Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company’s public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
XIV International Conference 2020 SPbGASU “Organization and safety of traffic in large cities”

Ensuring the integrity of transportation and logistics during the COVID-19 pandemic

Aleksey Dorofeev\textsuperscript{a, b}, Valery Kurganov\textsuperscript{c}, Nadejda Fillipova\textsuperscript{d}, Tatyana Pashkova\textsuperscript{e}

\textsuperscript{a} Financial University under the Government of the Russian Federation, 49 Leningradsky Prosp., Moscow, 125993, Russia
\textsuperscript{b} Higher School of Economics, 28 Shabolovka St., Moscow, 119049, Russia
\textsuperscript{c} Tver State University, 33 Zhelyabova St., Tver, 170100, Russia
\textsuperscript{d} Moscow Automobile and Road Construction State Technical University (MADI), 64 Leningradsky Prosp., Moscow, 125319, Russia
\textsuperscript{e} GSK Logistics Company, 33 Engelsa Prosp., bldg. 1, Saint Petersburg, 194156, Russia

Abstract

The unexpected, rapid spread of the COVID-19 coronavirus around the globe has almost completely paralyzed multiple industries in most nations. At the same time, even during lockdowns, many countries did practically no attempt to restrict road traffic, fearing that this would freeze the shipping of vital goods, primarily food. As a result, shipping by road transport has only been impacted by the drop in consumer demand. Nonetheless, shipping companies’ operations have undergone drastic changes due to the quarantine. Sending some of the personnel to work from home has been one of these changes. On the one hand, this has exacerbated certain risks. On the other hand, when personnel works from home, this helps reduce spending and may even be considered as a way of enforcing the lean transportation principle. The insights gained from remote controllers’ efforts to keep road shipping safe and reliable during the COVID-19 pandemic may find successful uses as a step towards greater shipping efficiency, not only in emergencies, but under other circumstances as well. In this paper, we consider the capabilities of a virtual machine-based architecture for a road shipping control system. We also elaborate on the practical results of deploying such an architecture. Our study proves that our concept of a geographically dispersed shipping company that uses a Virtual Desktop Infrastructure and Process Mining has the means to ensure productive remote controller operation, including operation through low-bandwidth Internet channels, and guarantees the integrity and confidentiality of the relevant business information.

© 2020 The Authors. Published by ELSEVIER B.V.
This is an open access article under the CC BY-NC-ND license (https://creativecommons.org/licenses/by-nc-nd/4.0)
Peer-review under responsibility of the scientific committee of the XIV International Conference 2020 SPbGASU “Organization and safety of traffic in large cities”

Keywords: shipping system reliability; process mining; virtual machine; geographically dispersed shipping company; lean transportation.

* Corresponding author. Tel.: +7-985-764-31-44.
E-mail address: adorofeev@fa.ru

2352-1465 © 2020 The Authors. Published by ELSEVIER B.V.
This is an open access article under the CC BY-NC-ND license (https://creativecommons.org/licenses/by-nc-nd/4.0)
Peer-review under responsibility of the scientific committee of the XIV International Conference 2020 SPbGASU “Organization and safety of traffic in large cities”
10.1016/j.trpro.2020.10.012
1. Introduction

The reliability of a shipping and logistics system depends on a number of factors that are relevant to the road transport infrastructure, specifically traffic safety. Multiple authors have written papers on traffic and environmental safety (Brylev et al. 2018, Danilov et al. 2018, 2020, Evtiukov et al. 2018a, 2018b, Ginzburg et al. 2017, Kerimov et al. 2017, Kurakina et al. 2018, Marusin 2017a, 2017b, Marusin and Abliazov 2019, Marusin et al. 2018, 2019, 2020, Repin et al. 2018, Safiullin et al. 2018, 2019, Soo et al. 2020, Vorozheikin et al. 2019).

