Evaluation of a Mobile Emergency Management System – A Simulation Approach

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ABSTRACT

Large public events such as sporting events, concerts, fairs and street festivals are quite common in metropolitan areas. Because of the high frequency of such events and the increasing number of involved parties, those being responsible for the organization and execution have to cope with increasing complexity and shortening time frames for planning and preperation. Because of the high concentration of passengers, unplanned incidents that occur during these public events can have devastating effects and can lead to crises and disasters. Emergency management systems that utilize mobile communication infrastructures can provide prompt information delivery to save human lives. In this paper we propose a system design for mobile emergency management and outline our approach of evaluating this system design using multi-agent based simulation. To make our simulation of passenger movements as realistic as possible we gathered empirical data for a large event as well as for normal rush hour traffic.

Keywords

Public events, Agent-based simulation, Mobile Services, Emergency Management.

INTRODUCTION

Large public events such as sporting events, concerts, fairs and street festivals are quite common in metropolitan areas. During these events, the mass of visitors alone can put quite a strain on the public transport system. Because of the high frequency of such events and the increasing number of involved parties, those being responsible for the organization and execution have to cope with increasing complexity and shortening time frames for planning and preparation. This can lead to several transport and security challenges. Problems often arise due to insufficient communication between different stakeholders, a missing information supply for passengers and attendees, inadequate training of personnel, scarce funds of the involved entities, inconsistent data management and missing abilities to detect incidents that could potentially lead to crises and disasters (Roßnagel et al. 2008). Because of the high concentration of passengers, unplanned incidents that occur during these public events can have devastating effects and may lead to crises and disasters. Furthermore, large events are an attractive target for terrorists, because of the magnitude of potential victims. To mitigate disaster effects, it is essential to undertake steps to increase the level of disaster preparedness, including infrastructure investments for warning systems and training activities (Johnston et al. 2007).

Emergency management systems (EMS) provide the capability to address this dilemma and to enable disaster forces to manage disasters, including detection and analysis of incidents. Persons in charge should be supported to prepare evacuations, control and support disaster forces and to locate victims (Carver and Turoff 2007). Since mobile communication infrastructures offer standardized wireless communication services in almost all countries (GSMworld 2008) and allow a fast diffusion of information, they provide a promising technological basis for saving human lives in emergencies. If a disaster event occurs, they can for example allow emergency managers to distribute warnings to the effected areas by cell broadcast to ensure warnings of potential victims in time (Fritsch and Scherner 2005). In the German research project VeRSiert, which is supported by the BMBF (German Federal Ministry of Education and Research) within the program "Research for Civil Security", such an infrastructure has been proposed for coordinating major events in Cologne (Roßnagel et al. 2008). In this paper we will present our approach to evaluate the proposed system design. The overall goal of VeRSiert is to improve the security of passengers and the intra-organizational communication and cooperation of the responsible institutions during large public events..

This paper is structured as follows. We first present requirements for emergency management systems from the literature and our system design that addresses these requirements. Then we outline our approach to evaluate this system. We then give an outlook on the next steps of our research, before we conclude our findings.

A MOBILE EMERGENCY MANGEMENT SYSTEM

Requirements

(Scherner et al. 2009) derived the following high-level requirements from the literature that need to be addressed by an emergency management system. They comprise (1) system effectiveness (Johnston et al. 2007), (2) reliability (Zeckhauser 1996), (3) cost efficiency (Zeckhauser 1996), (4) smooth service integration (Ritchie 2004), (5) multilateral user interaction (Turoff et al. 2004a), (6) availability (Faulkner 2001) and (7) security (Valtonen et al. 2004). They also argued that one of the most crucial requirements for preparedness is that ordinary people are used to the system in order to react on warning signals without any delay (Gruntfest and Huber 1989). Meeting this requirement is extremely difficult if the system design is solely used for warnings. The success of emergency management systems clearly depends on well-trained users being familiar with the service functionalities provided (Turoff et al. 2004b). For an infrequently used emergency management system, limited practical experience of users can be expected (Manoj and Hubenko Baker 2007). Technically, many services used for emergency management systems do not differ from services used in day by day use cases. For example the upload of a picture could be used to inform emergency managers but also for online community services. The challenge is that both functionalities have to be integrated in a design, which allows both perspectives and supports the user to become familiar with the functionalities itself (Scherner et al. 2009).

