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Decision-Making Support for Supervisory Control of Non-Banking Financial Institutions

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***Abstract*—With the change in the regulatory landscape in the financial sector, the organization of the activities of non-banking financial institutions (NBFI) is making more and more demands on the part of state regulatory authorities. To increase the effectiveness of supervision of NBFIs, regulatory bodies use systems that automate the supervisory activities, and, in particular, decision support systems. This paper presents a decision support system to plan supervisory activities over NBFIs in accordance with the principle of risk-based supervision, in which resources are concentrated on NBFIs with the maximum amount of risk or scope of activity. The developed system tracks and prevents violations, adjusts the correctness of actions in relation to NBFIs. In addition, the system plans supervisory activities, changes the supervision regimes for NBFIs and controls the timing. The application of the developed system increases the effectiveness of the regulatory bodies in terms of control and supervision of both individual NBFIs and the financial market as a whole.**

Keywords—supervision system, event planning, risk-based supervision.

I. INTRODUCTION

Non-banking financial institutions (NBFIs) have been in a rather difficult situation for several years [1, 2]. With a change in the regulatory landscape in the financial sector, more and more demands are being placed on the organization of the activities of NBFIs by regulatory bodies [3-5].

To increase the effectiveness of supervision of NBFIs, the automation of the oversight activities of regulatory bodies is used, for example, by developing monitoring systems, reporting, planning, forecasting, and decision support. Such systems are becoming more intelligent and user friendly [6-8], that's why they can be effectively implemented in various fields of activity. It is permissible to use them in real-time for making responsible decisions [9-11].

An important criterion for effective supervision is to ensure the stability of the NBFI. The goal can be short-term (for example, the impact on the NBFIs' clients) and long-term goals (for example, the financial market impact of the NBFIs). On the basis of system analysis, a phased action plan has been developed that is used to achieve global goals [12, 13]. In the process of system analysis, patterns of typical situations and reactions have been highlighted to support decision-making [14, 15]. In addition to analyze information on the activities of NBFIs, effective decision support requires a comprehensive review of the organizational and system-level characteristics [16, 17], while safety aspects must be taken into account [18, 19].

Recently, Big Data and artificial intelligence technologies have been actively developed, which in the future will allow the use of new technologies to support decision-making or to completely replace decision-makers [20, 21], but such technologies cannot be applied to official regulation of the financial market due to insufficient elaboration.

This paper presents a decision support system to plan supervisory activities over NBFIs in accordance with the principle of risk-based supervision, in which resources are concentrated on NBFIs with the maximum amount of risk or scope of activity.

II. DOMAIN ANALYSIS

A. Risk-oriented Surveillance

In accordance with the requirements of regulatory documentation, the NBFIs provides for different frequency and intensity of supervisory activities with a focus on identified risks in the activity. Other areas of risk-based supervision are the different scope and frequency of reporting as one of the main sources of information for the supervisor, as well as the varying frequency of verification. The supervisory regime is understood as the procedure for supervising activities with a given periodicity, intensity, and concentration on the identified risks in the activities of NBFIs, which is established depending on the category of "size and significance" and the risk profile of the supervised NBFIs based on the matrix of supervisory regimes.

Depending on the impact of the NBFIs on the financial system, financial sector and consumers of financial services and taking into account the size of the institution, social significance, and other factors, the NBFIs are classified in the following categories of "size and significance": large (significant), medium, and small. The risk profile of an NBFIs is determined based on the likelihood of occurrence and the significance of adverse events for the financial stability of the NBFIs or the implementation of core activities in the financial market. The risk profile of an NBFIs is a general description or a matrix of the main risks that an NBFIs faces, indicating the level of influence (for example, high, medium, low) and

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the likelihood of events. The specialized supervisory unit establishes a methodology for determining the risk profile, which contains the procedure, including a list of assessed indicators and criteria for attribution, the frequency and conditions for reviewing the risk profile. The methodology for determining the risk profile should provide for a comprehensive assessment of risks depending on the type of NBFIs, taking into account the specifics of the business model of NBFIs. Reporting is one of the main sources of information for the supervisor. At the same time, with a decrease in the intensity of supervision of NBFIs depending on its category, it is advisable to reduce the volume and frequency of reporting in order to optimize the burden on supervised NBFIs.

