A Diagnostic Method for Axle Counting Systems Based on the SNMP Protocol

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Abstract. The railway traffic control systems' development arise from the need to ensure, by these systems, a high level of safety and reliability, and a required functionality. It is linked with the use of technical achievements in constructing new devices and systems. This means that contemporary railway traffic control systems are computer systems, using modern ICT systems. Thanks to this fact, new possibilities for the diagnosis of these systems arise, as well as maintenance and diagnostics centres are created. At the moment, there are no standards regarding the way and range of collecting diagnostic data. That is why, the authors of the paper have proposed a method for diagnostic data collection, consisting in using SNMP, which is commonly used in the diagnosis of computer networks. The research has been conducted for one of the railway traffic control systems – the Axle Counting Systems (ACS). Therefore, two MIB bases, in which diagnostic data structure was defined, have been developed, as well as software of the SNMP agent and manager has been worked out. The SNMP agent allows modification of data concerning the axle counting system and it makes the data available to the SNMP manager. It also has an implemented function to notify the manager about faults in the form of sent traps. The conducted experimental research has proven usefulness of this technology, and, at the same time, the need to extend the research to include other types of the railway traffic control systems.

Keywords: Railway traffic control systems · ACS · Diagnostic method
SNMP · MIB

1 Introduction

Contemporary railway traffic control systems are computer systems, commonly using modern ICT systems [1, 2]. It allows building local control centres, in which operators control railway traffic not on one, but on many signalling boxes. Along with these objects, what often arises are maintenance and diagnostics centres for information reception and processing, the information coming from the control area and passed on by the diagnostic subsystems of individual traffic control systems [3–5]. The SOAP protocol or implicit protocols are commonly used in diagnostics of railway traffic

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control systems. SOAP is the technology which allows network applications to exchange data using HTTP protocol, data structure is determined by XML format. Because currently there is a lack of standards regarding methods of diagnostic data collection, its range and ways of presenting, the authors of the paper have conducted a research concerning using for this purpose, known for managing computer networks, the SNMP standard [6–9]. The research has included axle counting systems, which are of great importance when ensuring railway traffic safety.

2 Axle Counting Systems

The basic role when ensuring safety in the railway transport is fulfilled by railway traffic control systems [10–12]. As the train traffic needs to be run so that a safe distance between vehicles is kept, it is necessary to receive information about the trains' location. This task is accomplished by railway track occupancy control systems. There are many methods of this control, the most modern ones are Axle Counting Systems (ACS), which use wheel detection points. A single track section of the track system has two possible initial states: clear or occupied. The occupied state takes place when a positive number of axles is detected between two detection points placed at the beginning and at the end of the section, the clear state takes place when the total number of axles detected is equal to zero. A fault state is when one of the detectors is damaged or when the system shows the occupied state, whereas in fact it is clear (there are no vehicles in the section). The operator, in this case, is obliged to run a reset procedure, as a result of which the system will wait for a test drive of a vehicle. The necessity to reset track sections results in the fact that the system operator should have the access to the diagnostic information. The system in the reset state goes to the clear state only after balancing the number of axles in the section, as a result of a rolling stock crossing the section. The reset function should not be available for the sections which are permanently damaged. That is why, on the basis of the balance of the axles, the states of individual sections, i.e. occupied, clear, section after reset, fault, are being defined by the ACS.

At the moment, there are many axle counting systems, i.e. ACS2000 and FAdC manufactured by Frauscher, Clearguard ACM 200 by Siemens, SCA3 by ALSTOM, Az LE by Thales, EBI Track 2000 by Bombardier Transportation, UniAC1 by Voestalpine, BO23 by AltPro, E-CE95 by Electrans.

