

Mobile Crowdsensing: an enabler for Smart Cities Applications

Claudio Fiandrino

World Standards Day - Luxembourg

- 1 Introduction
- 2 Data Collection
- 3 Smart Public Street Lighting
- 4 Networking for Smart Cities
- 5 Conclusion

Smart Cities: Introduction

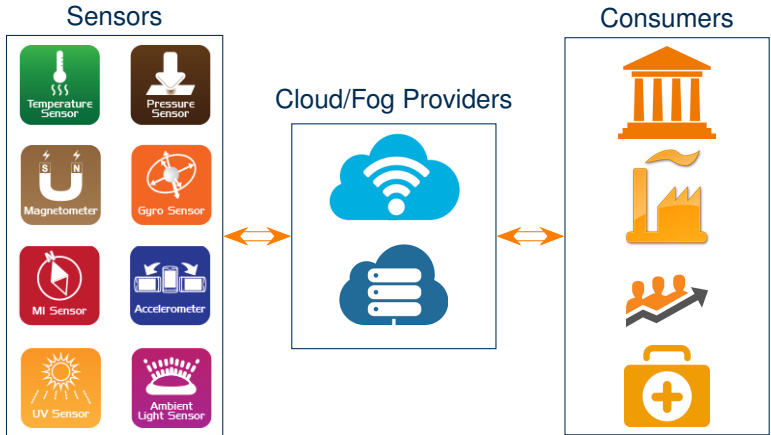
- 50% of worldwide population lives in cit
- Cities account for
 - 80% of worldwide gas consumption
 - 75% of global energy consumption
 - 60% of residential water use



N. B. Grimm, S. H. Faeth, N. E. Golubiewski, C. L. Redman, J. Wu, X. Bai, and J. M. Briggs, "Global change and the ecology of cities," in *Science*, vol. 319, no. 5864, 2008, pp. 756–760.

- ISO standards:
 - ISO/TS 37151 - first globally standardized methodology providing guidelines and metrics to assess the performance of community infrastructures
 - Temporal coverage
 - Areal coverage
 - Population coverage
 - 37120:2014 Sustainable development of communities – indicators for city services and quality of life
 - Total energy consumption per capita (kWh/year)
 - Number of authorized gas distribution service connections per 100 000 population
 - Percentage of municipal budget allocated to cultural and sporting facilities
 - Annual number of cultural events (exhibition, festival, concert, etc.)
 - Basic service proximity
 - ISO/NP 37122 Sustainable development in communities – Indicators for Smart Cities (under development).

Sensing as a Service (S²aaS) for IoT



Mobile Crowdsensing (MCS)

- Appealing paradigm for sensing and collecting data
 - Monitoring phenomena in smart cities
- Sensing as a Service (S²aaS) business model
- Sensors commonly available in mobile and IoT devices

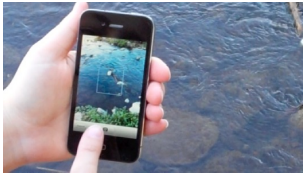


MCS Applications: Examples

Creek Watch

IBM Research

<https://www.scientificamerican.com/citizen-science/creek-watch/>

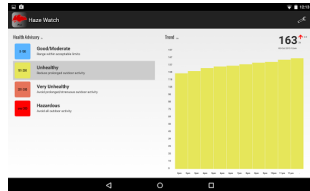


Haze Watch

University New South Wales

<http://www.hazewatch.unsw.edu.au/>

Used on daily basis in Singapore
<http://www.haze.gov.sg/>



- Custom simulator for crowdsensing activities
 - <http://crowdsensim.gforge.uni.lu>
 - Contact: crowdsensim@gmail.com



CrowdSenSim Mobile Crowdsensing Simulator



HOME

DOWNLOAD

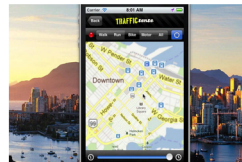
DOCUMENTATION

PUBLICATIONS

TEAM

About the Simulator

CrowdSenSim is a discrete-event simulator designed for research use in Mobile Crowd Sensing. It allows simulation of large-scale crowd sensing activities in urban scenarios and can be used to develop novel solutions in data collection, task assignment, monitoring and resource management. It is released under the GNU General Public License version 3.

