A Mine Production Tracking Platform and Its Initial Application in the Digital Transformation for a Vietnamese Coal Exploitation Company

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Abstract Promoting the application of information technology in production management is essential to improve the efficiency. Mine production data usually come in multiple categories such as rough and detailed planning, execution, assessment, examination, inspection and accreditation. These data need to be frequently exchanged between related people and groups. In current Vietnamese coal companies, this is generally achieved by using a common shared folder on a local network, which is highly vulnerable to multiple risks, e.g., data loss or defect, lack of access permission control, file simultaneous access problem, difficulties in synthesizing data for reports… and overall, will result in efficiency decline in production administration. In this study, a data management platform for the mine production data tracking which aims to solve the above problems by using a centralized server is introduced. The solution is then deployed in a coal exploitation company in Vietnam. With support from Viettech Company Ltd, an initial evaluation of the system shows a 10% human errors reduction.

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1 Introduction

Although many different definitions have been proposed, digital transformation in a broad sense can be understood as the process of applying novel technologies in the field of digital communication and data processing to solve problems of life [1]. This is a process closely related to the Industrial Revolution 4.0, promoting the application of science and technology to help change the way people live and work. For businesses, this is the process of integrating advanced technologies into their activities, helping to fundamentally and comprehensively change the way businesses operate and create value. Thus, this is not only a process of applying technology alone, but it also requires a change for people in terms of perception, culture, as well as the way of thinking, interacting, communicating, and working. Because of that deeply integrated nature, the digital transformation process will be very different between each industry, as well as within each business, and there is no universal formula.

In addition, digital technologies also enhance the production of data from the use process itself, and are a potential source of information for analysis, forecasting, decision-making, helping to solve problems in optimizing the operating processes of the organization [2]. The study in [3] shows that the digital transformation process for an organization is not only a reorganization of the operating structure, but also requires planners to build a model that integrates the strategy of the organization with that for digital technology [4], and proposed the concept of a digital business strategy (DBS), which is an organization's strategy created and implemented based on digital resources to create differentiated value. However, in [5], Kane pointed out that digital technologies themselves do not create much value for the organization, but applying them to the right circumstances allows to find new ways to create value.

In addition to new technologies for data processing, new system models have been introduced that bring high efficiency to applications, such as cloud computing, edge computing, Internet of things (IoT) [6]. Cloud computing is essentially a computing model that allows the allocation and sharing of storage, processing, and computing resources at the request of users through a network environment. This model has the outstanding advantage of separating the responsibilities for administration and maintenance of data and system resources from the process of using those resources and allows turning those responsibilities into the form of a service to provide to users, thereby helping to reduce costs in the stages of system development, distribution, operation, upgrade and maintenance. This model has now become especially popular for data storage services for individual users, but it also has great potential to improve the operational efficiency of businesses [7].

Although Vietnam's coal reserves are still very large, the coal seams are getting deeper and deeper, coal mining conditions are increasingly difficult, causing production costs to increase and reduce the competitiveness of domestic coal compared to imported coal. The mechanization and automation in the design, operation and supervision of the exploitation process have been interested by Vietnam National Coal and Mineral Industries Group (Vinacomin) for a long time, but the results achieved are still limited. Output of open-pit mines after decades of exploitation has gradually declined, while on the other hand, mining by opencast method greatly affects the composition of natural resources and the environment, so the proportion of opencast coal mining from 2013 to 2019 decreased from 49 to 40% [8]. Most of the open-pit coal mines are increasingly exploited to the depths, so the danger level, the coefficient of rock removal and the transport speed increase. From 1995 to 2019, the coefficient of rock removal increased from 3.41 m^3/ton to 11 m^3/ton, the transport distance increased from 1.0 km to 4.2 km. In underground coal mining, due to the complex geological and structural conditions of the coal seam, the high risk of gas explosion, the transportation supply is also increasing, causing the investment rate from 2000 to 2019 to increase from 50 to 180 USD/ton. Faced with these facts, since 2015, Vietnam has transformed from a coal exporter to a net coal importer, and the rate of trade deficit is increasing sharply [9].

