Modeling of the Customs Clearance and Control Processes Based on Combining Use of the IDEF Methodology and Theory of Queuing Systems

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Abstract – In this paper provides the results of research on the development of the method of constructing a model of customs procedures in terms of the theory of queuing systems based on their description by means of functional modeling IDEF0. The technique is based on use of the integrated IDEF0 models and theory of queuing systems with the ability to transition from a description of the system in IDEF0 to discrete-event models.

Keywords – Automation of industrial processes, information technology, decision-making system, customs procedures, IDEF0, discrete event simulation, queuing system.

I. INTRODUCTION

It is known that IDEF-models has been used successfully in the solving applied problems of modeling and automation of production processes, the development of automated processes and multi-service networks, modeling and optimization of supply and logistics, and many problems [1,2]. IDEF methodology is also well recommended themselves and for the simulation of customs procedures as a business process.

They can be used effectively to display and analyze models of the customs authorities and customs control procedures and workflow.

However, IDEF0 methodology does not allow to directly construct adequate IDEF0 models for complex production processes, where there is a need to predict the behavior of the system in response to control impacts and the development of preventive and corrective measures. This is primarily due to the presence of a system of logical and linguistic conflicts in determining the source of primitives [3].

For constructing a simulation models of complex manufacturing processes and systems based on IDEF0 methodology is required, firstly, an adequate interpretation of the purposes of modeling standards, secondly, a set of rules under which the original IDEF0 primitives are mapped to the basic concepts of the selected mathematical apparatus of modeling.

Thus in this paper we propose a methodology for integrated use of IDEF0 models and theory of queuing systems with the ability to transition from a description of the system in IDEF0 to discrete-event model for the construction of an adequate simulation model of the customs procedures.

II. SIMULATION OF CUSTOMS PROCEDURES BASED ON IDEF0 METHODOLOGY

Process of customs control on the whole period of the imported goods under customs control can be divided into 3 stages:

– Customs procedures when crossing the border;
– Customs escort cargo within the country to the destination;
– Customs clearance at the place of arrival.

Similarly, the goods in question, under other customs regimes, given the characteristics of the customs regime under consideration.

In turn, according to the national legislation at every stage to undertake certain customs procedures.

1. In the border customs posts:

– Documentary control;
– Control of risks for the national economic security risks (prohibited goods; dual-use goods; goods requiring special permit, the search of vehicles and of responsible carrier, the authenticity of documents);
– Provision of customs fees and charges;
– Customs inspection, sealing and delivery of control of delivery;
– Appointment route and support;
– Permission to enter.

2. When the movement of cargo within the country:

– Support domestically.
3. In foreign trade customs posts:
- Documentary control;
- Removal from the delivery control and placement in a customs warehouse;
- Control for national economic security risks (covering goods, customs valuation, accrual rates and customs duties);
- Provision of customs duties;
- Customs inspection;
- Permission to travel.

III. DESCRIPTION OF THE MAIN ELEMENTS OF THE IDEF0 MODEL OF CUSTOMS PROCEDURES IN TERMS OF QUEUING SYSTEMS

The technological process of customs control at the customs post can be considered as a set of technological operations, consisting in the processing of applications for customs clearance of foreign trade goods of varying intensity. Modeling and study of such processes is possible with the assistance of queuing theory.

The subject of queuing theory is to establish relationships between the nature of the flow of requests, the number of service points, the performance of individual item and ways to manage these processes.

In the role of customs activity requests for services performed goods and vehicles across the customs border. Traders of Hotels way or the other information required for customs clearance, act as the applicant. And the role of service delivery points assigned to Customs officials performing their duties in the process of customs clearance.

By posing the problem must describe rules of transition from abstraction to the standard IDEF0 by main terms used in describing the system as queuing systems (QS). In this way:

Inputs customs procedures are considered as incoming requests. Obviously, the IDEF0 diagrams of display inputs as object classes, while inputs for QS models specific instances of these classes (this is true for the other elements of the model).

The outputs of customs procedures are considered as outflows applications.

In accordance with the concept of decomposition is considered a hierarchy of applications corresponding to different levels of detail customs procedures in the diagrams IDEF0. In particular, the context diagram are assigned to the application 0-level, dependent block diagram of context - the application level 1, and so on. D. Then customs procedures s-level logically understood as a process service requests S-level.

Served by the application of this class leaves the system, instead of it coming into the system (as an input), generally speaking, several other classes of applications (obviously opposite situation is possible), as the number of inputs and outputs of the process may be different.

More difficult to interpret within the unit SMO is the concept of "governance". In this paper, the control process is also considered as the incoming stream of events, t. E. The incoming stream of events "control" is a stream of income representatives of the classes of control actions, since each such event changes the state of the system.
If we consider the mandatory customs procedures at border posts as a business process, it can be illustrated as follows. Consider a business process model with N inputs to outputs and L offices:

Define:

\[ (Z_{in}^i, i \geq 1)_{n=1}^{N} \]  
- incoming flows of application, where \( Z_{in}^i \) – interval between arrival of \((i-1)\)-th and \(i\)-th application of incoming flow with number \(n\);

\[ (U_{on}^i, i \geq 1)_{k=1}^{K} \]  
- outgoing applications flow, where \( U_{on}^i \) – interval between leaving moments of \((i-1)\)-th and \(i\)-th of outgoing flow with number \(k\);

\[ (W_{on}^i, i \geq 1)_{k=1}^{L} \]  
- revenue flow control actions, where \( W_{on}^i \) – interval time between receipt of \((i-1)\)-th and \(i\)-th control action type \(l\).

