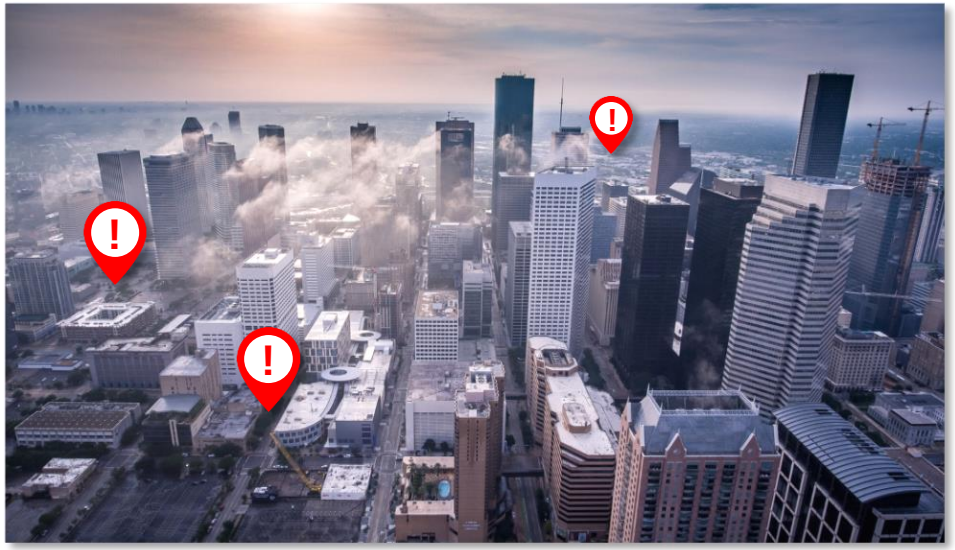


Technische Universität Berlin

How Future Citizens of Smart Cities Take Benefit from Geofencing Technology

An Urban Air Pollution Alert Service for Smart Cities

8th GeoIT Wherecamp, 2018, Berlin, Germany

Sandro Rodriguez Garzon
Service-centric Networking | Telekom Innovation Laboratories & Technische Universität Berlin

TELEKOM INNOVATION LABORATORIES

Service-centric NETWORKING

Urban Air Pollution a Problem?

Personal Experiences

Tiananmen Square, Beijing, China at 29.01.2013

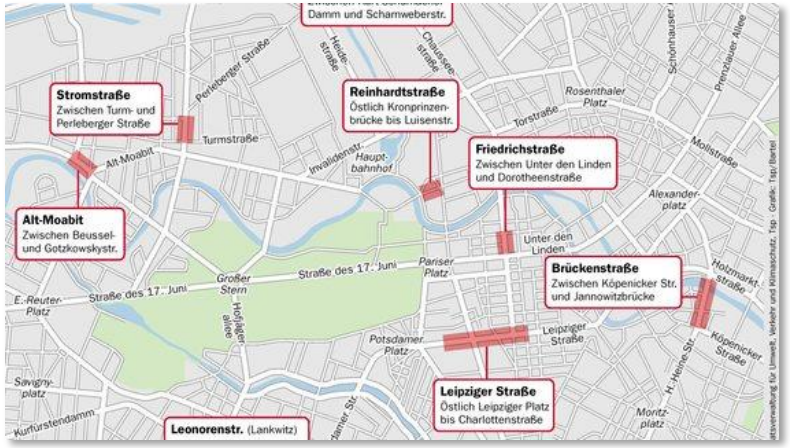
Detmolder Street, Berlin, Germany at 10.10.2018

Urban Air Pollution a Problem?

Latest Court decisions in Germany

Berlin must impose diesel bans at 11 street segments

Tagesspiegel, 09.10.2018



Stuttgart to start ban of older diesels in 2019

Automotive News Europe, 11.07.2018

German court says Frankfurt must ban older diesels

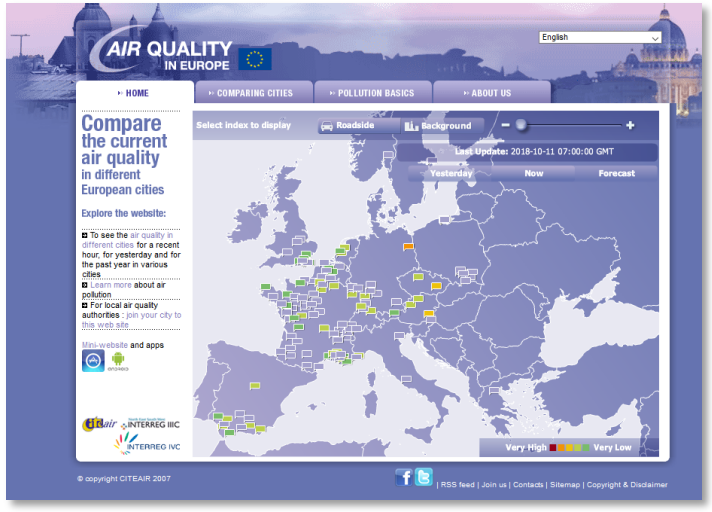
Reuters, 05.09.2018

In … Germany, Hamburg Bans Diesel Engines. On 2 Roads.