In recent years, Vinacomin has stepped up investment in the development of software related to management operations in the group as well as in its member companies, with the goal of standardizing the management computerization problem [10–12]. The basic factors that help increase labor productivity, reduce manual labor and production costs, and reduce the risk of pit accidents. However, in general, the management in the group is still highly manual, only focusing on basic operations, not meeting the actual needs. With the targeted deadline for digital transformation which is set to be year 2025 by Vinacomin, a lot of work is still needed to be done [13]. Therefore, continue to further improve the capacity, human resource management and development are identified as a key task determining success. In this paper, a software system proposed for the production data management in a coal mining company is introduced.

2 Software Design and Implementation

Each stage of the mining process may use the data presented in datasheets as well as other attached information. Each stage needs to be performed by individuals, groups, or units. In addition, the data in the previous stage also need to be transferred to the individual or group performing the following stage to be able to continue the work. Therefore, the need for information exchange within an enterprise is huge, as shown in Fig. 1, for example. However, at present, the companies do not have any tools to support the sharing and exchange of data and coordinated group work. Meanwhile, the information being updated into the datasheets is happening very often at different stages, making the information exchange flow and the reception of updated information even more complicated.

The solution proposed in this study aims to solve the aforementioned problem by implementing a data cloud in order to gather all the production data, so that

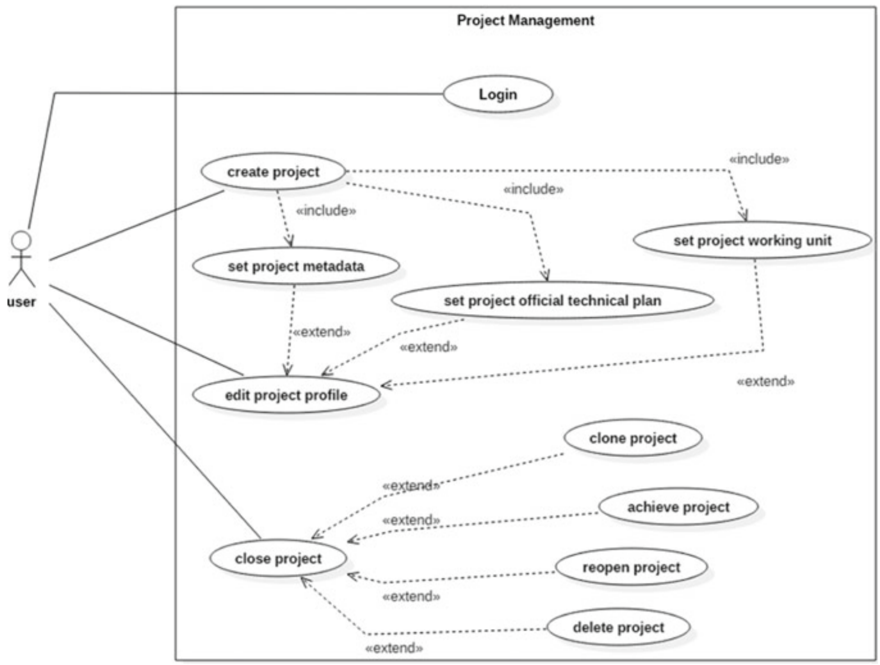

Fig. 1 Project management use case

individuals and groups are able to synchronize their data in real-time. The following functional requirements (FRs) are identified in Table 1.

Table 1 Functional requirements analysis

#FR	Description
FR1	*Users' role & permission management*
FR1.1	Manage user's role based on division unit
FR1.2	Manage user's data access permission based on project group
FR2	*Project management*
FR2.1	Manage project profile (create, update, close, achieve)
FR2.2	Manage project data phases (inspection, planning, design, blasting, exploitation)
FR2.3	Allow user of the same permission group to manage, edit project data collaboratively
FR2.4	Allow versioning and conflict resolving for shared documents
FR3	*Report generation*
FR3.1	Allow generating company working progress report
FR3.2	Allow generating customized project report
FR3.3	Allow generating official project report

Given those requirements, we will discuss some important use cases, database design, sequence diagram of the system. Since the system is built using modular approaches with event-driven NodeJS framework, there will be no class analysis. The diagrams follow IBM UML standards [14].

