NOSE: A NOmadic Scalable Ecosystem for pervasive sensing, computing and communication

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The Smart City paradigm is the dominant model for urban development

Integration of ICT and IoT in resource management and service provisioning

- Mobility, Energy (Smart Grid, …)
- Building, Public services,

Main features:

- Systemic vision:

  City as a system of interconnected components

What are the main prerequisites of the smart city paradigm?

- A **pervasive sensing and communication infrastructure**
  - High costs of installation and maintenance

- A **critical mass of users**
  - Justify investments

- **Administrative unity**

A clean slate approach: Design for smart

Invest : $ 25 billion
6 km2 of reclaimed land

How to bring smart city services to sparse communities?

- A large portion of humanity lives in small cities, towns and sparse urban agglomerations
- Such urban districts lack the main prerequisites for adoption of Smart City paradigm
  - No critical mass
  - Administratively fragmented
  - Fixed costs less sustainable
- The Smart City paradigm might create a new urbanization
  - Urban districts are at a competitive disadvantage
- Need for **cheap, alternative sensing and communication infrastructure**

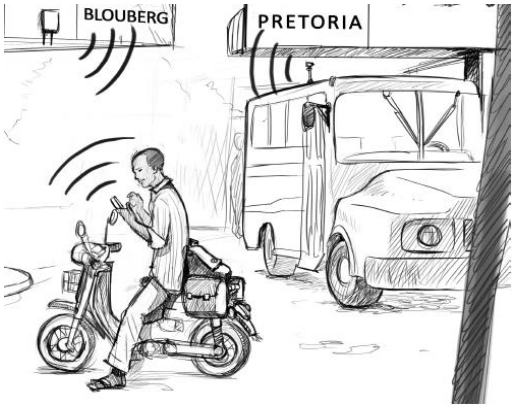

Raphaël Dupertuis

NOSE: Turning mobile infrastructure into a platform for sensing, computing and communication

Public Buses have Wi-Fi/3G/4G connectivity

- currently **underutilized**
- Others: postman, employees, etc.

We exploit such infrastructure to create



- **A mobile sensing and monitoring platform**
  - **Multi-service**
  - Replacing and/or integrating fixed, expensive infrastructure
- **A delay tolerant communication network**
  - Emergency, real time communications, disaster recovery
  - Connectivity of molok/smart bus stops everywhere, etc

Is NOSE a viable approach for a “smart district” paradigm?

Transport network is pervasive: Less administrative barriers

What about the economic barriers?

- Nomadic vs fixed infrastructure also means trading CAPEX vs OPEX
- Can we make a fair comparison (same performance)?

WE need to explore the CAPEX/OPEX tradeoff

Is it the time for a smart district?

- Plenty of existing work on mobile sensing
  - MIT CarTel, Pothole Patrol, among others
  - Environmental monitoring, mainly
- Focused on:
  - Technical feasibility
  - Measurement issues (calibration,…)
  - Lack of clear, well justified performance requirements
- Is the technology ready for production?

Design principles: scalability, modularity, ease of integration and management

External data sources

Crowdsensing - participatory sensing

Multi service platform

B2C Services

B2B Services

Internal Operations Services

Integration middleware

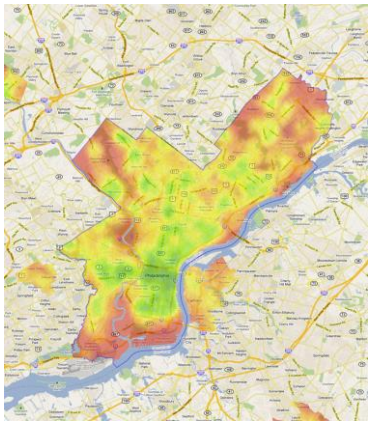
- Application interface
- Data management
- Mobile/fixed resources management
- Security and privacy