3 Simple Network Management Protocol

Simple Network Management Protocol (SNMP) is a standard serving for a remote monitoring and management of TCP/IP networks [13, 14]. In this protocol, one can distinguish two categories of devices: managed ones, in which the SNMP agent is launched, and managing ones, the so called NMS (Network Management System), in which the SNMP manager is launched. The agent collects and shares information about the current status of the device, the information can be read and modified by the manager. Communication is based on the request-response rule and is initiated by the manager. Additionally, there is a possibility to pass on the information to the managing device without a previous request. Such messages, called traps, are sent by the agent after the occurrence of emergency situations, e.g. faults. For the transmission of the SNMP messages, the UDP (User Datagram Protocol) is used. Currently, there are three versions of SNMP, whereby in versions 1 and 2 security is based on communities, which are not encrypted passwords, whereas version 3 supports authentication and encrypted communication [15, 16]. In the management process, MIBs (Management Information Bases) are used [17]. Each object in the base has an ascribed name, value, type, description and a set of operations which can be performed on this object (read/write). The objects are stored in a tree structure, in order to gain access to a given object one has to provide names of all tree nodes, separated by dots, from the root to the leaf, whereby the names can be descriptive or numeric [18]. An advantage of the SNMP standard is a possibility to define new MIBs, at the same time it can be used in other fields than the computer network management. This feature was used by the authors of the paper, who have proposed a concept to use the SNMP technology in the axle counting systems in the railway traffic control diagnosis.

4 MIB Specification of Axle Counting Systems

In order to define the range of data which can be accessible to the management station by the ACS, two private MIB files were developed. In the first file, called *TRAP-ACS-MIB.mib*, SNMP traps that can be sent by the agent were defined. In this case one deals with the following parameters:

– *sysName, sysLocation,* which are system objects, defined in RFC 1213,
– *faultCode* INTEGER type, which is a code for any errors,
– *faultDesc* DisplayString type, which is a short description of an error.

Content of the *TRAP-ACS-MIB.mib* file, including SNMP traps specification, has been presented in the Listing 1.

```
TRAP-ACS-MIB DEFINITIONS ::= BEGIN
IMPORTS
   DisplayString FROM RFC1213-MIB
   OBJECT-TYPE FROM RFC-1212
   enterprises FROM RFC1155-SMI;
-- (ACS) Axel Counter Systems
acs OBJECT IDENTIFIER ::= { enterprises 2022 }
acstrap OBJECT IDENTIFIER ::= { acs 2 }
faultCode OBJECT-TYPE
   SYNTAX  INTEGER (0..255)
   ACCESS  not-accessible
   STATUS  mandatory
   DESCRIPTION "Fault code
   1xx - System events
   2xx - Error while executing the reset
         axle counter track section"
   ::= { acstrap 3 }
faultDesc OBJECT-TYPE
   SYNTAX  DisplayString (SIZE (0..255))
   ACCESS  not-accessible
   STATUS  mandatory
   DESCRIPTION "Fault description"
   ::= { acstrap 4 }
acs-trap TRAP-TYPE
   ENTERPRISE acstrap
   VARIABLES { sysName, sysLocation, faultCode,
               faultDesc }
   DESCRIPTION "The variables included in the ACS trap"
   ::= 1
END
```

Listing 1. Specification of the SNMP traps of the ACS [own study].

In the second file, called *ACS-MIB.mib*, diagnostic parameters characteristic for the axle counting system status, which can be read by the management station, were defined. Among the variables, there are:

- *sections* INTEGER type, number of controlled track sections,
- *wheelsensor* INTEGER type, type of wheel sensor: RSR122(1), RSR123(2), RSR180(3), ELS-93(4), ELS-95(5), CTI(6), ZK24-2(7), MM4Z(8),

and the status board of the ACS:

- *sectionWhen* DisplayString type, timestamp,
- *sectionName* DisplayString type, section name,
- *sectionState* INTEGER type, section status: occupied(1), clear(2), fault(3), after resetting(4),
- *sectionAxesNumber* INTEGER type, number of axes.

