

Guest Editors' Introduction: Cloud-Based Smart Evacuation Systems for Emergency Management

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Smart evacuation systems must extract meaningful information from multiple sources in real time, while avoiding unnecessary data transmission or storage. Cloud computing is a natural fit for deploying such systems; however, we still need transformational techniques for managing the resulting big data.



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elcome to this special issue of *IEEE Cloud Computing*. We've compiled a number of excellent technical contributions that significantly advance the state of the art in smart evacuation systems for emergency management applications. The contributions range across such topics as integrating cloud resources with mobile-device-hosted applications, deploying evacuation systems across multiple cloud datacenters, and processing real-time big datastreams from wireless sensors on cloud resources.

Natural and man-made emergencies, such as tsunamis, earthquakes, floods, and epidemics, pose a significant threat to human societies. Well-coordinated emergency management activities that involve guiding citizens out of danger areas, placing medical teams at the most appropriate locations, and planning evacuation routes in real time, before and after a disaster, play a significant role in protecting critical infrastructures and minimizing casualties. Managing evacuation activities, which includes coordinating rescue teams, depends on the availability of historical data as well as on the effective real-time integration and utilization of data streaming from multiple sources including on-site sensors, social media feeds, and messaging on mobile devices. For example, during the 2010 flooding in Queensland, Australia, Queensland police analyzed messages posted on social media by people in affected regions to understand the situation on the ground and appropriately coordinate search and rescue operations.¹ The Queensland police also used social media as a clearing house for disaster-related information about aid, rescue centers, and other resources available to those affected.

However, the growing ubiquity of onsite sensors, social media, and mobile devices means there are more sources of outbound traffic, which ultimately results in the creation of a tsunami of data, beginning shortly after the onset of the emergency event. This data tsunami phenomenon presents a new grand challenge in computing, which is also referred to as the *big data problem*. During the 2010 Haiti earthquake,² text messaging via mobile phones and Twitter made headlines as being crucial for disaster response, but only some 100,000 messages were ac-

tually processed by government agencies due to the lack of an automated and scalable data processing infrastructure. Design and development of evacuation systems for emergency management requires a complete information and communication technology (ICT) paradigm shift such that systems aren't overwhelmed by incoming data volume, data rate, data sources, data types, and query types.

To process data as it arrives, smart evacuation systems need novel data processing techniques (and their implementation in evacuation systems) that can efficiently exploit cloud computing resources.³⁻⁵ These techniques must be capable of extracting meaningful information from multiple sources (social media and sensors) in real time, while avoiding unnecessary data transmission or storage. Efforts need to focus on developing cloud-based techniques to improve the performance of big data processing frameworks while balancing computational complexity and quality of service. Cloud computing resources are a natural fit for deploying evacuation systems for processing large volume and high-speed data at the scale required for producing real-time responses.^{6,7} However, to support truly smart evacuation systems, we must innovate and implement transformational techniques for orchestrating^{8,9} big data processing frameworks—such as Apache Hadoop (<http://hadoop.apache.org>), Apache Storm (<http://storm.apache.org>), and MongoDB (www.mongodb.org)—as well as the cloud computing resources used in these systems and applications.

The Articles

Emergency management systems must deal with dynamic processing of data to develop real-time situational awareness information for both the response teams and the affected people in the emergency zone. The data is streamed from various devices, including sensors and mobile devices. Because mobile devices have limited processing, storage, and battery resources, the sensed data from the scene of the emergency needs to be transmitted and processed quickly using the best available networks and clouds. To this end, the mobile cloud computing (MCC) paradigm will likely play a critical role in offloading computation and storage of sensor data to the best available cloud servers. However, applications running on mobile devices using clouds and

heterogeneous access networks such as Wi-Fi and 3G are prone to unpredictable cloud workloads, network congestion, and handoffs. To solve this critical problem, Karan Mitra, Saguna, and Christer Åhlund, in their article, “A Mobile Cloud Computing System for Emergency Management,” develop and validate a system for mobility management in MCC called M²C² that supports mechanisms for multihoming (connecting to several networks simultaneously), cloud and network probing, and cloud and network selection. The authors validate M²C² using prototype implementation and show that the proposed system supports mobility efficiently using MCC.

To improve the accessibility of mobile devices hosting evacuation services and applications, the article, “A Cloud-Enabled Building and Fire Emergency Evacuation Application,” by Hector Moner Poy and Brian Duffy, presents the design and development of the rescue worker interface (RWI), a cloud-based service to assist fire wardens in the event of a building fire emergency to perform evacuation tasks in a timely, efficient, reliable, and collaborative manner. Fire wardens equipped with handheld devices can monitor and control building systems in real time via the cloud. Mainly, they can view building evacuation status, fire evolution, building occupancy, and the location of other fire wardens. These capabilities give them greater control and situational awareness to face the emergency and manage the building egress with reduced risks.

To seamlessly scale evacuation applications across multiple cloud datacenters, Mianxiong Dong, He Li, Kaoru Ota, Laurence T. Yang, and Haojin Zhu, in their article, “Multicloud-Based Evacuation Services for Emergency Management,” propose the multicloud-based evacuation services (MCES) for emergency management system. The MCES system can deploy evacuation services across multiple cloud providers. Multicloud deployment improves the fault tolerance of the hosted applications. The system features an optimal controller algorithm implementation that computes the optimal number of virtual machine instances to be deployed across multiple datacenters while meeting performance and budget constraints. They adopt a three-layer cloud instance management architecture for supporting rapid capacity scaling. Through multiple simulations, they demonstrate that the MCES system significantly outperforms single cloud solutions under various emergency settings.

For enabling fast collection and processing of data from wireless sensors on cloud datacenters, Meikang Qiu, Zhong Ming, Jihe Wang, Laurence Yang, and Yang Xiang describe the smart cloud evacuation system (SCES) in their article, “Enabling

Cloud Computing in Emergency Management Systems.” SCES uses the powerful computing and storage capability of datacenters to process the massive volume of data collected by the wireless intelligent sensor network deployed in civil environment. The system also benefits from smartphone and social network platforms to set up the spatial and population models, which enables faster evacuation and better resource allocation.

In a postdisaster scenario, the communication framework is significantly affected due to generation and transmission of voluminous data at a high velocity. To process such data, Subhadeep Sarkar, Subarna Chatterjee, and Sudip Misra present an approach that includes opportunistic communication and efficient big data management policies in their article, “Evacuation and Emergency Management Using a Federated Cloud.” They focus on the collaboration of multiple private and/or public diverse clouds to perform damage assessment, and the determination of the spatial distribution of live victims and their physical and mental status. Based on the analytics, the system achieves real-time decision making in the rescue operation. ●●

We hope you will find the articles in this special issue to be informative and useful.

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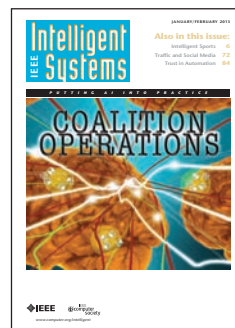
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