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**AUTOMATED VACATION SCHEDULING SUBSYSTEM FOR
DISTRIBUTED CRM SYSTEMS**

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Annotation. This paper describes a method for generating vacation schedules in distributed CRM systems. Salesforce platform was chosen as the CRM system. The structure of the subsystem for automatic generation of vacation schedules is designed for the selected CRM system. Based on the requirements, input and output data, was proposed information and algorithmic support with the use of fuzzy logic apparatus and neural networks.

Keywords. CRM, Salesforce, neural network, fuzzy logic.

Introduction. Customer Relationship Management (CRM) software [1] was announced as an innovative way to help businesses manage their business processes and customer relationships better and more efficiently than using other means.

One of today's popular CRM systems is Salesforce, which has a cloud-based database management system. The system has a platform for developing cloud applications - Force.com [2]. The user accesses the programs via the Internet as a utility, not as a piece of software running on a desktop or in a server room. This model is already widespread for the development of email and photo applications as well as business applications.

One of the actual tasks for CRM systems is the task of automatically generating employee vacation schedules. For small businesses, the human resource department (HR) can independently form a vacation schedule based on the employee's wishes. But in large enterprises with hundreds of employees, for the HR department it is hard to form a schedule of vacations, so it is decided to automate this process.

The aim. The purpose of the work is to design and implement a subsystem that will control the process of generating employee vacations in automatic mode [3, p. 16].

To-do list:

1. Determine the algorithm of subsystem operation.
2. Design the structure of the vacation management subsystem by using Salesforce platform capabilities.
3. Analyze and determine the main input and output parameters of each block of the subsystem.
4. Define algorithmic and propose mathematical and software for each block.

Algorithm of subsystem operation

The algorithm for automatically generating vacation schedules is as follows:

1. Depending on the history of approvals for previous years, all employees are offered a range of vacation dates at the beginning of the new calendar year. The vacation is taken completely, the splitting into several parts is not provided.
2. After that, each employee has the opportunity to edit the vacation dates. A new vacation request of the employee, which comes to the HR department where it is being reviewed for approval or rejection in the new period.
3. The following is an analysis of current projects and the level of engagement they have with an employee who wants to edit vacation dates. In addition, already approved vacation requests during the same period are analyzed.
4. Based on the history of approved employee vacation requests, the history of approved employee statements with the same priority, an indicator of the possibility of approving the desired period is calculated.
5. Based on the totality of the indicators described, a decision is made to approve or reject the new request for vacation.

Designing the structure of the vacation management subsystem

To implement the task of automatically generated vacation schedules, is proposed a subsystem based on the Salesforce platform (Fig. 1), consisting of the following blocks:

- the block «vacation period analysis (artificial neural network)», where artificial neural network (ANN), based on dates, analyzes the popularity of this period;
- the block «identify employee priority» defines the hierarchy of the employee's role;
- the block «vacation created analysis» unit checks how many requests has been already generated, taking into account the workload of the staff;
- the «workload of employees» analyzes the status of projects, taking into account the hierarchy of roles of employees and analysis of the formed holidays;
- the block «vacation permit analysis (fuzzy neural network)» generates on the basis of all submitted data the result of the vacation request.

The main feature of the database (DB) is object-oriented. And so instead of the standard definitions of table and row, the concept of object and record is used in the Salesforce platform. In Fig. 2 shows the generated database.

The blocks «identify employee priority», «workload of employees» and «Vacation created analysis» in terms of implementation are a set of procedures and functions for calculating specific metrics. The results of these blocks are numerical parameters that fall into the block «vacation permit analysis».

The input parameters of the vacation period block are:

- Employee ID that will allow you to determine the history of positions and priorities from the beginning of employment.
- History of approved requests.
- A history of approved requests of employees with a similar priority.

