Software and hardware solution for monitoring and managing the efficiency of work of construction objects based on analysis of the use of working time

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Abstract. Today, even taking into account the rapid progress, one of the most important problems of any organization is the loss of income due to violations of labor discipline of employees. The solution to this problem can be the use of specialized software and hardware products designed to monitor and control the actions of personnel. The construction industry is the most lagging behind in the issue of automation of accounting for actually worked time due to the complexity and versatility of the processes taking place at the construction site. Failure to meet the construction deadline leads to the accrual of fines, reducing the income from the contract. In addition, objects that are not completed on time spoil the statistics of the construction organization and can reduce the likelihood of receiving a new order, and the absence of the developed system lies in the fact that the information that this system will analyze will allow: discipline, calculate wages for the actual time worked and the amount of work performed, receive factual data on many problems and exceptional situations that arise during the implementation of projects.

Based on the definition that "working time" is, as stated in article 91 of the Labor Code of the Russian Federation, the time during which labor duties are performed, it is important for the employer to separate the time that the employee is at the workplace and works from the time when the employee does not fulfill his work duties, although he is at the workplace. The main functions of any management are the following tasks: planning, organization, control and motivation.

Optimization of the work process, increasing the efficiency of tasks, meeting the deadlines for the production of work is impossible without planning and controlling working time. In addition, a clear organization of tasks in the team is needed not only by the leader, but also by his employees.

In large organizations with a significant number of employees, the management cannot physically control every employee. The same problem arises when employees are far from the employer, that is, they do not work directly in the office, but at a construction site with a large construction site. In addition, the control functions for engineering and technical personnel are often not the only ones, and they also perform other duties.

No matter how much the employee is motivated, he will not be able to complete his tasks if he is hindered by circumstances beyond his control. During the production of work on a construction site, unforeseen circumstances or some difficulties often arise, due to which there is a deviation from the
work plan. The work performed on the construction site cannot be foreseen and planned to the smallest detail, due to the complexity and versatility of the construction process, which depends on many factors, human and natural origin.

Along with the increase in the number of simultaneous execution of projects, the number of tasks and the number of employees performing these tasks also grows, so manual control of each employee becomes impossible.

One of the options for solving this problem is program-targeted management, which allows to reduce the number of bottlenecks in the work process, and contributes to the successful achievement of the result.

Program-target management is focused on the final result, that is, the goal and the result are inseparable. Therefore, managing the process of achieving the goal, one should constantly take into account the available results.

In addition, in practice, the value of a modern leader is often determined by both the ability to resolve burning issues and the ability to prevent their occurrence.

Monitoring, as part of the control of working time, allows you to solve various tasks:

- fixing the beginning of the working day to identify systematic violators of labor discipline;
- checking the time to return to work after the lunch break and the presence of the employee during the working day;
- determination of the time of the end of the working day;
- identification of truants of work;
- division of working time into actually worked hours, vacation, sick leave, idle time due to the fault of the employer, and so on.

The introduction of methods for monitoring performance indicators is primarily necessary for the employer. This will allow you to pay for the hours actually worked, and not for delays and breaks at the workplace.

Monitoring data on the use of working time form the basis for analyzing the effectiveness of personnel.

Performance metrics include:

- final - evaluation of the results of the completed project as a whole;
- intermediate - control of the work done for the specified period;
- periodic - summing up after a certain period of time;
- selective - irregular random monitoring of individual employees at the discretion of management.

Time management, as a time management system, includes a number of elements that, when used together, can reduce the time required to implement various production processes:

- analysis of the used working time;
- formation of a strategy based on the results of the analysis;
- setting a goal that the boss plans to achieve using time management technology;
- planning of working hours and setting priorities;
- implementation - actions corresponding to the planned plan
- creation of methods to deal with the causes of irrational use of time;
- control over the achievement of goals, implementation of plans, summing up the results.

The creation of methods to combat the causes of irrational use of working time involves a preliminary analysis, during which the reasons that need to be eliminated will be determined. Waste of time can occur due to many factors. Many of them are the result of the actions of an incompetent leader, half of which occurs independently of him, but the other part is inextricably linked with the leader himself.

