IRSTI 73.29.75 https://doi.org/10.26577/be.2024-148-b2-06

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ECONOMIC BENEFITS OF ROUTE MONITORING: GPS TRACKING IN KAZAKHSTAN'S RAILWAYS

In the context of Kazakhstan's railway operations, this study explores the economic advantages derived from the implementation of GPS tracking technology focused on route monitoring. Employing Extreme Programming (XP) principles, a case study within a national railway company details the process, challenges, and outcomes of integrating GPS trackers on mobile phones for workforce location tracking and geo-fencing. Results demonstrate the significant improvement in monitoring workforce activities and precise payroll calculation based on actual working hours. Emphasizing the role of the XP methodology, the study showcases enhanced stakeholder communication, iterative development, and continuous system improvement. Technical aspects of the GPS tracking system, including architecture, data flow, and integration with existing railway management systems, are examined. Moreover, the study delves into encountered challenges such as privacy concerns, data security, and user acceptance during implementation. This case study presents valuable insights for transportation organizations aiming to implement location-tracking and geo-fencing technologies, providing a blueprint for effective project management, iterative development, and stakeholder engagement in pursuit of economic benefits through route monitoring.

Key words: remuneration system, GPS tracking, extreme programming, geo-fencing, automated payroll, railways.

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Маршруттар мониторингінің экономикалық артықшылықтары: Қазақстанның теміржол жүйесіндегі GPS-бақылау

Қазақстанның теміржол операциялары контекстінде бұл зерттеу маршруттар мониторингіне баса назар аудара отырып, GPS-қадағалау технологиясын енгізуден туындайтын экономикалық артықшылықтарды зерттейді. Экстремалды бағдарламалау принциптерін (Extreme Programming, XP) қолдана отырып, ұлттық теміржол компаниясы жұмыс күші мен геоқоршаудың орналасуын бақылау үшін ұялы телефондардағы GPS трекерлерін біріктіру процесін, қиындықтары мен нәтижелерін егжей-тегжейлі зерттеді. НӘТИЖЕЛЕР нақты жұмыс істеген сағаттар негізінде жұмыс күшін бақылау мен жалақыны дәл есептеудің айтарлықтай жақсарғанын көрсетеді. XP әдіснамасының рөлін атап көрсете отырып, зерттеу мүдделі тараптармен өзара әрекеттесуді, қайталанатын дамуды және жүйені үнемі жетілдіруді көрсетеді. GPS бақылау жүйесінің техникалық аспектілері, соның ішінде архитектура, деректер ағыны және қолданыстағы теміржолды басқару жүйелерімен интеграция қарастырылады. Сонымен қатар, құпиялылық туралы алаңдаушылық, деректердің қауіпсіздігі және іске асыру процесінде пайдаланушыларды қабылдау сияқты мәселелермен бетпе-бет келу зерттеледі. Бұл кейс-зерттеу маршруттарды бақылау арқылы тиімді жобаны басқару, итерациялық даму және мүдделі тараптарды экономикалық пайданы іздеуге тарту жоспарын ұсына отырып, орналасқан жерді бақылау және геоқоршау технологияларын енгізуге бағытталған көлік ұйымдары үшін құнды идеяларды ұсынады.

Түйін сөздер: сыйақы жүйесі, GPS-бақылау, экстремалды программалау, гео-аймақ, автоматтандырылған жалақы есептеу, темір жолдар.

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Экономические преимущества мониторинга маршрутов: GPS-отслеживание в железнодорожной системе Казахстана

В контексте железнодорожных операций Казахстана, данное исследование исследует экономические преимущества, вытекающие из внедрения технологии GPS-отслеживания с акцентом на мониторинге маршрутов. Используя принципы экстремального программирования (Extreme Programming, XP), в рамках национальной железнодорожной компании проведено кейс-исследование, детализирующее процесс, вызовы и результаты интеграции GPS-трекеров на мобильных телефонах для отслеживания местоположения рабочей силы и геозоны. Результаты демонстрируют значительное улучшение мониторинга деятельности рабочей силы и точного расчета заработной платы на основе фактически отработанных часов. Подчеркивая роль методологии XP, исследование показывает улучшенное взаимодействие с заинтересованными сторонами, итерационное развитие и постоянное совершенствование системы. Рассматриваются технические аспекты системы GPS-отслеживания, включая архитектуру, поток данных и интеграцию с существующими системами управления железной дорогой. Кроме того, исследуется столкновение с проблемами, такими как обеспокоенность конфиденциальностью, безопасность данных и принятие пользователей в процессе внедрения. Это кейс-исследование представляет ценные идеи для транспортных организаций, нацеленных на внедрение технологий отслеживания местоположения и геозон, предоставляя план эффективного управления проектом, итерационного развития и вовлечения заинтересованных сторон в стремлении к экономическим выгодам через мониторинг маршрутов.

Ключевые слова: система вознаграждения, GPS-отслеживание, экстремальное программирование, геозона, автоматизированный расчет заработной платы, железные дороги.

