GSM LOCALIZATION AND MONITORING IN ELECTRONIC TRANSPORT SECURITY SYSTEMS

Tomasz CIECHULSKI

Instytut Systemów Elektronicznych, Wydział Elektroniki
Wojskowa Akademia Techniczna, ul. Kaliskiego 2, 00–908 Warszawa
tciechulski@wat.edu.pl

Summary

The article contains survey and analysis of electronic security systems used in the public transport. The systems are based on comprehensive approach to many security issues such as monitoring (e.g. railway station), access control (e.g. access to service rooms of railway station), GPS tracking (e.g. private or service car), fire protection systems (e.g. passenger train), wireless alarm signals transmission through GMS modules (e.g. car anti-theft systems).

Keywords: security systems, video monitoring, transport, CCTV, GSM.

LOKALIZACJA GSM I MONITORING WIZYJNY W TRANSPORTOWYCH ELEKTRONICZNYCH SYSTEMACH BEZPIECZEŃSTWA

Streszczenie

Artykuł zawiera przegląd i analizę systemów zabezpieczeń opartych na lokalizacji GSM i monitoringu wizyjnym, wykorzystywanych w środkach transportu. Systemy te charakteryzują się kompleksowym podejściem do problematyki bezpieczeństwa. Obejmują one monitoring (na przykładzie zastosowania na dworcu kolejowym), kontrolę dostępu (w przypadku dostępu do służbowych pomieszczeń dworca kolejowego), namierzanie GPS (w przypadku samochodu prywatnego lub służbowego), a także transmisję sygnałów alarmowych drogą bezprzewodową poprzez moduły GSM (w przypadku systemów zabezpieczających przed kradzieżą samochodu).

Słowa kluczowe: systemy bezpieczeństwa, monitoring, transport, telewizja przemysłowa, GSM.

1. INTRODUCTION

Current state of the telecommunication solutions and satellite navigation allows to use the integrated network services based on determining the position of vehicles and trains in real time. It also allows to control and automatic supervision of the state of the cargo. Traffic telecommunication is very important factor of effective control systems of vehicles and trains.

Positioning system allows to observe the vehicles routes, searching vehicles, and changing the strategy or their destinations. Continuous monitoring gives important information in case of theft, change of logistic decisions or in the event of unexpected difficulties in traffic. The main receiver of such services are: transport industry and national railways where the information received from monitoring systems are connected directly with the company operating income.

Localization system is also very helpful in managing the transport of dangerous or very valuable cargo, limiting the risk of traffic disaster, thefts, and helping to localize the vehicle in case of theft. Effective response in real time to events such as disruptions in planned routes is important not only because the optimal use of trains but more likely because the security of transport.

Availability of satellite monitoring and localization of the vehicles in every place and time has significant value wherever there is poor infrastructure and many roads are in bad condition, for example in Poland and other countries of Eastern Europe.

It is very important that systems to be created in the future will be available to localize the vehicles and to transmit data, basing on the Global System for Mobile Communications (GSM). In the same time they could be reliable source of information about location of companies' objects [3].

2. GSM TERMINAL LOCALIZATION USED IN ALARM SYSTEMS

TDoA[1] is one of methods which manages to determine the subscriber localization with big accuracy. It relies on terminal localization which is

[1] Time Difference of Arrival.

determined as a source of electromagnetic waves. The time of propagation of the signal measured in different positions is compared to each other. It is required that the subscriber terminal should be at range of at least three BTS's[2] equipped with a time measure device.

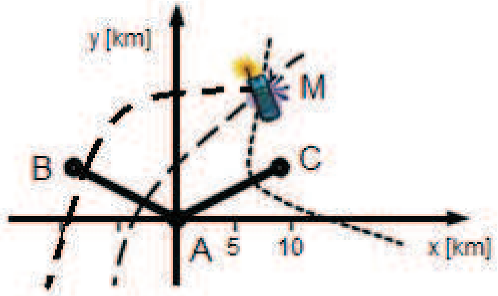

Fig. 1. Determination of electromagnetic wave source position. (M – emission source, A, B, C – BTS).

Station A is the master, and stations B, C are slaves. In this case, the differences between times of signal propagation to the stations can be determined as follows:

$$\Delta t_{Aj} = \frac{1}{c}\left(R_{jM} - R_{AM}\right) \qquad (1)$$

where:
j = B or C;
R_{jM} – distance between emission source to B or C;
R_{AM} – distance between emission source to A;
$c \approx 3 \cdot 10^8$ m/s (velocity of electromagnetic wave).

