IMPROVING DISTRIBUTION PROCESS USING BUSINESS PROCESS MODEL AND NOTATION

Svetlana Živanović [a,*], Vukašin Pajić [a], Milorad Kilibarda [a]

[a] University of Belgrade, Faculty of Transport and Traffic Engineering, Serbia

Abstract: *The distribution process is divided into a number of sub-processes that are implemented in order to meet the requirements of the end-user. For this reason, the distribution is characterized by extreme complexity (division into a series of complex activities), and it represents an area of continuous optimization. BPMN (Business Process Modelling Notation) is a tool used for the purpose of modelling business processes, as well as displaying the environment in which the elements of the system can communicate or exchange information. For this reason, BPMN has found significant application in logistics, and therefore in the distribution process. The aim of this paper is to improve distribution process by using BPMN as a tool. In this particular case, the application of BPMN obtained results on the utilization of resources, the time necessary for individual activities, as well as the costs of the process, which are a good basis for further analysis and decision-making in order to improve this process.*

Keywords*: distribution, BPMN, process optimization, logistics*

1. INTRODUCTION

Distribution is one of the basic logistics processes. The distribution process begins with the receipt of the order from the customer and ends with the transportation process (i.e., unloading at the destination). This process is especially important for making contact with the end-user. The quality of this process, in addition to procurement, is a key factor in the competitiveness of a logistics company. As distribution is a process that requires a large number of participants, as well as activities, it is necessary to control and manage all activities (Pajić et al., 2021).

The realization of the distribution process achieves physical, organizational and information connections between the source (production) and end-users. This connection is based on means of storage and packaging, products, staff and their interactions. All the mentioned elements enable and support the realization of the process. Distribution logistics is defined as the most appropriate way to analyze, select

* zivanovic.svetlana98@gmail.com

and implement all activities and strategies related to providing products to the customer in a way to ensure market performance without failure. Within the distribution process, a large number of sub-processes and activities are realized, such as choosing the location of the distribution center and warehouse, choosing the way of storing goods, packaging management, shipping and loading, transport of goods, etc. The BPMN is the leading language for noting business process modeling and allows business analysts and managers to increase the efficiency and quality of processes and performs the main function of modeling business processes - presenting processes so that the current process can be analyzed and improved in the future (Mutanov et al., 2020). From one side, models, when simulated, can even be more realistic than traditional experiments as they allow the efficient observation of a number of cases. On the other side, simulations, when made via BPMN models, allow combining and capturing a number of workflow patterns, thus setting up a coherent environment for the integration of complex interaction behavior (Cimino et al., 2016). The paper is structured as follows. After the introduction, section 2 covers the distribution process and the need to optimize it using BPMN. The following section provides an overview of the input quantities used in the model. In the next chapter, the output values and the description of the results obtained by the simulation are given. Finally, the last section draws some conclusions and directions for future research.

2. DISTRIBUTION PROCESS MODELLING USING BPMN

The distribution represents the efficient movement of finished products from the end of the production line to the consumer. The ultimate goal of every company is that distribution activities such as transportation, storage, material handling, packaging, inventory control, order processing and customer service increase the value of goods. The apropos, the selling price of goods delivered to a customer must be higher than the amount of total costs incurred in production and distribution activities. The classic distribution channel is the path by which goods move from producer to consumer. It consists of a set of interdependent institutions, i.e., intermediaries which are connected in order to facilitate the transfer of goods and property from the producer to the final consumer, or customer. The purpose of the distribution channel is to facilitate the spatial and temporal transformation of goods from producers to consumers. Each of these areas requires detailed analysis, monitoring and managing processes in order to ensure the optimal functioning of the distribution process. It is possible to achieve savings and eliminate losses in this area. Of course, improvements are not possible without the application of certain expertise and approaches, and attention must be paid to choosing an effective concept depending on the specific environment. For this reason, simulation software in this area is extremely useful because it can be used to model different system configurations and determine the real behavior of the same in an economical and relatively fast way. BPMN modeling and simulation can be interchangeably used as a basis for making managerial or technical decisions (Mutanov et al., 2020).

