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Simulation of Container Data Processing Using Petri Nets

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Abstract: This article presents a process model for processing container data using Petri nets obtained from an automatic monitoring system for rolling stock and containers. This model makes it possible to check the operation of parallel processes and evaluate the quality of work as a whole.

Keywords: Petri nets, container, automatic system, modeling, Internet of things.

The algorithm for processing data about containers has a unique character. The container can be located separately from the rolling stock, on a carriage or as part of a specific train. But the most important information is the location, namely the territorial object in which the container is located.

The geolocation sensor is attached to the container from the outside. One individual sensor for one locomotive. The sensor periodically sends a signal about the location of this container, that is, the longitude and latitude coordinates. From the ASMPS database, the container number is searched by the sensor number. Since the numbers of sensors and containers are interrelated. If the number is not found when searching for a container from the database, the sensor information will not be saved in the database. The system console will indicate that the container was not found in the database. This can mainly happen when the sensor has not been registered in the system.

The sensor will transmit a data set that includes information about the geolocation of the container. The system will process longitude and latitude data to determine the corresponding territorial feature. The parameters of the size and characteristics of the territorial object are pre-entered into the database. Through the Automated Transportation Data Processing System (ATDPS), the availability of a container on the wagon will be checked. This information is checked using the sending model of the automated control system.

If the container is not detected on the car, then parameters such as the car number and train index will remain empty. If the container is on a wagon, the system will determine the wagon number. Then, information about the destination station of the loaded car will be obtained from the ASOUP database. Using the car number, it will be possible to search for the location of the container on a specific train. The train search operation is carried out using automated control system. If a wagon is not detected on a train, information about the container is stored as being on a wagon that is not coupled. The index of the train on which the container is located is determined. A container history object is created, the parameters of which are filled in according to the received data and saved.

The Petri net (PN) theory, first described in 1962 by the German mathematician Carl Petri, is now widely used in almost all branches of scientific research. SPs are a convenient mathematical apparatus for formalization, analysis and modeling of discrete event systems]. Due to the loosely coupled multi-level structure, SPs can be used to effectively simulate various technological processes. SP methodology is widely used for fault detection and diagnosis of discrete event systems .

Definition. The Petri net C is a quadruple , $C = (P, T, I, O)$.

$P = \{p_1, p_2, \ldots, p_n\}$ – a finite set of positions, $n \geq 0$. $T = \{t_1, t_2, \ldots t_m\}$– a finite set of transitions, $m \geq 0$. The set of positions and the set of transitions do not intersect $P \cap T = \emptyset$. $I: T \to P\infty$ is an input function - a mapping from transitions to sets of positions.$O: T \to P\infty$ there is an output function - mapping from transitions to sets of positions.

Definition. The Petri net graph $G$is a bipartite oriented multigraph, $G = (V, A)$, where $V = \{u_1, u_2, \ldots, u_s\}$is the set of vertices, and$A = \{a_1, a_2, \ldots, a_T\}$ – a set of directed arcs, $a_i = (v_j, v_k)$, where $v_j, v_k \in V$. The set Vcan be divided into two disjoint subsets$P$ and $T such$ that$V = P \cup T$, $P \cap T = \emptyset$and for any directed arc $a_i \in A$, if $ai = (vj, vk)$, then either $v_j \in P\ and\ v_k \in T$, or $v_j \in T, a\ v_k \in P$.

Markingμ Petri nets$C = (P, T, I, O)$ is a function that maps a set of positions $P$to a set of non-negative integers N.

$\mu: P \to N$ (1)

Marking μcan also be defined as an n-vector $\mu = (\mu_1, \mu_1, \ldots,, \mu_n)$, where $n = |P|$and $\mu_i \in Neachi = 1, \ldots, n$. The vector μdefines for each positionμ_i Petri net is the number of chips in this position.

A marked Petri net $M = (C, \mu)$is a set of Petri net structures$C = (P, T, I, O)$ and markings $\mu$and can be written in the form $M = (P, T, I, O, \mu)$.

