A Global Concept for Remote Railway Digital Video Surveillance

Ivaylo P. Topalov[1] and Borislav P. Avramov[2]

Abstract – **An investigation of the technical possibilities to create railway digital video surveillance system based on united network conception with GSM-R is done. For that reason a different computers, telecommunication and fail-safe technologies are applied, the software and hardware requirements are discussed.**

Keywords – **GSM-R, digital video surveillance, railway.**

1. INTRODUCTION

In recent years the digital signal processing became a main direction in developing of the video surveillance systems. The digital video recording (DVR) is playing the leading role in expansion of safeguard systems using the last technologies.

The nowadays development of a rail transport in Bulgaria and Europe leads a speed increasing and the relevant developing of a fail-save control systems. They can be improved by implementation of a different computer and telecommunication technologies such as digital video surveillance and digital wireless communication.

From the beginning of 90-ty years the Europe UIC started standardization based on investigation of an applied digital radio communication. Experts from 32 European railways administrations signed a memorandum for agreement on GSM-R technology and developed the project named EIRENE [1]. An elaborated catalogue of requirements was developed based on the ground of the executing MORANE project [2]. The new system is already tested to confirm all requirements up to 500 km/h. A frequency band with 19 canals around 900MHz is reserved for GSM-R voice communication and fail-safe ETCS data transmission [3]. Some of the most common user's services available on GSM and ISDN networks were accepted in GSM-R railway radio systems [4] [5]. Such communication platform gives the opportunity to elaborate a mobile digital video surveillance system to observe the railroad, trains traffic and station platforms [6] [7].

2. DIGITAL VIDEO SURVEILLANCE (DVS) TECHNOLOGY

The DVS is a PC based network observation system recording still or moving images in a specified area. Using the network browser a selected users can remotely monitor in a real time through the network different TV-cameras and clips. The selected event will send an alarm request to the control centre alerting the safeguard and /or will swiftly send a message. It can also record the event in an audio/video file. Other useful functions are [6] [7]:

Motion detection to save time for data retrieval;

Wavelet compression for better image quality;

Programmable multiple detection zones for each camera;

Point-to-point or multicast transmission of live video via Internet/LAN;

Web-based user interface for easy operation;

Send message to monitoring units or communication devices when detect event;

Motion detection, Round-the-Clock, or by Schedule recording mode;

Interaction with UPS device;

Multiple passwords to view permitted cameras;

Playback while monitoring;

Remote playback, remote recording;

Unlimited users view from remote without taking extra bandwidth (LAN).

Using standard for unified voice and video compression MPEG-4 the coded files are up to 300 times less then original. It is possible a video frames to be transferred through the computer network and via telecommunication canals and base station to reach a wireless terminal.

To guarantee authentication and the security of the sent images like digital copiers a digital watermarking is available for application. Special software marks the unvisible points onto the video image and so the specific point constellation should be detected in the received end. The advantages are three:

- Elimination of the opportunity the frame passing through the INTRANET or INTERNET to be fake;
- The recorded video information with actual date and time can be used as a piece of evidence;
- The point's constellation is put into every frame leads to increasing of the data reliability and authentication of the observed screen image.

The system controls simultaneity a lot of video servers and is possibly to interact with other information systems in a network environment. For an example if a request for video processing is received from local computer video control (LCVC) but is not serviced, it will be forwarded to the next free server.

[1]Ivaylo Penev Topalov, is with the Department of Communication and Railway Signalling Engineering in Todor Kableshkov Higher School of Transport. 158 Geo Milev Street, Sofia 1574, Bulgaria.
E-mail: ivo_topalov@hotmail.com

[2]Borislav Petrov Avramov, is with the Department of Communication and Railway Signalling Engineering in Todor Kableshkov Higher School of Transport. 158 Geo Milev Street, Sofia 1574, Bulgaria. E-mail: b.avramov@vtu.bg

