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Fuzzy System Synthesis And Adjustment Fuzzy To Evaluate The Effectiveness Of Information Exchange Management Within Corporate Portal Network

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K E Y W O R D S: corporate portal network, the effectiveness of information exchange management, integral index, fuzzy system.

ABSTRACT: An integrated indicator is proposed in order to assess the effectiveness of information exchange management within a corporate portal network. The classification of corporate portal network state is presented. A fuzzy system is used in order to determine an integral index, which is based on the algorithm of zero order Sugeno fuzzy inference. The input variables of a fuzzy system are the correct service probability and an average response time, an output value is presented by the integral index value. Fuzzy rules are proposed which establish the relationship between the values of input variables and the result of fuzzy inference. The degree of compliance between input variables and fuzzy sets is defined by piecewise continuous membership functions. The operation of a system is presented by a consistent implementation of fuzzy inference main stages: fuzzification, aggregation and defuzzification. An algorithm is developed for the setting of fuzzy system parameters, based on the use of an expert survey and the least square method. The study results may be used to assess the effectiveness of information exchange management in a corporate portal network.

Introduction

Nowadays corporate portals become a universal tool for information exchange with employees, partners and customers in various fields of activity: in science and education, industry and construction, trade and commerce, arts and sports, medicine, law, in a variety of public and private services [1]. At that same time the amount of organizations interested in the integration of its online resources in a portal network increases rapidly each year. The obtaining of information in such networks should be organized through open data transfer channels with the provision of the required quality of user service and the protection against an unauthorized access. Nowadays, organizations portals have a different structure and are implemented on different hardware and software platforms using different, sometimes incompatible, technologies [2]. In this regard, an actual trend is the creation of tools which allow to ensure a secured network-to-network information interaction of corporate institutions. A series of scientific studies is performed within this trend [3-8]. This article is devoted to the problem solution concerning the development of a system in order to assess the effectiveness of information exchange management among corporate portals.

Private performance indicators

To evaluate the effectiveness of a corporate portal network information exchange management it is proposed to use the indicators P (correct service probability) and T (an average response time). The first value characterizes the ability of a system to ensure information security in a tested network, and is calculated as follows:

$$P = \frac{N_1 + N_2}{N},$$

where N_1 is the number of requests calculated during a predetermined time interval Δt, the treatment of which allows to obtain a correct access permissions to the appropriate resources; N_2 – the number of requests calculated during calculated during a predetermined time interval Δt, the treatment of which allows to obtain a correct access denial to the appropriate resources; N - the total number of requests received by an access server during a predetermined time interval Δt.

T value indicates the speed a user's response obtaining to a request, i.e. it is a management system performance value concerning the information exchange of a corporate portal network. In order to determine this parameter one may use the following expression:

$$T = \frac{1}{N_P} \sum_{i=1}^{N_P} T_i ,$$

where T_i is the response time for the treated inquiry number i, measured from the moment of a request sending by a user request until the moment of access obtaining to the corresponding resource or this access denial; N_P – the number of requests processed during a predetermined time interval Δt .

The above presented values P and T are private indicators that characterize the information security and productivity, ensured by the functioning in the corporate portal network of information exchange management system. In order to evaluate the effectiveness of this system use it is advisable to use an integral index, defined on the basis of the obtained private indicators.

Integral efficiency index

The evaluation of information exchange effectiveness in a corporate portal network should be based on the calculation of an integral index, the value of which is directly related to a tested network state.

Corporate portal network status is determined by the levels of information security and performance provided in it, which, in its turn, are characterized by the corresponding values of the individual probabilistic and time parameters.

Table 1 proposes the classification of corporate portal network states, designated as S1, S2, S3 and S4. The higher the status of a corporate portal network, the more effective it implements the information exchange management. S1 is the highest state, characterized by the sufficient levels of data security and performance. If a network has an insufficient level of information security and performance, it is in the lowest S4 state. The classification of network states is performed dependent on the values of particular indicators P and T.