Introduction

In today's landscape, the fusion of technology and economic paradigms stands as the linchpin of operational efficiency across diverse industries. Central to organizational resilience, workforce management undergoes a profound metamorphosis in the wake of digital advancements. This manuscript focuses on an innovative case study within Kazakhstan's national railway, spotlighting the seamless amalgamation of digital tools to optimize remote work management.

Within the pivotal realm of transportation and logistics, the railway sector emerges as a prime arena ripe for reaping economic benefits through technology-driven methodologies. Yet, amidst this broad digital transformation, articulating specific research motives becomes paramount.

This study navigates an exploration into the successful incorporation of employee location tracking and boundary optimization technology within the framework of a national railway company in Kazakhstan. The integration of Global Positioning System (GPS) trackers on mobile devices, coupled with the application of strategic programming methodologies, has instigated a fundamental shift in economic strategies for workforce management.

At its essence, the convergence of mobile technology and geospatial information systems embodies unprecedented precision in monitoring employee movements within the railway premises. Beyond fortifying staff safety by ensuring adherence to safety protocols, this technology provides crucial insights for resource allocation and operational efficiency enhancements.

Furthermore, the adoption of strategic programming methodologies injects a novel facet into this endeavor. This agile software development approach champions iterative progress, continual feedback, and collaborative teamwork. Its infusion into the implementation of boundary optimization and employee tracking systems facilitated swift adaptability to evolving demands, integrating valuable end-user insights to tailor a solution harmonized with the distinct challenges of the railway industry.

Throughout this manuscript, a systematic elucidation unfolds, detailing the intricate process of implementing the employee location tracking and boundary optimization system. This comprehensive exploration encompasses an in-depth analysis of encountered challenges, deployed strategies, and attained outcomes. Additionally, the article delineates the broader ramifications of embracing strategic programming, extending its

potential applications beyond conventional software development domains.

In summary, this manuscript illuminates a groundbreaking case study that encapsulates the fusion of technology and economic methodologies, overcoming pivotal challenges in workforce management within a national railway company. The integration of GPS tracking and boundary optimization technology, synergized with strategic programming, serves as an exemplary model for industries striving to optimize employee monitoring, operational efficiency, and precision in economic management. By disseminating insights from this initiative, the aspiration is to catalyze further innovation at the dynamic intersection of workforce management and technological-economic integration.

The ensuing sections meticulously explore the literature review, project methodology, implementation intricacies, encountered challenges, achieved outcomes, and the broader implications of this successful initiative for the railway industry in Kazakhstan, considering its potential applicability beyond national borders

Literature Review

Employee attendance monitoring has attracted significant scholarly attention, highlighting diverse technological applications. Soewito implemented smartphone-based attendance management using the SDLC Waterfall methodology, emphasizing continuous monitoring (Soewito, 2019). Sudheer explored GPS and GPRS technologies, employing embedded ARM microcontrollers in ID cards for automated attendance recording within designated work areas, albeit requiring enhancements like fingerprint authentication (Sudheer, 2016). Lodha investigated Bluetooth smart wireless technology for student position monitoring, highlighting advantages such as low power consumption and rapid data transfer (Lodha, 2015). Hameed integrated RFID with wireless entry database records, offering comprehensive attendance metrics (Hameed, 2015).

However, prevailing studies often focus on location tracking within confined spaces, like offices or specific work zones. Our study diverges by tackling a more expansive context: the Kazakhstan Railway, an expansive territory ranked 9th globally in area. Addressing unique challenges, our focus extends beyond mere employee location tracking to ensure accurate work-time records and fair wage calculations in areas lacking consistent cellular signal coverage. This broadens the scope beyond traditional office-based monitoring.

Moreover, our research emphasizes the transition from conventional paperwork-intensive methods to digital solutions. Our goal is to streamline record-keeping and wage calculation without necessitating extensive manual documentation, marking a departure from previous approaches.

Beyond technical considerations, this article delves into the incorporation of Extreme Programming (XP), an agile methodology. XP allows real-time user feedback incorporation during implementation, ensuring adaptability and user-centric design in remote work management tools.

Sonal's 2016 project enhanced security through unique logins and passwords on Android devices, enabling comprehensive monitoring of mobile activities and geographical locations (Sonal, 2016). Aparna introduced a Smartphone Monitoring System in 2013, storing various data in a centralized database while tracking physical locations and unauthorized contacts (Aparna, 2013). Prajakta's 2015 software facilitated communication between field workers and managers through Android devices, storing relevant details in a centralized server for managerial access (Prajakta, 2015). Shermin's 2015 system emphasized location-based time and attendance tracking using GPS on mobile devices and personalized computers (Shermin, 2015). Nirmal's 2016 project integrated employee and GPS tracking, preventing unauthorized resource usage and enabling oversight of employees' activities (Mohan, 2019), (Pressman, 2015).

While the scientific community demonstrates considerable interest in employee location tracking, much of the emphasis remains on office settings. This study distinguishes itself by addressing challenges specific to expansive territories like the Kazakhstan Railway. It highlights the necessity for reliable tracking and fair wage computation in areas lacking continuous cellular coverage, all the while advocating the adoption of XP for the development of user-centric tools.

Methodology

Maximizing economic efficiency through Extreme Programming (XP) in railway workforce management.