To compare the incoming / outgoing flows and their respective departments require additional information about the structure of the system, rather than a diagram of the business process level considered. Its source, apparently, is a diagram of dependent processes (for convenience in Fig.4 diagram dependent processes are superimposed on the diagram of the parent process).

In this example, the incoming stream corresponding to the input 1, compared with the outgoing flows 1, 2 and \(K\); incoming stream corresponding to input 2 is compared with the output stream 2 and \(K\). It should be noted that the comparison may not be direct, i.e. in one dependent process, and indirectly, i.e. a few dependent processes for which output one of them is input or manipulated variable to another.

Thus, each incoming stream or control action may correspond to not one, but several outflows, as, indeed and vice versa.

The above comparison is conveniently represented as a matrix \(M\) of size \((N + L) \times K\), whose elements:

\[ m_{ij} = \begin{cases} 1, & \text{input controlling } i \text{ corresponds to output } j \vspace{0.5cm} \\ 0, & \text{otherwise} \end{cases} \]  
where: \(i = 1, \ldots, (N+L), \ j = 1, \ldots, K\)

Consider now that the most important element of the QS: service time applications. Let incoming entities in the business process service goes through a series of steps (t. E. Associated with outbound application indirectly through a number of subsidiaries business processes), and the input of each of them served several external flow applications (from the parent business process) and several - from other subsidiaries of business processes (Fig. 5).

These steps form a chain of transitions incoming application type \(i\) parent business process in the application of its subsidiaries business processes before its release as an outbound application type \(j\) parent business process.
If the chain splits in any of the stages (corresponding, for example, several alternative decision-making procedures), we consider two chains, each of which corresponds to the different paths of transition applications.

Fig. 5. Stages of service requests

Enter values:

- \( t_j \) - moment generating outgoing requests p-th dependent business process included in the chain connecting the i-th input parent business process and its j-th output;
- \( \eta_p \) - when generating the output of the above subsidiary business process in response to the received inputs;
- \( t_s \) - the time of receipt of incoming applications s-flux;
- \( \eta_s \) - waiting time application s-th stream in line due to a busy device.

So the ratio will be apparent

\[
\hat{t}_p = \max_{r \in R_p, s \in S_p} \left[ t_r + \eta_r, t_s + \eta_s \right] + \eta_p
\]

Where: \( R_p \) - a plurality of incoming flows p-th dependent of a business process, is an outgoing flows of other subsidiaries of business processes;

\( S_p \) - a plurality of incoming flows p-th dependent of a business process that are external to the parent business process.

Then the moment of generation of output j parent business process in response to its input i will be determined by the relation

\[
t_j = t_p = \max_{r \in R_p, s \in S_p} \left[ t_r + t_s + \eta_r + \eta_s \right] + \eta_p
\]

or

\[
\eta_j = t_j - t_i = \max_{r \in R_p, s \in S_p} \left[ t_r + t_s + \eta_r + \eta_s \right] + \eta_p - t_i
\]

for each of the chains of dependent business processes, corresponding to the transition \( i \rightarrow j \).

Further, since each of the business process, the previously standing in the chain, and the relation

\[
t'_p = \max_{r \in R_p, s \in S_p} \left[ t'_r + t'_s + \eta'_r + \eta'_s \right] + \eta_p
\]

So

\[
t'_j = t'_p = \max_{r \in R_p, s \in S_p} \left[ t'_r + t'_s + \eta'_r + \eta'_s \right] + \eta_p =
\]

\[
= \max_{r \in R_p, s \in S_p} \left[ \max_{r \in R_p, s \in S_p} \left[ t'_r + t'_s + \eta'_r + \eta'_s \right] + \eta'_r + \eta'_s \right] =
\]

\[
= \max_{r \in R_p, s \in S_p} \left[ \max_{r \in R_p, s \in S_p} \left[ \max_{r \in R_p, s \in S_p} \left[ t'_r + t'_s + \eta'_r + \eta'_s \right] \right] + \eta'_r + \eta'_s \right] + \eta'_r + \eta'_s
\]

There was one important assumption made on the determination of the level of detail of model and taking into account points to incoming/outgoing requests. Namely, the generation of dependent exit the business process begins only after the receipt of all inputs associated with it. In other words, the standby situation at any stage of the incoming external application impossible. This allows not detail when considering the business process level s below the model s-1.

It is necessary to make a comment about the management of customs procedures, despite the fact that the control actions, as well as the application presented inbound events, they have important differences. Firstly, the residence time in the feedback control system is zero, since it has an impact on system state variables and does not require any "pending", therefore, secondly, it does not participate in the computation of the operating characteristics of the system as QS.
Since the customs posts at the same time are treated in several applications for customs clearance service system are, generally speaking, multi-channel.

IV. CONCLUSION

Thus, we can draw the conclusion that the proposed methodology the integrated use of IDEF0 models and the theory of queuing systems provides the possibility of transition from the description of the system in the IDEF0 model for discrete event simulation for construction of an adequate model of customs procedures.

Also, the obtained QS models are given the opportunity to allow a computational experiments and definitions of certain functional characteristics of the organization and for implementation of customs procedures associated to the presence of queues and the customs service of downtime.

And the QS models can be useful for solving problems of the planning and optimization of performance of customs procedures and automating them.

REFERENCES