ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

Grey System Theory Approach to Quality of Intranet

N. Slavek[1], D. Krmpotić[2], D. Blažević[3]

Associate Professor, Dept. of Software Engineering, Faculty of Electrical Engineering Osijek, Osijek, Croatia[1]

PG Student, Dept. of Computer Engineering and Automation, Faculty of Electrical Engineering Osijek, Osijek, Croatia[2]

Assistant professor, Dept. of Computer Engineering and Automation, Faculty of Electrical Engineering Osijek, Osijek, Croatia[3]

ABSTRACT: This work discussed the effectiveness of he Gray system theory to determine the Intranet quality. ISO 9126 [1] is used to define the Intranet quality factors and characteristics. The ranking of these factors and characteristics were used to determine the importance of this quality attributes. The Grey system provides multidisciplinary approaches for analysis and abstract modelling of systems for which the information is limited, incomplete and characterized by random uncertainty. The Grey relational analysis uses information from the Grey system to dynamically compare each characteristic quantitatively.

KEYWORDS: Grey system theory, Grey relational analysis, Intranet, Intranet quality.

I.INTRODUCTION

In this paper we investigate the effectiveness of the Grey system theory to determine the ranking of relative importance of Intranet quality factors and characteristics. The intranet emerged in the nineties as the application of internet technologies to internal business applications [2]. The number of intranet applications increases and software developers face a new set of quality requirements. More and more organizations from all sectors are attracted by the tremendous benefits of intranet applications: cost and time savings, increase of productivity, flexibility, open architecture, consistency, and removal of departmental boundaries [13]. The intranet technology is identical to that of the internet. Only in one way are the two different: private versus public usage [16]. While there is lot of similarities between them, they are really two different things. The internet is the global World Wide Web, while an intranet is a private internet operating within a company. One main difference is that users of an intranet can get on the internet, but due to protection measures like computer firewalls, global internet users cannot get onto the intranet unless they have access to it. An intranet can be run without an internet connection. From a management perspective, successful intranet application implies higher return on investment, low risk, shorter payback time, more business opportunities, and technology - enabled employees, and shorter development life - cycle [3]. In the wave of use of the intranet, there is an increasing need for quality management. The questions are [2]: can an intranet application be measured quantitatively? Can well-known software quality factors and characteristics be applied? The definition of quality is 'the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs' [10]. The quality is customer focused, the importance of software quality factors and characteristics of intranet application should be determined for different types of users: software system professionals, end-users, software developers, and end user management.

II. RELATED WORK

There has been little study of quality measurement for intranet applications. Welch, D. E [16] analyzed the intranets as the New Engine of Corporate Productivity. Hareton K. N. Leung [2] attempts to identify practical software metrics for intranet applications. From the results of a survey, the three key quality characteristics are identified; the reliability, functionality and efficiency. Schnaider, C. [13] analyzed the intranet architecture integrating information design with business planning.McCall, Richards, and Walters [12] propose factors and criteria for software quality. Liu, S., Lin, Y. [11] introduced the grey systems; its foundations, methodology and applications. Sifen, L., Forrest, J. [15] analyzed the current developing status on grey system theory. Chih-Hung T.,Ching-Liang C., Lieh C. [7] applayed grey relational

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

analysis to the Vendor Evaluational Model. Xiong, Y. [17] used the grey relational evaluation of financial situation of listed company.

III. ISO QUALITY FACTORS

McCall, Richards, and Walters [12] propose a useful categorization of factors and criteria that effect software quality. It is difficult and in some case impossible to develop measures of these quality factors. Many of the metrics can be measured only subjectively. ISO 9126 implified the model in an attempt to identify quality attributes for software. It is general and commonly accepted, being state-of-the art in product quality specification. The standard identifies six key quality attributes called quality factors listed in Table 1. The ISO quality factors do not necessarily lend themselves to direct measurement. However, they do provide a worthwhile basis for indirect measures and a checklist for assessing the quality of the system.