Our research methodology strategically adopts XP; an iterative and incremental approach entrenched within agile software development, renowned for its adherence to an object-oriented paradigm. XP embodies collaboration, adaptability, and active

customer engagement throughout the software development process, aligning with our pursuit of economic efficiency within the Kazakhstan Railway context (Rostislav, 2011) (Burham, 2020) (Oxley, 2017).

Planning Phase: Enhancing Economic Goals Insights: The XP planning phase serves as a pivotal juncture for defining clear and economically prioritized user stories or requirements. Facilitating extensive communication among stakeholders, developers, and the client, this phase aims to establish a shared understanding of project objectives and economic scope. Common Economic Practices: Techniques like User Story Mapping, Release Planning, and the collaborative "planning game" enable the alignment of economic objectives, allowing stakeholders and the development team to estimate and prioritize tasks collaboratively. Emphasis is on setting short-term, economically feasible goals for each iteration, ensuring economic viability.

Design Phase: Economically Efficient Solutions Insights: Within XP's design phase, emphasis lies in devising economically simple, flexible, and maintainable solutions. Embracing continuous economic feedback and iterative design processes facilitates the evolution of the system architecture and design, aligning with economic objectives. Common Economic Practices: Strategies such as Simple Design, Refactoring, Pair Programming, and System Metaphor establishment contribute to creating an economically coherent and adaptive design structure. The focus is on maintaining economic adaptability to changing requirements, ensuring efficient resource allocation.

Coding Phase: Economic Development Insights: The coding phase marks the actual economic development phase, wherein developers collaborate in pairs, coding to fulfill economically defined user stories while ensuring high code quality and adherence to economic coding standards. Common Economic Practices: Methodologies like Test-Driven Development (TDD), Collective Code Ownership, Continuous Integration, and Pair Programming remain integral to this phase. The goal is to produce economically clean, functional code with comprehensive test coverage, optimizing economic resource utilization.

Testing Phase: Ensuring Economic Viability Insights: XP's testing phase entails rigorous economic testing at multiple levels (unit, integration, and acceptance) to validate functionality and ensure software aligns with specified economic requirements. Common Economic Practices: Test-Driven Development (TDD), Automated Testing, and Continuous Economic Feedback loops ensure maintenance of high software quality. Customer involvement in economic acceptance testing guarantees alignment with economic user expectations.

In summary, XP's structured four-phase approach embodies collaborative, adaptive, and iterative economic principles, fostering continuous economic improvement throughout the software development lifecycle. By adhering to these key components and practices, our study applies a structured and agile approach to maximize economic efficiency in managing remote work within the Kazakhstan Railway's economic framework

Application of XP Phases in the Research: Economic Insights.

In our study aimed at optimizing remote work management within Kazakhstan Railway, the implementation of XP's four phases unfolded as follows:

1. Planning Phase: Economic Perspectives

During the initial planning phase, a series of interviews were conducted with representatives from Kazakh Railways, with a primary focus on the technical condition assessment division–the track diagnostics center (CTD). The interviewees held diverse roles and had extensive experience within the organization:

Firstly, the Director of the CTD, bringing over 15 years of expertise in railway operations and management.

Secondly, the Chief Engineer of the CTD, with more than 10 years of experience overseeing technical aspects in railway diagnostics and maintenance.

Thirdly, the Deputy Director of the CTD, with a professional tenure exceeding 20 years, responsible for strategic decision-making and operational oversight within the CTD.

Additionally, there were Production Site Supervisors, each with over 10 years of experience, managing on-site railway maintenance activities.

Furthermore, Standardization Specialists of the CTD were involved, responsible for precise calculation methods related to engineers' working hours for railway track diagnostics.

The CTD Economist was also part of the interviews, tasked with planning and monitoring the CTD labor fund budget, possessing a comprehensive understanding of financial aspects within railway operations.

Lastly, an Accountant for the calculation and payroll of CTD employees, with over 20 years of

experience in payroll management and meticulous attention to compensation matters, was included in the interview process.

Selected after discussions with CTD management, these interviewees provided invaluable economic insights into critical remote work management issues. The Planning phase surfaced crucial economic concerns articulated by CTD stakeholders:

Selected interviewees provided insights into economic concerns:

Supervisor Monitoring Constraints: Existing monitoring mechanisms relying on manual paper-based route sheets hinder real-time oversight. Supervisors aspire to continuously track employee movements via a map, observing specific checkpoints along their routes to enhance economic efficiency.

Time-Intensive Payroll Handling: Current payroll processes, reliant on paper route sheets transferred to Excel, result in time-consuming aggregation prone to human errors. This impacts accurate payroll and overtime calculations, posing economic challenges.

Work Hour Reporting Inconsistencies: Absence of oversight mechanisms leads to inflated work hour reporting during track diagnostics, challenging the verification of actual task completion times, impacting economic resource allocation.Stakeholder analysis was integrated, identifying key stakeholders critical to the project's economic success. These stakeholders encompassed CTD employees, middle and top-level managers, HR and accounting functions, and the internal audit team evaluating annual payroll process quality within CTD.

This approach ensured a comprehensive economic exploration of remote work management challenges within Kazakhstan Railway, aligning our study with economically viable solutions.

