

GUARDIAN – Emergency Response System with Incremental Information Delivery Model

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The main goal of this article is to show concepts of developing Emergency Response Systems (ERS), which withstands to the modern way of thinking about threat notification. It is also showed an idea of an *incremental information delivery model* – the new way of thinking about emergency actions management. The last issue considered are guidelines to develop Emergency Response Systems.

Keywords: emergency response system, Safety-Oriented Society, incremental information delivery model.

1. Introduction

In the modern world, people have to face many dangerous situations: from robberies, rapes and fires to car accidents or murders. Most of the crimes included in the police statistics could be detected on the spot, if the emergency services could react early enough. The response time is one of the main factors in any rescue operation in order to maximize the chance of saving a human's life.

There exist a number of solutions to presented issue ([3], [11], [12], [15]). The most promising are IT Emergency Response Systems (ERS) and IT Rapid Emergency Response Systems (RERS), which seem to have the shortest response time. The domain of ERS systems is still dynamically developed and many new solutions appear ([23], [24]). However, they are still imperfect, mainly because of their approach to reporting threats and delivering information about accident during rescue procedures [7].

The goal of this paper is the presentation of GUARDIAN – Emergency Response System developed at the Warsaw Military University of Technology. The article also describes an *incremental information delivery model* and the idea of *Safety-Oriented Society*. The last section presents guidelines which technologies are the best to implement the new model of information delivering and its utilization during rescue procedures.

The article does not describe in detail the organization of rescue action management.

More information about this problem can be obtained in [14] and [16].

The remainder of this paper is organized as follows. Section 2 introduces the GUARDIAN project and shortly describes its essential features. In Section 3, the GUARDIAN's architecture is discussed. Section 4 shows the basic execution path of considered Emergency Response System. In Section 5, the Incremental information delivery model is showed, which is used in GUARDIAN project. Section 6 compares GUARDIAN with the other IT ERS solutions. Section 7 describes realization capabilities of IT Emergency Response Systems. In Section 8, we discuss problems and development opportunities of GUARDIAN. Section 9 shows short summary of our conclusions resulting from work on GUARDIAN system.

2. The GUARDIAN project

GUARDIAN is a new type of Emergency Response System, which is it considered as a RERS system [25]. It has been developed for rapid response to the occurrence of any kinds of threats. Using a mobile technology, including GPS and smartphones, GUARDIAN allows to instantly call for help in just a few seconds. With use of GUARDIAN installed on the phone it is possible to quickly notify the nearby emergency services with just one click about the danger. Therefore, it provides an effective solution, where protecting the health and life of a human is important.

Research shows that the currently used information systems developed to report threats are highly ineffective [6]. For example, calling the emergency number in Poland, it is necessary to spend up to six minutes to report a threat to the operator. This is undoubtedly too long taking into account that, for example, human brain can withstand without oxygen for approximately four minutes. Described problem is mainly caused by complexity of reporting threats procedure. Despite the fact, that mentioned process is constantly improving, it still needs too much of human interaction. This leads to the conclusion that the bottleneck of rescue procedures is the human reaction both on one and the other side of the communication channel. With that in mind, our team implemented GUARDIAN – a system that provides three essential features in managing rescue procedures:

- the automation of the process of notifying about the threat – only one click is needed to start a rescue action
- the support of the communication between the emergency services and the headquarters
- the provision of up to date information about the rescue action status.

3. GUARDIAN's architecture

GUARDIAN's architecture is shown on Figure 1. The system has a three main parts: the Reporter Client, the Emergency Client and the Central Server.

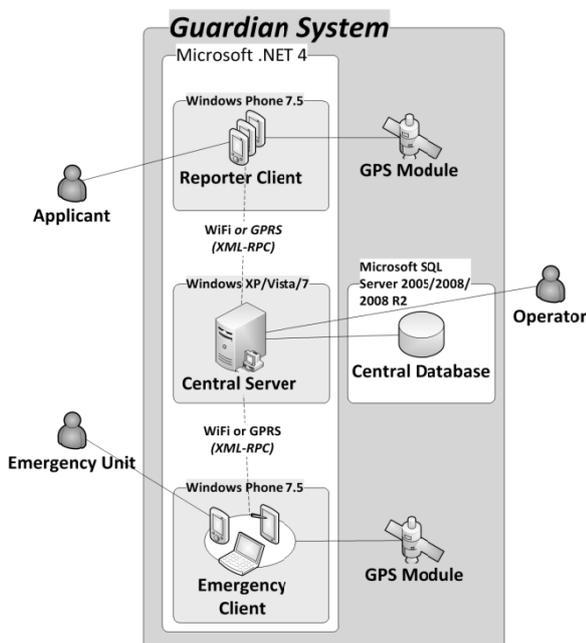


Fig. 1. The architecture of the GUARDIAN system

The Reporter Client is a part of the system deployed on a Smartphone, which means that it is a mobile application. Using a GPS Module and a specially designed widget, it allows the user to send a notification with basic information such as the position, basic personal information (entered during the installation of the GUARDIAN mobile application on the phone) and essential information about the incident e.g. its type. The application provides a set of additional forms which can be filled in after the primary notification about the threat. This approach enables emergency services to start the rescue action with a minimum of information which is necessary to launch it. All additional information can be delivered during the rescue action avoiding the situation, in which waiting for a whole information about accident will delay the rescue operation.