The purpose of this work is to develop a methodology for creating a system for monitoring and managing the efficiency of construction projects for a large construction company based on an analysis of the use of working time and compliance with technological processes.
The solution to this problem is the creation of a system that will allow monitoring the working time of workers and fixing problems that have arisen in the construction industry, forming the information received into analytical reports. The development of this software and hardware solution is based on the following principles:

- Maximum focus on the end user, achieved through the creation of tools for adapting the system to the level of user training, learning and self-learning opportunities;
- Orientation of the problem towards solving a certain class of problems, united by a common information processing technology, a block of operations and operating modes;
- Formalization of professional knowledge, that is, the ability to independently automate new functions using the developed system and solve new problems in the process of gaining experience with the system; – ergonomics, that is, the creation of a user-friendly working environment and a friendly interface for communication with the system.

To achieve this goal, you must complete the following tasks:

1. Conduct an analysis of existing systems for automation of accounting of working hours of construction organizations, biometric authorization systems, identify shortcomings.
2. Determine the requirements for the system being developed.
3. Develop a block diagram of the system.
4. Design the interface of the software tool.
5. Develop an algorithm for the operation of this system.

The developed software and hardware complex must ensure the receipt of the most objective and reliable data on the actual state of affairs at the construction sites of the organization.

As part of the tasks set, the system requires the following functionality: fixing (fixing) the tracker ("Smart helmet") for the employee through authorization ("Info kiosk"), a system for direct monitoring of working hours using trackers, an interface for the engineering and technical personnel of the construction site ("Digital Worker"), dashboard for viewing reports on the construction site ("Architect-Web").

In order to visualize the flow of the business process within the boundaries of the work time monitoring system, the BPMN 2.0 notation was used. The system operation algorithm implies the operation of 4 "pools":

- worker;
- working time monitoring system;
- engineers and technicians;
- Leadership [1].

For the functioning of the working time monitoring system, it is necessary to ensure interaction with the following groups of employees:

- direct employee monitored using the tracker,
- Engineer - an engineering and technical worker who carries out operational management at the site of work,
- management - the manager analyzes the statistics received by the system in the form of structured reports and, based on them, performs the functions of tactical and strategic management of the enterprise [2].

Let's consider the algorithm in more detail. At the beginning of the working day, the employee, whose data is entered in the information monitoring system, must receive a tracker and inspect it for damage.

For authorization in the monitoring system, the Infokiosk system is used. This system identifies the employee using biometric data, scanning and face recognition using a built-in camera. In case of recognition error, the employee can enter his identification number manually.

After that, the tracker is applied to the RFID-tags reader and then the system reads the unique tracker key, thus linking the data from the tracker to a specific employee.
After successful authorization, the employee can start working. The system records the start time of his working day, which allows him to identify the level of punctuality and use this data to reward or punish violators of labor discipline [3].

In addition, at the time of fixing the beginning of the working day, the system analyzes the planned amount of work of the employee, in accordance with the work schedule, and his actual presence at the construction site. The use of the monitoring system adds some additional responsibilities for foremen and foremen of the construction site: the full functioning of the system requires monitoring the situation through the "Digital Worker" application and entering the causes of the anomalies that occur.

Therefore, for the convenience of the engineering and technical personnel, who can quickly monitor the occurrence of problems at the construction site, the system divides the working day into periods of twenty minutes. During these periods, the readings from the sensors are taken every minute. The system operates with averaged values for five minutes, which minimizes the probability of fixing erroneous indicators of the tracker sensors. The anomaly is recorded only if the readings from the sensors are outside the normal range in all four five minutes of the fixed twenty-minute period of the working day [4,5,6].

Figure 1 shows an example of how a day is split by the system. Each hour is divided into periods of 20 minutes. Each period for smaller ones - 5 minutes. The first period of 20 minutes is automatically recorded as normal, unless a delay is detected. The time from 12 noon to 13:00 in this example is a lunch break, during which the fixation of indicators is not carried out [7].