The primary goal of BPMN was to provide a notation that is readily understandable by all business users, from the business analysts who create the initial draft of the processes, to the technical developers responsible for implementing the technology that will support the performance of those processes, and, finally, to the business people who will manage and monitor those process. Another factor that drove the development of BPMN is that, historically, business process models developed by business people have been technically separated from the process representations required by systems designed to implement and execute those processes. Thus, it was a need to manually translate the original process models to execution models. Such translations are subject to errors and make it difficult for the process owners to understand the evolution and the performance of the processes they have developed. To address this, a key goal in the development of BPMN was to create a bridge from notation to execution languages.

BPMN allows the creation of end-to-end business processes and is designed to cover many types of modeling tasks constrained to business processes. The structuring elements of BPMN will allow the viewer to be able to differentiate between sections of a BPMN diagram using groups, pools, or lanes. Basic types of submodels found within a BPMN model can be private business processes (internal), abstract processes (public), and collaboration processes (global) (Vlasov and Gonoshilov, 2019; Bacchetti et al., 2020). BPMN simulation has been used by Dachyar and Miranda (2019) in order to improve distribution process in logistics service provider companies. On the other hand, Cimino et al. (2016) used BPMN simulation in order to evaluate the impact of smart technologies on harbor's logistics. Vlasov and Gonoshilov (2019) also used BPMN for simulating manufacturing system in the context of electronic product manufacturing. Figure 1 shows one type of distribution process. The distribution process, in this case, begins with the preparation of the goods, followed by the processes of enlarging, merging the goods and preparing the documents. In parallel with the mentioned processes, the processes of vehicle selection, route definition, as well as the distribution of goods according to the directions of shipment are realized. Based on Figure 1, it can be seen that after the mentioned processes there is an inclusive decision. This element actually shows that before loading the goods into the means of transport, it is necessary to realize both branches with the previously mentioned activities. That is, loading into a means of transport is enabled only under the condition that all previous processes have been successively realized. It is considered that the distribution is done over long distances, which justifies the fact that one order is transported by one means of transport. The funds transport the goods to three unloading places within which the following processes are realized: waiting at the unloading place, unloading, qualitative and quantitative control, receipt, but also loading returns (Pajić et al., 2021).

