DEVELOPMENT OF AN AUTOMATED PROCESS MODEL FOR DEVICE REGISTRATION AND CONTROL IN RAILWAY AUTOMATION AND TELEMECHANICS

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Abstract. The article introduces an implementation-ready framework that unifies equipment registry, runtime control, and document operation management in railway automation and telemechanics. There are three layers to the piece. First, we formalize the digital circulation of scientific articles by representing tasks, phases, and their transitions with graph structures, making both the process and data flows explicit. Second, we construct an information schema linking sections, stations, devices, events, and expenditures, ensuring that each device retains a unified “passport” and a complete life-cycle record. Third, we implement the model in the automated control and accounting system for railway automation and telemechanics devices (ASA-CRAT) software stack: a C# application that communicates with a Microsoft SQL Server database and supports secure, role-based access. Users register devices, record movements and configuration changes, schedule planned works and replacements, log decommissioning, and export reporting forms. Modules handle plan tracking, cost entry, and printing, while audit trails preserve provenance of edits. Interoperability with existing paper-electronic procedures will be maintained for legally important records, but day-to-day work will move to a single system mode. The findings demonstrate useful benefits, including quicker document preparation, more cross-organizational traceability, and prompt access to up-to-date technical data for decision-making. It is a unified standard for electronic document management, a capable of being deployed software solution capable of expanding across signaling and communication units in extensive railway networks, and an expandable architecture for overseeing information sources and devices.

Keywords: electronic document of technical documentation, signaling and communication distance, repair and technological section, server, database.

Аннотация. В статье представлена готовая к внедрению платформа, которая объединяет реестр оборудования, контроль времени выполнения и управление документооборотом в железнодорожной автоматике и телемеханике. В этой статье есть три уровня. Во-первых, мы формализуем цифровое распространение научных статей, представляя задачи, этапы и их переходы в виде графических структур, что делает понятными как процесс, так и потоки данных. Во-вторых, мы создаем информационную схему, связывающую

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разделы, станции, устройства, события и расходы, гарантируя, что каждое устройство будет иметь единый “паспорт” и полный отчет о жизненном цикле. В-третьих, мы внедряем модель в программный комплекс автоматизированной системы управления и учета устройствами железнодорожной автоматики и телемеханики (ASA-CRAT): приложение на C#, которое взаимодействует с базой данных Microsoft SQL Server и поддерживает безопасный доступ на основе ролей. Пользователи регистрируют устройства, регистрируют перемещения и изменения конфигурации, планируют запланированные работы и замены, регистрируют вывод из эксплуатации и экспортируют отчетные формы. Модули обрабатывают отслеживание плана, ввод затрат и печать, а контрольные журналы сохраняют происхождение изменений. Для ведения юридически важных документов будет сохранена совместимость с существующими бумажно-электронными процедурами, но повседневная работа будет переведена в режим единой системы. Полученные результаты демонстрируют полезные преимущества, включая более быструю подготовку документов, большую межорганизационную прослеживаемость и оперативный доступ к актуальным техническим данным для принятия решений. Это единый стандарт электронного документооборота, готовое к внедрению программное решение, которое может быть распространено на узлы сигнализации и связи в обширных железнодорожных сетях, а также расширяемая архитектура для контроля источников информации и устройств.

Ключевые слова: электронный документ технической документации, дистанция сигнализации и связи, ремонтно-технологический участок, сервер, база данных.

Annotatsiya. Ushbu maqola temir yo‘l avtomatika va telemexanika sohasida qurilma reyestri, ish jarayonlarini boshqarish va hujjat aylanishini yagona tizimda birlashtiruvchi, joriy etishga tayyor dasturiy platformani taqdim etadi. Taklif etilgan yechim uch qatlamdan iborat. Birinchidan, texnik hujjatlarni raqamli aylanishi vazifalar, bosqichlar va ularning o‘tishlarini graf tuzilmalari orqali formallashtiriladi, bu esa jarayon va ma’lumot oqimlarini aniq ko‘rsatadi. Ikkinchidan, uchastkalar, stansiyalar, qurilmalar, hodisalar va xarajatlarni bog‘lovchi axborot sxemasi quriladi; har bir qurilma yagona “pasport” va to‘liq ishlash ma’lumotlariga ega bo‘ladi. Uchinchidan, model temir yo‘l avtomatika va telemexanika qurilmalarini ro‘yxatga olish va nazorat qilishning avtomatlashtirilgan tizimi (ASA-CRAT) dasturida amalga oshiriladi: Microsoft SQL Server bilan ishlovchi C# ilovasi xavfsiz, rollarga asoslangan kirishni qo‘llab-quvvatlaydi. Foydalanuvchilar qurilmalarni ro‘yxatdan o‘tkazadi, ko‘chirish va konfiguratsiya

