Mass Events Monitoring Through Crowdsourced Media Analysis

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***Abstract*—In the context of Smart Cities, the crowdsourced approach provides huge amount of information that can be exploited for the detection and monitoring of critical events. To this aim, a framework to collect and analyze a multitude of crowdsourced data is described in this paper. The proposed system exploits the existing Radio Access Network (RAN) to collect profiled users' contributes within a specific area of interest, which are properly analyzed. The results of such processing are made available to the service that required the monitoring. This supports the decision making process devoted to the critical event response.**

***Index Terms*—Crowdsourcing; Data Monitoring; Mobile Edge Computing; Multimedia Analysis.**

I. INTRODUCTION

Nowadays, the pace of urbanization is exponentially increasing, with a multitude of information sources such as wireless sensor networks, cameras, smartphones, wearable devices and social networks. Such a huge amount and variety of data provide new technological assets to deal with unprecedented challenges in the context of smart cities.

In this scenario, the occurrence of critical events, such as fires, heartquakes or explosions, needs to be quickly noticed in order to safeguard the nearby citizens, who are often unaware about accidents and risk their safety or hinder the emergency operations. In this context, transports and ICT play a crucial role in disaster response and management based on information collected from smart heterogeneous entities such as personal devices, cameras, connected vehicles, forming the recent emerging Internet of Things (IoT) paradigm [1]. IoT aims to have more pervasive connected objects which provide heterogeneous information useful for future Smart Cities. The Smart City aims to have a distributed, shared, horizontal and social intelligence, which encourages the participation of citizens and the organization of the city in a perspective of optimizing resources and results [2].

The management of the aforementioned critical events, in a Smart City context, requires two main actions: event detection and monitoring. The first aims to detect signal anomalies, such as anomaly values on mass movements, pollution data, etc. The detection phase is devoted to a continuous observation of a number of predefined data and the design of statistical models of these observations in a normal context. When a critical event occurs, the system detects an anomalous data pattern with respect to ordinary conditions. This kind of analysis aims to promptly understand what it is happening and how the event is evolving, in order to support the decision making process. Although the detection can be easily obtained by the continuous observation of signals over a specific geographical region, the monitoring of an event could require the collection of live customized data in not observable areas. As an example, an anomaly detection system could spot unusual behavior, such as the presence of mass of people who are moving towards an area due an accident. To quickly understand what is happening in that specific area, a monitoring system needs to collect more specific data related to the involved region. In this context, it could be optimal to have a video stream from cameras which observe that region. However, there is no guarantee of the presence of such devices. One solution could be to ask nearby people to contribute on collecting specific data through their personal devices, exploiting a crowdsourced approach.

In this work, we propose a framework able to correlate user data such as video, images and text, exploiting this information in order to detect and monitor critical events and rapidly notify the citizens. To this aim, the proposed framework exploits the existing Radio Access Network (RAN), which also provides computational capabilities defined by the Mobile Edge Computing (MEC) paradigm [3]. Such a computing paradigm allows the allocation of MEC IT application servers that can be directly integrated on the LTE access nodes in order to provide low latency and location awareness for real time services, allowing the pre-processing of the data provided by the users located within the range of the specific Base Transceiver Station (BTS) [4].

The rest of this paper is structured as follows: Section II describes some background information on detection of critical events and how the crowdsourced approach can facilitate a disaster management. Section III presents an overview of the reference scenario. Section IV describes the architecture and a typical execution flow of the proposed framework. Finally in the last Section, some consideration and future work have been presented.

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II. Related Work

Many approaches have been proposed to automatically detect patterns such as accidents (e.g., stampedes, fire) but also busy roads and traffic jam. In [5], authors proposed an automatic event detection technique for camera anomaly based on image analysis. Starting from a procedure that extracts reduced-reference features from multiple regions in the surveillance images, this technique detects anomaly events by analyzing variation of features when image quality decreases and field of view changes. In [6], it is presented a solution to detect anomaly specifically designed for traffic cameras. This work introduced a new state transition system that involves the outcomes of image quality assessment and mixture of optical flow histogram analyzing. A two-stage scheme was proposed to reduce the computational complexity in order to meet the real-time requirements of large-scale monitoring system. This method can be used for traffic camera only. The work proposed in [7] demonstrates how crowdsourcing can be facilitated in the contexts of smart buildings and cities in order to support a more effective and efficient integrated disaster management approach. In this scenario, is explained how various participant users including critical infrastructures, cars, buildings, and humans could be connected via sensors and mobile APIs in order to acquire data from surrounding environment.

In order to monitor abnormal events, the proposed approach acquires data related to the environment by exploiting personal devices, video surveillance systems deployed in the city and wireless air quality sensor systems. These information can be analyzed with proper techniques of pattern recognition and data analysis, enabling the distribution of computation on the smart cities with Mobile Edge Computing, exploiting a crowdsourced approach.