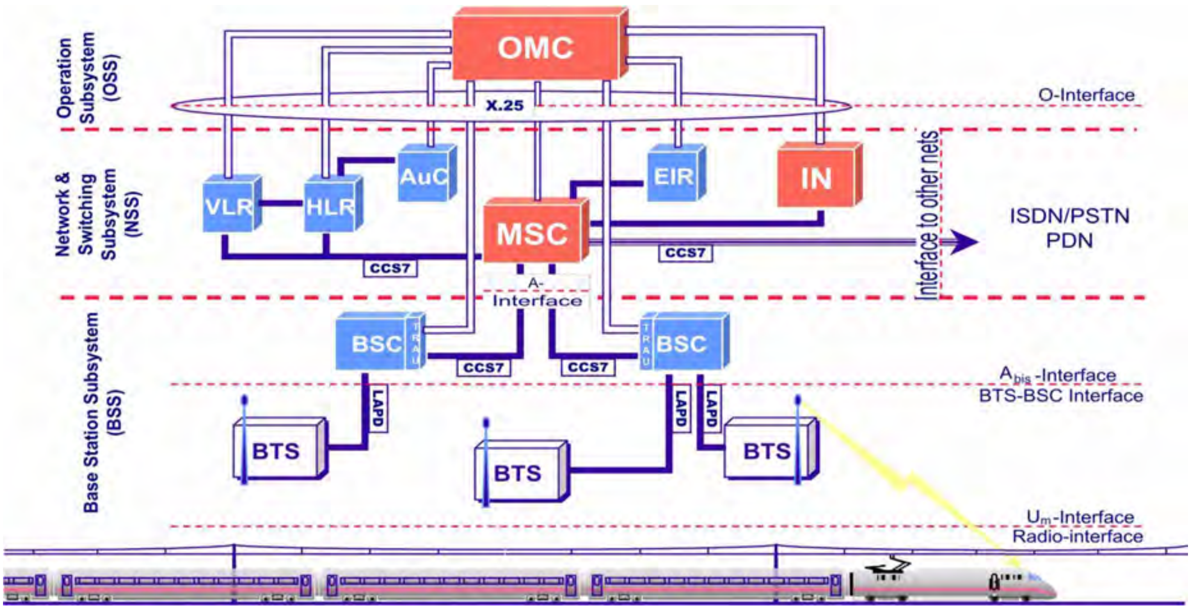

Fig. 1. GSM-R Architecture

3. GSM-R NETWORK PLATFORM

GSM-R is a railway radio communication system using different information processes and personal for transmission of high reliable data to control the railway traffic. Signal information from and to the trains is directed to the locomotive drivers such way that on future developing of the system will be possible to implement an automatic train control (ATC) system. This shows the direct dependence of the railway traffic from the specifications of radio communication platform to support end-to-end secure communication [4].

3.1. Specific fail-safe requirements.

To guarantee the necessary fail-safe requirements in radio communication and signalling control systems on GSM-R in some network elements a hardware redundancy is applied. The physical connection from the fixed network to the wireless interface is with extended accessibility and reliability compared with common use systems. So in the whole accessibility of the system the weakest section in the chain is critical for the security and every element of the structure is reliable weighted. To guarantee the reliability requirements for an outdoor work the minimal received level on the train cab should be better than -85 dBm and the electromagnetic cover probability should be better then 95% along any GSM-R section. The accessibility of the transmission canal in the network should be better then 98.5%. So the train radio transmitters and the receivers should be hot reserved.

To provide the software reliability a special algorithm for system errors processing and remote control diagnostic is applied. In case of partial malfunction the reserved units will support only the main user and test functions. The application of routers with physical and software redundancy is another media sets to reach high accessibility and reliability.

Network elements such as MSC, BSC and BTS would be connected with reliable digital connections through copper or fibre optic cables. The maintenance and control in GSM-R network is organized from network management centre (NMC) or network operation maintenance centre (OMC) [7].

3.2. Evolution of Radio data transfer.

GSM-R supports most of standard GSM user's sets of voice and data services and the decreased number of canals in cells gives the opportunity of high quality High Speed Circuit Switched Data transmission (HSCSD) [9]. So it's possible to transmit near real time a video frames from the railway path to the locomotive cab in a united digital data stream. It will prepare the ground for the next step in GSM evolution – Enhanced Data rates for Global Evolution (EDGE).

