communication, GPS
railway, telemonitoring

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POSSIBILITIES OF TELEMONITORING SYSTEMS IN RAILWAY TRAFFIC

The need for the use of telematics system is also affecting the railways to ensure on-line and up-to-date information on the transport operations. This paper presents the current state of the system development, and its position in the global informatics system of the Hungarian State Railway Co. The article also outlines the main attributes of the developed fleet management system and the future plans of development.

PAPER TITLE IN POLISH

Summary in Polish. No longer then 3 sentences. For natives obligatory, for foreigners organizer ensure translation.

1. INTRODUCTION

The use of telematics systems is wide spreading in the area of road transport, and almost all road transportation companies have their own real-time fleet management system. The need is also arising in the field of rail transportation, and it is affecting the Hungarian State Railways (HSR) also. The HSR developed several systems in the past few decades for keeping pace in the race for competitiveness in the area of transportation.

The problem emerges as the new informatics systems of the railways needs more and more precise and up to date information of the fleet. The handling of the engines is managed by the Traction Subsidiary Company of the State Railways, and its previous logbook system which is handling all information of the trains was "paper-based" meaning all information was generated on paper-forms and was inserted to the informatics system after the service of the driver or engine ended. Naturally these data were nor online, nor real-time.

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The development and implementation of the online telematics abd telemetrics system, started in 2006 with a pilot project under the cooperation between the HSR and the Department of Control and Transportation of the Budapest University of Technology and Economics. Under the interval of the pilot project, several systems were tried, and several manufacturers were invited, and on the experiences of this project, the development of the final system for the HSR was started in 2007. Now, all engines are equipped with an onboard unit, registering the position of the train and measuring the main engine and cockpit attributes. The development of the overall system is not finished yet, though it is operable now. This paper presents the current state of the system development, and its position in the global informatics system of the HSR and the future plans of development.

2. GLOBAL SYSTEM STRUCTURE

The telematics and telemetrics system takes its place in the informatics system of the Hungarian State Railways as can be seen in Figure 1. The telematics system is part of the IT system of the Traction Company, since this firm possesses and manages the engine fleet of the Hungarian Rails.