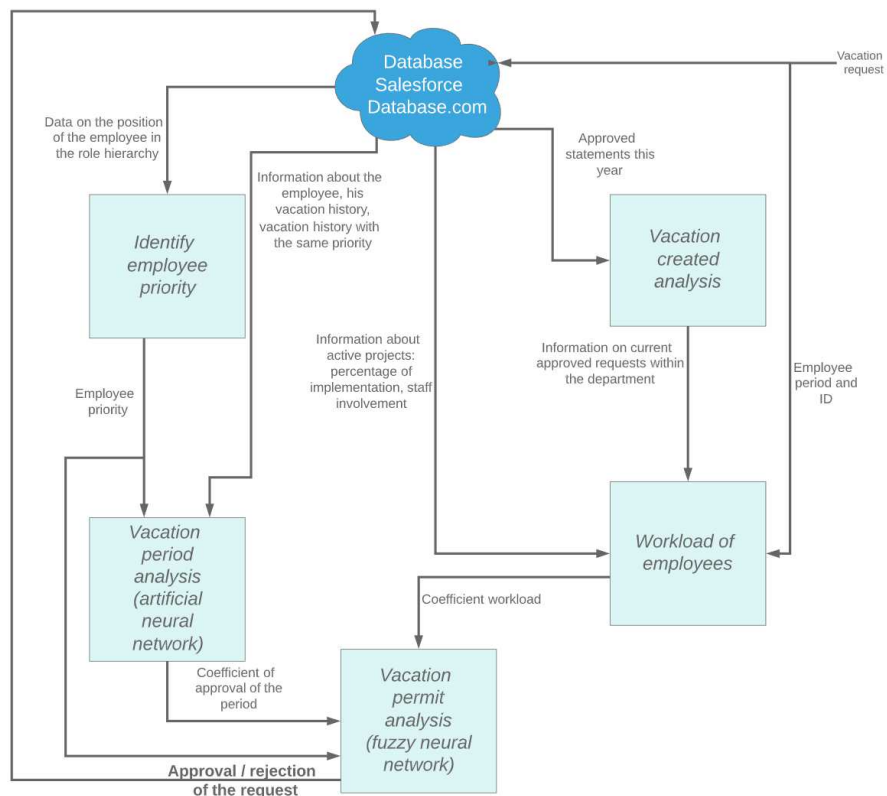


Fig. 1. The structure of the Salesforce vacation management subsystem



Fig. 2. Database structure on the Salesforce platform

For the implementation of this block it is proposed to use artificial neural network of back propagation [4, p. 4], at the output of which will be the coefficient of possibility of obtaining a positive decision about the new period (Fig. 3).

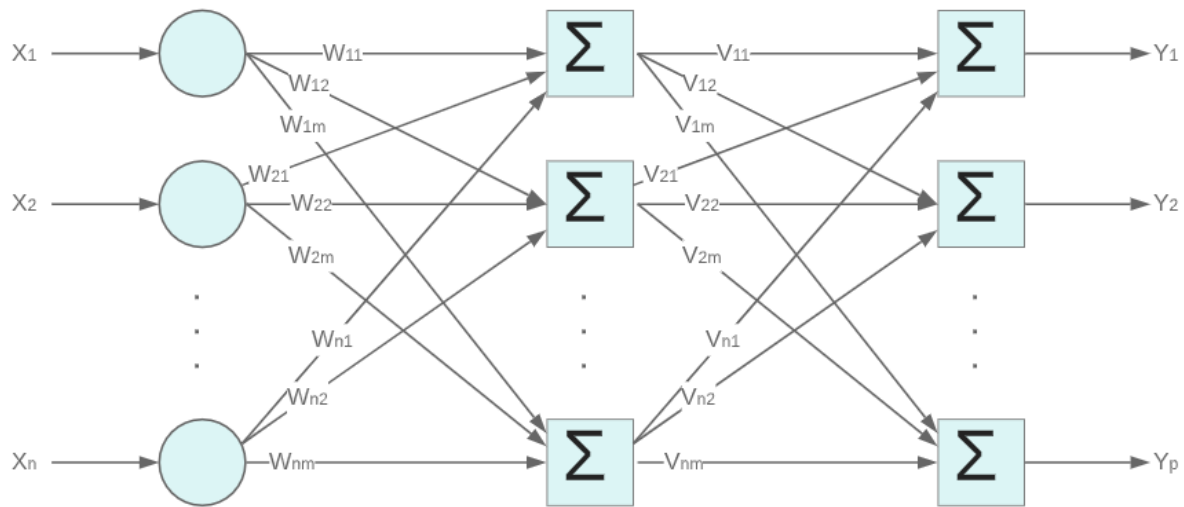


Fig. 3. General view of artificial neural network back propagation

Input Layer - contains date ranges, the number of employees receiving leave during this time, and their priorities.

The following are computing and analyzing layers. The number of neurons in the hidden layers, as well as the number of hidden layers is determined on the basis of numerous experiments.

Neural network output - A numerical parameter in the range from 0 to 100.

Since large enterprises need to analyze a great deal of information and the decision is made with a certain probability, one of the fuzzy neural networks, namely ANFIS [5, p. 1447], which is an adaptive neural network of fuzzy, is used to construct the vacation permit analysis unit. Output using the Takagi-Sugeno algorithm with direct signal propagation. This approach will allow you to obtain a universal high-performance automated estimator.

Let's take a closer look at the network model.

x_1 , x_2 and x_3 input variables are managed variables that make up the input layer of the network.

The first layer determines the fuzzy terms of the input parameters. The outputs of the nodes of this layer represent the values of the membership function at the specific values of the inputs $\mu_i(x_j)$.

The second layer defines the fuzzy rules. This layer is not adaptable. Each node in this layer corresponds to one uncertain rule. The node of the second layer is connected to those nodes of the first layer that form the prerequisites of the corresponding rule. The outputs of the node ω_i are the degree of execution of the rule, which is calculated as the product of the input signals.