Table 1 *Quality attributes according to ISO 9126*

Functionality	The degree to which the software satisfies stated or implied needs.
Reliability	The capability of software to maintain its level of performance under given conditions for a given period of time.
Usability	Attributes that determine the effort needed for use and the assessment of such use by a set of users.
Efficiency	The relationship between the level of performance of the software and the amount of resources used under stated conditions.
Maintainability	The effort needed to make specified modifications.
Portability	The ability of the software to be transformed from one environment to another.

These quality factors can be further broken down into lower level quality characteristics, as shown in Fig. 1. The ISO 9126 model consists of 32 software quality characteristics.

Fig.1. Hierarchical view of ISO 9126 model

In this paper the ISO 9126 standard was chosen, and its software quality factors were used to identify key quality attributes of intranet application. The ranking of these factors and characteristics were used to determine the importance of this quality attributes. Their relevance was studied to identify the key quality characteristics.

This study will utilize the Grey relational analysis in the Grey theory to establish a complete and accurate evaluation model for selecting the Intranet with the best quality factors and characteristics.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

IV. GREY SYSTEM THEORY

The Grey system Theory was first proposed by Deng (1982) [2]. Grey system provides multidisciplinary approaches for analysis and abstract modelling of systems for which the information is limited, incomplete and characterised by random uncertainty. The term grey stands for abstracting poor, incomplete and uncertain, and is especially used in relation to the concept of information.

Grey system theory typically deals with systems, objects or concepts having well – defined external boundaries but internal uncertainty or vagueness, while conversely fuzzy mathematics deals with systems, objects or concepts having a well – defined internal characteristics but not well defined boundaries [11].

The information that is either incomplete or undetermined is called Grey. The Grey system provides multidisciplinary approaches for analysis and abstract modeling of systems for which the information is limited, incomplete and characterized by random uncertainty [15].

The aims of Grey system theory are to provide theory, techniques, notions and ideas for resolving (analyzing) latent and intricate systems, for example [8]:

1. To define and constitute Grey process replacing the stochastic process and to find the real time techniques instead of statistical model to deal with the grey process, in order to obtain an approach to modeling with few data, avoiding searching for data in quantities;
2. To develop a novel family of Grey forecasting methods instead of time series and regressive methods – all of these may be referred to as an approach to deal with grey processes;
3. To build a differential model – Grey model (GM) – by using the least 4 data to replace difference modeling in vast quantities of data;
4. To study the mechanism theory, including Grey sequence theory and Grey structure theory;
5. To establish a non – function model instead of regressive analyzing;
6. To study feeling and emotion functions and fields with whitening functions;
7. Based on Grey relations, Grey elements and Grey numbers to be used to study Grey mathematics instead of classical mathematics study;
8. To turn the disorderly raw data into a more regular series by Grey generating techniques for the benefit of modeling instead of modeling with original data;
9. To develop novel control techniques e. g. the Grey forecasting control replacing classical control which is referred to as afterward control, also relational control, generating control and programming control

Main contributions to Grey System Theory came from: Grey Systems and control, Grey Relational Analysis (GRA), and Gray Modeling (GM). The GRA uses information from the Grey System to dynamically compare each factor quantitatively. Approach is based on the level of similarity and variability among all factors to establish their relation. GM is developed based on requirements for system modeling with limited data.

The 1st order one variable Grey Model denoted as GM (1, 1) is especially applicable for forecasting. GM (1, 1) model uses the variation within the system to find out the relations between sequential data and then establish the prediction model [15].

The three terms that are typical symbols and features for Grey System are [7]:
a) The Grey number in Grey system is a number with less complete information
b) The Grey element represents an element with incomplete information.
c) The Grey relation is the relation with incomplete information.