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o‘zgarishlarini qayd etadi, reja ishlari hamda qurilmalarni almashtirishlarni rejalashtiradi, hisobdan chiqarishni rasmiylashtiradi va hisobot shakllarini yuklab oladi. Modullar reja ijrosini kuzatish, xarajatlarni kiritish va chop etishni ta’minlaydi, audit jurnallari tahrirlar kelib chiqish tarixini saqlaydi. Huquqiy ahamiyatga ega yozuvlar bo‘yicha amaldagi qog‘oz–elektron tartiblar bilan muvofiqlik saqlangan holda, kundalik ishlar yagona tizim rejimiga ko‘chiriladi. Natijalar hujjat tayyorlash tezlashgani, tashkilotlararo nazorat kuchaygani va qaror qabul qilish uchun yangilanib boruvchi texnik ma’lumotlarga tezkor kirish imkoni yaratilganini ko‘rsatadi. Yechim elektron hujjat aylanishi uchun yagona standart, keng temir yo‘l tarmoqlaridagi signalizatsiya va aloqa bo‘linmalariga kengaytiriladigan dasturiy tizim va axborot manbalari hamda qurilmalarni boshqarish uchun kengaytiriladigan arxitekturani taklif etadi.

Kalit so‘zlar: texnik hujjatlarning elektron hujjati, signalizatsiya va aloqa masofasi, ta'mirlash va texnologik bo‘lim, server, ma'lumotlar bazasi.

Introduction.

A considerable improvement in labor and employing more specialists to administer technical documentation is necessary for implementing programs oriented at technological reassigning of the automation system. Therefore, implementing a program to transfer the signaling system to an automated one is critical for Uzbekistan railways JSC.

The move to automation in railway control requires an electronic process of documentation facilitating decision-making in train operations as well as in installation, running, and upgrading of the system.

Implementation of electronic document management systems is one of the leading challenges in the direction of shifting railway transportation initiative to electronic governance. A significant amount of technical documentation manually created, processed, and evaluated continues to remain in archives of Uzbekistan railways JSC. At the same time, various services and organizations continue to deliver primary data in strictly the same order, which leads to an increase in cases of “Operator errors” and increased costs due to inefficient work.

Surveys in technical writing have been conducted by the project “Automated system of accounting and control of railway automation and telemechanics devices” (ASA-CRAT), and those have been transformed into theoretical models and methods of implementing electronic document management [1–6].

Material and Methods

This section describes the software functions of the electronic document and technical documentation (EDTD) subsystem of the systems of railway automation and telemechanics (SRAT). The transportation activities apply rational algorithms

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as a formal grammar, particularly in high-tech systems such as railways and control and analysis systems. The train safety and railway automation system is thus made of numerous discrete events [7].

These factors determine the persistent trend in the process of creating electronic documents of technical documentation (EDTD) and, as such, the persistent necessity for new system-technical solutions. Of course, engineering systems' solutions must be substantiated by quantitative proof. This means provide the necessary resources and support to enable creation and maintenance of EDTD systems.

All EDTD information is stored in the database management system, MS SQL Server. The database structure follows the client-server model by distributing work across two layers. As regards to performance, there are two core modules in software, i.e., client and server.

Microsoft SQL server's database management system (DBMS) houses all details of the EDTD. Following client-server architecture concepts, there are two divisions of work run by this database in two tiers. The system's functioning is divided into two areas, i.e., client and server areas.

The central component of the database structure is the database server. It has a procedural interface by which certain data can be sent from the database to the client.

Visual Studio 2019 integrated development environment utilized C# programming language to come up with a solution to the problem of generating applications.

This standardized-by-Microsoft C# programming framework is an extremely powerful software development tool, serving even experienced programmers. It can be traced to its integrated environment consisting of an editor, debugger, programming language, object-oriented programming, extensive in-built graphical capabilities, and an option to take advantage of modules and procedures written in other programming languages.

These study results were used to develop the "Automated system of accounting and control of railway automation and telemechanics devices (ASA-CRAT)" reported in [8,9].

In an effort to control technical process activities and monitor device status, ASA-CRAT was installed. Applying information technology in providing security, control, and connectivity to the outside world of e-business is part of office life in ASA-CRAT. This program allows one to add, modify, and delete devices and appliances. The automated system supports local and network communication at the level of document flow procedures.