APPROVE
Director _____

Route sheet
for a business trip of JSC "NC "KTZ" employees
май 2022
наладчик МДК

RETIREMENT					ARRIVAL				
№	**The date**	**The time**	**Point of depature**	**Signature**	**№**	**The date**	**The time**	**Destination**	**Signature**
1	17.05.2022	10:05	signature	print	2	17.05.2022	21:35	signature	print
3	18.05.2022	08:30	signature	print	4	18.05.2022	14:10	signature	print
5	18.05.2022	14:40	signature	print	6	18.05.2022	21:25	signature	print
7	19.05.2022	09:10	signature	print	8	19.05.2022	15:45	signature	print
9	19.05.2022	22:00	signature	print	10	20.05.2022	03:30	signature	print
11	20.05.2022	13:25	signature	print	12	20.05.2022	21:20	signature	print
13	21.05.2022	10:55	signature	print	14	21.05.2022	15:15	signature	print
15	22.05.2022	11:15	signature	print	16	22.05.2022	17:05	signature	print
17	23.05.2022	10:05	signature	print	18	22.05.2022	15:25	signature	print
19	23.05.2022	16:40	signature	print	20	23.05.2022	19:45	signature	print
21	24.05.2022	12:35	signature	print	22	24.05.2022	20:25	signature	print

Figure 1 – A sample of a completed route sheet in paper form
Note – source: KTZ internal materials translated

2. Design: Economic Considerations

Upon reviewing various prior research studies, our preference gravitated towards employing GPS technology (Burham, 2020). The additional equipment influenced this decision and extra expenses required for RFID or microchip tags. Moreover, given that the majority of employees carry cellphones during work, utilizing the GPS capabilities within these devices proves advantageous in terms of cost-effectiveness.

The Global Positioning System (GPS) serves as a technological innovation reliant on satellite-derived signal data to pinpoint precise locations. Processing this signal data enables establishing location points and recording various data, including distance traveled, departure and arrival times, crucial for economic efficiency.

A beta iteration of the mobile application, known as Dilau Tracker, was developed with specific economic objectives for the preliminary project. Firstly, the focus was on validating the hypothesis feasibility regarding the beta variant's ability to effectively gather real-time geolocation data from CTD employees' mobile devices across Kazakhstan's entire railway network, even in areas lacking cellular signal for data transmission. Various technologies such as GPRS, EDGE, HSPA, LTE (Sunrise...) were utilized, emphasizing cost-efficiency.

Next, the objective was to confirm the dependability and accuracy of geolocation markers on the map. This aimed to ensure consistent representation of points concerning chronological references, thereby visualizing uninterrupted employee movement routes and promoting economic efficiency in monitoring.

Following that, the goal was to verify the accurate recording of station and haul passages by CTD workers along their movement route. This involved leveraging preloaded GPS coordinates of these control points on the map for economic resource allocation.

Another objective was to validate the capability to automatically generate a digital route record based on employee mobile device geolocation input while logging progress through checkpoints. This aimed to streamline economic operational processes.

The next focus was to assess geolocation precision, ensuring the mobile device's location accuracy on the map within a 100-meter radius. This was crucial for efficient resource allocation.

Additionally, there was an objective to evaluate CTD employees' readiness to transition to a novel working hour recording method, considering economic implications and potential productivity gains.

Another goal was to test the mobile application's compatibility with various Android or IOS operating system-supporting devices used by CTD employees, focusing on economic device versatility.

Lastly, the objective was to identify potential shortcomings of the beta version during the trial operation period from August 01, 2022, to October 30, 2022. The aim was to find preemptive solutions before the official launch of the industrial version, thus ensuring economic effectiveness.

This meticulous economic-focused design phase ensured the economic viability of the GPS-based solution within Kazakhstan Railway, emphasizing cost-efficiency and resource optimization.

3. Coding: Economic Framework Development

The Dilau Tracker system, designed to efficiently manage remote work within Kazakhstan Railway, encompasses a structured framework comprising major components: the Control Panel, Mobile Application, Reporting System, and Integration Module. These components synergistically address outlined research gaps and align with research objectives. To provide a comprehensive visualization of the framework, a diagram (Figure 2) elucidates interconnections and functionalities among these major components.

Economic Framework Components.

1. Control Panel: Economic Centralized Management

The Control Panel acts as a centralized interface facilitating crucial functionalities for system administration and user interaction. Key functionalities include user authorization and registration, real-time visualization of user movement data on a geographical map, automated generation of electronic route sheets, and checkpoint management, emphasizing economic resource allocation and operational efficiency

2. Mobile Application: Economic User Connectivity.

Integral to the system, the Mobile Application (see Figure 3) operates on user devices, enabling remote tracking and communication. Its economic functionalities encompass user authorization and registration, mobile device movement data collection, and user action logging for monitoring and evaluation purposes, focusing on economic efficiency and seamless data acquisition