A chosen fragment of an ACS-MIB.mib file has been presented in the Listing 2.

```
ACS-MIB DEFINITIONS ::= BEGIN
IMPORTS
   DisplayString FROM RFC1213-MIB
   OBJECT-TYPE FROM RFC-1212
   enterprises FROM RFC1155-SMI;
-- (ACS) Axel Counter Systems
acs OBJECT IDENTIFIER ::= { enterprises 2022 }
acsinfo OBJECT IDENTIFIER ::= { acs 1 }
-- ACS parameters
   sections OBJECT-TYPE
      SYNTAX INTEGER (1..65535)
      ACCESS  read-only
      STATUS  mandatory
      DESCRIPTION "Number of controlled track sections"
   ::= { acsinfo 1 }
(…)
-- Section status
  sectionTable OBJECT-TYPE
      SYNTAX SEQUENCE OF SectionEntry
      ACCESS not-accessible
      STATUS mandatory
      DESCRIPTION "A table (concept) with information
         about the state of ACS"
   ::= { acsinfo 3}
   sectionEntry OBJECT-TYPE
      SYNTAX SectionEntry
      ACCESS not-accessible
      STATUS mandatory
      DESCRIPTION "A single table entry (concept) with
         information about the state of ACS"
      INDEX { sekcjaIndex }
   ::= { sectionTable 1 }
   SectionEntry ::= SEQUENCE {
      sectionIndex INTEGER, -- Index
      sectionWhen DisplayString, -- When
      sectionName DisplayString, -- Section name
      sectionState INTEGER, -- Section status
      sectionAxesNumber INTEGER -- Number of axes
   }
   sectionIndex OBJECT-TYPE
      SYNTAX INTEGER (1..65535)
      ACCESS read-only
      STATUS mandatory
      DESCRIPTION "A unique value for each entry in the
         table with information about the state of ACS"
      ::= { sectionEntry 1 }
   sectionWhen OBJECT-TYPE
      SYNTAX DisplayString (SIZE (0..20))
      ACCESS read-only
      STATUS mandatory
      DESCRIPTION "The date and time of the event"
```

```
    ::= { sectionEntry 2 }
 (…)
 END
```

Listing 2. Specification of SNMP objects of the ACS [own study].

5 SNMP Agent and NMS Monitor

Conducting research, which aim is to assess usefulness of the SNMP technology in the railway traffic control systems diagnosis, on the basis of the axle counting system, required constructing a dedicated software. In order to do that, two programs were designed: the SNMP agent, which is a simulator of the axle counting system and the NMS (Network Management Software). The SNMP agent stores and shares, on manager's request, all necessary data which structure was defined in private MIBs for the axle counting system. That is to say, the agent's software required implementing compilation functions of these MIB structures. The agent's main screen has been presented on the Fig. 1.

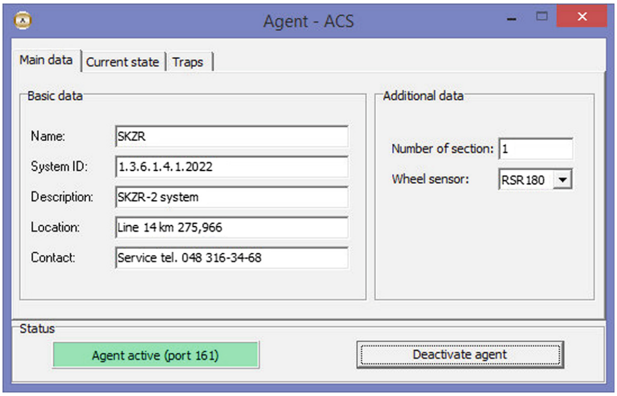

Fig. 1. SNMP agent's main screen [own study].

Because of a simulation of real ACS, the agent's software includes a possibility to create and modify system work history, which has been presented in the Fig. 2.

The agent also contains a functionality consisting in allowing sending traps to the manager, which has been presented in the Fig. 3.

