Gathering Information from Transport Systems for Processing in Supply Chains

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DOI 10.1515/eng-2016-0096
Received June 24, 2016; accepted July 30, 2016

Abstract: Paper deals with complex system for processing information from means of transport acting as parts of train (rail or road). It focuses on automated information gathering using AutoID technology, information transmission via Internet of Things networks and information usage in information systems of logistic firms for support of selected processes on MES and ERP levels. Different kinds of gathered information from whole transport chain are discussed. Compliance with existing standards is mentioned. Security of information in full life cycle is integral part of presented system. Design of fully equipped system based on synthesized functional nodes is presented.

Keywords: logistics, RFID, AutoID, traceability, Internet of Things, trainset

1 Introduction

Businesses, consumers and authorities in various markets around the world are interested in setting up systems for tracking and tracing of products at various points in the supply chain. This shared interest is most evident in the food, beverage and pharmaceutical products, but key principles can be applied to any industry sector. GS1 is a top-level organization for standardization of such a kind systems [1].

Organizations require consistent traceability solutions spanning the full supply chain regardless of country or industry sector [2–4].

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Communication networks are nowadays dynamically self-organized and self-configured, with the nodes in the network automatically establishing an ad hoc network and maintaining the mesh connectivity.

Technical means for gathering data (sensors) are equipped by processors with sufficient processing power not only for primary data preprocessing but also for communication tasks. Basic data aggregation from particular data sources are common tasks in gathering systems. Important behavior of these modules is low power consumption, e.g. long operating time without battery replacement.

Data processing systems support almost all activities on ERP and MES levels. They can support all data processing activities and presentation of information [5–7].

2 Methods

All particular parts mentioned in previous chapter can be put together to bring new added value to CSM systems, to extend information with tracing and visibility. What is necessary to build such system?

– Subsystem for gathering data from smart transportation units
– Subsystem for data transfer from any defined place
– Subsystem for primary data storing and verifying
– Connector to process data in ERP and MES software

2.1 GS1 Rail Vehicle Visibility Standard

This standard [1] defines requirements, procedures, message formats and others for performing gathering and processing tasks in rails (train transport). It extends keys and attributes applied in the EPCIS Rail [8, 9].

GLN (Global Location Number): The SGLN EPC scheme is used to populate an EPCIS event with a GLN (either with or without the optional extension component), which uniquely identifies a physical location: urn:epc:id:sgln:CompanyPrefix.LocationReference.Extension.

GIAI (Global Individual Asset Identifier): The GS1 Identification Key is used to identify an Individual Asset.
The key comprises a GS1 Company Prefix and Individual Asset Reference.

The needs for information sharing are mainly found to be two-fold:

- tracking of vehicles as they travel within countries and across different countries (“asset tracking”) and
- associate the vehicle data with the Wayside Train Monitoring System (WTMS) data about vehicles and vehicle components to enhance preventive maintenance.

RFID enabled AVI (Automatic Vehicle Identification) systems usually comprise of fixed readers and wheel sensors. The fixed trackside readers identify the vehicles of the passing train, while the train speed can be up to the full line speed at that track location. The AVI system is capable of identifying all tagged vehicles and their order in the train, and also is able to detect the presence of vehicles with missing or broken tags and their relative location in the train. The latter is important for the WTMS (Wayside Train Monitoring System) use case, since it enables the measurement results to be linked to the correct vehicles in a train set. In addition, the AVI system can determine the travel direction, the orientation, axle count, speed and length of each vehicle.

![Fixed trackside RFID configuration.](image1)

In this rail visibility standard [1] the following EPCIS event types and actions are applied:

- ObjectEvent (action OBSERVE), which serves as an observation of a uniquely identified rail vehicle in passage along its journey, or upon its arrival at or departure from a terminus;
- TransactionEvent (action ADD), which serves as a “summary” event following the observation of a passing train’s trailing vehicle, reiterating the proxy GIAIs of positively identified vehicles, as well as relevant totals (e.g., number of wagons, number of axles) for all – identified and unidentified – vehicles.

