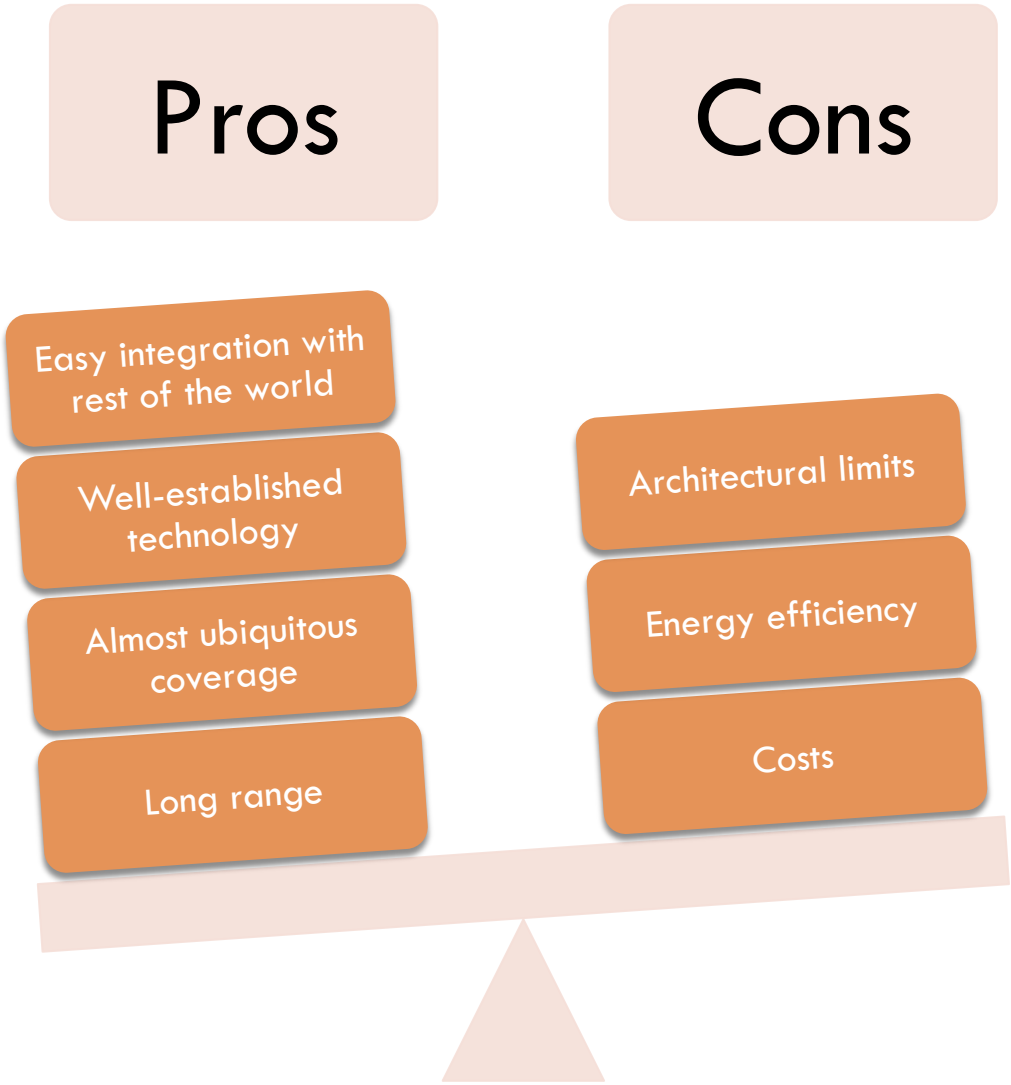


Short range multihop

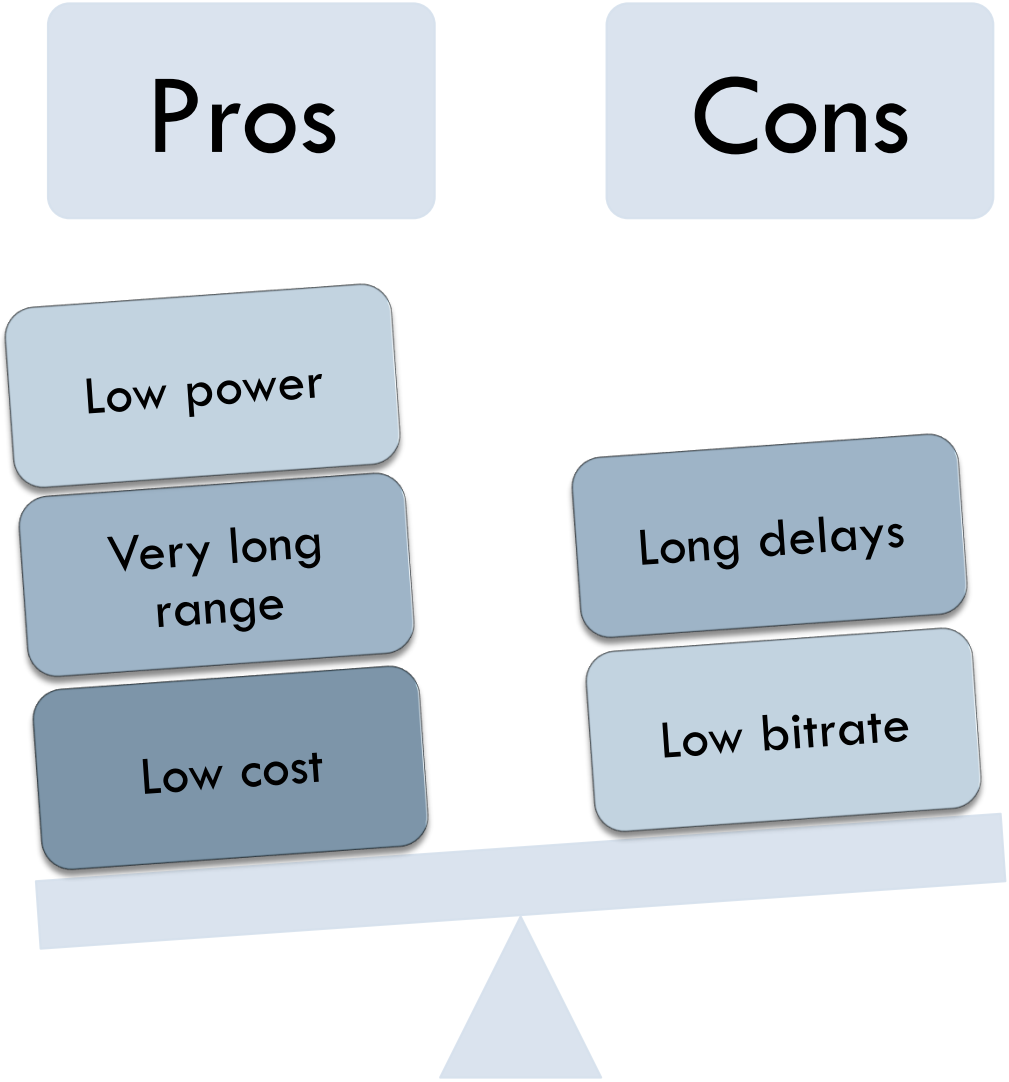


See: https://www.youtube.com/watch?v=xUFUp-ylfC4

