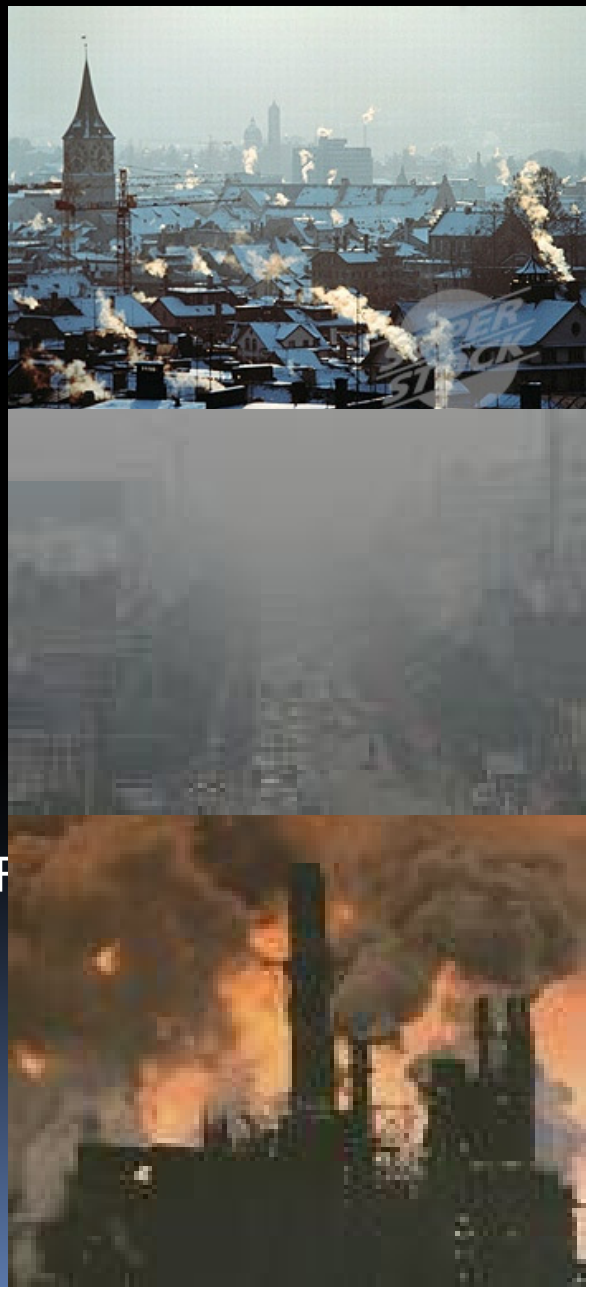
nano-tera.ch
swiss scientific initiative in health / security / environment systems

FNSNF



OPENSENSE

OPEN SENSOR NETWORKS FOR AIR QUALITY MONITORING

Karl Aberer, EPFL
Boi Faltings, Alcherio Martinoli, Martin Vetterli, EPF
Lothar Thiele, ETH Zürich

