The Use of Mobile Communication in Traffic Incident Management Process

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Abstract

In cases of major traffic or other incidents it is very important to manage events dynamically in real time for one primary reason, i.e. in order to reduce death causalities and other technical and technological damages. A unique name for this system is Incident Management System. The critical point in the traffic incident management chain is the procedure after detecting the incident and the appropriate verification thereof. It is the process of informing other participants in road traffic. This paper gives a description of one such technology, known as Cell Broadcasting. A technological overview of the system along with its applications and experience in real-life environment is given here.

Keywords: intelligent transportation systems, Incident Management System, Cell Broadcasting, location based broadcasting.

1 Introduction

Everyday life in most cities of the world is becoming more dynamic. Growing needs of the population of urban areas are realized through continued

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increase in mobility and requirements for quality and travel safety. Urban and transportation planners are faced with many demands on the one hand and infrastructure constraints on the other hand. Increased mobility adversely affects the environment and the climate, human health, quality of life, social conditions and safety aspects of people and the wider society. We do not and cannot give up mobility, so we look for answers that introduce innovative, sustainable and energy efficient solutions that will contribute to the quality of life of citizens. Increased mobility has resulted in a significant increase in road traffic incidents and the induced damages and costs [1].

An "incident" is defined as any non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand. Such events include traffic crashes, disabled vehicles, spilled cargo, highway maintenance and reconstruction projects, and special non-emergency events (e.g., ball games, concerts, or any other event that significantly affects roadway operations). Although the problems most often associated with highway incidents consequence is traveler delay, by far the most serious problem is the risk of secondary crashes. Another related issue is the danger posed by incidents to response personnel serving the public at the scene.

Other secondary effects of incidents include:

- Increased response time by police, fire, and emergency medical services.
- Lost time and a reduction in productivity.
- Increased cost of goods and services.
- Increased fuel consumption.
- Reduced air quality and other adverse environmental impacts.
- Increased vehicle maintenance costs.
- Reduced quality of life.
- Negative public image of public agencies involved in incident management activities [2].

Road traffic incident management is a functional part of the holistic approach to solving traffic problems known under the term Intelligent Transportation System (ITS). The advanced development of communication and navigation technologies and their implementation in various phases of incident management can significantly reduce the consequences of incident event such as congestion, delay, pollution and especially dangerous secondary incidents [3].

Real-time incident management in traffic comprises coordination activities undertaken by several actors in order to reduce the negative impact, i.e., recovery of the traffic flow to the conditions of normal flow. One of the basic problems in incident management is the warning of other participants in traffic, as well as effective coordination of various organizations, i.e., services included in this process [4, 5]. Besides, incident management comprises also legal regulations which require careful planning of all segments. The success of the incident management lies in careful development of clear (and efficient) instructions and procedures, which are acceptable and understandable for all the involved services, organizations and individuals. One of the important conditions to achieve this is high-quality communications among the participants, i.e. information transparency and real-time data flow. Absence of such an approach which combines cooperation, communication and training, represent one of the main reasons of inefficient incident management process, today [6, 7].

The critical point in the traffic incident management chain is the procedure after detecting the incident and the appropriate verification thereof. It is the process of informing other participants in road traffic (special importance are the motorists) by using different technologies. Motorist information involves activating various means of disseminating incident-related information to affected motorists. Media used to disseminate motorist information include the following:

1. Commercial radio broadcasts.
2. Highway advisory radio (HAR).
3. Variable message signs (VMS).
4. Telephone information systems.
5. In-vehicle or personal data assistant information or route guidance systems.
6. Commercial and public television traffic reports.
7. Internet/on-line services.
8. A variety of dissemination mechanisms provided by information service providers.

Motorist information needs to be disseminated as soon as possible, and beyond the time it takes clear an incident. In fact, it should be disseminated until traffic flow is returned to normal conditions. This may take hours if an incident occurs during a peak period, and has regional impacts [2]. Recently, mobile (wireless) communications and their associated technologies and services have become increasingly important.

The development of wireless communications systems and their application in everyday life of citizens have enabled the use of mobile communications technology in urban processes, and opened the possibility of entirely new solutions that until now could not be realized. This new, technologically advanced solutions based on mobile communications systems have opened new possibilities in the creation of an urban and traffic policy, which should serve the increasing population needs to ensure their mobility, accessibility, efficiency, rationality of energy and environmental conservation.