Cellular-based solutions



LPWAN


Pros
Cons
Low power
Very long range
Low cost
Long delays
Low bitrate

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PART C: pilots and trials

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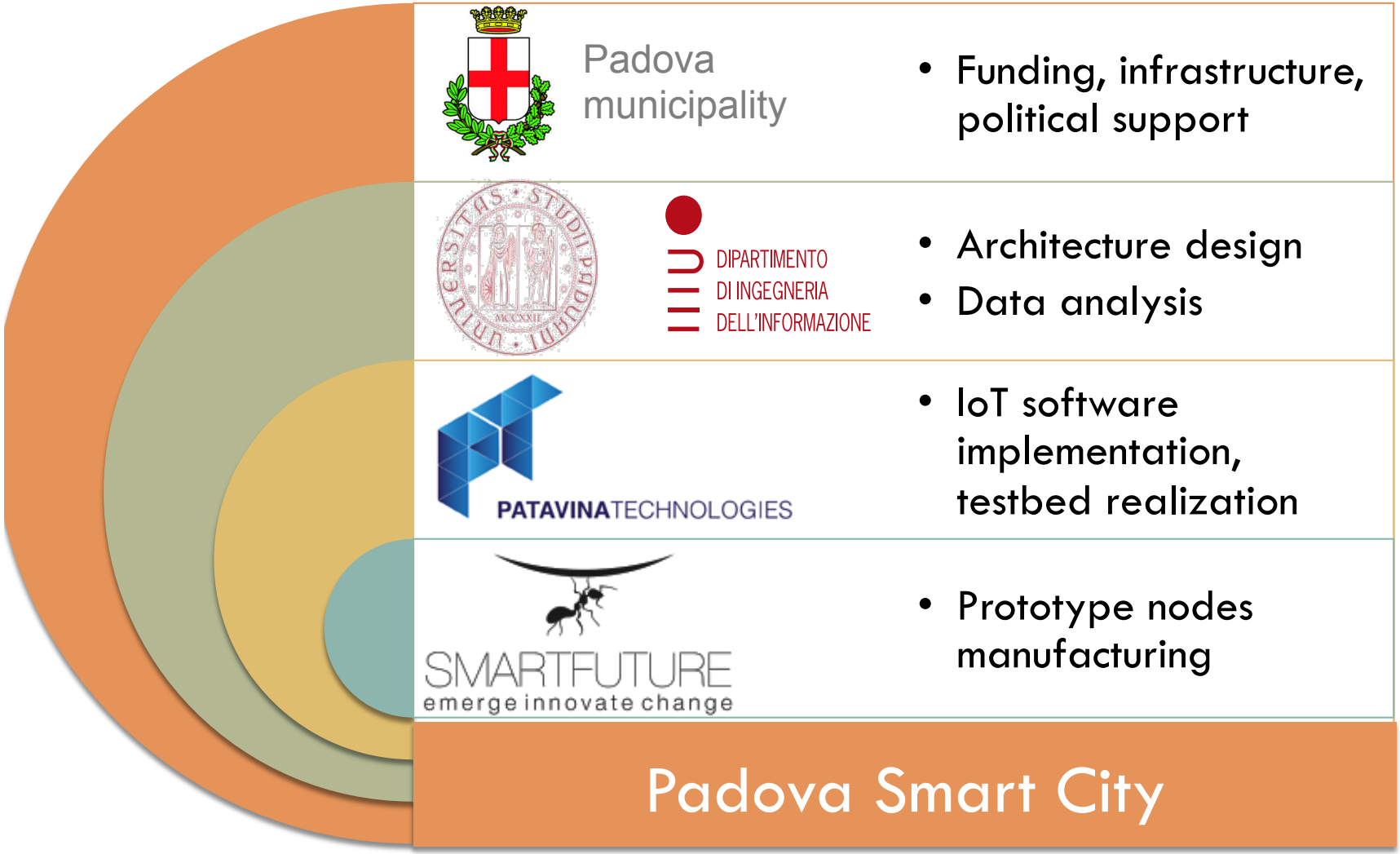
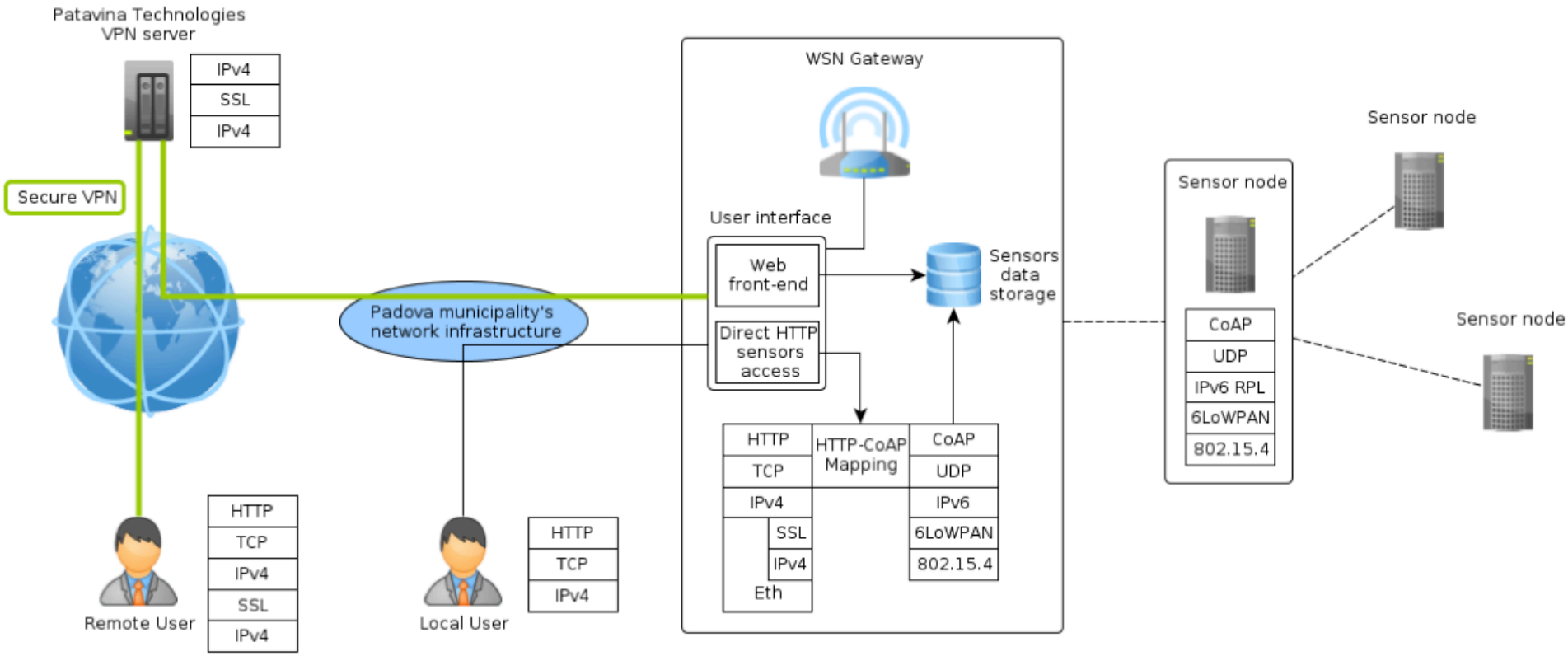
PSC: the players