There are several aspects for the theory of Grey system [14]:

1. Grey generation: This is data processing to supplement information. It is aimed to process those complicate and tedious data to gain a clear rule, which is the whitening of a sequence of numbers. The expected goal for each factor is determined based on the principle of data processing, described as follows:

I) If the expectancy is the bigger- the-better, than it can be expressed by formula (2).
II) If the expectancy is smaller- the- better, than it can be expressed by formula (3)

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

III) If the expectancy is nominal-the best, and when the targeted value is: $X_0 : (X_{ij})_{\max}$, $X_0 : (X_{ij})_{\min}$, than it can be expressed by formula (4).

2. Grey modeling: The modeling is performed in order to establish a set of Grey variation equations and Grey differential equations, which is called the whitening of the model. This is done by step 1 to establish a set of Grey variation equations and Grey differential equations. The Grey model is denoted as GM (*n*, *h*), which is a *n*-th order differential equation of *h* variables. This Grey differential equitation is used for infinite information. Most of the previous researchers have focused on GM (1, 1) models because of its computational efficiency. GM (1, 1) model have time – varying coefficients. It means that the model is renewed as the new data become available to the prediction model. A Grey differential equation having *N* variables is called GM (1, N).

3. Grey prediction: By using the Grey model to conduct a qualitative prediction, this is called the whitening of development. Grey models predict the future values of a time series based on a set of the most recent data.

4. Grey decision: A decision is made under imperfect countermeasure and unclear situation, which is called the whitening of status. It is primarily concerned with the Grey strategy of situation, Grey group decision making and Grey programming [5 Deng]. Grey strategy of situation deals with the strategy – making based on multi objects which are contradictory in the ordinary way. Important is to make a satisfactory strategy by means of effect measure maps, which transfer the disconformities samples resulting from different objects into identical scales.

5. Grey relational analysis (GRA): Quantify all influences of various factors and their relation, which is called the whitening of factor relation. It uses information from the Grey system to dynamically compare each factor quantitatively, based on the level of similarity and variability among factors to establish their relation. GRA analyze the relational grade for discrete sequences.
6. Grey control: Work on the data of system behavior and look for any rules of behavior development to predict future behavior. The predicted value can be fed back into the system in order to enable system control.

This study will adopt above mentioned research steps to develop an influence factors evaluation model based on GRA, and apply to influence factors evaluation and selection. The Grey relational analysis uses information from the Grey system to dynamically compare each factor quantitatively.

V. GRAY RELATIONAL ANALYSIS

Let the number of the listed software project is *m*, and the number of the influence factors is *n*. Then an *m* x *n* value matrix (calling eingenvalue matrix) is set up [17].

$$\mathrm{X} = \begin{bmatrix} x_1(1), x_1(2), \ldots . x_1(n) \\ x_2(1), x_2(2), \ldots x_2(n) \\ \ldots . \\ \ldots . \\ x_m(1), x_m(2), \ldots x_m(n) \end{bmatrix} \tag{1}$$

In formula (1), $x_i(k)$ means the value of the number *i* listed project and the number *k* influence factors.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

$x_0(k)$ denotes the element of the referential series for attribute *k*, $x_i(k)$ denotes the element of the compared series for attribute *k*.

Usually, three kinds of influence factors are included, they are:

1. Benefit – type factor (the bigger the better),
2. Defect – type (the smaller the better)
3. Medium – type, or nominal-the-best (the nearer to a certain standard value the better).

It is difficult to compare between different kinds of factors because they exert a different influence.
Therefore, the standardized transformation to these factors must be done. Three formulas can be used [7]:

$$x_i(k) = \left[x_i(k) - \min x_i(k)\right] / \left[\max x_i(k) - \min x_i(k)\right] \tag{2}$$

The first standardized formula is suitable for the benefit – type factor.

$$x_i(k) = \left[\max x_i(k) - x_i(k)\right] / \left[\max x_i(k) - \min x_i(k)\right] \tag{3}$$

The second standardized formula is suitable for defect –type factor.

$$x_i(k) = 1 - \left|x_i(k) - u_i\right| / \left|\max x_i(k) - u_i\right| \tag{4}$$

The third standardized formula is suitable for the medium – type factor.