B. Domain Model

To describe the main entities of the subject area, a model has been developed ("Fig. 1"). Using a set-theoretic approach, we describe a domain model to support decision making.

Imagine the process of supervision in the form of a sequence of activities presented at discrete points in time t:

$$\{y^t\}, t = \overline{1,m}. \quad (1)$$

Many consistent evaluations of events are presented:

$$\{w^l\}, l = \overline{1,L}. \quad (2)$$

w^l can be a complex assessment, which consists of a few simple ones.

The function defined at time points is selected $t = \overline{1,m}$:

$$F(t,\theta) = (\theta, \varphi(t)), \quad (3)$$

where θ – parameter vector $\theta = (\theta_1, \dots, \theta_k)$,

φ – vector function $\varphi = (\varphi_1, \dots, \varphi_k)$,whose components are unknown functions.

The task of supporting decision-making is to find such a predictive sequence that will be most consistent with the composition of the activities and their assessment, that is:

$$y_t = (\theta, \varphi(t)), t = \overline{m+1, m+n}. \quad (4)$$

As a measure of proximity, we take

$$D(\theta) = \sum_{t=1}^{m} R(\tilde{y}_t - (\theta, \varphi(t))), \quad (5)$$

where R – strictly convex function.

As a result, we get the problem:

$$D(\theta) \rightarrow min,$$

which can be reduced to a linear dynamic programming problem:

$$D(\theta) = \sum_{t=1}^{m} |\bar{y}_t - (\theta, \varphi(t))|. \quad (6)$$

C. Event Planning Algorithm

An action planning algorithm has been developed using a risk-based approach ("Fig. 2"). The essence of this algorithm lies in the fact that each NBFI is assigned a certain mode of supervision, in accordance with which a list of activities on this NBFI is formed. Each event establishes the period of appointment of the event and the period of planned action of the event.

Fig. 2. Supervisory planning algorithm.

Step 1. Choosing NBFI. At this step, the NBFI is determined for which a change in the list of activities is required. An NBFI is determined on the basis of an analysis of available information: size and turnover, impact on the financial sector, the number of consumers of financial services.

