Analysis of Business Processes in a Distributed Organizational and Technical System Based on Snapshots

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Abstract

Distributed organizational and technical systems belong to the class of complex hierarchical man-machine systems. The analysis of the state for such systems is a nontrivial task. The methods of system analysis are used, so the complex system is decomposed into subsystems and business processes, implemented at various hierarchical levels to achieve the main goal. Analysis of the state of business processes allows you to increase the efficiency of decision-making procedures to optimize these business processes. An algorithm for creating a snapshot of a system of business processes in a distributed organizational and technical system is considered. The DRAKON language was applied as the basic language for constructing models of business processes, which makes it possible to obtain a prototype of a finite-state machine when building models of business processes. The visualization of business processes in the state space allows the decision maker to improve the efficiency of the decision-making.

Keywords

Distributed organizational and technical system, business process, finite-state machine, state space, DRAKON, business process analysis

1. Introduction

As it is known, distributed socio-technical systems, for example, large construction companies, chemical enterprises, airline companies belong to the class of hierarchical man-machine systems, the analysis of the state of business processes in which is a difficult task. To solve it, the methods of system analysis are applied, namely, the system is decomposed into subsystems and business processes implemented at various hierarchical levels to achieve the goal [1].

When building models of business processes, various methodologies are used, for example, based on the BPMN (Business Process Model and Notation) specification [2–4]. Business process management in the systems under consideration is implemented based on a hierarchically organized management system [5]. Each level of management utilizes information from various data sources: sensors, reports, oral messages, etc. This information allows solving the current problems of analyzing the state of the system and make management decisions to improve the efficiency of the distributed system. To analyze the state of a distributed organizational and technical system, information about the current state of business processes is required [6].

Each level of the hierarchical management system contains a description of business processes with varying degrees of detail, which requires the formation of various semantic indicators that reflect the state of the business process [7]. These indicators can include data on the main characteristics of business processes, presented, for example, in the form of graphs, tables, etc. [8].

Data collection, transmission, storage and processing of large data streams in organizational and technical systems is a complex technical and organizational task [9, 10]. The form of presenting a

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large amount of data on the current state of the system to improve the efficiency of decision-making should reflect the qualitative characteristics of business processes [11].

One of the approaches used in the analysis of the state of distributed information systems is the formation of snapshots of the state [12]. The space of states of a distributed organizational and technical system reflects, depending on the degree of detailing of production processes, their generalized indicators [13, 14].

The complexity of assessing the state of production processes is associated with the need to form data sets characterizing these processes, which is not a trivial task for large systems [14]. To assess the current state of the organizational and technical system, the development of mechanisms for generating snapshots of the system state requires the development of protocols for the exchange of messages between business processes.

Below, we will consider the sequence of the main stages of forming snapshots of the states of a distributed organizational and technical system.

2. Building a business process model based on the DRAKON language

Figure 1 shows a model of states of a business process, presented in the form of a digital automaton:

$$M = (S, P), \tag{1}$$

where $S = (s_i, i = 1\ldots4)$ is a set of states of a business process,

$P = (p_{i,j}, i = 1\ldots4, j = 1..4)$ is a set of transitions from one state to another.

If the system provides for the preservation of states at the current moment in time, then it is possible to form an array of data reflecting the life cycle of a business process.

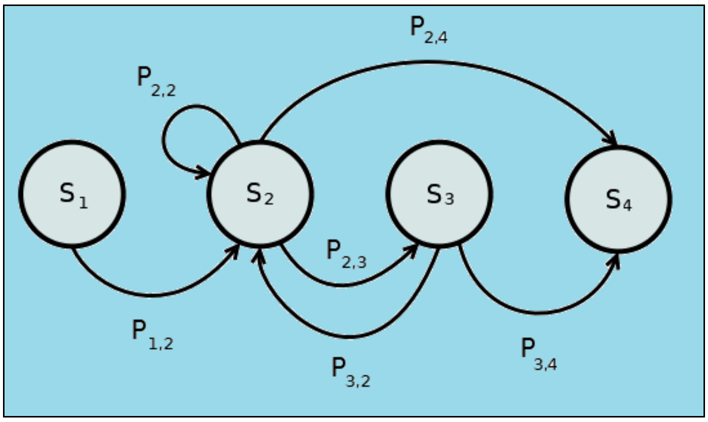

Figure 1: Finite-state machine model of a business process

To describe business processes, various visual modeling tools are used based on the languages for describing business processes IDEF, BPMN, etc. These tools are widely applied to solve information systems design problems within the framework of an architectural approach, business process analysis, etc.

One of the languages for visual modeling of information systems is the DRAKON language [15–17]. The main advantage of this language is the utilization of the concept of states and tree-like algorithmic structures, which facilitates the solution of the problem of transition from the description of business processes to their representation in the form of a state model of a digital automaton.