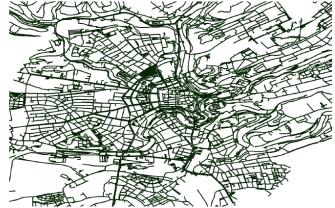
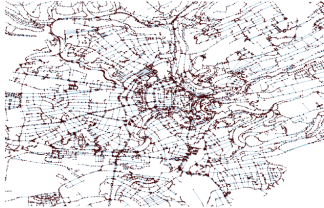


© 2015-2016 - CrowdSenSim • University of Luxembourg

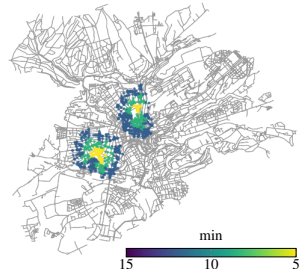
C. Fiandrino et al., "CrowdSenSim: a Simulation Platform for Mobile Crowdsensing in Realistic Urban Environments," in IEEE Access, vol. 5, pp. 3490-3503, 2017. DOI: 10.1109/ACCESS.2017.2671678

Modeling Urban Environments

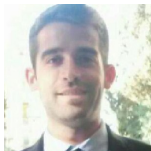
- Integration with OpenStreetMap and OSMnx package
 - OSM not accurate → New algorithm



Other applications:
Parking, Street Lighting
Waste Management

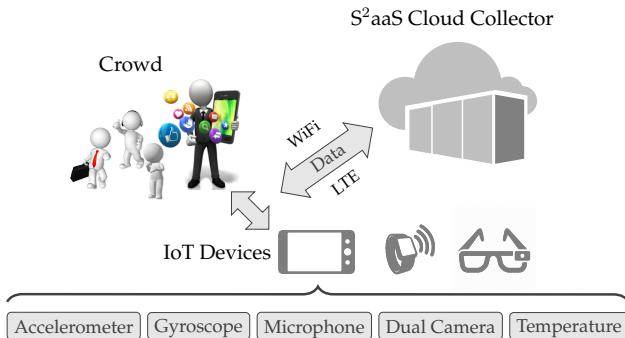


The CrowdSenSim Team



- 1 Introduction
- 2 Data Collection**
- 3 Smart Public Street Lighting
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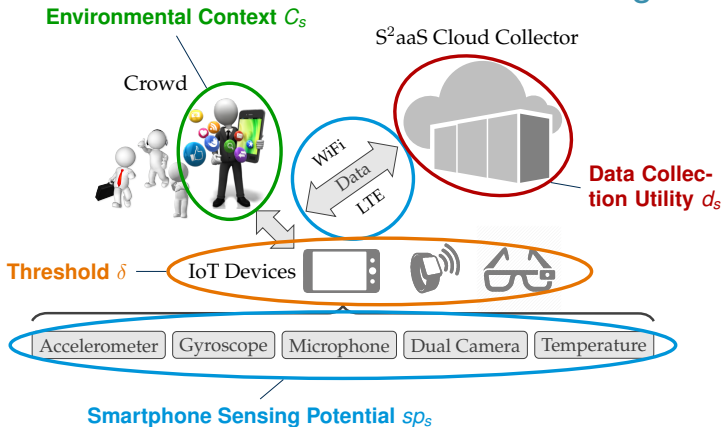
Mobile Crowdsensing Scenario



[1] A. Capponi, C. Fiandrino, D. Kliazovich, P. Bouvry and S. Giordano, "A Cost-Effective Distributed Framework for Data Collection in Cloud-Based Mobile Crowd Sensing Architectures," in IEEE Transactions on Sustainable Computing, vol. 2, no. 1, pp. 3-16, Jan.-March 1 2017. DOI: 10.1109/TSUSC.2017.2666043

[2] A. Capponi, C. Fiandrino, D. Kliazovich, P. Bouvry and S. Giordano, "Energy Efficient Data Collection in Opportunistic Mobile Crowdsensing Architectures for Smart Cities" in IEEE INFOCOM WKSHPS on Smart Cities and Urban Computing (SmartCity), Atlanta, GA, USA, May 2017

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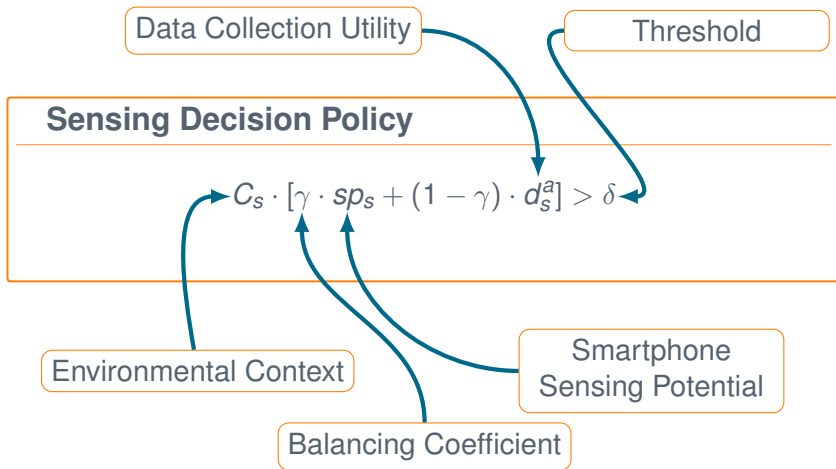
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Proposed Opportunistic Framework