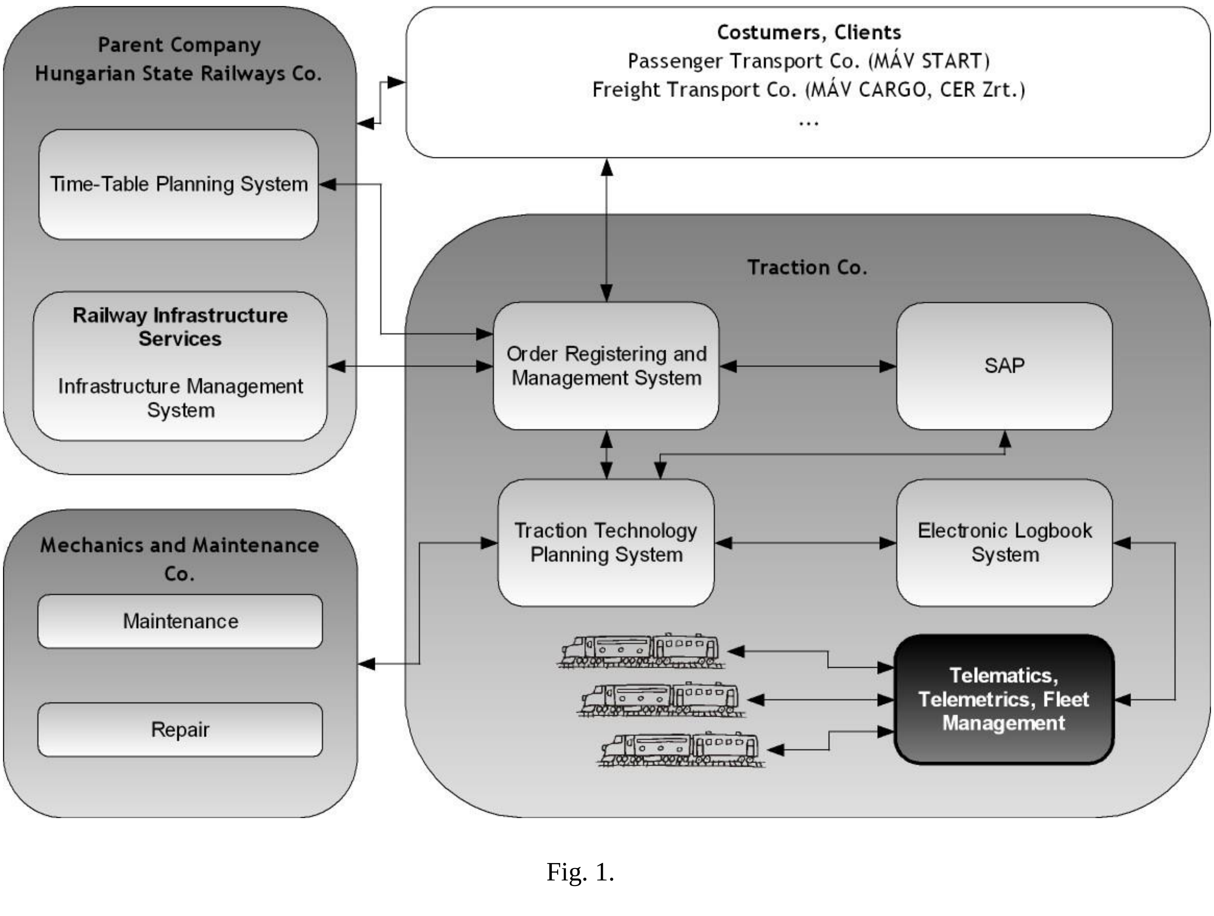

Fig. 1.

The system is part of the *Electronic Logbook System (ELS)*, which manages all communication with the fleet, and stores all data received from the trains.

The ELS is connected to several systems (though for simplicity reasons, all connections are not marked on the figure), but it main interface leads to the *Traction Technology Planning System (TTPS)*.

It can be said, that the TTPS is the main core system for the Traction Co., since the TTPS handles the engine drivers' service and working time planning, the planning of the engine turns and allocation. Therefore the TTPS must be connected with the *SAP* system of the Railway Co., the *Order Registering and Management System (ORMS)*,and also with the *Maintenance and Repair Systems* of the Maintenance subsidiary company of the Rail Co.

The ORMS handles the ordering procedure. Its main task is to receive the main attributes of the orders, and after transforming it to preliminary schedule, and transfers it to the TTPS (and to the ELS) systems. Naturally it is connected to the SAP also, and to the main Customer Companies, such as the "MÁV START", which is handling the passenger, and "MÁV CARGO" which is handling the freight transport services.

3. TELEMATICS

In the following section the main architecture of the telematics system is outlined. In addition the elaborated network model and the developed communication protocol are explained.

3.1. ARCHITECTURE

The construction of the online fleet management system [7] is demonstrated on Figure 2. The two main components are:

- on-board computer,
- central server.

