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Generalized Net Model of Processes of Loading and Transportation of Raw Materials of Open Construction Site

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Abstract: The generalized net model of the process of loading and transportation of raw materials is constructed. Its possible applications and extensions are discussed.
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1 Introduction

The modelling of loading and transportation of raw materials at open area construction sites is a part of project for development of a method and algorithms for adaptive management of a technological process that provide: quick adaptation of the management system to the changes of the working environment; improvement of the aggregate (system) accuracy of field measurements in the real time constraints and the gaps in the incoming data from the objects; reducing time for forming management decisions; reducing the time for implementing the management system; reducing the cost of deploying and operating the management system.

The modelling of loading and transportation of raw materials at open area construction sites is a part of project 8IF-02-16/12.12.2017 “Innovative method and algorithms for adaptive open production processes automation” (National Innovation Fund of Bulgaria, Session 8, 2017). The developed method and algorithms for adaptive management of a technological process provide: quick adaptation of the management system to the changes of the working environment; improvement of the aggregate (system) accuracy of field measurements in the real time constraints and the gaps in the incoming data from the objects; reducing time for forming management decisions; reducing the time for implementing the management system; reducing the cost of deploying and operating the management system.

The Generalized Nets (GNs, see [1–3]) are a suitable tool for modelling of parallel processes. They are extensions of the ordinary Petri nets and all of their extensions and modifications. By this reason, here, they are used as a tool for modelling of the process of loading and transportation of raw materials.

The process of loading and transporting of raw materials is an essential element of the complex technological process in open industries. In the present work the dumpers are considered as the main enforcement mechanisms, but within the project are considered different types of mechanization: loaders, excavators, bulldozers, rollers, cranes and others. For their inclusion in the general formal description of the production proces, it is assumed that the extension (details and cloning) of the model discussed here will be developed, which is subject to further development. Other works, different from transportation (aggregates production, paving, etc.) also will be included in the future extensions of the model.

2 A generalized net model

The GN contains 4 transitions, 13 places and 5 types of tokens (see Fig. 1).

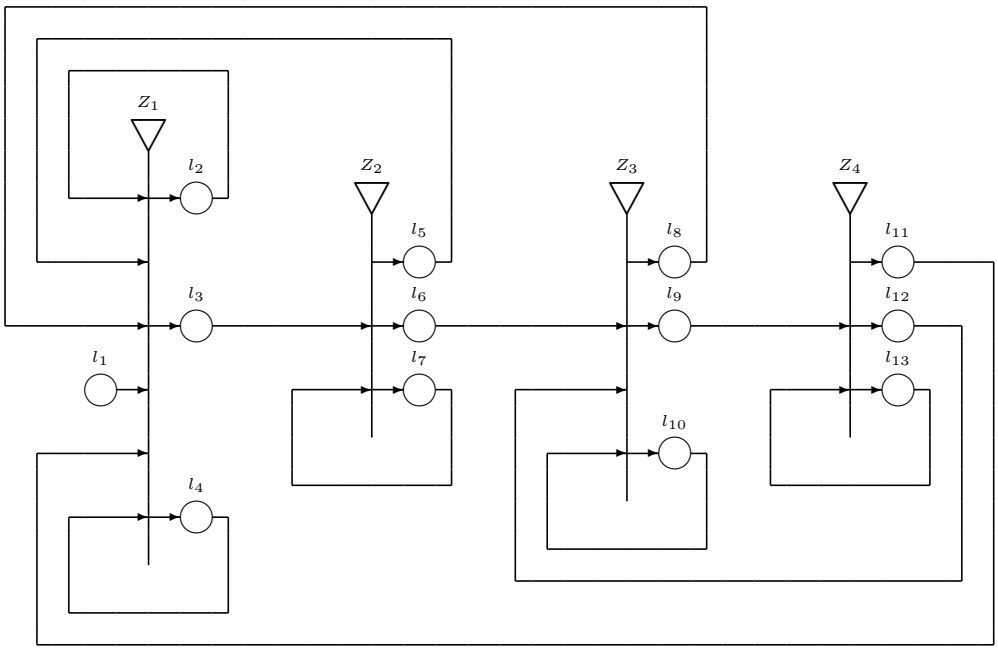

Figure 1.

Token τ enters place l_1 with the initial characteristic

"task for loading and transportation of raw materials".

Token δ stays permanently in place l_2 with the initial and current characteristic

"Database with full information about the processes of loading

and transportation of raw materials".

