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OpenSense RTD 2010

FNSNF

Route Selection of Mobile Sensors for Air Quality Monitoring

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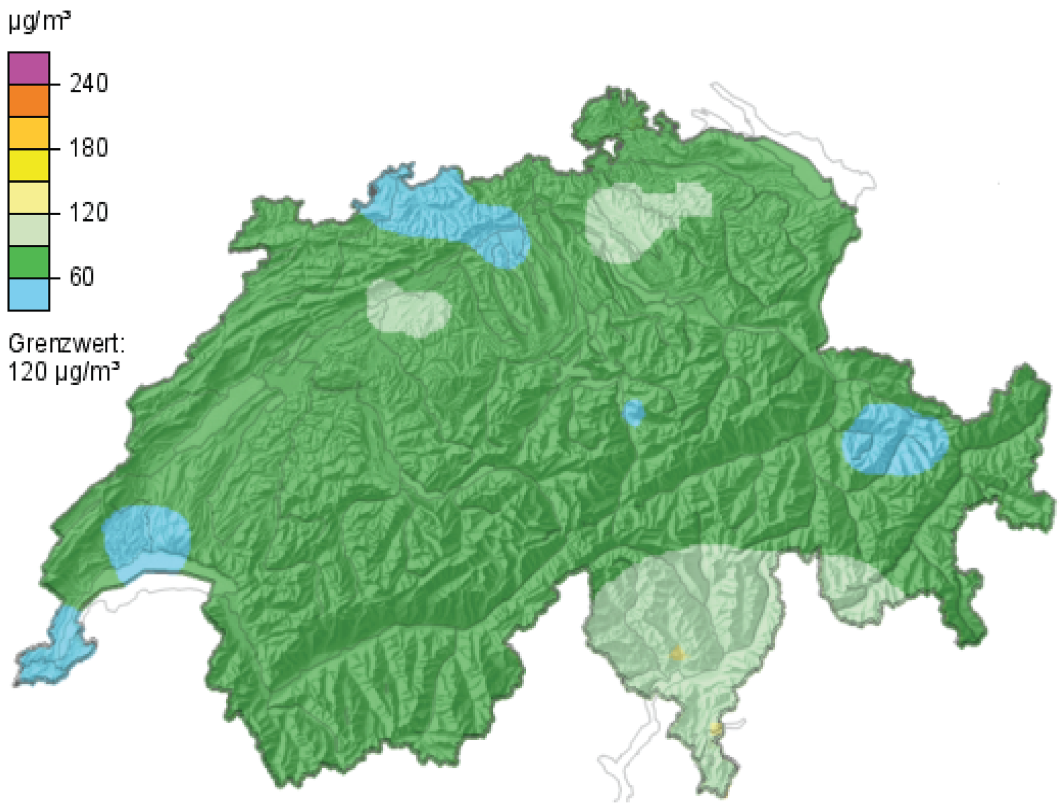


Ozone concentration levels (source: BAFU / NABEL data)

OpenSense: Sensing the Air We Breathe

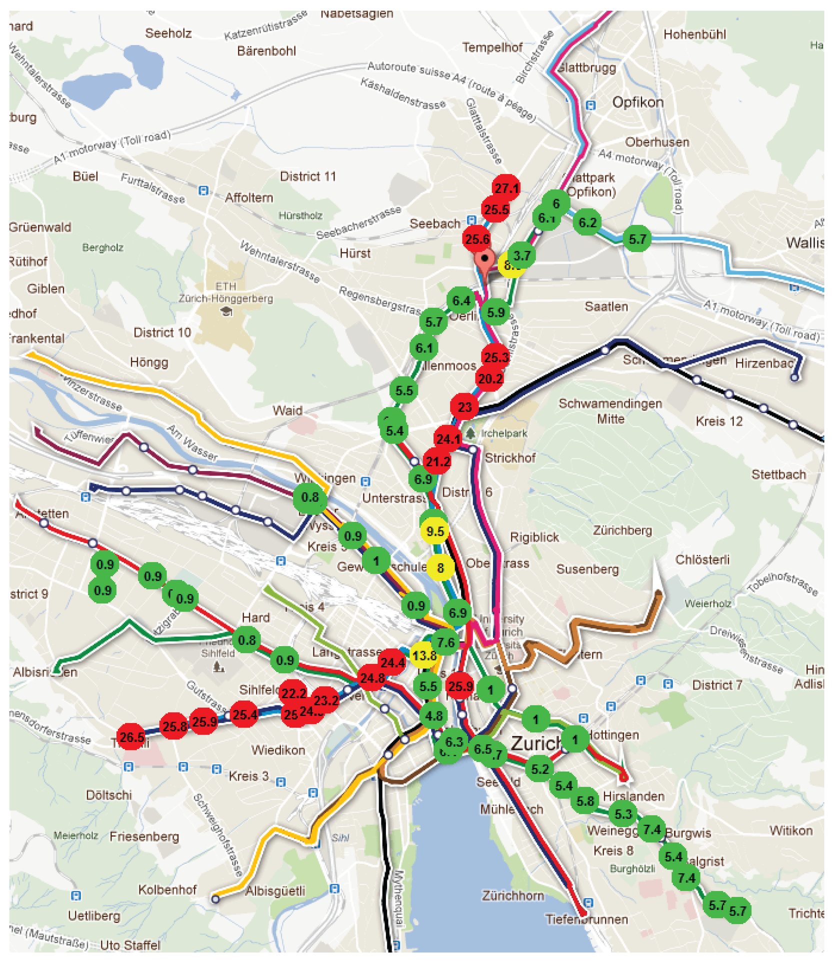
- Air pollution is a major concern in urban areas
- Currently measured by monitoring networks managed by official authorities
- Analytical instruments accurately measure wide ranges of air pollutants
- Cost, size, and laborious maintenance severely limits number of stations