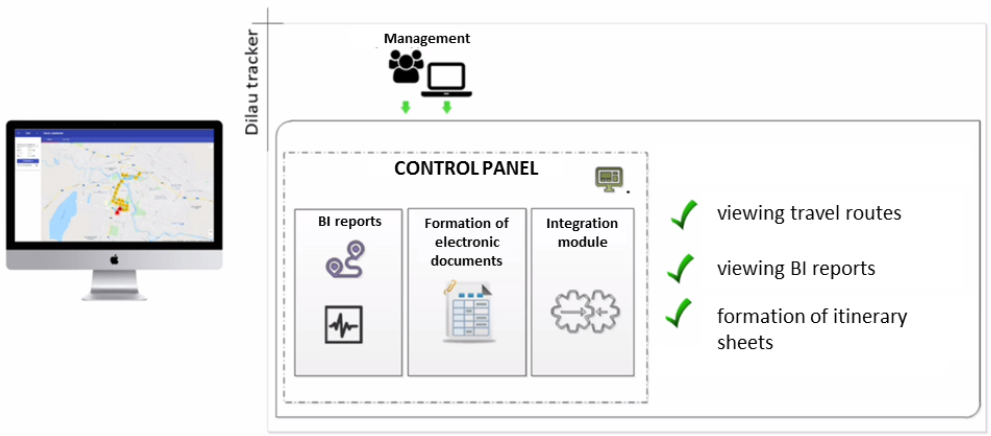

Figure 2 – Web application functionality
Note – source: authors development

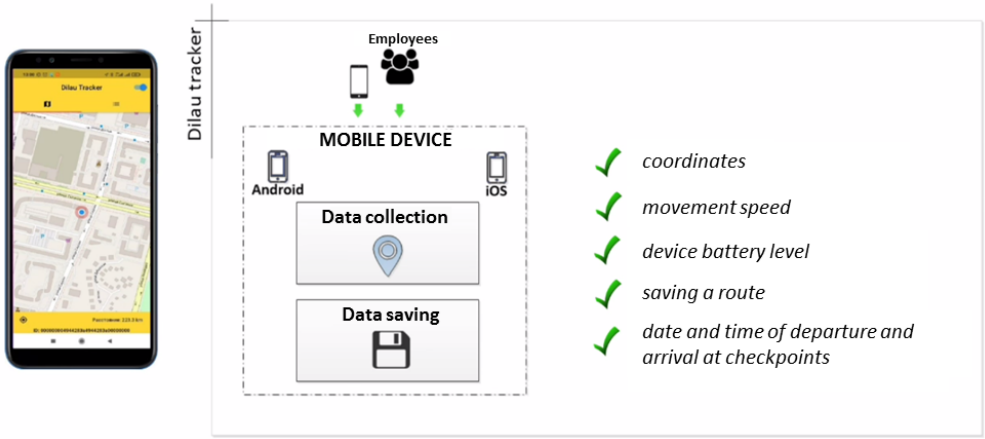

Figure 3 – Application functionality
Note – authors development

3. Reporting System: Economic Decision Support

The Reporting System provides a platform for viewing detailed reports derived from system-generated data, aiding in performance evaluation and decision-making processes, enhancing economic decision support within the railway operations.

4. Integration Module: Economic Interoperability.

The Integration Module ensures seamless data exchange with external systems through API integration, crucial for economic interoperability and enhancing system efficiency.

Functionality and Workflow: Economic Optimization

Each component's functionalities align with specific workflows designed to address identified research gaps and achieve economic research objectives:

- Control Panel Functionality Workflow emphasizes user interaction and efficient data handling, streamlining supervisory tasks to bridge the gap in real-time monitoring and management, enhancing economic operational efficiency.

- Mobile Application Functionality Workflow ensures smooth user mobility and data collection, focusing on remote user interaction and efficient data gathering, optimizing economic workflow between field operations and the central system.

- Reporting System Functionality offers comprehensive views of generated reports for informed decision-making, catering to economic performance assessment and user activity evaluation.

- Integration Module Functionality facilitates seamless data exchange with external systems, aligning with economic interoperability and integration objectives.

The Dilau Tracker system operates on a robust software stack comprising:

- Linux OS
- PostgreSQL as the object-relational database management system
- Java for backend programming, JavaScript for frontend, and Dart for mobile applications
- Frameworks such as Spring for Java backend, Angular/ReactJS for frontend, and Flutter for mobile app development.

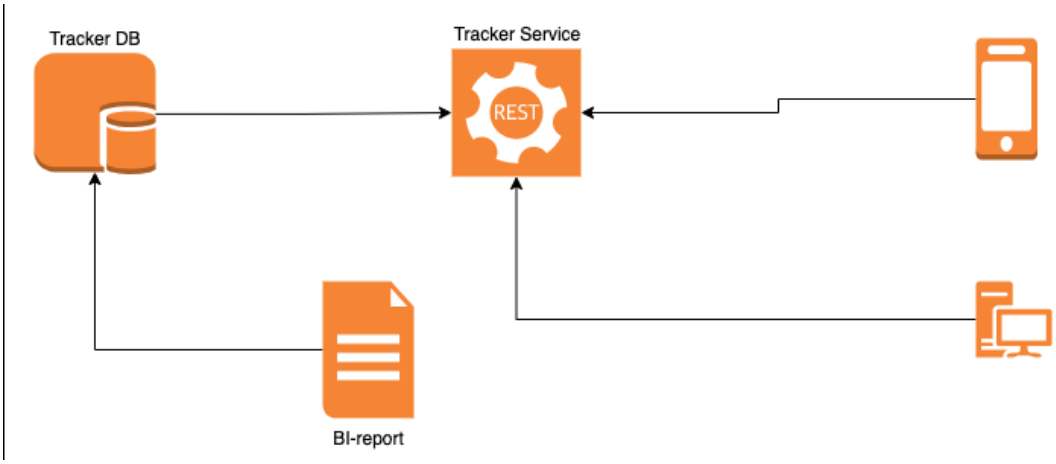

Figure 4 – Solution Logic Architecture
Note – authors development

Server Deployment involves two distinct servers:

1. Application Server: Hosting backend services, web applications, including the Control Panel, and PostgreSQL database with essential postgis extensions for coordinate-based operations.

2. PPPoE Server: Dedicated to deploying the reporting system.

Containerized Deployment using Docker technology streamlines system administration, minimizes resolution times, and allows scalable deployment via cluster deployment. Docker Compose is utilized to facilitate the deployment process across both servers.

4. Testing

The testing phase during the initial pilot rollout involved comprehensive user engagement and feedback collection, fostering an iterative and collaborative approach between development teams and end-users for ongoing system enhancement. The deployment of the Dilau tracker system underwent rigorous testing and user engagement, presenting opportunities for iterative improvements through feedback-driven modifications and collaborative strategies:

1. User Engagement and Feedback Collection: Economic Participation.

The pilot rollout successfully onboarded 365 users into the system, primarily utilizing their personal mobile phones for work-related assignments, after consenting to engage in the system. Subsequently, the observed user engagement displayed an escalating trend over time. Initially, daily usage involved a modest count of up to 20 individuals engaging with the mobile application. This count progressively increased, with an average daily user count reaching 60 to 70 individuals, culminating in a peak of 124 employees accessing the application on a single day.

2. Feedback-Guided Iterative Enhancements.

The feedback obtained from beta version testers of the Dilau tracker mobile application resulted in a sequence of iterative improvements, highlighting the collaborative relationship between development teams and end-users.

Firstly, challenges related to user adoption were addressed. The team responded to issues faced by some employees, such as smartphone unavailability or malfunctioning devices. Recommendations included providing company-provided mobile

devices or establishing incentives for using personal phones. These suggestions were informed by an online user survey indicating preferences.

Next, efforts were directed towards enhancing the regularity of usage. Recognizing sporadic usage patterns among initial rollout participants, recommendations emphasized the importance of continual employee engagement with the mobile application throughout the workday. Educational efforts focused on conveying the significance of consistent usage and maintaining well-prepared smartphones.

Following that, various recommendations for functional improvements were identified. These included the implementation of push notifications, integration of temporary work schedules, introduction of employees' work plans into the system, and optimizing map usage to reduce Internet traffic.

Moreover, feedback regarding security and access issues prompted plans to introduce an authorization and registration feature using SMS codes. This approach aimed to eliminate the dependency on manual password management in the initial registration interface, as illustrated in Figure 5.

Additionally, users' suggestions for enhanced supervisory controls within the Control Panel led to plans for real-time activity tracking of mobile application users and the provision of detailed activity status for supervisors. The initial Control panel interface is depicted in Figure 6.

Furthermore, recommendations for efficiency and coordination involved improving route sheet generation capabilities. This included the ability to create route sheets for multiple employees or employee groups simultaneously, streamlining the process for supervisors and enhancing operational efficiency.

Addressing system discrepancies in checkpoint logging, adjustments were made to include more precise coordinates, expanded boundaries around control points, and improvements in registering checkpoints. These changes aimed to ensure accurate tracking of employee movements in geo-fencing and checkpoint logging.

Lastly, feedback from accounting and personnel departments led to planned efforts for integrating route sheet information between the Dilau tracker system and the company's SAP ERP accounting system. This integration is aimed at ensuring data accuracy and streamlining workflow processes.

3. Collaboration and Continuous Improvement.

The feedback-driven iterative enhancements underscore the collaborative efforts between development teams and end-users. The system's agile development approach, coupled with ongoing user feedback, plays a pivotal role in refining functionalities and addressing user-specific requirements. These continuous improvement cycles, driven by user engagement and team collaboration, highlight the iterative nature of the framework and its responsiveness to evolving user needs and technological advancements.