Another component of the GUARDIAN system is the Central Server. Its main task is receiving notifications and assigning the closest emergency units to them. To achieve this the application on the Central Server uses the Google Maps API and a specialized graph and network algorithm to find the shortest or fastest path. The data about all the rescue actions that have taken place so far are stored in the Central Database. In this way the Central Database provides data for post-incident analysis (which is called AAR – *the After Action Review process* [22]) in order to develop better rescue procedures for any kind of future incidents and threats.

The third part of the system is an Emergency Client. Using a mobile application on the Smartphone, it allows emergency units to receive notifications about the accident that occurs near them and provide services to communicate with every unit that has been assigned to threat and the headquarters.

Each part of GUARDIAN can be wired through a Wi-Fi or GPRS connection using XML-RPC protocol [8], which allows to communicate with other parts of the system even if one of the communication channel is unavailable. It meets one of the most important requirements of the ERS system i.e. a several communication channels.

4. Basic execution path

To explain the way GUARDIAN operates during rescue procedures, an activity diagram on Figure 2 is presented.

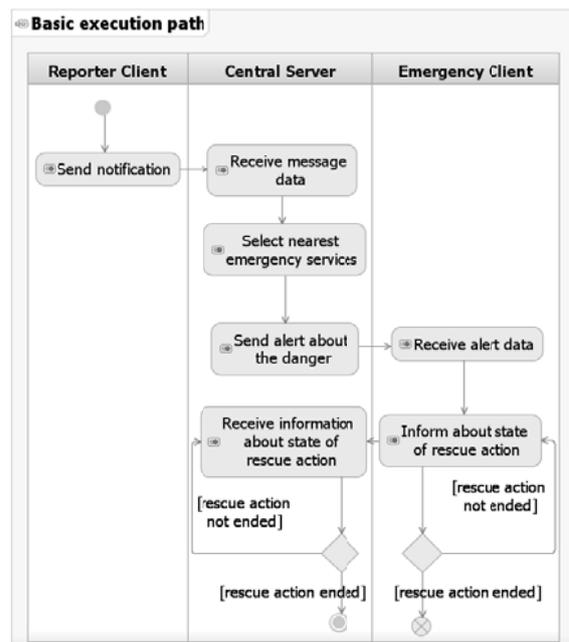


Fig. 2. Activity diagram for basic execution path of the GUARDIAN system

In the first step is sent an alarm by clicking on the widget installed on the Applicant smartphone. After that, the engagement of the person calling for help is finished, which is consistent with the idea that human activity should be minimized.

Next, the Central Server receives a notification about the danger and reads data from it. The basic message contains information about the applicant's position, his/her personal information and the type of the threat. Based on this, GUARDIAN searches for the nearest emergency units and sends an alert to designated rescue services using XML-RPC protocol.

Meanwhile the applicant has an opportunity to send additional data about the incident, but it is completely optional. This kind of information delivery model will be described in detail in the next section.

During that time, the Emergency Client retrieves notification sent by the Central Server, which contains information needed to start a rescue action: the place of accident and the type of the threat. Moreover, emergency units are notified about changes in situation that take place during the rescue action in endangered area. This feature helps to respond to the dynamically changing situation during the rescue action. Additionally, the Emergency Client allows emergency services to inform the Central Server about the state of the rescue action. When a unit notifies about the end of the rescue operation, the whole procedure is terminated as

well as the basic execution path of the GUARDIAN system.

5. Incremental information delivery model

During analysis of the execution path of the GUARDIAN system we can see that after notifying the Central Server about the incident, the activity of the applicant can be finished. However, during a rescue action the applicant has an opportunity to send additional information about the incident. This model of information delivery, for the project GUARDIAN purposes, is called *incremental information delivery model*.

The idea of mentioned model, included in GUARDIAN system, is showed on Figure 3. The information about an incident is delivered incrementally. Firstly only basic data is sent and they include: personal information of applicant, his GPS coordinates, which allows to detect endangered place and type of emergency service to summon. Even though the information from the primary message is quite modest, it is good enough to start a rescue action. Using them, it is possible to send appropriate emergency unit with required equipment into right place. Then, if the situation gives an opportunity, an applicant can send additional data, which contains for instance a photo from the endangered place, filled special forms or deliver more information using an automatic telephone service.