GOAL: Improve the resolution of current air pollution maps in cities with lightweight OpenSense sensors

Mobile OpenSense Nodes to Optimize Coverage

- OpenSense nodes are installed on top of several public transport vehicles
- Zurich public transport (VBZ) operates 14 tram and 54 bus lines
- Over 15 vehicles are operating on each of the 68 lines during the day

PROBLEM: Which routes to pick for installation of OpenSense sensors?



Ozone concentration levels (source: data.opensense.ethz.ch)

Reference Stations

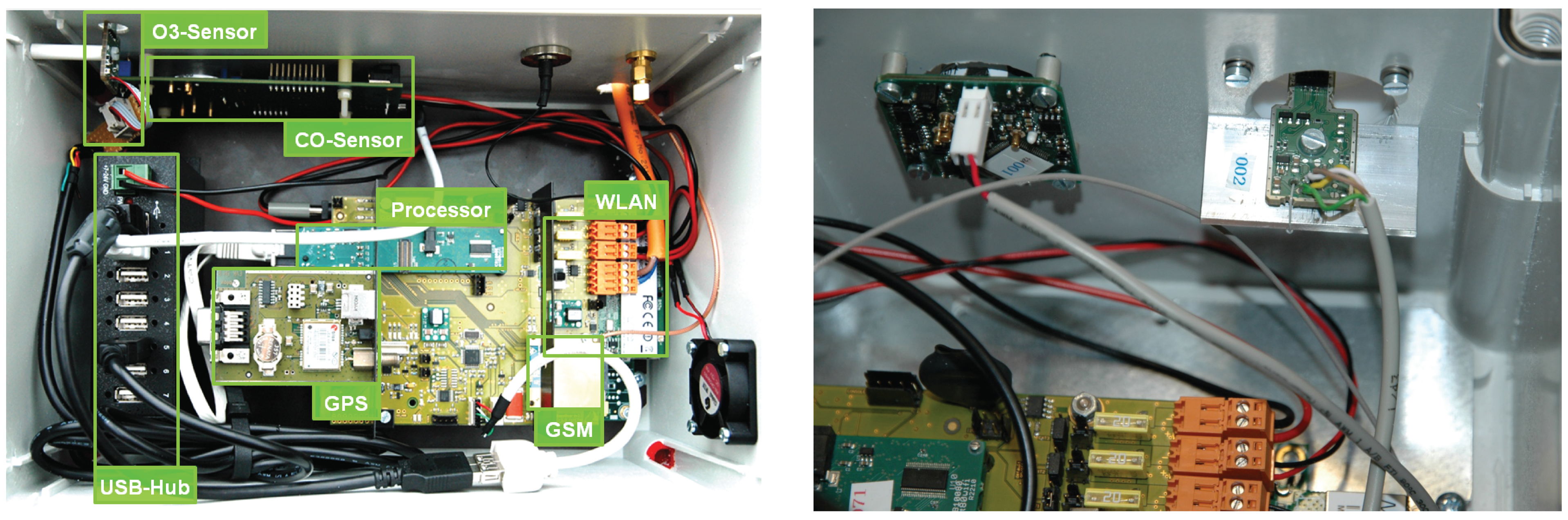
Precise pollution recordings

- NABEL (National Air Pollution Monitoring Network): 1 station in Zurich: O_3, CO, NO_2, SO_2, PM10, NMVOC
- OstLuft (Cantonal Air Pollution Monitoring Network): 4 stations in Zurich: O_3, NO, NO_2

