REAL-TIME WORKING-TIME MONITORING ALGORITHM BASED ON HYBRID RFID-BIOMETRIC IDENTIFICATION FOR MEDICAL AND EDUCATIONAL INSTITUTIONS

Qayumov Sirojjon Kahramon ogli
Information Technologies and Management University, master's student

Abstract: *The article proposes a real-time working-time monitoring algorithm for medical and educational institutions based on hybrid RFID-biometric identification. The study focuses on the transformation of raw entry and exit events into reliable attendance records through identity confidence scoring, schedule matching, duplicate-event filtering, offline buffering and audit logging. The proposed approach combines low-cost RFID registration with optional biometric verification for high-responsibility zones. A mathematical model for event validity, daily working-time calculation and anomaly indication is presented. The analytical comparison shows that the hybrid model can increase the reliability of attendance records, reduce manual reporting time and improve administrative transparency.*

Keywords: *working-time monitoring, RFID, biometric identification, real-time algorithm, attendance control, edge terminal, schedule matching, medical institution, educational institution.*

INTRODUCTION

The digital transformation of institutional management requires reliable information about the presence and workload of employees. In medical institutions, the timely presence of doctors, nurses, laboratory assistants and technical personnel is connected with patient safety and service continuity. In educational institutions, the attendance of teachers, laboratory staff and administrative employees affects lesson quality, academic discipline and the stability of the learning process. For this reason, working-time monitoring should be treated as an information-management problem rather than as a simple registration procedure.

Manual journals and ordinary electronic check-in systems cannot always satisfy the requirements of modern institutions. A paper journal is easy to organize but difficult to verify. A standalone card reader is faster, but card sharing and unregistered corrections can reduce trust in the data. Biometric devices improve identity confirmation, yet their use must be limited by privacy, cost and acceptability. Therefore, a balanced technical solution is needed: the system should use a simple identification method for ordinary cases and stronger verification when the institutional risk is higher.

The aim of this article is to develop an algorithmic basis for a software-hardware complex that monitors employee working time in real time. Unlike a general attendance system, the proposed algorithm focuses on the full logic of reliable event processing: identity verification, confidence estimation, duplicate-event filtering, schedule matching, offline buffering, calculation of effective working time and generation of administrative alerts. This approach is especially suitable for institutions where several schedule types exist simultaneously.

2. Problem Statement and Institutional Requirements

Medical and educational institutions have a heterogeneous work structure. A hospital can include day shifts, night duties, emergency calls, laboratory schedules and administrative office hours. A university or school can include teaching hours, consultation hours, examination periods, department meetings and technical-service duties. As a result, one fixed "arrival and departure" rule cannot fully describe institutional attendance. The monitoring algorithm must support multiple schedule models and must clearly separate normal deviations from real disciplinary problems.

The main requirements for the proposed system are accuracy, continuity, transparency, data protection and adaptability. Accuracy means that the system should register the correct employee, time and location. Continuity means that records should not be lost when the internet connection is temporarily unavailable. Transparency means that administrators must see not only the final result, but also the reasons why the system classified a record as on time, late, absent, overtime or suspicious. Data protection requires encryption, access control and audit logging. Adaptability means that schedules can be configured for different departments without rewriting the system core.

The research gap addressed in this article is the insufficient algorithmic explanation of how a software-hardware attendance complex should process events in real time under institutional conditions. Many systems only store a timestamp, while medical and educational organizations require schedule-aware, auditable and privacy-conscious interpretation. The proposed algorithm fills this gap by describing the internal transformation from a captured event to a management indicator.

3. Hybrid Identification Model

The proposed solution uses a hybrid identification model. In ordinary working zones, the employee can be registered by RFID card or QR code. In high-responsibility zones, such as hospital laboratories, archive rooms, examination centers or restricted administrative areas, the same event can be confirmed by face or fingerprint verification. This flexible model reduces cost while keeping identity reliability where it is most needed.