Table 1. Corporate portal network state classification

Designation of states	Characteristic of states	
S1	Sufficient level of data security Sufficient level of performance	High value of P indicator Low value of T indicator
S2	Sufficient level of data security Insufficient level of performance	High value of P indicator High value of T indicator
S3	Insufficient level of data security Sufficient level of performance	Low value of P indicator Low value of T indicator
S4	Insufficient level of data security Insufficient level of performance	Low value of P indicator High value of T indicator

The levels of information security and performance is difficult to define by strict numerical criteria, so these levels are associated with some fuzzy sets: "High (low) value of the index P" and "High (low) value of the index T". In this case, the obtaining of a desired integral index numerical values is possible on the basis of a fuzzy inference, successfully used to solve various problems in the field of informational communications [9-14]. To evaluate the effectiveness of information exchange management by a corporate portal network a fuzzy system was synthesized. The condition of a tested network is characterized by the output value S, which depends on the probability of correct service P and response time T.

Studies showed that to determine the status of corporate portal network it is advisable to use a model based on zero-order Sugeno fuzzy inference algorithm, according to which the fuzzy rule base is as follows:

$$If\ \left(P = \alpha_P\right)\ u\ \left(T = \alpha_T\right),\ then\ S = Y_1,$$
$$If\ \left(P = \alpha_P\right)\ u\ \left(T = \beta_T\right),\ then\ S = Y_2,$$
$$If\ \left(P = \beta_P\right)\ and\ \left(T = \alpha_T\right),\ then\ S = Y_3,$$
$$If\ \left(P = \beta_P\right)\ and\ \left(T = \beta_T\right),\ then\ S = Y_4,$$

where α_P is the term «High value of P indicator»;

β_P is the term «Low value of P indicator»;

α_T is the term «Low value of T indicator»;

β_T is the term «High value of T indicator»;

$Y_1 = 1$, $Y_2 = 2$, $Y_3 = 3$ и $Y_4 = 4$ – the values of individual conclusions concerning fuzzy rules.

The degree of P and T value belonging to some fuzzy sets is defined by the values of corresponding piecewise continuous membership functions $\mu_\alpha(P)$, $\mu_\beta(P)$, $\eta_\alpha(T)$ and $\eta_\beta(T)$ (fig. 1 and fig. 2) with the parameters $p_{\alpha 0}$, $p_{\alpha 1}$, $p_{\beta 0}$, $p_{\beta 1}$, $t_{\alpha 0}$, $t_{\alpha 1}$, $t_{\beta 0}$ and $t_{\beta 1}$.

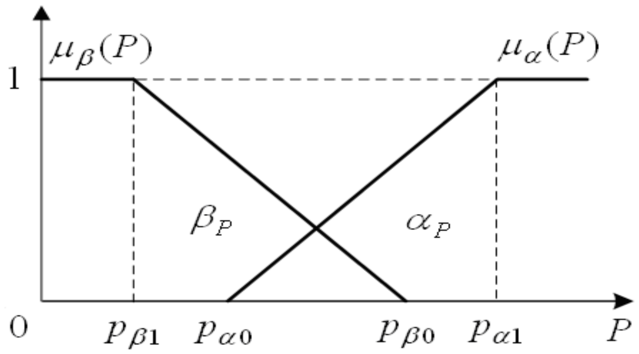

Figure. 1. Membership functions $\mu_\alpha(P)$ and $\mu_\beta(P)$

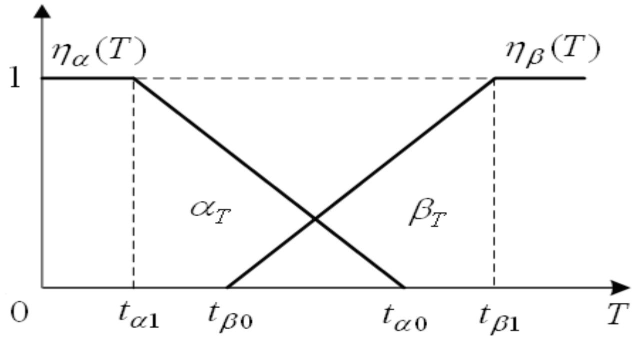

Figure 2. Membership functions $\eta_\alpha(T)$ and $\eta_\beta(T)$

According to the used algorithm of fuzzy inference fuzzification, aggregation and defuzzification procedures are performed sequentially [15] and then the value of the desired indicator S is calculated.