Token λ stays permanently in place l_4 with the initial and current characteristic

"foremen and technical managers".

Token γ stays permanently in place l_{10} with the initial and current characteristics

"garage - list of the currently existing lorries".

Token β stays permanently in place l_{13} with the initial and current characteristic

"building site".

The GN-transitions have the following forms.

$$Z_1 = \langle \{l_1, l_2, l_4, l_5, l_8, l_{11}\}, \{l_2, l_3, l_4\},$$

	l_2	l_3	l_4
l_1	$false$	$false$	$true$
l_2	$true$	$false$	$false$
l_4	$W_{4,2}$	$W_{4,3}$	$true$
l_5	$true$	$false$	$false$
l_8	$true$	$false$	$false$
l_{11}	$true$	$false$	$true$

$\rangle$,

where
$W_{4,2}$ ="there is new information for including in the Database (token δ)",
$W_{4,3}$ ="there is a resolution for the current task".

When token τ enters the GN through place l_1, on the next time-step it enters place l_4 and merges with token λ that obtains the characteristic

"resolution for implementation of the task (necessary resources, sites)".

On the next time-step, token λ splits to three tokens – the original token λ that continues staying in place l_4, token λ' that enters place l_2 and marges with token δ, and token τ that enters place l_3. Token δ it its new form represents an extension of the Database with the new information from the team leader, while token τ obtains the characteristic

"production plan and schedule for realization of the current task".

Tokens τ' (from place l_5), γ' (from place l_8) and β' (from place l_{11}), enter place l_2 and unite with the token δ extending the information in the Database.

$$Z_2 = \langle \{l_3, l_7\}, \{l_5, l_6, l_7\},$$

	l_5	l_6	l_7
l_3	$false$	$false$	$true$
l_7	$true$	$true$	$false$

$\rangle$.

Token τ from place l_3 enters place l_7 with the characteristic

"a process chart for implementation of the current task".

On the next time-step, it splits to two tokens – the original token τ enters place l_6 with the characteristic

"a list for the necessary lorries for realization of the current task"

and a token τ' that enters place l_5 with the same information that will enter the Database (token δ in place l_2).

$$Z_3 = \langle \{l_6, l_{10}, l_{12}\}, \{l_8, l_9, l_{10}\},$$

	l_8	l_9	l_{10}
l_6	$false$	$false$	$true$
l_{10}	$true$	$W_{9,10}$	$true$
l_{12}	$false$	$false$	$true$

$\rangle$,

where $W_{9,10}$ ="a lorry (a number of lorries) from the garage must go the building site".

Token τ from place l_6 enters place l_{10} and merges with token γ with the above mentioned characteristics.

On the next time-step, token γ splits to three tokens – the original token γ that continues staying in place l_{10} with the above mentioned characteristic, token μ with the characteristic

"list of the lorry (lorries) from the garage that must go the building site",

and token γ' that enters place l_8 with the same information that will enter the Database (token δ in place l_2).

$$Z_4 = \langle \{l_9, l_{13}\}, \{l_{11}, l_{12}, l_{13}\},$$

	l_{11}	l_{12}	l_{13}
l_9	$false$	$false$	$true$
l_{13}	$true$	$W_{13,12}$	$true$

$\rangle$,

where

$W_{13,12}$ ="the lorry (lorries) has/have finished its (their) activities and must return to the garage".

Token μ from place l_9 enters place l_{13} and merges with token β with the above mentioned characteristic.

On the next time-step, token β splits to two tokens – the original token γ that continues staying in place l_{13} with the above mentioned characteristic, and token β' with information about the lorry (lorries) activities, that will enter the Database (token δ in place l_2).

When predicate $W_{13,12}$ is true, token β splits to three tokens – the original token γ, a current token β', and the token μ with the characteristic "list of all lorry (lorries) activities accomplished at the building site".

3 Conclusion

The present GN model describes the processes of loading and transportation of raw materials as a core part of the production process in open area industries. It can be used for synchronization and optimization of the processes in a real process management and automation system.

In near future, this model will be extended in several directions. First, place l_2 that corresponds to the Database that contains full information for the company activities, will be described by a separate GN. The functioning and the results of the work of the used Data Mining tools will be represented by respective GNs that will be sub-nets of the new GN (see [4]).

Second, transition Z_4 will be changed by a separate (sub-)GN that will represent the processes at the building site.

Third, a set of derivative GNs will be developed to cover the set of processes and mechanisms within the scope of the main project.

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