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Results and Discussion

In order to confirm the generalized formal framework, an asset registration and operational control automation system for railway automation and telemechanics was implemented. The system was tested on the Tashkent communication and signaling distance (SCD-1).

An architecture diagram of ASA-CRAT software complex is given in figure 1. At Uzbekistan railways JSC, repair and technology sections (RTS), signaling and communication distance (SCD) will install ASA-CRAT in centralized servers with common database to launch the system rollout. ASA-CRAT, in combination with registration module and an electronic document management subsystem, will control document flow and increase the efficiency of communication and signal equipment.

These modules utilized the main findings [7, 9, 12]. The technical report created to interface ASA-CRAT in the architecture of the electronic document management system is shown in figure 1.

By shortening the time it takes to generate documents, electronic document management systems expedite the procedure of making decisions. The introduction of electronic document management in railway automation and telemechanics features an increased processing time of technical documentation, amplified information-security requirements, and an extensive scope of work.

In information and communication technology, there would be an increased possibility of interaction between interest-driven businesses through its application, and also there would be automation and maintenance of interaction between businesses operating in different industries.

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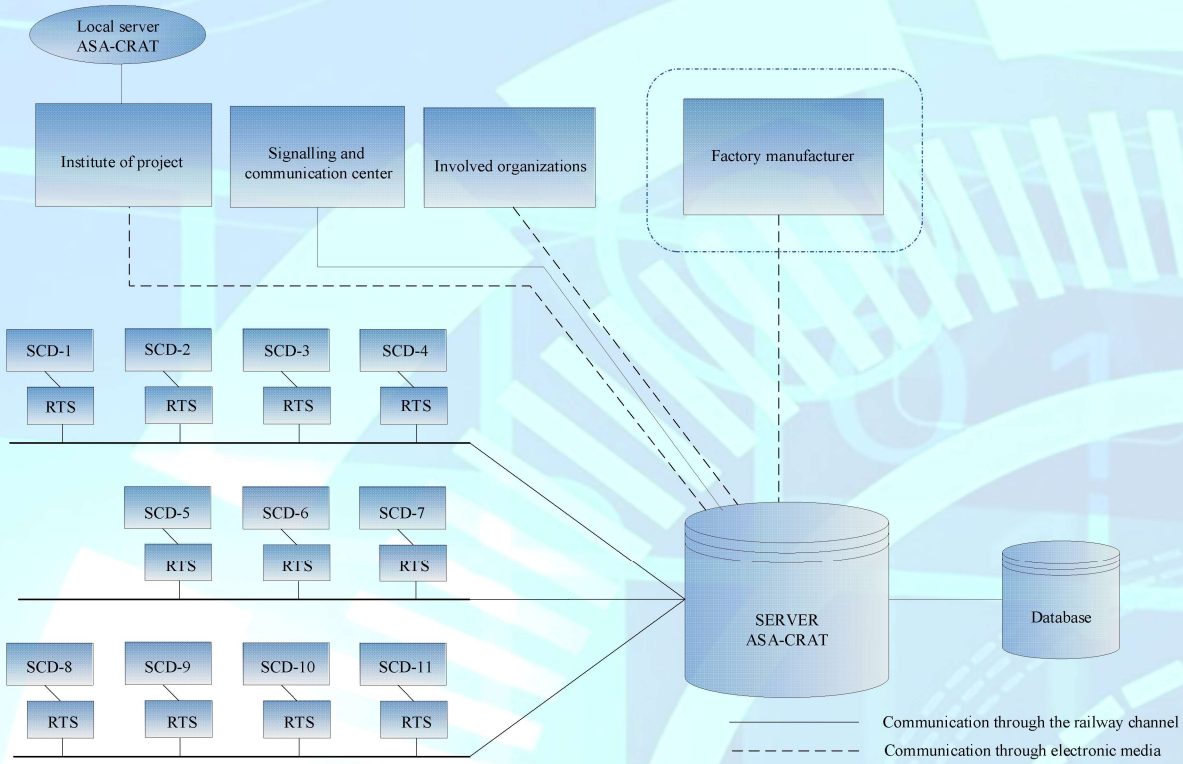


Figure 1. Architecture of the electronic accounting and control system

Automatic management of rail and information technology helps in easier monitoring and control of large volumes of data in a device. They form the basis for both collecting all necessary data from all necessary sources and enabling fast and centralized transferring of information from a device.