Static Sensing Infrastructure

Nomadic Sensing Infrastructure

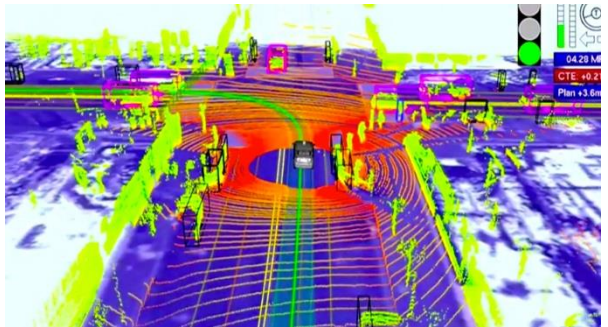
Candidate Services

Environmental Monitoring («District Pulse»)



Road surface monitoring

City scanning



A system for real time road surface monitoring

Objectives:

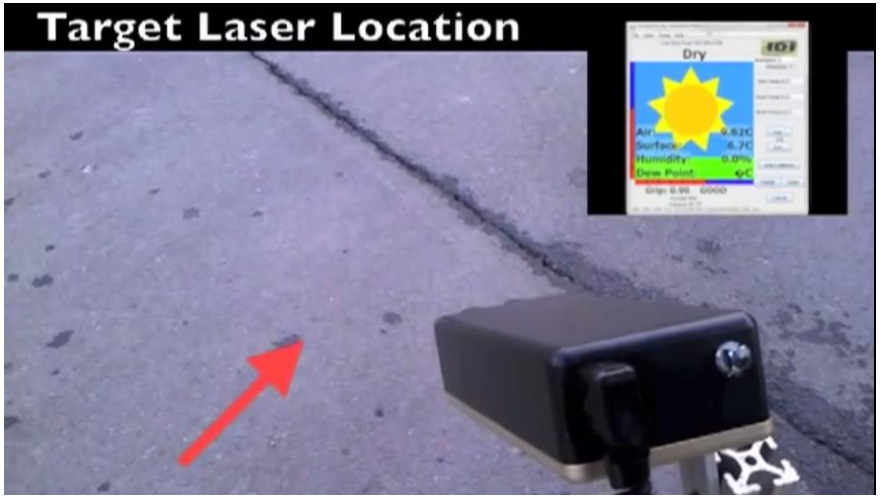
- Offer **a real time view** and **a forecast** of road surface conditions
  - Tracking of ice, snow, water, soil, crackings, shape changes, amount of salt
  - Integration with data from other sources (weather forecasts, fixed sensors, etc.)

Applications:

- **Inform on time** drivers about hazards due to road surface state;
- **Increase efficiency of interventions:**
  - Intervene only when and where it is actually needed;
  - Improve traffic conditions;
  - Improve road safety (better prevention of hazards);
  - Optimize use of salt.

Components

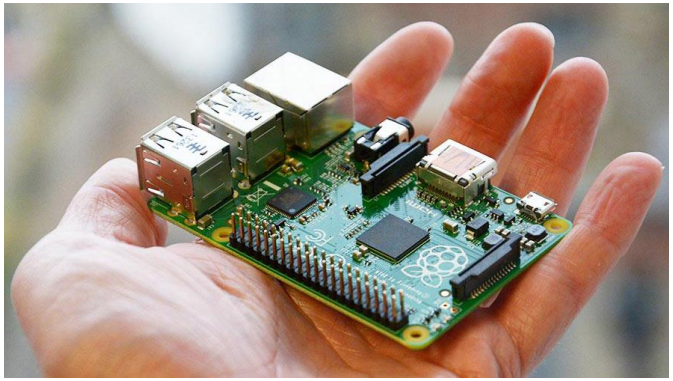
- On Bus communication system
- On board road surface sensors
- Servers for data collection, data mining, forecast, visualization



Mounted on rear/front bumpers
Or on top

Environmental Monitoring

- Complement to weather forecast: air pressure, temperature, humidity
- Pollution: CO, CO2, NO, NO2, SO2, O3, particles (PM1, PM2.5 and PM10 measurements)
- Pollen map
- Output on a map
- Candidate device: Raspberry Pi + on board sensors / **Airquality Egg**



City Scan

- Obtain measurements of various parameters of the city
- Exploiting API of Kinekt 2, and/or other sensors
- Many possible applications:
  - Pedestrian density estimator
  - Parking occupation estimator
  - Traffic density estimator
  - People mood monitoring
  - ….
- Make available data for mining and analysis