Event data consists of all when, what, and why information. So, there is a possibility, for example to calculate (1) a simple average speed $v_a$ [km/h] of train set:

$$v_a = \frac{s}{t} = \frac{\text{Dist}_{\text{readPoint}} - \text{Diff}_{\text{eventTime}}}{t} \quad (1)$$

where $s$ [km] is the distance between points located by readPoint/bizLocation (urn:epc:id:sgln:734005385.011.511) and $t$ [hrs] is the time difference between related event-Time (2014-12-08T12:00:00.000+02:00).

### 2.2 Mesh Networks and Internet of Things

Wireless Mesh Networks (WMNs) have emerged as a key technology for next-generation wireless networking. Because of their advantages over other wireless networks, WMNs are undergoing rapid progress and inspiring numerous applications. Wireless mesh networks are dynamically self-organized and self-configured, with the nodes in the network automatically establishing an ad hoc network and maintaining the mesh connectivity. WMNs are comprised of two types of nodes: mesh routers and mesh clients [10].

![Example of Smart Grid Network](image2)

Due to the ability of dynamic (re)configuration, when added to train set, each wagon can identify and communicate with its neighbors and transfer particular identification data to the locomotive. In the locomotive data processing unit, these particular data are aggregated and transferred by communication means of the Internet of Things to target information systems (ERP and/or MES). Selected information can be presented to the locomotive-driver (global state of whole train and each part of it and...
immediate security alarms or exceedance of technical limits).

There are several communication wide area networks for Internet of Things (LoRa, SigFox etc.). They are optimized for long term operation of end nodes. The disadvantage is the limitation of the amount of data that can be transferred, but reliability is increased by redundancy of transmission (communication with more base stations and repetition of transmission). Daily amount of data $DA_d$ (2) is usually limited (for example in SigFox network) to:

$$DA_d = n \cdot s_m = 140 \cdot 12 = 1680 \text{ B} \approx 1.64 \text{ KiB}$$

where $n$ represents number of messages and $s_m$ size of message.

3 Solution

Extraordinary or emergency events in transport processes bring down their efficiency and often require additional costs. Information and communication technologies can build supporting systems that can avoid these kinds of malfunctions. Many of particular tasks were solved already with simulations and other verifications [11–16]. Crashes, breakdowns and downtimes in transportation systems take place quite often. This results from poor technical state of vehicles and transportation means. There are many causes for these failures. These incidents are often accompanied by some loss of human lives or health. Considerable loses are also caused by necessary restrictions on the transport route owing to damage and subsequent long-lasting intensive repairs. There are solutions which in practice are able to remedy these deficiencies or limit them, but these solutions do not solve the root cause of these incidents, only their effects.

3.1 Smart Logistic Unit

Technical solution consists of the installation of elements of information technology (IT) for each traffic/transport means (e.g. rail wagon, container, etc.) to be operated on railway. These elements allow for monitoring, recording and evaluation of all or any previously selected operational and planning parameters.

Operating parameters can be:
- wheel speed / wheelset bearing temperature
- brake system pressure
- brake status of the brake cylinder
- axle load
- involvement in sets
- transport space parameters (temperature, humidity, etc.)
- detecting of involvement of traffic / transport means in the trainset
- location of the means (wagon)
- direction of movement
- more...

Planning parameters can be:
- tonnage
- area and volume of space
- manufacturer
- type and model of traffic / transport means
- serial number (or other identification)
- service information:
  - inspection intervals
  - the time and place of the last inspection
  - the next time of the inspection
- identification of the owner
- identification of the tenant
- more...