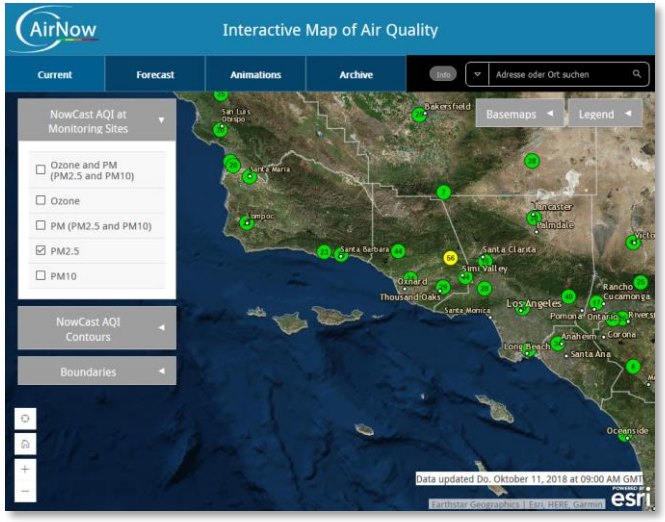
New York Times, 31.05.2018

Air Pollution Information Sources

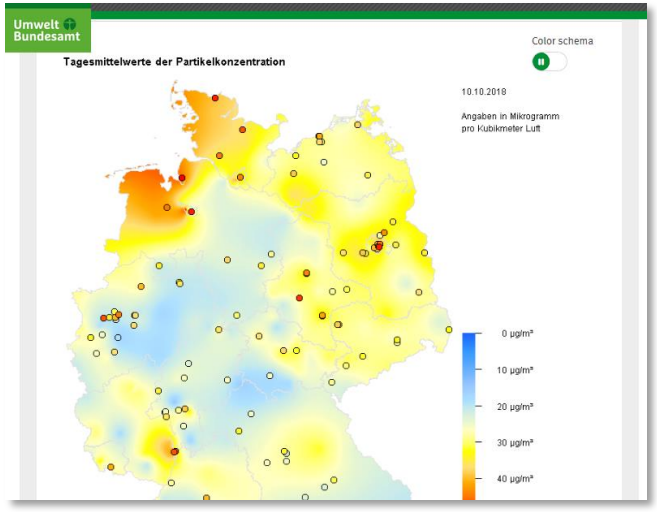
Websites



www.airqualitynow.eu



www.airnow.gov



www.umweltbundesamt.de

Disadvantage: Citizens need to regularly query for the current air quality

Air Pollution Information Sources

Mobile Applications

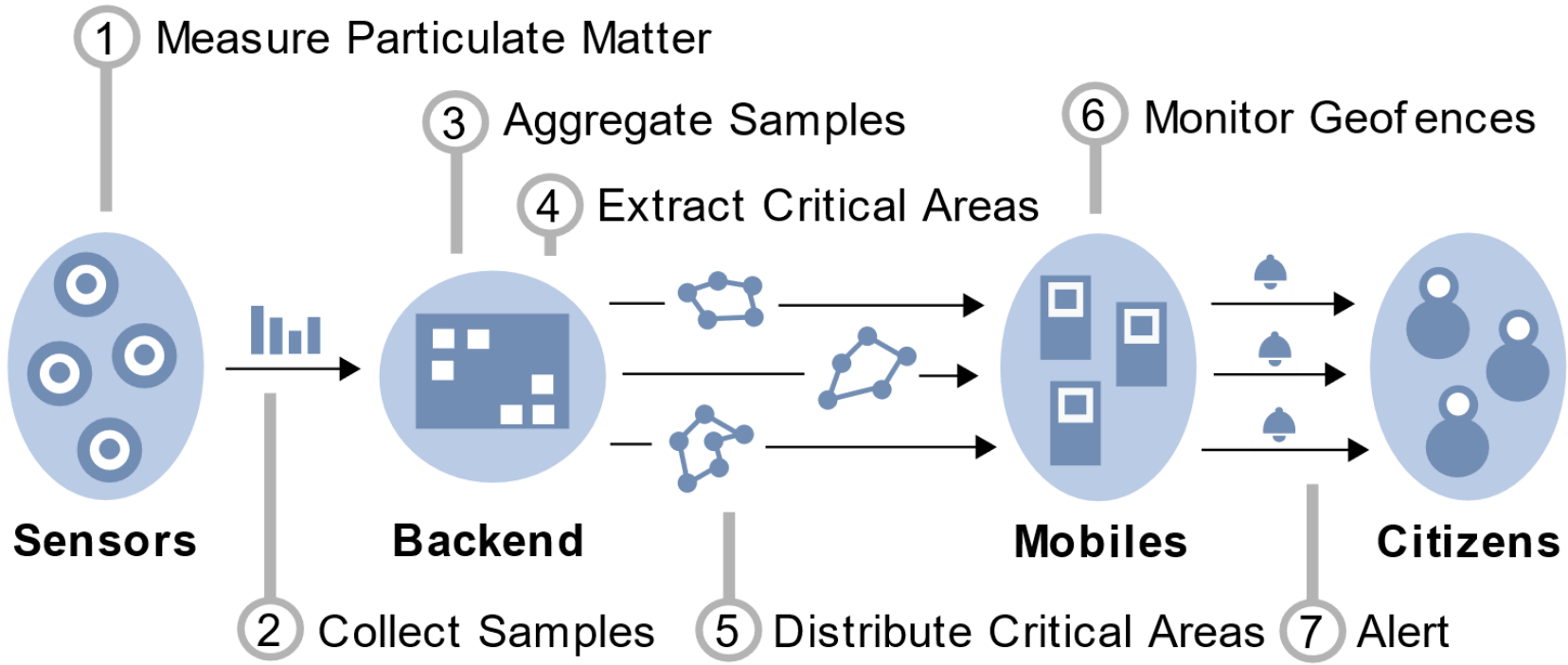
	Air Quality	**BreezoMeter**	**World AQI**	**Plume Air Report**
Notifications	▪ yes	▪ yes	▪ yes	▪ yes
Resolution	▪ Cities ▪ Stations	▪ Cities ▪ Stations ▪ Position	▪ Cities ▪ Stations	▪ Cities
Frequency	▪ n/a	▪ 1 hour	▪ 1 hour	▪ n/a

