Chapter 2
Emergency Response and Post-Disaster Recovery Using Smartphone-Based Applications

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ABSTRACT

The number of natural disasters, such as tsunamis, earthquakes, flooding, cyclone, and bushfires, is rapidly increasing globally, and they are claiming thousands of lives while destroying numerous properties. One of the major concerns of these natural disasters is the destruction of communication links, such as powerline and Internet connections, which make it difficult to enable communication among the affected people and the rescue teams. However, the evolution of smart devices equipped with multiple short-range communication technologies, such as Bluetooth and Wi-Fi provides an opportunity to form an ad-hoc network with co-located smart mobile device users and communicate their positions and other relevant information to the rescue workers. This chapter provides a detailed description of recent advancement in this area and highlights important aspects that are needed to be considered for practical implementation.

INTRODUCTION

The number of natural disasters, such as Tsunami, earthquake, flooding, bushfire, etc. and the destruction of lives and properties is increasing globally. The international disaster database suggests that in 2018, 315 natural disasters occurred across the world that resulted in 11,804 deaths while affecting a total of 68 million people and causing economic damage of US$131.7 billion (Natural disaster 2018, 2019). During the recent bushfire incident in Australia (2019-20), around 17 million hectares have burned, which is more than the size of South Korea and 33 people lost their lives including nine firefighters (Richards, Brew, & Smith, 2020). Approximately, 3000 homes have also been destroyed (Richards, Brew, & Smith, 2020). During a natural disaster, people often get trapped into damaged properties and need to be rescued within the first 72 hours, which is known as the golden relief time (Mezghani, Kortoc, Mitton, &

DOI: 10.4018/978-1-7998-6705-0.ch002

Francesco, 2019). However, the destruction of electric lines and cellular networks during such natural disasters make it difficult to establish communication with the affected people, locate their positions, and rescue them (Lu, Cao, & La Porta, 2017; Mezghani, Kortoc, Mitton, & Francesco, 2019; Sciullo, Trotta, & Di Felice, 2020). The rescue workers need to know the exact position of the affected people, their current conditions, and the severity of the damage before making a well-informed rescue decision and conducting a rescue operation. On the other hand, emergency information diffusion is also important in these scenarios to inform the affected people about the upcoming warnings or provide them with rescue instructions. The destruction of powerline hampers the traditional medium of communication, such as TV and radios. The destruction of cellular towers can also impact the availability of the cellular network, which ultimately makes it difficult to broadcast information through mobile messaging or phone calls. The availability also suffers due to high demand during a disaster. In these scenarios, making contact between rescue workers and the survivors become challenging and crucial.

The advent of smart mobile devices equipped with short-range communication technologies, such as Wi-Fi and Bluetooth, has opened new possibilities to address the above-mentioned issues. Smart mobile devices, such as smartphones, tablets, and PDAs have become extremely popular among users worldwide. The number of smartphone users around the world is currently 3.5 billion, which is approximately 45% of the world's population and it is expected that by 2021, the number of smartphone users will reach 3.8 billion (O'Dea, 2020). A similar trend is also observed for other smart mobile device usages. The short-range communication capability of these devices allows them to form a peer-to-peer type ad-hoc network among co-located devices to exchange messages, images, videos, and/or location information. The maximum distance for this type of communication between two devices can be 10m ~200m based on the underlying technology. In this case, Bluetooth offers a shorter range and consumes less energy while Wi-Fi does the opposite. However, it is possible to extend this range using multi-hop communication. Figure 1 shows the use of multi-hop communication in forming an ad-hoc network to share messages or contents including pictures, videos, or texts. In this case, the application installed in a source node (i.e., smart device user) is trying to send a message (can contain text, videos, or images) to a receiver node. Although an end-to-end communication path is shown in the figure for ease of presentation, such a persistent communication path is usually not available in an ad-hoc network due to node movement and intermitted connectivity. Therefore, the actual message delivery happens through multiple message-forwarding events that may occur at different timesteps rather than instantly. In such a network, a few devices play the role of a forwarder node who keeps carrying the message until they reach the destination or another suitable forwarder. This kind of message forwarding technique is called store-carry-and-forward message forwarding. Further details about this are discussed later in the routing module section. This type of communication is also referred to as opportunistic communication, and the path used for this communication is termed as an opportunistic communication path as demonstrated in Figure 1.

Multi-hop communication technique presented above can be employed in an emergency post-disaster response scenario to establish bi-directional communication among the affected people and the rescue workers. Such bi-directional communication will enable rescue workers to obtain necessary information from the survivors and spreading warnings, relief, and rescue information. In this case, a smartphone-based emergency application can use the short-range communication capability of smart mobile devices to form the network and exchange messages. The use of such a smartphone-based application will be highly beneficial in a disaster scenario as the infrastructure-based communication is reliant on the availability of cellular networks and its availability may be compromised due to the disaster. Researchers