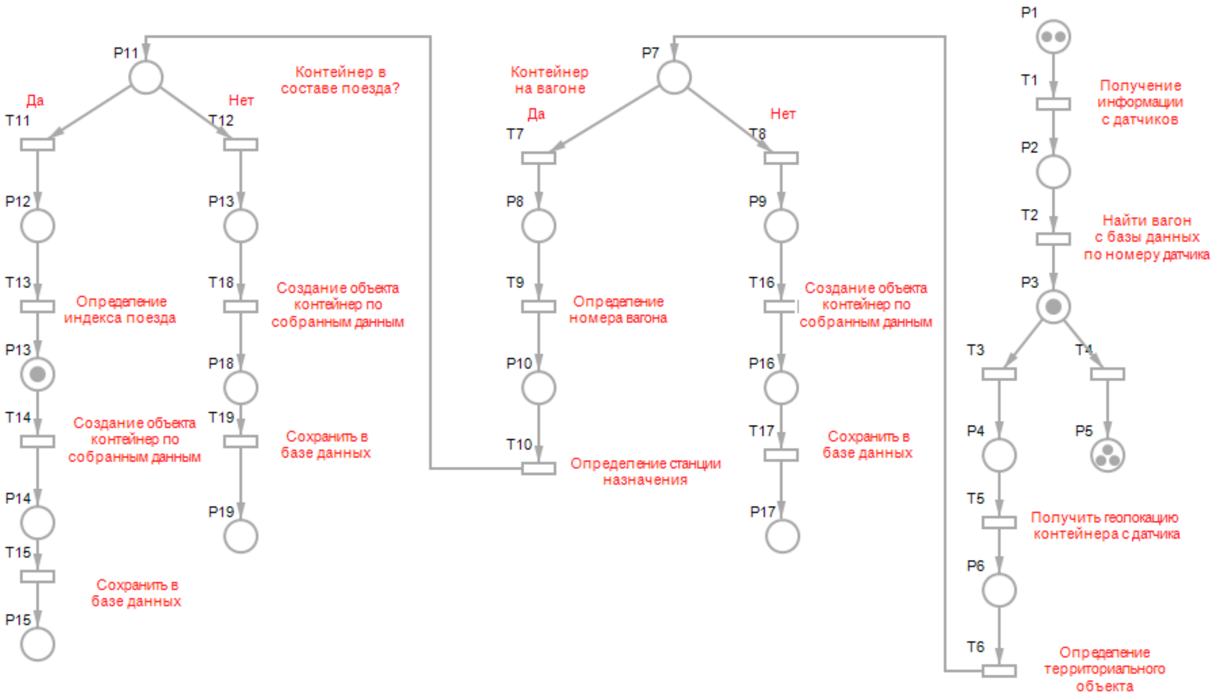

Figure 1. Data Processing Process Model

All proposed extensions are aimed at creating the ability to check for zero in Petri nets. The simplest extension of Petri nets that can be checked for null are restraining arcs. Restraining arc from position p; into transition t, has a small circle rather than an arrow at the end of the arc attached to the transition. The triggering rule changes as follows: a transition is allowed when tokens are present in all of its (regular) inputs and absent in the restraining inputs. A transition is triggered by removing tokens from all of its (regular) inputs.

Let's define an extended input and output function

$I: T \to P\infty\,, \quad O: T \to P\infty$ [2]

so that

$\#\left(t_j, I(p_i)\right) = \#\left(p_i, O(t_j)\right), \#\left(t_j, O(p_i)\right) = \#\left(p_i, I(t_j)\right)$ [3]

For the Petri net in Fig. 1, the extended input and output functions are:

$M = (P, T, I, O, \mu)$ [4]

$P = (p_0, p_1, p_2, p_3, p_4, p_5, p_6, p_7, p_8, p_9, p_{10}, p_{11}, p_{12}, p_{13}, p_{14}, p_{15}, p_{16}, p_{17}, p_{18}, p_{19})$ [5]

$T = (t_0, t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8, t_9, t_{10}, t_{11}, t_{12}, t_{13}, t_{14}, t_{15}, t_{16}, t_{17}, t_{18}, t_{19})$ [6]

The created model using a Petri net provides a clear representation of the sequence of actions and logical connections between positions. The illustration presented as part of this work was developed using the HPSim program . The correct functioning of Petri nets was checked, and imitation of the movement of “chips” through the network allows us to identify vulnerabilities during modeling. Considering that the loading planning system is automated, the Petri net method is excellent for assessing the effectiveness of automated systems.

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