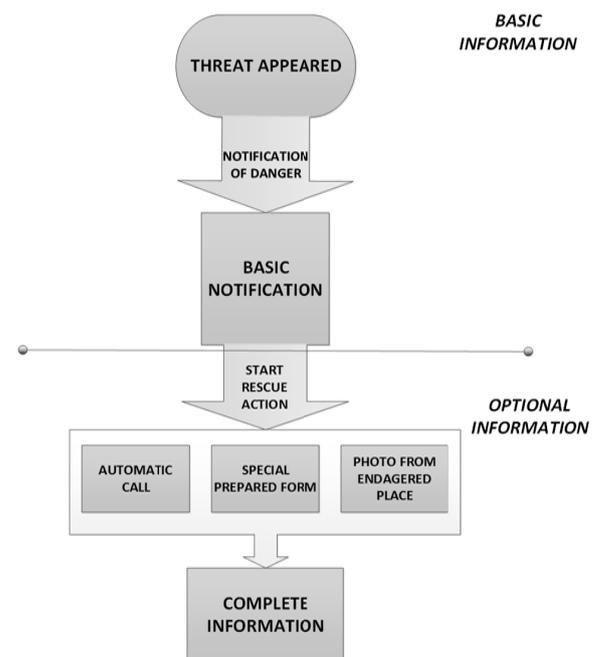


Fig. 3. Diagram of *incremental information delivery model* on the example of the GUARDIAN system

To sum up, the *incremental information delivery model* assumes that:

- 1) there is one type of notification, which is obligatory to start a rescue action;
- 2) other steps of information delivery are optional and they are used to extend the knowledge about the situation at the endangered place all the time during the rescue action.

The presented idea is an approach, which is adequate to the dynamics of situation at the endangered area. This leads to the conclusion, that the idea of the *incremental information delivery model* should be implemented in every ERS currently developed, which allows applications to improve the time of reaction to the reported threats.

6. Comparison with other systems

GUARDIAN with his incremental information delivery model is not the only way to respond to the dynamically nature of rescue actions. For example, some of modern rapid response ERS systems use other types of handling the dynamic nature of threats, which is reflected in computer simulation or predictive models.

One of the solutions from that domain is a framework, developed by J. Sanjay and Ch. McLean [4]. It allows modeling and simulation for emergency response, which is especially useful in rescue action process developing. Using provided models of reaction for appropriately threat, it gives us opportunity to predict human behavior during danger situation. However, it does not implement any mechanisms to inform about the threats, but only to analyze rescue action.

Another solution, which is connected with RERS systems is *FireFly* [2]. Using danger prediction model, including fire zone model [5], and evacuation path finder, it informs about the threat and simultaneously determines the best evacuation path. This approach fits well in complex buildings and areas seems to be a complete technology for saving human life. Unfortunately, for best work it requires a set of sensors situated in analyzed place, which is expensive and limits mobility of system.

Apart from those systems mentioned earlier, there are more other solutions. Some models used to monitoring threats like radiation or contamination are presented in ([13], [17]). Simulation models of diseases spreading can be found in ([19], [21]). Predictive models has been applied in another system developed at Military University of Technology named *CARE*

and *FireFly*, mentioned earlier. More information about this solution can be found in ([2], [18], [20]).

7. Realization capabilities

The idea of the *incremental information delivery model* and modern technology, like wireless connection and GPS, make possible to create very effective RERS systems. Based on the experience gained during the development of the *GUARDIAN* it can be said, that some of the technologies are the best matches to develop effective emergency response systems. These technologies include dedicated electronic devices, Web Services and mobile platforms.

One of the solutions, which should be considered, is implementing Emergency Response System using dedicated electronic devices. The architecture of this approach is similar to the one used on the mobile platform except that mobile devices are replaced by specially designed electronic devices. This approach gives us promising possibilities. In this case, we can use a wireless connection or a GPS module, but also any kind of sensors that can monitor the environment (including a person's health) and automatically notify emergency services about any threats. Thanks to that, it is possible to receive profit from both the mobile platform and web services with additional features, provided with more electronic elements. But there are also some disadvantages of this solution. Using dedicated electronic devices, the targeted market is narrower (due to cost of the solution). This results in a smaller group that can be saved using the system.