PSC: architecture



Target application: monitoring public lighting system

- WSN gateway placed inside the switch box that controls the monitored streetlights
  - A low-voltage DC power socket is available in the box
- 8 sensor nodes equipped with multiple sensors
  - light, temperature, humidity readings
  - Mounted close to the bulbs of streetlight poles
    - Battery-pack powered
- One sensor node equipped with benzene sensor
  - placed inside the switch, power by DC source

Nodes placement

Sensor node protected by transparent plastic shield that permits air circulation

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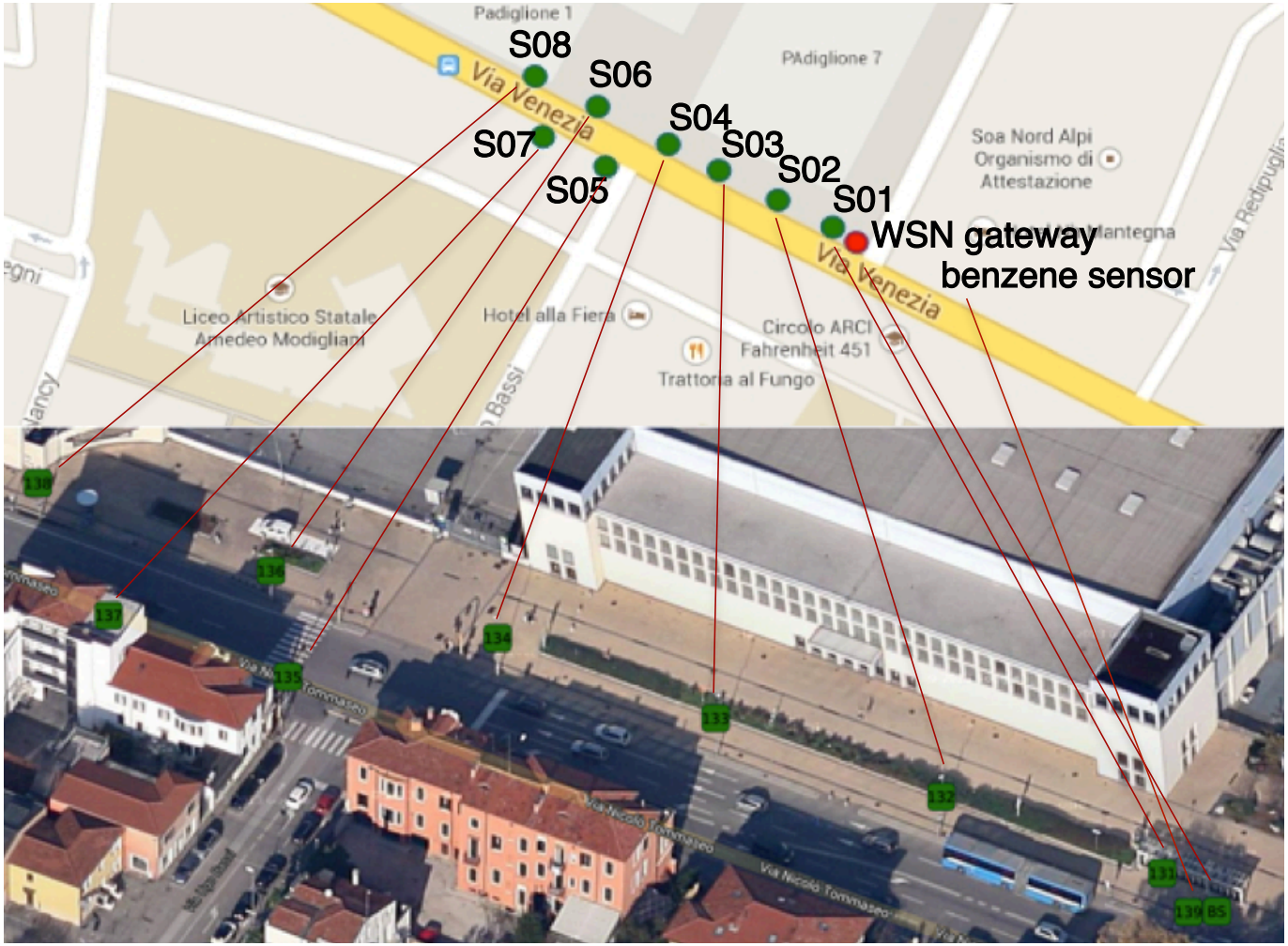
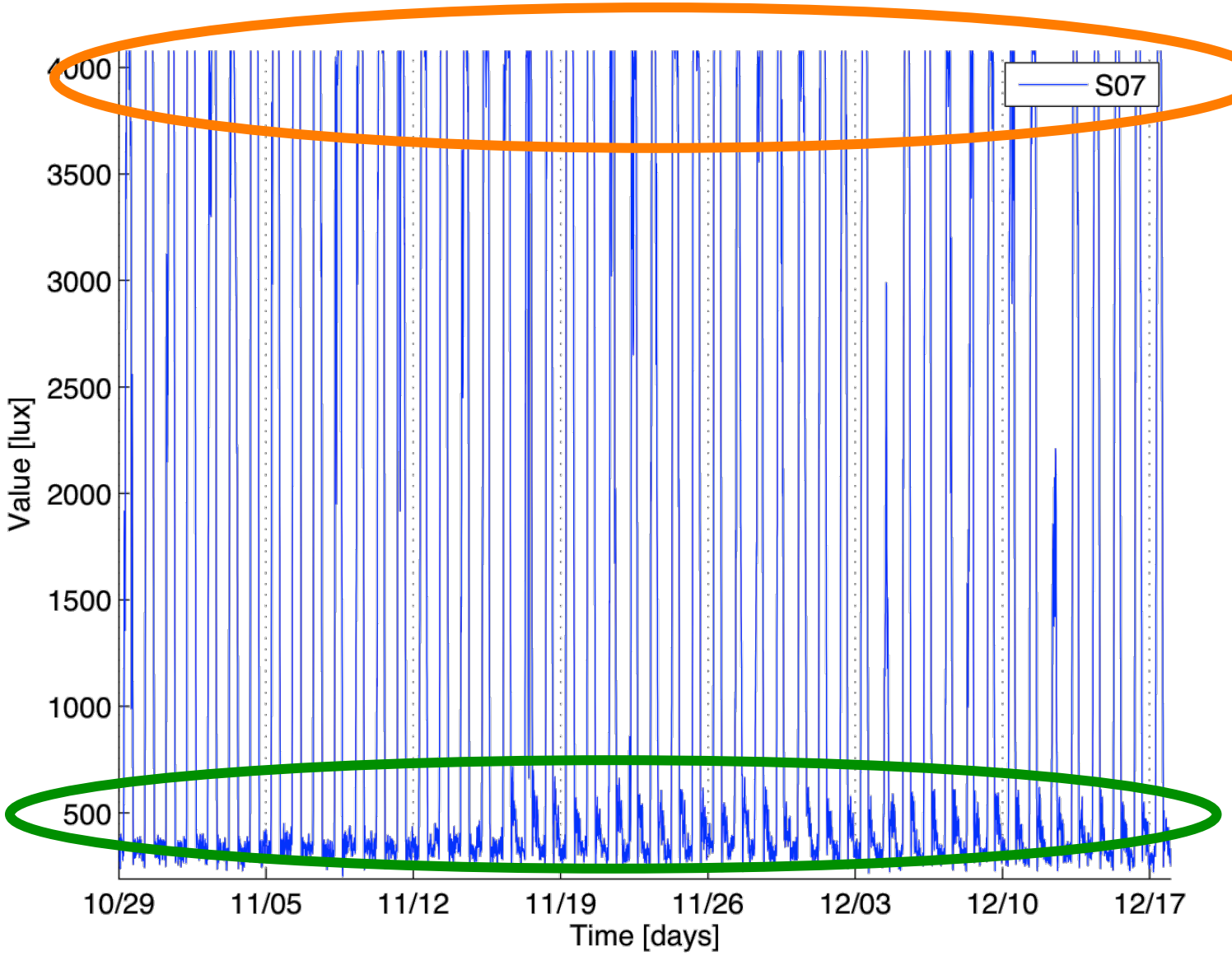
Nodes' location on the map



