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IT system for locomotive maintenance control – safety improvement in rail transport.

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Abstract

The operation of rail vehicles causes their components to wear. Each part has its predetermined lifetime, which may be followed by its failure. The effect of prolonged operation of locomotives without replacing endangered components may be their sudden failure. We want to avoid such situations because of the threats they pose. One of the most serious here is the derailment of rolling stock by, for example, a worn-out bogie. To increase this security, we offer an IT system that controls the deadlines for replacing used components in the locomotive. Currently, existing IT systems allow only the signalling of equipment failure. There is no such alert system against the wear of a given part. In this work, we propose the IT system for maintaining locomotive preventive repairs. The responsibilities of this system will include ensuring timely replacement of parts on the locomotive. The system will report the approaching deadline for parts replacement through wireless communication with the server and directly to the driver. For communication with the server, we suggest using the GSM-R system used on railways. These activities are part of the global trend of smart railways.

Keywords: preventive maintenance, railway safety, wireless communication, railway enhanced services, data security, IoT, MQTT.

1 Introduction

The operation of rail vehicles causes their components to wear. Each part has its predetermined lifetime, which may be followed by its failure. The effect of

prolonged operation of locomotives without replacing endangered components may be their sudden failure. We want to avoid such situations because of the threats they pose. One of the most serious here is the derailment of rolling stock by, for example, a worn-out bogie. Breakdowns also have an impact on train delays, which translates into an increase in indirect costs related to rolling stock as well as social costs incurred by passengers. Hence, keeping the rolling stock in good shape depends very much on periodic inspections and repairs.

Generally, we have three methods to prevent failures. The first is the signalling of sudden malfunctions and immediate replacement of worn sets [1], the second consists of the preventive replacement of parts [2] and the third based on the conditional replacement of sets [3]. It is clear that the safety of passengers and goods transport largely depends on the efficient rolling stock. To increase this security, we offer an IT system that controls the deadlines for replacing used components in the locomotive.

Currently, existing IT systems allow only the signalling of equipment failure [4]. There is no such alert system against the wear of a given part. This problem particularly applies to older locomotives that do not have computer systems on board. The task of the system presented here is to record events related to the replacement of a component and to signal the approaching date of replacement of a specific part. This signalling involves transmitting information to organizations dealing with the repair of locomotives and to the motorist currently on the train. In its assumptions, the system should work for all types of trains, regardless of the IT infrastructure installed in it. In this work, we propose the IT system for maintaining locomotive preventive repairs. The responsibilities of this system will include ensuring timely replacement of parts on the locomotive. The system will report the approaching deadline for parts replacement through wireless communication with the server and directly to the driver. These activities are part of the global trend of smart railways [5]. The IT solutions market in the field of Internet of Things (IoT) and the Industrial Internet of Things (IIoT) on the railways is growing by 14.4% annually [6].

2 Methods

The main component of the system presented here is the NVIDIA Jetson nano minicomputer [7]. Further elements of the system are GSM/GPS/WiFi communication, and an OLED display. This choice is not accidental. This computer works at a voltage of 5V, and at a maximum load consumes 4A, this gives demand for power of 20W. The device has the Linux operating system version UBUNTU 18.04. From the software side, the main element of the system is the MariaDB database working as relational database server. This database stores information about each component in the locomotive. The most critical information needed for preventive replacement of a part is; component name, lifetime, date of last replacement. The whole system closes with proprietary software written in Python. The broad library base for this language allows combining various components into one efficient system. The OLED display presents data about which part to replace and how much time left to replace (Figure 1).

Figure 1: The experimental IoT setup.

After replacing the worn-out assembly, the mechanics communicate with the device through the secured channel and confirm the replacement. For this purpose, they can connect directly to the device via an Ethernet port or wirelessly using WiFi. They will have a web interface at their disposal, after which they will be able to change the date of the last replacement of a given part after logging in. The whole system is complemented by GSM communication, which allows informing a team of repairmen about the need to replace a component in the locomotive. Data about many trains can thus go to one server. For data transmission, we recommend the encrypted MQTTS protocol used in IoT. An additional option is to use geolocation to indicate the approximate location of the locomotive.

3 Results

The device's task is to register locomotive components in the database and check the current time. These actions are needed to determine the upcoming replacement date of the part. The most significant aspect is the device's communication with the server via the GSM module. Here a terrain obstacles may hinder communication. During testing, as soon as the base station was within the transmitter range, no packet loss was reported. Simulations of the upcoming replacement time of a given component did not reveal any irregularities in the system's operation. The display correctly showed the name of the part to be replaced. After connecting to the Ethernet or wireless (WiFi) port, you could update the database status without any problems. The problem that especially required attention was information security. Password encoding in the SHA256 standard ensures the exclusion of unauthorized persons during operations on the device. The SSL/TLS protocol is responsible for encoding the entire network transmission. The only serious problem would be

device theft and reading SD card sectors. In this arrangement, the device itself should be specially protected. The device should be entered in the condition of the locomotive and the driver should be responsible for its loss. The device should be mounted in a visible place for the driver, who should receive video and audio signals.

4 Conclusions and Contributions

In conclusion, the presented system allows managing locomotive repairs based on the life cycle of individual components and their wear related to the time that have been driven by this rail vehicle. The IT system of locomotive maintenance allows in the future to reduce the number of failures, and at the same time, increase the possible speed of rolling stock. A team of mechanics is informed directly about the need to replace a given sub-assembly. This solution will significantly improve the repair management of many locomotives that are currently in operation. New to other solutions is the possibility of using this system to operate older equipment without interfering with the electric installation of the locomotive. Nowadays, there are many countries in the world in which rail vehicles are older than 30 years. In the case of such a system, its implementation costs are also of considerable significance. The hardware layer alone should not cost more than 200$. The proprietary software alone is more expensive, priced at approximately 900$. We should also include the monthly costs associated with maintaining the GSM connection for communication with the central railway server. This price does not seem to be excessive for the possibility of increasing the safety of rolling stock. In the future, data security can be increased by encrypting the file or by using an encrypted file system at the operating system level.

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