Figure 2 shows a model for describing the "*Process #k*" business process in the DRAKON language. As follows from Figure 2, the states of the system are presented in the form of independent graphical objects, and the completion of sub-processes within the current state transfers the process to another state.

When describing a business process using the DRAKON language, in accordance with the model (1), the developer creates a finite-state machine model:

$$M = (S, P, C, V), \tag{2}$$

where S = (*State* 1, ..., *State n*-1, *State n*) is a set of states of the business process "*Process # k*",
P = (*Subprocess* 1.1, ..., *Subprocess n*-1.1, *Subprocess n*.1) is a set of sub-processes,
C = ({*if* (•)}) is a set of conditions for choosing the next step,
V = (*Name* #, *End*) is a set of terminal vertices.

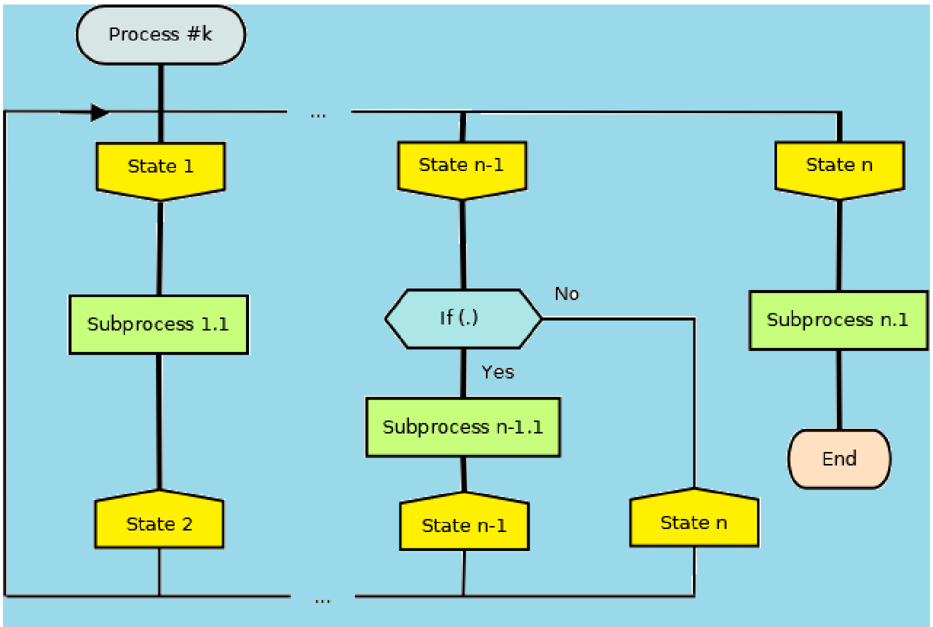

Figure 2: Description of a business process in DRAKON language

The time in the diagram changes from top to bottom and from left to right. The business process algorithm is divided into several parts, which are represented by vertical branches. As noted earlier, each business process is divided into sub-processes, which is indicated in the branch name at the top of the branch. At the bottom of the branch, the names of the following branches are given, which are selected depending on the result of the sub-process algorithm. This presentation of the business process is intuitively transparent and makes it easier at the stage of building the model to involve managers who are not associated with modeling and programming in the verification process.

We now turn to the procedure for creating a snapshot for the considered above distributed system of business processes.

3. Creating a snapshot of a distributed system of business processes

When analyzing the state of computing distributed systems, the concept of a system snapshot is used, which reflects the state of a computing system and computing processes [13]. The complexity of creating a snapshot is caused by the need to bypass all system nodes and collect data on their state (Figure 2). To solve this problem, various algorithms for the formation of a data array are used [13].

To generate a snapshot of the state of business processes, it is necessary to define a set of distinguishable states, develop protocols for exchanging data on the state of processes, and solve the problem of visualizing business processes in a given state space.

Figure 3 shows a snapshot of the system of business processes at specific points in time.

In our case, a system is understood as a stochastic undirected graph (2), the vertices of which change their position in the accepted metric state space. Elements of the set are

$$F = (B_{i,j},\ i = 1...n,\ j = 1...m), \tag{3}$$

where B_{ij} is a business process in the state space $D(R_k, R_m)$.

Edges between vertices are formed dynamically based on the specified Euclidean metric.