Distance differences can be stated as follows:

$$\Delta R_{Aj} = R_{jM} - R_{AM} \qquad (2)$$

The TDoA method also known as reverted hyperbolic system, is characterized by good accuracy, despite of using antennas with non–directional characteristics. Theoretical model of this thread assumes that signals transmitted by the source reach the ith transceiver after time ti. Measured time ti is not very useful at that time. The parameters used in the TDoA method is the difference between times of signal propagation between pairs of stations. And that differences give information which is used to forward signal processing.[1]

According to fig. 1 the following devices need to be added to Base Transceiver Stations: block of the time standard, receiver and the sampling module for received signal. Output product of added block is precisely marked sequence of signal samples transmitted by terminal and received by the BTS. This information can be transmitted forward to the TDoA processor localized inside or outside any BTS. Compared sequences of time samples in the processor could determine time differences of their arrival and on this basis the precise location of terminal is possible. This data can be transmitted to the monitoring centre where they can be implemented on digital maps.

3. VISION MONITORING IN RAILWAYS

The development of technology allowed to connect the cameras with computer networks in direct way. According to this there are wide possibilities of watching images from camera located in very different localizations from whichever camera by using any computer connected to the network in any place in the world (we can use PC or laptop). The network camera has network interface and has assigned its own IP address.

IP monitoring is the kind of technology designed especially for new–built installations. While in small, local monitoring systems there will be built systems based traditionally on digital record on hard disks, insomuch that in large systems, in diffuse objects, in new–built houses with modern structure of teletechnical communication installations there is need to imply monitoring based on CCTV[3] IP technology. The usage of monitoring inside the network based on TCP/IP protocol gives widespread possibilities of organizing large and extensive installations.[9]

One of many international companies constructing monitoring systems, integrates under its services more than 290 monitored buildings spread in 60 countries. In this installation there is more than 2700 cameras working condensed in one system.

In such form general monitoring of i.e. petrol station or water intake sources in one region territory is not considered as very difficult task. However, because of the simplicity of structure and big possibilities of replacement of the staff through the software support these systems are worth of building for only few cameras. There are predictions that in next five years the monitoring IP will be the standard of security installations. The structure and architecture of monitoring IP is very similar as the proper computer network. The devices used for image signal processing have their own IP addresses. It is possible to use the analog parts of monitoring systems such as cameras, wall of analog cameras applying analog to digital signal converters considered as webservers. In the opposite way the communication is supported by decoders.

The recording of the signal can be carried on locally in traditional DVRs[4] as well as in stream signal recorder using remote control.

[2] Base Transceiver Station.

[3] Closed–Circuit Television.

[4] Digital Video Recorder.

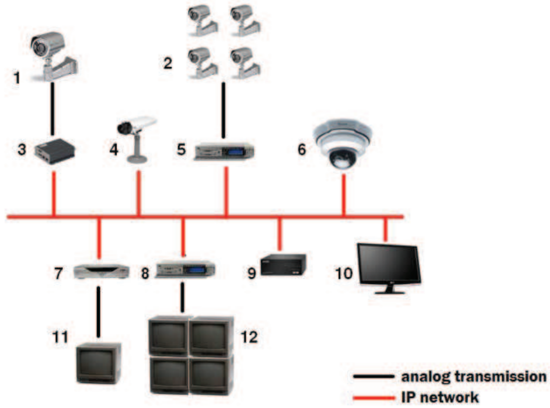

Fig. 2. Simplified scheme showing the genesis of the CCTV installation in IP network, where:
1 – analog camera, 2 – wall of analog cameras,
3 – one–channel webserver, 4 – IP camera,
5 – four–channel webserver, 6 – rotary IP camera,
7 – digital to analog decoder,
8 – multichannel digital to analog decoder,
9 – Network Video Recorder (NVR),
10 – digital monitor, 11 – analog monitor,
12 – wall of analog monitors

In fig. 2 there is presented simplified scheme of CCTV installation in IP network, where there are included analog as well as digital parts of installation (black colour – analog part, red colour – digital IP part).

This type of system as well as in more advanced configurations can be easily applied in new–built transport objects.

Fig. 2 shows that structure of CCTV network is quite simple and its modernization with adding new cameras is easy. The cameras can be plugged in whichever place and sharing the image can be easily configured. For example part of the recorded images in CCTV can be shared with technical supervision and serve inspection of the building. Other images from the network can be shared with security guards and other forces. The most important images can be send to the police in real time. The basic and the new one element of such installations is IP camera which in special conditions is considered as computer. IP camera can be plugged directly into LAN od wireless network through FME connector with bandwidth 10/100 Mb/s (RJ45 jack). IP cameras are independent network devices which can be used to monitoring offices, warehouses, shops, etc. They are equipped with ports RJ45 (Fast Ethernet), WLAN 54 Mb/s and client station 802.11b/g[5] (WiFi). Built–in WWW server allows to do remote configuration of the cameras and sending images to Internet browsers. The cameras can be configured also from the managing software level which allows to watch images from many cameras at one time and to save them on the hard drives continuously or automatically. The new items in the system are also independent and freestanding devices designed for saving the images from IP cameras – NVR recorders. Some IP cameras own the alarming port which allows to connect outside sensors and RS–485 port allowing to connect the camera turntable. The cameras can also be adapted for outdoor installations through applying hermetic case. Few models using built–in infrared illuminators have possibility for working at night and can record the sound.[4]