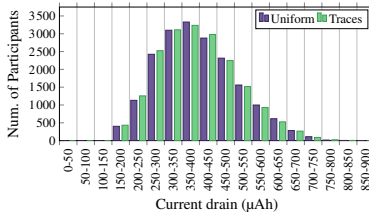
Sensing Decision Policy

$$C_s \cdot [\gamma \cdot sp_s + (1 - \gamma) \cdot d_s^a] > \delta$$

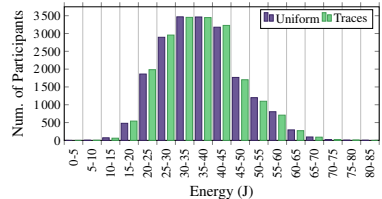
Proposed Opportunistic Framework



- Energy spent for sensing and communications



(a) Sensing Cost



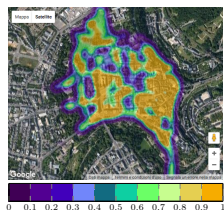
(b) Communication Cost

- Sensing and communication same distribution but different scales
- Real-world traces are the results of a study on pedestrian mobility and are public available on Crowdad (ostermalm_dense_run2) ¹

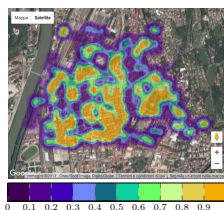
¹<http://crowdad.org/kth/walkers/20140505>

Performance Evaluation

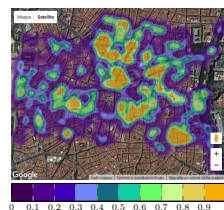
- Normalized distribution of amount of collected data for the different cities over the time period 8:00 AM - 2:00 PM



(a) Luxembourg



(b) Trento



(c) Madrid

The proposed Framework

- MCS systems for S²aaS applications in smart cities
- Data collection in opportunistic MCS systems
- Energy-efficient and cost effective

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Current Street Lighting Implementations (I)

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October 13, 2017

Mobile Crowdsensing

Not environmental sustainable:

- 19% of worldwide use of electrical energy
- 6% of total emissions of greenhouse gases
- 40% of the cities' energy budget



European Energy Innovation Publisher, "LED Lighting Technologies", in 2nd Annual LED Professional Symposium & Exhibition.

Current Street Lighting Implementations (II)

- ISO 93.080.40 - Street lighting and related equipment
- ErP Directive REG, 245/2009
- IEC 60598-2-3:2002+AMD1:2011 CSV

Not energy efficient
because of:

- Technology
- Control system

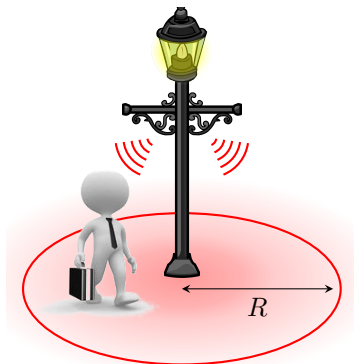


TYPE	NOM. WATTAGE (W)	LAMP EFFICACY (LM/W)	ENERGY (KWH/1000 H)	AVERAGE LIFE (H)
HPS-97241	150.0	110.0	172.7	24 000
HPS-93010296	250.0	129.0	283.4	24 000
MH-NaSc	100.0	90.0	165.0	10 000
LED-GRN60	46.8	131.0	51.8	100 000
LED-GRN100	73.3	138.0	82.7	100 000

New Heuristics for Street Lighting (I)

The new proposed heuristics rely on *occupancy*² and each lamppost operates *independently*

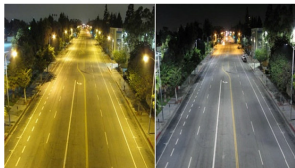
- IoT-augmented lamps
- Strategies:
 - Delay-based (DEL)
 - Encounter-based (ENC)
 - Dimming (DIM)



²F. Leccese, "Remote-Control System of High Efficiency and Intelligent Street Lighting Using a ZigBee Network of Devices and Sensors," in IEEE Transactions on Power Delivery, vol. 28, no. 1, pp. 21-28, Jan. 2013.