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

OpenSense Vision

Community driven, large-scale air pollution measurement in urban environments

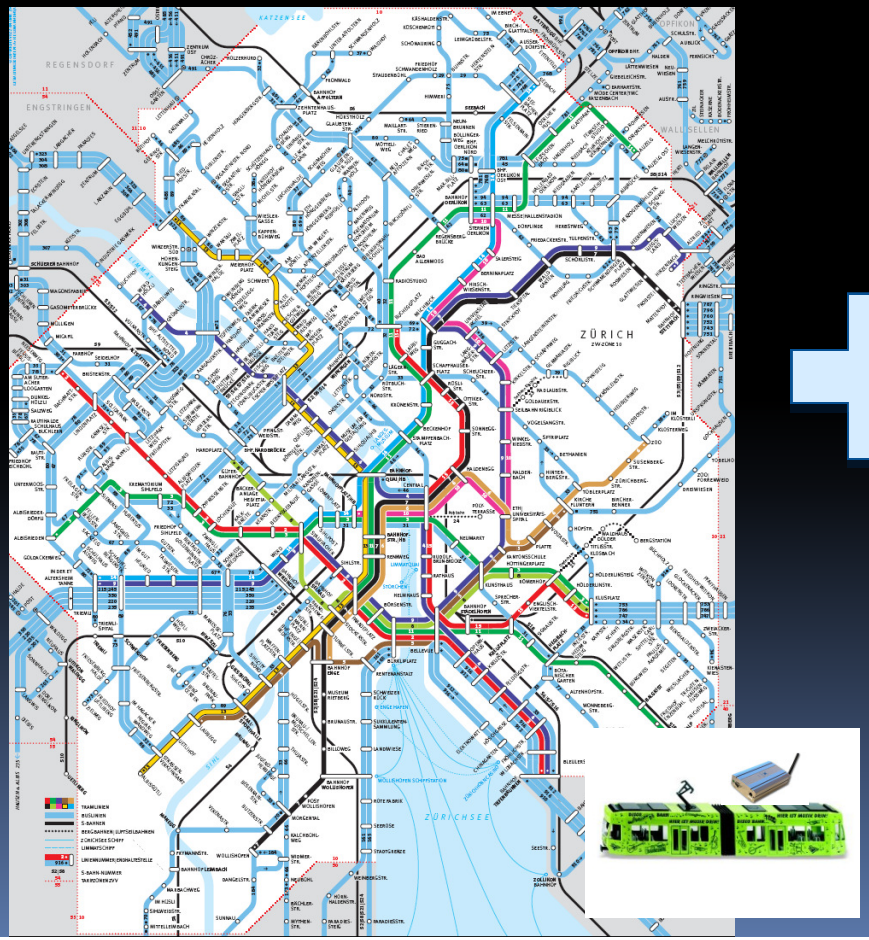
- Important problem: **air pollution**
  - Affects **quality of life** and **health**
  - **Urban population** increasing
  - Air pollution is highly **location-dependent**
    - traffic chokepoints
    - industrial installations
- **Few monitoring stations** measure pollutants

- Important technical opportunities and challenges
  - Massive measurements that exploit
    - Wireless sensor networks
    - Mobile stations
    - Community involvement
  - More data, more noise, but also more redundancy
- Can we produce better quality data?

Address key challenges in communication and information systems for urban air quality monitoring

Basic Sensing Infrastructure

Mobile sensor nodes on public transportation and private mobile devices



Wireless sensing and communication infrastructure

Overall Goal

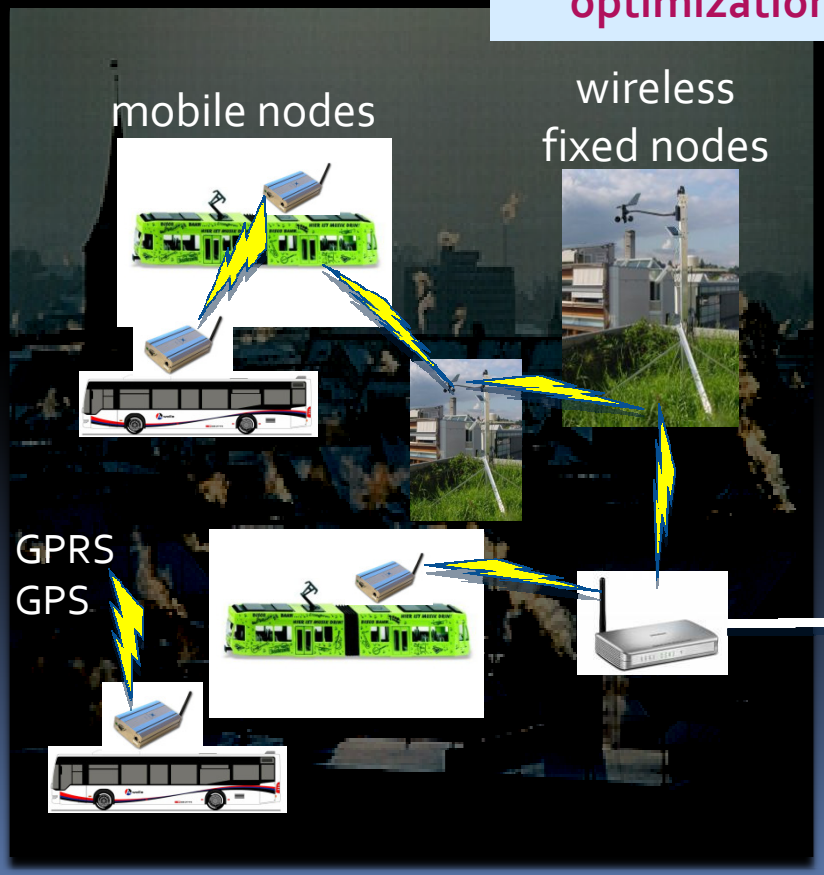
NANO

SENSING SYSTEM
From many wireless, mobile, heterogeneous, unreliable raw measurements …

