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ARCHITECTURE OF AUTOMATED DIGITAL CONTROL FOR RAILWAY SIGNALING DEVICES

Astanaliev Elmurod Tursunali ugli
PhD student at the department of automation and telemechanics of Tashkent state transport university.
E-mail: transportacademy1997@gmail.com

Abstract: The article presents the development and description of an automated system for accounting and control of signaling devices in railway automation and telemechanics. The study focuses on the creation of an electronic document management system (EDTD), its formalized scheme, and a functional model ensuring automation of document processing in organizations. The system provides key capabilities such as registration, distribution, monitoring of documents, execution control of related orders, reporting, and secure message exchange. A client–server architecture was selected to ensure multi-user operation, information integrity, data confidentiality, and centralized archiving. The server program functions as the core element, handling requests, managing the database, processing queries, and ensuring user registration. It also supports logging, data protection, and multi-threaded client interaction via IP. Administrators are responsible for system configuration, user rights management, error monitoring, and backup creation, while users perform document registration, editing, and execution tasks according to assigned roles. By integrating a secure registration tool and customizable database connections, the system minimizes dependence on external software. The results demonstrate that the proposed system enhances efficiency, transparency, and control in managing railway automation documentation, ensuring reliability of processes and compliance with organizational requirements.

Keywords: electronic technical document management, railway automation and telemechanics, signaling devices, database, server.

Introduction

The automated accounting and control system for signaling devices streamlines your organization's document workflow. It enables:

- Document registration;
- Routing and assignment of electronic documents to staff;
- Tracking document progress and completion of related orders;
- Generating reports and maintaining logs;
- Internal electronic messaging between employees.

The designed system allows a team of employees to work together in a coordinated manner and is multi-user. The system's structure and configuration requirements — such as identifying system users, controlling access rights to processed data, and guaranteeing data integrity and security — are to responsible for this.

The system uses a client – server model and runs on the organization's local network.

This setup provides:

- Flexible scaling to any number of workstations, based on workload, task types, and staffing.
- Strong data integrity under concurrent multi-user access.
- Data safety through centralized backup and restore.

- Confidentiality via managed permissions and role-based access control.

Document logging and workflow tracking rely on these core concepts:

- Document registration: an authorized registrar creates a new record in the system.
- Registration form: structured metadata capturing key attributes to locate the document and track its route.
- Assignment: management issues a task to an employee for carrying out actions on the document.
- Execution: the responsible executor or co-executors perform the required steps and forward the document to the next stage.
- Execution control: a designated controller monitors processes and deadlines throughout the organization.

Material and Methods

The server program. The document management system relies on the employment of a specialized program called the document management server to work. The document management server performs the primary tasks that guarantee users' work: accepting requests, gaining database access, processing data, and providing results. User contact with the document management system and document manipulation are not possible until the main program is run.

The workflow server software itself operates on a server, which is a computer that is part of the organization's network. Depending on the volume of document work, either a network workstation or a separate computer might be chosen for the workflow server. We can predict that a document flow server running on a middle-class workstation is perfectly fine for minor document flows (up to 100 per day), and that it can be used concurrently for regular office tasks without experiencing a significant slowdown. But it should be remembered that adding new documents to the database and creating jobs and messages related to documents increases the database's size and disk space. As a result, it is important to make sure that there is enough hard drive space to accommodate the possibility of an increase in document flow [1-5].

Program administration. A system used by numerous users ought to be controlled centrally. System administrators are a select group of employees who perform these tasks by implementing a unified process for setting up and monitoring a system.

In particular, the following are among the responsibilities of the system administrator:

- consideration of the organization's current structure in its system;
- user enrollment;
- observing error and system messages;
- making changes to the database tables.