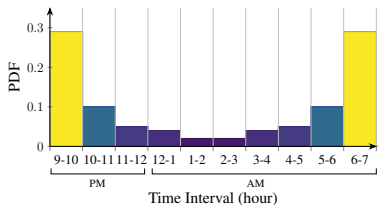
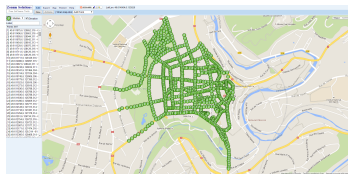
New Heuristics for Street Lighting (II)

METHOD	DESCRIPTION	EFFICACY
Current (CUR)	Continuous light emission at maximum intensity.	Lo
Delay-based (DEL)	Lampposts switched on when users pass nearby. If nobody is present within R , lampposts remain active for time window W and then are switched off.	Hi
Encounter-based (ENC)	Lampposts switched on upon the first user encounter. They remain active the whole night.	ME
Dimming (DIM)	Lampposts operate at 60% light intensity in absence of users within R . Lampposts light dim the intensity in proportion to the number of nearby users.	Hi

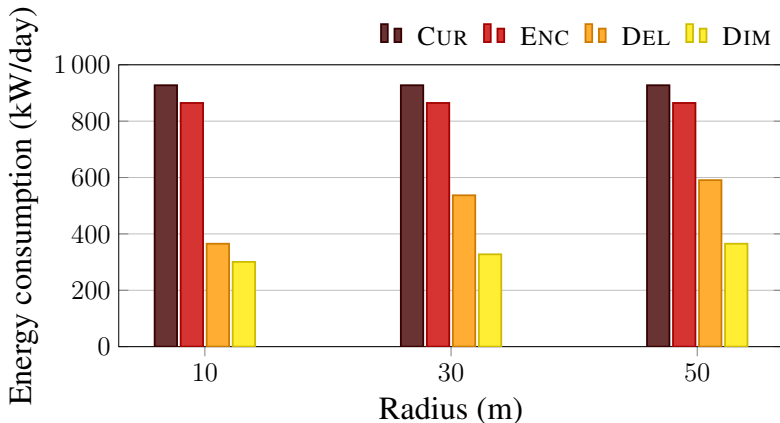


- Luxembourg City center
- Users: 20 000
- Walking speed: \mathcal{U} [1 – 1.5] m/s
- Walking period: \mathcal{U} [10 – 20] min
- Simulation period: 9 PM - 7 AM
- 537 Lampposts
- R : {10, 30, 50} m
- W : {2, 5, 10, 20} min

Evaluation Settings



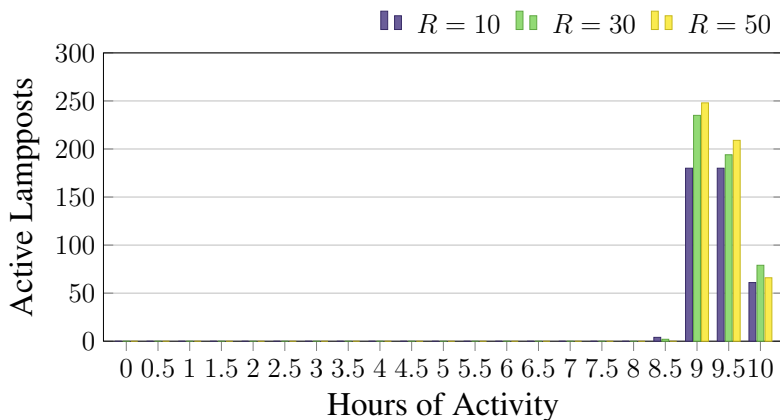
Energy Comparison of Heuristics



- DIM significantly outperforms other heuristics
- ENC already improves current systems

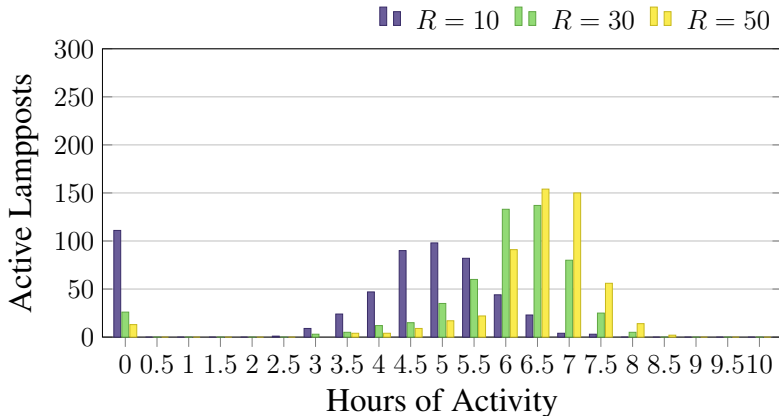
Distribution Active Lampposts: ENC vs DEL