4. GLOBAL CONCEPT FOR REMOTE RAILWAY DIGITAL VIDEO SURVEILLANCE.

4.1. Futures and requirements.

The design of the DVS system as a network configuration is based on a structure characteristics of GSM-R communication platform [4]. So that way is possibly to implement a universal radio data transmission system with soft control and multifunctional services of the whole transport processes and will decrease the maintenance expenses of railway equipment. To improve the safety traffic condition only the forward directed pictures are transmitted to the second driver in locomotive cab [10]. The implementation of widely used standards allows utilization of cheaper and worked off technologies. Additional price discount can be achieved by adoption the existing network software.

On Fig. 2 the general scope for railway remote DVS application is given. The traction surveillance control is a conventional computer based network system connected by a copper or fibre optic cables. It collects and records in DVS centre the video clips of the real railroad traction near the dangerous path points. Only a vehicle movement activates the cameras and the OMC/NMC operator observes on terminal the composition traction (Fig. 3).

The passenger terminals control is an integrated security and safety control system. The real time images from station

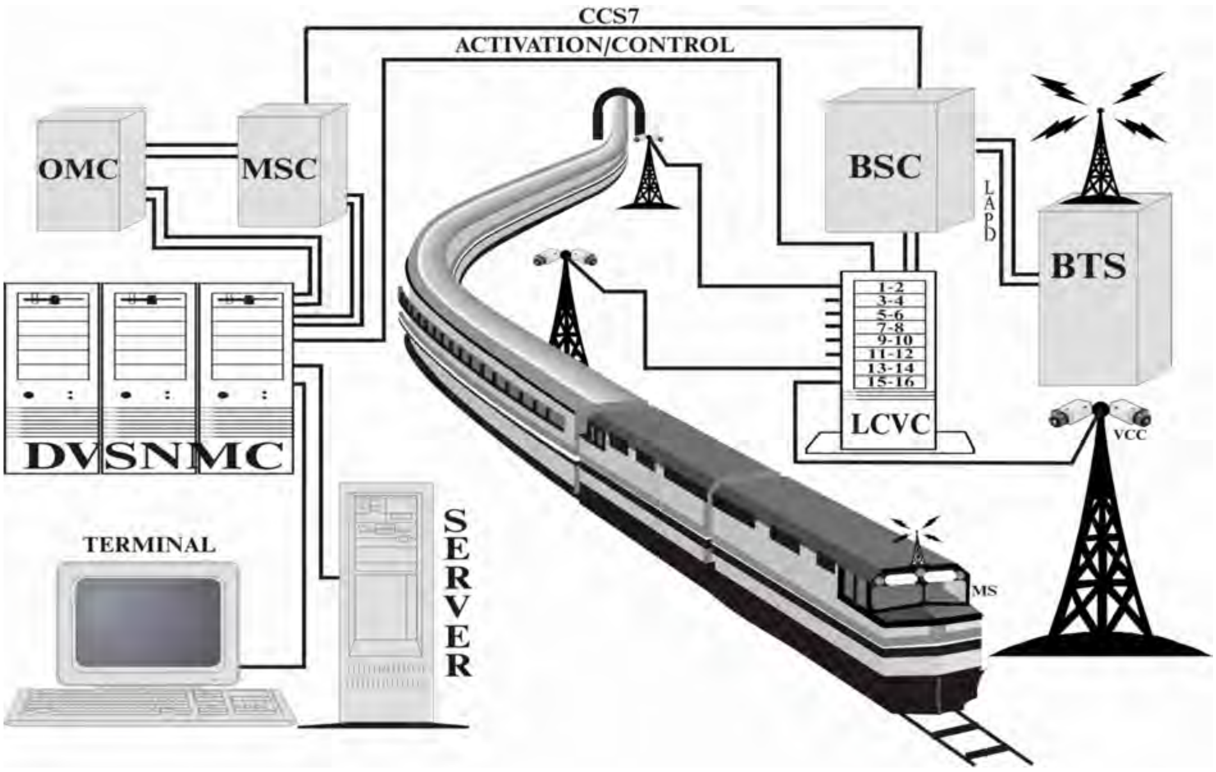

Fig.3: Mobile Concept for Railway Remote Digital Video Surveillance

platform are sent simultaneously to the railway dispatcher, security guard and to the departing/arriving train driver. Meanwhile the video information not concerned with the security or a movement is not available for routing without permission. The wireless transmission uses the reserved in GSM-R HSCSD canals [9]. In case of cell overload the connection returns to a standard data transmission mode with reduced image resolution.