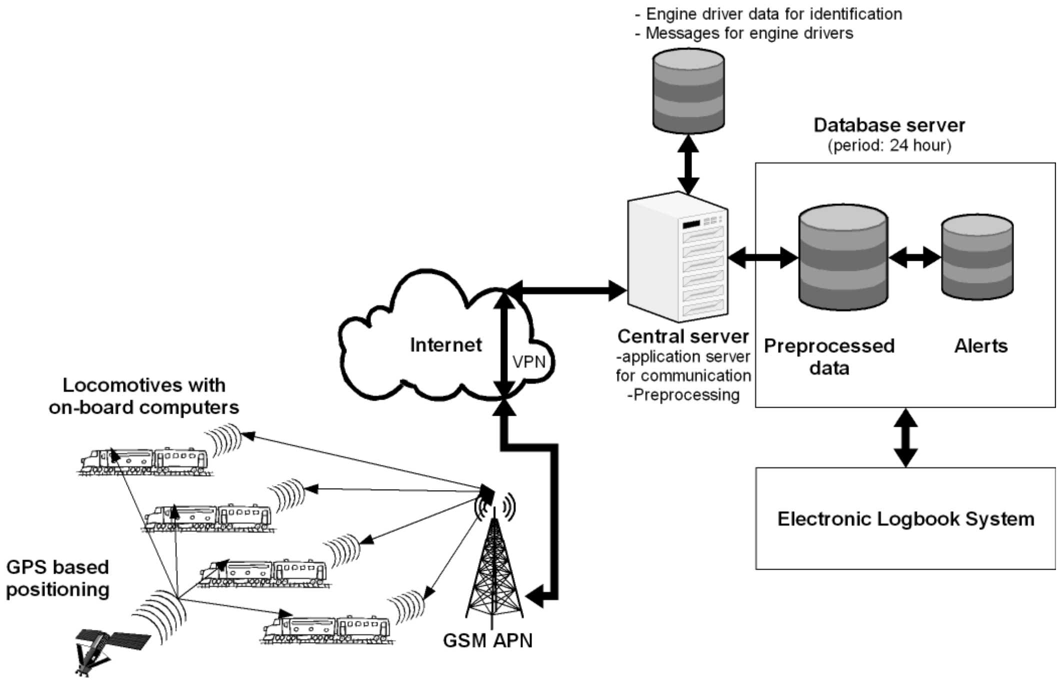

Fig. 2. System architecture

The operation of the system is the following. The on-board units (OBU) on the locomotive measure the operational parameters of the locomotive (state of the switches, energy consumption, motor parameters, etc.), and its position (aided by GPS based location), and they store the data given by the engine-driver (the name of the actual activity, etc.). These parameters are sent to a central server at the actualization of previously defined events (alarm-signal, sudden decrease in fuel level, etc.) and in previously defined periods of time.

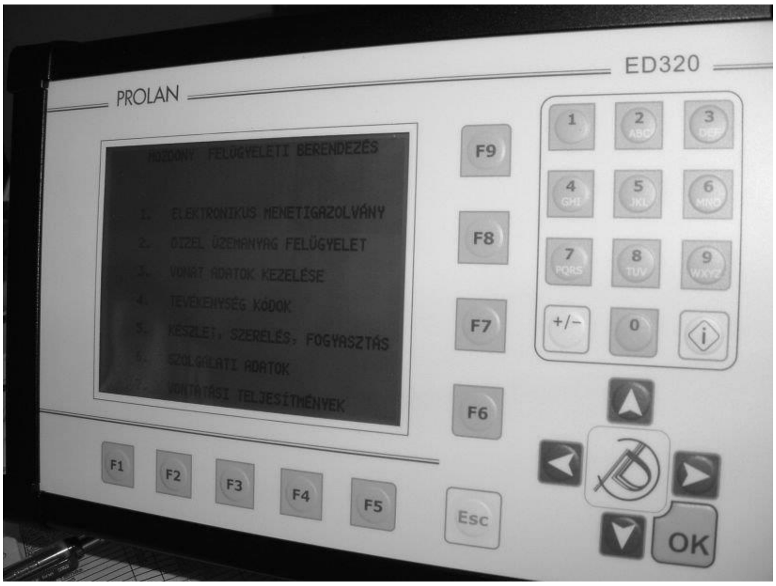

Fig. 3. The MMI of the on-board unit

On-board computers communicate with the central server through GSM network. The incoming data are evaluated and stored in a database. If necessary the central server can send an alarm to a given e-mail address or even a mobile phone. In this structure communication from the server towards the locomotive is plausible as well. Aided by this the incoming data packages can be confirmed, a written message can be sent to the engine-driver and the parameters of the board unit can be set.

Locomotives are detectable and observable almost constantly (online) and the operating parameters (running performance of vehicles, energy consumption, activities and work time of drivers, delivery performance) can be followed by a later evaluation of data stored in the centre (offline).

The most important aspects of the building of an on-board unit are heavy-duty design (EMC protection, shake protection, fluctuation of environmental temperature, etc.) and modularity. Therefore one should use a system that is built up of individual units. The connection of these by a series communication connection is worth realizing for the sake of simplicity and easy expansion. For this the most appropriate is the Controller Area Network (CAN) bus system.

Board unit [2] is made up of the following main units:

- GSM/GPS module,
- central unit,
- incoming unit,
- human interface device,
- diagnostic adapter,
- CAN bus,

- power supply unit and background batteries.

The Man-Machine Interface of the OBU is shown on Figure 3. The OBU was designed and manufactured for MÁV-TRAKCIÓ by PROLAN Co.

3.2. NETWORK MODEL

The communication system can be build up by OSI model [3] as shown on *Table 1*. The connection point between the OBU-s and the server is the session layer (TCP socket).

Basically the network model is built on IP based technologies and protocols. The OBU-s communicates with help of the GSM based internet service. The modems use General Packet Radio Service (GPRS).

Considering the safety aspects [6] the OBU-s connect to a dedicated GSM APN and there is Virtual Private Network (VPN) between the internet service provider (ISP) and the central server.

In our model the Transmission Control Protocol (TCP) is used in the transport and session layers because of the following advantages in relation to the User Datagram Protocol (UDP) [1]:

- Ordered data transfer,
- Retransmission of lost packets,
- Discarding duplicate packets,
- Error-free data transfer,
- Congestion/Flow control.

In the data block of TCP packet a record structure was built up, which contains the data of the locomotive and the train. For the declaration of the structure and data types a standard XML schema [4] was created.