Proposed System Design

(Roßnagel et al. 2008) proposed a system design that addresses the requirements above and allows for an integration of emergency and value adding services into a centralized platform. Figure 1 illustrates how the different parties interact within the system design and which services are provided by and to whom.

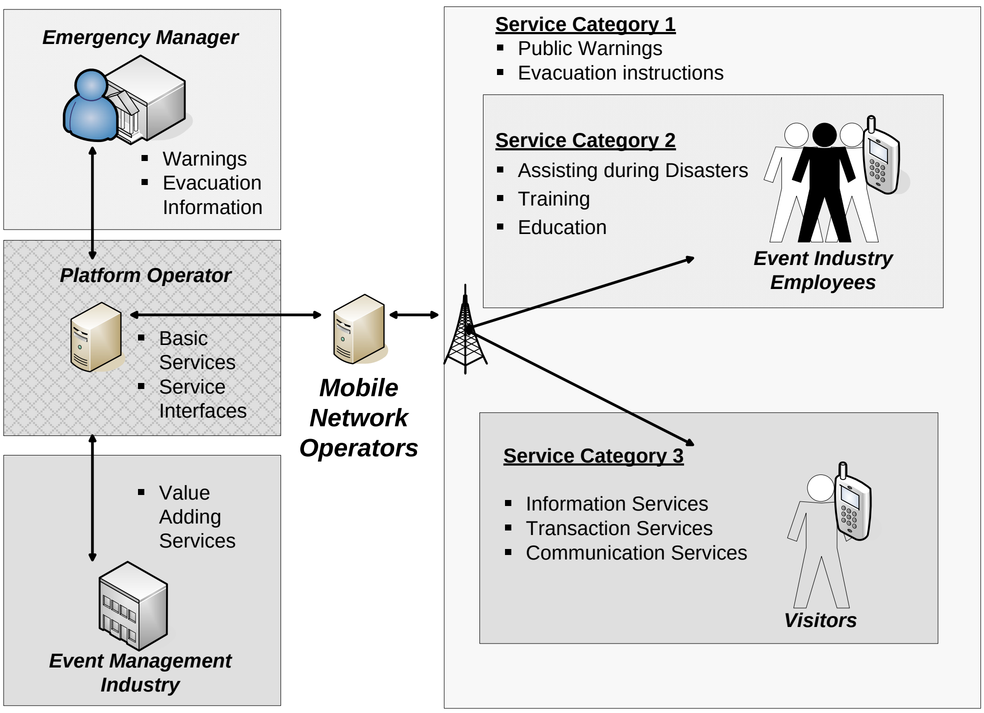

Figure 1: Proposed System Design

The central component in this design is the service platform, which is maintained by the platform operator. The platform communicates with mobile network operators and provides basic services for service providers from the event management industry and the emergency manager via standardized service interfaces. The basic services include localization of mobile subscribers, message delivery via SMS and CBS, multilateral data transfer, access to information databases, support for mobile communities and billing services for mobile payment and mobile ticketing.

The platform operator can be a public or private entity. Its main task is to operate the information system infrastructure and to provide basic services via service interfaces to the involved parties. The emergency manager provides all emergency management related services to the public and ensures efficient notifications, which is henceforth classified as service category 1. Furthermore, this role makes services available to the event management sector and its employees (service category 2) in order to help them to prepare for emergencies and to offer guidance in emergency situations. For the implementation of these emergency services, the emergency manager utilizes the basic services provided by the service platform. The event management industry offers commercial services to visitors (service category 3). These services are built upon the basic services provided by the service platform, which allows a rapid development of services due to the already existing building blocks. The service aggregation on behalf of the event management industry is done by the platform operator who takes on the role as information intermediary (Bhargava and Choudhary 2004).

Offering commercial services via the same infrastructure is one of the major challenges. The contribution of this approach is therefore that a) people get involved in mobile services as they are offered by mobile emergency services and b) commercial players have a vital interest in keeping the used infrastructure up-to-date. Thereby the emergency management system can meet the requirements effectiveness, reliability and cost efficiency by using the same infrastructure for several different use cases. It is not a stand-alone system, which has to be maintained separately and necessary adaptations to changing requirements are becoming more likely. The system now serves a regular secondary use. Furthermore, the stakeholders get used to the system in day-by-day use cases and gain experiences how to react to different messages.

