An Air Quality Monitoring System for Smart Cities

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Motivation

- The quality of air is a remarkable concern in modern cities
  - Effects of pollutants on human health and ecosystem

- Observing the concentration trend of atmospheric pollutants in different urban areas would allow to:

  - detect potential alarm scenarios
  - suggest appropriate countermeasures
  - support urban management

Background

- Current air quality monitoring systems in the urban area are based on fixed monitoring stations
  - Issues:
    - High cost of deployment and maintenance
    - Restricted access to data
      - Open data are aggregated
    - Static deployment
      - Coarse-grained monitoring
      - Scalability issues

Air Quality Monitoring in Palermo

- Air quality is monitored by a network comprising:
  - Ten fixed monitoring stations
    - Precise measurements of:
      - sulfur dioxide
      - carbon monoxide
      - nitrogen dioxide
      - ozone
      - PM_{10}
    - Data processing
    - Data transmission to a central system
  - A central processing system
  - Four control stations
  - Two public displays

Our Proposal

- A Vehicular Sensor Network (VSN) to complement existing network of fixed stations:
  - Sensor nodes are installed on public transportation vehicles, e.g. buses
  - Pros
    - Fine-coarse spatial coverage
    - Low cost
  - Cons
    - Temporal coverage issues
      - Can be handled (buses move on fixed and established routes many times during the day)

Our Proposal

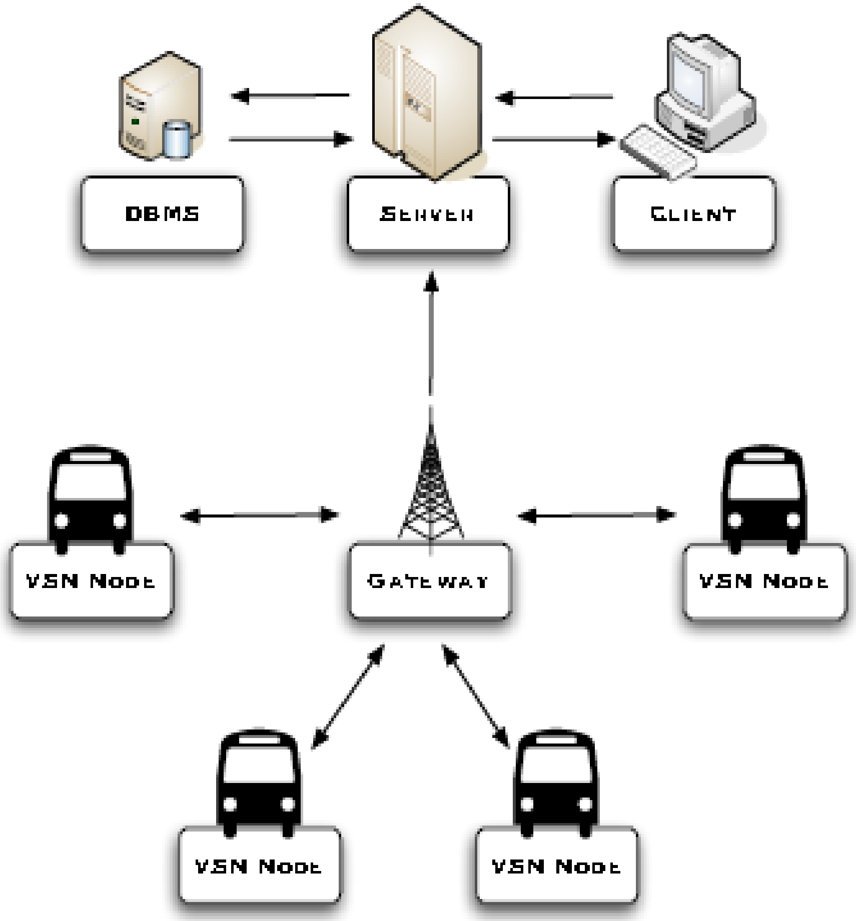
Enable citizens to monitor their daily exposure to gas pollutants

- Coarse-grained
  - Web applications providing global pollution maps
- Fine-grained
  - Smartphone application
    - tagging and monitoring user actual movements
    - model daily individual exposure to air pollution

The Air Quality Monitoring System

Main Components:

