Development of simulation model for the site of mining and transportation of ore of the mining and processing plant

IOP Conf. Series: Materials Science and Engineering **709** (2020) 022091 doi:10.1088/1757-899X/709/2/022091

Development of simulation model for the site of mining and transportation of ore of the mining and processing plant

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Abstract.This paper presents the results of simulation modeling of the mining and transportation of ore at a mining and processing plant. A hybrid multi agent-simulation approach is used to analyze the bottlenecks of the simulated process.

1. Introduction

The work of Alenichev V.M. and Sukhanov V.I. [1-2] and also [3-4] is devoted to the development of problem-oriented decision support system (DSS) and the use of geographic information systems in the design and planning of mining at open pits. The experience of using GPSS discrete-event simulation modeling to mining and processing production is presented in [5], modeling of the organization of ore flow and cost management of a mining enterprise is presented in [6]. The use of the AnyLogic simulation system for the task of analyzing mining in an underground potash mine is presented in [7]. The multi-agent approach was used in the problem of optimizing solutions in a multi-agent system for improving the quality of iron ore sinter [8] and in designing and pre-project analysis of mine robot-technical systems [9].

For the task of modeling the site of mining and transportation of ore of the mining and processing plant (GOK), data of Lebedinsky GOK is taken, which is in open sources. The task deals with the extraction and transportation of minerals to the processing plant.

At present, many hybrid models of multi-agent dynamic processes have been developed, such models include the network of needs and capabilities Skobelev P.O. and Wittih V.A. [10], hybrid approach implemented in the AnyLogic system [11]. In this work, we use the model of the multi-agent resource conversion process (MPPR) and its software implementation in the form of a dynamic situation simulation system Bpsim.MAS [12] and the method for analyzing bottlenecks [13] for modeling mining and processing production. The work [5-6] is devoted to the development of problem-oriented decision support systems in the design and planning of mining at quarries.

2. Objects of research and experiment technique

For the calculation of queuing networks (SMO), the theory of probabilistic networks is used, which is based on Markov and semi-Markov processes. Finding bottlenecks in the network is an important aspect of analyzing its work. The network node creates a bottleneck which load factor *Uk* approaches unity. From the point of view of the application of operational analysis of probability networks to the model of MPPR in the analysis and elimination of bottlenecks, it is necessary to analyze the following parameters: 1) the utilization rate of the node (the operations and agents correspond to nodes, it is also necessary to analyze the utilization rate of the means); 2) the average duration of the application in the queue to the operation, the agent (the size of the queue of applications to the operation, the average queue of applications to the agent rule); 3) the attendance rate of the node and the average duration of processing requirements in the node. Similarly, the queue evaluates the average state of resources (both input and output in relation to a particular operation or agent rule).

Consider the process of mining and transporting ore. Transportation is carried out: from the bottom to the transshipment sites - by road, from the transshipment sites to the processing plants - by rail. The transportation distance from the quarry to the processing plant is 14 km, for trains. Railway transport - 25 trains consisting of: 25 electric locomotives, 50 motor-cars, 225 dump cars. Road transport: BelAZ - 50 pcs. The length of transportation by road is 1.2 km. Agents in the model are used to redistribute applications, collect and analyze statistics on bottlenecks. The number of excavators for mining and reloading - 27 pcs.

3. Experiments

The number of trains and vehicles is the key parameters in our task, through their variation and diagnosis of bottlenecks - queues for loading and transportation. General data for experiments: eight working hours shift is simulated. The main results of the experiments are summarized in a table.