Airtify System

Targeted Use Case

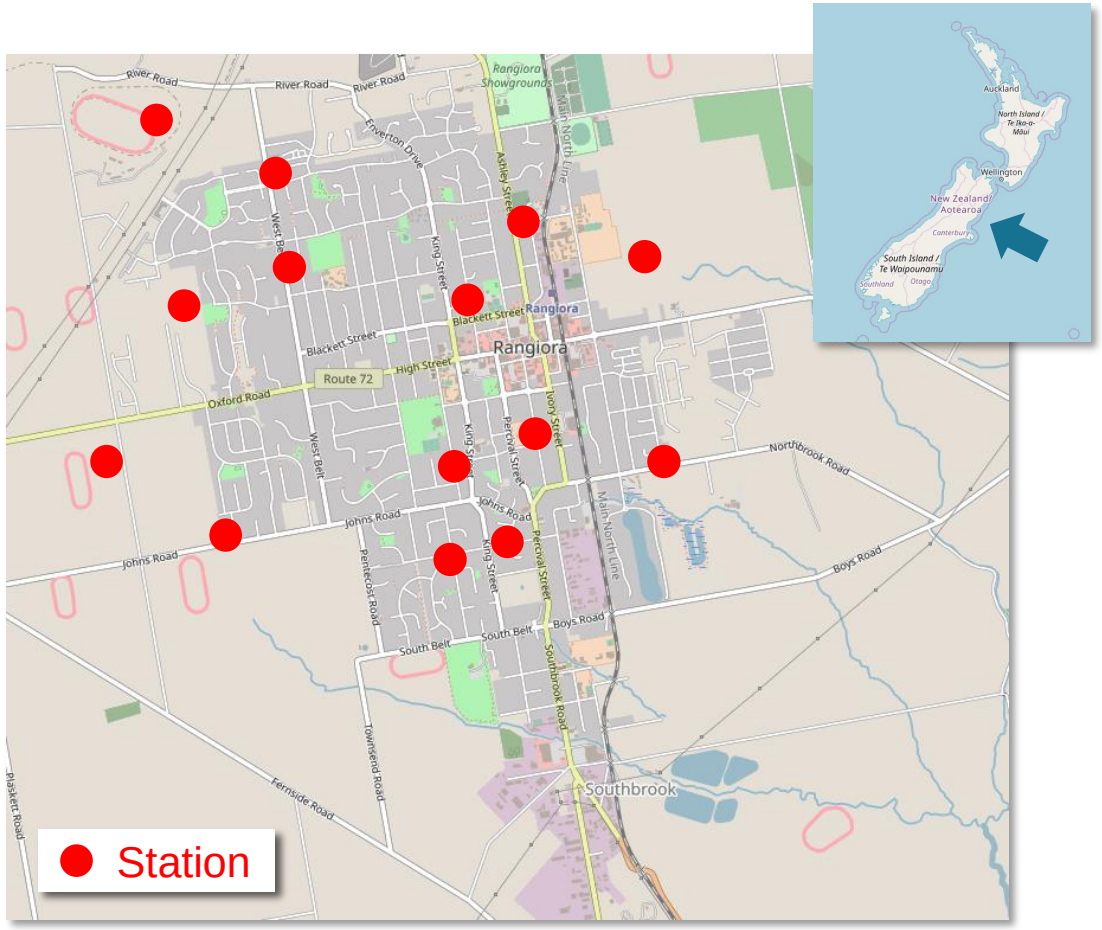
Airtify System

Big Picture



Airtify System

Sensor Testbed

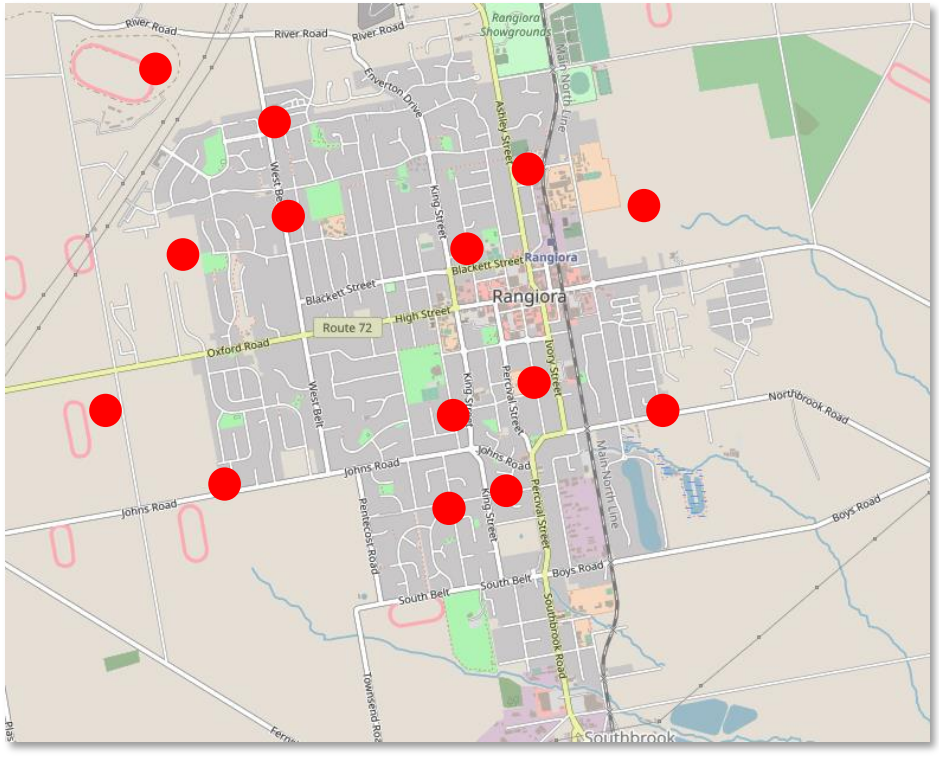


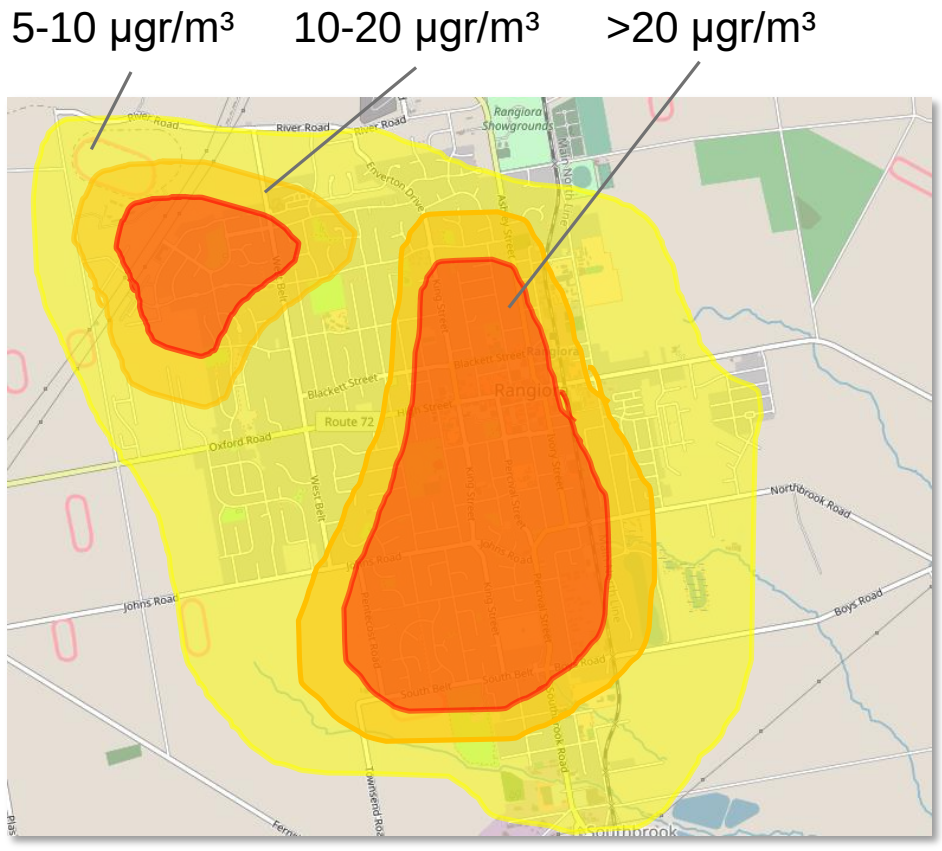
- Rangiora, South Island, New Zealand
- Population: approx. 18.100
- Area: 16.83 km²
- Flat terrain with no high-rise buildings
- Equally distributed land-use characteristics

- 14 low-cost Outdoor Dust Information Nodes (ODIN)
- Measures particulate matter with diameter smaller or equal to 2.5 µm (PM2.5)
- Output in µgr/m³
- 18 days in August 2016
- One sample per min
- 26.394 combined samples (each incl. 14 samples)

Airtify System

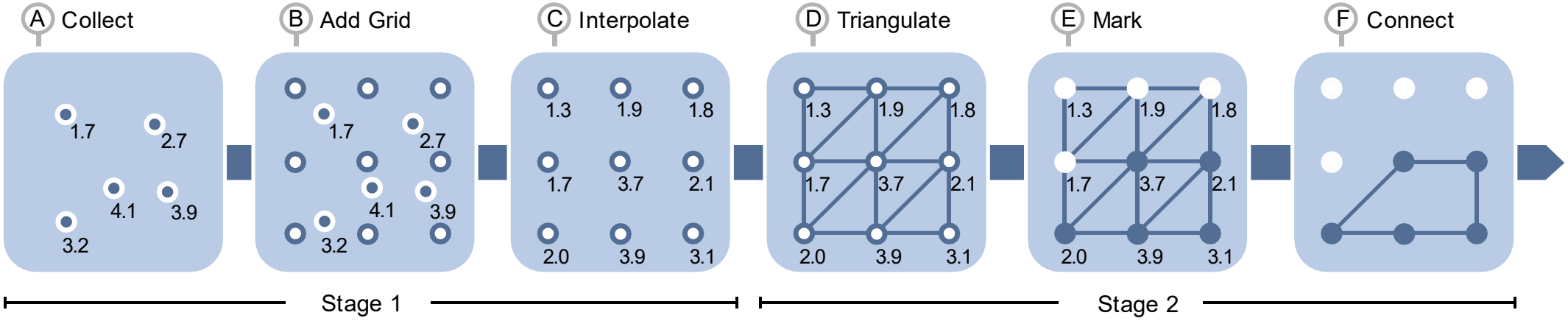
Extraction of Critical Areas





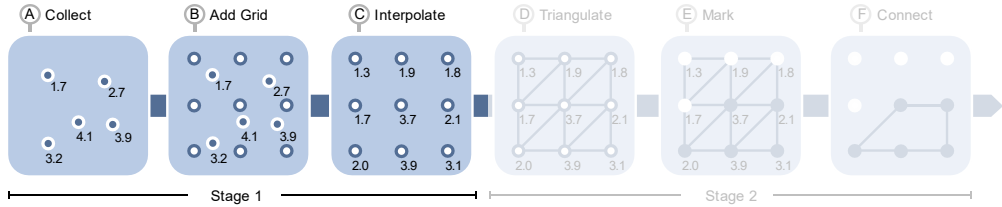
Airtify System

Extraction of Critical Areas I



Airtify System

Extraction of Critical Areas II



Stage 1:

Collect

- One sample per minute
- Aggregate samples with different timestamps
- Assumption: Particulate matter concentration does not change signifi-cantly at a sampling frequency of 1/min

Add Grid

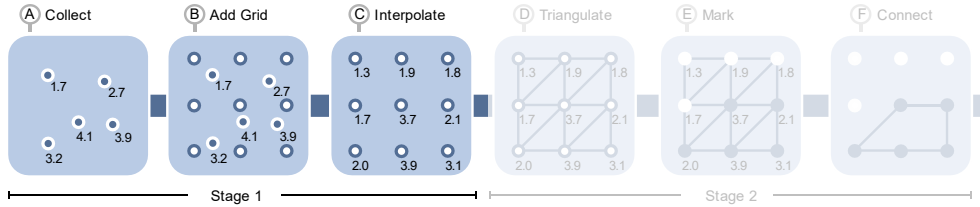
- Artificially increase the number of samples
- Enforce an evenly-distributed sample set

Interpolate

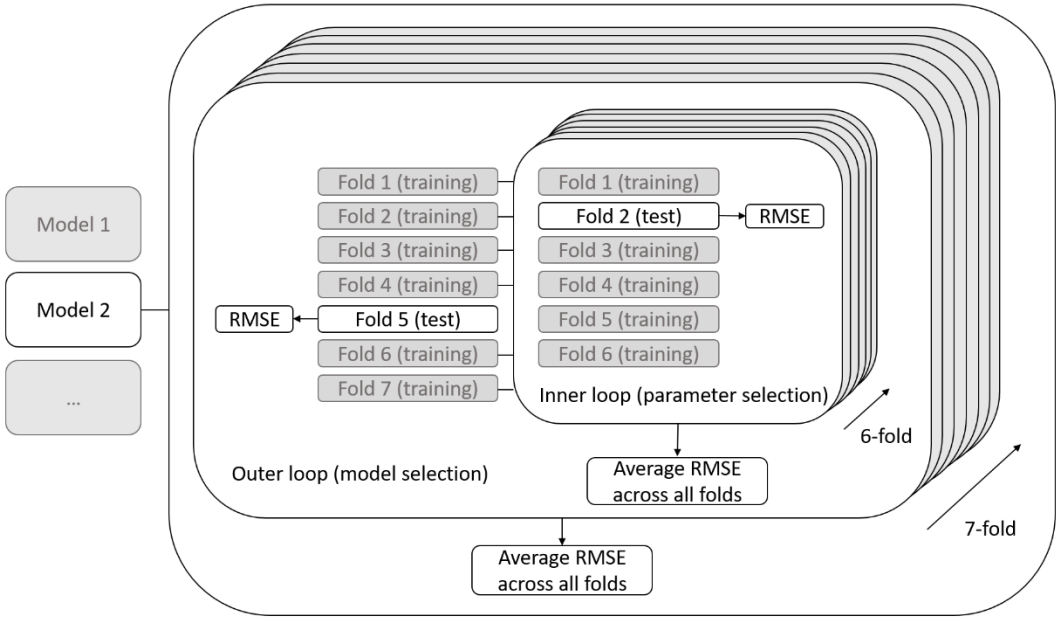
- Potential methods:
  - Proximity models
  - Dispersion models
  - Land-use regression
  - Non-parametric classification
  - Spatial interpolation
- Applied: Kernel regression with a Cauchy kernel

Airtify System

Extraction of Critical Areas III



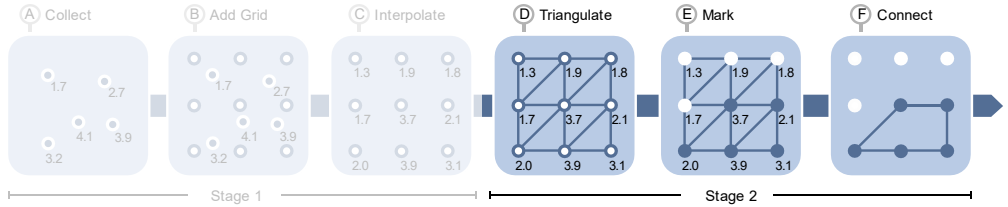
Stage 1: Comparison of models for interpolation by k-fold-cross validation



Model	Number of Wins	Median RMSE
Gaussian	172	5.023
Cauchy	352	5.532
Epanechnikov	142	6.719
Uniform	281	6.043
Polynominal^2	48	5.685
Polynominal^3	1	6.153
Polynominal^4	1	4.927
Polynominal^5	2	7.218
Polynominal^6	1	3.718