2.1 Use Case Analysis

There are 3 major use cases of the system: (1) The user initializes and manages different stages of a project; (2) The user edits shared mining data collaboratively via excel add-ins or web application; and (3) The user generate report from mining data. The first use case is presented in Fig. 1. In this use case, user can perform project management actions such as: create, update and close project. The second use case shows user can edit shared mining data from center server (see Fig. 2). Multiple users can perform edit and update actions at the same time. There will be a synchronization process running in order to ensure data synchronization between users. In addition, user can perform conflict resolve in case a conflict is raised. The last major use case is report generation where the systems automatically generate company mining statistic report or user's defined customized report (see Fig. 3). User can also pick from a list of pre-defined official reports for mining data within the company.

2.2 Database Design and Permission Management

The database schema, as shown in Fig. 4, includes two main groups, i.e., user information and production data. The software provides a permission control mechanism to manage user's administrative right and data access possibility based on the group that the user takes part in [15]. The list of account information fields is shown in Table 2.

For administrative right, depending on user account group, user can perform several actions on account management such as: add, remove, edit account's information. The root account has full administrative right on all user accounts. For data access permission, user can only access data within his/her division data views. In any project, one division should be involved in different phases of mining production. The data access permission should also be aligned with these project phases.

In addition to user management, the software allows administrators to manage division and its involved projects. Two types of division are defined: administrative division and on-site working division. The administrative divisions are responsible for setting up technical plan, quality control and accounting. On-site working divisions, in contrast, are unit of workers who directly works at mining tunnel. This, in turn, allows managing data access permission of users. User access permission to certain data view of a project is inherited from his/her division. Since a user can

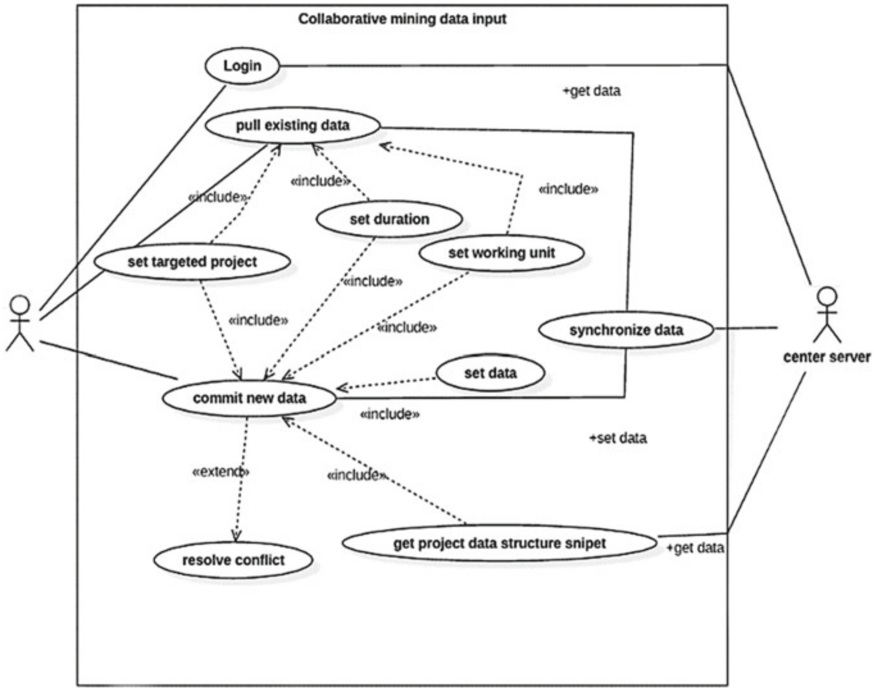

Fig. 2 Collaborative mining data input use case

be in multiple divisions at the same time, the user's data access permission is the cumulative sum of his/her inherited data access permission.

2.3 Mining Data Management

To track mining production data, the platform allows multiple users from different divisions to work simultaneously with mining project data. This includes creation of a new project, setting up mining annual plan for the entire company and for the project specifically, update daily mining production data, on-site quality control and checking data, etc. Here, we introduce the concept of global plan which is a collection of mining plans that should be met. For each plan, a structure consist of multiple production targets are formed.