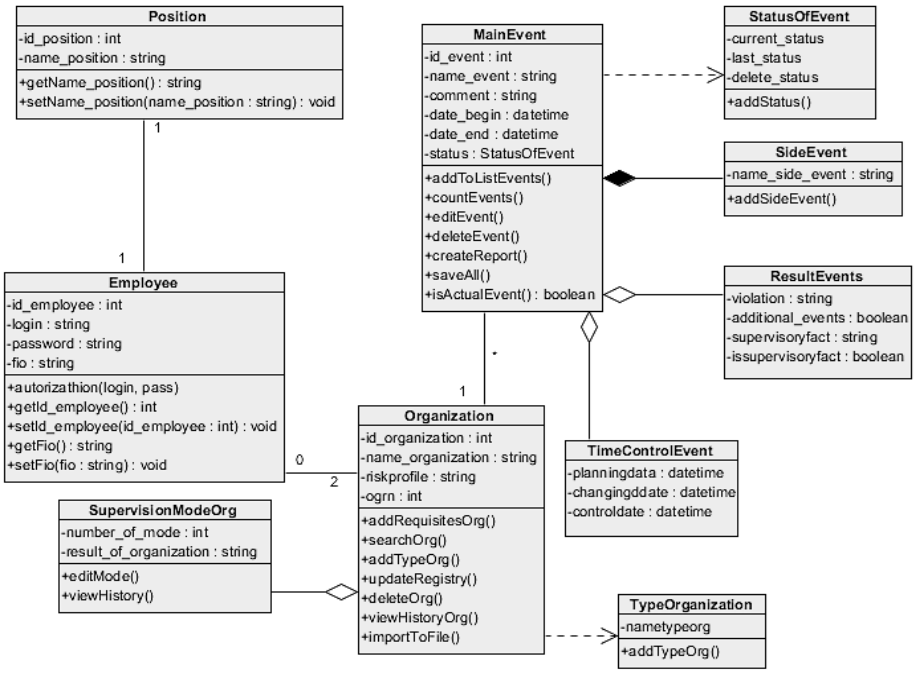

Fig. 1. Domain model.

Step 2. Appointment of a surveillance mode. The risk profile of the NBFI is determined and, in accordance with a customizable risk matrix, a supervision mode is assigned.

Step 3. Definition of the list of activities. In accordance with the supervisory regime, a liver of activities is formed in relation to NBFIs.

Step 4. Setting an appointment period. For each event in the list, the frequency of its holding is assigned. The frequency takes into account possible weekends and holidays, as well as the presence of unscheduled events in relation to NBFIs.

Step 5. Setting the planned period of action. For each event in the list, a planned validity period is assigned.

III. System Features and Capabilities

The system provides for three user roles: system administrator, supervisor, decision-maker. To work in the system, an employee must log in to it by entering a username and password. Depending on the role, the user will have access to various functions and features described below.

A. System Administrator

The following functions should be available to employees with the Administrator role:

- appointment of the main and reserve NBFIs to employees;
- maintaining internal register of NBFIs.

Appointment of primary and backup NBFIs to employees. The database should be loaded with registers of NBFIs market entities, of which the main NBFIs are assigned to each supervisor. Only one employee can be assigned as the main NBFI. For convenience, the entire list of NBFIs can be divided into types. It is also possible to search for a specific NBFI by state registration number or name. One NBFI can be assigned as a backup to several supervisors. An NBFI cannot be both reserve and primary at the same supervisor.

Maintaining an internal register of NBFIs. Entering details of supervised NBFIs that are absent for microfinance market entities loaded into the register for any reason and self-regulatory NBFIs is made by the "Administrator" in the "Internal Register of Organizations" window. After filling out all the fields provided for in the internal registry, the NBFI will appear in the "Assign Organizations" window, and it will be possible to designate the supervisor as the main or reserve NBFI.

B. Supervisor

The following functions should be available to employees with the Supervisor role:

- action planning for supervised NBFIs;
- viewing the history of changes in surveillance modes;
- setting the parameters of the supervisor;
- import events from files of various formats.

Planning for supervised NBFIs. Depending on the supervision mode, category, type of NBFI, risk profile, based on the analysis of these parameters, the date of the appointment of the event and the planned period of the action, its type and name change.

View the history of changes in surveillance modes. Each change in the supervision regime is recorded, as a result of which the list of ongoing surveillance activities changes. As a result, a list is prepared with a change in the status of the surveillance regime by dates, regulatory document, type of facility, category and name of the surveillance regime.

Setting supervisor work parameters. The supervisor needs to be given special rights to export and import NBFIs and events. The supervisor should be familiar with the list of all NBFIs and supervisory activities, changes in the modes of supervision, to exclude subsequent errors.

Import events from files of various formats. The reports are being loaded, with their semantic characteristics, with information on the supervised NBFI, on the NBFI and its activities, separately on supervisory activities, on the history of changes in the supervisory regime for each of the NBFIs. Import is made from files of various formats.

C. Decision-maker

The following functions should be available to employees with the Decision-Maker role:

- decision support for planning activities in relation to NBFIs;
- viewing the list of supervisors and their NBFIs;
- generation, viewing, and printing of summary reports.