The onboard infrastructure

Environmental Monitoring

Raspberry Pi + sensors

City Scanning

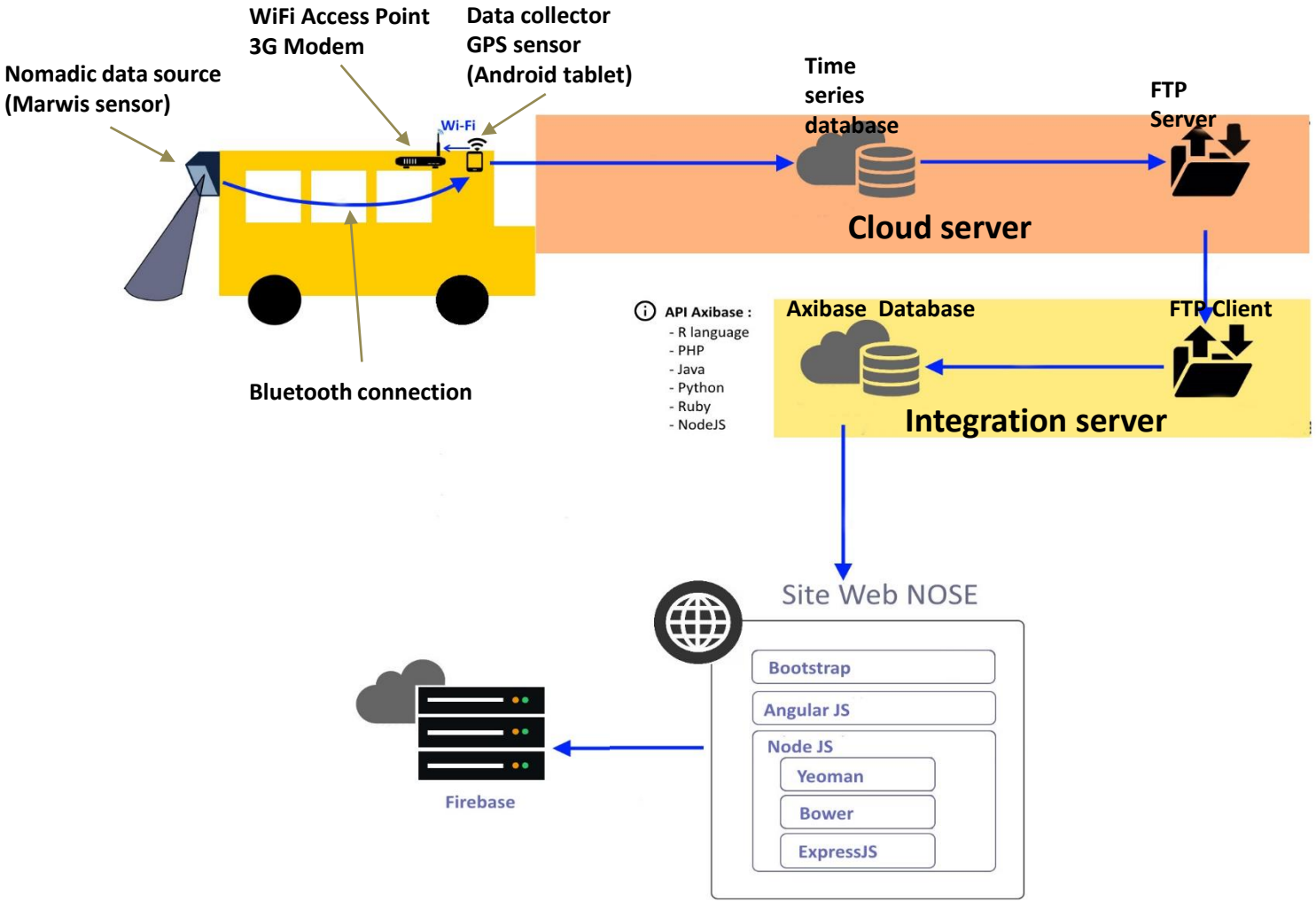
Kinekt 2 ?