Mining project is another concept introduced to manage the mining production data. Each project starts with a plan to mine at several locations for a selection of divisions. Data of one project includes: a global mining plan, daily geodetic data, technical assurance, on-site division mining plan and accreditation data. Data from different users and groups once committed will be synchronized to a centralized data cloud, so that other users with right permissions can update to their datasheets. This

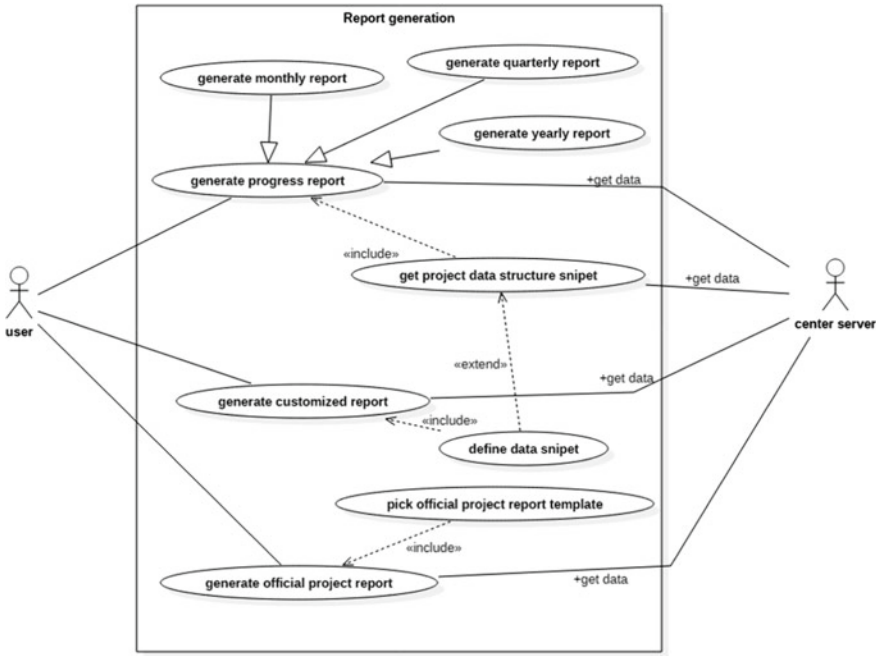

Fig. 3 Report generation use case

helps users to work seamlessly on the same data without need to exchange data files through emails or sharing networks, which causes bottleneck in the workflow, and is also exposed to many security threats. The process of committing new data to the center server is explained in the sequence diagram Fig. 5.

Mining production data then can be viewed with multiple dimensions, as detailed in Table 3. Any combination of these dimensions results in a different view of the centralized data. By defining multiple data dimensions, user can pick different view of the centralized data to have a good understanding about the current production progress. Furthermore, this allows the platform to perform automatic report generation as well as data analysis of the production flow in the future. In the future, a big data management in the mining industry should be considered [16].

2.4 *Conflict Resolution Strategy*

The goal of this platform is to allow multiple users to work with the centralized database at the same time. Achieving this will speed up the data input process as well as enhance error detection chance. Data should be seamlessly synchronized between divisions hence allows a silent and efficient data acquisition process for the higher level of management.