Web Services is another valuable technology to develop the modern emergency response system. Using Web Services we can provide a notification service, deployed on a server that can be obtained from every device which is connected to the Internet. This solution seems to be quite attractive because there is no need to use any dedicated devices. However, there are also disadvantages that significantly reduce the effectiveness of the Web Services. First of all, we have restricted precision to determine the accurate position of the endangered person, because described approach do not include a GPS module. Detecting the position through Wi-Fi or Internet Service Provider data is not adequate enough in many real situation due to large approximation of these technologies. In this way it is worth to use mobile platforms with a GPS module, which are installed in most modern mobile devices.

In our opinion, the best way to develop an Emergency Response System that suits current needs is the mobile platform, with use of GPS system and programs, like widget, developed on mobile operating system. That is the reason for creating GUARDIAN in the presented way, using Android and Windows Phone operating system and mobile devices equipped with GPS module. This approach assumes that users have a mobile device such as a smartphone or tablet with the mobile application, which allows user to send notifications to the Central Server. Mobile platforms provide some crucial services during a rescue action, for instance a wireless connection and a GPS module ([9], [10]). Fortunately, the current situation on the mobile device market suggests that the amount of mobile device users will grow year by year. In conjunction with high precision in detecting endangered place, the mobile platform is one of the most adapted technology intended to develop rapid response ERS systems.

These considerations show a classic problem of balancing costs and capabilities. The presented approaches are different taking into account usability, features and costliness. Moreover, the field of the RERS systems is still young and dynamically developed, so looking for one best solution is unfounded.

8. Problems and development opportunities

Despite the fact, that GUARDIAN implements most of features connected with modern RERS systems, there are still some problems that are not completely solved, for example:

When an applicant informs the Central Server about the danger the basic message can give us fast information about the place of the danger only in the case when the applicant is in the endangered place. To solve this, we have provided a special form to fill, but this results in violating the incremental information delivery model. So the main problem is to provide a solution which is consistent with the model;

If an applicant sends a notification and his mobile devices is stolen, the thief can cancel the alarm. The solution is to create an authorization and authentication mechanism, but this results in additional delay in the process of threat notification.

Although the functionality of the GUARDIAN system seems to be sufficient,

there are some ways to extend its capabilities, which includes for example:

- 1) *Patient card* – After installing the Reporter Client, the application will be asking for basic information about user's health. The answer to the questions will be optional, but they will allow to provide the best medical help in case of a danger;
- 2) *Crime maps* – Using data gained during rescue operations, the GUARDIAN system will be able to create crime maps, which will show the most dangerous areas, sorted by the type of a threat. This feature will be useful especially for the police and other emergency services;
- 3) *Visualization of rescue operations* – Another idea is to provide a management panel in the system with basic statistics and information about ongoing rescue operations. This could help decision makers in the headquarters to choose the best solution. We are convinced that this way of data visualization is very important, especially when we are talking about a system which is crucial for a human life;
- 4) *Analytical tools* to explore and mining data from the Central Database, particularly in the context of danger notification procedure optimization.

The data gained by the GUARDIAN system will allow to do some research into the effectiveness of rescue actions and used procedures. It will also be helpful to do post-accident analysis, which could even be evidence in some sort of cases. Using data mining methods, we could be able to search for some patterns in incidents and thanks to that we could develop a method, for instance, to predict the execution of rescue operation. This kind of knowledge is invaluable when human life is paramount.

9. Summary

Because domain of Emergency Response System is relatively new branch of IT systems, we suppose that many of innovative approaches will appear soon. One of the solutions, presented in this paper, is the GUARDIAN system, which fulfils the principles of creating modern ERS systems defined in the article. Additionally, we have identified some rules to create that kind of systems and technologies useful to satisfy all the presented requirements. In one of the sections were presented some of best practices, suggested to implement for every innovative Emergency Response System.

To provide the best system for rapid response to threats, we have to replace operators in headquarters and standard methods with new solutions. The GUARDIAN system gives an opportunity to create an innovative ERS system and allows to take the first steps in implementing the guidelines described earlier.

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GUARDIAN – system reagowania na zagrożenia z przyrostowym modelem dostarczania informacji

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Głównym celem artykułu jest przedstawienie współczesnych koncepcji dotyczących systemów reagowania na zagrożenia oraz idei społeczeństwa zorientowanego na bezpieczeństwo. Zaprezentowany został również pomysł przyrostowego modelu dostarczania informacji – podejścia, które w sposób istotny zmienia sposób myślenia o kwestii zarządzania akcją ratunkową. Ponadto omówiono możliwości rozwoju współczesnych systemów reagowania na zagrożenia na przykładzie systemu GUARDIAN wytworzonego i rozwijanego w Wojskowej Akademii Technicznej.

Słowa kluczowe: społeczeństwo zorientowane na bezpieczeństwo, system reagowania na zagrożenia, przyrostowy model dostarczania informacji.