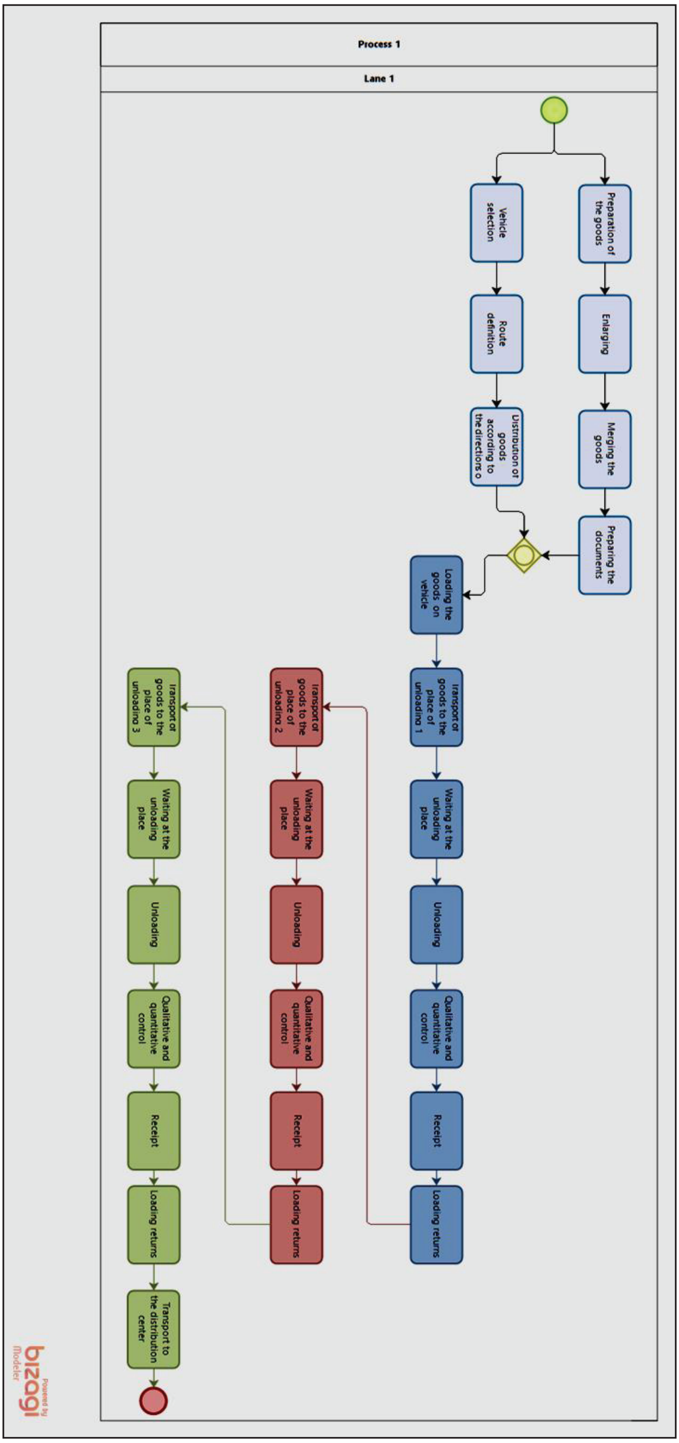

Figure 1. The distribution process demonstrated using BPMN model (Bizagi, 2022)

3. SIMULATION OF DISTRIBUTION SCENARIOS

After creating the model, it is necessary to define the resources used in the implementation of each activity. Each activity requires a certain amount of time, but also other resources such as financial ones. One of the key tasks of improving the distribution process is to optimize resources. The optimal number of resources is a prerequisite for the efficient functioning of the system. If the number of resources is insufficient, the system is inefficient, and if that number is greater than the required resources, they represent tied-up capital. Two scenarios of distribution for a different number of resources were defined, after which the simulation was performed. The first scenario is set so that all distribution processes are implemented efficiently without waiting, downtime, and time losses with high-quality service. Of course, this scenario requires more resources. The second scenario involves reducing the number of resources engaged to carry out the same task. Through the simulation process, it was examined how the different number of resources engaged in these scenarios affect the key indicators of the distribution process (Pajić et al., 2021; Bacchetti et al., 2020).

The input data were implemented in a simulation model within two scenarios (Table 1). In the first scenario, there are eight order pickers, forklifts and administrators, 27 drivers and vehicles and 16 store managers. In the second scenario, the number of store managers, i.e., employees performing reception and control was reduced from 16 to 14. The times that are deterministic in the simulation model are presented as mean activity values, while the times shown by the interval are represented by a uniform distribution. The BPMN model recognizes two types of costs: fixed and variable, which can be calculated in two ways, as costs of implementing activities or as costs per hour of work. In addition, hourly labour costs for workers are shown, as well as fixed costs of resources in order to facilitate the monitoring of changes within the defined scenarios.

Table 1. Input data

	Time [min]	*Resources*	*Costs*
Preparation of the goods	*15*	*order pickers*	*1.5 eur/h*
Enlarging / Merging the goods	*3-5*	*order pickers*	1.5 eur/h
Processing the documents	*2*	*administrator*	*2 eur/h*
Vehicle selection	*6-8*	*administrator*	*2 eur/h*
Route defination	*60*	*administrator*	*2 eur/h*
Distribution of goods according to shipping directions	*30*	*order pickers*	*1.5 eur/h*
Loading the goods into the vehicle	*20*	*order pickers*	1.5 eur/h
		forklift	*15000 eur/forklift*

Transport of the goods to the place of unloading	*25*	*driver*	*2 eur/h*
		vehicle	*30000 eur/vehicle*
Waiting at the unloading place	*10*	*driver*	*2 eur/h*
		vehicle	*30000 eur/vehicle*
Unloading	*20*	*driver*	*2 eur/h*
		vehicle	*30000 eur/vehicle*
		store manager	*2 eur/h*
Quantitative and qualitative control	*5-7*	*driver*	*2 eur/h*
		store manager	*2 eur/h*
Receipt	*10*	*store manager*	*2 eur/h*
Loading returns	*8-10*	*driver*	*2 eur/h*
		vehicle	*30000 eur/vehicle*
		store manager	*2 eur/h*