The third layer normalizes the implementation of the rules. Non-adaptive nodes in this layer calculate the relative weight of the fuzzy rule.

The fourth layer determines the contribution of each fuzzy rule to the network output. The fourth layer node calculates the contribution of fuzzy rule v_i to the network output.

The fifth layer forms the control signal.

The structure of the described network is shown in Fig. 4.

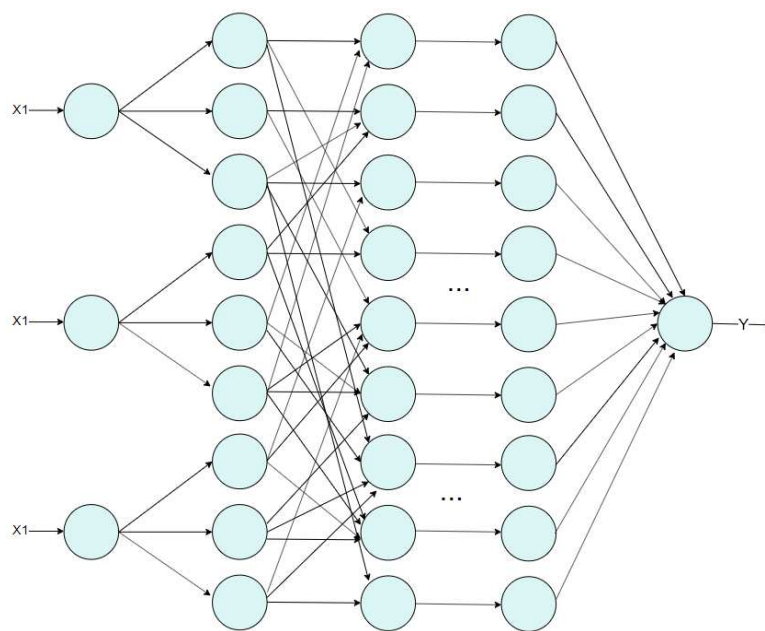


Fig. 4. ANFIS network structure for vacation approval analysis unit

The following factors influence the decision to approve a vacation request:

1. *Employee workload* in current affairs (projects, various types of robots), percentage of completion of certain types of robots, deadlines, role of employee in types of robots, etc. In addition, this option affects the possibility of approving or rejecting the requests in cases where the current conditions are the same. For

example, a request may be approved if the vacation period intersects with already approved vacations of not more than a day / two (or at the discretion of management).

2. *Employee priority*. An employee with a lower priority is most likely to be denied vacation with concurrent vacation time and equal load in current affairs with management or a higher priority employee.

3. *The popularity of the period*. Based on the approved requests of the previous years, the period when employees are most actively taking leave is determined. This allows employees to distribute vacation time across the department or across the enterprise more evenly. This parameter is the output of ANN in block «vacation period analysis (artificial neural network)».

The first and second factors are calculated algorithmically on the basis of personnel database data.

In the table. 1 formed rule base (RB) for the algorithm to determine whether an employee will go on vacation.

Table 1

A rule base for a fuzzy neural network

Employee priority	Employee workload	The popularity of the period	Result
low	low	low	yes
low	low	medium	yes
low	low	high	yes
low	medium	low	yes
low	medium	medium	change of
low	medium	high	change of
low	high	low	no
low	high	medium	no
low	high	high	no
medium	low	low	yes
medium	low	medium	yes

medium	low	high	yes
medium	medium	low	yes
medium	medium	medium	yes
medium	medium	high	change of
medium	high	low	change of
medium	high	medium	no
medium	high	high	no
High	low	low	yes
high	low	medium	yes
high	low	high	yes
high	medium	low	yes
high	medium	medium	yes
high	medium	high	yes
high	high	low	change of
high	high	medium	change of
high	high	high	no

To assign a qualitative value to a quantitative one, we used a conditional scale for each of the input parameters. For priority it is a scale from 0 to 10, where 0-3 is low priority, 4-7 is medium, 8-10 is high. Similarly for the other two parameters, however, the scale range is accepted from 0 to 100. The table uses all possible combinations of input parameter ranges.

Matlab was used to test the selected ANNs [6].

The Salesforce platform uses its own Salesforce Einstein artificial intelligence platform to implement this subsystem. The Bulk API is used to access the Salesforce Einstein API, as such a web service can process big data, unlike the REST API. Also in Salesforce settings you need to specify an endpoint <https://api.einstein.ai>, since Salesforce does not allow calls to network addresses that are not specified in the platform settings.

Conclusion. The features of the algorithm of automatic generation of vacation schedules were considered in the work, subsystem design was performed, the input

and output parameters of each subsystems block were analyzed and their implementation was proposed by using the apparatus of fuzzy logic and neural networks. Database and a rule base have also been created to implement the subsystem. The novelty of the work is the implementation of blocks of the projected subsystem as additional services for the distributed Salesforce CRM system by using artificial intelligence Salesforce Einstein.

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