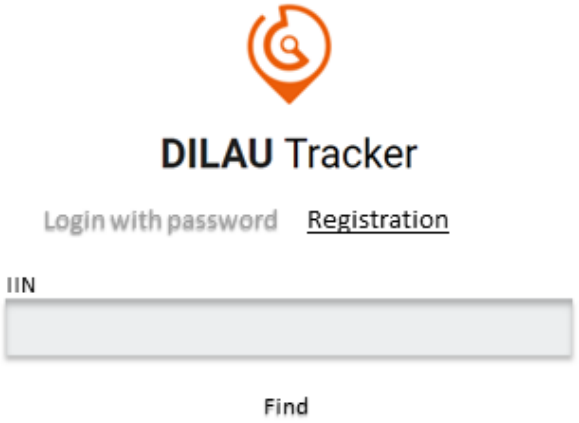

Figure 5 – Registration interface for mobile application
Note – print screen form application developed by authors' team

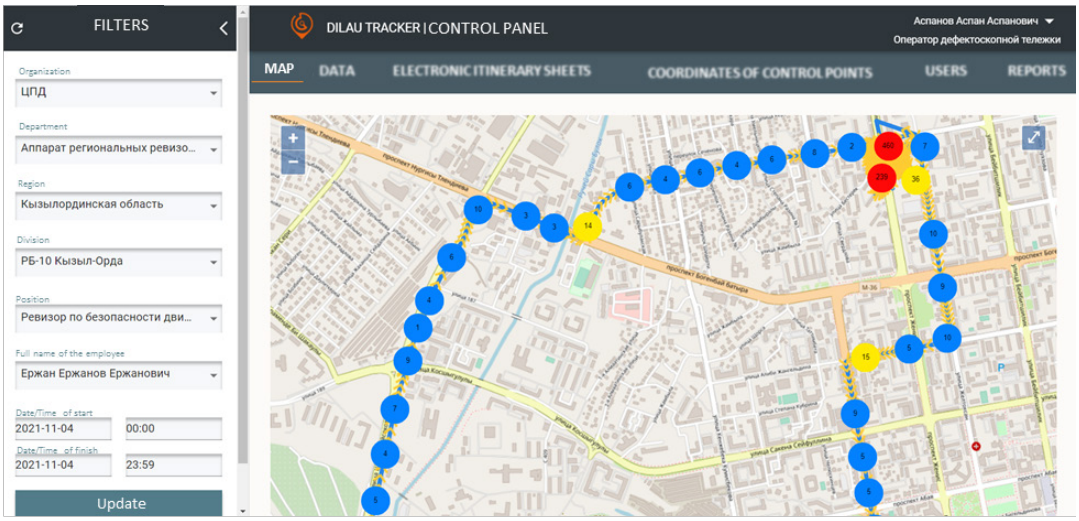

Figure 6 – Control Panel interface example
Note –print screen form application developed by authors' team

Results and discussions

The integration of employee location tracking and geo-fencing technology through GPS trackers on mobile phones resulted in significant positive outcomes within the realm of Kazakhstan Railway's remote work management, profoundly influencing the economic efficiency of route operations.

Firstly, precision in route-based payroll calculation was achieved. The implemented system utilized real-time location data along designated routes to enable accurate working hour calculations. This strategic shift effectively minimized errors and discrepancies in payroll processing associated with manual timekeeping methods. The result was enhanced economic accuracy and resource optimization along specific routes.

Next, efficiency in route operations was enhanced through the adoption of automated location tracking. This eliminated the need for manual timekeeping, substantially reducing administrative burdens specific to route management. The integration notably bolstered operational efficiency along designated routes, emphasizing the economic streamlining of labor resources and route-centric tasks.

The system also augmented transparency in route monitoring. By accurately recording and readily providing accessible working hour data for review along specified routes, the technology fostered heightened transparency between employees and management. This transparency ensured enhanced clarity, accountability, and optimal economic resource allocation within designated routes.

Furthermore, a reduction in overpayments along designated routes was observed. Rigorous evaluation assessed the impact of the system on overpayments for CTD engineers' overtime work along specific routes. Comparative analysis between pre-implementation and post-implementation periods revealed a significant 70% reduction in overpayments along designated routes. Data extracted from the accounting system showcased a noteworthy decline in overpayments, ensuring economic accuracy in payroll calculations and expenditure along specific routes.

Evaluation Process and Research Validity.

The evaluation process entailed a robust comparative analysis of overpayment data, focusing specifically on overtime payments to CTD engineers along designated routes. The comparison between pre-implementation and post-implementation periods ensured a thorough measure of the system's effectiveness in curtailing overpayments along specified routes. Consistency in the average monthly headcount during these periods fortified the validity of the research evaluation.

Furthermore, ongoing user testing and feedback collection reinforced research validity, allowing continual identification of critical issues and iterative improvement of both the beta version of the mobile application and the web interface, specifically tailored for route management. The application of the XP methodology facilitated adaptability and continuous enhancement in alignment with the evolving economic needs of the company's route-centric operations.

Before vs After Analysis.

The insights gathered from interviews and discussions with CTD management illuminated critical issues affecting remote work management within the organization. A comparison between the pre-implementation challenges and the observed post-implementation benefits highlights a transformation:

Before Implementation:

1. Supervisor Monitoring Constraints: Relying on manual submission of paper route sheets hindered real-time oversight.

2. Time-Intensive Payroll Handling: Manual processes resulted in time-consuming calculations, prone to errors affecting accurate payroll.

3. Work Hour Reporting Inconsistencies: Lack of oversight mechanisms led to inflated work hour reporting during track diagnostics, posing challenges in verifying actual task completion times.

After Implementation, the system facilitated:

1. Real-time monitoring of employee movements via a map.

2. Streamlined payroll processes, reducing errors and saving time.

3. Accurate tracking of work hour reporting, ensuring consistency and verification of task completion times.

The implementation of the digital solution effectively addressed these challenges, enhancing operational efficiency and accuracy in various aspects of remote work management within Kazakhstan Railway.