INFORMATION SYSTEM
… to reliable, understandable and Web-accessible real-time information

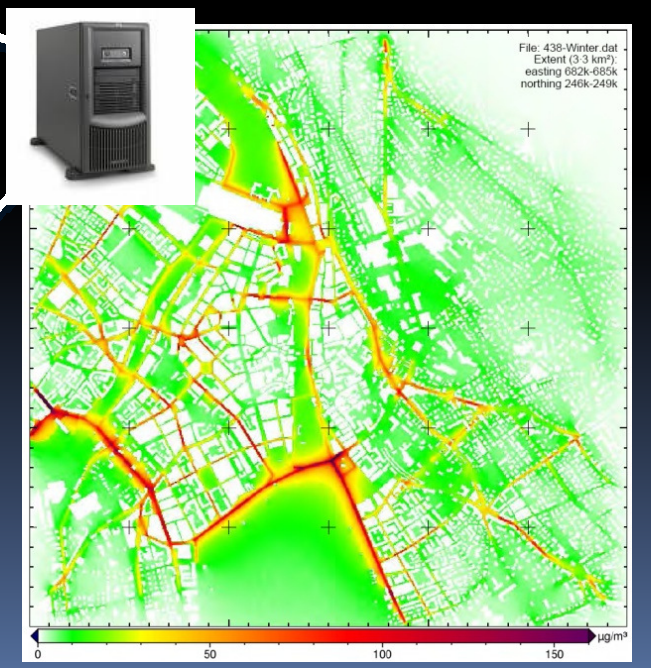
TERA

sensor network control
optimization of data acquisition



Internet

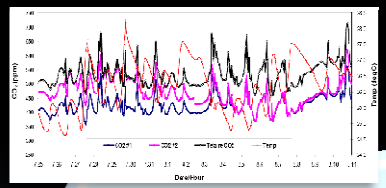
interpretation and
presentation of data



Scientific Challenge

Is massive sensing with large numbers of heterogeneous and mobile sensors technically feasible and practically useful?

MOBILE SENSORS
Controlled vs. uncontrolled **mobility patterns**

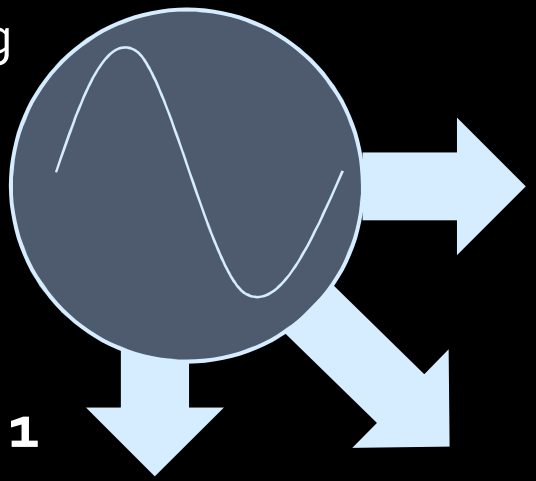


HETEROGENEOUS SENSOR NETWORKS
Many sources of **correlation**

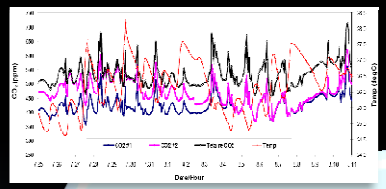
COMMUNITY SENSING
Reliability and **trustworthiness** of measurements and interpretation

Scientific Questions

Correct interpretation of sensor measurements requires understanding of their context!