Experience shows it is impossible to foresee the development of railway infrastructures and the scope of information technologies without their use. The fast gathering, processing, and understanding of information can not be realized efficiently through classical paper-and-pencil means. Today, most of the usual tasks can be performed using technology. It still remains essential to interconnect rail vehicle gear with signal systems and to develop an adequate plan for maintaining, repairing, and decommissioning these systems.

For communication and signaling distances, the software is utilized.

Major functions of the system:

•adopt and maintain an integrated registry holding device “passports” and accurate sites of installation;

•repeatedly capture asset life cycle events: transfers, removals, acceptances, and replacement

•assemble equipment into functional sets and provide all information necessary to technical specifications;

•oversee and validate unit-exchange work streams and concurring agreements;

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•planning and management of technical maintenance of technological facilities and equipment;
•produce output documents and run targeted searches across the registry in line with set production guidelines.

ASA-CRAT is an extensive database containing all relevant information on the equipment and history thereof. On the other hand, one of those clients who have used this database and meet the needs for automation and telemechanics and machinery is ASA-CRAT itself.

ASA-CRAT documents devices alongside their anticipated early replacements at receiving locations. It functions as an automated registry for the transfer and exchange of equipment. The system upholds a centralized archive of device passports and accurate installation sites. It organizes replacement schedules, oversees decommissioning processes, and regulates the movement of devices across locations. It orchestrates the availability and distribution of removable modules while supplying necessary technical information. It supervises the implementation of replacement strategies and verifies adherence to protocols. It evaluates faults to detect malfunctions. It generates outgoing documentation and reports and facilitates ad hoc inquiries to identify devices within the database.

For improving centralized systems, and blocking procedures, as well as signaling effectiveness, at stations and at remote control points, ASA-CRAT is built to keep records and also monitor automatic and telemechanical railway systems which utilize computer technology in information processing, storing, and retrieving.

In papers [9–12], algorithmic models based on structured algorithms underlay an automated system.

Distribution of appliances between firms relies upon the solution to the above optimization problem in [5].

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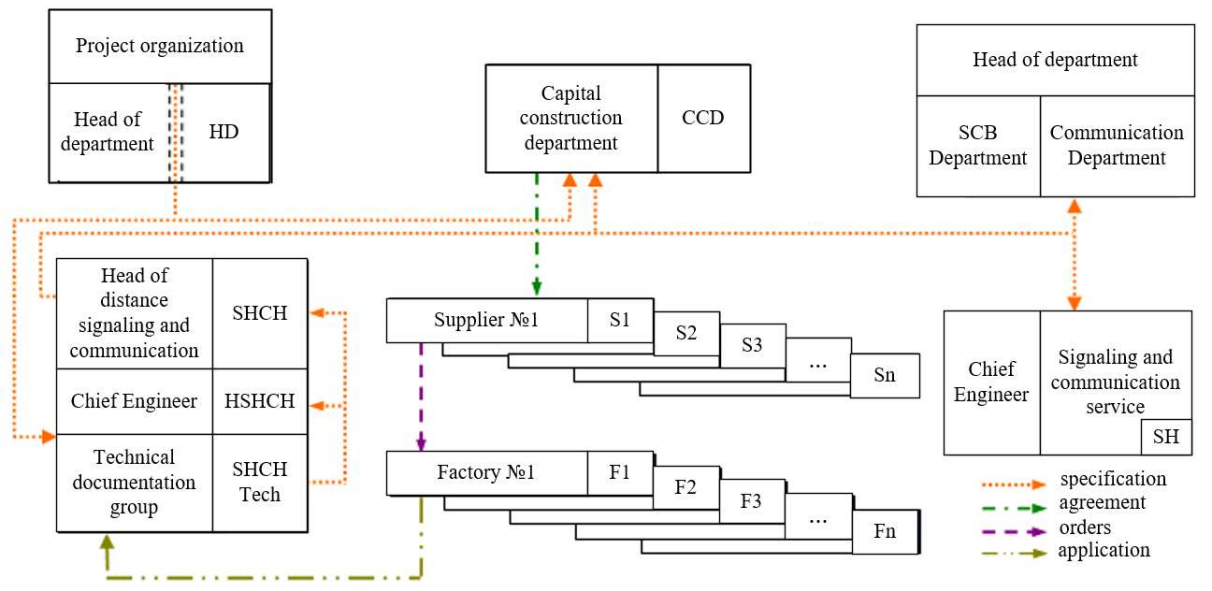


Figure 2. Structure of ASA-CRAT information sources

Figure 3 illustrates a segment of the ASA-CRAT database architecture. The relational structures of the database tables and their interconnections are represented in the logical database model. This diagram delineates the manner in which data pertaining to railway apparatus is maintained. Each device is assigned a distinct code, designation, dimensions, pricing, and manufacturer. Locations where devices are situated are enumerated. Links establish relationships between devices, locations, and operational groups. Monitors requisition lists, shipments, and receipts, thereby ensuring accurate documentation and prompt service. Furthermore, it organizes records for train-related devices. Each entry contains a code, designation, quantity, dimensions, and cost. Individuals involved in the sale or manufacture of components are identified. Locations that utilize these components are also cataloged. Connections depict the flow of items, indicating the sender, recipient, and timeline. Requests are categorized as assigned, completed, or pending.