III. Scenario

Over the last few years, with considerable complicity of social networks, we have discovered the enormous value that people can bring to different areas by means the information they produce. Common users have become prosumer (producer-consumer) of original contents.

The scenario considered in this paper regards the detection and the monitoring of abnormal events in a city with the help of its citizens. The main strength of a crowdsourced approach is the pervasiveness of the people, who can be considered as “mobile sensors”. A similar pervasiveness is hard to achieve using an infrastructure of real sensors (eg. cameras) mainly to their costs in terms of hardware, installation and management. People are instead inclined to share information and multimedia contents about their activities and the environment around them. Each user can be considered as a source of information and can contribute to improve the knowledge on the area where it is located and about a possible occurring event. The contributions from many different users can be combined to obtain an overall view of the area of interest. The proposed scenario exploits a crowdsourced approach to determine the type of event that occurs in a specific area and monitor how the situation evolves.

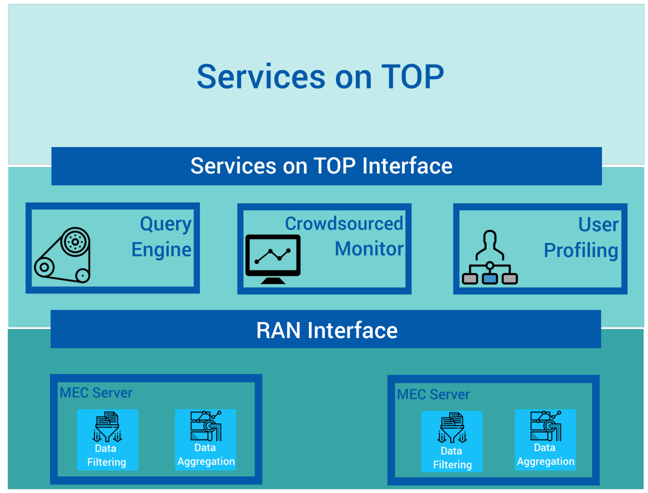

Fig. 1. Proposed Framework

After an event detection notification, due to the observation of abnormal signals, the proposed framework receives the geographic information of the involved area. This information is exploited to make a request to a proper MEC application, which handles the communication between the involved users and the framework. The system empowers the BTS to broadcast a “fast query” to the users within the interested area.

IV. Proposed Framework

This section describes the proposed framework in order to achieve a quick and efficient monitoring and being also able to identify the specific critical event, warn citizens and call the rescue services.

Initially, the event detection is carried out evaluating the sudden movement of a large mass of people, through the sensors on the personal devices, such as: accelerometer, gyroscope, proximity sensor and GPS position, enabling an implicit crowdsourcing.

The main components of the framework, shown in Figure 1, are the following:

- Service Interface: this component provides the access API to the framework’s capabilities, which can be properly exploited by an external service;
- Query Engine: this module is devoted to the definition of fast queries used to interact with users, in a simple and immediate way, with the aim of acquiring general information about the status of a specific area affected by an event. Moreover this module is also responsible for generating multimedia contribution request to improve the awareness about the area of interest.
- Crowdsourced Monitor: this module includes a set of algorithms devoted to perform analysis and the inference on the user gathered contents. The obtained results are provided to the services on TOP and affect the user profiling.
- User Profiling: this component collects historical data about users interactions and performs a profiling based