Traps, in accordance with a definition in the MIB base have been divided into: system events and reset errors. The first group of traps contains: "No connection to the controller", "A connection to the controller is resumed", "The system time was changed", "The backup power supply is ON", "The power supply is ON", "Diagnostic mode is enabled", "Diagnostic mode is disabled", "User login". The second group contains the following reset errors: "Track section occupied", "Incorrect control code",

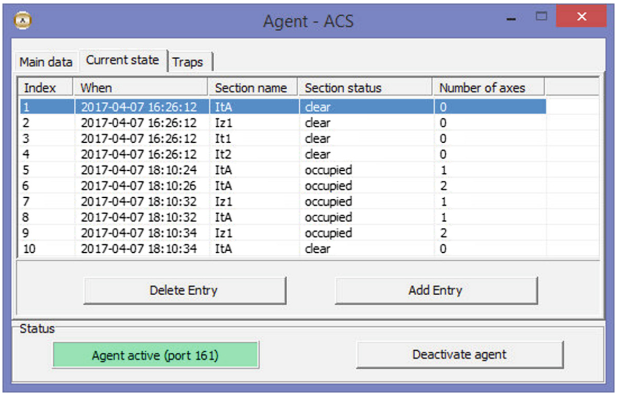

Fig. 2. SNMP agent's screen serving for simulation of ACS [own study].

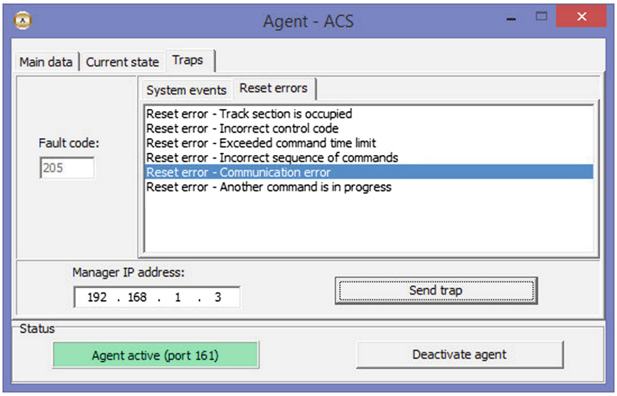

Fig. 3. SNMP agent's screen serving for sending traps [own study].

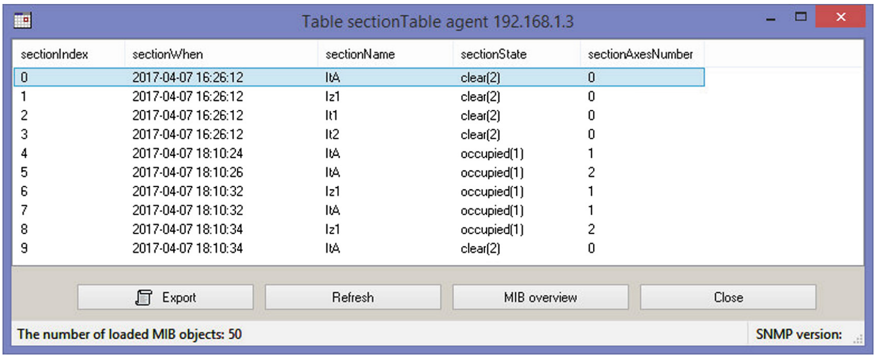

Fig. 4. Reading of ACS work history [own study].

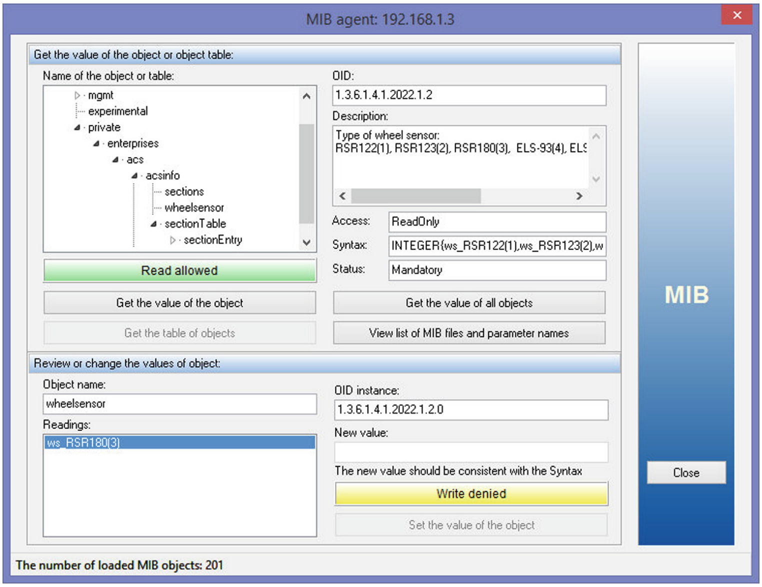

Fig. 5. Reading MIB objects of ACS [own study].