The block diagram of a fuzzy system used to assess the effectiveness of information exchange management in a corporate portal network, is shown on Fig. 3.

Having calculated the value of the output indicator S, you may determine the status of a corporate portal network according to Table 2. The criterion of information exchange management effectiveness in a corporate portal network is the maximization the integral index: $S \rightarrow \max$.

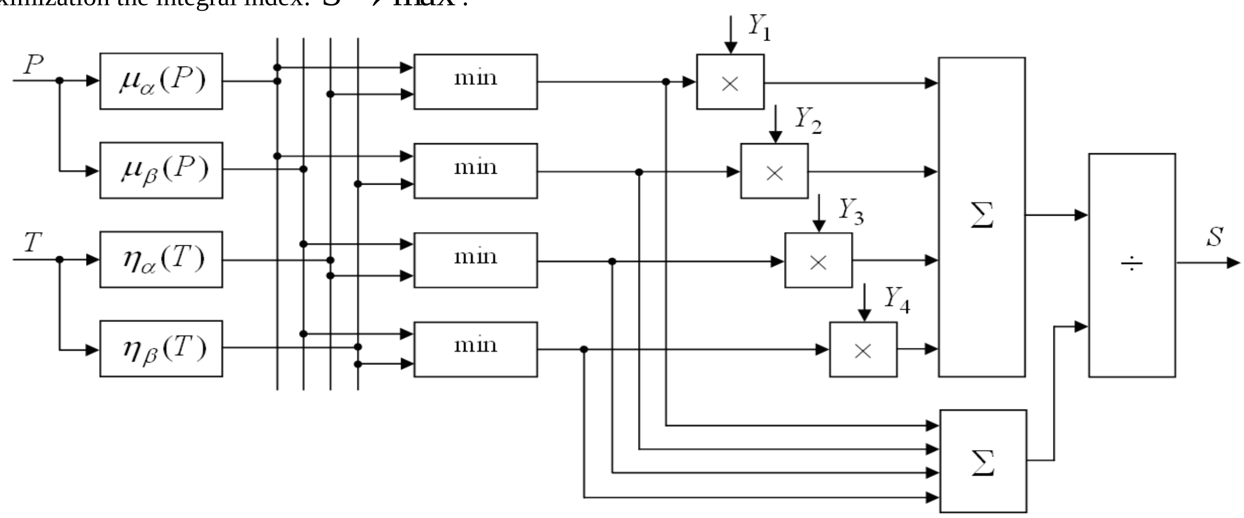

Figure 3. Fuzzy system structural scheme

Table 2. Criteria for corporate portal network state

State	Criterion
S1	$S < 1{,}5$
S2	$2{,}5 > S \geq 1{,}5$
S3	$3{,}5 > S \geq 2{,}5$
S4	$S \geq 3{,}5$

In order to ensure an adequate assessment of information exchange management effectiveness in a corporate portal network based on the proposed fuzzy system it is necessary to configure it, choosing the correct parameter values of membership functions, i.e. the values $p_{\alpha 0}$, $p_{\alpha 1}$, $p_{\beta 0}$, $p_{\beta 1}$, $t_{\alpha 0}$, $t_{\alpha 1}$, $t_{\beta 0}$ and $t_{\beta 1}$. The configuration of a fuzzy system specified parameters is reasonable to carry out using an expert survey.

Fuzzy system parameter configuration

In order to configure the parameters of a fuzzy system it is proposed to use the statistical processing of data obtained as the result of an expert survey.

K of experiments is performed in a studied network for this. Each experiment number k ($k = \overline{1, K}$) lasts during a predetermined time interval Δt. During each k experiment the services of the network under study are used actively by a group of experts consisting of M_0 men. At the end of the experiment N, N_P, N_1, N_2 and T_i ($i = \overline{1, N_P}$) values are determined, on the basis of which the values of $P = p_k$ and $T = t_k$ characteristics are calculated according to the formula (1) and (2). In order to provide a wide range of P and T characteristics values, by changing the test load different experiments create various conditions of a network operation.