Task 1



HETEROGENEOUS SENSOR NETWORKS

Correlation to other measurements:

- Physical Models
- Simulation Models
- Data analysis

Task 2

MOBILE SENSORS

Loc. and time of measurement:

- Sampling under mobility
- Intermittent connectivity
- Control of node activity

Task 3

COMMUNITY SENSING

Producers and users of data:

- Data quality and reputation
- Qualitative models
- Efficient access to model data

Utility-based control

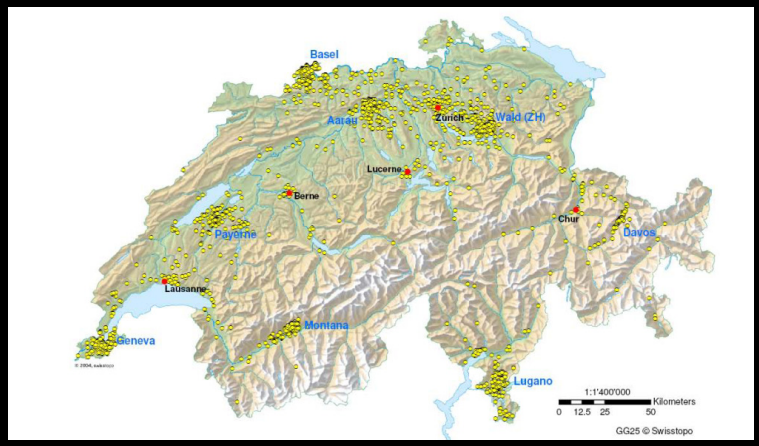
- The problem of control in community sensing networks needs to consider a wide variety of factors
  - quality of measurements (classical problem), energy consumption, communication cost, mobility patterns, privacy violation, personal relevance, etc.
- Utilitarian approach towards sensing and data management
  - Models *utility* of data being produced and consumed
  - Uses *utility* to control data production
- Layered utility model
  - Models several levels of abstraction depending on capacity of devices (cloud computing vs. low-power sensor)

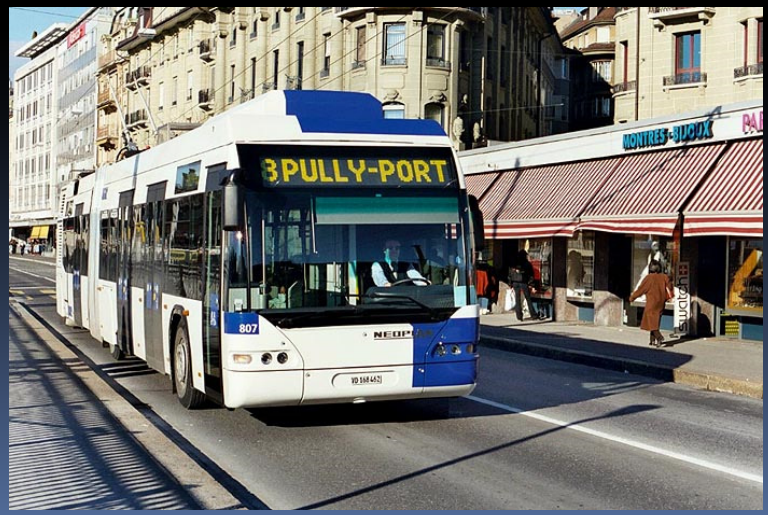
Karl Aberer, Saket Sathe, Dipanjan Chakraborty, Alcherio Martinoli, Guillermo Barrenetxea, Boi Faltings, Lothar Thiele, OpenSense: Open Community Driven Sensing of Environment. ACM SIGSPATIAL International Workshop on GeoStreaming (IWGS) 2010 (with ACM GIS 2010).

Experimental Validation

Verify our approach by a real system deployment

1. Preventive Health Studies
   - In collaboration with Swiss Institute for Tropical and Public Medicine
   - Sapaldia Study
2. Deployment on public transportation networks
   - Lausanne and Zürich
   - Community involvement