● Evaluation of methods ENC



Distribution Active Lampposts: ENC vs DEL

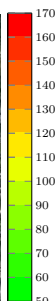
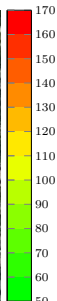
- Evaluation of methods DEL



- ENC switches off un-utilized lampposts

Heatmap of Energy Consumption

- Comparison ENC vs DEL³



³<https://developers.google.com/maps/documentation/javascript/examples/layer-heatmap>

Conclusion - Street Lighting

Summary

- Efficient and cost effective public street lighting
- Heuristics based on available technologies
- Performance evaluation in realistic urban environments

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CrowdSensing as Profiler of Network Status

- Connectivity (LTE/WiFi) essential for any smart service
- CrowdSensing help to monitor the network status:
 - Efficiency of current deployments
 - Which techniques suitable for improvements
 - Scalability in meeting future traffic demands
- Example: OpenSignal

<https://opensignal.com/>



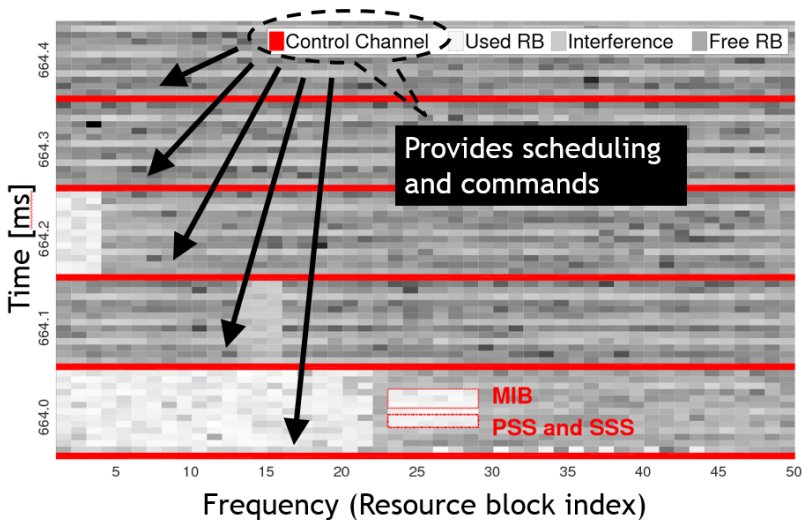
OpenSignal
better signal & faster data

- CrowdSensing-solutions are not accurate...
- ... alternatives exists:
- Online Watcher for LTE (OWL) developed at IMDEA
<http://wireless.networks.imdea.org/software>

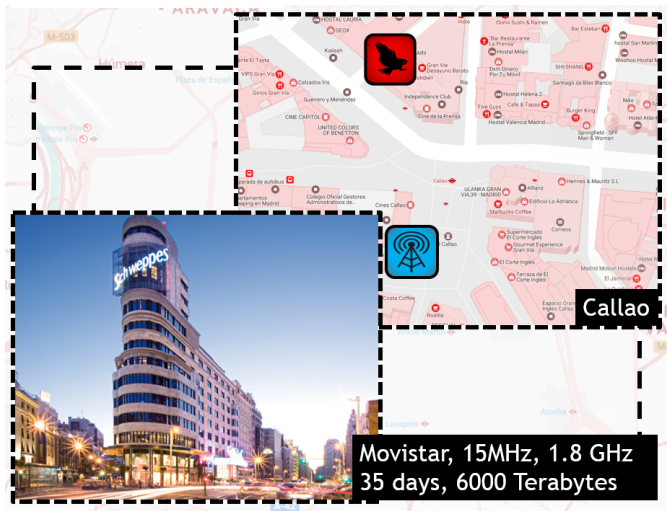


LTE is complex

- OWL does not intrude into users privacy...
- ... still captures relevant information



Measurements



- Active vs passive traffic
- Anticipatory networking

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Mobile CrowdSensing

- Appealing paradigm for distributed sensing
- Several scenarios of applicability

CrowdSenSim

- Large-scale simulations in realistic urban environments
- Crowdsensing activities
- Smart-City services
- Info:
 - Access and download:
<http://crowdsensim.gforge.uni.lu>
 - Contact: crowdsensim@gmail.com