Airtify System

Extraction of Critical Areas IV



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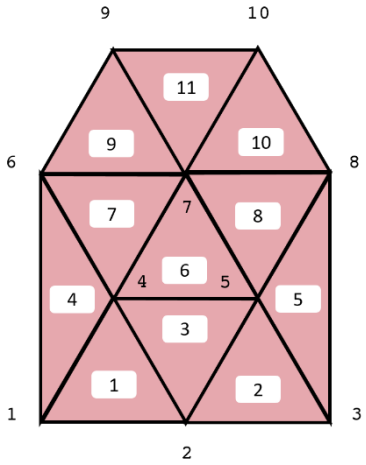
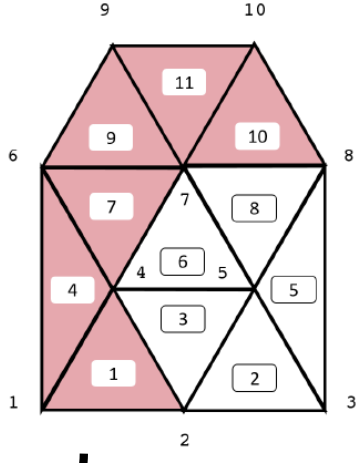
Stage 2



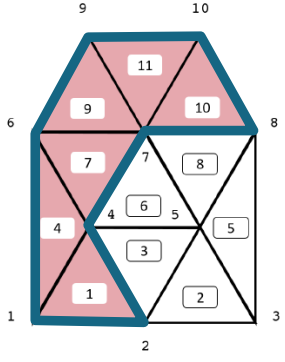
$$= \begin{bmatrix} -43 & 172 \\ -43 & 174 \\ -43 & 176 \\ -41 & 173 \\ -41 & 175 \\ -39 & 172 \\ -39 & 174 \\ -39 & 176 \\ -37 & 173 \\ -37 & 175 \end{bmatrix} \begin{bmatrix} 1 & 4 & 2 \\ 2 & 5 & 3 \\ 2 & 4 & 5 \\ 1 & 6 & 4 \\ 3 & 5 & 8 \\ 4 & 7 & 5 \\ 4 & 6 & 7 \\ 5 & 7 & 8 \\ 6 & 9 & 7 \\ 7 & 10 & 8 \\ 7 & 9 & 10 \end{bmatrix} \begin{bmatrix} 3 & -1 & 4 \\ 5 & -1 & 3 \\ 6 & 2 & 1 \\ 7 & 1 & -1 \\ 8 & -1 & 2 \\ 8 & 3 & 7 \\ 9 & 6 & 4 \\ 10 & 5 & 6 \\ 11 & 7 & -1 \\ -1 & 8 & 11 \\ -1 & 10 & 9 \end{bmatrix}$$

Marking (Excluding Points)



$$= \begin{bmatrix} -43 & 172 \\ -43 & 174 \\ -43 & 176 \\ -41 & 173 \\ -41 & 175 \\ -39 & 172 \\ -39 & 174 \\ -39 & 176 \\ -37 & 173 \\ -37 & 175 \end{bmatrix} \begin{bmatrix} 1 & 4 & 2 \\ -1 & -1 & -1 \\ -1 & -1 & -1 \\ 1 & 6 & 4 \\ -1 & -1 & -1 \\ -1 & -1 & -1 \\ 4 & 6 & 7 \\ -1 & -1 & -1 \\ 6 & 9 & 7 \\ 7 & 10 & 8 \\ 7 & 9 & 10 \end{bmatrix} \begin{bmatrix} -1 & -1 & 4 \\ -1 & -1 & -1 \\ -1 & -1 & 1 \\ 7 & 1 & -1 \\ -1 & -1 & -1 \\ -1 & -1 & 7 \\ 9 & -1 & 4 \\ 10 & -1 & -1 \\ 11 & 7 & -1 \\ -1 & -1 & 11 \\ -1 & 10 & 9 \end{bmatrix}$$

Triangulation (Delaunay)



Boundary Extraction

```
"coordinates": [
          [
            172.59439945220947,
            -43.30104007235948
          ],…,[
            172.5944423675537,
            -43.301227464575554
          ]
        ]
```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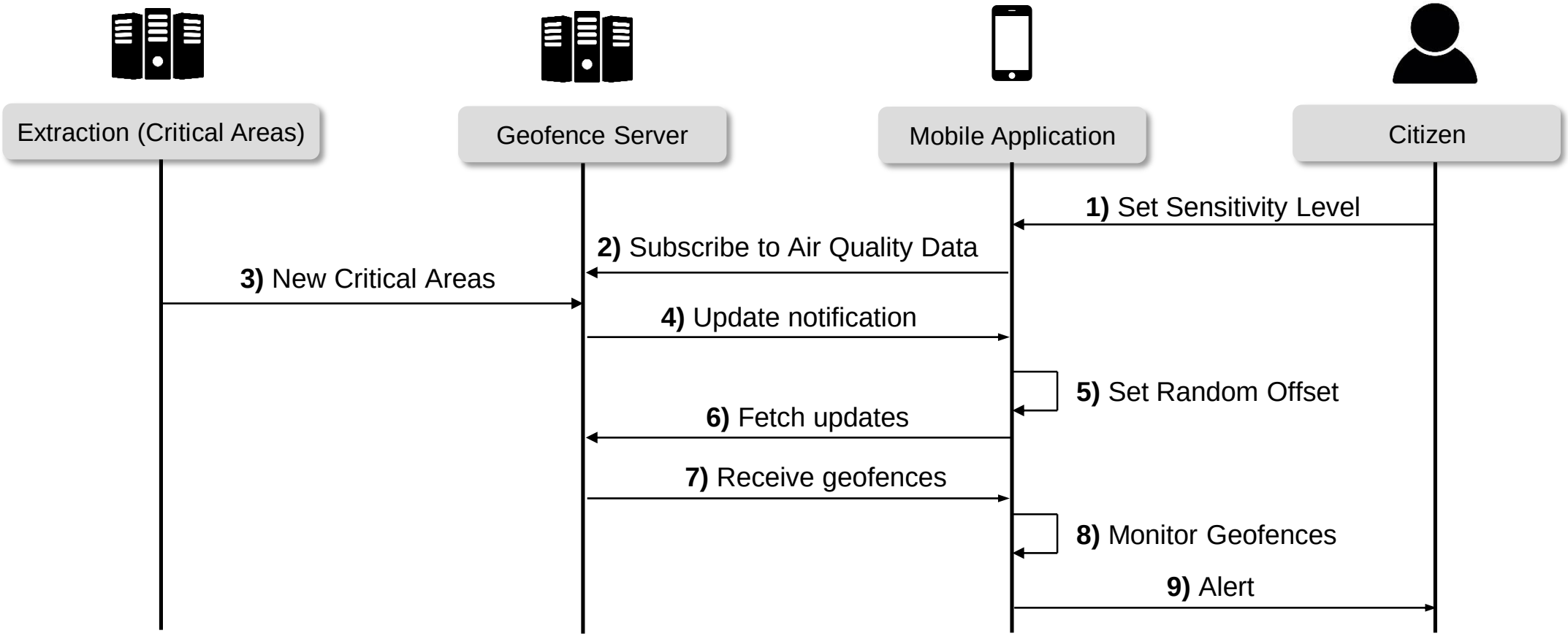
Service-centric NETWORKING