The penetration of mobile communications is growing rapidly levels of 90% coverage are no longer exceptions [8]. Telecom operators, due to competition and saturation, are offering new services and focus on differentiation through value-added services.

This paper provides the description of one such technology, known as the Cell Broadcasting. In Section 2 a general model of Traffic Incident Management System is described. In particular, the importance of timely information about traffic incidents is pointed. The problem of traffic congestion caused by the incident is described. Some features of the Cell Broadcasting technology and some systemic functions are described in Section 3. The basic features of its architecture and a description of some specific interfaces are given. In Section 4, several examples of using Cell Broadcasting are shown. Some possibilities of GIS interfaces are presented. The concluding part gives the basic results of the work and the guidelines for future research.

2 Traffic Incident Management Process Model

There are several different events that influence the normal or desired traffic flow in road network. In [4] the following events are identified which may lead to temporary reduction in road network capacity (compared to requirement):

- vehicle-conditioned incidents, ranging from minor vehicle damage to multiple accidents with the injured and fatalities;
- debris/barriers on the road;
- maintenance activities;
- unpredicted congestions; and
- any combination thereof.

Another cause is extreme weather conditions, such as heavy rain or storms. Planned events (e.g., sport/cultural activities) or repeating events (e.g., peak congestions in the cities), are less interesting here due to the possibility of planned action.

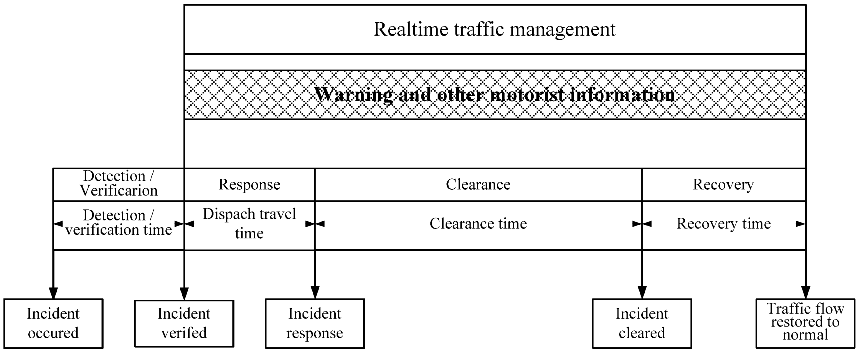

Figure 1 Phases in incident management.

The incident management process, as shown in Figure 1, is divided into four phases: incident detection and verification, incident response, clearance of the incident and recovery to normal traffic flow.

Incident detection may be defined as a process of identifying the space and time coordinates of the incident (incident situation) and possible nature of the incident itself. Incident detection methods are realized by private calls (phone, mobile phones), calls from SOS road phones, police report, report of the patrolling services and the operation of the automatic incident detection system. Incident verification means checking, which is used to determine the exact position and nature of the incident. In this way the possibility of responding to false alarms is reduced. Incident verification is carried out by the employees using the image obtained by specialized cameras (CCTV), or based on the comparison of several incoming calls about the incident.

The next step is very important. It is necessary to inform (warn) all participants in this road section about the nature of the incident. Implementation of this type of systems reduces the negative consequences of adverse events or sometimes an early warning of danger results in the adverse events not occurring. Figure 2 shows the relationship between the size of damage made in relation to the starting time of reaction. The figure is a display of statistically processed information on fires and their consequences. The diagram shows the impact of the shortest response of human and technical resources. It also shows the effect of sending real-time management information and alerts to people in danger, and in some cases, to participants in traffic approaching a site affected primarily or secondarily by consequences of accidental events [9, 10].