IP camera digitizes the analog video signal. The computational efficiency of built–in processor is very important factor because it is strictly connected with the quality of image sent through the network and thereby installation functionality – so significant for extensive transport objects and systems. The camera with frame rate 25 fps and with QCIF[6] can be applied only in systems with small responsibility in opposite to camera with 25 fps and Full D1[7].

Very important features of IP cameras are:
- connection to the Internet allows every user to watch in real time the images from office, hotel, city or transport object (i.e. railway station, airport, etc.);
- they allow to watch images from other location;
- in case of using the analog cameras there is possibility for usage network video server to allow watching images from any place or quickly and cheaply expand the supervision system;
- the usage of network camera does not require additional costs, instead of buying separate monitor for camera, the already working PC monitor can be used;
- there is no need to organize new wiring, already existing computer wiring is used;
- network cameras technology eliminates the necessity of replacement the tapes in video recorder – the images are saved on PC hard disk or in NVR recorder.[2]

4. VISION MONITORING SYSTEM INCLUDING THE TCP/IP PROTOCOL

The client–server architecture and TCP/IP protocol can be used for wide communication in different types of data networks. The system allows to transmit to monitoring centre the view, the sound or any other digitized signal. The basic architecture of such system is showed in fig. 3.

[5] One of the WLAN standards with bandwidth up to 54 Mb/s.

[6] Quarter Common Intermediate Format – recording format with resolution 176 x 144 pixel.

[7] Resolution of 720 x 576 for PAL and 720 x 480 for NTSC.

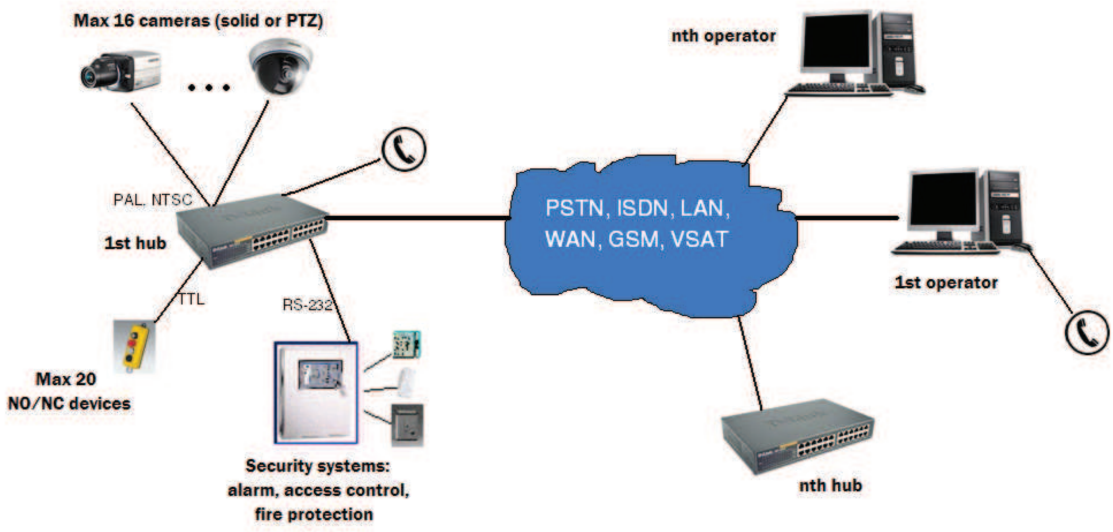

Fig. 3. Architecture of electronic security system including vision monitoring and other alarm systems of M^3S type

The main element of the M^3S [8] system is the multimedia hub M^2C which collects every data incoming from local systems (cameras, microphones, sensors, etc.). The hub converts them to the digital signals, compress them and saves.
Every data can be transmitted through the network to the managing station in monitoring centre. Every hub has 4÷16 video inputs and 5÷20 programmable bistable inputs (NO/NC[9]). Image coding is implemented by programmed coder working in JPEG or Wavelet standard. Hubs provide the communication with Pan–Tilt–Zoom[10] cameras allowing their remote control. Alarm systems, fire protection or access control systems can also be added to hubs. In one system there could be many M^2C working at one time and their number is limited only by network bandwidth.