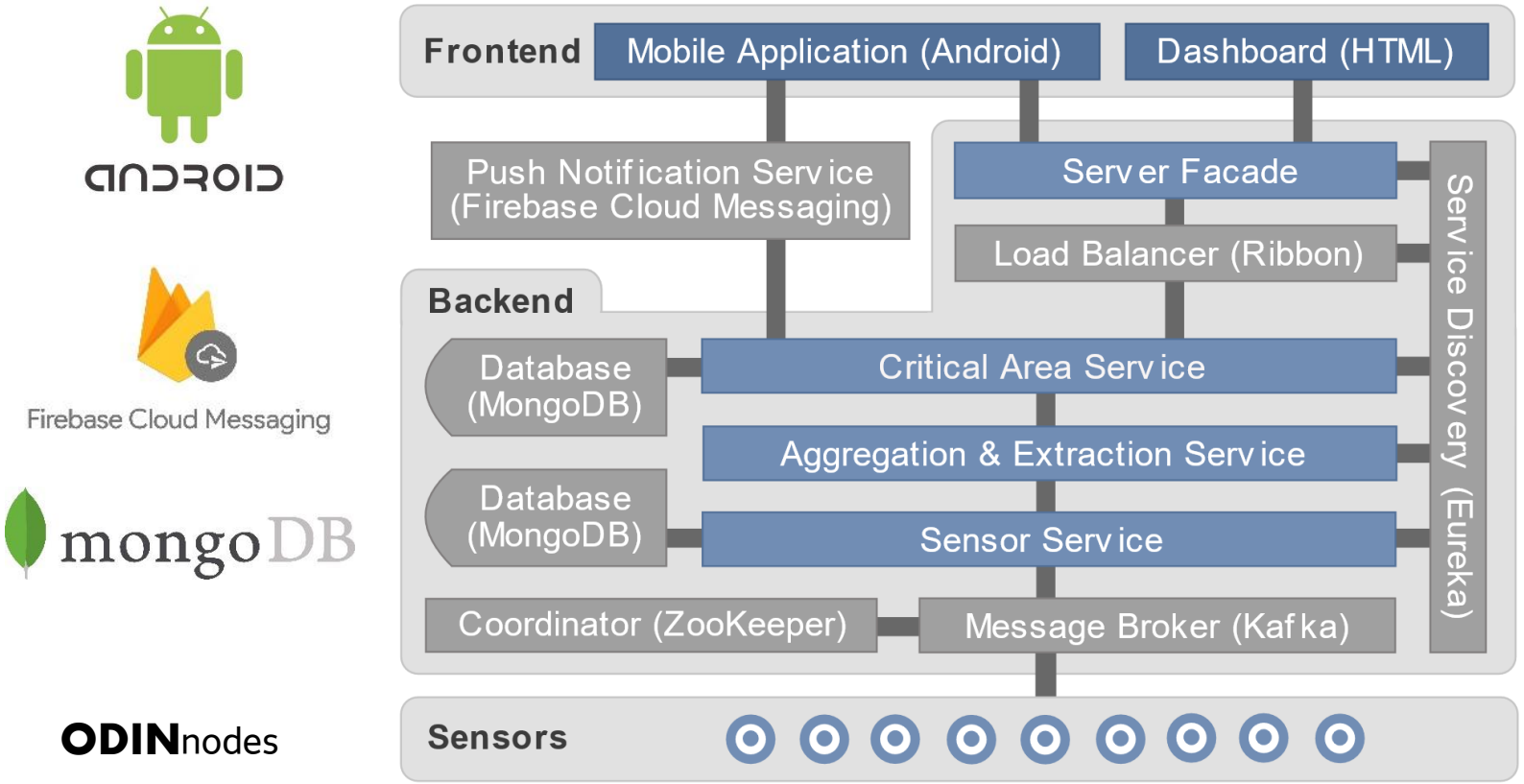
Airtify System

Distribution and Monitoring of Critical Areas



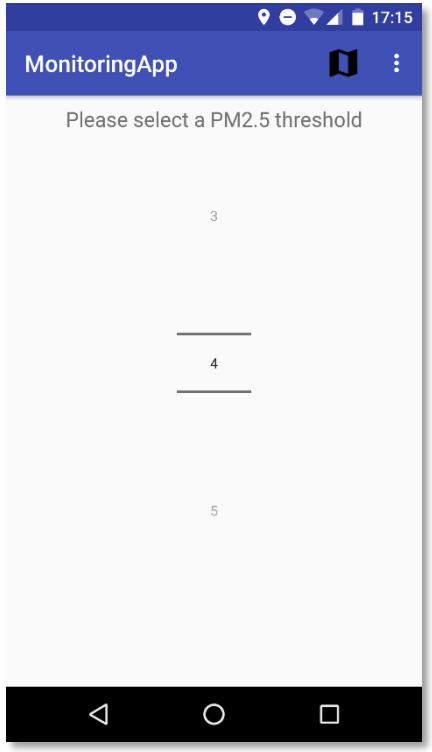
Airtify System

Implementation: Architecture

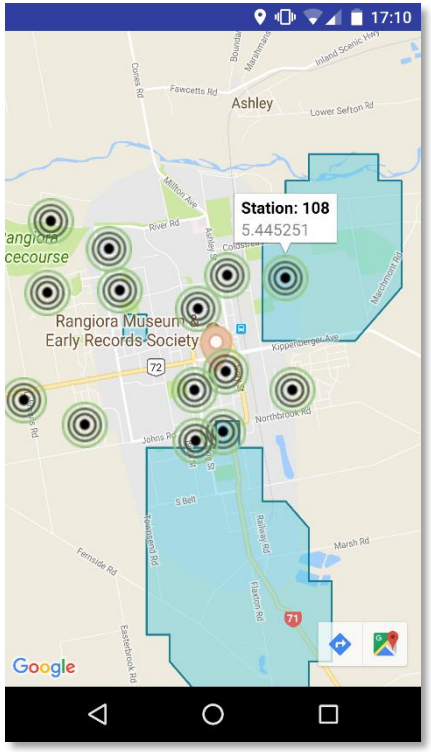


Airtify System

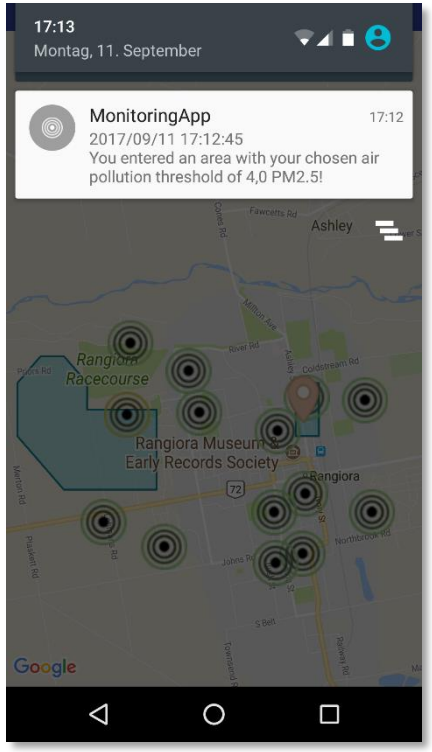
Implementation: Mobile Application



Selection of Sensitivity Level



Map View

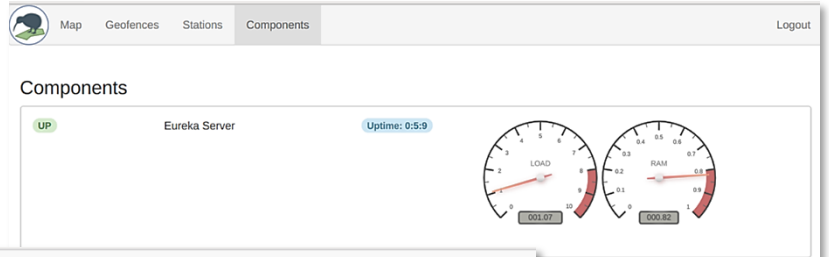


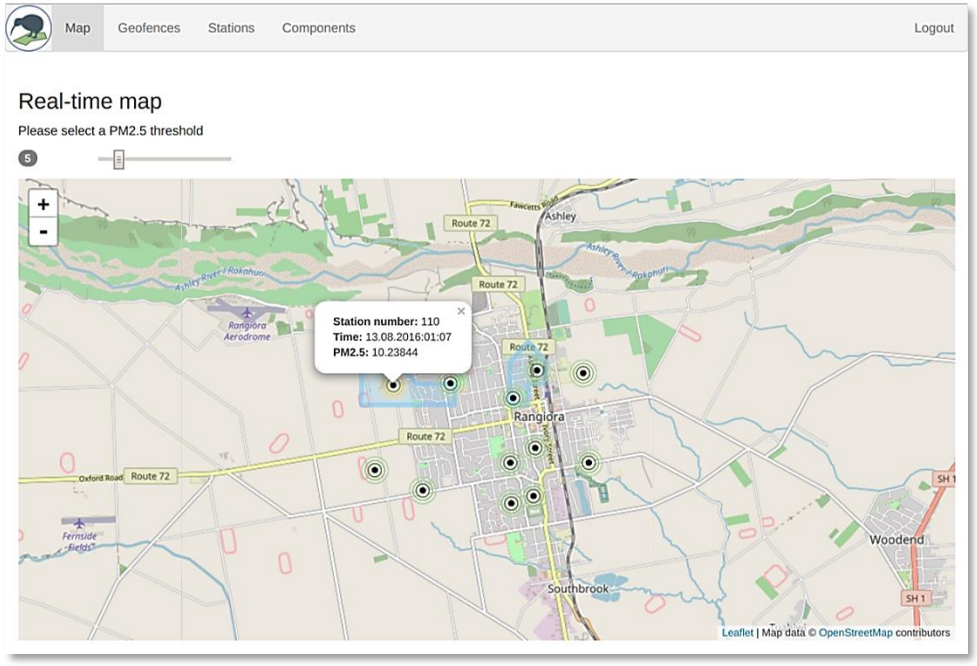
Air Pollution Alert

Airtify System

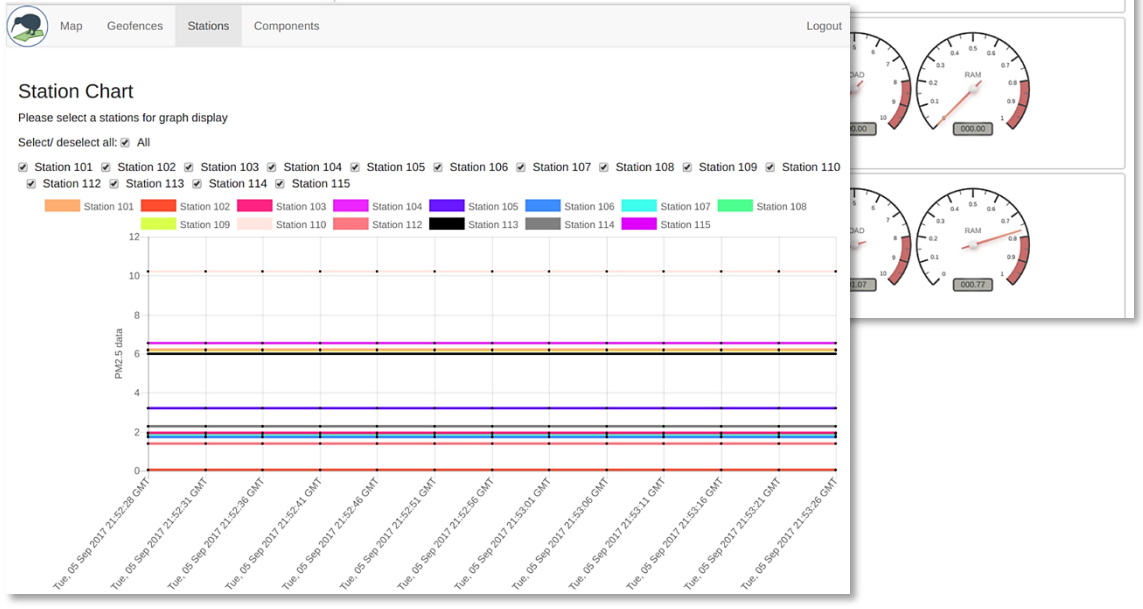
Implementation: Dashboard

Backend Status View