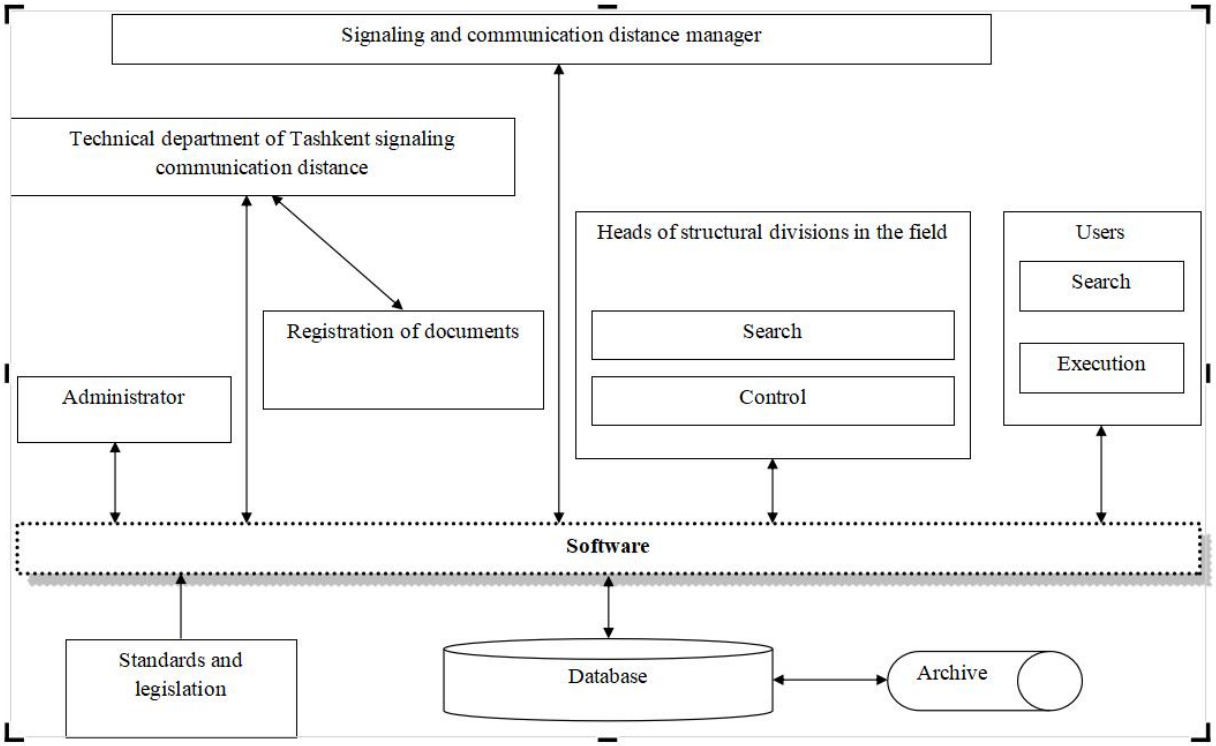

Fig.1. Conceptual design of an automated registry and control system for signaling devices

The system administrator is also responsible for starting and stopping the workflow server, setting and maintaining the system, backing up the system databases, and restoring the system in the event of an outage.

Side of the client. System users are employees of an organization who have enrolled in the system and use it to process documents based on their work duties. The administrator gives the system user the authority to carry out specific tasks and view specific documents, depending on the nature of the activity [6,7].

Users of the system may be granted the following privileges:

- control over how orders and tasks are carried out. Such privileges enable a user to carry out the duties of a controller and oversee the implementation of documents and staff directives;
- management of the system. Such rights allow a user to carry out the duties of a system administrator, including creating user accounts, granting users rights, and altering system configurations;
- the level of access to each of the available document streams can also be granted to the user by adding the following to the relevant list;
- this stream contains a list of people who have the ability to alter documents (registrar rights).

Figure 1 illustrates the model of the automated system for signaling device registration and control as well as the data processing structure.

Results and Discussion

The workflow server application carries out a number of tasks:

- handling of requests from clients;
- production of logs including service information;
- acts as a go-between for the client and the database;
- completes the process of registering a user.

The automated accounting and control system of signaling devices' structure diagram is displayed in figure 2.

In order to prevent data loss during transmission, requests to the server software should be sent over the IP protocol. It was determined to deal with managed connections by using a collection of low-level NetSockets classes as a software data transfer method. Since a system may have several clients (the number of clients should not be restricted by software; instead, it is determined by hardware performance and network bandwidth), the server program must interact with each client independently. It is therefore intended to divide clients into separate threads, which will be created when receiving a signal indicating a new connection and terminated upon the user's disconnection. Several sorts of network requests must be created in order to interact with various data transmission modes, including sending, receiving, and sending and receiving at the same time [8-11].