- In-Vehicle nodes, each provided with a microcontroller, communication devices and sensors
- Gateways, receive data from each node and forwards them to the central server
- Central server, store gathered data, ensuring integrity, security and availability

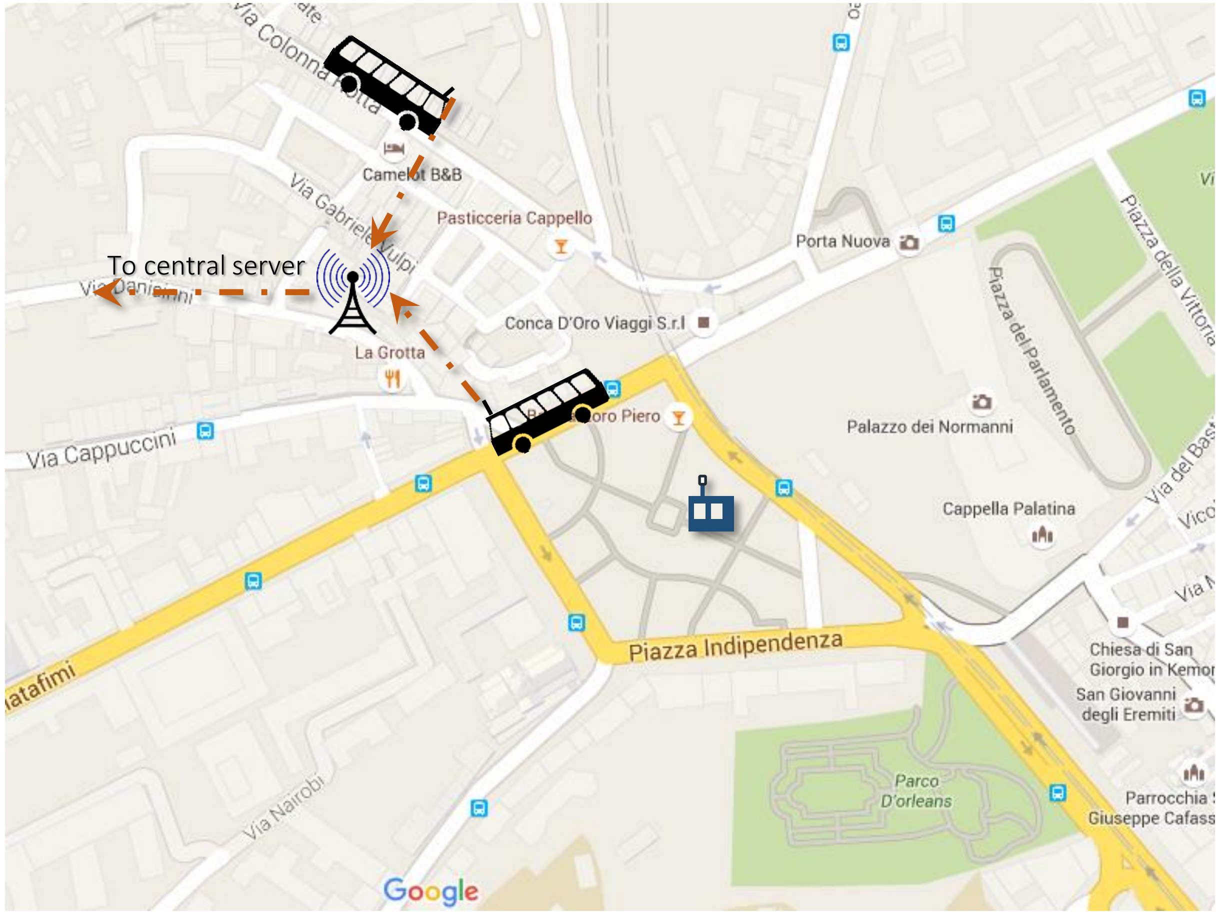


The Air Quality Monitoring System

Periodically, vehicular nodes:

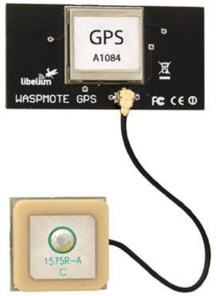
- measure air pollutants
- store the measurements along with:
  - time
  - current location given by the Global Position System (GPS) module
- Detect access points displaced along the routes (traffic light poles, bus stops)
- Transmit collected data to the central server through the access points