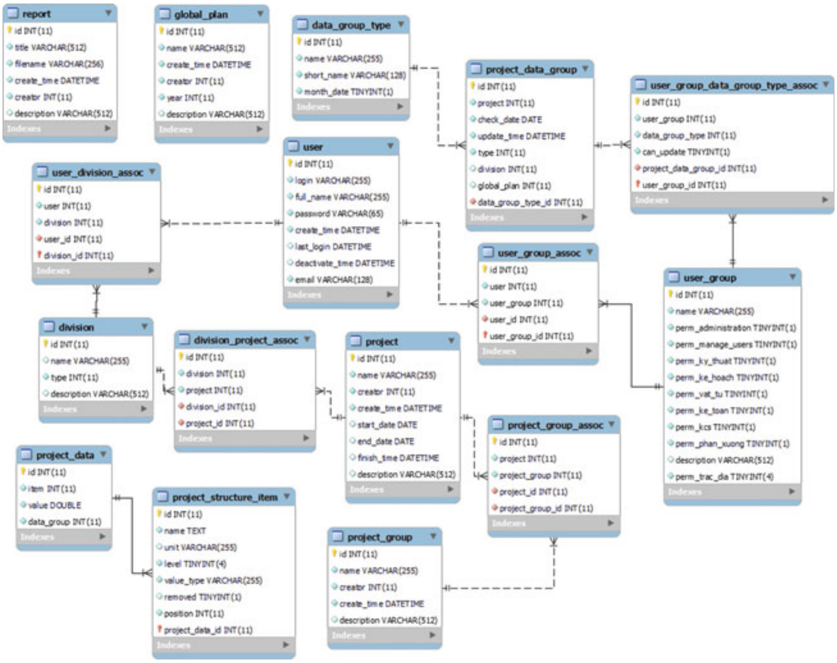

Fig. 4 Database schema

Table 2 User's profile information

Data	Type	Description
Username	Text	Username for login
Fullname	Text	User's full name
Email	Email	User's email address
Division	Enum	User's division unit
Account group	Enum	Define user's permission (data access and administrative right). A user can belong to multiple account groups
Account permission	Enum	Define the administrative right of the user based on user's account groups
Data permission	Enum	Define user data permission (read/write of different data views)
Date of creation	Date	Time of creation
Last access	Date	Time of the last logged in session

In this platform, user can perform data update and synchronization using two different methods: via web interface or Excel add-in. Both methods allow user to view current production data and input in new data given sufficient permission. The data will then be recorded along with user account information to form a new version of the centralized database.

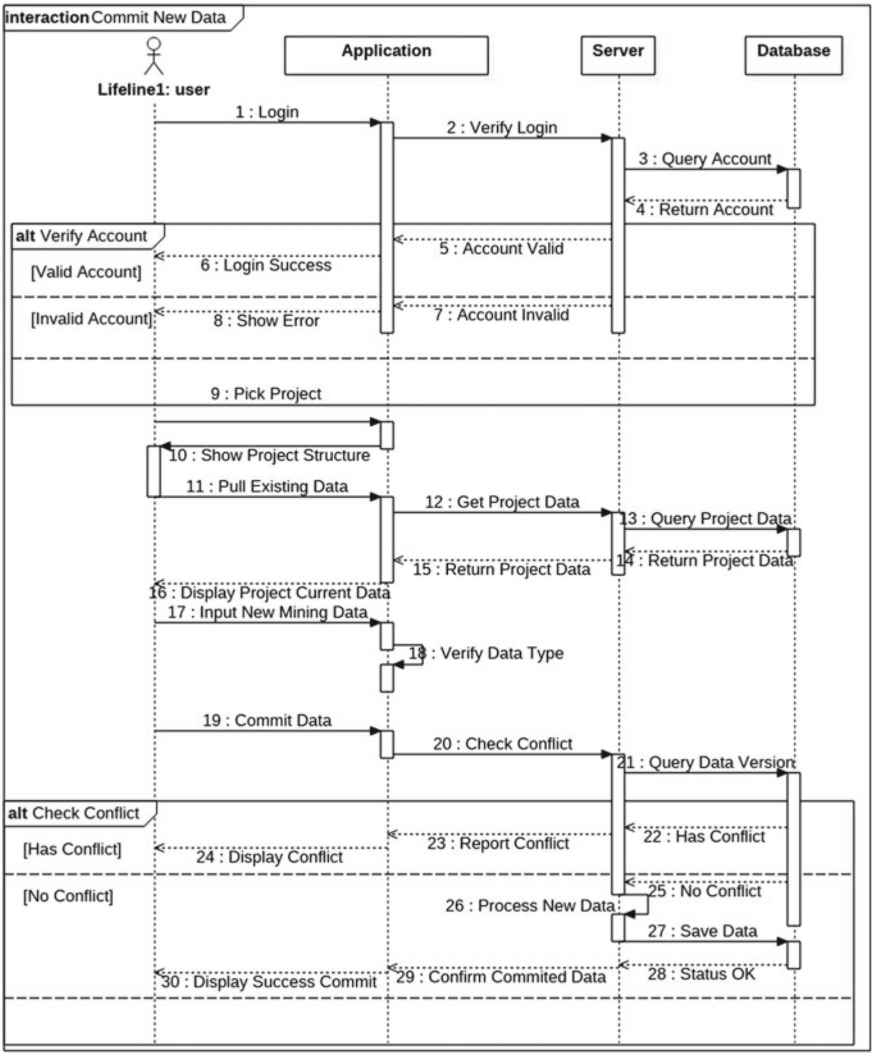

Fig. 5 Data commit and synchronization sequence diagram

Table 3 Mining project data dimensions

Dimension	Type	Description
Project	ID	The project ID number
Division	Enum	Involved divisions in the project
Date	Date	Time dimension for the project
Location	Enum	A project can have different mining locations
Target	Number	Different mining targets such as: total extracted coal, mining distance

However, multiple users' data input can lead to conflict [17] if one mining target is set by two different users at the same time. A passive resolution strategy is employed. In this strategy, both changes will be recorded as different version in the centralized database. User will be notified with new coming changes and decide on which version to be kept.

