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DIAGNOSTIC INFORMATION TRANSMISSION SYSTEM
FOR RAILWAY TRAFFIC

As a result of the co-operation between the Institute of Control Systems and the company supporting rail track services, the concept of communication system using remote data transfer has appeared. The information was meant to be diagnostic in order to support users during service tasks. So far no rail infrastructure objects control has been planned. As a communication medium a cordless data transfer by SMS (short message system) has been chosen, using GSM modems.

SYSTEM TRANSMISJI INFORMACJI DIAGNOSTYCZNYCH
W RUCHU KOLEJOWYM

W referacie przedstawiony został przykład zastosowania transmisji informacji diagnostycznych z wykorzystaniem krótkich wiadomości tekstowych SMS. Zaprezentowano ogólną koncepcję systemu opracowanego na potrzeby obsługi infrastruktury kolei. Opisano rolę jaką pełnią poszczególne elementy systemu. Scharakteryzowano również komunikaty wymieniane pomiędzy obiektami, wraz z ich podziałem ze względu na funkcję którą mają realizować. Naświetlone zostały funkcje modułu komunikacyjnego podczas przygotowania wysyłanych i odbieranych komunikatów. Przedstawiony został też sposób wizualizacji zebranych danych diagnostycznych i formy ich prezentacji.

1. INTRODUCTION

Many areas of actual industry require such an indispensable function of systems in control of equipment operating parameters. This becomes especially important in case of remote diagnostic of devices spread over a large area. Considerable scattering of control points results in the very high costs of supervision over the operating parameters when performed by maintenance teams. In many cases such supervision would be difficult to perform. We my also expect problems related with transmission media (such as lack of access to the telephone lines). We have to deal with this drawback in case when the railway sites are dispersed over the entire country. Diagnostics of technical condition of the traffic control and management equipment is very important for the safety of the railway traffic. Number of data to be monitored at railway sites and to be sent between the system's nodes is not very large, and the access time to the diagnostic data is not a critical issue in this case, thus it is not necessary to re-send the data upon each change of status of the object. Data may be sent in the

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packages including changes of status within a selected period of time on request of the operator. For thus defined assumptions, a diagnostic data transmission system was developed;using short text messages SMS, using GSM modems, among others because of high electromagnetic noise level in the railway facilities.

2. DIAGNOSTIC INFORMATION TRANSMISSION SYSTEM

2.1. SYSTEM ARCHITECTURE

The diagnostic information transmission system was designed and created based on client – server architecture. A computer located in the diagnostic center (CTD) realizes tasks entrusted to the server, whereas object station computers (OTD) are client of thus designed system.

The system consists of the following elements:
- diagnostic center (CTD)
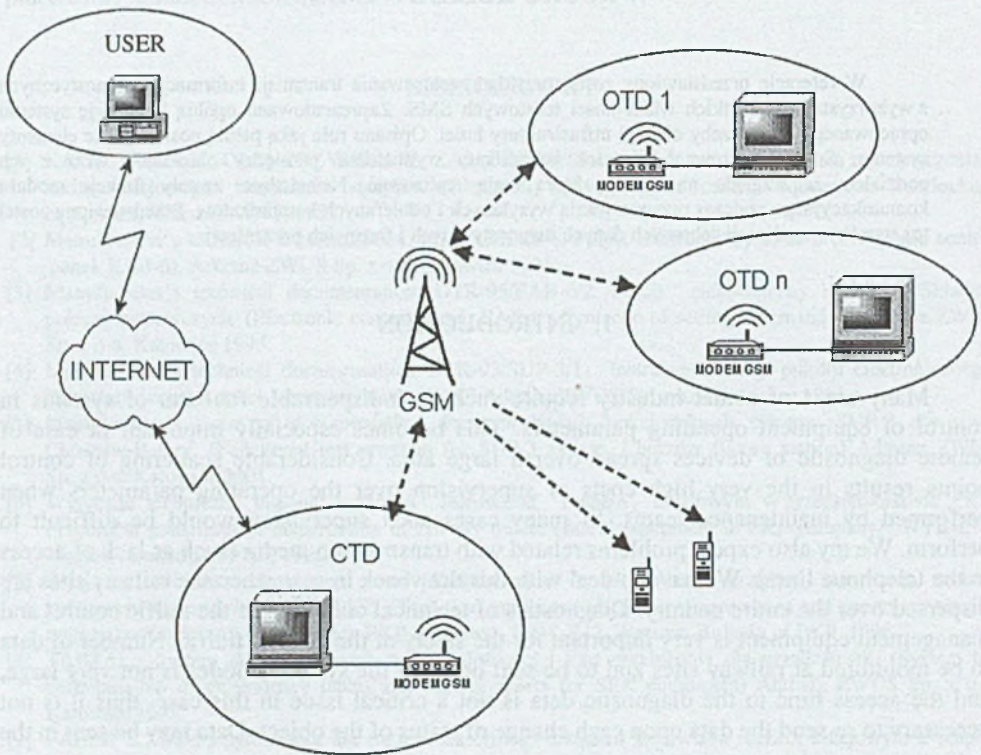- object station (OTD)
- users' cellular phones