At the end of each experiment a survey of all the experts is carried out concerning their opinions about information security level (sufficient or insufficient) and network performance.

After the completion of all experiments the evaluations of membership functions are calculated for each value p_k and t_k:

$$\mu^*_{\alpha k} = \frac{M^+_p(p_k)}{M_0};$$

$$\mu^*_{\beta k} = \frac{M^-_p(p_k)}{M_0};$$

$$\eta^*_{\alpha k} = \frac{M^+_t(t_k)}{M_0};$$

$$\eta^*_{\beta k} = \frac{M^-_t(t_k)}{M_0};$$

where $M^+_p(p_k)$ - the number of experts who believe that at $P = p_k$ the information security of a network corresponds to a sufficient level;

$M^-_p(p_k)$ - the number of experts who believe that at $P = p_k$ the information security of a network corresponds to an insufficient level;

$M^+_t(t_k)$ – the number of experts who believe that at $P = t_k$ the performance of a network corresponds to a sufficient level;

$M^-_t(t_k)$ – the number of experts who believe that at $P = t_k$ the performance of a network corresponds to an insufficient level.

Then from the set $\overset{*}{\mu}_{\alpha} = \left\{\overset{*}{\mu}_{\alpha 1}, \overset{*}{\mu}_{\alpha 2}, ..., \overset{*}{\mu}_{\alpha k}, ..., \overset{*}{\mu}_{\alpha K}\right\}$ the set $\hat{\mu}_{\alpha} = \left\{\hat{\mu}_{\alpha 1}, \hat{\mu}_{\alpha 2}, ..., \hat{\mu}_{\alpha l}, ..., \hat{\mu}_{\alpha L_1}\right\}$ is developed by the choice of estimates, the values of which correspond to the following condition: $0{,}1 \le \overset{*}{\mu}_{\alpha k} \le 0{,}9$. Similarly the sets $\overset{*}{\mu}_{\beta} = \left\{\overset{*}{\mu}_{\beta 1}, \overset{*}{\mu}_{\beta 2}, ..., \overset{*}{\mu}_{\beta k}, ..., \overset{*}{\mu}_{\beta K}\right\}$, $\overset{*}{\eta}_{\alpha} = \left\{\overset{*}{\eta}_{\alpha 1}, \overset{*}{\eta}_{\alpha 2}, ..., \overset{*}{\eta}_{\alpha k}, ..., \overset{*}{\eta}_{\alpha K}\right\}$ and $\overset{*}{\eta}_{\beta} = \left\{\overset{*}{\eta}_{\beta 1}, \overset{*}{\eta}_{\beta 2}, ..., \overset{*}{\eta}_{\beta k}, ..., \overset{*}{\eta}_{\beta K}\right\}$ develop the sets $\hat{\mu}_{\beta} = \left\{\hat{\mu}_{\beta 1}, \hat{\mu}_{\beta 2}, ..., \hat{\mu}_{\beta l}, ..., \hat{\mu}_{\beta L_2}\right\}$, $\hat{\eta}_{\alpha} = \left\{\hat{\eta}_{\alpha 1}, \hat{\eta}_{\alpha 2}, ..., \hat{\eta}_{\alpha l}, ..., \hat{\eta}_{\alpha L_3}\right\}$ and $\hat{\eta}_{\beta} = \left\{\hat{\eta}_{\beta 1}, \hat{\eta}_{\beta 2}, ..., \hat{\eta}_{\beta l}, ..., \hat{\eta}_{\beta L_4}\right\}$ respectively, the elements of which have the values within the range from 0,1 to 0,9.