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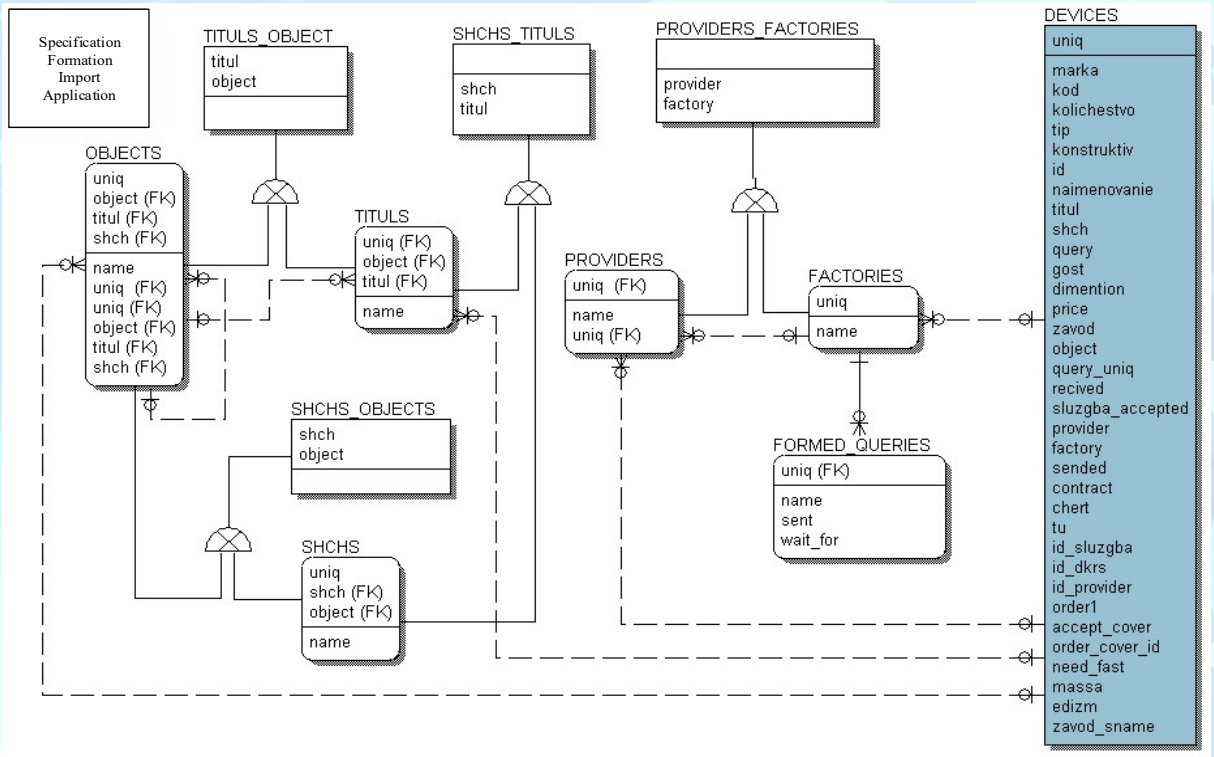


Figure 3. Fragment of the logical model of the ASA-CRAT database

Conclusion. Integrating the device maintenance process in the railway automation and telemechanics system with related sectors significantly increases the efficiency of electronic document management and maintenance.

This article presents the theoretical underpinnings for developing a railway automation and telemechanics model for the official EDTD system. The EDTD process is the official model that matches the theoretical results. Graph theory tools are used to bring the formal EDTD model up to the logical level. The ASA-CRAT program makes use of the major theoretical findings. In addition to the software architecture, the specifications for the used client and server components are given. Operational testing at the Tashkent signaling and communication distance (SCD-1) confirmed benefits: faster preparation of documents, reliable traceability of device histories, and timely, centralized access to current data. The client – server architecture on MS SQL Server with a C# application supports role-based workflows and scalable deployment across signaling and communication divisions.

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