The managing station for M^3S system is concerned as a personal computer with adequate software, including graphic user interface for administration and monitoring the signals incoming from the hubs. This station has role of the digital map that shows working of every connected systems, receives and decodes the video stream and allows to control the cameras. There is possibility of observing the view from 16 cameras at one time on one monitor and view from one camera can be displayed in full screen mode on one monitor. Operating of managing station is supported by so–called quick automatic response scenarios. [8]

The existence of defined event in alarm system or movement detection in view of camera causes automatic reaction of M^3S system (notification of the operator, start of recording, change of recording mode, start of video stream transmission from defined camera, notification of the security service, etc.). The architecture of the security system presented on fig. 3 including vision monitoring and other alarming systems is characterized by:

– remote monitoring and supervision of distant and distracted on large area objects throughout available transmission links (networks PSTN[11], ISDN[12], GSM, GPRS[13], Ethernet, Token ring, Frame Relay, ATM, VSAT);
– digital recording of events with possibility of simultaneous replaying of the recording and on–line preview;
– high and stable quality of recorded image and long time of recording (limited only by hard disk drive capacity);
– parameters such as recording, transmission, control are defined independently for each camera;
– digital transmission of encoded video streams and signals incoming from other electronic security systems plugged into M^3S system;
– coding of video streams in JPEG and Wavelet standards;
– remote control of Pan–Tilt–Zoom cameras;
– video multicast allowing to view the image from one camera by many operators;
– sound communication between operator and monitored object is provided by duplex transmission;

[8] Multi Media Monitoring and Surveillance.
[9] Normally Open/Normally Closed.
[10] Pan–Tilt–Zoom – provides remote control (rotary movement, zoom, etc.)

[11] Public Switched Telephone Network.
[12] Integrated Services Digital Network.
[13] General Packet Radio Service.

- observation of the state of alarm inputs and possibility of change of the state of control outputs;
- NO/NC sensors handling;
- monitoring of working of other electronic security systems, i.e. access control, fire protection system with cautionary sound system;
- event recording in the data base with description including date, time of occurrence and description of the event;
- automatic connection setup with managing station after alarm occurrence;
- support of video stream in PAL[14] and NTSC[15] standards;
- archiving of video record on DAT tapes and DVD–RAM disks;
- recorded images archive management;
- cooperation with Uninterruptible Power Supply (UPS) devices;
- easiness of adding new cameras and operating stations;
- simple management of the system, easy configuration, open architecture.

5. SUMMARY

Constant radio connection with at least three Base Transceiver Stations is necessary for precise definition of terminal localization. This case is fulfilled in urban agglomerations, city areas or their nearest neighbourhoods where there is one network operator. In weakly urbanized areas the condition of subscriber connection with three BTS's will be very difficult to fulfill or impossible. The cooperation between network operators in rescue–alarm surface will be solution to this situation. System cooperating with European emergency telephone number (112) improves the security of the subscribers and allows to provide them prompt assistance in emergency of life and health treats.

Vision monitoring based on TCP/IP protocol largely facilitates administrative activities in the system. It allows to operator to control the whole system in real time. It gives the user elastic possibility of checking the state of the system from every place connected to the Internet. The specifications of the system allow digital recording and archiving of the image and diagnostic parameters on optical data carriers and hard disk drives. The system is protected against sudden decline of power by using the UPS's and immediate notification of the operator about emergency situation that has occurred. It is provided by Internet communication or GSM cellular network.

[14] Phase Alternating Line.
[15] National Television System Committee.

LITERATURE

1. Czopik G., Roszak M., Witczak A., *Lokalizacja terminala GSM dla potrzeb ratownictwa,* Warszawa 2001.
2. Kołakowski J., Cichocki J., *UMTS system telefonii komórkowej trzeciej generacji,* Warszawa 2003.
3. Krawczak R., *Metody określania położenia terminali w systemie GSM,* Warszawa 2001.
4. Liderman K., *Podręcznik administratora bezpieczeństwa teleinformatycznego*, Warszawa 2003.
5. Liderman K., *Bezpieczeństwo teleinformatyczne*, Warszawa 2001.
6. Liderman K., *Analiza ryzyka i ochrona informacji w systemach komputerowych*, Warszawa 2008.
7. Mielnik P., Witczak A., Poniecki A., *Synchronizacja czasu z wykorzystaniem GPS – wnioski i doświadczenia,* Warszawa 2000.
8. Praca zbiorowa, *Vademecum teleinformatyka*, Warszawa 2004.
9. Wesołowski K., *Systemy radiokomunikacji ruchomej,* Warszawa 2003.

Tomasz CIECHULSKI, M.Sc, is a teaching and research employee in the Faculty of Electronics of Military University of Technology. He holds Master of Science degree in electronics and telecommunication since 2012. He is 1st year D.Sc. candidate in the Institute of Electronic Systems. His research area of interest includes electronic security systems, GSM and GPS localization, neural networks and analysis of load distribution in power systems.