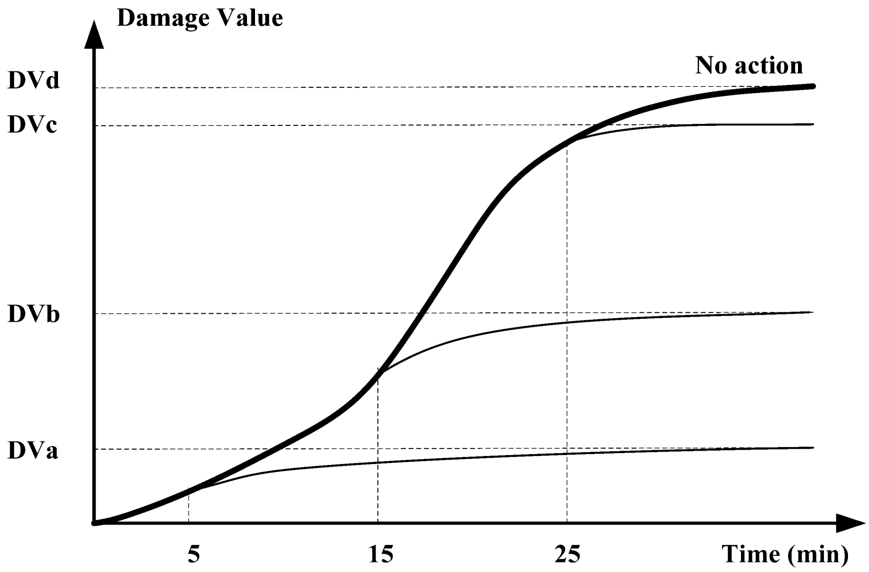

Figure 2 Quantity of caused damage in relation to initial response time.

We see from Figure 2 that if the intervention, which can range from intervention management of informing people to physical rescue of endangered, started after only 5 minutes, according to curve (a) the damage remained at the DVa level. If the intervention starts later, after 25 minutes, the damage was much higher, at DVd level.

Similarly, Figure 3 graphically shows the effect of reducing the cumulative arrivals of vehicles due to traffic flow diverting to alternative routes via cell broadcast messages about the emerged incidental situation [4, 11]. Also, as a positive consequence the response time of urgent services is shortened at the incident the situation due to the decrease (diversion) of traffic flow, and instructions to drivers on how to conduct themselves as they approach the place of incident.

Timely and accurate incident management and provision of information in real or near real time can significantly reduce the unwanted side effects that can exceed several times the incident that caused them.

According to the experience of leading projects in this area, it is generally considered that one minute lost for detection and verification requires four minutes to normalize the traffic flow.

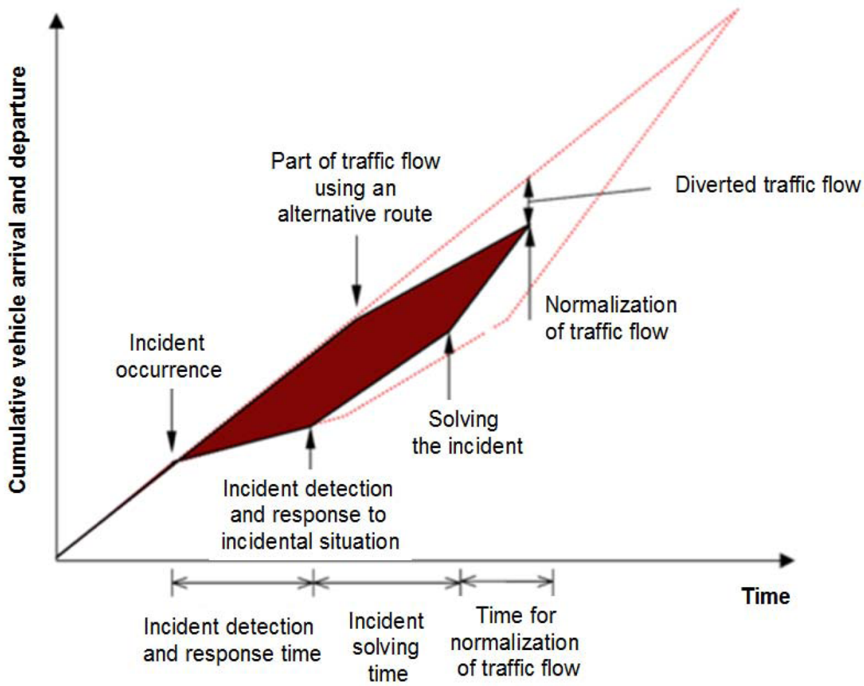

Figure 3 Relationship of cumulative vehicle arrival and departure.