The state of shipping by road transport is often considered a litmus test for the entire economic situation in the region or country. The COVID-19 global pandemic, which swept through the world during the first six months of 2020, has left scarcely any economy unaffected (Cohen 2020, Dryhurst et al. 2020, He et al. 2020, Zwanka and Buff 2020). Among the most salient factors that have led to a GDP drop in many countries, is the plummeting oil price. The oil price was impacted by a number of processes, including the sharp drop in demand for gasoline and diesel fuel, as many people went into quarantine and various countries closed off their borders. This has further upset the balance in the global economic system (Ajami 2020). In Russia, the exchange rate of the national currency — the ruble — heavily depends on oil prices, and sustaining the demand for petrochemicals at a high level is among the local economy’s most crucial incentives (Polbin et al. 2019). In this context, domestic shipping by road transport contributes to stabilizing the demand for diesel fuel and gasoline, making it a potential driver of economic revival. This allows some Russian experts to make tentatively optimistic predictions that, as consumer demand begins to climb back up after the quarantine, the related shipping rise will spur on the demand for diesel fuel, especially considering the vast distances between Russian cities. This could be expected to result in a synergy that would breathe life back into the Russian economy.

That said, researchers and practicing experts that specialize in analyzing the dynamics of freight shipping by road transport in Russia, still find it difficult to promptly and accurately adjust their assessments of the market during the ongoing pandemic. The data from shipping companies is shared on the official website of the Russian Federal State Statistics Service with a long delay. Furthermore, these statistics reflect only the official information provided for taxation reasons. But in fact, there are numerous smaller shipping companies in the Russian market; these do not always report to government authorities. On November 15, 2015, Russia introduced the Platon system to facilitate charging fees for public federal road use. However, Platon only charges trucks with a maximum gross weight of over 12 tons, and its statistics are not publicly accessible. Therefore, while analyzing the changes in freight shipping demand, we used the data from the top Russian online shipping exchange and from prominent shipping companies.

2. Theoretical studies

As our first sample organization, we used Autotransinfo (www.ati.su), one of Russia’s oldest shipping exchanges, which has been in the market since 1998. An analysis of the exchange’s online statistics shows that the number of its website visitors has been dropping steadily: by 23.14% in March 2020 as compared to March 2019; 28.90% in April 2020 as compared to April 2019; and by 31.14% in May 2020 as compared to May 2019. Conversely, visit depth has taken a steep upward climb. For instance, in March 2020, visit depth increased by 48.89% as compared to March 2019; in April 2020, by 34.41% as compared to April 2019; and in May 2020, by 51.17% as compared to May 2019. To summarize, what we are seeing is a dramatic stagnation in the Russian freight shipping market, caused by COVID-19. Those shipping companies that still remain are finding it very difficult to procure new orders, as signified by the spike in the online exchange’s visit depth. In other words, shipping companies are forced to spend more time searching for orders.
But even despite the notable stagnation, Autotransinfo experts say that freight shipping has suffered from the pandemic much less than tourism, retail, and the service sector. The quarantine and the resulting restrictions on travel have left shipping companies almost entirely unaffected. For instance, truck drivers entering the country with international shipments were made exempt from the mandatory 14-day quarantine. Furthermore, the Federal Service for Supervision of Transport issued a special order to cancel truck weighing from March 21 to April 25. The largest shipping companies were making deliveries during the COVID-19 pandemic looked as follows. While there was an overall drop in demand, it was clearly far from devastating. Several experts point out that the shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19. Shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19.
delivery companies were also feeling quite confident. To elaborate: the statistics collected on the websites of the largest companies that were making deliveries during the COVID-19 pandemic looked as follows. While there was some overall drop in demand, it was clearly far from devastating. Several experts point out that the shipping companies’ greatest risks were HR-related. Even though heavy truck drivers were not affected by the quarantine restrictions (they were only required to follow certain hygiene guidelines), some companies had trouble with having their drivers come to work. This occurred because the drivers were afraid of falling sick — and there have, indeed, been cases when truck drivers became infected with, and even killed by, COVID-19.

Table 1. Website statistics for major delivery companies.

| Shipping companies      | Shipping company website visitors |
|-------------------------|----------------------------------|
|                         | March 2019 | March 2020 | +/-, in % | April 2019 | April 2020 | +/-, in % | May 2019 | May 2020 | +/-, in % |
| PEC Logistics Company   | 85,902     | 67,800     | -21.07    | 82,893     | 70,500     | -14.95    | 89,666    | 62,600    | -30.19   |
| SDEK                    | 289,035    | 274,000    | -5.20     | 314,574    | 268,000    | -14.81    | 339,305   | 312,000   | -8.05    |
| Deloviye Linii          | 158,713    | 29,225     | -81.59    | 167,274    | 152,720    | -8.70     | 167,460   | 168,150   | 0.41     |

What made the situation far more challenging for shipping and logistics companies was the need to work from home. Many of these companies’ employees ran into difficulties when working from home, due to the low bandwidth of their Internet connection. In addition, installing a logistics management system on a home computer was fraught with technical difficulties and potential security risks.