The implementation of employee location tracking and geo-fencing technology through GPS trackers on mobile phones, coupled with the application of the XP method, within a national railway company in Kazakhstan, has brought forth essential insights and outcomes. This section delves into the pivotal findings and economic implications derived from this research endeavor.

The adoption of GPS trackers for monitoring employee locations and enforcing geo-fencing within a railway company setting demonstrated promising outcomes, notably in augmenting operational efficiency and ensuring workforce accountability along designated routes. Real-time location data empowered the company to optimize resource allocation, leading to efficient route scheduling and improved response times during emergencies. The integration of geo-fencing further established virtual boundaries, ensuring adherence to specified work zones–an imperative factor in maintaining safety and preventing unauthorized access to restricted areas along designated routes.

Moreover, the application of the XP method yielded substantial advantages in managing the development and implementation of this technology solution along designated routes. The iterative and incremental nature of XP fostered continuous feedback loops and collaboration among the development team, stakeholders, and end-users. This iterative approach proved particularly advantageous, allowing the incorporation of evolving route-specific requirements and immediate adjustments based on real-world feedback. Consequently, the implemented solution aligned closely with the company's route-centric needs and adeptly addressed potential challenges more effectively.

However, this project also underscored specific economic challenges and considerations. Privacy concerns emerged as a significant issue, particularly with regards to route-specific employee tracking, raising pertinent questions about the balance between operational optimization and individual privacy rights along designated routes. Achieving this equilibrium mandates the establishment of a comprehensive data protection framework, ensuring responsible and ethical collection, storage, and utilization of employee data, particularly along specified routes.

The successful implementation of this technology solution hinged on comprehensive training and change management initiatives. Educating employees about the purpose and economic benefits of the system was essential in mitigating any resistance to adoption along designated routes. Additionally, the seamless integration of the technology with existing systems and processes necessitated meticulous planning and execution to prevent disruptions and ensure a smooth economic transition along designated routes.

Conclusion

The integration of employee location tracking, geo-fencing technology, and the application of XP methodology has demonstrated significant effectiveness in transforming remote work management practices within Kazakhstan's national railway company. The tangible outcomes observed highlight the substantial impact and economic potential of this integrated approach in reshaping workforce management paradigms in the transportation sector, particularly within the realm of Route Management. Aligning Objectives with Attained Results. The study's primary goals focused on enhancing efficiency, precision, and transparency in remote work management, specifically along

designated routes. The achieved results directly align with these objectives, showcasing substantial accomplishments:

Firstly, operational augmentations were evident. The implementation of employee location tracking and geo-fencing technology brought about notable enhancements in various operational facets. This included accurate payroll computation using real-time location data, significantly reducing errors and discrepancies in wage calculations along designated routes. Additionally, there were significant efficiency gains by replacing manual timekeeping with automated location tracking, alleviating administrative burdens and enhancing operational efficiency along designated routes.

Secondly, transparency and economic savings were notable outcomes. The system not only fostered improved transparency between employees and management by accurately documenting working hours but also resulted in noteworthy cost savings through a 70% decrease in overpayments along designated routes. The empirical validation of this reduction emphasizes the system's efficiency in mitigating overpayment instances related to overtime work along specified routes.

Thirdly, employee satisfaction and continuous improvement were observed. The precise calculation of working hours and iterative enhancements facilitated by the XP methodology contributed to heightened employee satisfaction along designated routes. This iterative process led to continual refinement of system functionalities based on ongoing user feedback, highlighting XP's efficacy in meeting evolving user needs and ensuring sustained improvements along specified routes.

Research Contributions and Limitations.

The study's contributions lie in its successful demonstration of a comprehensive framework that integrates technological advancements with agile development methodologies to address critical challenges in remote work management, especially along designated routes. The research validated the system's economic efficacy through a multi-layered evaluation process, ensuring statistical validity, practical effectiveness, and alignment with user requirements along specific routes. However, it is imperative to acknowledge certain limitations and potential areas for further exploration:

- Privacy and Training Considerations: The project underscores the significance of addressing privacy concerns and implementing robust data protection measures, emphasizing the importance of thorough training and change management efforts to ensure seamless integration and employee acceptance, particularly along specified routes.

- Future Directions: Future research endeavors could delve deeper into privacy-preserving implementations of similar technologies and explore enhanced strategies for employee training and acceptance along designated routes. Furthermore, investigating the long-term effects of system implementation and its adaptability in varying organizational contexts could provide valuable economic insights for broader industry adoption.

Implications for Future Practices.

The insights derived from this case study offer valuable economic perspectives for organizations aiming to enhance efficiency, transparency, and workforce management practices, specifically along designated routes. The successful integration of advanced technology and agile methodologies holds the potential to revolutionize operational practices not only in transportation but also across diverse industries, paving the way for heightened efficiency, transparency, and employee satisfaction along specified routes.

Complementary Data

The research is financially supported by grant №AP14871940 from the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan.

Data Availability Statement:

No Data associated in the manuscript

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Received: 18 January 2023
Accepted: 06 June 2024