Siren: Context-Aware Computing for Firefighting

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Abstract. Based on an extensive field study of current firefighting practices, we have developed a system called Siren to support tacit communication between firefighters with multiple levels of redundancy in both communication and user alerts. Siren provides a foundation for gathering, integrating, and distributing contextual data, such as location and temperature. It also simplifies the development of firefighting applications using a peer-to-peer network of embedded devices through a uniform programming interface based on the information space abstraction. As a proof of concept, we have developed a prototype context-aware messaging application in the firefighting domain. We have evaluated this application with firefighters and they have found it to be useful for improving many aspects of their current work practices.

1 Introduction

Each year, fires kill about 4,000 civilians and 100 firefighters in the United States alone [1]. Firefighting is a dangerous profession that calls for quick decisions in high-stress environments, constant reassessment of dynamic situations, and close coordination within teams. Furthermore, the smoke, heat, and noise in a structure fire mask the environment and force firefighters to operate with an incomplete picture of the situation. One firefighter we interviewed summarized it best: “Firefighting is making a lot of decisions on little information.”

Improvements in information gathering, processing and integration can help firefighters work more effectively to prevent injury and loss of life, as well as minimize
property damage. The pervasive computing community itself can also benefit from research in this area. The nature of emergency response is fundamentally different from office environments, in terms of physical risk, psychological state, and operating conditions. This poses unique challenges for designers and researchers investigating context awareness, new interaction techniques, and information visualization, to name a few. If we can make an impact in this highly stressful domain, where the systems we offer are secondary to the primary task, we might also be able to apply these results in less extreme environments for a wider audience, such as computing while driving.

From an extensive four-month field study of current firefighting practices [23], we found that firefighters often need to exchange information about their situation and their surrounding environment in a spontaneous and opportunistic manner. This type of interaction needs to be spontaneous because the time when information exchange will occur depends on the dynamically changing situation and often has to be done without direct human initiation. It also needs to be opportunistic because the constant movement of firefighters in a complex urban structure makes it difficult to maintain an always-on communication channel among them. Such interaction is especially useful when firefighters need to be alerted about imminent dangers.

The problem is that spontaneous and opportunistic interactions among firefighters are not well-served by current systems. Today, most firefighters rely on two communication channels on the scene of a fire. The first is a broadcast channel for voice communication. The second is a data broadcast channel for status updates between an incident commander—the person in overall charge of an emergency—and dispatchers at a centralized emergency response center. Both channels use the 800MHz to 900MHz radio band. Often, only the voice channel or data channel can be used at a given time. Moreover, both channels are broadcast driven and manually operated to support explicit communication rather than the tacit communication needs between firefighters.

Advances in pervasive computing technologies are providing us with an opportunity to let firefighters “see through the eyes of fellow firefighters” and provide a greater understanding of the overall situation. Small, cheap, wirelessly networked sensors (such as smart dust [2]) can be deployed on firefighters and in buildings, capturing contextual information—such as temperature, sound, movement, toxicity, and a person’s location—at a level never seen before. The wealth of sensor data about firefighters and the environment can be exchanged between firefighters to help improve safety and effectiveness.

Towards this end, we have developed Siren, a peer-to-peer context-aware computing architecture that gathers, integrates, and distributes context data on fire scenes. To make tacit communication between firefighters more robust in the face of an inherently unreliable transport, Siren offers multiple levels of redundancy in communication and feedback. Siren also simplifies development of emergency response applications by providing a uniform programming interface based on the information space abstraction [3]. Using Siren, we have developed a prototype context-aware messaging application and conducted an informal evaluation of this application with