3 Implementation and Deployment

Users can work with the data using either web interface or through an Excel add-in. With the web interface, user can access from any web browser. The interface allows user to perform administrative actions such as: manage user profiles, manage projects, update mining data, or generate pre-defined reports. An example of web interface can be seen in Fig. 6.

With the Excel add-in, user can perform more complex tasks for data update/synchronization. User can also generate custom report of any combination of

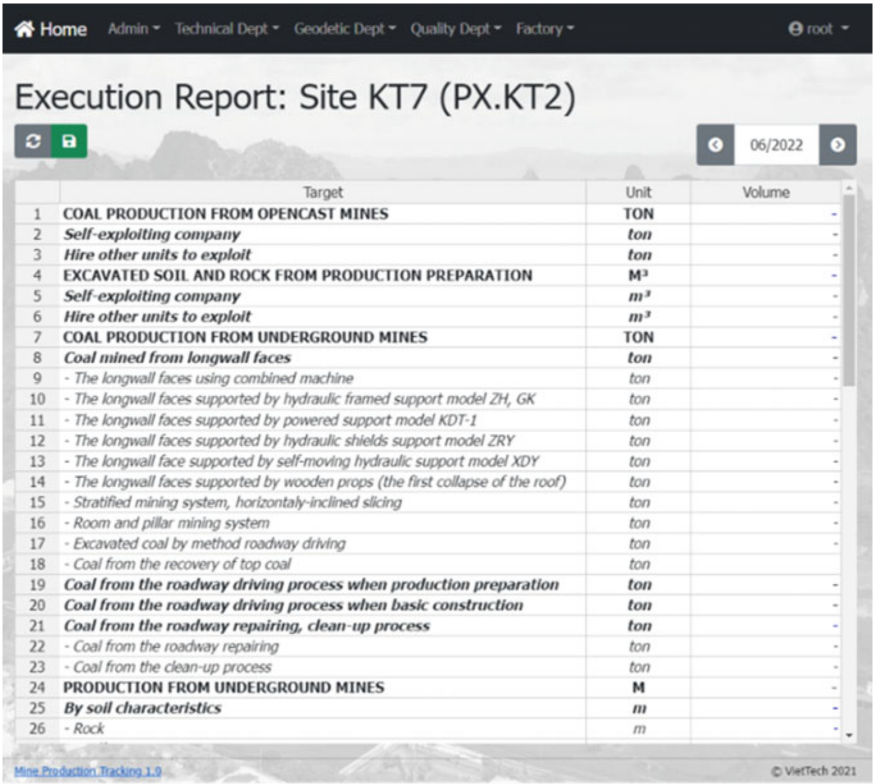

Fig. 6 Platform web interface

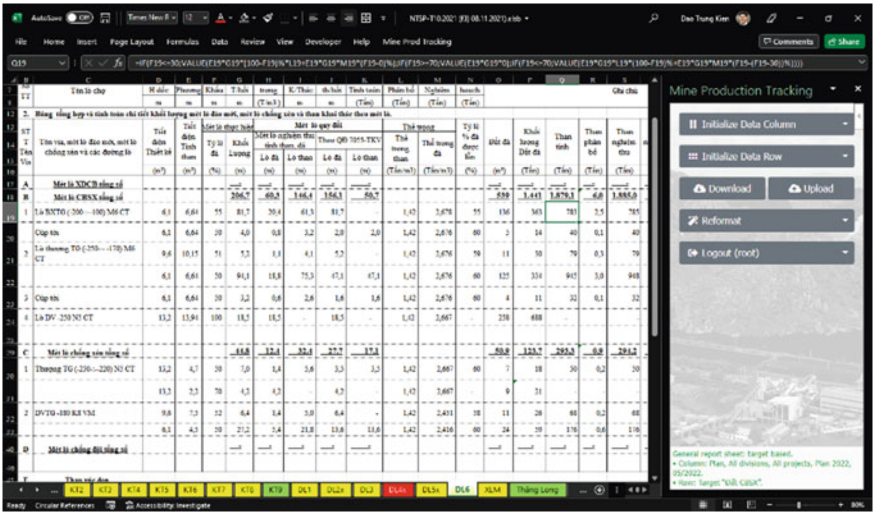

Fig. 7 Excel add-in interface

data dimensions. An example of the Excel add-in working interface is demonstrated in Fig. 7. The centralized server acts as a web server that provides centralized data and services such as account login, report generation and data backup.