Decision support for planning activities in relation to NBFIs. Based on the results of previous events, the system, taking into account the supervision regime, allows the user to support decision-making on the appointment of events and analysis of their effectiveness.

View a list of supervisors and their designated NBFIs. You can view the main and reserve NBFIs to monitor the performance of their duties with the ability to select a supervisor from the list.

Formation, viewing and printing of a summary report. A report is generated for all responsible employees. The report, in particular, reflects past due events and unplanned events. In addition, a report is prepared on the planned and carried out events and a report on events, which reflects the events deleted or transferred by the supervisor.

IV. System Features Components

The main components of the developed system and their interaction are shown in "Fig. 3". A description of the components providing the implementation of the system functionality is given below.

A. Integration Module

The system interacts with existing NBFIs reporting registers through an integration module that implements the Enterprise Service Bus pattern. In addition to the event model, which causes the processing and transmission of data under a certain scenario (for example, the receipt of a new report, the registration of a new NBFIs), a federal model is used in which the data is not duplicated, but requested if necessary.

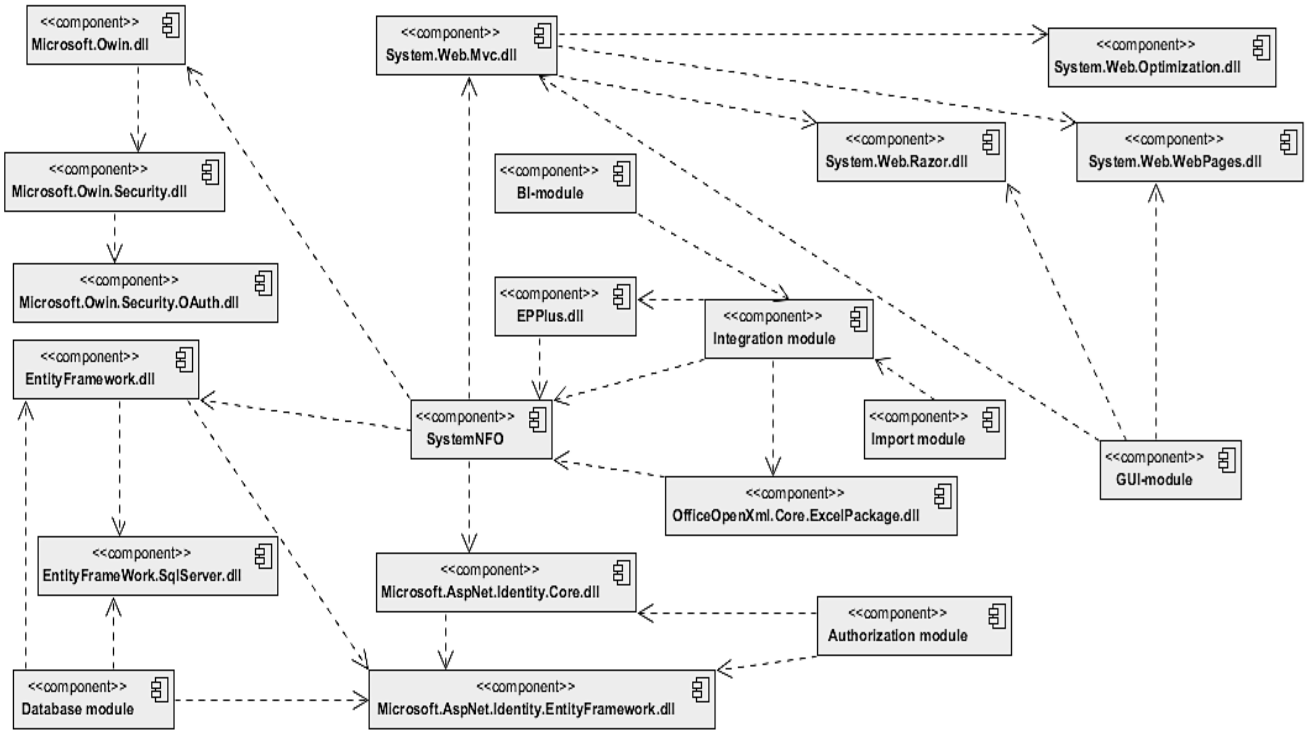

Fig. 3. System components.