Real-time Urban Air Pollution Map View

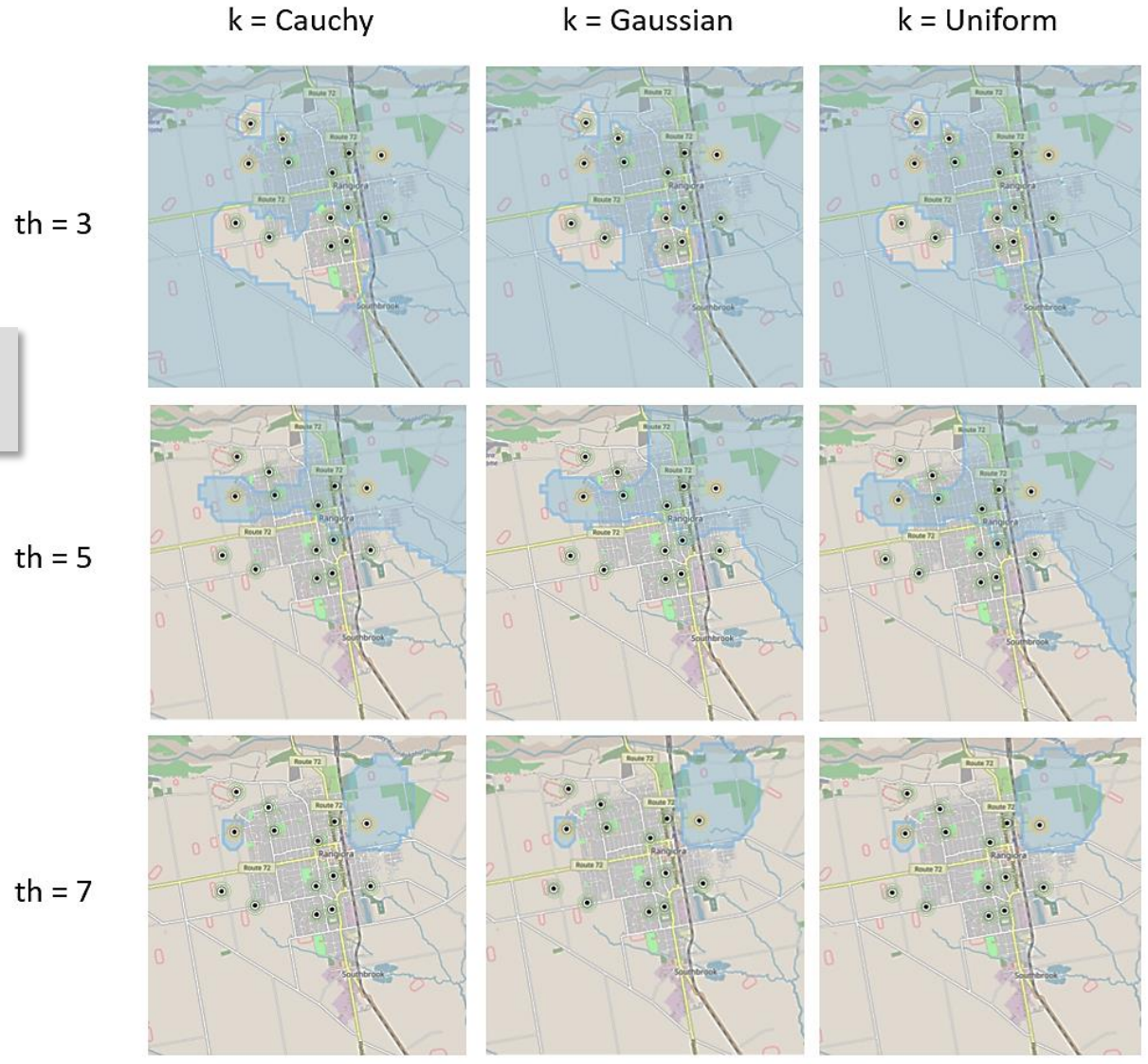


Air Pollution History Chart View

Airtify System

Evaluation I

Different Kernels
Different Sensitivity Level

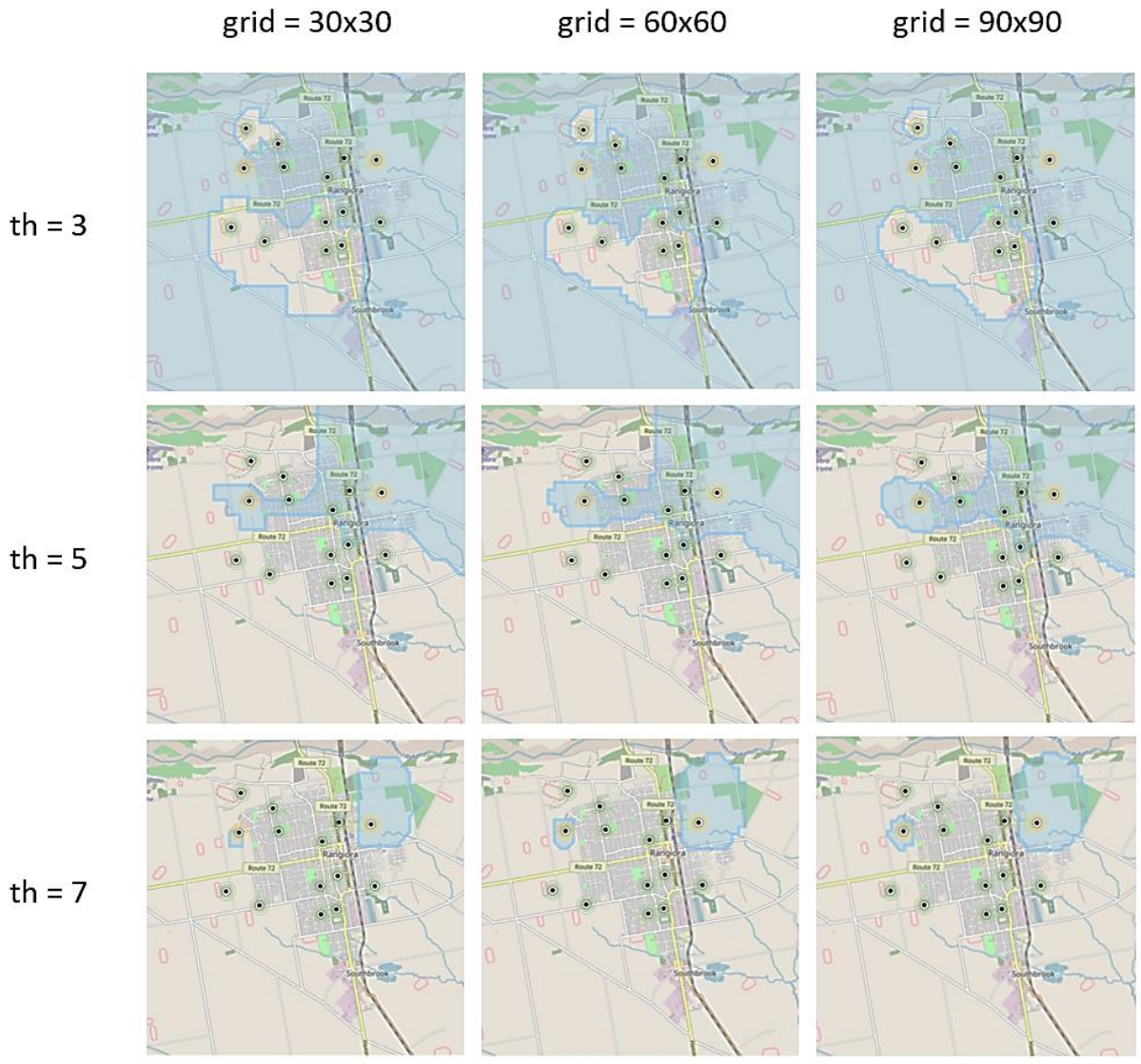


Airtify System

Evaluation III

- Cauchy Kernel
- Bandwidth = 0.001

Different Grid Resolutions
Different Sensitivity Level



Airtify System

Evaluation IV

- Cauchy Kernel
- Bandwidth = 0.001

Different Grid Resolutions

Backend Setup

- Intel Core i5-6300 CPU
- 4 Kernels (2.3 GHz)
- 8 GB RAM
- Virtualized Ubuntu (6.9 GB RAM)