EVALUATION BY USING SIMULATION OF PASSENGER MOVEMENTS

Simulation of Passenger Movements

In order to evaluate the effectiveness of our proposed system design, we will use a multi-agent based simulation of passenger movements similar to (Pan et al. 2007). Using this approach, each passenger is represented by an independent software agent. Each agent has a plan which comprises of a series of actions the agent performs or service the agent is using. Services can be any stationary point, where an agent can stop to interact with it. Examples are ticketing machines, train schedules, shops, restaurants, check rooms for baggage, escalators and elevators. Agents can also carry certain items like luggage or cell phones. In our simulation each agent is trying to fulfill his plan. If obstacles or other agents are in the way of reaching the next step of the plan the agent will walk around these obstacles. Agents are also capable of revising the plan in the case of an event occurs, for example a warning message on their cell phone.

We use the CAST software (Airport Research Center 2009) for simulating airport terminals. It offers a three-dimensional environment and realistic passenger flow behavior. We adapted this software to the public transportation domain, by creating our simulation room, which is a realistic model of the central train station of Cologne and is based on real geometric data and true to scale. In addition, we defined new services that exist in this train station such as ticketing machines. Figure 2 shows two screenshots of our simulation.

To quantify the effectiveness of the mobile emergency management system we will identify key performance indicators (KPI) and their scenario-specific values. KPIs are measurable results that can be obtained during a simulation run in a predefined scenario, such as the time that was used for evacuating the train station after a bomb alert. To prove the reproducibility and to ensure reliable results of a chosen environmental situation, multiple simulation runs of the same scenario will be performed. This simulation approach allows us to test different scenarios as well as different measures to mitigate the effects of emergency incidents in a fast and cost effective way. In addition, the measurement of KPI allows us to compare and evaluate the effectiveness of different emergency management efforts and technologies. It also enables planners of events to identify bottlenecks and to develop solutions to complex operational problems. It is expected that verified simulation modules performing passenger movements and additional agent behavior can be used to quantify the performance and effectiveness of dedicated communication scenarios effectively and precisely.

Figure 2: Two screenshots of the simulation of the Cologne central station

Gathering of Empirical Data

Obviously the quality of the simulation results is dependent on the level of detail of the simulation model reflecting the reality. For instance information about the geometric data of the simulation, the location and the quantity of passengers, the individual agent behavior and the location, capacity and range of mobile communication cells have to be acquired in order to get realistic results. Furthermore statistic information about the distribution of passenger properties such as gender, cell phone usage (yes/no/which provider) and mental state (drunk, aggressive, fearful, uncomfortable) can be important parameters. Once that data has been collected, a simple parameter variation inside the model followed by additional simulation runs will help to understand the dependencies between agent properties, their behavior and applied strategies. To achieve a high quality of our simulation runs we started to gather the necessary data. We based our simulation model on real geometric data and ensured that it is true to scale. We also identified and photographed all service points and build their representation in our simulation room. We also counted the number of passengers entering and leaving the station at all exits during a defined time frame of two hours using 10 minute intervals of measurement. We performed this passenger count for a particular large event (”Kölner Lichter 2009”) as well as for normal rush hour traffic. In order to acquire information about the particular plans of passengers, we used the method of single person pursuit. The researchers picked random passengers to follow and to record their activities during their stay in the central train station. We are also trying to obtain the information about location, capacity and range of the mobile communication cells in the central station from the network providers.

NEXT STEPS

In order to bridge the gap between reality and the simulation model iteratively, a demonstrator that shows how the reality can be reflected by using a multi-agent simulation model will be developed. By continuous refinement of the existing object models and the adjustment of the simulation components against the real behavior of the agents, the model shall finally reflect the mobile emergency management scenario appropriately and return the relevant KPIs to give estimation about the effectiveness of the applied strategy. The central step to this lies in the continuous effort to complete the necessary empirical data.

CONCLUSION

During large public events, the mass of visitors alone can put quite a strain on the public transport system. Unplanned incidents can have devastating effects and can lead to crises and disasters. Mobile EMSs could be used to mitigate the effects of such incidents. We proposed such a system design. In order to evaluate the effectiveness of it we will perform a multi agent based simulation.This approach promises to be quick, powerful, flexible and cost efficient. Also, it allows the creation of scenarios which can not be created in reality, because they could endanger passengers. To achieve a realistic representation of passenger movements we gathered a large amount of empirical data. However, we still have to perform additional measures before we can obtain realistic results.

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