DEVELOPMENT OF A SOFTWARE-HARDWARE COMPLEX FOR MONITORING EMPLOYEE WORKING TIME IN MEDICAL AND EDUCATIONAL INSTITUTIONS

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Abstract: *The paper presents a software-hardware complex for monitoring employee working time in medical and educational institutions. The proposed solution combines RFID/QR identification, optional biometric verification, an edge controller, a central API server, a relational database and an analytical dashboard. The article describes the system architecture, event processing algorithm, working-time calculation model, security requirements and practical reporting functions. A scenario-based analytical comparison shows that the integrated complex can reduce manual errors, improve schedule discipline and provide transparent data for administrative decisions.*

Keywords: *working time monitoring, software-hardware complex, attendance system, RFID, biometric verification, edge controller, medical institution, educational institution, digital management.*

INTRODUCTION

Medical and educational institutions operate through strictly organized human resources. Hospitals, clinics, universities and schools depend on the timely presence of doctors, nurses, laboratory staff, teachers, administrators and technical personnel. In such institutions, working-time discipline is not only a payroll issue; it is directly connected with service continuity, patient safety, lesson quality, laboratory availability and public trust. A delayed shift change in a medical unit or an unregistered absence in an educational department can affect many people at the same time.

Traditional paper-based attendance journals are still used in many organizations because they are simple and inexpensive. However, they create several problems: manual errors, duplicated records, delayed reporting, weak auditability and limited analytical value. When administrators need monthly timesheets, overtime statistics or absence dynamics by department, the paper method requires repeated manual consolidation. This process increases the probability of mistakes and does not support real-time management.

The purpose of this paper is to propose a software-hardware complex for monitoring employee working time in medical and educational institutions. The proposed system is designed as an integrated digital solution that captures entry and exit events, verifies employee identity, compares records with approved schedules,

calculates working time and generates reports. The central idea is to combine hardware reliability with software intelligence: terminals register events at the entrance or department level, while the software layer transforms these events into verified attendance indicators.

The selected article topic is therefore: "Development of a software-hardware complex for monitoring employee working time in medical and educational institutions." The topic corresponds to the master's thesis direction because it includes both engineering components and practical information-system design: sensors and readers, embedded controller logic, database architecture, web-based monitoring, data security and institutional reporting.

2. Related Work and Research Gap

Attendance monitoring systems usually rely on one of four approaches: manual registration, card-based identification, biometric verification or mobile/cloud-based check-in. Manual registration is flexible but weak in accuracy and auditability. Card-based systems using RFID or NFC are faster, yet they can be affected by card sharing. Biometric systems can improve identity confidence, but they require careful privacy, security and usability design. Mobile systems are convenient, but they depend on smartphone availability, GPS reliability and network conditions.

For medical and educational institutions, a universal time-attendance device is not sufficient. These organizations have specific requirements. Medical staff can work in day shifts, night shifts, emergency duties and rotating schedules. Educational staff may have teaching hours, office hours, laboratory duties, examination periods and administrative assignments. Therefore, the system must support different schedule types, department structures and reporting formats. It must also work when internet connectivity is temporarily unavailable, because a missed event at the entrance should not become a lost attendance record.

The research gap addressed in this paper is the lack of a compact practical model that integrates physical event capture, identity verification, schedule-aware processing, offline buffering, role-based access and analytical reporting in one architecture. Many attendance systems record the time of arrival and departure, but they do not sufficiently explain how the raw event becomes a reliable management indicator. The proposed complex fills this gap by describing the full cycle from hardware registration to administrative decision support.

3. Proposed Software-Hardware Complex

The proposed complex consists of four interconnected layers. The first layer is the hardware registration layer. It includes RFID/NFC reader, QR-code scanner or camera-based face verification module, real-time clock, display, buzzer, local memory and a network interface. The second layer is the edge processing layer. It

validates the event, checks device status, stores records locally during network interruptions and sends synchronized packets to the server. The third layer is the server layer, which includes REST API, authentication service, attendance database, schedule engine and notification module. The fourth layer is the user layer: administrator panel, department head dashboard, HR report module and employee self-view interface.