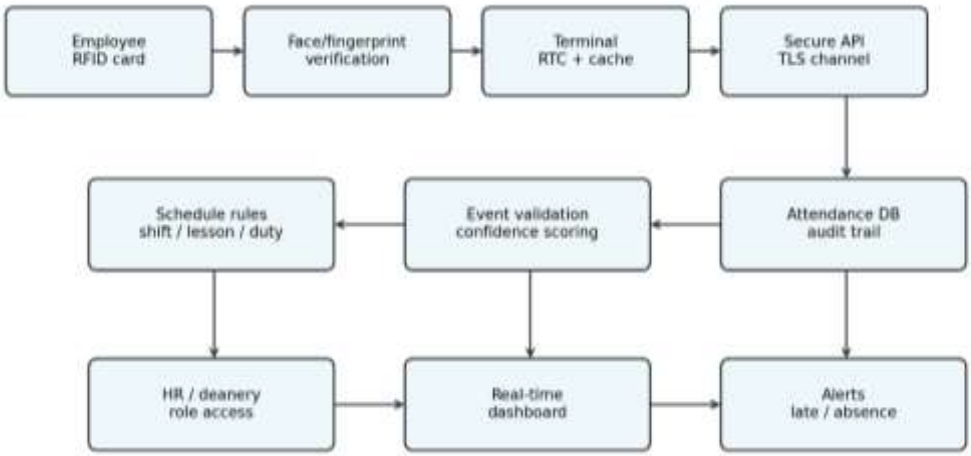

Figure 1. Hybrid RFID-biometric event processing flow for institutional working-time monitoring.

Each event registered by the terminal is represented as a structured data object:

$E_k = (ID_i, t_k, D_j, Z_j, M_k, C_k, R_k)$ (1)

In Eq. (1), ID_i is the employee identifier, t_k is the registration time, D_j is the device identifier, Z_j is the institutional zone, M_k is the verification method, C_k is the identity confidence score and R_k is the registration result. A record is accepted only when the employee, device and verification method satisfy the rules assigned to the corresponding zone.

The identity confidence score can be calculated as follows:

$$C_k = w_1C\_RFID + w_2C\_BIO + w_3C\_DEV - w_4R\_DUP \quad (2)$$

Here, C_RFID reflects card or QR validity, C_BIO reflects biometric match quality, C_DEV reflects terminal reliability, R_DUP is the duplicate-scan penalty, and w_1, w_2, w_3, w_4 are institutional weights. The formula allows the system to apply different confidence rules for ordinary and restricted zones.

4. Real-Time Monitoring Algorithm

The algorithm begins when the terminal reads the employee identifier. If the selected zone requires stronger verification, the terminal requests biometric confirmation. After that, the system calculates identity confidence, checks whether the event is repeated within a short interval, stores the record locally if the network is unavailable and sends the event to the central API when the connection is active. The server then compares the event with the approved schedule and assigns attendance status.

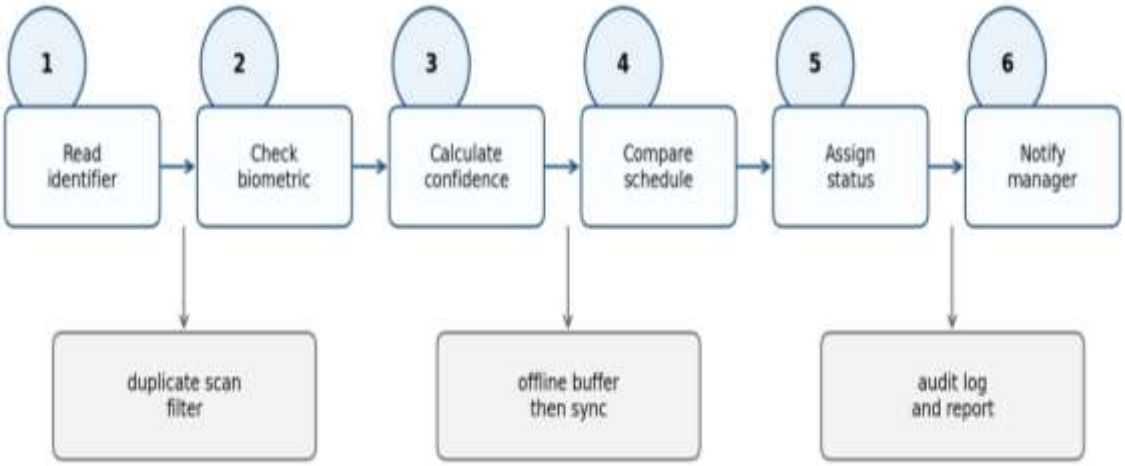

Figure 2. Algorithm for determining attendance status in real time.

The effective daily working time is calculated using matched entry and exit events:

$$W_i(d) = \Sigma(t\_exit - t\_entry) - B_i(d) + O_i(d) \quad (3)$$

In Eq. (3), $W_i(d)$ is the daily working time of employee i, $B_i(d)$ is approved break time and $O_i(d)$ is confirmed overtime. In medical institutions this formula can be adapted to night shifts and emergency duty, while in educational institutions it can be connected with lesson schedules and department assignments.

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

$$S_i(d) = \{ \text{on time, if } a_i \le p_i + \delta; \text{ late, if } a_i > p_i + \delta; \text{ absent, if no valid event exists} \} \quad (4)$$

Here, a_i is the actual arrival time, p_i is the planned arrival time and δ is the tolerance interval. The value of δ can be defined by the institution. For example, a clinical

department can apply a stricter tolerance than an administrative department because shift continuity is critical.