Table 1

The 7-layer model of the communication subsystem

OSI model	Used protocol or service
Physical layer	GSM, 100BASE-TX
Data link layer	GPRS, Ethernet
Network layer	Internet Protocol (IP), Virtual Private Network (VPN)
Transport layer	Transmission Control Protocol (TCP)
Session layer	TCP socket
Presentation layer	UTF-8
Application layer	XML based protocol

3.3. COMMUNICATION

For the reliable communication an XML [5] based protocol was designed with the following main properties:

- The OBU has to initiate the communication. (The OBU-s are the clients, the center is the server.)
- The link is permanent; the disconnection is permitted only if an error occurs.
- If there is not any working link, it needs to be established as soon as possible
- The protocol uses the XML 1.1 standard. The data must be validated by an XML Schema Definition (XSD) file. Only the convenient data can be accepted.

- Every message must be acknowledged. The sending of a message has to be repeated until acknowledgement. (The timeout is 30 seconds.) The errors caused by frozen TCP sockets can be eliminated by this method.
- Every message must contain an ordinal number. The persistence of this number needs to be checked for finding absent messages.
- The protocol is change-oriented. Only the changed data should send to the server. This technique can decrease the communication costs.
- Every message must contain the following data:
  - Ordinal number
  - Timestamp (UTC)
  - GPS data (validity, longitude, latitude, heading, speed)
- At the start of the communication the OBU must login to the server with its own individual identifier.

A part of the developed XSD is shown below. This is the structure of the GPS data:

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema elementFormDefault="qualified" id="MFB"
xmlns:xs="http://www.w3.org/2001/XMLSchema">
<xs:complexType name="GPS">
  <xs:sequence>
    <xs:element minOccurs="1" maxOccurs="1" name="Status" type="xs:byte" />
    <xs:element minOccurs="1" maxOccurs="1" name="lon" type="xs:double" />
    <xs:element minOccurs="1" maxOccurs="1" name="lat" type="xs:double" />
    <xs:element minOccurs="1" maxOccurs="1" name="course" type="xs:integer" />
    <xs:element minOccurs="1" maxOccurs="1" name="speed" type="xs:integer" />
  </xs:sequence>
</xs:complexType>
```

3.4. FUNCTIONALITY

The telematics system, as its recent state has the following functionalities:

- *Self identification*, where the OBU identifies the engine UIC number to the server.
- *Data sending*, where the OBU sends the collected data to the server
  - Base data group: message UID, timestamp, GPS position, speed and heading.
  - Technical parameters data group: engine speed, engine temperature, energy consumption, switch states, etc.
  - Activity data group: train data, customer data (any service related data, if not given by server).
- *Message from the server to the driver,* where the operator sends non-formal message to the driver.
- *Message from the driver to the operator*, same as above, opposite way.
- *Service start-stop messages*, Service start/stop notifications for engine drivers and other workers (including human authentication and authorization).
- *Data request from the OBU*, where the OBU requests for data stored on the central system.
  - Accumulated Fuel level, if there are more engines connected together into traction formation.
  - Train Data, train number, accumulated weight, etc.

- *Emergency alerts:* Both generated by the OBU or the engine driver. (fire, accident, malfunction, detected anomalies, etc.)
- *Geofencing:* where the OBU detects the entering/leaving of a previously given area, and sends notification. (stations, point areas, crossings, etc.)

4. FUTURE PLANS

In the near future several new functions are going to be developed in the above mentioned system. Thanks to the modular and the high-performance on-board units the improvement can be resolved with less investment. One of these future developments will be the "On-line Time-Table System", enabling the engine driver to get its current service time table online, and follow its changes on the display of the on-board unit during the service periods.

Another possible future development is the driver assistance system, where the driver not only gets its service time table, but depending on track engagement and track characteristics, the driver would get precise driving speed recommendations from the online system for optimizing the energy consumption of the railway engine.

To better follow the engine drivers' service time, and for the better management of their working hours, the drivers will be equipped with an online handheld communicator, which's system will be integrated with the current telematics system, so all driver allocation and operational management problems will be handled online.

The real-time information of the trains also enables the creation of the future passenger information system, where the passengers can acquire up to date information about the possible arriving times, and delays. This system is also enables the freight customers to follow the route of their goods.

5. CONCLUSIONS

On the experience of the three years of system development, it can be said that the introduction of real time telematics system of the HSR fastened up the Rail management process. The data generated by the new fleet management system is more precise than the previous systems' were, and the online train allocation and the fast answers to the anomalies in transportation became easier. The introduction of the system opened the path for many upcoming systems, such as the online passenger information system.

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