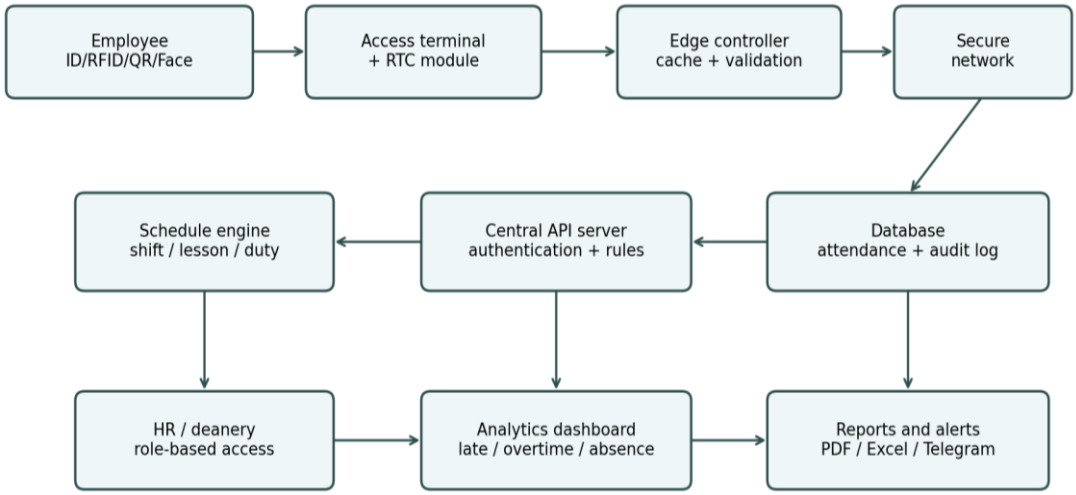

Figure 1. Architecture of the proposed software-hardware complex for working-time monitoring.

In the proposed architecture, every attendance record is treated as a verified event rather than a simple timestamp. A record contains employee identifier, terminal identifier, event type, time, location, verification method and quality indicator. This structure allows the system to distinguish normal entry, repeated scanning, early departure, late arrival, overtime and unconfirmed event cases. The system also keeps an audit trail so that every correction made by an administrator can be traced.

The software part is designed as a modular web application. The main modules are employee registry, department registry, schedule constructor, terminal management, event journal, rule engine, report generator, notification module and security settings. For example, a hospital can define 24-hour duty schedules, while a university can define weekly lesson-related attendance periods. This modularity makes the system adaptable for both medical and educational institutions without rewriting the core program.

The hardware terminal can be implemented on the basis of an embedded controller such as ESP32, STM32 or Raspberry Pi depending on the required performance. The terminal must have a stable power source and, if possible, a backup power option. Local caching is important: if the network fails, the terminal continues to register events and later synchronizes them with the central server. This

principle increases fault tolerance and prevents data loss during short-term infrastructure failures.

4. Mathematical and Algorithmic Model

The system begins with event registration. Let each event be represented as follows:

$e_{ik} = (ID_i, \tau_k, D_j, T_k, M_k, Q_k)$ (1)

Here, ID_i is the employee identifier, τ_k is the event time, D_j is the device or department identifier, T_k denotes event type such as entry or exit, M_k denotes the verification method, and Q_k is the identity confidence or device quality indicator. A valid record is stored only when the event satisfies the minimum quality threshold and the device is recognized by the system.

The daily working time of an employee can be calculated from paired entry and exit events:

$W_i(d) = \Sigma(t\_out - t\_in) - B_i(d) + O_i(d)$ (2)

In Eq. (2), $W_i(d)$ is the effective working time for employee i on day d, $t\_out - t\_in$ is the duration between matched exit and entry events, $B_i(d)$ is approved break time and $O_i(d)$ is confirmed overtime. This formula is simple enough for administrative use but flexible enough for shift-based institutions.

The attendance status can be determined by comparing actual arrival time with the planned schedule:

$S_i(d) = \{$ on time, if $|a_i(d) - p_i(d)| \le \delta$; late, if $a_i(d) > p_i(d) + \delta$; absent, if no valid event exists $\}$ (3)

In Eq. (3), $a_i(d)$ is actual arrival time, $p_i(d)$ is planned arrival time, and δ is an institutional tolerance interval. For hospitals, δ may be small because shift continuity is critical. For educational institutions, δ can be adjusted according to academic and administrative policy.

Anomaly detection is used to identify suspicious or administratively important cases. A simple analytical indicator can be calculated as:

$A_i = \alpha_1 R_i + \alpha_2 L_i + \alpha_3 E_i + \alpha_4 C_i$ (4)

Here, R_i is repeated scanning frequency, L_i is late-arrival intensity, E_i is early-leave frequency and C_i is the number of correction requests. The coefficients α_1, α_2, α_3 and α_4 are determined by the institution. A high value of A_i does not automatically mean a violation; it indicates that the administrator should review the case with supporting evidence.