3 Basic Technical Characteristics of Cell Broadcasting

The key to successful delivery of mobile services with added value is in finding the right combination of network services and content. An example of such a combination of content and functionality of the mobile network is providing the location-based technology, recently often used in entertainment and marketing industry.

These innovative telecom services began to develop more strongly after 2000. One of the services is “Location-qualified telecom messaging” which allows end users to receive different kinds of “push” specific information in relation to their current location, from multiple senders. One of the pioneering services in this area is the cellular broadcast system for sending telecom messages for emergency activities. Such services are based on sending alphanumeric messages to mobile phones (cell phones) that are found in a particular area that is dynamically determined by the content provider. The

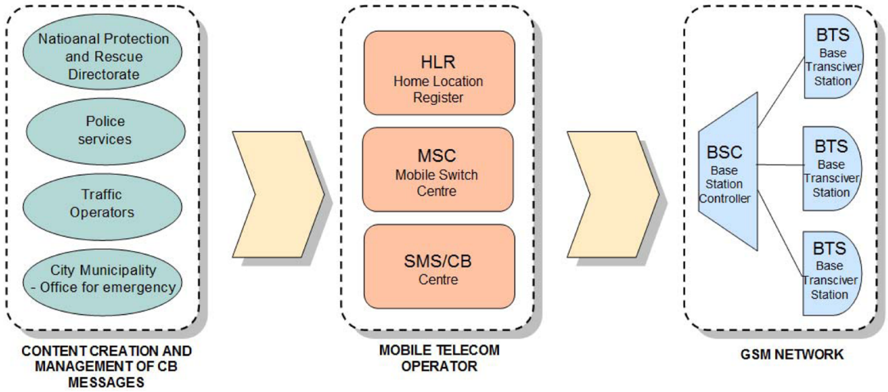

Figure 4 Functional diagram of cell broadcast system.

smallest area to which the content provider can send the contents is a radio cell, and the largest is a complete wireless network.

The Cell Broadcast System distributes information in a message format, very similar to the familiar SMS messages. These messages can be in a text or binary form. The length of a message is between 1 and 15 pages of 82 bytes (93 characters). A very important feature of this system is the distribution of information to a large number of users in a very short time. Processing required for the distribution of information is completely independent of the number of users that receive the information. The end user determines what information is to be presented to him and whether he wishes to receive this content. There are more than 65,000 channels available (in the ETSI terminology called "Message Identifiers"), each corresponding to a particular type of information.

The user individually activates and deactivates the reception of the first 999 broadcast channels. The rest of the channels must be activated via the OTA. Moreover, such a messaging system offers a range of unique functionalities such as support for sending specific information about location.

Apart from features provided by work in real time, the terminal required to receive broadcast information is continuously with the user, so he can read it immediately upon message delivery.

The system architecture of "location-qualified telecom messaging" gives the operator complete control over the network topology, whether it is a GSM or a UMTS (Universal Mobile Telecommunications System) network (Figure 4).

It also allows the content provider to work under largest load and with most complex cellular networks with their frequent changes. This is accomplished by dividing the system into two components, usually placed in two domains:

- Cell Broadcast Center (CBC) is a network element in the mobile network, which sends broadcast messages to a specific radio cells.
- One or more Cell Broadcast Entities (CBE) are connected to the CBC, and can be used locally (by operators) and remotely (by independent content providers) to define and send telecom messages with location importance.

Using the Cell Broadcast function, the end user selects relevant information, while blocking all other information. Received Cell Broadcast messages are displayed instantly on the display of the cell phone, or can be stored as Short Message Service (SMS) in the memory for later reading. The user selects relevant information by activating the so-called Cell Broadcast Channel (in ETSI terminology: "Message Identifiers").

This kind of telecom messaging supports messages in several languages, encoded in the ETSI Default Alphabet and Unicode (UCS2), as defined in [GSM 03.38 Phase 2+] and [3GPP TS 23.038] [12, 13].