The Calculation of the Grey Relational Grade

The grey relation grade represents the correlation between two series. It can be calculated by steps as follows:

a) The absolute difference of the compared series and the referential series should be obtained by using the following formula [17]:

$$\Delta x_i(k) = \left|x_0(k) - x_i(k)\right|, \tag{5}$$

and the maximum and the minimum difference should be find out.

b) The distinguishing coefficient *p* is between 0 and 1. Generally, the distinguishing coefficient *p* is set to 0.5.

c) Calculation of the relational coefficient and relational degree by (6) as follows:

In Grey relational analysis, Grey relational coefficient ξ can be expressed as follows:

$$\xi_i(k) = (\Delta \min + p\Delta \max) / (\Delta x_i(k) + p\Delta \max) \tag{6}$$

and then the relation grade follows as:

$$r_i = \sum \left[w(k)\xi(k)\right] \tag{7}$$

In equation (7), ξ is the Grey relational coefficient, *w (k)* is the proportion of the number *k* influence factor to the total influence indicators. The sum of *w (k)* is 100%. The result obtained when using equation (6) can be used to measure the quality of the listed software projects.

The generation of Grey relation is shown in Figure 2.

Pogreška! Knjižna oznaka nije definirana.

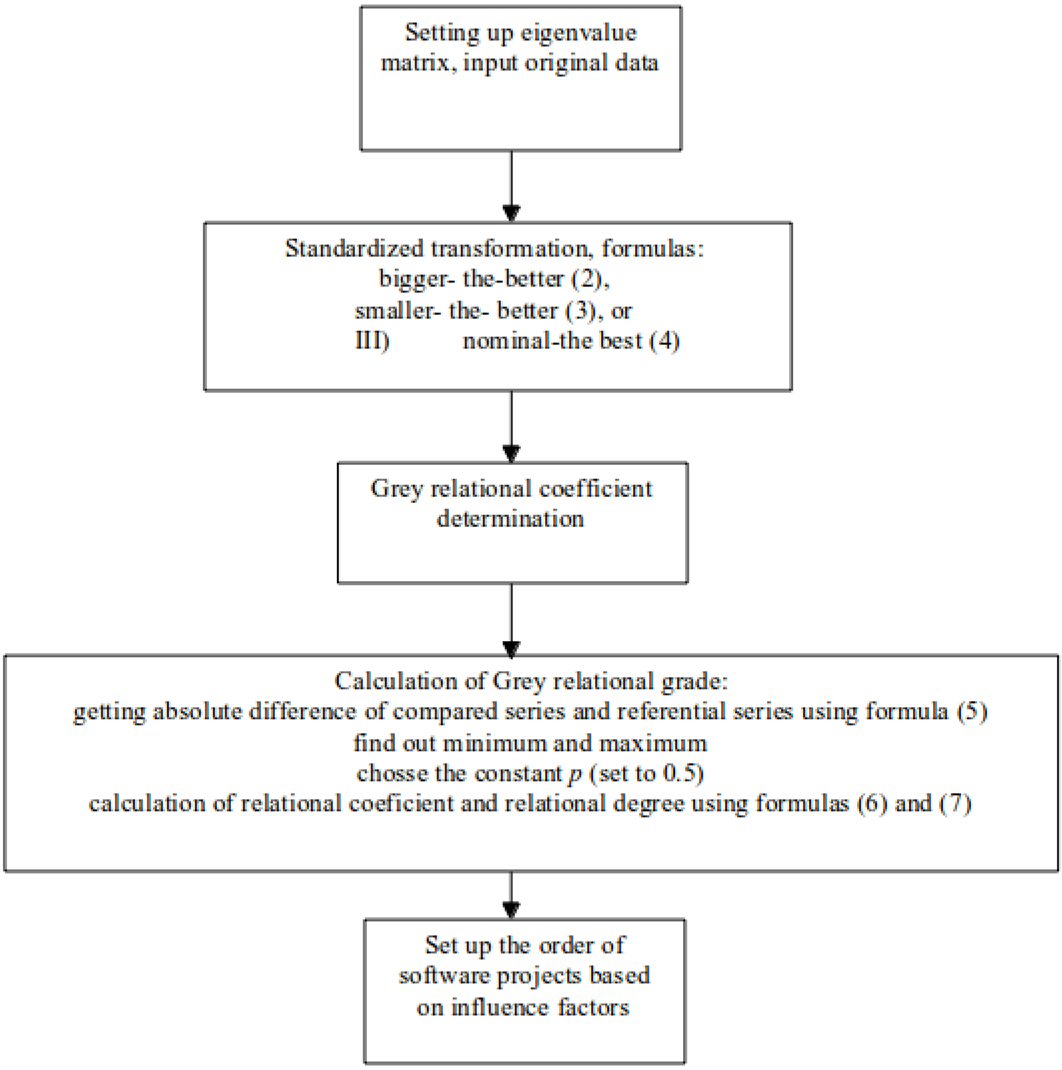

Fig. 2. The generation of Grey relation diagram

V. RELEVANCE OF ISO QUALITY CHARACTERISTICS IN INTRANET APPLICATIONS

The study involves a survey of quality characteristics in intranet applications. For that purpose we used published results from H.N.K. Leung [8].

A survey was performed to determine the user view of the relative importance of quality characteristics in an intranet application. Respondents consisted of end-user, end-user management, developers and IT professionals.

Responders were asked to rank the relative importance of the six quality characteristics by assigning a number from one (most important) to six (least important) for each characteristic. Table 2 summarizes the responses, it shows the distribution of scores for six intranet software.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