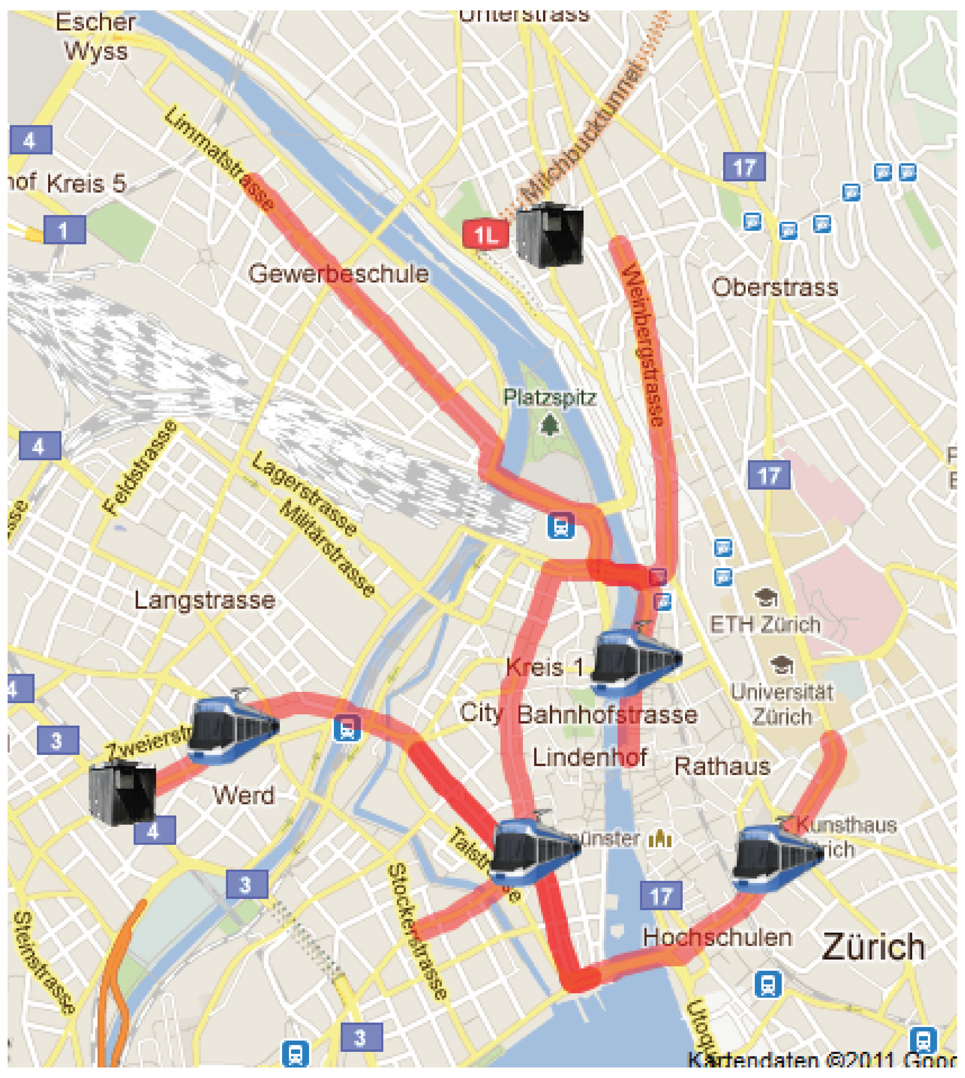
OstLuft stations in Balsberg and Winterthur

NABEL station in Duebendorf

OpenSense Nodes



OpenSense Node: O_3-Sensor, CO-Sensor, Accelerometer, GSM, WLAN, GPS



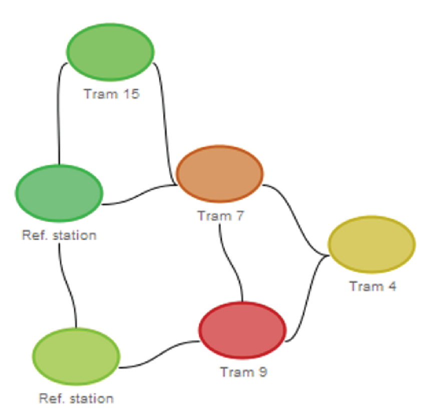
Checkpointing Constraints

Two vehicles make a checkpoint if the distance between them is below a certain threshold. Checkpoints are used for

- Relating measurements in space and time
- Comparing sensor readings and sensor calibration
- Recognizing faulty sensors

X-Checkpoint - between two OpenSense nodes
R-Checkpoint - between an OpenSense node and a reference station

Given the checkpoints between all pairs of sensors, it is possible to construct a checkpoint graph. If a checkpoint graph is connected, the set of selected vehicles fulfills checkpointing constraints.