Furthermore, such information can be sent in binary format for processing using machine-to-machine applications). A range of applications can take advantage of Cell Broadcast technologies, including the following examples:

- Traffic signs and information boards along the road can be equipped with mobile receivers.
- Dispatching systems can use the CB messages to send information to vehicles (taxis, police or firefighters).
- Traffic information for the navigation systems.

User interfaces of today's mobile phones support different procedures to activate the Cell Broadcast channel. Although manufacturers of mobile terminals develop and enhance functions, it is extremely important for the service of content providers to facilitate the activation of the Cell Broadcast channels. There are two ways to do this:

- Using the index message.
- Use the activation via Over the Air (OTA) – of services and tariff changes.

The index message is a specially formatted CB message with which channels from the menu can be selected and activated.

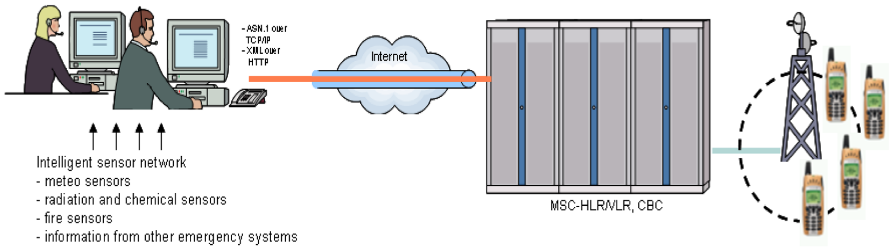

Figure 5 Cell broadcast system architecture.

In the case of activation via OTA, remote activation of CB channels (e.g., via a website) can be done by sending a binary SMS (also referred to as an OTA message) to the mobile device which updates the Subscriber Identity Module (SIM) card and activates the CB channels.

In addition to improving the user interface, activation of CB channels via OTA can provide a CB charging service (or its activation).

The center for location-specific telecom messaging is the central point for distribution of CB messages via a GSM network or a UMTS network. CBE submit broadcast claims to the CBC [14, 15]. Several CBE can be also interfaced to the center. CBC will address the appropriate cell controllers (Base Station Controller in a GSM network and Radio Network Controller in a UMTS network), which in turn will ensure the transmission of broadcast messages by the corresponding radio cells (Base Transceiver Station in a GSM Network and Node-B in a UMTS network). CBC supports a number of cell controllers in accordance with ETSI standards.

3.1 Interfaces for Cell Broadcast System

The CBE-CBC interface allows the CBE access to functions of the CBC. The interface accepts requests, processes them and transfers error messages or confirmation to the CBE. Message encoding (e.g., Universal Character Set 2) is transparent to the CBE-CBC interface.

The CBC provides two protocols for access to CBE:

- Protocol based on ASN.1.
- Protocol based on HTTP/XML.

CBE is connected to the CBC Center via LAN or a network interface, such as ISDN, X.25 or the Internet (Figure 5).

Figure 6 Alphanumeric cell broadcast system interface.

In the CBC, bandwidth control is performed on the CBE-CBC interface. That means when CBE exceeds the configured maximum bandwidth, the CBC will slow down sending replies.

Commands for cell controllers are provided with a list of cells, identifying the radio cells involved in commands. The cell controller is also responsible for the repetition of CB messages at a certain frequency. When a CB message is stopped, the cell controller reports the number of broadcasts by radio cell. ETSI has defined a standard for this interface (GSM 03.49 and [3GPP TS 25.419]), which the CBC supports. The CBC also supports interfaces to cell controllers that are not in accordance with ETSI standards.

The replies of the cell controller can change the internally maintained status variables of cell controllers and radio cells. The CBC attempts again to send failed messages for a configurable number of times. If after these attempts, the command is still not accepted, the command will be cancelled.

The CBC Center can be controlled remotely using the OMC (Operations and Maintenance Centre) via the web interface (Figure 6). Functions which the web interface provide are basic functions such as:

- start up and shut down of the CBC or its parts,
- entering basic information about the system (for e.g., position of a radio cell or which cell controller controls a specific radio cell),
- monitoring CBC activity.

The same functionality is provided in the CBC. An SNMP interface is available for remote monitoring of alarms.

The CBC automatically imports data on the topology of the GSM and the UMTS network (i.e. the relationship between radio cells and cell controllers) with file import tools. Data must be presented in the files, transferred using a file transfer protocol (FTP).