In the simulation process, it was estimated that the optimal number of vehicles is 27. If that number is lower, there is a problem during loading (average loading time, in that case, is 2 hours), and if the number of vehicles is higher - the system is oversized. This is reflected in the average waiting time for the resource, which in that case is 0, i.e., there is no waiting, and it is clear that this is not a realistic scenario. The aim of this paper was to present the problems that often occur in practice while cooperating with different clients. Namely, clients want to reduce costs, and they usually accomplish that by reducing resources (funds, workers, etc.). This significantly complicates the distribution process. Although everything works well in the system (as is the case in the second scenario in the initial part of the chain), the client has a problem with receiving, performing qualitative and quantitative control, loading returns, etc. This also affects other unloading places, i.e., the waiting time is increasing significantly and the transporter can be characterized as inefficient, although the problem is not his fault, but in the client's choice and communication with them. Namely, in the second scenario, the number of store managers, i.e., employees performing reception and control was reduced from 16 to 14. This caused major changes in the system, which are shown in Table 2.

Table 2. Output results of the model - Average time of realization of activities

Observed time	The first scenario	The second scenario
Total duration of the process	7h 35min 7s	7h 58min 29s
Average time to prepare documents	2 min	3 min
Average time of receipt of goods at unloading place 1	10min 1s	10min 54s
Average time of control realization (quality and quantity) at unloading place 1	8min 45s	10min 32s
Average time of unloading of goods at unloading place 1	22min 3s	24min 21s
Average loading time of returns at unloading place 1	12min 10s	13min 32s
Average waiting time at unloading place 2	12min 33s	13min 1s
Average time of receipt of goods at unloading place 3	10min	10min 56s

Based on the previous table (Table 2), it can be noticed that the implementation times of certain activities have increased. The number of workers has not been drastically reduced, but the realization times in the second scenario are longer. This disturbance in the realization of activities at the first unloading place also caused disturbances at the unloading places two and three. This was certainly expected, given that the configuration of the system is such that one vehicle goes around all 3 unloading places.

In addition to the average time of realization of activities, it is important to monitor the average time of waiting for a resource because it shows the (in)efficiency of the observed system. Based on the data, it can be concluded that in the first case the complete distribution system is very efficient, while in the second case is not so efficient. In addition to the mentioned results, BPMN provides other types of outputs related to financial indicators, as well as the degree of resource utilization. The mentioned results are given in the tables below (Table 3 and Table 4).

Table 3. Model outputs - Average resource waiting time

Observed time	***The first scenario***	***The second scenario***
Average resource waiting time when unloading at place 1	*2 min 3s*	*4min 21s*
Average waiting time for a resource when unloading at place 1	*2 min 2s*	*4min 14s*
Average resource waiting time when loading returns at place 1	*3 min 9s*	*4min 35s*
Average waiting time for a resource when receiving goods at place 2	*15s*	*1min 48s*
Average resource latency when loading returns at place 3	*3min 11s*	*4min 32s*

Table 4. Output results of the model - costs of realization of the distribution process

Costs	***The first scenario***	***The second scenario***
Total cost (eur)	*2.317.104,6*	*2.315.998,6*

Table 4 is proof that financial indicators are not the only indicators that should be monitored when assessing the efficiency of a particular system, although they are certainly important. Namely, according to financial indicators, scenario 2 is better because cost savings have been achieved. However, it is very important to investigate the cause. Whether it is a matter of greater efficiency of realization or as in this case, the requirements are simply not realized. Namely, out of the total number of requests (which occurred in the observed period of one month) which amounts to 4321 requests, 4275 were realized in the first scenario (i.e., on average 1.53 were not realized on a daily basis). In the second case, 4271 requests were realized, i.e., 1.67 requests were not realized on a daily basis.

Apart from the fact that the lower realization of the request affected the costs, it also affected the degree of utilization of certain resources. In the second case, there is a - lower level of utilization of drivers, as well as vehicles. This could be expected considering that more orders have not been realized. While creating the scenarios, it was noticed that administrators could improve utilization (by reducing from 8 to 6), which was done in scenario 2. Store managers have almost 100% utilization, which causes system inefficiency (overload). Utilization of order pickers, forklifts, etc. is the same in both cases because these data have not been changed so that the simulation could be successfully implemented (reducing the number of order pickers generates problems in the implementation of activities in the initial part of the chain - before loading into the vehicle). Utilization data are presented in Table 5.