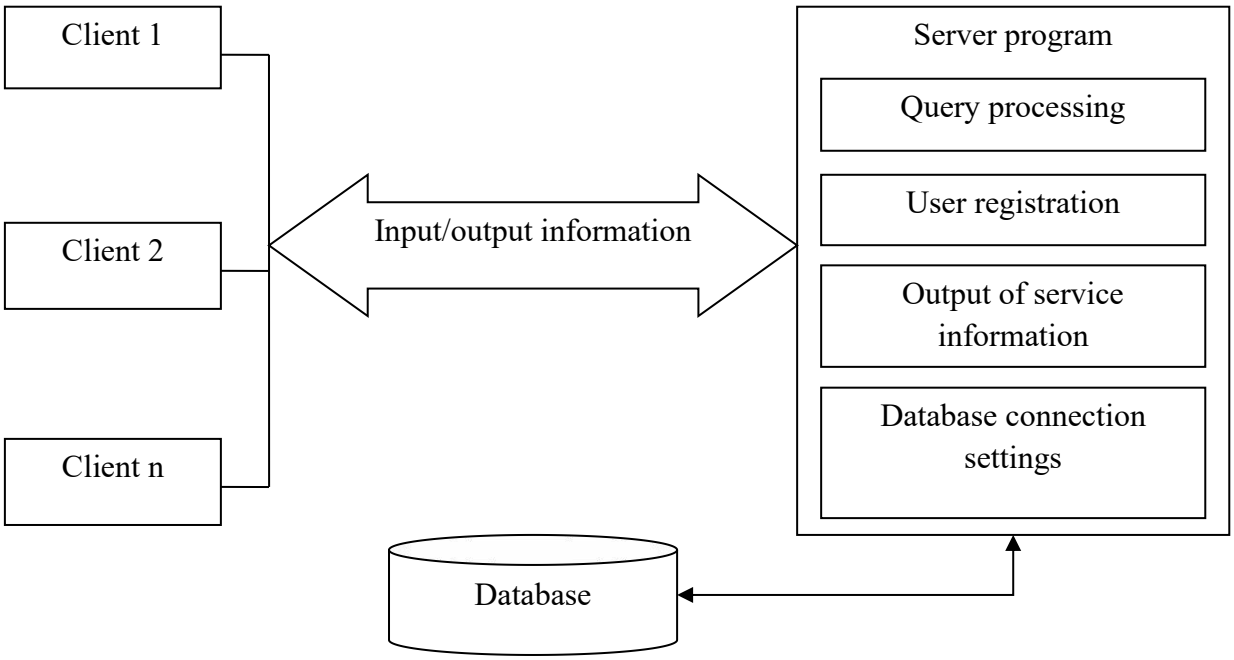

Fig.2. Functional model of the automated system for logging and supervising signaling devices.

It is necessary to partition the code into distinct classes based on semantic aspects in order to adhere to object-oriented programming guidelines. Three primary classes of server programs can be identified based on the tasks they perform:

- an interface class for user interaction;
- class of client interactions on a network;
- classification of the database connection.

These classes are all related to one another and are used to handle client requests. The program itself is initialized first, followed by the inclusion of the designated main classes. The network class accepts commands from the client, executes them using a helper class to communicate with the database, responds to the client if required, and displays the output of its work on the user interface. It is also possible to apply other structural linkages. The implementation of consolidation, a programming technique that separates data and code into a single block to shield them from outside interference and misuse, is made possible by this class division. Consolidation enables you to hide the object's implementation from the user while combining code and data

into an object. The user is shown merely the object's specification (interface) in this scenario. Only through this interface may the user interact with the object.

The real-time service information recording component must be used to ascertain the server's condition and the accuracy of client request execution. It is recommended that the server program's main window display this updated list, also known as the event log or log, so that the system administrator can access it at their convenience. This should primarily contain the outcomes of database query processing, as this is a highly vulnerable area of the system, particularly if the server software and data storage are physically located on separate systems.

A system user registration tool must be integrated into the server interface in order to minimize the number of extra apps. The username (login or alias), true name, surname, patronymic, and password are required as the primary identifying information. The organization's phone number, physical address, and email address are additional user identifiers that must be considered. The password needs to be kept in the database in an encrypted format to raise the system's security level.

An essential server component is the database connection configuration and the mechanism for initial deployment. To allow the server to use any available host as a data source, the administrator must be able to specify connection parameters—IP address, database name, and credentials for a user with read, write, and update privileges. The server should also include a utility that automatically creates the required tables and provides them with initial data. This design enables the document workflow system to be put into operation without third-party tools and without requiring SQL proficiency.

Conclusion

This article presents the design and rationale of an automated system for accounting and control of signaling devices built on an electronic technical document management (EDTD) framework and its formalized model. The work defines the system's scope and capabilities for document routing, reporting, and communication within railway automation and telemechanics operations.

The platform adopts a multi–user, client–server architecture deployed on an organization's local network. This choice enables flexible scaling of workstations, integrity protection under concurrent access, centralized backup and recovery, and rights-based confidentiality. These properties align the software design with operational demands for reliability and controlled access to technical records.

The document circulation is rigorously defined. Registration is performed by a registrar; assignments formalize tasks; execution proceeds through responsible executors or co-executors; and a controller oversees timing and compliance. This role model stabilizes accountability and strengthens deadline control across divisions.

The server side is engineered for dependable networked operation. Requests use IP; data exchange relies on low-level NetSockets with separate threads per client to maintain responsiveness at load. Code is organized into three cooperating classes — user interface, client network interaction, and database connection — to enforce consolidation and maintainability. An event log surfaces real-time service information for administrators, while integrated user registration and secure credential storage enable controlled access. Database connection parameters and initial deployment tools are embedded to reduce external dependencies and simplify rollout.

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