B. *BI-module*

The analytics module provides the ability to generate both predefined reporting documents and custom ones using the wizard. Reports are built with logging for time periods (month, quarter, half-year, year), for NBFIs, for the supervised regions.

C. *Database Module*

The database module uses the Entity Framework. An entity is a set of data associated with a particular object. The interaction with the database is carried out on the basis of the Code First principle, a class is created for the data model that will be stored in the database, and then the Entity Framework generates the database and its tables using this model.

D. *Import Module*

The import module is designed to download reports, read them and write to the system database. The import module allows you to configure import rules in Wizard mode. Import allows you to implement a system where activities were previously conducted using other software.

E. *Authorization Module*

The authorization module through role-based access allows you to implement the necessary users' access to the system, user personal data is encrypted using built-in protection mechanisms. Users in the system can have 3 roles: system administrator, supervisor, decision-maker.

F. *GUI-module*

The user interface module is built primarily from the components Mvc, Razor, and WebPages. In the view, the capabilities of Razor and HTML are used to build a user interface.

G. *Other Components*

Owin is used to abstract the web server and components of the framework. ASP.NET Identity in the system is used to control user access to the application. The Entity Framework in the system is used to abstract from the database itself and work with data regardless of the type of storage. MVC is used to separate application data, user interface, and control logic. Razor is used to explicitly define server blocks of code in HTML. The WebPages component is used to build presentation pages for the user, and the Optimization component is used to optimize internal processes. The main component of SystemNFO has EPPlus and OfficeOpenXml components at its disposal. The EPPlus component is needed to open an Excel file and save the reporting data in the correct format from the database of NBFIs and supervisory activities. The OfficeOpenXml component is needed to read and write Excel files.

V. IMPLEMENTATION

The system provides for three user roles: system administrator, supervisor, decision-maker. To work in the system, an employee must log in to it by entering a username and password. Depending on the role, the user will have access to various functions and features described below.

A decision support system has been developed using a client-server architecture to plan events over NBFIs, as well as generate reports on NBFIs and events. The system is implemented in C # using the Entity Framework, the MVC design pattern, and SQL Server database management system.

System interface in supervisor mode shown in "Fig. 4".