WIFI AP + 3G modem

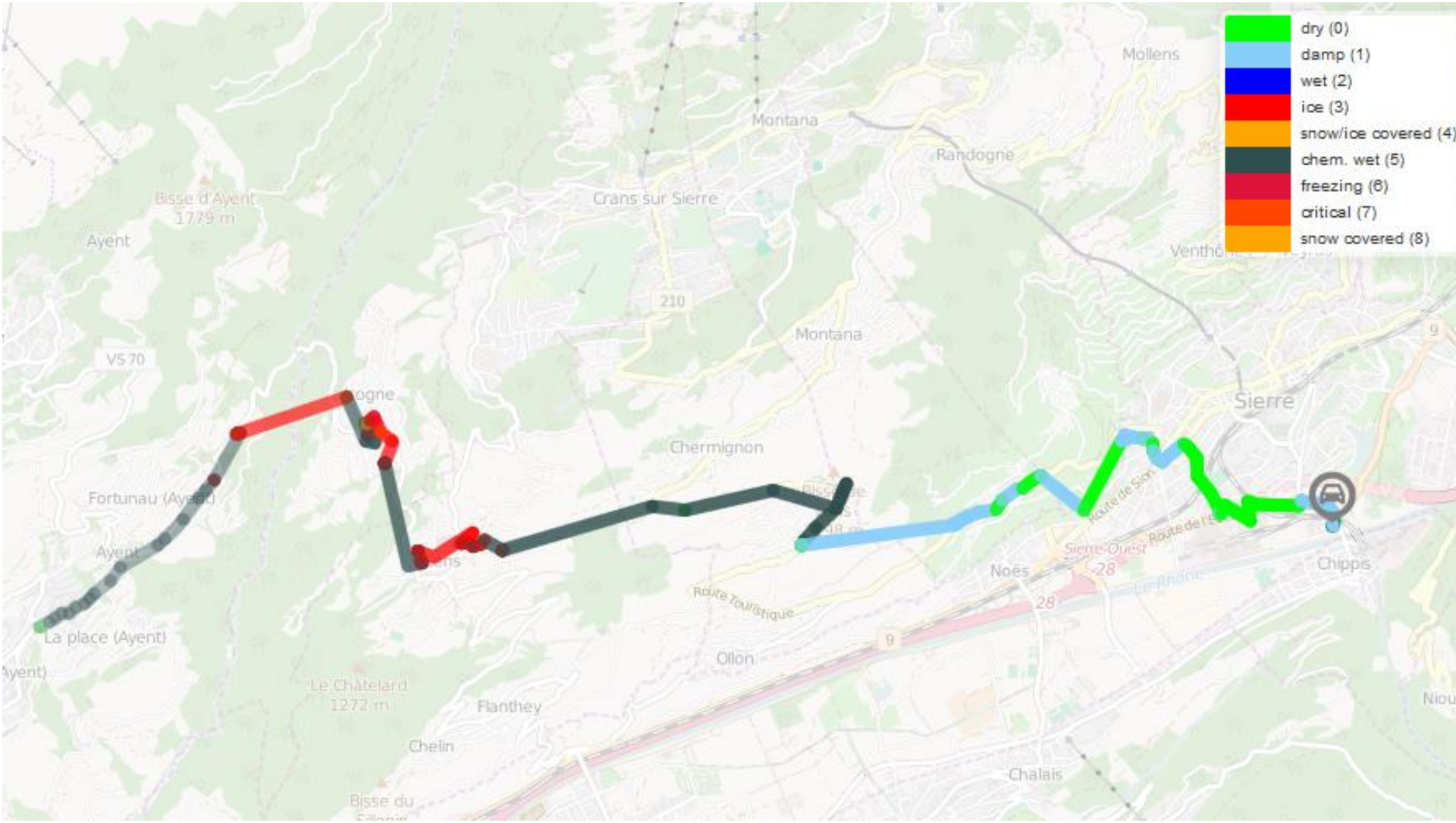
Road Surface Monitoring

Marwis Sensor

Data path for the Road Surface Monitoring Service



http://vmhiotmiddleware.hevs.ch/nose/dashboard/ice/default



Lessons learned

- The opportunistic nature of nomadic infrastructure requires systems to be:
  - Adaptive
  - With built in redundancy
- They tend to be
  - Less accurate
  - Less available
- We established a technical baseline for economic analysis of capex/opex tradeoffs
  - Still open issue
- Cultural barrier
  - Not yet considered

Thank you!