For a network element such as a Cell Broadcast Center, characteristics such as availability and capacity are of decisive importance.

Basic features are:

- Scalability, CBC can be implemented as CBS Smart (entry level platform), or dual-node Power CBS.
- Availability, several techniques are used in the CBC to improve system availability (Fail-take: if one node fails the other will take over.

3.2 Comparison of Cell Broadcast System and Short Message Service

SMS is one-to-one technology whereas CB is one-to-many. This significantly impacts the cost structure of such services allowing for easier network dimensioning. In an average network it would take 100 SMS with the same content approximately 30 seconds to reach its destination, whereas in a CB-enabled network, a similar message transmission takes 30 seconds to reach all end users tuned into a CB channel, up to several million at a time. Unlike SMS, the time to broadcast a message over a CB channel is insensitive to the number of subscribers scheduled to receive the message. In a typical CB, a message can be sent within 30 seconds to all handsets. Efficiency of communicating the message does not decline in peak hours and CB does not use the signaling network (IN7) to carry messages as with SMS. Some basic characteristics of Cell Broadcast System and Short Message Service are presented in Table 1.

4 Application of Cell Broadcasting in Traffic

The main application of Cell Broadcasting in traffic is sending alphanumeric messages for location-specific alarms and messaging within the framework of mobile telecommunications network. The main purpose is to warn and inform motorist and other participants about the event in this road section. Also, same system can be used to inform about other incidents such as natural disasters, infrastructure or chemical accidents, and terrorist or other security incidents. In Japan, since 2008, DoCoMo (Japan's premier mobile provider of leading-edge mobile voice, data and multimedia services) has implemented an alarm and messaging system for dangerous weather conditions and alert for earthquakes using the cell broadcast service. New York City in 2007 launched the "Crisis text via CB" project intended for early warning of citizens. The Indian operator BSNL (Broadband – Bharat Sanchar Nigam Ltd) has introduced a cellular broadcast of important information on disaster, as well as crisis management. The U.S. FEMA (Federal Emergency Management Agency) under the Department of Homeland Security in the United States implements

Table 1 Basic characteristics of SMS and CBS [16].

Characteristic	Short Message Service	Cell Broadcast Service
Handset compatibility	All handsets support SMS	Most handsets support CBS except Few numbers.
Transmission form	Unicast and Multicast communication	Broadcast service. Message received indiscriminately by every handset within broadcast range
Mobile number dependency	Dependent. Foreknowledge of mobile number(s) is essential	Independent. Message is received on activate broadcasting channel
Location dependency	Independent. User receives the message anywhere	Dependent. Targets one cell or more
Geo- information	Achieved by obtaining cell ID from the network operator	Cell(s) location is known for broadcaster beforehand
Service barring	No barring	Received only if the broadcast reception status is set to "ON"
Reception	Message is received once the mobile is switched on	No reception if handset is switched on after broadcasting
Congestion and delay	Affected by network congestions. Immense number of SMS may produce delays	Congestion is unlikely as CBS are sent on dedicated channels. Almost no delays except if received in poor coverage area
Delivery failure	Network overload might cause delivery failure	Busy mobile handset might fail to process a CBS message
Delivery confirmation	Sender can request delivery confirmation	No confirmation of delivery
Repetition rate	No repetition rate	Can be repeated periodically within 2 to 32 minutes intervals
Language format	Identical to all receivers	Multi-language messages can be broadcast on multiple channels simultaneously
Spamming	Some mobile service providers support internet connectivity. Internet-based SMS spamming is possible	Not possible expect through uncontrolled access to mobile network infrastructure and lack of safeguards by an irresponsible service provider

TRAFFIC INCIDENT !
LOCATION: Zagreb Bypass (Knot Jankomir)
MESSSAGE: Traffic Congestion
DESCRIPTION: The chain collision on the east-west
START TIME: 2010-07-12 18:25
END TIME: 2010-07-12 19:25

Figure 7 Example of traffic messaging [17].

the "Emergency Cell Broadcast Network" system for cities and areas till now frequently threatened by natural disaster.