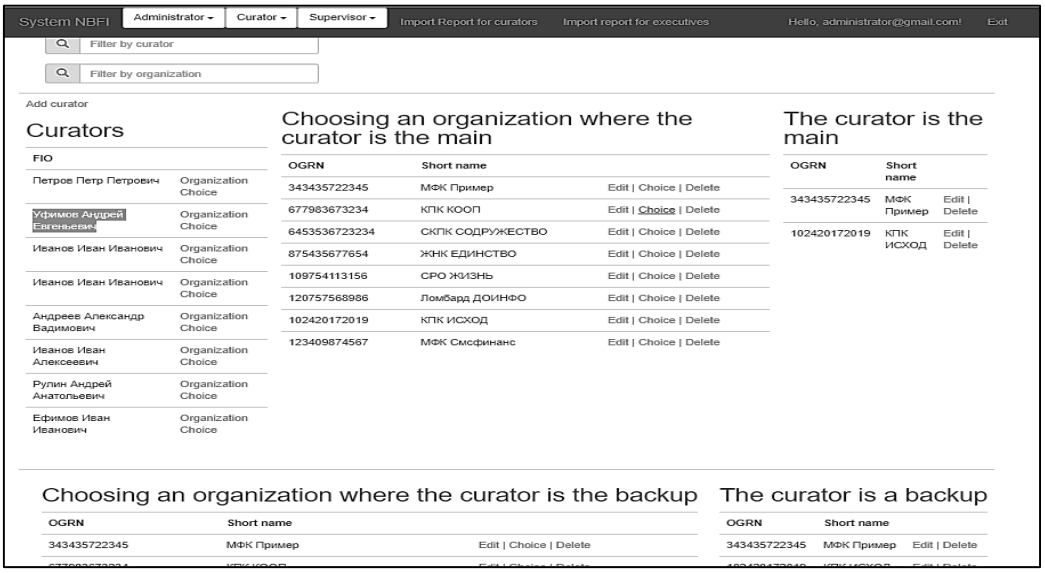

Fig. 4. Decision support in the appointment of activities.

The lower part of the screens shows the activities carried out in relation to NBFIs, which are divided into: current, past and deleted. Functions for manual adjustment of the composition of events are available, i.e. an event can be added, deleted or edited. At the same time, all activities carried out on the composition of the activities are recorded, which will allow adaptation.

"Fig. 5" shows the system interface when appointing supervisors to supervise NBFIs. When appointing supervisors, their previous experience in working with supervised NBFIs and the achieved KPIs are analyzed.

The system is intended for regulators who keep records of supervisory measures in relation to NBFIs and carry out control over the implementation of measures on time.

VI. Conclusion

Thus, this paper presents a decision support system to plan supervisory activities over NBFIs in accordance with the principle of risk-based supervision.

A decision support system has been developed to implements the following functions:

- decision support for the planning of oversight activities;
- planning of oversight activities over NBFIs;
- monitoring the implementation of activities;
- distribution of tasks between employees based on their workload, previous experience and KPI;
- generation of reports on NBFIs and events.

The system increases the effectiveness of the regulator in terms of control and supervision of both individual NBFIs and the market as a whole. The system tracks and prevents violations, as well as adjusts the correctness of actions in relation to NBFIs. The system plans supervisory activities, changes the modes of supervision and warns about the end of the deadline.

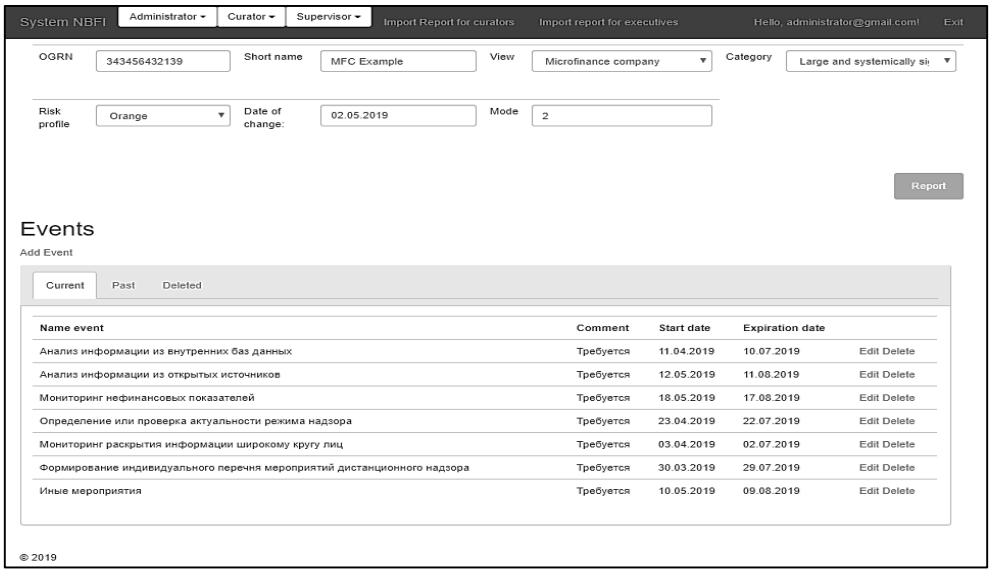

Fig. 5. NFBIs appointment for supervisiors.

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