Table 2. Distribution of scores for six Intranet software

Factors	*Score 1*	*S2*	*S3*	*S4*	*S5*	*S6*
Functionality F1	8	7	12	2	1	0
Reliability F2	11	12	5	1	1	0
Usability F3	4	0	2	12	6	6
Efficiency F4	7	7	6	6	4	0
Maintainability F5	0	2	3	7	12	6
Portability F6	7	2	12	2	6	0

For all scores, the expectancy is shorter-the-beter, or defect type factor, which can be determined by the equation (3).
The reference series is therefore *Xo* = (0, 0, 2, 1, 1, 0).
The above equation (3) can be used to do the standardized transformation in this sample. The scoring points for each attribute are normalized in order to obtain matrix table of comparative series based on the expectancy of each individual event, as shown in Table 3. An ideal standard series is established (X_0 =1) in the last line in Table 3.

Table 3. The compared series and the referal series

Factors	*Score 1*	*S2*	*S3*	*S4*	*S5*	*S6*
F1	0.272	0.416	0	0.909	1.00	1.00
F2	0	0	0.700	1.00	1.00	1.00
F3	0.636	1.00	1.00	0	0.545	0.666
F4	0.363	0.416	0.600	0.545	0.272	1.00
F5	1.00	0.833	0.900	0.454	0	0.666
F6	0.363	0.833	0	0.909	0.545	1.00

VI. THE GREY RELATIONAL COEFFICIENT DETERMINATION

Next step is to calculate the absolute difference of the compared series and the referential series using equation (5), and find out the maximum and minimum. Table 4 shows the grey relation coefficient.

Table 4. The Grey relational coefficient

Factors	*Score 1*	*S2*	*S3*	*S4*	*S5*	*S6*
F1	0.407	0.461	0.333	0.846	1.00	1.00
F2	0.333	0.333	0.625	1.00	1.00	1.00
F3	0.578	1.00	1.00	0.333	0.523	0.600
F4	0.440	0.461	0.555	0.523	0.647	1.00
F5	1.00	0.750	0.833	0.478	0.333	0.600
F6	0.440	0.750	0.333	0.846	0.523	1.00

The Grey relational coefficient for each contestant can be obtained by equation (6) shown in Table 4.
The Grey relational grade is then obtained using equation (6). The Grey relation grade for each contestant are:
$\Gamma_{01} = 0.674$; $\Gamma_{02} = 0.715$; $\Gamma_{03} = 0.672$; $\Gamma_{04} = 0,604$; $\Gamma_{05} = 0.665$ $\Gamma_{06} = 0.742$.