Data collection and reporting

- Each node reads sensors data every 5 minutes
- The average of three readings is stored in a buffer
  - 1 average value every 15 minutes
- A packet can carry 7 (averaged) values for each of the four sensors
  - One full packet transmitted every 7x15=105 min to the gateway

Example of light readings



Daytime
(saturation)

Nighttime

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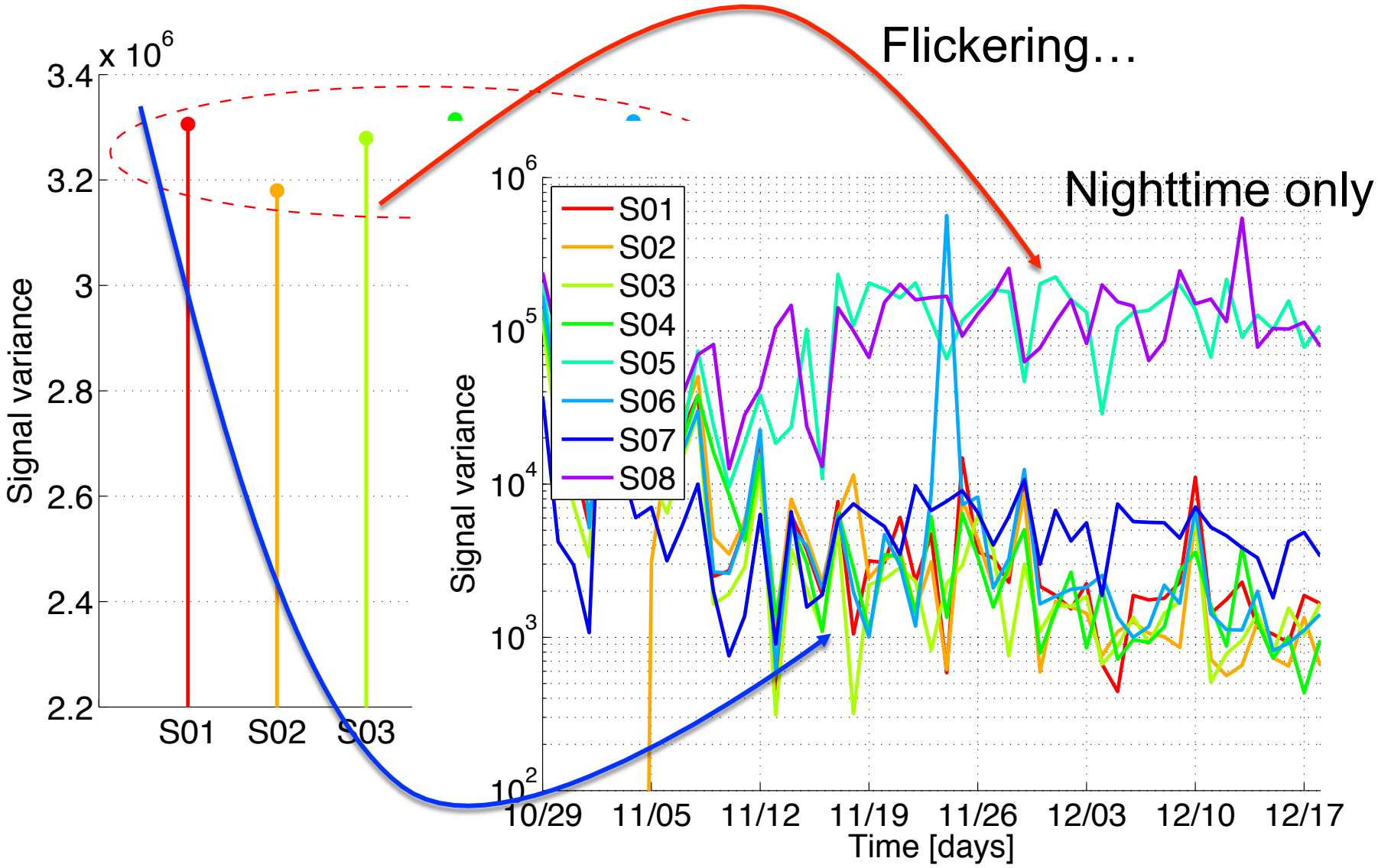
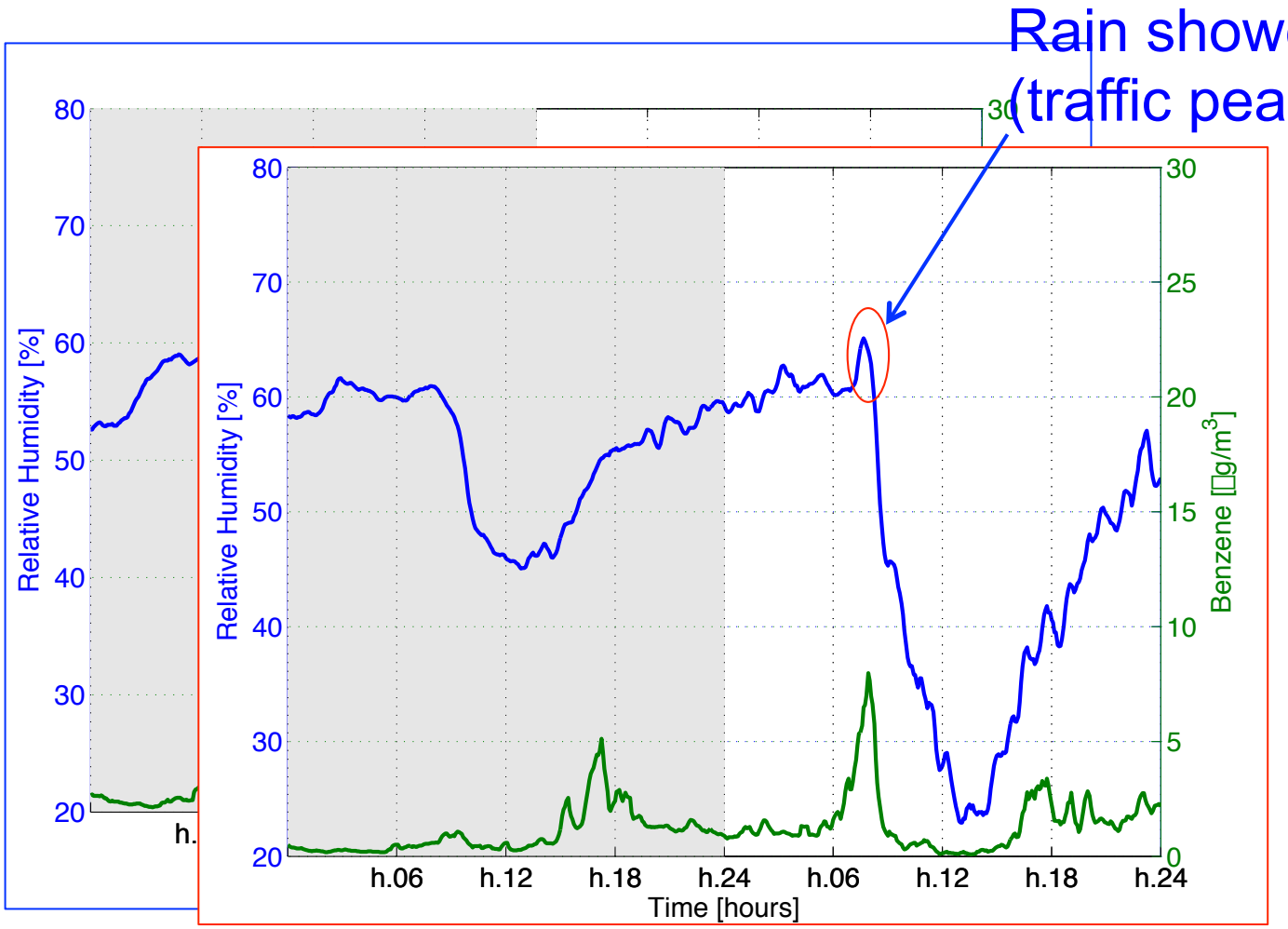
Variance analysis