For administrative review, the system calculates an anomaly indicator:

$$A_i = \beta_1 L_i + \beta_2 E_i + \beta_3 D_i + \beta_4 K_i \quad (5)$$

In Eq. (5), L_i is late-arrival frequency, E_i is early-departure frequency, D_i is duplicate or suspicious scan frequency and K_i is correction-request frequency. A high anomaly value is not an automatic disciplinary conclusion; it only indicates that the record should be reviewed with evidence.

5. Analytical Evaluation and Discussion

A scenario-based analytical evaluation was prepared to compare three attendance-control approaches: paper journal, ordinary RFID registration and the proposed hybrid RFID-biometric real-time algorithm. The comparison was based on criteria that are important for medical and educational institutions: identity reliability, schedule compatibility, offline reliability, privacy control and reporting value.

Table 1. Comparison of attendance monitoring approaches

Approach	Identity reliability	Schedule compatibility	Offline reliability	Privacy control	Reporting value
Paper journal	Low	Low	High	Medium	Low
Ordinary RFID registration	Medium	Medium	Medium	Medium	Medium
Hybrid RFID-biometric algorithm	High	High	High	High	High

The analytical comparison indicates that the hybrid algorithm is more suitable for institutional use because it separates identification, verification and schedule interpretation. RFID registration gives speed and low cost, while biometric confirmation increases reliability in restricted zones. Offline buffering protects the institution from data loss during network problems. Audit logging supports administrative transparency because every correction and exception can be traced.

The proposed algorithm is also useful for real-time management. A department head can see which employees have arrived, which shifts are incomplete and which records require review. In a hospital, this can help maintain continuity between shifts. In a university, it can help monitor department staff, laboratory support and administrative duties. Reports can be generated by employee, department, date, schedule type or status category.

At the same time, the implementation must respect ethical and legal requirements. Biometric verification should be used only where it is justified. The system should not store unnecessary biometric images; it should store protected templates or verification results. Access to attendance data must be role-based, and employees should be informed about what data is collected, why it is processed and how long it is stored.

6. Scientific Novelty and Practical Value

The scientific novelty of the article is the development of a schedule-aware real-time algorithm for working-time monitoring in medical and educational institutions. The algorithm does not limit itself to the registration of entry and exit events. It estimates

identity confidence, checks duplicate scans, supports offline buffering, compares events with different schedule types and produces auditable attendance statuses.

Another novelty is the flexible use of hybrid RFID-biometric identification. The proposed model allows the institution to choose the verification level according to risk. This is important because a single method cannot be equally effective for all departments. The same organization can use simple RFID in ordinary offices, and stronger verification in laboratories, archives or examination areas.

The practical value is expressed in reduced manual work, faster report preparation, improved accuracy of attendance data and better control of shift or lesson-related duties. The algorithm can become the basis for a web-based software-hardware complex that includes terminals, server API, database, dashboard and reporting module. It can also be integrated with personnel management systems, payroll modules and institutional analytics platforms.

7. Conclusion

This article proposed a real-time working-time monitoring algorithm based on hybrid RFID-biometric identification for medical and educational institutions. The proposed approach combines fast registration, reliable identity verification, schedule-aware processing, offline buffering and audit logging. The mathematical model includes event structure, identity confidence calculation, effective working-time calculation, attendance status determination and anomaly indication.

The analytical discussion shows that the hybrid algorithm has advantages over paper journals and ordinary RFID systems because it increases data reliability and provides meaningful administrative information. Future research should focus on prototype development, testing in a real institution, evaluation of user acceptance, measurement of registration accuracy and improvement of personal data protection mechanisms.

REFERENCES:

29. 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.

30. 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.

31. 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.

32. 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.

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

34. 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.

35. Pardayeva G.A., Raximqulov FUQAROLAR MUROJAATLARINI STATISTIK TAHLIL QILISH UCHUN AXBOROT TIZIMINI ISHLAB CHIQISH // UNIVERSAL AKADEMIK VA KO'P FANLI TADQIQOTLAR JURNALI. – 2026. – T. 4. – №. 32. – S. 87-90.

36. Qodirov B. TALABALARDA KOMPLEKS MA'LUMOTLAR BAZASI KOMPETENSIYALARINI RIVOJLANTIRISH UCHUN TIZIMLANGAN PEDAGOGIK STRATEGIYALAR //Osiyo ilmiy tadqiqotlar va innovatsiyalar jurnali. – 2026. – T. 5. – №. 1. – S. 143-147.