Fig.1. Block diagram of the system architecture

The diagnostic center computer acting as a system server is provided with GSM modem and an installed software consisting of administrative and communication part.

Object stations, similarly as the diagnostic centers, are provided with GSM modems and software enabling communication and administering of the system. In addition OTD has installed applications controlling the objects.

Both diagnostic center and object stations operate based on an InterBase 6 database.

The cellular phones may also perform the role of specific clients' stations.

2.2. SYSTEM OPERATION

The diagnostic information being sent is created by the applications controlling physical objects of a railway trunk line. These applications transfer obtained data through the communication server to the local database of the object station (OTD). This information is subsequently processed by the client's station software and sent to the server using communication modem and GSM modem. The short text message (SMS) arrives to the modem at the server's side (CTD) and it is received by the communication module in a similar way. Then the software of diagnostic system processes it then writing to the database takes place. There is also a possibility to send the information from CTD to the specific object stations.

The administration software installed on the diagnostic center's computer enables edition of glossary files containing, among others, data about the message addressees (phone numbers of object stations and users of cellular phones), or names of alarms generated by the objects. It enables also a verification of status of communication with the object stations and possible control enforcement of connection with the selected object station.

The communication part of CTD software is responsible for retrieving the messages created after user's interaction and on their basis generating short text messages (SMS). For this purpose the message is being "cut apart" to the smaller pieces and assigned with information about consecutive number and general number of parts it is divided into. In addition, the message is supplemented with control characters addressed to the specific operators of the cellular phone network in order to receive a confirmation of message delivery.

The diagnostic center is the main element of the distributed transmission system and it controls the condition of connection with all object stations by generating an appropriate control message. It sends information about the glossary data and parameters of system operation to all OTD station in order to retain consistency of data on all objects. If necessary, it sends also information to the phone owners, thus notifying the appropriate persons about condition of equipment (such as notifying the maintenance team about a burned out lamp in the signal). It may also perform the function of the web server giving the authorized users access to the diagnostic data. If the required information is located in the CTD database, it is displayed, and in case of lack of desired information the center generates an appropriate message in order to obtain data from the object.

The object stations, similarly as the diagnostic center, are provided with the software enabling communication and administration of the system that the administration module enables configuration of the OTD station and follow-up of communication process. The communication software is identical with the one used by the diagnostic center. One of the main functions of the system designed is collection of detailed diagnostic data about condition of specific facilities. This information is generated by the applications controlling the objects,

then, on request of data retrieval issued by CTD, it is sent through the communication server to the OTD database, and from there, through the GSM network, to the Diagnostic Center.

Cellular phones being clients of the system are only able to receive the text messages concerning the alarms generated in the objects. Messages between CTD and OTD are exchanges in a binary form, whereas to the cellular phones they are forwarded in text form.

2.3. MESSAGES

Messages sent between the diagnostic center, object stations and user's phones may be divided into several basic types.

Object station configuration – on request of OTD administrator a request for object configuration for object application is issued. As an answer, the application returns a message with information about configuration to be subsequently sent to CTD. The diagnostic center keeps the data about configuration of all object stations.

Information about object status – during analysis of diagnostic information, the user may request data about object within a selected time interval, that are not in the center base. In this case CD generates a request message to yield diagnostic information and sends it to OTD. Software of the object station communicates using communication server with object application and receives data about status of the object in a selected moment of time (beginning of the requested time interval) and changes that have occurred within the indicated interval. Then the data obtained are being sent to the diagnostic center, where they are written to the base and where their visualization is possible.

Separate groups of diagnostic information are alarms spontaneously generated by the object application (without issue of a request). As understood by the system, alarm is any deviation of the correct operation of the object equipment or return to the correct operation (removal of malfunction). A message with an alarm is sent to the center, where it is written to the base and may be visualized in a similar way as the remaining states of the object. In addition, receiving an alarm message by the CTD, results in sending it to the selected addressees as the SMS to the cellular phones (text form). It enables quick reaction of appropriate persons to the malfunctions that have occurred on the railway line while the need of continuous monitoring of all devices by the maintenance teams is eliminated.

