Politecnico di Torino
Dipartimento di Automatica e Informatica

PhD in Computer and Control Engineering
XXXVI cycle

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Crowd monitoring and city sensing techniques supported by next generation mobile networks

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1. Introduction

The rise of the Internet of Things (IoT) and the widespread use of **smart mobile devices** with computing and sensing capabilities has unlocked a new way to support decision making in smart city services. The training of advanced Artificial Intelligence (AI) models and **crowd monitoring** techniques have become crucial, not only for safety and security, but also for numerous practical business applications and better management of urban spaces, facilities and services.

2. Crowd monitoring through WiFi Beacons

We addressed the problem of people counting and crowd monitoring leveraging the use of **WiFi probe request** packets sent by smart devices carried by people on the move. Our implemented methodology, described in [1], uses off-the-shelf hardware (Fig. 1) to count people boarding public transportation vehicles. The experimental results show that the proposed approach to people counting can achieve a good level of accuracy, while overall carrying a low-price tag, compared to video-processing systems.

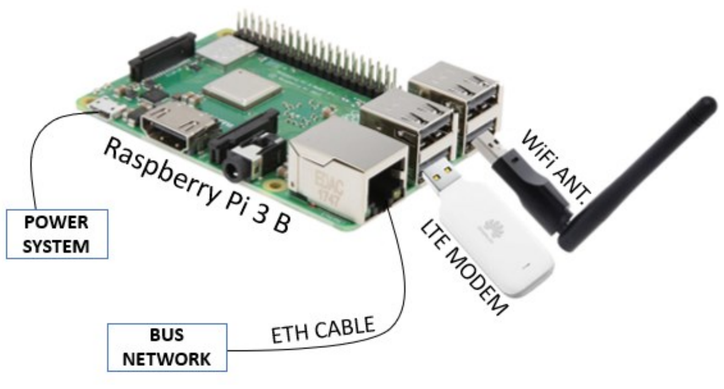

Figure 1. Hardware solution composed of a Raspberry Pi 3 Model B, a USB WiFi dongle, and a USB 3G and 4G/LTE modem.

Furthermore, in [2] we analyzed in detail the behaviour of probe request messages and how different device vendors implement **MAC address randomization** techniques.

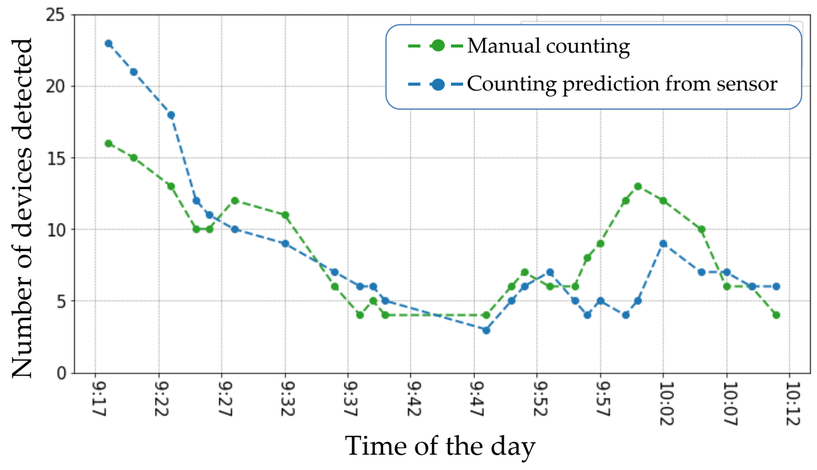

Figure 2. Performance evaluation of the sensor compared to the ground truth.

3. Federated learning in an urban scenario

We addressed the use of cooperative learning solutions to train a **Neural Network** (NN) model while keeping data local to each vehicle involved in the training process. In [3] we focused on **Federated Learning** (FL) and explored how this cooperative learning scheme can be applied in an **urban scenario** where several cars, supported by a server located at the **edge of the network**, collaborate to train a NN model.

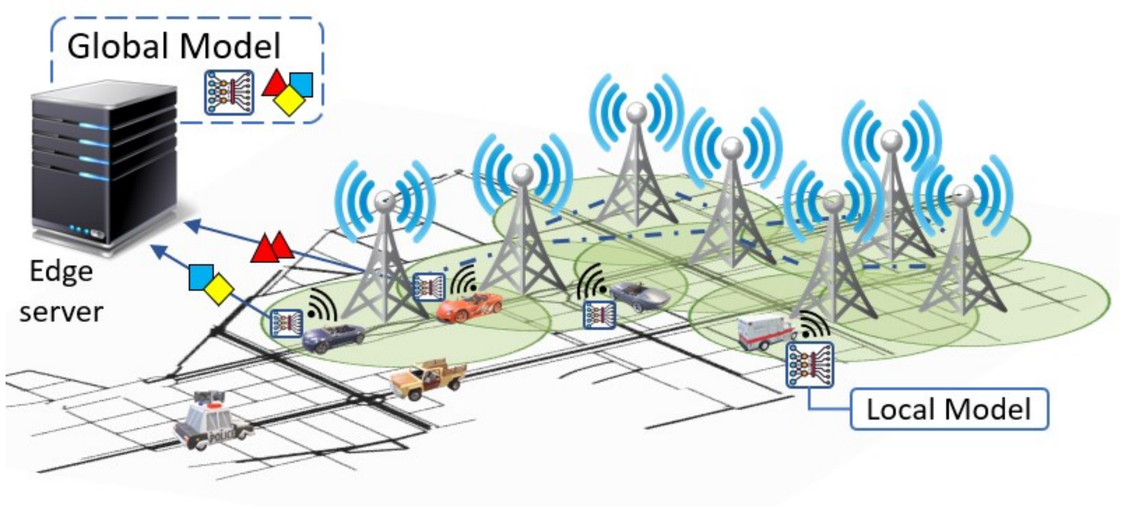

Figure 3. Federated Learning framework for an urban scenario based on the city of Turin.

4. References

1. K. Gebru, M. Rapelli, R. Rusca, C. Casetti, C. F. Chiasserini and P. Giaccone, Edge-based passive crowd monitoring through WiFi Beacons, 2022 Computer Communications
2. R. Rusca, F. Sansoldo, C. Casetti, P. Giaccone, What WiFi Probe Requests can tell you, IEEE CCNC 2023
3. G. La Bruna, C. Risma Carletti, R. Rusca, C. Casetti, C. F. Chiasserini, M. Giordanino, R. Tola, Edge-assisted Federated Learning in Vehicular Networks, IEEE MSN 2022