4 Conclusion

In this paper, a design and implementation of a mine production tracking platform is presented. Using a combination of an online web app and an Excel add-in, the platform allows multiple users to collaboratively working with a centralized data of mine production. It enhances not only working efficiency but also allows real-time production data report and conflict resolution. Initial application in a coal company shows a sight of improvement especially in eliminating a vast majority of human error within the process. An initial evaluation of the system carried out by Viettech Company Ltd. shows an average 10% of human errors reduction across all departments in the company. However, deploying such platform in real-case scenario demands a throughout transformation in workflow. Hence, having the platform, the focus is now on investing on human resources to adapt with the new technology.

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References

1. Demirkan, H., Spohrer, J.C., Welser, J.J.: Digital innovation and strategic transformation. IT Prof. **18**(6), 14–18 (2016)
2. Günther, W.A., Mehrizi, M.H.R., Huysman, M., Feldberg, F.: Debating big data: a literature review on realizing value from big data. J. Strateg. Inf. Syst. **26**(3), 191–209 (2017)
3. Bharadwaj, A., El Sawy, O.A., Pavlou, P.A., Venkatraman, N.: Digital business strategy: toward a next generation of insights. MIS Q. 471–482 (2013)
4. Kahre, C., Hoffmann, D., Ahlemann, F.: Beyond business-IT alignment-digital business strategies as a paradigmatic shift: a review and research agenda. In: Proceedings of the 50th Hawaii International Conference on System Sciences (Jan 2017)
5. Kane, G.C.: The American red cross: adding digital volunteers to Its ranks. MIT Sloan Manag. Rev. **55**(4), 1 (2014)
6. De Donno, M., Tange, K., Dragoni, N.: Foundations and evolution of modern computing paradigms: cloud, IoT, edge, and fog. IEEE Access **7**, 150936–150948 (2019)
7. Shroff, G.: Enterprise Cloud Computing: Technology, Architecture, Applications. Cambridge University Press (2010)
8. Chinh, N.T.: The current situation, supply—demand, coal imports: challenges and development policies. Vietnam Energy Mag. (2020)
9. Vietnam National Coal and Mineral Industries Group (Vinacomin): report of the action program implementation conference on focusing on promoting the application of informatization and automation in production and management to improve production and business efficiency in the period 2017–2020 (2017)
10. East Sea Energy Environment.: https://esec.vn/en/du-an-ecostruxure-power-scada-cho-khach-hang-cao-son-coal-vietnam-vinacomin. (May 2022)
11. Vietnam National Coal and Mineral Industries Group (Vinacomin).: http://www.vinacomin.vn/dang-uy/tuyen-than-cua-ong-buoc-dot-pha-cong-nghe-tu-dong-hoa-202110051816520468.htm
12. Vietnam National Coal and Mineral Industries Group (Vinacomin).: http://www.vinacomin.vn/tin-tuc-vinacomin/nganh-than-chuyen-doi-theo-xu-the-cach-mang-40-202007171532165145.htm
13. Quang Ninh newspaper.: https://baoquangninh.com.vn/chuyen-doi-so-trong-cac-doanh-nghiep-nganh-than-3182638.html
14. IBM Developer.: https://developer.ibm.com/articles/an-introduction-to-uml/
15. Triartono, Z., Negara, R.M., Sussi.: Implementation of role-based access control on OAuth 2.0 as authentication and authorization system. In: 6th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), pp. 259–263 (2019)
16. Qi, C.-C.: Big data management in the mining industry. Int. J. Miner. Metall. Mater. **27**, 131–139 (2020)
17. Ji, T., Chen, L., Yi, X., Mao, X.: Understanding merge conflicts and resolutions in Git rebases. In: IEEE 31st International Symposium on Software Reliability Engineering (ISSRE) (2020)