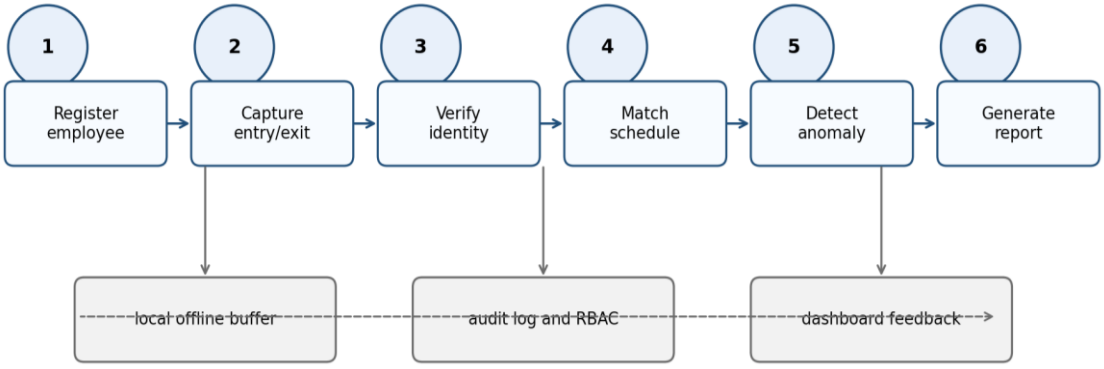

Figure 2. Event processing algorithm of the proposed working-time monitoring complex.

5. Results and Analytical Discussion

A scenario-based analytical evaluation was prepared to compare four possible approaches for working-time monitoring: paper journal, standalone RFID terminal, biometric terminal and the proposed integrated software-hardware complex. The evaluation is not a final production experiment; it shows expected methodological advantages under institutional conditions. The indicators were selected according to the needs of medical and educational organizations: identity reliability, reporting speed, fault tolerance, privacy control and suitability for schedule-based management.

Table 1. Analytical comparison of working-time monitoring approaches

Approach	Identity reliability	Reporting speed	Fault tolerance	Institutional suitability
Paper journal	Low	Low	Medium	Limited: manual consolidation is required
Standalone RFID terminal	Medium	Medium	Medium	Useful, but card sharing risk remains
Biometric terminal only	High	Medium	Low/Medium	Accurate, but requires strict privacy control
Proposed integrated complex	High	High	High	Suitable for shifts, lessons, reports and audit

The comparison shows that the proposed complex has practical advantages because it does not depend on a single identification or reporting mechanism. When

RFID is sufficient, the organization can use RFID cards. When identity confidence is critical, biometric verification can be activated. When the internet is unavailable, the edge controller stores events locally. When department heads need reports, the dashboard provides calculated indicators instead of raw timestamps.

For medical institutions, the most important function is shift continuity. The system can show whether the next shift has arrived before the previous shift leaves. It can also generate reports for night duties, emergency personnel and laboratory staff. For educational institutions, the system can be connected with department schedules and academic calendars. It can show attendance by faculty, department, laboratory or administrative unit. This helps managers identify overload, repeated lateness, staffing gaps and discipline trends.

Another important aspect is data security. Attendance data and biometric templates are sensitive because they are connected with employees. Therefore, the proposed system must apply role-based access control, encrypted communication, protected backup, audit logging and minimal data collection. Biometric images should not be stored as ordinary photos; instead, the system should store protected templates or verification results according to institutional policy and technical standards. Administrative corrections must be recorded with user ID, time, reason and previous value.

6. Scientific Novelty and Practical Value

The scientific novelty of the study is the development of an integrated model in which hardware event capture, edge validation, schedule-aware processing and analytical reporting are considered as one system. The proposed model does not treat attendance monitoring as a simple “entry-exit” journal. Instead, it converts raw events into verified indicators that are meaningful for institutional management.

The second novelty is the inclusion of a hybrid verification strategy. The system can combine RFID/QR identification with optional biometric confirmation. This allows the institution to balance cost, accuracy and privacy. For example, ordinary office areas can use RFID, while high-responsibility zones such as medical laboratories, archive rooms or examination-control points can require stronger verification.