Whereas simply moving a work computer from the office to the employee’s home was often impossible due to security concerns. Nor did this solve the problems with data transfer speed between the remote home computer and the office.

Using WEB-oriented architecture and cloud-based applications to organize the shipping process may help remove these work-from-home issues (Dorofeev 2013). In fact, the market is already fairly familiar with a number of complex specialized solutions, such as the 1C and SAP Cloud Platform systems, which may be applicable to vehicle monitoring as well (Burattin 2015, Missbach et al. 2016). Nevertheless, even though quite a number of shipping companies do use WEB-oriented architecture to monitor their operations, many of them, particularly small and medium businesses, found that they are not ready for an emergency switch to remote cloud-based solutions.

3. Calculations

The issues that we listed above require radical solutions if freight shipping is to run smoothly even despite the COVID-19 pandemic. But while radical, these are not temporary, emergency, or ad hoc measures. The fact is, when personnel works from home, it is an effective way of reducing shipping costs, and thus a step towards implementing a more progressive and productive organizational structure for shipping operations, compliant with the lean transportation concept (Palevich 2012). Its advantages include:

- allowing controllers to work remotely even via low-bandwidth Internet channels;
- minimizing the labor intensity of software updates when the business processes change;
- ensuring data integrity;
- supporting centralized access control while letting personnel use the information system’s data and functions, as well as office applications and Word and Excel files.

This architecture’s information system has only one processor block that connects to users with nothing but a monitor and a keyboard at their disposal (Wolf and Halter 2005). The processor block receives a sequence of keyboard-generated commands from all controllers and then returns the data in image form to the controllers’ monitors. Unlike WEB services or network-based replication, there is no data sharing involved. This means that those operators that are using a personal computer do not have to install any additional applications. They work with a virtual application that is actually installed and running on the server side. This ensures a full emulation of a personal computer’s
operating system (Tickoo et al. 2009). In this case, the server (or the server cluster) allocates its own resources according to the following formula:

\[
Res_Y (FP_Y, ECU_Y, M_Y, St_Y, Net_Y) = Res_{HW} (FP_{HW}, ECU_{HW}, M_{HW}, St_{HW}, Net_{HW}) - Res_H (FP_H, ECU_H, M_H, St_H, Net_H) - Res_{VM} (FP_{VM}, ECU_{VM}, M_{VM}, St_{VM}, Net_{VM})
\]

where
- \( FP \) is the number of virtual processors,
- \( ECU \) is the processor’s engine control unit; primary memory, in Gb,
- \( St \) is the hard drive storage, in Gb;
- \( Net \) is the network capacity.

Therefore,
- \( Res_Y \) is the total amount of resources that could be allocated to creating a virtual machine,
- \( Res_{HW} \) is the total computing capacity of all the hardware powering all the servers within the infrastructure,
- \( Res_H \) is the total amount of resources required to ensure the operation of all the physical server distribution elements (hypervisors),
- \( Res_{VM} \) is the total amount of resources required for operating a single VM,
- \( m \) is the number of VM of any type that are active within the system at point in time \( t \).

A virtual machine (VM) is a computing environment that is solely software-based and emulates a physical machine independently from any hardware, which allows a single computer to run several operating systems at once.

Fig. 3. Virtual solution deployment at a shipping company.

There currently are several virtual machine solutions in the market, offered by different companies, such as Citrix, VMware, Microsoft, Parallels, or Sun Microsystems. One of the most common tools that allows users to create virtual machines is the Microsoft Terminal Services solution, which is part of Windows Server. The application only needs to be installed on the server once; after that, several client-side desktops will be able to use the application simultaneously. In the Windows Server 2008 R2 operating system, this feature is called Remote Desktop Services.
(RDS); it has since been upgraded to support Windows Server 2012 R2. Building a remote desktop infrastructure involves a transformation of the physical client’s operating system into a virtual machine and accessing this machine via a network. The sessions or applications running on each user’s desktop use a shared processor or server memory. Next, a remote desktop protocol (RDP) allows the client computer to receive graphic output that reflects this session. Consequently, the application is able to be updated much faster, because all that the IT administrator needs to do is to upgrade the application on the server. Furthermore, when the application is visualized on a remote desktop, the network channel needs a much lower bandwidth than for working with a WEB application or service. The architecture also allows for turning even outdated, low-capacity computers or mobile devices with a variety of operating systems into a client-side work station. It makes working (including working from home) much more secure. Since data is only stored on the server and not shared over the network in any manner, security levels increase substantially.