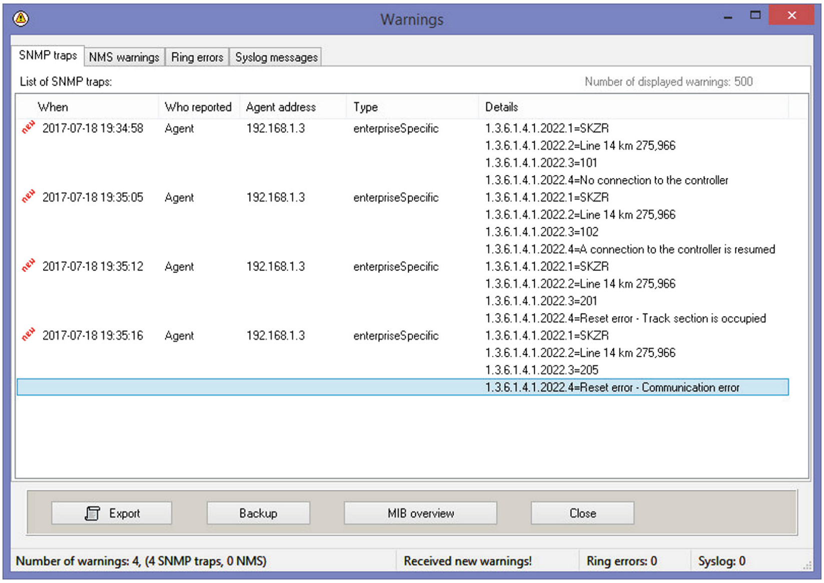

Fig. 6. Example traps with information about the ACS failure [own study].

"Command time limit exceeded", "Incorrect command sequence", "Communication error", "Another command is already in progress".

As it has already been mentioned, an NMS software was designed, allowing the operator to send requests to the SNMP agents, which are individual axle counting systems, as well as to collect traps. It allows for a quick diagnosis of the status of monitored systems and for a detection of faults, which shortens their duration. The first functionality, which was taken into account in the NMS application, was the implementation of a MIB compiler.

The NMS software allows reading historical data concerning its work, and both the parameters of a chosen ACS (Figs. 4 and 5).

The NMS software has also an enabled feature to collect traps sent by the SNMP agent. When an event occurs, the trap details are logged along with the time, hostname, IP address, and trap type and can be used for a later analysis (Fig. 6).

6 Conclusion

SNMP should be regarded as a set of standards for computer network management, which is composed of data exchange protocol, security and management mechanisms and database structure specification, including data definition language and information formats. The authors of the article, inspired by this technology, have proposed to use the SNMP technology in the railway traffic control systems diagnosis. At the moment, there are no standards in this matter, which results in the fact that each producer offers their own solutions, which are not coherent where it comes to data collection and the way of its presentation. In this paper, an example structure of a management information base, designed for the needs of the ACS, and a dedicated software of the SNMP agent and manager have been presented. The research conducted by the authors of the article, concerning the use of SNMP in the ACS diagnosis, has proven a significant usefulness of this technology. Based on it, the authors conclude that SNMP could also be used in the diagnosis of other types of the railway traffic control systems. Developing a common standard based on SNMP would allow standardizing data structures for the railway automation systems diagnosis. Such an attitude could also guarantee both developing a common diagnostic system for the railway traffic control systems, and unifying interfaces between the systems. It would certainly be a big facilitation in building maintenance and diagnostics centres.

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