Processing Time

Grid Points	900	1225	1600	2025	2500
Time(s)	24.0	48.8	65.3	94.0	190.6

Rangiora Setup

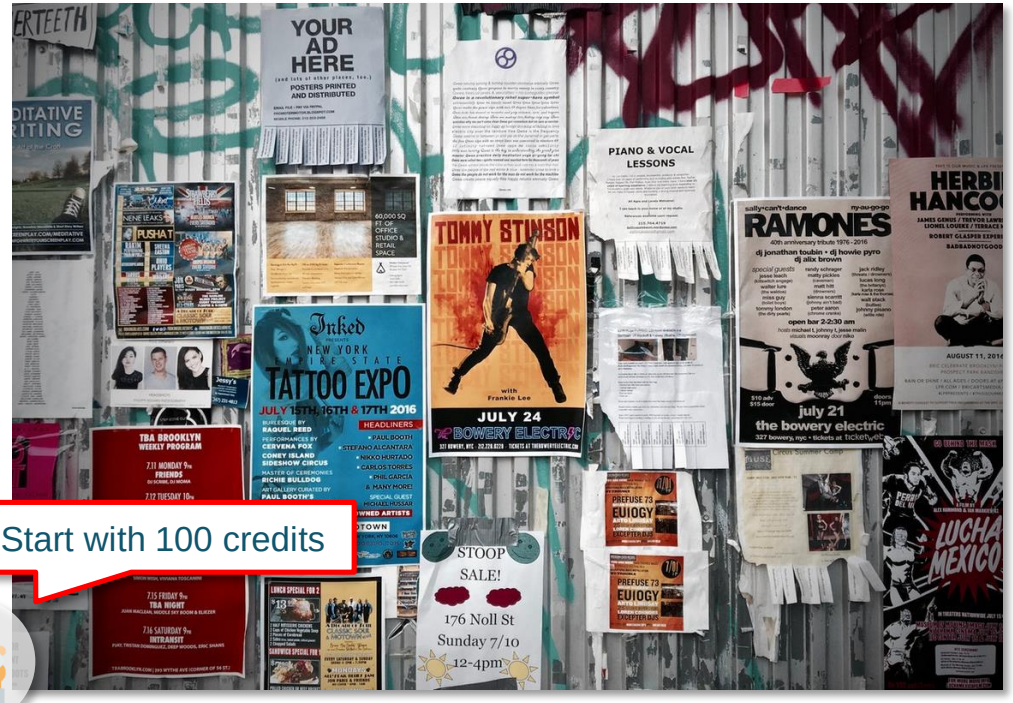
- Cauchy Kernel
- Bandwidth = 0.001
- 300m Grid Resolution

Energy Consumption

Mode	Idle	Tracking	Google	Map
Consumption (mAh)	198	198	352	506

Smart City Applications based on Geofencing Technology

Targeted Advertisement

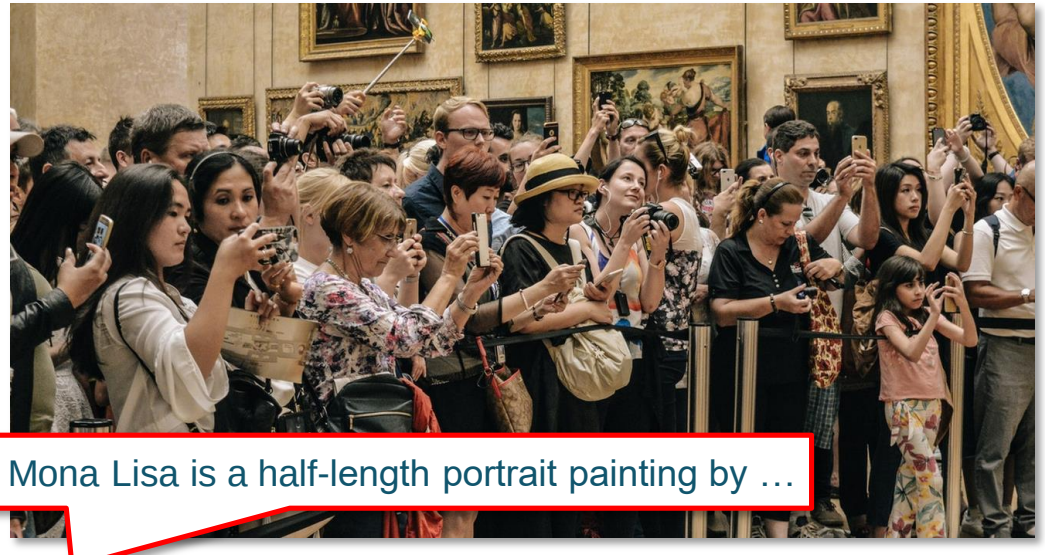


Only today: Buy 1 & get 1 free

Start with 100 credits

Smart City Applications based on Geofencing Technology

Tourist Guides



Smart City Applications based on Geofencing Technology

Targeted Polling

Technische Universität Berlin

New playground at Main Street?

Close down post office?

FlashPoll MOBILE PARTICIPATION

eit Digital

www.flashpoll.eu

Smart City Applications based on Geofencing Technology

Targeted Weather Warnings

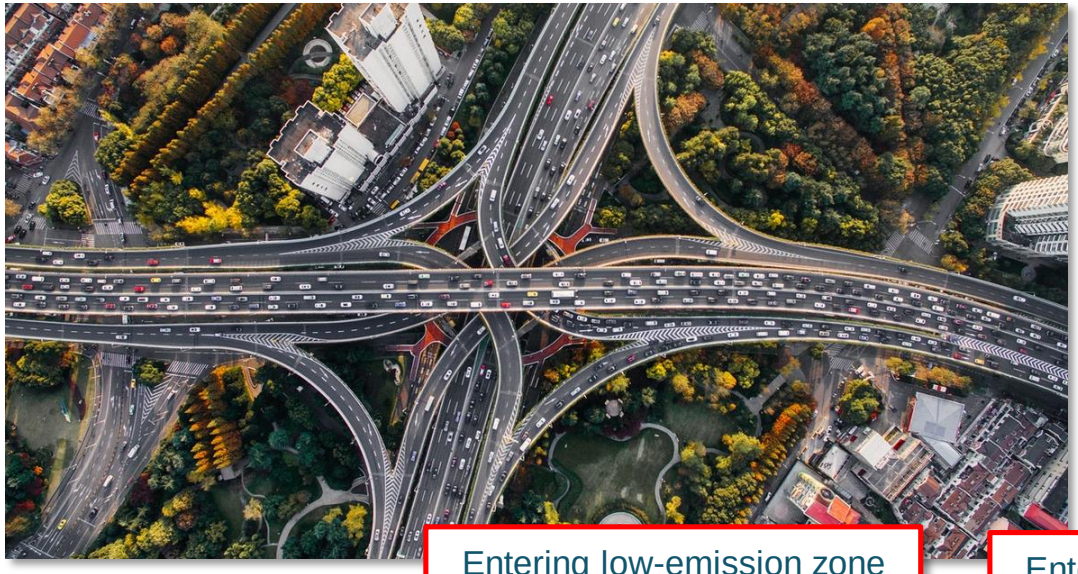
Smart City Applications based on Geofencing Technology