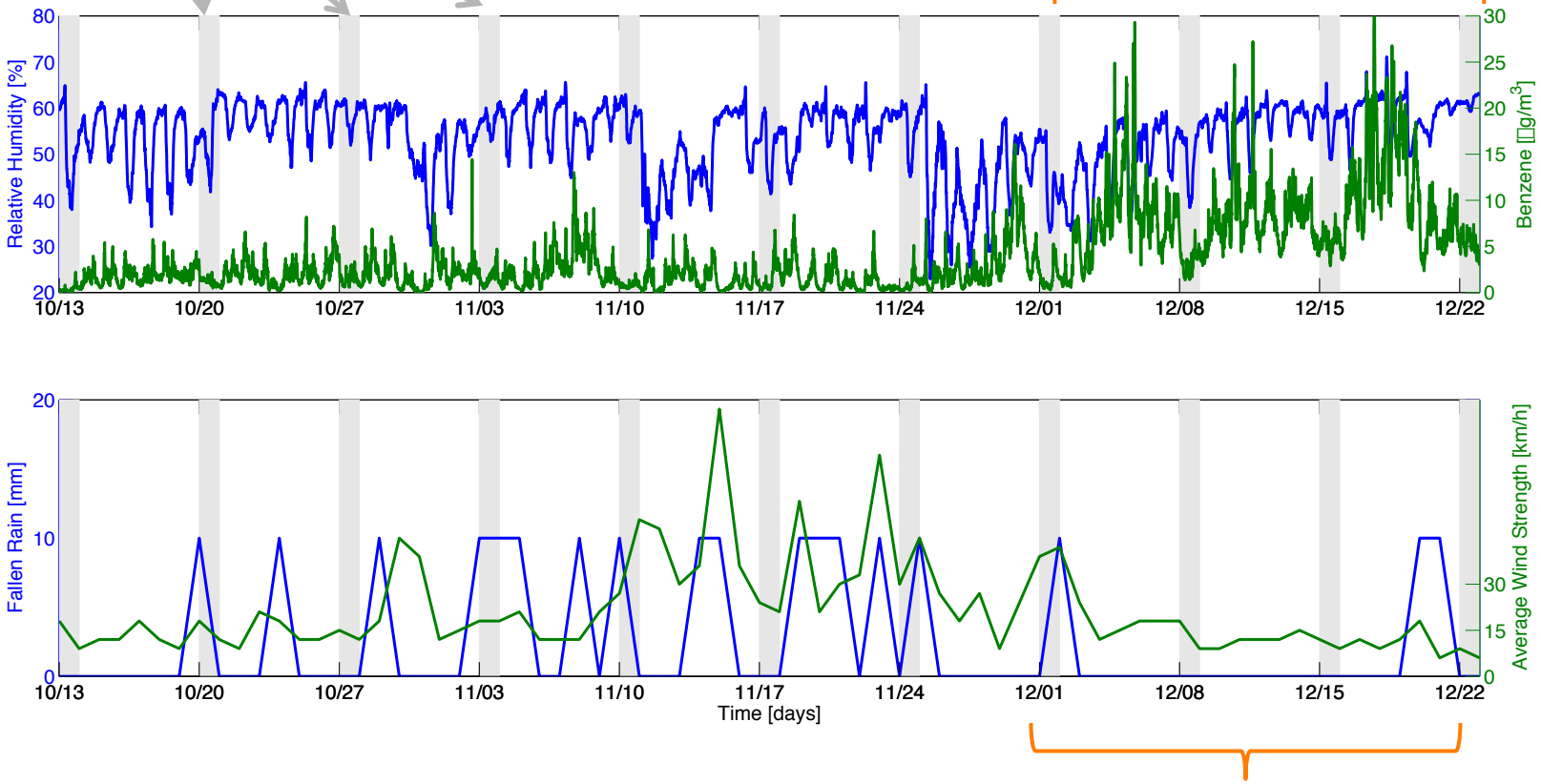
Pollution and weekdays…



Benzene analysis

Sundays

More pollution….



Nice weather….

Conclusions

- Smart City
  - a nice promise… but still to come!
- Why?
  - Many enabling technologies… not yet a clear winner
  - Many data… not clear what to do with them
  - Many players… not clear who leads the play
- Then, what?
  - Keep working on service design, data mining, and signal processing for performance improvements!
  - More trials: 1 test teaches more than 1000 simulations!

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Questions?

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