Towards a Mobile Cloud Framework for First Responder Teams in Smart Emergency Management

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Abstract. Smart city systems integrate multiple information and communication technologies (ICTs) to enhance the efficiency of urban services and quality of citizen's life while decreasing operational costs and efforts. To manage smart city infrastructure, Mobile Cloud Computing (MCC) has emerged as a disruptive technology that facilitates its users to exploit portable and context-aware computation with pay-per-use software/hardware resources. We propose to exploit the MCC technologies to develop a framework that facilitates first responder teams to operate smartly in emergency situations.

Keywords: Smart infrastructure · Mobile cloud system · Software engineering

1 Introduction

In recent years, smart city systems have emerged as solutions that transform the conventional cities and societies into information and communication (ICT) driven metropoles [1]. Smart city systems offer improved and digitized urban services such as smart health, transportation and emergency management to the stakeholders and empowers citizens, public administration and organizations to utilize such services efficiently and cost-effectively [1, 2]. Mobile Cloud Computing (MCC) represents the state-of-the-art mobile computing technology that exploits mobility and context-awareness to support the operations and infrastructure of smart cities based on portable computation and location-aware communication [3]. In smart cities, disaster and emergency management needs an effective coordination and mobilization of the first responder teams to respond to the catastrophic scenarios in a smart way [4, 5].

First responder teams refer to a group of people who are responsible for providing services and operations in case of emergency scenarios such as fire fighters, emergency medical paramedics or rescue workers [5]. For a successful completion of their tasks, the individuals in the first responder team needs to establish an effective coordination and task allocation among them [6]. In this paper, we propose a framework that

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facilitates and empowers first responder teams to operate and coordinate efficiently in different emergency situations. The proposed framework utilizes the MCC technologies as the unification of mobile and cloud computing can benefit from the mobility and context awareness (of mobile computing) and the computation and storage services (of cloud computing) to provide systems that are portable, yet resource sufficient [5].

Framework Overview: Our proposed framework consists of two main layers namely mobile computing layer and cloud computing layer as illustrated in Fig. 1. Cloud computing layer is used for data storage and computation of data intensive task – referred to as machine centric layer. Mobile computing layer utilizes the services of mobile device such as context awareness and mobility services to capture and share contextual information of an emergency scenario. Mobile computing layer acts as the interface for the first responder teams – referred to as human centric layer. Mobile and cloud layer communicate with each via the network connectivity that has challenges such as latency and availability of communication between the layers [11].

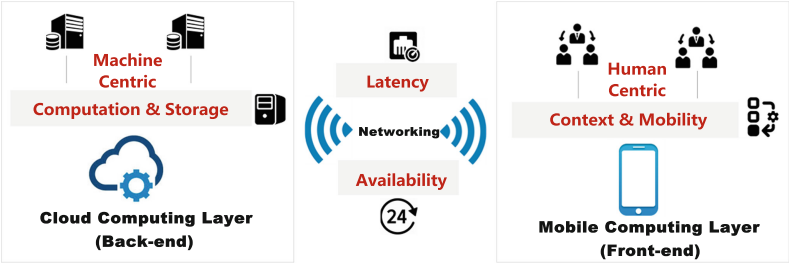

Fig. 1. A layered representation of the proposed framework.

Assumptions and Contributions: Our solution is based on assumptions of high network availability to maintain an effective coordination between the first responder teams. Moreover, a secure public or private cloud server and resource efficient mobile devices are central to the framework. We highlight the primary contributions as:

- *Unification of Mobile and Cloud Computing* technologies to enable first responder teams for emergency management in smart city context. The proposed solution aims at timely application and acquisition of the contextual information to facilitate collaborative activities of the first responders in emergency management.
- *Smart City Infrastructure* is specifically focused based on provisioning of emergency services. In contrast to [8, 9], the proposed solution utilizes mobility but also combines the cloud computing that facilitates a cost-effective implementation of ICT infrastructure for emergency management in smart city context.