The practical value of the work is reflected in several outcomes. First, it reduces manual attendance errors and shortens report preparation time. Second, it increases transparency because every record and correction is logged. Third, it supports different institutional schedules, including night shifts, weekly lesson schedules and temporary duty assignments. Fourth, it can be used as a basis for payroll calculation, internal control, workload analysis and digital transformation of human-resource management.

The proposed complex can also be expanded in future work. Integration with payroll systems, electronic document management, student information systems or hospital management systems can create a unified digital environment. Additional analytics can forecast staff overload, identify repeated bottlenecks and recommend schedule adjustments. However, such expansion should be implemented gradually and with strong attention to data protection and user acceptance.

7. Conclusion

This paper proposed a software-hardware complex for monitoring employee working time in medical and educational institutions. The system combines identification terminals, edge processing, central server logic, database storage, schedule-aware analytics and role-based dashboards. The approach is intended to improve accuracy, transparency and management efficiency while reducing manual work.

The proposed model includes event representation, working-time calculation, attendance status determination and anomaly scoring. These elements help transform raw registration data into useful administrative information. The analytical comparison indicates that the integrated complex is more suitable for institutional conditions than paper journals, standalone RFID terminals or biometric devices used without a complete software layer.

Future work should include prototype implementation, testing in a real medical or educational institution, measurement of registration accuracy, user-experience analysis and evaluation of data security measures. The final version of the complex should be modular, scalable and compatible with institutional regulations on personal data protection.

REFERENCES:

28. Rashidovich BG, Ugli NBU, Ugli NBB AI dan foydalanib, piyodalar o'tish joylarida to'xtash yoki yurishda davom etish haqida real vaqt rejimida maslahat bera oladigan murakkab qaror qabul qilish tizimini yaratmoqda //Universum: texnik fanlar. – 2026. – T. 6. – №. 1 (142). – S. 50-54.

29. Ugli NBU, Baxtiyorovna NS ilg'or biometrik autentifikatsiya tizimi: ALGORITMIK MODELLAR, XAVFSIZLIK TAHDILARI VA MULTIMODAL BAHOLASH RAMALARINI CHUKUR O'RGANISH //Universum: texnicheskie. – 2026. – T. 6. – №. 1 (142). – S. 64-68.

30. Ugli N. B. U., Ugli A. T. K. ADAPTIVE MULTIMODAL BIOMETRIC AUTHENTICATION SYSTEMS: A HUMAN-CENTERED ANALYSIS OF DESIGN,

EVALUATION, AND SECURITY CHALLENGES //Universum: технические науки. – 2026. – Т. 6. – №. 1 (142). – С. 69-72.

31. ugli Norboev B. U. et al. Artificial Intelligence in Education and the Digital Preconditions of Tertiary Expansion in Uzbekistan: ARDL Evidence from 2000–2023. – 2026.

32. Ochilova S., Berdiyev G., Xujaqulov N. Fraktal nazariyasiga asoslangan musiqa kompozitsiyasining tahliliy usullari //Journal of Transport. – 2025. – Т. 2. – №. 3. – С. 136-139.

33. Alimov U., Zohirov Q., Berdiyev G. WAYS TO DEVELOP COORDINATION SKILLS IN KURASH //Mental Enlightenment Scientific-Methodological Journal. – 2024. – Т. 5. – №. 09. – С. 9-14.

34. Pardayeva G.A., Raximqulov FUQAROLAR MUROJAATLARINI STATISTIK TAHLIL QILISH UCHUN AXBOROT TIZIMINI ISHLAB CHIQISH // UNIVERSAL AKADEMIK VA KO'P FANLI TADQIQOTLAR JURNALI. – 2026. – Т. 4. – №. 32. – S. 87-90.

35. Qodirov B. TALABALARDA KOMPLEKS MA'LUMOTLAR BAZASI KOMPETENSIYALARINI RIVOJLANTIRISH UCHUN TIZIMLANGAN PEDAGOGIK STRATEGIYALAR //Osiyo ilmiy tadqiqotlar va innovatsiyalar jurnali. – 2026. – Т. 5. – №. 1. – S. 143-147.

36. Pardayeva G. A., Choriyev B. S., Sulaymonova D. B. SUN'IY INTELLEKT TEXNOLOGIYALARIGA ASOSLANGAN RAQAMLI TA'LIMDA ADAPTIV O'QITISH METODIKASINING NAZARIY MODELI VA AMALIY ASOSLARI //Inter education & global study. – 2025. – Т. 3. – №. 10 (1). – С. 256-265.