The organization messages – it is a special group of messages created in the system beyond the permanent message exchanges during normal operation. This group contains the following messages:

-       change of glossary contents – a message that is sent each time when any data concerning glossaries in the CTD base are changed. Its function is to perform the same changes in the OTD bases glossaries and maintenance of consistency of bases. It is sent from the diagnostic center to all object stations.

-       verification of connection with the station – a message that is sent each time upon exceeding the configured time from the last data exchange with the selected station. It enables determination of correct operation of the object station. In case of lack of response to the connection check one may assume that a malfunction of the object station may have occurred. In case of absence of connection check performed a malfunction of an OTD computer could be erroneously taken for a correct operation of the system (no alarms). A message of this type is always being sent by the diagnostic center to the selected object station.

-       confirmation of connection with the center – it is a response of object station on request of connection check issued by the diagnostic center.

-    requires of re - sending of a message – in the case of operator's malfunction, missing any message fragment, it may be remedied by the request of a re-sending of the lost message. This message is generated again both by the diagnostic center and the object station.
-    change of station configuration – in case of change of the object station configuration (a re-reading of configuration after object modification, change of nomenclature assumed for the selected object), this information is being sent to the center. Lack of such information in CTD is likely render impossible review of the diagnostic data of a selected object by the user. Change of station configuration takes place in the OTD database, and the message is generated at the object and then sent to the center.

2.4. COMMUNICATION MODULE

An important element of the system is its communication part, dealing with the access to the GSM modem, as well as initial message processing. The module communicating with the model is a separate part of the system and serves the purpose of connecting the software with the hardware. It makes available the modem service functions such as receiving and sending of a single message, erasing the accumulated messages from the SIM card.

The next part is responsible for processing, causes cyclical verification whether the GSM modem has received the messages, If yes, the message is taken from the SIM card of the modem and erased. Next, the message itself is being checked and its origin. If the message is issued by the sender whose phone number is not entered into the database, or the sender is a number identified as a phone, not a modem, this message is ignored. As a rule, CTD and OTD should receive the messages only from each other. The trace about a "false" message is written in the log of the program. However, if the SMS was sent by another modem it is subject to further processing. Now the information about number of packages constituting the complete message is being checked and in the case when the complete set is received, the restored message is written to the database in order to enable other programs take the appropriate actions.

During sending, the program divides the message (if necessary) to the shorter sequences, supplements them with information about the consecutive and total number of packages and flag for the operator (request of issue of message delivery confirmation). Thus prepared, the messages are one by one sent to the receiver but each new package is sent only upon receipt of confirmation about the delivery of previous one. This is aimed at avoiding the overflow of receiver's SIM card and loss of the message fragment. However, if upon a determined period of time (system parameters) no confirmation arrives, one may suspect that the operator is at fault and the package is being re-sent.
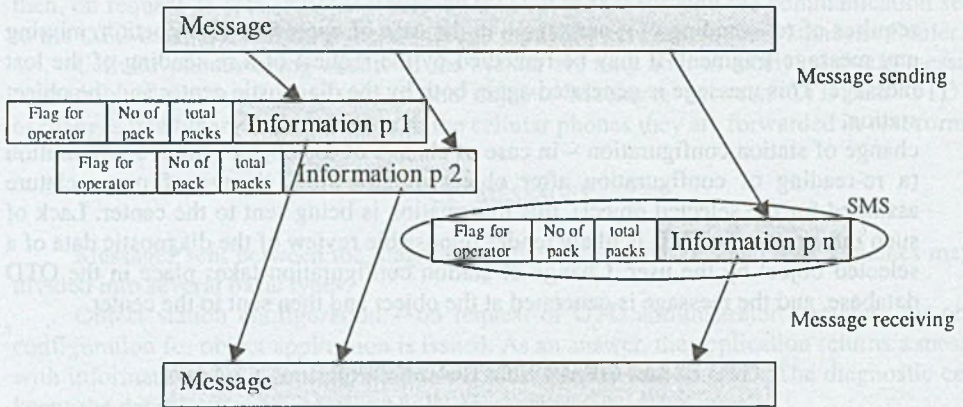
Fig.2. Sending and receiving message

If, for some reason, the received message set lacks one package, a request is issued to re-send the missing part.