Fig. 2. Global railway DVS solution

The vehicle control is carried out mainly on the train. The local train DVS computer collects data from the wireless cameras, placed inside and outside according to the trainload. The information is at train chef and/or train guard disposal and by needs they send it to the locomotive cab. The DVS dispatcher can retrieve it by the GSM-R downlink to resolve an arising problem.

4.2. Structure and connections.

The Railway Remote Digital Video Surveillance System (RRDVSS) will contain remote computer part for local two-way video surveillance of railway path and part of server connected via INTRANET (Fig. 3). The (LCVC) will scan the video control cameras (VCC) continuously and will save the compressed data on disk.

On first vision it looked not economically to store such large volume of information, but the coded images takes only about 150MB per day. Simultaneity with the recording the video data the information will be send to the Digital Video Surveillance Network Management Centre (DVSNMC). By using the wire interconnection in GSM-R network the time delay of the video packets will be less then one second.

Along the railroad, communication points should be arranged to connect the LCVC to the fixed GSM-R network. The connection between BSC and LCVC should be organized by ISDN links with LAPD. LCVC is necessary to be fixed nearly BTS and using the resources and functional redundancy of the system. Some of the temporary unused canals should be directed to LCVC.

The compressed information from VCC should be transferred to the DVSNMC. DVSNMC is controlling the video services according to the railway traffic and sends a command to the appropriated VCLC to transmit the local frames in BTS with actual date and time. Using the GSM-R radio canales the video frames are reaching the locomotive receiver connected to the mobile computer terminal (MCT) and the actual pictures from the forward path are displayed. For that purpose a work canal is reserved for uninterrupted data transfer with conformation. According to the fact that the GSM data stream is limited to 9.6kb/s [4] [5] is felicitous to work with packets containing the complete images in JPEG format. To constrain the unused data stream in cases of not passing locomotives along observed railroad is necessarily to elaborate train position software. Such program will be reading the actual cell position of MT from HLR and this allows sending the observed picture according to the train speed and direction. Meanwhile the images with the train composition movement taken from the backwards TV-