The final results with ranking are given in Table 5.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

Table 5. The ranking

Factor	Result	Ranking
F1	0.674	2
F2	0.715	1
F3	0.672	3
F4	0.604	5
F5	0.665	4
F6	0.480	6

The ranking order for these six quality factors are F6, F2, F1, F5, and F4.

VII. CONCLUSION

This paper discusses the scoring method that is being used for intranet quality factors. According to the analysis in this paper it is shown that the Grey relational grade deduced by Grey theory can be used to establish an accurate and precise evaluating model for detecting the ranking of quality factors. Grey relational analysis possesses an overwhelming advantage to solve the problems that traditional method could not overcome when there is a tie score dispute.

REFERENCES

ISO 2006, ISO/IEC 14143-6:2006- "Information technology-Software measurement-Functional size measurement - Part 6", ISO/IEC, 2006.
Hareton. K. N. Leung, "Quality metrics for intranet applications", Information & Management Vol 38, p.p. 137-152, 2001.
Campbell, P.,"The Intranet: Slashing the cost of business, International Data Corporation, http://home.netscape.com/comprod/announce/ide/summaryhtml, 1998.
Chen, S., Li, Z. And Xu, Q. "Grey Target Theory Based Equipment Condition Monitoring and Wear Moode Recognition" Wear, Vol. 260, 2006.
Chen, L. R., Lin, C. H., Hsu, R. C., Ku, B.G. & Liu C.S., "A Study of Li-ion Battery Charge Forecasting Using Grey Theory", IEICE/IEEE MTELEC'03, pp. 744-749, 2003.
Chiang, Y. M., Hsieh, H.H., "The use of the Tagouchi method with grey relational analysis to optimize the thin-film sputtering process with multiple quality characteristics in color filter manufacturing", Computers & Industrial Engineering", Vol.56, pp 648 – 661, 2009.
Chih-Hung, T.,Ching-Liang, C., Lieh, C., "Applaying Grey Relational Analysis to the Vendor Evaluational Model", International Journal of the Computer, The Internet and Management, vol. 11, no. 3, pp. 45-53, 2003.
Deng, J., "Introduction to Grey System Theory", The Journal of Grey System,pp. 1 – 24, 1989.
Ebert, C., Dumke, R. „Software Measurement", ISBN 978-3-540-71648-8, Springer, Berlin, NY, 2007.
Kempter, H., Frank, H., "Measurement based quality control of real-time system specification" Software Quality Management III, Vol. 2, 1995.
Liu, S., Lin, Y., "An Introduction to Grey Systems: Foundations", Methodology and Applications, IIGS Academic Publisher, Slippery Rock, 1998.
McCall J., Richards, P., Walters, G., "Factors in Software Quality", NTIS AD-A049-014, 015, 055, 1977.
Schnaider, C., "Intranet Architecture – Integrating Information Design with Business Planning", intrack.com/intranet/iarchi.shtml, 1997.
Suhk-Hook Suh., "Fuzzy-Bayes Fault Isolator Design for BLDC Motor Fault Diagnosis", International Journal of Control, Automation, and Systems, Vol.2, No. 3.,2004.
Sifen, L., Forrest, J., "The Current Developing Status on Grey System Theory", The Journal og Grey System Vol. 2, 2007.
Welch, D. E., "Intranets – The New Engine of Corporate Productivity", welch.com/wpapers/intranet.html, 1996.
Xiong, Y., "Grey Relational Evaluation of Financial Situation of Listed Company", Journal of Modern Accounting and Auditing, Vol.3, No.2, ISSN1548-6583, USA, 2007.