No continuous connection needed



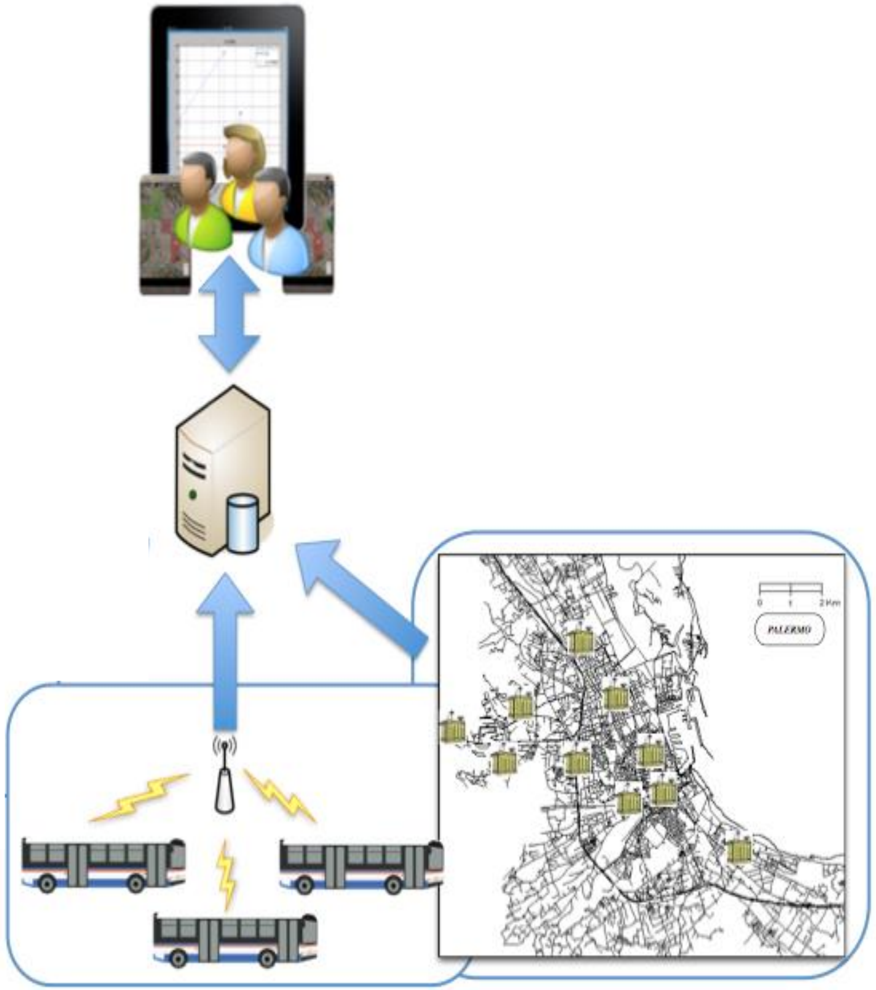
VSN node hardware

- Features of the Waspmote hardware platform:
    - Atmel ATmega1281 microcontroller (8 KB SRAM, 4KB EEPROM, 128 KB Flash)
    - 2GB SD Card storage for measurements
    - GPS
    - Communication modules
    - Gas sensor board to monitor:
        - Temperature
        - Relative humidity
        - Nitrogen dioxide (NO_2)
        - Carbon dioxide (CO_2)
        - Carbon monoxide (CO)
        - Ozone (O_3)
    - Lower power required than other platforms
    - All communications modules are certified and interoperable