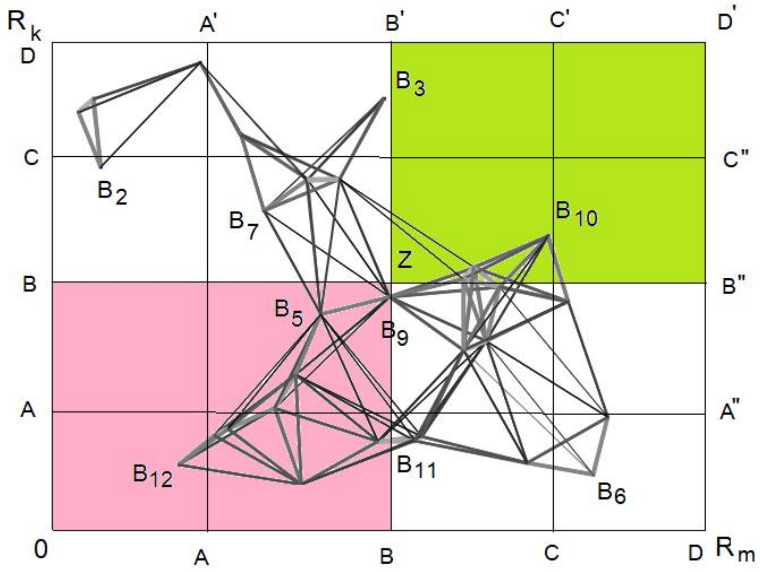

Figure 3: Business processes' snapshot

To have more clear view of the snapshot making, let us consider an algorithm for constructing a snapshot of a system of business processes:

Algorithm BPS (**B**usiness **P**rocess **S**napshot in state space)

Begin

Step 1. Development of models of business processes with the DRAKON language.

Step 2. Choosing a metric characterizing the proximity of processes at a given moment in time (1).

Step 3. Building a state space model (2).

Step 4. Development of a protocol for data exchange between business processes as part of the snapshot generation algorithm.

Step 5. Formation of images at specified times (3).

Step 6. Visualization of the state space.

Step 7. Analysis of clusters formed in the state space.

End.

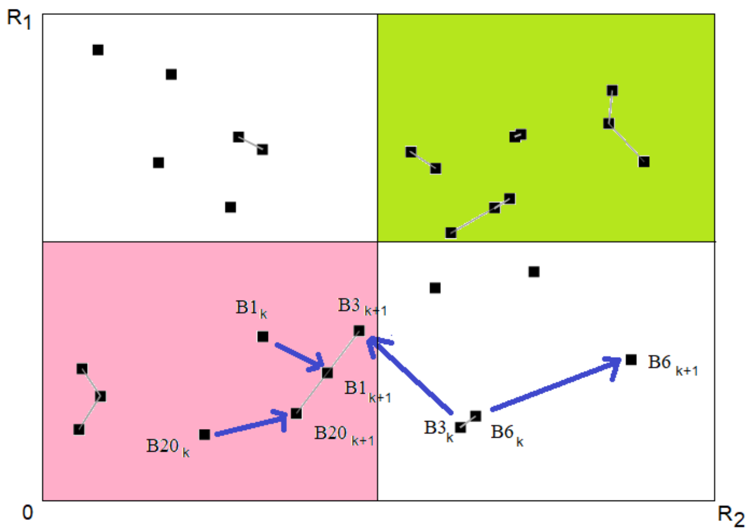

Figure 4: Formation of clusters of business processes

Figure 4 shows a snapshot of the system of business processes at times t_k and t_{k+1}, obtained on the basis of the proposed algorithm for generating a snapshot of the system of business processes.

As follows from Figure 4, the trajectories of business processes change, and at time t_{k+1} subgraphs are formed, for example, $G_s=(B20_{k+1}, B1_{k+1}, B3_{k+1})$, characterizing the states of business processes in a certain quadrant of the state space. The desired result could be that all processes move to the upper right quadrant marked in green, for example, while providing process safety tasks [9].

4. Conclusion

Analysis of the state of business processes of a distributed organizational and technical system in the state space allows you to fix the trajectories of business processes. To solve this problem, an algorithm for generating a snapshot of a system of business processes is proposed. The DRAKON language was chosen as the basic language for constructing models of business processes, which makes it possible to obtain a prototype of a digital automaton when building models of business processes. The visualization of business processes in the state space allows the decision maker to improve the efficiency of the decision-making.

The proposed algorithm includes the following main steps. At first, development of models of business processes with the DRAKON language is conducted. Then building a model in the form of a digital automaton for each business process is provided. The next stages are building a state space model and choosing a metric characterizing the proximity of processes, as well as development of a protocol for data exchange between business processes as part of the snapshot generation algorithm. Final stages are formation of images at specified times and visualization of the state space and analysis of clusters formed in the state space.

As possible directions for further research, it is necessary to point the development of methods for clustering business processes in the framework of the algorithm of creating a snapshot of a distributed system of business processes, as well as developing examples of snapshots for various types of distributed organizational and technical systems.

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