

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

#### 4. References

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- 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