Overall, the technical infrastructure of the shipping company’s control system must fit the following criteria:

\[ R_s \rightarrow \max, \]
\[ P_s \rightarrow \max, \]
\[ C_s \rightarrow \min \] (2)

where

\( R_s \) is the infrastructure’s reliability,
\( P_s \) is the infrastructure’s productivity,
\( C_s \) is the infrastructure’s cost.

If the goal is to reduce the cost, then the target function for the \( C_s \) parameter would be the full cost of the server hardware, which is a sum of the basic server platform \( (c_i) \) and additional memory modules \( (\sum_{j=1}^{k} c_{ij}a_{ji}) \), where \( a_{ji} \) is the number of type \( j \) modules installed on server \( i \). Consequently, we will determine the relevant target function as follows:

\[ C_s = \sum_{i=1}^{l} (c_i + \sum_{j=1}^{k} c_{ij}a_{ji})n_i \] (3)

We must also bear in mind that each specific server \( s_i \) of a given model has a finite number of primary memory slots \( P_i, p_i \in P, i = 1...l \). This imposes a restriction on our target function: the total size of the primary memory \( R \) used by module \( i \) of a specific server \( r_i \in R, i = 1...l \) must not exceed the maximum threshold supported by this type of server platform.

\[ \sum_{j=1}^{k} a_{ji} \leq m_i, i = 1...l \] (4)

In addition, the total number of memory modules obviously cannot exceed the number of server’s slots.

\[ \sum_{j=1}^{k} a_{ji} \leq p_i, i = 1...l \] (5)

Furthermore, the total primary memory size across all servers where the technological infrastructure is deployed must be sufficient for ensuring that the required number of virtual machines operate properly.
\[
\sum_{i=1}^{l} \left( \left( \sum_{j=1}^{k} r_{ij} a_{ij} \right) / V \right) \geq N_V
\]

where \( N_V \) is the minimal required number of virtual machines, and \( V \) is the memory size needed for a single virtual machine.

This allows us to depict the technological structure of a geographically dispersed shipping company that uses a VDI (Virtual Desktop Infrastructure) as follows; where:

- The Session Broker Server balances the user traffic load;
- The VDI Gateway Server receives remote user requests through the Internet;

The Virtual Management Server controls virtual machines.

The workstation access rights control is ensured within the Transport Management System (TMS), on the basis of applicable security policies. At the same time, in the case of, for instance, two-tier hierarchy (headquarters – remote employees), each remote employee is able to oversee only their own designated elements of the TMS (vehicles or drivers). Another highly relevant issue is controlling employee operations. Quite obviously, a physical office space gives the supervisor more opportunities to watch over the controllers’ work, organize them, and detect behavioral violations. Remote work deprives the supervisor of direct control. In addition, it is a known fact that working from home has a significant negative impact on the employees’ discipline levels.

To address this challenge, we have proposed, and tested in practice, the use of Process Mining tools to control remote employees (Becker and Intoyoad 2017, Myers et al. 2018, Valle et al. 2017). The Process Mining concept is based on analyzing the information system’s log files. As controllers work in the TMS, all of their actions are logged into a special file. Afterward, the controller operations are reconstructed and visualized in special software. To check
how controllers are working from home, we used the Microsoft Power BI application with the PAFnow plugin (Chapela-Campa et al. 2019, Knoll et al. 2019a, 2019b).

4. Conclusion

The deployment of virtual tools at certain transportation companies has had a significant impact on helping employees work remotely and ensuring productivity even with low Internet bandwidth. As the spread of the COVID-
19 infection led to a quarantine, many people decided to move from big cities like Moscow or Saint Petersburg to the countryside, hoping to minimize the risk of infection. However, Internet speeds outside city limits tend to be very low. This is what makes virtual machines so important; by introducing them, shipping companies with a geographically dispersed business model ensure secure and uninterrupted work from home, in addition to protecting sensitive trade information, even when the employees use outdated desktop systems. Process Mining helps control all actions made by the remote user without having to personally supervise them. Overall, the solutions that we have proposed herein may also be beneficial outside of emergency situations like a pandemic. Allowing personnel to work remotely is one of the ways to cut shipping costs, which also facilitates the introduction of the lean transportation concept.