The communication program generates messages in two formats. During transmission of data between the computers (CTD and OTD) in a binary form, whereas during sending the messages from CTD to the user (cellular phone) they are sent in text format. The messages to the phones are stripped of information concerning total number of packages sent and number of the package, but they are accompanied by an open information about time and date of creation of announced alarm (in the case of binary value transmission the date and time are sent in the floating dot format).

2.5. VISUALIZATION OF DIAGNISTIC INFORMATION

All information about the objects collected in the diagnostic center database may be reviewed using visualization software. However it is not easy, if for the necessity to use a computer in CTD. A more user-friendly form, giving an access to the same information and characterized by the similar way of its representation is Internet access. In this case, in order to obtain access to the diagnostic data it is sufficient to have a computer with access to the Internet. CTD, besides the diagnostic information transmission system server function, has to also perform the function of the web server. In order to maintain the confidentiality of presented data, access to the page, and more exactly to the database, and is protected with a password. Only authorized persons may review the information about system devices operation. The presented data include train traffic (track circuit occupancy), direction of travel, indications of signals and possible alarms announced on the train route for the selected section of the railway trunk line over the indicted time interval. Visualization may take place in a continuous way – animation, or selectively – jump to the selected condition. During follow-up of operation in a continuous way, subsequent events (states of the line) are displayed together with information concerning date and time of their occurrence. The second method allows for entry of status number to be displayed and then it is possible to review the condition of object at the previous or subsequent steps, using the control keys.

This enables better analysis of behavior of devices on the line, detection of all irregularities in its operation. Besides information displayed in a graphical way is possible to switch on the text presentation of messages with possibility of filtering. This makes easier the analysis of behavior of object being diagnosed from the point of view of selected message types. During continuous follow-up of information the message window is being scrolled in such a way that the messages for a current visualization process item are visible and they are additionally displayed in bold.
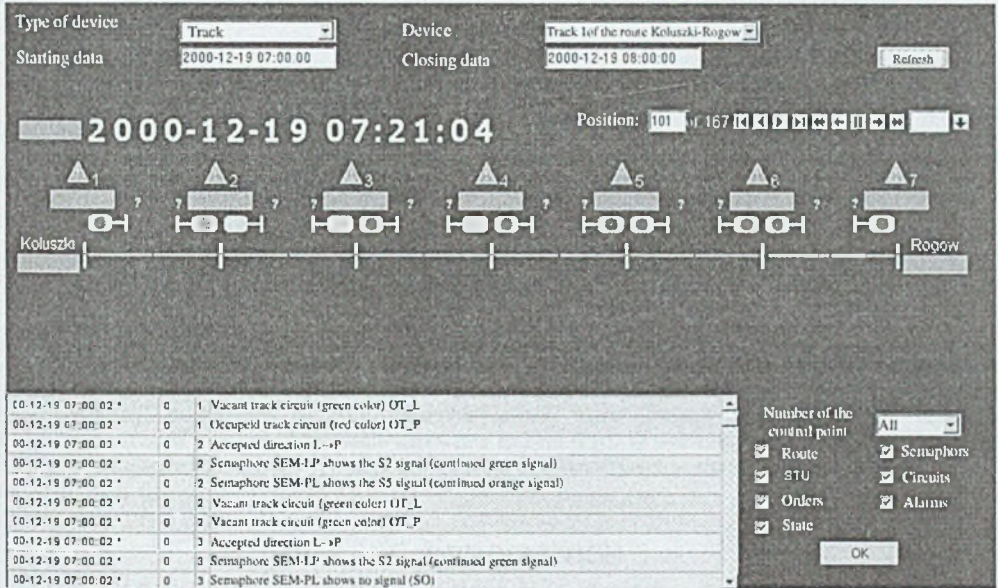

Fig.3. Visualization of diagnostic data

3. SUMMARY

The client-server idea assumed during creation of the project as well as transmission using short text messages using the GSM network has proven adequate for the assumption made. The diagnostic center located at the "available" place with Internet connection gives a good opportunity to review, check and analyze of data about railway lines. The object stations, distributed over the considerable area, frequently situated at the places without possibility of telephone line or Internet connection. Places, where they were located feature high level of electromagnetic field. Low level of the mobile phone network rendering difficult discussion by a phone; could impair also GSM transmission. In spite of low signal level, SMS messages have been sent without disruption.

The railway line diagnostic system is just an instance of data transmission application using text messages and it may be used everywhere, where the small amounts of data are being sent. This system may be installed almost everywhere without a need to spend money for development of telecommunication infrastructure (Internet, telephone).

Reviewer: Prof. Andrzej Lewiński