Then it is necessary to obtain the equations of lines $y_1(P) = a_1 P + b_1$, $y_2(P) = a_2 P + b_2$, $y_3(T) = a_3 T + b_3$ и $y_4(T) = a_4 T + b_4$, smoothing the values of the following set elements $\hat{\mu}_{\alpha}$, $\hat{\mu}_{\beta}$, $\hat{\eta}_{\alpha}$ и $\hat{\eta}_{\beta}$ respectively. The approximation of the membership function assessments is proposed to carry out using the least squares method [16], according to which the line coefficients are calculated according to the following formulas:

$$a_1 = \frac{L_1 \sum_{l=1}^{L_1} p_l \hat{\mu}_{\alpha l} - \sum_{l=1}^{L_1} p_l \sum_{l=1}^{L_1} \hat{\mu}_{\alpha l}}{L_1 \sum_{l=1}^{L_1} p_l^2 - \left(\sum_{l=1}^{L_1} p_l\right)^2},$$

$$b_1 = \frac{\sum_{l=1}^{L_1} \hat{\mu}_{\alpha l} - a_1 \sum_{l=1}^{L_1} p_l}{L_1},$$

$$a_2 = \frac{L_2 \sum_{l=1}^{L_2} p_l \hat{\mu}_{\beta l} - \sum_{l=1}^{L_2} p_l \sum_{l=1}^{L_2} \hat{\mu}_{\beta l}}{L_2 \sum_{l=1}^{L_2} p_l^2 - \left(\sum_{l=1}^{L_2} p_l\right)^2},$$

$$b_2 = \frac{\sum_{l=1}^{L_2} \hat{\mu}_{\beta l} - a_2 \sum_{l=1}^{L_2} p_l}{L_2},$$

$$a_3 = \frac{L_3 \sum_{l=1}^{L_3} p_l \hat{\eta}_{\alpha l} - \sum_{l=1}^{L_3} p_l \sum_{l=1}^{L_3} \hat{\eta}_{\alpha l}}{L_3 \sum_{l=1}^{L_3} p_l^2 - \left(\sum_{l=1}^{L_3} p_l\right)^2},$$

$$b_3 = \frac{\sum_{l=1}^{L_3} \hat{\eta}_{\alpha l} - a_3 \sum_{l=1}^{L_3} p_l}{L_3},$$

$$a_4 = \frac{L_4 \sum_{l=1}^{L_4} p_l \hat{\eta}_{\beta 1} - \sum_{l=1}^{L_4} p_l \sum_{l=1}^{L_4} \hat{\eta}_{\beta 1}}{L_4 \sum_{l=1}^{L_4} p_l^2 - \left(\sum_{l=1}^{L_4} p_l \right)^2},$$

$$b_4 = \frac{\sum_{l=1}^{L_4} \hat{\eta}_{\beta 1} - a_4 \sum_{l=1}^{L_4} p_l}{L_4}.$$

Having obtained the smoothing line coefficients a_1 and b_1, one may determine the necessary parameters $p_{\alpha 0}$ and $p_{\alpha 1}$ from the equations $a_1 p_{\alpha 0} + b_1 = 0$ and $a_1 p_{\alpha 1} + b_1 = 1$. Having solved the equation we obtain the following:

$$p_{\alpha 0} = -\frac{b_1}{a_1}, \quad p_{\alpha 1} = \frac{1 - b_1}{a_1}.$$

Similarly, the expressions are derived to determine the following parameters $p_{\beta 0}$, $p_{\beta 1}$, $t_{\alpha 0}$, $t_{\alpha 1}$, $t_{\beta 0}$ and $t_{\beta 1}$:

$$p_{\beta 0} = -\frac{b_2}{a_2}, \quad p_{\beta 1} = \frac{1 - b_2}{a_2},$$

$$t_{\alpha 0} = -\frac{b_3}{a_3}, \quad t_{\alpha 1} = \frac{1 - b_3}{a_3},$$

$$t_{\beta 0} = -\frac{b_4}{a_4}, \quad t_{\beta 1} = \frac{1 - b_4}{a_4}.$$

Conclusion

In order to evaluate the effectiveness of information exchange management in a corporate portal network an integral index was proposed characterizing the information security and performance provided in this network. In order to calculate this value a fuzzy system was synthesized based on the algorithm use of zero order Sugeno fuzzy inference. An algorithm of a fuzzy system parameters is developed, based on the use of an expert survey and the method of least squares. The criterion of information exchange management effectiveness in the system of a corporate portal network is the maximization of the proposed integral index. The results of the study may be used to assess the effectiveness of information exchange management in a corporate portal network.

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