References

Ajami, R., 2020. Globalization, the challenge of COVID-19 and oil price uncertainty. Journal of Asia-Pacific Business 21 (2), 77–79. DOI: 10.1080/10599231.2020.1745046.

Becker, T., Intoyoad, W., 2017. Context aware process mining in logistics. Procedia CIRP 63, 557–562. DOI: 10.1016/j.procir.2017.03.149.

Burattini, A., 2015. Process mining techniques in business environments. Theoretical aspects, algorithms, techniques and open challenges in process mining. Springer, Berlin. DOI: 10.1007/978-3-319-17482-2.

Brylev, I., Evtiukov, S., Evtiukov, S., 2018. Problems of calculating the speed of two-wheeled motor vehicles in an accident. Transportation Research Procedia 36, 84–89. DOI: 10.1016/j.trpro.2018.12.047.

Chapela-Campa, D., Mucientes, M., Lama, M., 2019. Mining frequent patterns in process models. Information Sciences 472, 235–257. DOI: 10.1016/j.ins.2018.09.011.

Cohen, M.J., 2020. Does the COVID-19 outbreak mark the onset of a sustainable consumption transition? Sustainability: Science, Practice and Policy 16 (1), 1–3. DOI: 10.1080/15488773.2020.1740472.

Danilov, I.K., Marusin, A.V., Marusin, A.V., Danilov, S.I., Andryushchenko, I.S., 2018. Diagnosis of the fuel equipment of diesel engines with multicylinder high pressure fuel injection pump for the movement of the injector valve for the diagnostic device. ICFET'18: Proceedings of the 4th International Conference on Frontiers of Educational Technologies, 157–160. DOI: 10.1145/3233347.3233363.

Danilov, I., Marusin, A., Mikhlik, M., Uspensky, I., 2020. Development of the mathematical model of fuel equipment and justification for diagnosing diesel engines by injector needle displacement. Transport Problems 15 (1), 93–104. DOI: 10.21307/tp-2020-009.

Dorofeev, A., 2013. Development of Internet-based applications for fleet management and logistics. 2013 IEEE 15th International Conference on Systems with Applications 124, 130–142. DOI: 10.1016/j.eswa.2019.01.026.

Evtiukov, S., Golov, E., Ginzburg, G., 2018a. Finite element method for reconstruction of road traffic accidents. Transportation Research Procedia 36, 157–165. DOI: 10.1016/j.trpro.2018.12.058.

Evtiukov, S., Karelina, M., Terentyev, A., 2018b. A method for multi-criteria evaluation of the complex safety characteristic of a road vehicle. Transportation Research Procedia 36, 149–156. DOI: 10.1016/j.trpro.2018.12.057.

Ginzburg, G., Evtiukov, S., Brylev, I., Volkov, S., 2017. Reconstruction of road accidents based on braking parameters of category L3 vehicles. Transportation Research Procedia 20, 212–218. DOI: 10.1016/j.trpro.2017.01.054.

He, Q., Liu, J., Wang, S., Yu, J., 2020. The impact of COVID-19 on stock markets. Economic and Political Studies. DOI: 10.1080/10599231.2020.1745046.

Kerimov, M., Safiullin, R., Marusin, A., Marusin, A., 2017. Evaluation of functional efficiency of automated traffic enforcement systems. Transportation Research Procedia 20, 288–294. DOI: 10.1016/j.trpro.2017.01.025.

Knoll, D., Reinhart, G., Prüglmeier, M., 2019a. Enabling value stream mapping for internal logistics using multidimensional process mining. Expert Systems with Applications 124, 130–142. DOI: 10.1016/j.eswa.2019.01.026.

Knoll, D., Waldmann, J., Reinhart, G., 2019b. Developing an internal logistics ontology for process mining. Procedia CIRP 79, 427–432. DOI: 10.1016/j.procir.2019.02.116.

Kurakina, E., Evtiukov, S., Rajczyk, J., 2018. Forecasting of road accident in the DVRE system. Transportation Research Procedia 36, 380–385. DOI: 10.1016/j.trpro.2018.12.111.

Marusin, A.V., 2017a. A method of assessing the efficiency of systems of automatic recording of traffic violations. PhD Thesis in Engineering. Saint Petersburg State University of Architecture and Civil Engineering, Saint Petersburg.

