ScuDo

Scuola di Dottorato ~ Doctoral School

WHAT YOU ARE, TAKES YOU FAR

XXXIV Cycle

Crowd monitoring using MAC probing in Smart Cities

Kalkidan Gebru

Supervisor: Prof. Carla Fabiana Chiasserini

Research context and motivation

- **Smart city** projects and their applications are aimed at improving our daily life. To make our cities smarter, it is critical to monitoring people's mobility and learn the behavior of dynamic environments. Our goal is to do this using existing hardware infrastructure**.**
- We start by focusing on **crowd monitoring** in **smart cities,** which is pivotal to safety, transport, and environment-related applications, as well as the basis for effective crowd mobility forecasting.
- One way of detecting the presence of an individual in a given environment is from **WiFi probes**, broadcasted signals from mobile devices which contain a **MAC address.**

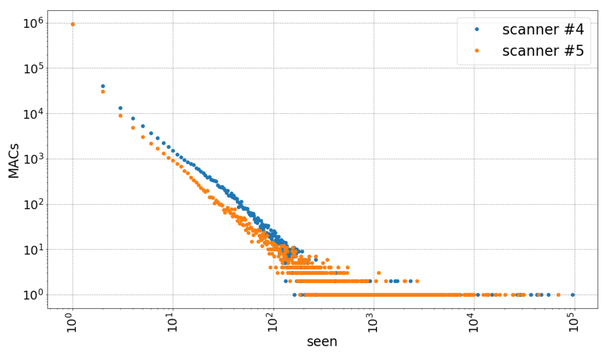
Addressed research questions/problems

We aim at answering the following research questions:

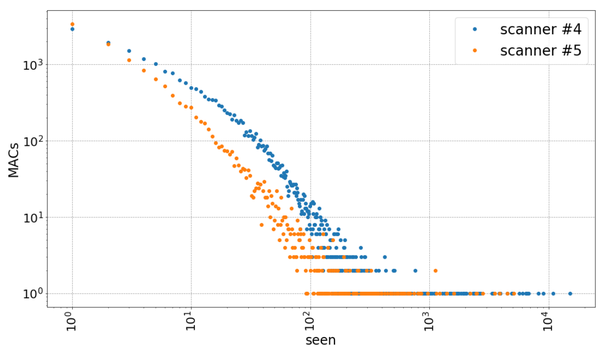
- **How many people are at, or passing by, a given place, where, and when**?
- **How can we identify groups of people and their movement within the crowd?**
- **What the arrival and departure time of a group?**
- **Once properly monitored and understood, how can we predict people's mobility and movements?**

As the first step, we focus on monitoring of individuals' mobility and movements. To do this, we need suitable metrics, which can be tracked and measured through WiFi probes.

Problem: for privacy purposes, the (MAC) address in WiFi probes are randomized.



MAC address occurrence
(All captured MAC addresses)



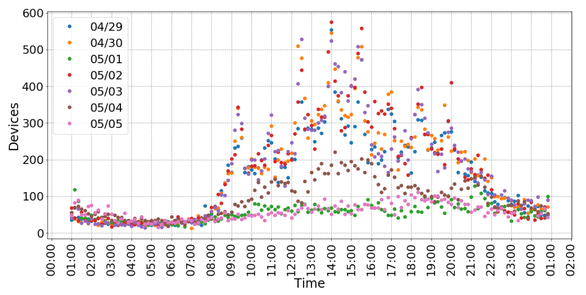
MAC address occurrence
(POLITO students)

Submitted and published works

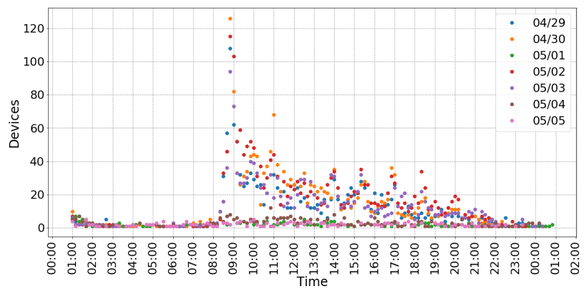
- Avino, Giuseppe; Marina, Giordanino; Frangoudis,Pantelis A.; Vitale, Christian; Casetti, Claudio Ettore; Chiasserini, Carla Fabiana; Gebru, Kalkidan; Adlen, Ksentini; Aleksandra, Stojanovic. "A MEC-based Extended Virtual Sensing for Automotive Services", AEIT International Conference of Electrical and Electronic Technologies for Automotive (AEIT AUTOMOTIVE) Torino (Italy), July 2019, pp. 1-6.
- Giuseppe Avino ; Paolo Bande ; Pantelis A. Frangoudis ; Christian Vitale ; Claudio Casetti ; Carla Fabiana Chiasserini ; Kalkidan Gebru ; Adlen Ksentini ; Giuliana Zennaro. "A MEC-based Extended Virtual Sensing for Automotive Services", IEEE Transactions on Network and Service Management, July 2019