Checkpoint graph

Two trams making a X-checkpoint

Route Selection Algorithm

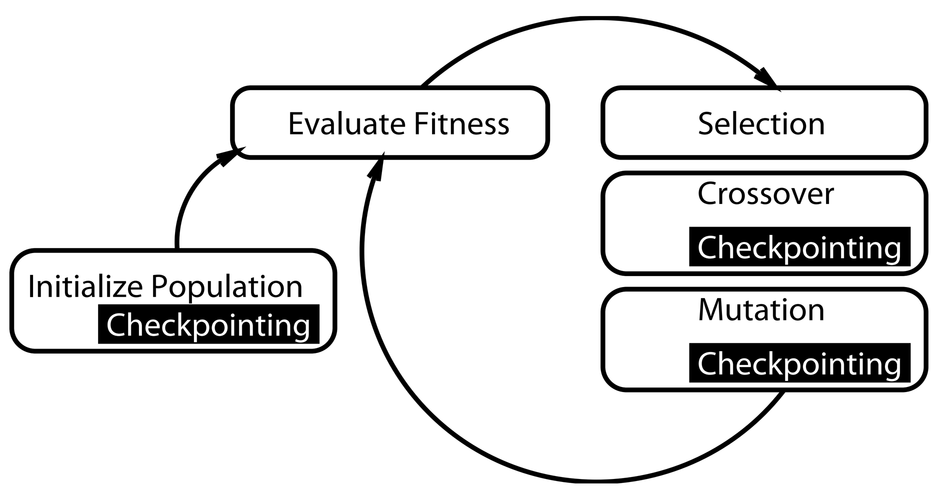
Route selection problem involves high computational complexity even for a small number of OpenSense nodes

City	Network	Routes	Vehicles	Stops
Zurich	tram	13	260	187
Canton Zurich	bus	283	732	2'543
Berlin	bus	149	1'300	2'634
Chicago	bus	152	2'000	12'000
NY City	bus	324	5'908	15'226
Long Island	bus	48	389	n/a

Statistics on public transport networks in different cities

SOLUTION: Evolutionary algorithm

Input: public transport network
Output: a set of vehicles best suitable for the installation

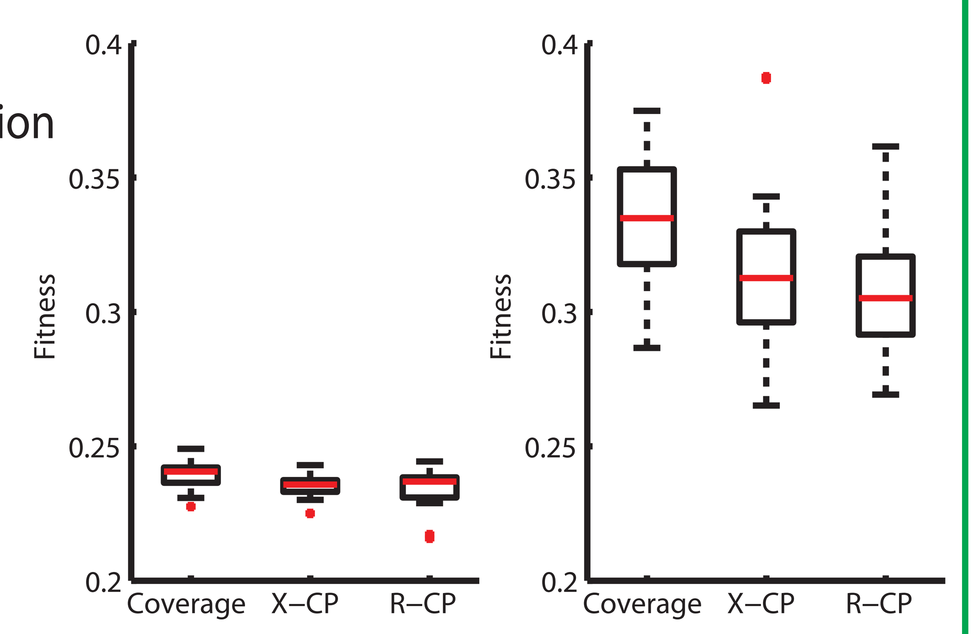


Structure of the evolutionary algorithm

Algorithm parameters:

- Number of measurement stations
- Locations of the reference stations
- X-checkpointing or R-checkpointing constraints
- Maximum execution time

Fitness: inverse to coverage of the city center



Performance evaluation

OpenSense Website: http://opensense.epfl.ch, OpenSense Zurich Deployment: http://www.opensense.ethz.ch