The rest of the paper is organized as follows. Related research is presented in Sect. 2. Framework architecture and its implementation plan are presented in Sect. 3. Conclusions and dimensions of future research are discussed in Sect. 4.

2 Related Research

In this section, first we present some of the relevant research on event management in smart city systems (Sect. 2.1) that follows a discussion of the platform for first responder teams (Sect. 2.2). Highlighting the most relevant research justifies our proposed contribution and helps us to define the scope of our presented framework.

2.1 Event Management in Smart City Systems

Event management such as disaster recovery, traffic planning and emergency handling are becoming commonplace in smart city systems. Specifically, in [7] the authors proposed a critical infrastructure response framework for Smart cities. This research highlights the needs to gather real-time information from different urban services (e.g.; firefighting, surveillance and monitoring) within the city environment to make right decisions in critical situations. The proposed framework aims to provide a response approach to first responders based on the flows of information in smart cities and support efficient and timely responses in critical scenarios. The role of cloud computing is vital in managing smart city infrastructure. In [4], the proposed emergency event management system controls the coordination between emergency management and local first responder teams by collecting data and handling critical events easily in smart cites.

Considering the smart emergency management, the studies [8, 9] proposed emergency management platforms. These platforms aim to provide a support while making decision in critical situations for public protection via the use of wireless sensor networks and social media. In smart emergency context, considering the research state-of-the-art, we propose a novel approach by unifying mobile and cloud computing. The benefit of our proposed approach is to empower the first responder teams with mobile and context-aware infrastructure that lacks in the existing research.

2.2 Platform for First Responder Teams

To support platforms for the first responder teams, some of the recent research have focused on the simulation and experimental training of the first responder teams. Specifically, the research in [5] provides a simulated environment (as virtual reality) to simulate a medical emergency case where a critical thinking is needed for the right response by the team. Similarly, the authors in [6] conducted an experiment to allow first responders including police officers to securely access the information in a mobility-driven environment. It is vital to mention about the studies [7, 8] that exploit mobile and service oriented computing respectively to empower first responder teams to be aware of critical emergency scenarios and coordinate effectively as a team.

Our proposed solution advances the research state-of-the-art by unifying mobile and cloud computing technologies for smart emergency management. In our solution, mobile cloud computing is exploited as state-of-the-art mobile computing technology. Our proposal compensates for resource poverty of a mobile device by offloading computation and memory intensive tasks to back-end cloud servers – maintain system's efficiency for first responder teams.

3 Architecture and Implementation of the Framework

First, we present the architectural overview (in Sect. 3.1) and then discuss the proposed implementation of the framework (in Sect. 3.2).

3.1 Layered Architectural View for the Proposed Framework

A. Front-End – Context-Aware Mobile Computing Layer

As the bottom layer of the solution that supports the operations of the on-field activities by the first responder teams as in Fig. 2. The layers support the interaction and orchestration of the mobile devices (coordinator to peer setup) to communicate and share the context specific information in a given emergency management scenario. This layer acts as a context sensitive user interface that allows the human driven first responder teams to capture, process and share the information from the emergency scene. From a technical point of view, this layer consists of a number of software services that exploits a mobile device to enable the interaction of the emergency management workers in the first responder teams.