Several operators and content providers develop traffic information services in real time. Two main types can be distinguished in these applications. One is the basic version in which location and traffic information is sent to users and displayed as text messages on their mobile devices. More advanced versions of these services are continually sending dynamic information on road conditions and their display on a navigation system (Figure 7).

For content providers, Cell Broadcast is a unique way of distributing information to large groups of users. Combining geographic information with demographic information, the content provider can target specific areas in a very advanced and effective manner. The areas are selected using the alphanumeric designation of the CBS or with Geographical Information System (GIS), and using an intuitive graphical user interface for entry of text messages and parameters (Figure 8).

Mobile networks are constantly expanding with new radio cells. The Cell Broadcast Center automatically retrieves updated information about the network topology in a preset time. Newly-added cells are now used for all current messages whose broadcast area overlaps with the new cells. This process is automatic and transparent to the content provider.

5 Conclusion

Reactions to incident events in real time reduce material damage and human casualties. Such properties have systems for early warning, that allow dislocation of people out of vulnerable locations. Especially an important role is played by these telecommunications systems in traffic that is very dynamic

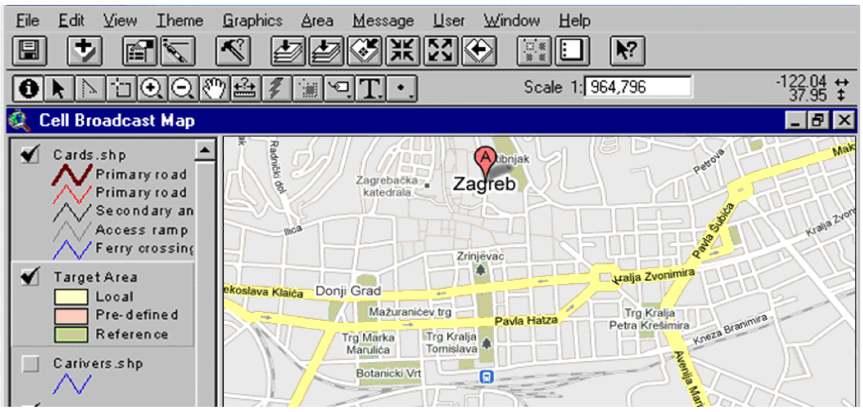

Figure 8 GIS interface for CBS.

and therefore complex in terms of management. The introduction of advanced telecommunications solutions increases safety in unfolding traffic reduces the number of casualties in traffic accidents and leads to faster response and actions by emergency services. Due to the success of implementation of such telecom systems, they become an integral part of the strategic program for design and deployment of regional ITS systems (ITS – Intelligent Transportation Systems). Tracking the number and severity of the consequences of accidents before and after the introduction of ITS provides a relatively objective quantification of the security gains and mitigates the effects of these events. Except in traffic incidents, similar processes and technology can be applied in the case of other emergencies, major accidents and disasters. Measuring the percentage reduction in response time is not a direct indicator of benefits, but is a very important factor. Reducing response time significantly affects the reduction of fatalities and prevent further casualties after the initial traffic (or other) accidents. Warning systems on highways improve driver perception of the accident scene and help reduce stress while traveling. Perception of safe travel is not only about reducing the number of accidents and their consequences, but also about increasing the perception of personal safety and security in transport. Also, dynamic and location-selective management of large incidents reduces the possibility of uncontrolled process (e.g., panic in humans). The introduction of new telecommunications technologies with the above properties, such as Cell Broadcast Systems, substantially increases the effectiveness of security systems in the public and the transport sector.