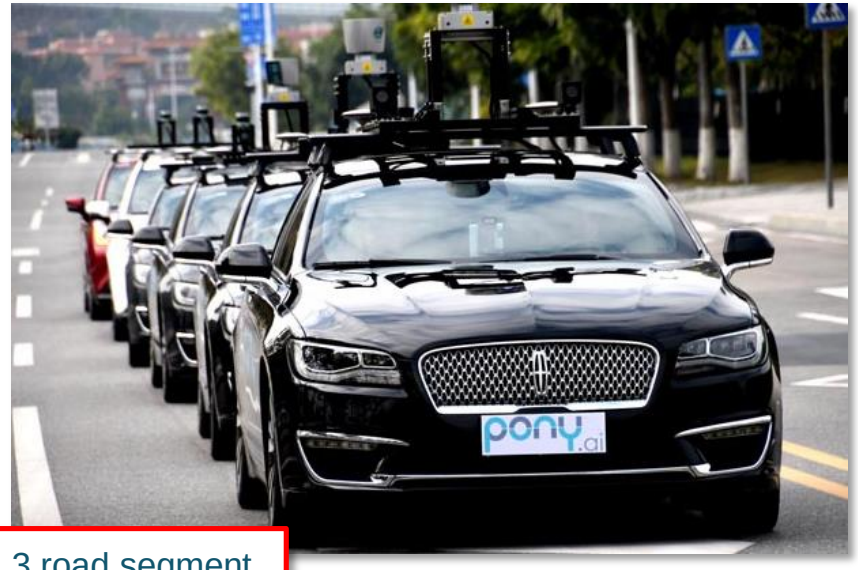
Drone Flight Management

Source: *Drones in the Contemporary Urban City*, newsbud.com

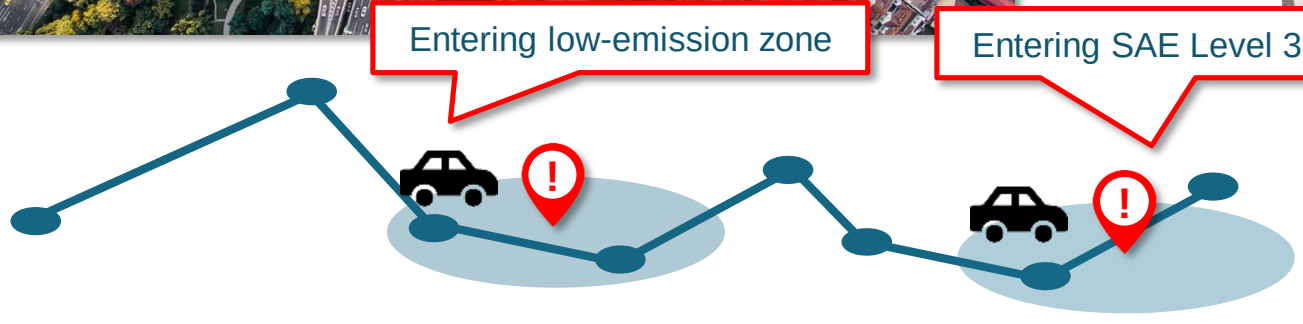
Smart City Applications based on Geofencing Technology

(Autonomous) Driving





Source: *Beijing Grants Road-Test Licence to Autonomous Driving Startup Pony.ai*, yicaiglobal.com

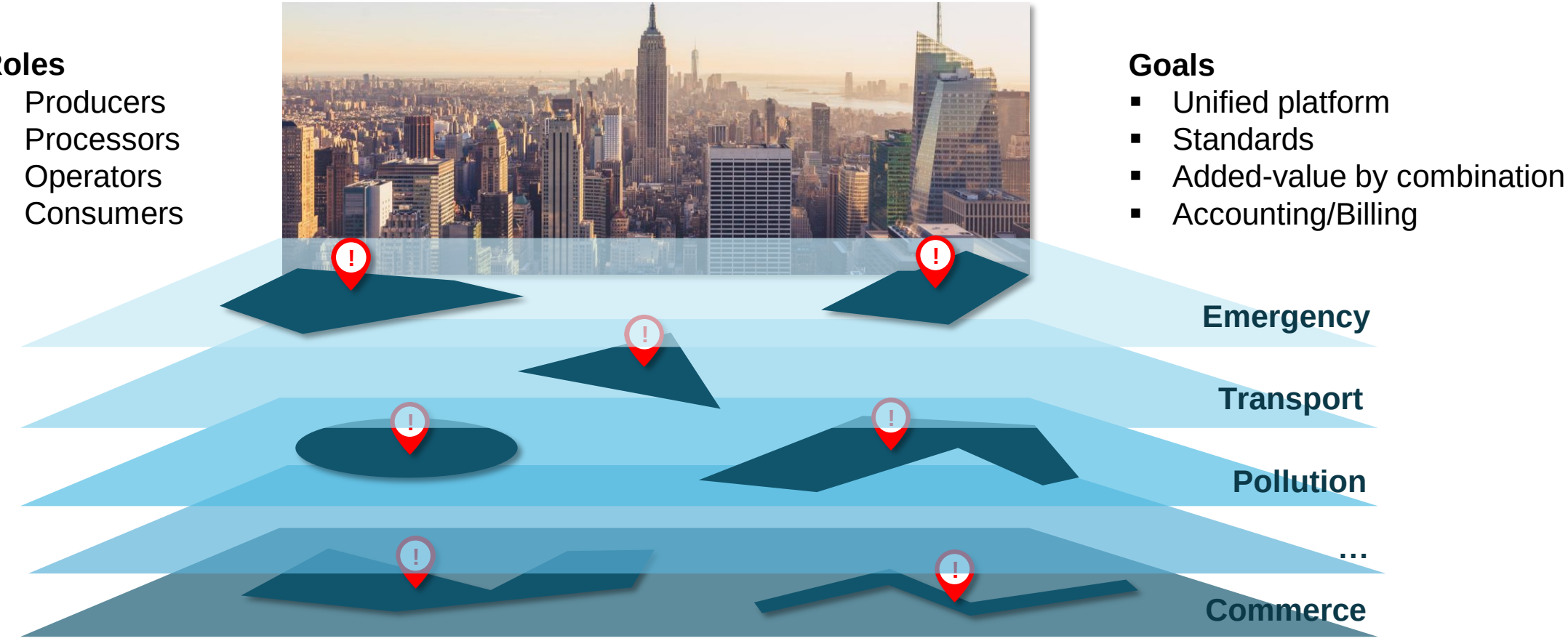


Long-term Vision

Geofencing for Smart Cities

Roles

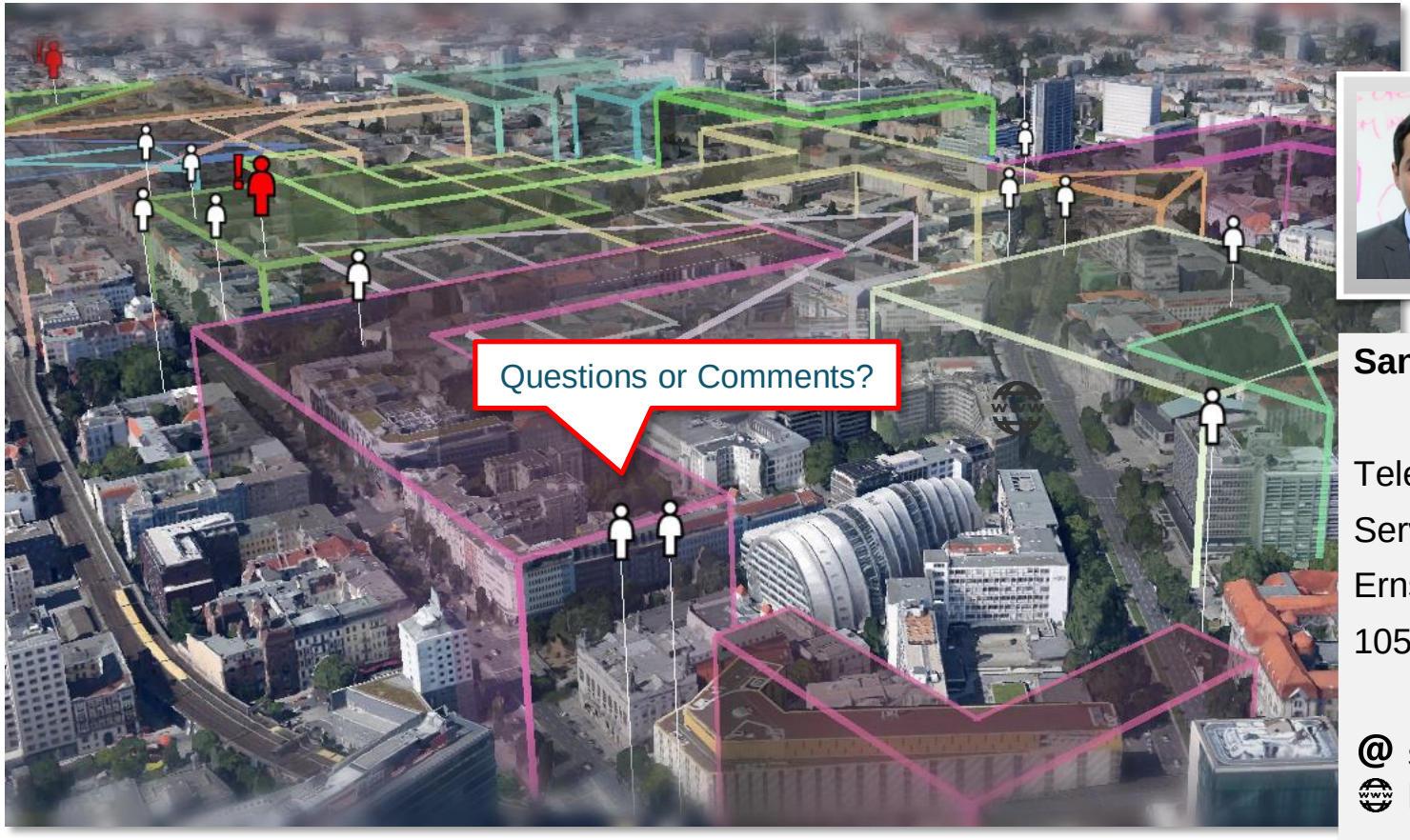
- Producers
- Processors
- Operators
- Consumers

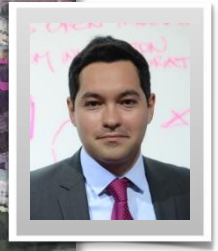


Goals

- Unified platform
- Standards
- Added-value by combination
- Accounting/Billing

Thank You





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http://www.snet.tu-berlin.de