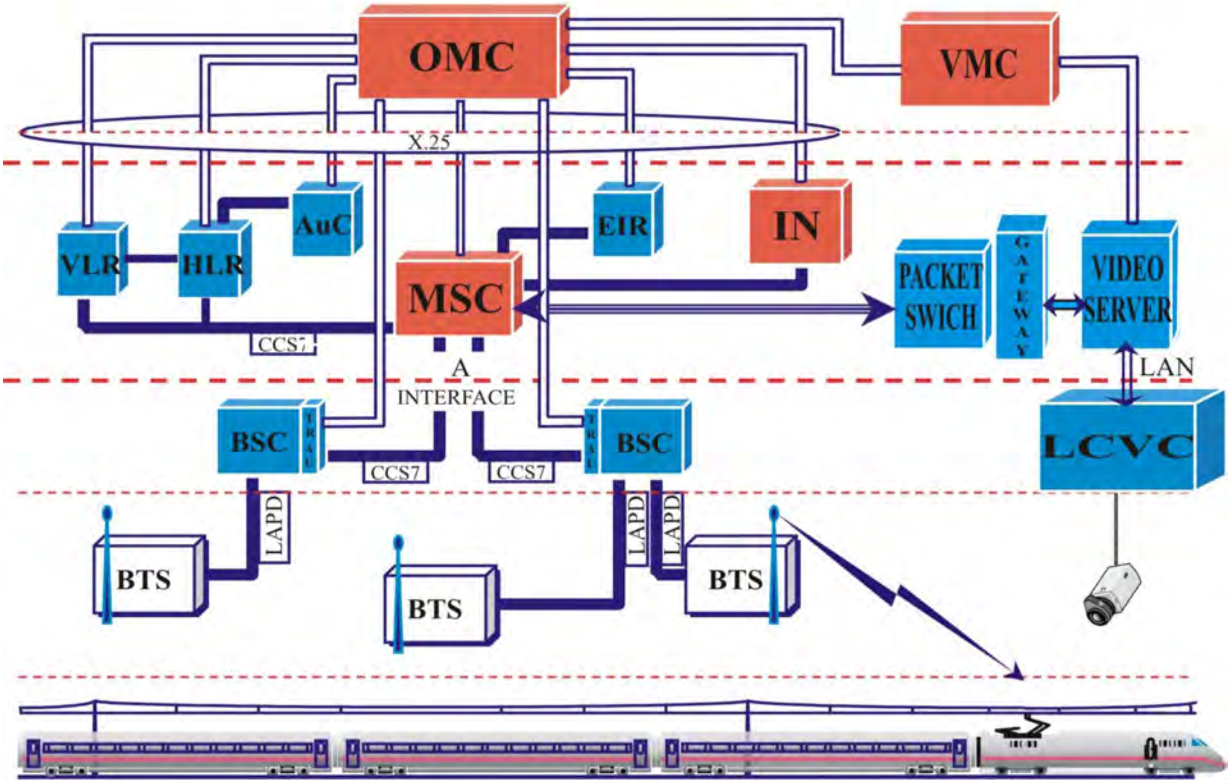

Fig. 4. GPRS video data transfer over GSM-R network

cameras will be transported to DVSNMC and in case of need it will e transferred in locomotive cab. The beginning of the digital recording ought to start from motion detection program after that the clip will be saved on the system server. In the same manner will be treated the transferred to the MCT and confirmed with reports frames. To guarantee authentication of the received data an installation on LCVC a digital watermarking program is needed and only the checked frames should be transmitted. In case of disparity the clip should be rejected and an alert command would be send to the DVSNMC terminal.

CONCLUSION

An investigation of the possibilities to implement a GSM-R global concept for remote railway digital video surveillance based on unified optical and wireless network is done. For that reason a different computers, telecommunication and fail-safe technologies are combined, so the appropriate software and hardware requirements are discussed. As a result, the highlight features of Global Mobile Concept for Railway Remote Digital Video Surveillance are described. The necessary structure was analyzed and some figures pointed out the practical realization of RRDVSS project on already builded GSM-R network can be realized on available price. The nowadays GSM data transfer technology can be enhanced with HSCSD to approach a real time remote observation.

The periodical received frames in locomotive cab from the railway path and the train composition will decrease the risk of arising incidents. By that time such situations are unavoidably in case of limited visibility and/or vehicle brake length.

And something more - the continuous video frames data transmission is convenient for calculation of BER and block errors to give a statistical base for reliability evaluation.

REFERENCES

[1] EIRENE Draft System Specification, version 7.0 UIC EPT, 1996.

[2] MORANE Sub-System Requirements Specification, A 04/02 T 6002, 1996.

[3] HÖRMANN, Digitales Betriebsfunknetz, Machbarkeitsstudie für Planung, Errichtung und Betrieb eines digitalen Betriebsfunknetzes auf Grundlage des GSM-Standards für Eisenbahnen Entwurf, 2000.

[4] TS-GSM 01.02 European digital cellular telecommunications system (Phase 2): General description of a GSM Public Land Mobile Network (PLMN).

[5] TS-GSM 09.02 European digital cellular telecommunication system (Phase 2) Mobile Application Part (MAP) specification.

[6] Topalov I., B. Avramov, Izsledvane na vasmojnostite za distancionno nabludenie na jp dvijenieto po GSM-R mreja, Telecom 2002, Varna, Bulgaria, 2002.

[7] Topalov I., B. Avramov, Osobenosti na terminalnite ustroistva za GSM-R slujebni komunikacii, XII Nauchna konferencia s mejdunarodno uchastie “TRANSPORT 2002”, vol. 1 pp. 479-484, Sofia, Bulgaria, 2002.

[8] Topalov I., B. Avramov, Isledvane vasmojnostite za GPRS prenos na video kadri po GSM-R mreji, Telecom 2003, Varna, Bulgaria, 2003.

[9] Topalov I.P., B.P. Avramov, Mobile Concept for Railway Remote Digital Video Surveillance, “INFOTRANS 2003, Pardubice, Chech Republic, 2003.