Table 1. The main results of the experiments

Compositions (Comp.)	Belaz	Minqueue ofBelaz	U_k Belaz	The average of Belaz	Min gueue of train comp.	U_k train comp.	The average of train comp.	Labor for loading for railway trains, t	Final production, t
25	50	10	69%	14,56	0	86%	2,8	34263	26190
25	40	1	86%	4,99	0	86%	2,8	34263	26190
32	38	1	87%	4,13	1	76%	6,03	29462	30555
29	37	0	88%	3,76	0	83%	3,89	29462	29682

4. Conclusion

A multi-agent simulation model was developed for the extraction and transportation of Lebedinsky GOK to diagnose bottlenecks. Because of the conducted simulation experiments, the bottlenecks of the processes were diagnosed and recommendations for their elimination were made. As part of the logistics process model, recommendations were made on the distribution of railroad trains (29 trains) and vehicles (37 BelAZ).

5. Acknowledgment

The work is supportedby 211 acts of the Government of the Russian Federation, agreement No. 02.A03.21.0006.

References

[1] Alenichev V.M., Khokhryakov V.S., Sukhanov V.I. 1998 Modeling of natural-raw technological complexes (mining). Ekaterinburg: Ural Branch of the Russian Academy of Sciences, 273 p.

[2] Alenichev V.M., Sukhanov V.I. 2005 The concept of the formation of career space using information technology *Gorny informative-analytical bulletin* № 9.

[3] Sokolov I.V., AntipinYu.G. 2012 Systematization and economic-mathematical modeling the development of underground reserves by combined deposits mining *EURASIAN MINING*. № 1 P. 29–32.

[4] Yendiyarov S., Zobnin B., Petrushenko S. 2012 Expert system for sintering process control based on the information about solid-fuel flow composition *Proceedings of World Academy of Science, Engineering and Technology*, France, Issue 68, August pp. 861-868 (SCOPUS).

IOP Conf. Series: Materials Science and Engineering **709** (2020) 022091 doi:10.1088/1757-899X/709/2/022091

[5] Goroshkov V.Yu., Devyatkov VV, Nifantyev E., Fedotov MV 2013 Simulation modeling of mining and processing production *Proceedings of the sixth All-Russian scientific-practical. conf. "Simulation modeling. Theory and Practice" (IMMOD 2013): a collection of reports. Kazan*: Academy of Sciences of the Republic of Tatarstan, V.2. S.95-99. http://simulation.su/files/immod2013/material/immod-2013-2-95-99.pdf

[6] Panasyuk Ivan Petrovich 2005 Simulation modeling of the organization of the ore flow and the management of the costs of the mining enterprise: Abstract of dissertation of the candidate of economic sciences. 08.00.13 St. Petersburg.

[7] V.E. Chernenko, A.A. Malykhanov, Discrete-event modeling of mining in an underground potash mine IMMOD-2013. https://www.anylogic.ru/resources/articles/modelirovanie-gornoy-dobychi-v-podzemnom-kaliynom-rudnike/

[8] Endiyarov, S. V. 2013 Optimization of solutions in a multi-agent system for improving the quality of iron ore sinter *Steel* № 9. p. 12-14.

[9] Konyukh V.L., Taylakov O.V. 1991 Pre-project analysis of mine robot-technical systems. Novosibirsk: Science 182 p.

[10] V. A. Wittich, P. O. Skobelev 2003 "Multi-agent interaction models for the design of the nets of requirements and capabilities in open systems," *Automatics and telemechanics* vol. 1 pp. 177-185.

[11] AnyLogic simulation software. https://www.anylogic.com/

[12] K.A. Aksyonov, E.F. Smoliy, N.V. Goncharova, A.A. Khrenov, A.A. Baronikhina, Development of Multi Agent Resource Conversion Processes Model and Simulation System, Computational Science – ICCS 2006: 6th International Conference, Reading, UK, May 28-31, 2006. Lecture Notes in Computer Science, Vol. 3993, P. 879–882. WOS:000238417300114 DOI: 10.1007/11758532_114

[13] K. Aksyonov, A. Antonova, Wang Kai, O. Aksyonova ,"Rules for construction of simulation models for production processes optimization". 3rd International Workshop on Radio Electronics and Information Technologies, REIT-Spring 2018; Yekaterinburg; Russian Federation; 14 March 2018. pp. 8-19.