In accordance with the scheme, the third five-minute interval of the twenty-minute period is being fixed (16:10-16:15). In the period from 11:40 to 12:00, none of the five-minute intervals was recorded as normal, therefore, in this twenty-minute period, the system recorded an anomaly in terms of activity indicators, which required the engineer and technical worker to enter the cause of the anomaly.

| 8:00 | 9:00 | 10:00 | 11:00 | 12:00 |
|------|------|-------|-------|-------|
| ![Periods] | ![Periods] | ![Periods] | ![Periods] | ![Periods] |

![Figure 1](image) Breaking the working day into periods Monitoring takes place according to two indicators - location and activity. For both indicators, a separate fixation of the anomaly occurs, which makes it possible to track the occurrence of problems according to these two criteria separately [8-10,11].
So, if the employee's activity level determined by the sensors does not correspond to the norm, then the system fixes an anomaly for this indicator and in the "Digital worker" application a function opens to enter the cause of the anomaly for this indicator for a particular employee. If the location of the worker is determined outside the working area, then the anomaly is determined by the indicators of the location sensor, which also requires entering the cause of this anomaly [10,12-14].

During the monitoring process, the location of the employee is recorded on a map in the "Digital Worker" android application. An individual's mark on the map is circular and divided into two semicircles. The upper semicircle corresponds to activity indicators, and the lower semicircle corresponds to location indicators (see Figure 2).

If, according to a certain indicator, a deviation from the norm is recorded in the current five-minute interval, then the semicircle corresponding to this indicator turns yellow. For a foreman or foreman, this is some signal that, perhaps, there are some problems with this employee, and if you pay attention to this in time and take an operational management decision, then the anomaly will not be recorded, - this way the system allows you to get rid of the problem even before its occurrence.

If the indicator is within the normal values, the semicircle remains green. But, if according to the indicator, not a single five-minute interval of a twenty-minute period of a working day is recorded as corresponding to the norm, then the corresponding semicircle turns red, and the engineering and technical personnel need to determine the cause of the anomaly and enter it into the system.

Figure 2. Labels of workers on an interactive map in the main working application "Digital worker".
The process of monitoring indicators from the tracker does not stop until the employee marks the end of the working day using the "Infokiosk" program. In order to record the end of the working day, it is enough to swipe the tracker over RFID-tag readers and hand over the tracker for storage [15].

After the data about the employee for the past working day has been received, the system compares them with the planned indicators, which is reflected in the report for this criterion. For the head of the organization, a special interface "Architect-Web" is provided, which reflects all information about the actual situation at the construction site.

Statistical data are formed into easy-to-read and analyze reports, having studied which, the head can make adjustments to the operation of the enterprise, making strategic and tactical management decisions.

For example, according to the reports provided by the Zodchiy-Web system, the manager found that a significant number of problems recorded at the construction site were associated with the delivery of a cement-sand mixture with a low level of quality: the mixture has high flow and low workability. For this reason, bricklayers spend more time on masonry work and are outside the working area.

Analyzing this information, the manager can decide to change the supplier (mortar-concrete unit) to another, and after a while pay attention to the statistics on this problem. By adjusting the activities of the organization, the manager can achieve a significant increase in the efficiency of work production.

Above - selected statistics for reasons of anomalies, below - selected statistics on payroll overpayment. In addition to direct management of the organization, the "Zodchiy-Web" interface can be used by employees of the personnel department, accounting department, as well as for heads of sections.

Recording the actual working time worked (taking into account violations of discipline, overwork) allows you to determine the most fair wages, paying extra for overwork to especially hardworking employees and subtracting money from wages for violation of labor discipline.

Based on the results obtained, it can be concluded that the developed system will improve the efficiency of the construction enterprise by monitoring the working time of workers, fixing problems arising at the construction site and generating reports for the management of the organization based on the statistical data received.

Based on the factual data received from the system, management can make management decisions, adjusting work for the better, thereby achieving maximum efficiency in the production of work, surpassing the competitors in their industry.

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