Table 5. Output results of the model - degree of resource utilization

The first scenario		**The second scenario**	
resource	utilization	resource	utilization
driver	99.33%	driver	99.28%
vehicle	92.70%	vehicle	92.65%
administrator	84.95%	administrator	97.08%
store manager	83.83%	store manager	95.76%
order picker	93.62%	order picker	93.62%

Finding the optimal way to operate the system is a complex task. Namely, it cannot be stated with certainty which of the previous two scenarios (scenarios 1 and 2) is optimal. The differences in utilization are insignificant, but the store managers are overburdened within the second scenario. On the other hand, the costs under the second scenario are lower, but also the number of realized purchase orders is lower (not drastically). Processes are more efficient in the first scenario, but they are more expensive. So, every system needs to make a decision whether it will be aimed at reducing costs or towards greater efficiency - there is no one-size-fits-all solution. The only recommendation is that the data on the system should be viewed comprehensively through the analysis of causal relationships. In that case, BPMN is an extremely useful tool because it leads to system optimization with minimal investment, and also gives quality results for further analysis.

4. CONCLUSION

The complexity of business processes has increased over the years, and this trend continues at an accelerated pace. For this reason, adequate software solutions have been sought for years, which will ensure that business processes are presented in the right way. Certainly, the most convenient and fastest way is computer modeling. This type of modeling provides consideration of all key activities in business processes, identification of potential risks etc. In addition, these tools often offer a basis for conducting simulations that are used to experimentally monitor the functioning of a particular system.

After entering the input data and conducting the simulation, it is possible to notice potential places of optimization, i.e., the need to increase or decrease resources and the like. Of course, all the mentioned activities can be realized by calculation, but the process is much longer and more complex. From the observed example it can be concluded that the duration of the distribution process differs as a function of the number of resources used. Certainly, the goal of every logistics system is to find the optimal number of resources that will enable the processes to be realized continuously, i.e., without waiting (delays). In addition, it is important that there are not too many resources, i.e., that they are not used, because in that case they represent tied-up capital. Based on the presented example of the distribution process, several conclusions can be drawn. Namely, financial savings that mean reducing the number of resources must be done carefully and analytically. Reducing resources at one end of the chain can cause changes in all other activities, as was the case with Scenario 2. In addition, financial indicators are by no means the only indicators of system efficiency. It must be precisely determined what is the cause of the increase/decrease of certain costs in the system. And certainly, communication within the system, understanding of other stakeholders and understanding of the distribution system as a whole that depends on the efforts of all participants is a prerequisite for establishing a Win-Win situation and optimizing business.

REFERENCES

[1] Bacchetti, A., Bertazzi, L., Zanardini, M. (2020). Optimizing the distribution planning process in supply chains with distribution strategy choice. Journal of the Operational Research Society, 1-14.

[2] Bizagi (2022). Available online: https://help.bizagi.com/bpm-suite/en/index.html?modeling_the_process.htm.

[3] Cimino, M.G.C.A., Palumbo, F., Vaglini, G., Ferro, E., Celandroni, N., La Rosa, D. (2016). Evaluating the impact of smart technologies on harbor's logistics via BPMN modeling and simulation. Information Technology and Management, 18, 223-239.

[4] Dachyar, M., Miranda, G.S. (2019). Design on improvement of distribution process in logistics service provider companies using business process reengineering approach. Proceedings of the International Conference on Industrial Engineering and Operations Management, 90-97.

[5] Mutanov, G., Sayabek, Z., SerikBekuly, A. (2020). Application of System-Dynamic Modeling to Improve Distribution Logistics Processes in the Supply Chain. Communications, 22(3), 29-39.

[6] Pajić, V., Andrejić, M., Kilibarda, M. (2021). Evaluation and selection of KPI in procurement and distribution logistics using SWARA-QFD approach. International Journal for Traffic and Transport Engineering (IJTTE), 11(2), 267-279.

[7] Vlasov, A.I., Gonoshilov, D.S. (2019). Simulation of manufacturing systems using BPMN visual tools. Journal of Physics: Conference Series, 1-7.