References

[1] S. Mandžuka, Z. Kljaić and P. Škorput. Application of ICT in the traffic incident management system. In *Proceedings CTI – MIPRO*, Vol. II, pp. 359–362, Opatija, 2011.
[2] Traffic Incident Management Handbook, Federal Highway Administration Office of Travel Management, November 2000.
[3] I. Bošnjak. *Intelligent Transportation Systems 1*, Faculty of Transport and Traffic Sciences, Zagreb, 2006 [in Croatian].
[4] P. Škorput. Real-time incident management system. M.Sc. Thesis, Faculty of Transport and Traffic Sciences, Zagreb, 2009 [in Croatian].
[5] P. Škorput, S. Mandžuka, N. Jelučić. Real-time detection of road traffic incidents. *Promet*, 22(4):273–283, 2010.
[6] C.L. Dudek, C.J. Messer and N.B. Nuckles. Incident detection on urban freeways. *Transportation Research Record*, 495:12–24, 1994.
[7] H. Dia, G. Rose and A. Snell. Comparative performance of freeway automated incident detection algorithms. In *Proceedings of Roads 96: Joint 18th ARRB Transp. Res. Conf. and Transit New Zealand Land Transp. Symp.*, pt. 7, pp. 359–374, 1996.
[8] Global mobile statistics 2011: All quality mobile marketing research, mobile Web stats, subscribers, ad revenue, usage, trends, . . . , http://mobithinking.com/mobile-marketing-tools/latest-mobile-stats, visited June 2011.
[9] S. Mandžuka, Z. Kljaić and Z. Kordić. Mobile Telecommunication technology for Incident Management System. In *Proceedings of XVII Telecommunications Forum TELFOR*, 2009.
[10] Ch. Wattegama. ICT for Disaster Management, Asia-Pacific Development Information Programme, 2007.
[11] W.M. Evanco. The impact of rapid incident detection on freeway accident fatalities. Mitretek Center for Information Systems McLean, Virginia, 1996.
[12] Ericsson. Content Delivery System, FC 101 097/3, Stockholm, Sweden.
[13] Ericsson. Mobile Positioning System, FC 101 0351, Stockholm, Sweden.
[14] 3GPP TS 23.041; 3GPP TS 23.041. Technical realization of Cell Broadcast Service (CBS), 3GPP, V4.1.0
[15] GSM 03.41. Digital Cellular Telecommunications System (Phase 2+); Technical Realisation of the Short Message Service Cell Broadcast (SMSCB), ETSI.
[16] A. Aloudat, K. Michael and J. Yan. Location-based services in emergency management – From Government to citizens: Global case studies, Recent advances in security technology, Australian Homeland Security Research Centre, Melbourne, 2007, pp. 190–201.

Biographies

Sadko Mandzuka received his Univ. Ing. (1980), M.Sc. (1992), and Ph.D. (2003) degrees in Automatic Control from the Faculty of Electrical Engineering, University of Zagreb. He is currently Head of Transportation Telematics Chair, Faculty of Traffic Science, University of Zagreb. He has wide experience in the area of Floating Vessels Control Theory, Intelligent Transportation System, Artificial intelligence Technology, Traffic Incident Management System, etc. His main areas of interest are control problems in Intelligent Transportation Systems, applications of Artificial intelligence techniques to engineering optimization and Urban Traffic Incident Management System. He is author of more than 70 internationally reviewed publications. Professor Mandzuka received the prestigious Croatian State Award by the Ministry of Science in 1997. He is a founding member of the Croatian Robotic Association, Vice President of ITS-Croatia, and Collaborating Member of Croatian Academy of Engineering.

Zdenko Kljaić graduated in 1996 from the Faculty of Traffic and Transportation Engineering, University of Zagreb, and in 1997 received a Bachelor of Science in Electrical Engineering. He is currently attending the postgraduate masters study Information Management at the Faculty of Economics and Business, University of Zagreb. Furthermore, he studied in the field of strategic design and project management, and since 1998 has a specialization in designing and managing electrical construction projects in large and complex structures. He is a member of the Board of ITS Croatia (Intelligent Transport Systems), a member of the Assembly of Croatian Chamber of Traffic and Transportation Engineers. Since 2000, he has been permanently employed in Ericsson Nikola Tesla, Croatia, in the development of advanced solutions for Industry and Society.

Pero Škorput received his Dipl. Ing. degree (2002) and M.Sc. degree (2010) in the field of Transport and Traffic Science from University of Zagreb. He is currently postgraduate student in ITS. He has five years work experience in Ericsson Nikola Tesla as expert for telecommunication and System development. He is currently an Assistant at Faculty of Transport and Traffic Sciences for Courses: Basic of Traffic Engineering, Intelligent Transport System and Artificial Engineering. He is general secretary of Intelligent Transport Systems Croatia. His main research interests include Traffic Incident Management and Ontology Engineering in Transport and Traffic Domains.