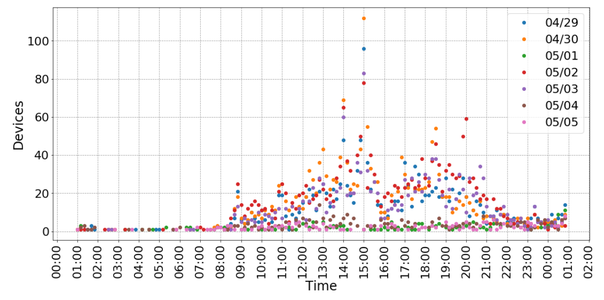
Novel contributions

- We captured the movements of groups (POLITO and high school students) from a crowd.
- We performed **automatic** separation between arrival hours and departure hours of students.



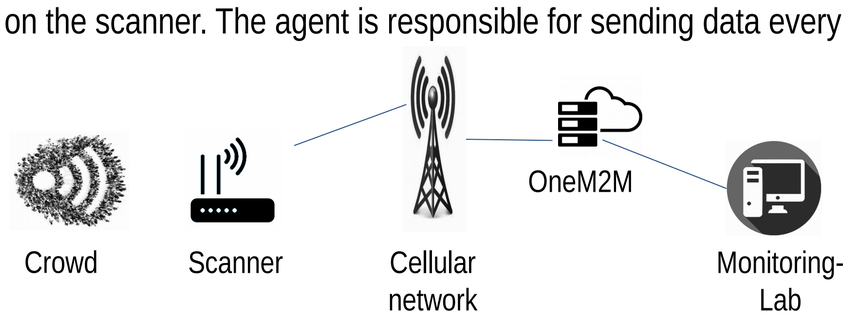
- Classifiers are applied on a per-group basis, for separating arrivals and departures of a group, and on a per-device basis to detect if it is mobile or not.





Adopted methodologies

- We placed two WiFi scanners near two gates of Politecnico di Torino to passively listen to probes that are transmitted by the WiFi interface of mobile phones. From the collected WiFi probes, regular lesson hours of POLITO and high school students are correctly detected and confirmed.
- The OneM2M platform, implemented based on the standard, is used for storing probe data. The platform follows a «store & share» paradigm. Users (data producers and consumers) can send data, read data, or subscribe to notifications of when data is received in a container. The supported protocols are HTTP, MQTT and CoAP.
- WiFi scanners are used to capture transmitted probes from the crowd in the area or passing by. Before storing the probe data, each MAC address is encoded with SHA224/28 bytes for privacy reasons. These scanners have a SIM card to support communication with cellular network.
- The communication between the scanners and the OneM2M platform takes place over the cellular network. Any probe data stored on the scanners are periodically sent to the OneM2M platform. For this, an agent (application entity) of the oneM2M platform is present on the scanner. The agent is responsible for sending data every 2 minutes.



Future work

- Develop MQTT client for automated data query from the OneM2M platform
- Work on establishing ground truth to identify flows on different routes
- Address randomization problem through vendor-based MAC address processing
- Add more scanners to cover more area and flows between Politecnico di Torino and the Porta Susa railway station
- Identify more classifiers to support the monitoring process
- Automate the classification process by using the identified classifiers

List of attended classes

02LWHRV Communication (Nov 2018, credits: 1)
01SWPRV Time management (Nov 2018, credits: 1)
01RISRV Public speaking (Nov 2018, credits: 1)
01QTEIU Data mining concepts and algorithms (Dec 2018, credits: 4)
01QORRV Writing Scientific Papers in English (May-Jun 2019, credits: 3)
01RONKG Python in the Lab (May 2019, credits: 4)
01PJHRV Cloud computing per applicazioni e-science (Jun -Jul 2019, credits: 4)
IEEE Summer School of Information Engineering - AI and Machine Learning for ICT Applications (Jul 2019, credits: 5)

POLITECNICO DI TORINO

PhD program in
Electrical, Electronics and Communications Engineering