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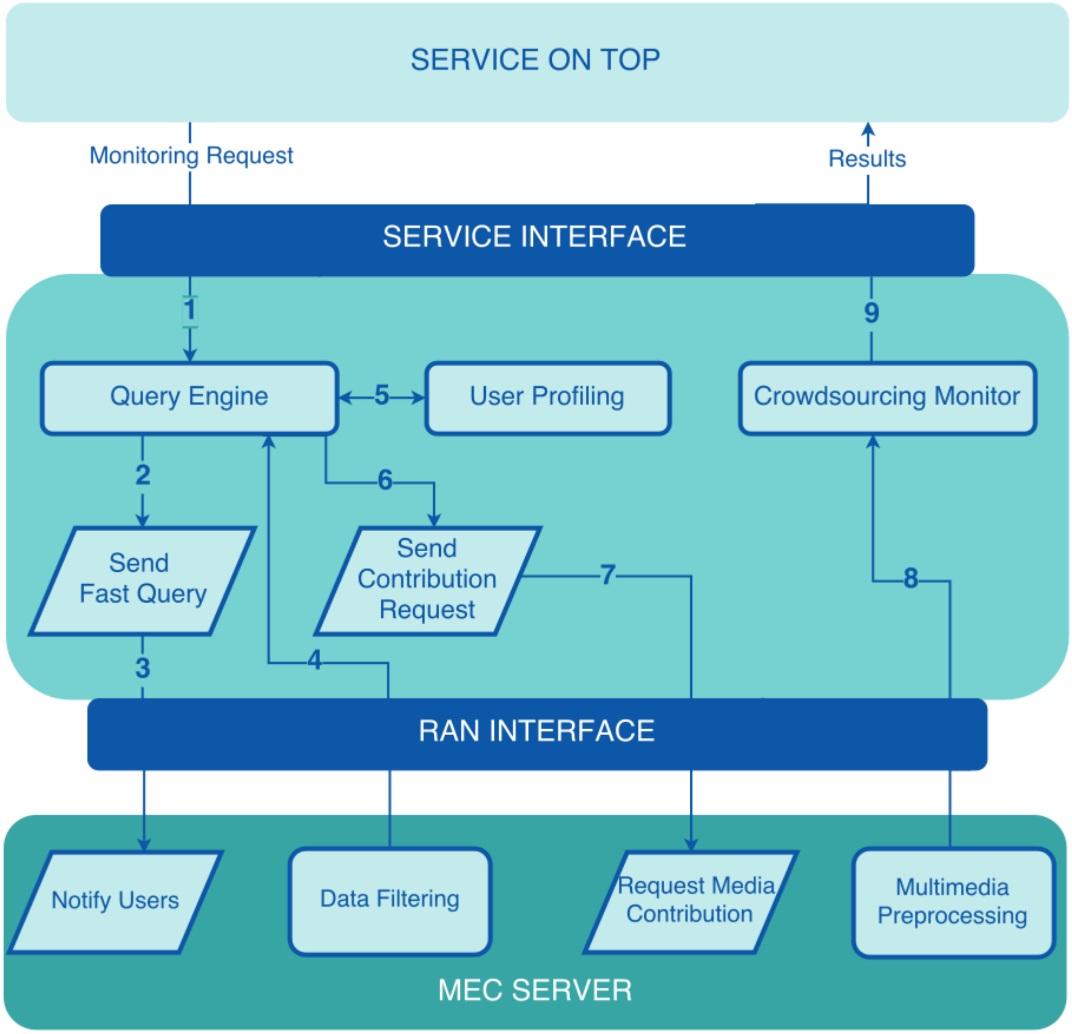

Fig. 2. A flow diagram that describes the step-by-step interactions among the different modules of the proposed framework

on the quality of the obtained information and the used devices.

- RAN Interface: this module allows the interaction between the proposed framework and the RAN by means a proper API.

In Figure 2, the details of the monitoring process are shown. The monitoring process may be triggered by an automatic system of event detection or by an operator to gain awareness of what is happening in the affected area and acquire additional details about the event in progress. The numbered arrows describe a typical execution flow. Here follows a step-by-step description of the actions taken by the system to serve the request:

1) The framework receives through the *Service On Top Interface* a monitoring request for a specific area.
2) The *Query Engine* processes the received request and prepare a set of fast queries to send to the users located in the area of interest.
3) The *RAN Interface* forwards the query messages to the specific BTS, which covers the area and sends broadcast text messages, containing the short questions.
4) The MEC Application deployed on the *MEC Server* analyzes the users' answers and filters them according to the information accuracy (e.g., event awareness).
5) The *Query Engine* combines the acquired information with the historical users' profile data (e.g., trusted users, device model).
6) The *Query Engine* exploits this information to define the suitable contribution request.
7) The *RAN Interface* sends the contribution request to the specific BTS which forwards it to the users demanding multimedia contribution (e.g., video stream, pictures).
8) In this step, the MEC Application performs some preprocessing on the multimedia contributes. For instance, if the number of provided video streams is high, they can be filtered considering several quality factors (e.g., video resolution, frame rate, stability). This prevents the system to elaborate noisy information, and the reduction

of the amount of the data to process.

9) The *Crowdsourcing Monitor* performs the analysis of the acquired data. These analysis depend on the kind of the required data and the aim of the analysis. For instance, if the system requires to perform the visual monitoring of the area of interest, the video streams provided by the users can be clustered according to the visual content with the aim to understand what is the most viewed scene [8].

The whole above described process is made transparent to the user by means of both the mentioned interfaces. The system only requires the area of interest to be monitored.

V. Conclusion

This work presents a framework able to provide a quickly monitoring of critical events, obtained by exploiting a crowdsourcing approach and Mobile Edge Computing paradigm. Upon receiving a monitoring request, the system defines a process that allows to collect, analyze and make proper inferences on crowdsourced data, with the aim to provide useful results to the service. The contributes of the users are selected considering several factors including user proximity, quality of the provided information, user profiling, as well as the user answer to a fast query. The collected data are then aggregated and analyzed. Examples of contributes aggregation analysis are visual clustering and saliency of video streams. The analysis results are then provided to the Service On Top and exploited to update the users' profiles.

In the next steps of this work in progress project, we are building up an actual prototype of the proposed framework with the aim to achieve experimental results and assess the effectiveness of the method described in this paper.

In the last few years, emerging technologies have been leading toward the realization of efficient cities, where technology will be applied to improve and support citizens' daily living in a realistic Smart City scenario in which the proposed framework is fully integrated.

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