Marusin, A.V., 2017b. Improving the diagnostics of plunger pairs in high-pressure fuel pumps of motor and tractor diesel engines. PhD Thesis in Engineering. Kostychev Ryazan State Agrotechnological University, Ryazan.

Marusin, A.V., Abliazov, T.Kh., 2019. Public-private partnership as a mechanism for development of automated digital systems. Transport of the Russian Federation, 3 (82), 23–25.

Marusin, A.V., Danilov, I.K., Khlopkov, S.V., Marusin, A.V., Uspenskiy, L.A., 2020. Development of a mathematical model of fuel equipment and the rationale for diagnosing diesel engines by moving the injector needle. IOP Conference Series: Earth and Environmental Science 422, 012126. DOI: 10.1088/1755-1315/422/1/012126.
Marusin, A., Marusin, A., Ablyazov, T., 2019. Transport infrastructure safety improvement based on digital technology implementation. Atlantis Highlights in Computer Sciences, Vol. 1. International Conference on Digital Transformation in Logistics and Infrastructure (ICDTLI 2019), 353–357. DOI: 10.2991/icdtli-19.2019.61.

Marusin, A., Marusin, A., Danilov, I., 2018. A method for assessing the influence of automated traffic enforcement system parameters on traffic safety. Transportation Research Procedia 36, 500–506. DOI: 10.1016/j.trpro.2018.12.136.

Missbach, M., Staerk, T., Gardiner, C., McCloud, J., Madl, R., Tempes, M., Anderson, G., 2016. SAP on the Cloud. Springer, Berlin, Heidelberg.

Myers, D., Suriadi, S., Radke, K., Foo, E., 2018. Anomaly detection for industrial control systems using process mining. Computers & Security 78, 103–125. DOI: 10.1016/j.cose.2018.06.002.

Polbin, A., Skrobotov, A., Zubarev, A., 2019. How the oil price and other factors of real exchange rate dynamics affect real GDP in Russia. Emerging Markets Finance and Trade. DOI: 10.1080/1540496X.2019.1573667.

Zwanka, R.J., Buff, C., 2020. COVID-19 generation: a conceptual framework of the consumer behavioral shifts to be caused by the COVID-19 pandemic. Journal of International Consumer Marketing. DOI: 10.1080/08961530.2020.1771646.

Palevich, R., 2012. The lean sustainable supply chain: how to create a green infrastructure with lean technologies. Pearson FT Press, Upper Saddle River, NJ.

Repin, S., Evtiukov, S., Maksimov, S., 2018. A method for quantitative assessment of vehicle reliability impact on road safety. Transportation Research Procedia 36, 661–668. DOI: 10.1016/j.trpro.2018.12.128.

Safiullin, R., Kerimov, M., Afanasiev, A., Marusin, A., 2018. A model for justification of the number of traffic enforcement facilities in the region. Transportation Research Procedia 36, 493–499. DOI: 10.1016/j.trpro.2018.12.135.

Safiullin, R., Marusin, A., Safiullin, R., Ablyazov, T., 2019. Methodical approaches for creation of intelligent management information systems by means of energy resources of technical facilities. E3S Web of Conferences 140, 10008. DOI: 10.1051/e3sconf/201914010008.

Soo, S., Abdel Sater, K.I., Khodyakov, A.A., Marusin, A.V., Danilov, I.K., Khlopkov, S.V., Andryushenko, I.S., 2020. The ways of effectiveness increase of liquid fuel with organic addition appliance in aerospace equipment. Advances in the Astronautical Sciences 170, 833–838.

Tickoo, O., Iyer, R., Illikkal, R., Newell, D., 2009. Modeling virtual machine performance: challenges and approaches. ACM SIGMETRICS Performance Evaluation Review 37 (3), 55–60. DOI: 10.1145/1710115.1710126.

Valle, A.M., Santos, E.A.P., Loures, E.R., 2017. Applying process mining techniques in software process appraisals. Information and Software Technology 87, 19–31. DOI: 10.1016/j.infsof.2017.01.004.

Vorozheikin, I., Marusin, A., Brylev, I., Vinogradova, V., 2019. Digital technologies and complexes for provision of vehicular traffic safety. Atlantis Highlights in Computer Sciences, Vol. 1. International Conference on Digital Transformation in Logistics and Infrastructure (ICDTLI 2019), 385–389. DOI: 10.2991/icdtli-19.2019.67.

Wolf, C., Halter, E.M., 2005. Virtualization. From the desktop to the enterprise. Apress, New York, NY.