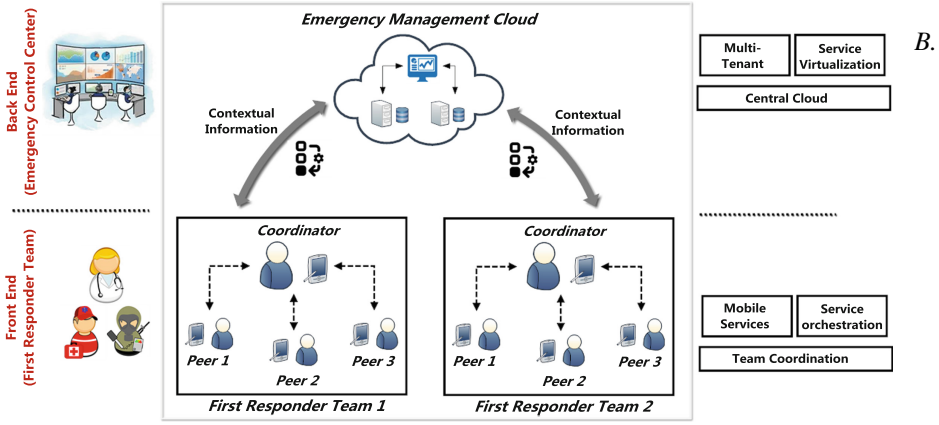

Fig. 2. Layered architecture view for the proposed framework.

Back-End – Computation-Specific Cloud Computing Layer

It is the top layer of the solution that primarily supports the storage and computation specific operations of the first responder teams to support the on-field emergency management activities as in Fig. 2. The technical combination, i.e.; mobile and cloud computing layers can facilitate the computation and data intensive operations away from (resource-efficient) mobile systems to (resource-sufficient) cloud servers [1, 2]. We aim to exploit the elasticity and resource provisioning of cloud computing to offer computational, resource and energy efficiency of context-aware and portable (mobile)

systems for emergency operations. Software services at this layer ensures multi-tenant and virtualized resources for collaborative, on-field activities of the first responders.

3.2 Proposed Implementation for the Framework

The architecture of the framework as illustrated in Fig. 2 represents a blueprint for the system to be implemented by relying on reuse of architectural knowledge [10]. We are in process to develop the framework as a prototype for validations and proof of concept. We highlight the tools/technologies to implement the framework as in Fig. 3.

A. Implementing Mobile Computing Layer

It primarily depends on the *Ionic framework* to gather the context information in the emergency scenario. Moreover, the *JavaScript* based user interfacing allows the emergency teams to work with customized and intuitive interface(s) for collection of the contextual information as in Fig. 3. The front-end mobile layer aims to notify the first responder team when certain incident happens and provide a platform for coordination and task management.

B. Implementing Cloud Computing Layer

This layer is responsible to receive and provide data to the on-field mobile devices. The data exchange is enable with the *REST API* to transfer states of a device as software services. Cloud layer has two primary functions that include (i) data processing managed by the *Amazon EC2*, and (ii) data storage using *MongoDB* as in Fig. 3. The front-end service calls the backend services with amazon cloud processing and storage for data retrieval and storage.

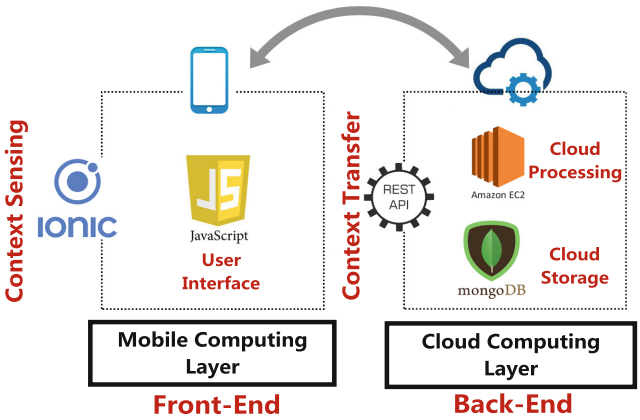

Fig. 3. Overview of tools and technologies for framework implementation

4 Conclusions and Dimensions of Future Research

We have proposed a framework that unifies the mobile and cloud computing technologies to deliver a solution that empowers the first responder teams to coordinate and operate in an emergency situation. The solution aims to incorporate mobility, context-awareness and computational efficiency to enable data and knowledge driven smart emergency management for smart city based systems.

As part of the future research, we are in process to develop the framework's prototype as the proof of concept that can be evaluated and deployed to support smart systems, i.e., smart cities in general and smart emergency management in particular. Furthermore, in future we aim to rely on the ISO/IEC-9126-1 qualitative and multi-level validation of the framework to assess its usefulness/applicability in real context.

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