Based on the controlled and continuously evaluated parameters, it will be possible to schedule maintenance, continuously monitor the technical condition of each wagon and even to signal failure in real-time. Signaling faults in real time will restrict the operation of damaged traffic / transport means or, in case of serious damage, will disallow the means to be operated and remove it immediately from operation. Thus equipped transport / shipping agents will be subject to scheduled maintenance: by mileage, wear-out of critical parts, amount of cargo transported or other specified conditions. Transport / shipping agent will also signal unevenly placed load, overload, etc. Such traffic / transport vehicle will not be allowed to the transport route until the fault is resolved. Usage of IT elements on a railway car or road truck will enable unambiguous identification and transfer of operating parameters to the relevant information systems, simplifying the operation of transport systems, statistical records, monitoring of technical conditions and the resulting maintenance and inspections scheduling. Each transport / shipping means is also equipped for local communication.

Figure 3 shows an example of the technical solution. Total block arrangement and interactions of individual functional parts are presented. Conveying transport means with automatically identified operational state is a standard accompanied with intelligent data logger DL, which receives data via data links (21, 22, ... 2n) from sensors (SN1, SN2, ... SNn) like speed sensor, temperature
sensor, pressure sensor, brake pad wear sensors, position sensors, cylinder sensors, etc. The memory module (MM) stores the technical, accounting, administrative and other information about traffic / transport means. The module is bidirectional data-linked (31) to a data logger (DL). Data logger (DL) communicates bi-directionally using communication modules (CM1, CM2 ... CMn) with technical service at the depot, and other nodes / means of transport via the communication infrastructure. For manual access to the system, a user module (UM) is also provided. When necessary (failure or emergency situation) alternative communication is used by independent communication module. Individual communication modules communicate with a data logger unit DL using links (41, 42, ... 4n).

3.2 Data Processing Background

Standard communication (Figure 4) between individual traffic / transport means (KZ1 ... KZn) within one train set (using redundant communication modules KM1, KM2) is directed to the coordinator (KO) in the head of train set (locomotive, etc.). Here the information from each connected traffic / transport vehicles is processed and using the communication module (KM0) transmitted to the higher information system. In case of failure of this communication, alternative communication is used for the transmission using other suitable communication block within the set (eg. KM0 placed on KZ1). For transmission of fault / emergency information, each wagon / container etc. is able to communicate directly to the higher system using Internet of Things network. In case when standard communication is not possible, module SM1 can be used for off-line data transfer.

4 Discussion

In current practice frequent accidents, breakdowns and downtimes occur in railway transport due to poor technical condition of the wagons. The main cause is poorly controlled technical condition of vehicles, maintenance and low level of prevention that results from the non-existent evidence of technical and operating parameters of railway cars (speed, distance traveled, load, resp. overload vehicles etc.). These situations are acute and the increasing number of railway accidents and collisions is getting worse. As a result, substantial funds are spent just for the repair and maintenance of rolling stock, the railway line itself and real estate (stations, demolished trolley lines etc.). These incidents are often accompanied by loss of human lives or health.

The presented solution is able, in practice, to remedy these deficiencies or limit them. But this solution do not solve the root cause of an incident, but helps to take over an emergency situation as a result. Operation state monitoring, timely scheduled maintenance of traffic / transport vehicles (fleet and others) can reach a stage where it will be possible to prevent problem caused by traffic / transport means access to transport route and thereby minimize the chances of risk / emergency situations.

5 Conclusion

Working order of transport means is not communicated/provided in its full complexity. This common situation causes frequent accidents during the transport means’ operation. Implementation of described system
for systematic monitoring and recording of the technical state of logistic / transport units (railcars, locomotives and others in other kinds of transport) may prevent a lot of predictable failures in transportation. New automatically gathered information will be processed in information systems on MES and/or ERP levels so new quality of outputs, suggestions can be provided for management of logistic processes. The solution is applicable in all companies that operate transportation. These companies can get significant benefit from this kind of system.

Acknowledgement: The presented solution was designed in cooperation and support of Gaben Company under project RFID Research Center Gaben CZ.1.03/4.2.00/13.01170 covered by OPPI Ministry of Industry and Trade, Czech Rep. and other projects.

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