Mobile Application

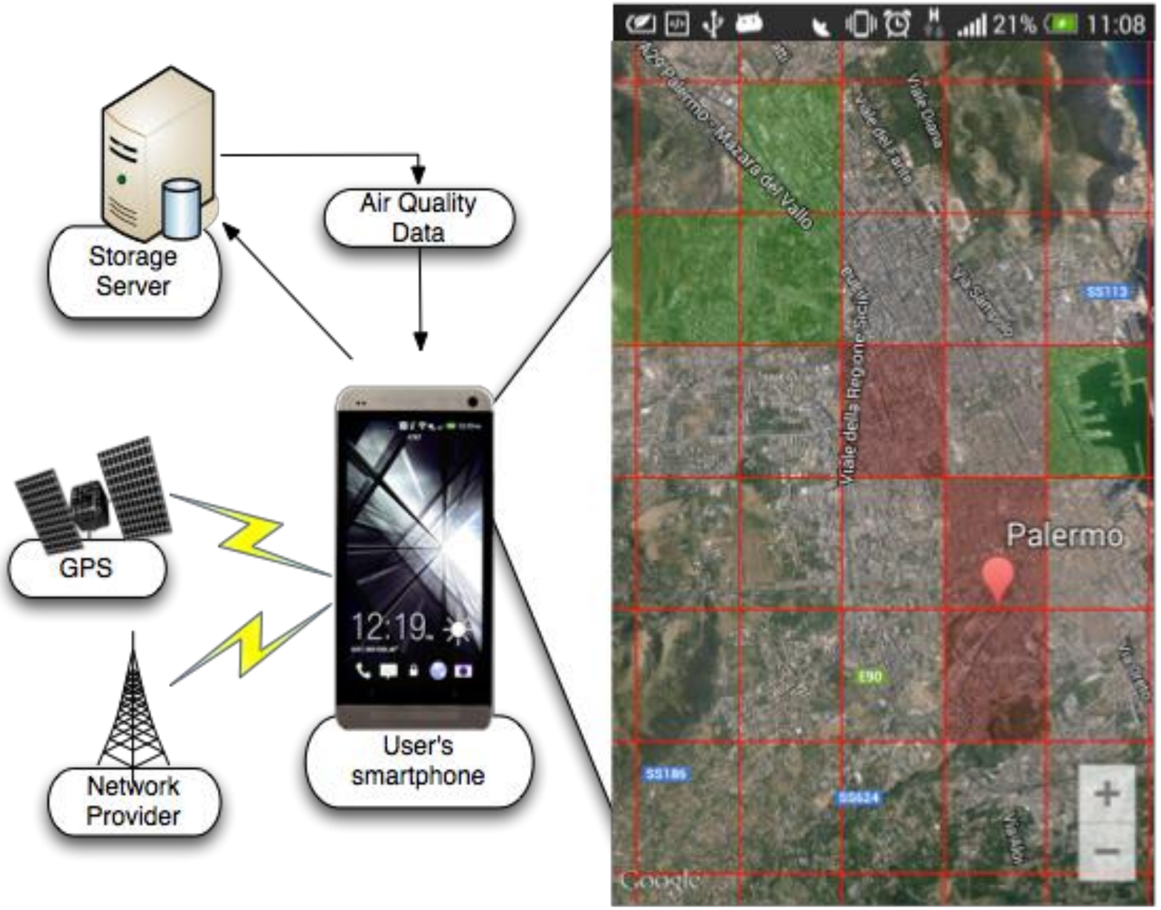
- Modeling individual exposure to air pollution requires combining information about:
  - Concentration of an air pollutant
    - Spatiotemporal variant phenomenon
    - Represented by modeled or interpolated grids with discrete time steps
  - Individual movements
    - Space-time paths
    - Represented by GPS tracks



Mobile Application

Tasks

- Tracks user movements in the urban grid
- Segments tracking data with respect to the grid
- Computes of the user exposure levels to pollutants according to the amount of time spent in each cell
- Gives a color-coded representation of impact or exposure (AQI)



Conclusions

- We proposed an architecture for urban air quality monitoring
  - Targeted to the specificities of Palermo
  - Based on VSN deployed on the city public bus fleet
    - No energy constraints because vehicles can provide continuous power
    - High computational capabilities because vehicles can be equipped with sufficient computational resources
    - Fine-grade spatial and temporal coverage
    - Ease of deployment
    - Low cost commodity hardware
  - Access to collected data by users
    - Web applications
    - Mobile application for daily individual exposure to pollutants

Future Work

Participatory sensing through integration with:

- IoT
- Wireless Sensor Networks
- Personal monitoring devices

To support:

- Urban traffic forecast and management
- Individual daily route planning
- Health awareness and assessment campaigns

References

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