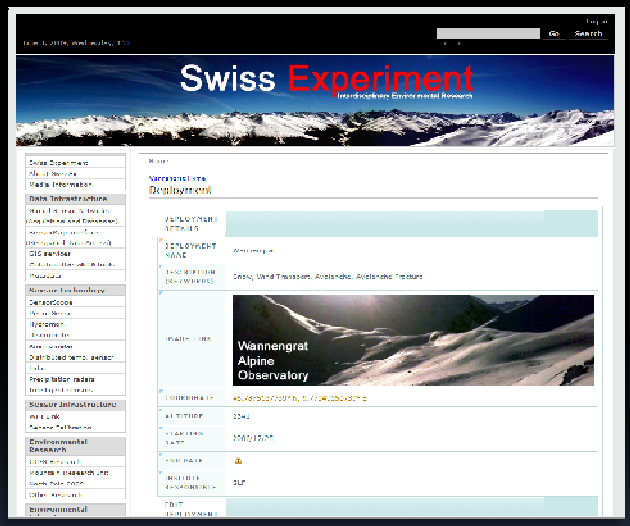


IC Infrastructure

- Existing platforms in use for hydrological and geophysical engineering

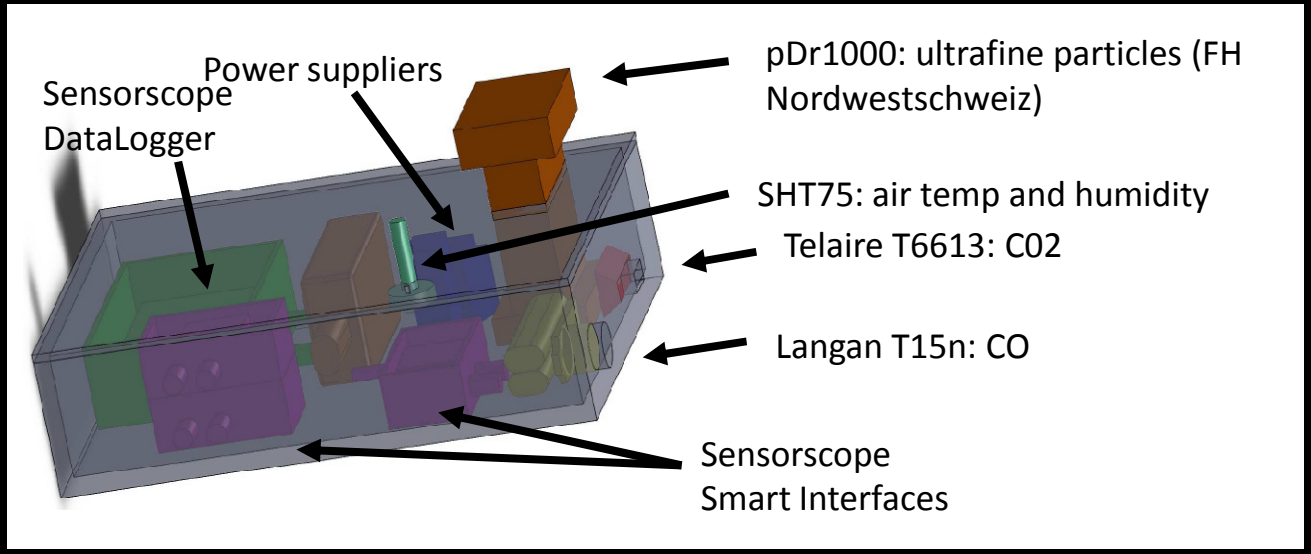
Fixed wireless sensor networks based on SensorScope stations
Flexible configuration

Mobile nodes based on PermaSense nodes
Robust and long-lived



Web-based information system based on the Swiss Experiment platform

Sensors



Pollutant	Normal range in urban environment	NAAQS Levels/Averaging time	Sensor choice	Resolution/ Precision
NO_2	0.008-0.04 ppm	0.016 ppm Annual avg 0.053 ppm Daily avg	Alphasense NO2 BA (under test)	± 0.005 ppm/NA
CO	0.5-5 ppm (normal) 5-20 ppm (near gas stoves)		Langan CO T15d	0.05 ppm (0.005 optional)/NA
CO_2	500-1500 ppm		Telaire T6613	NA/ ±35ppm@500ppm
Temp/Hum	NA	NA	SHT75	0.04°C,0.4% ±0.3°C, ±1.8%
Particles	???	???	DiSC (to be adapted)	Range: 10-200nm/NA

Conclusions

- Unique project in community sensing in terms of scope
  - End-to-end perspective
- Applications in personal and preventive health
  - Transfer of results to cities in emerging countries
- Pronounced interest by public authorities and industry