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Case Simulation of User-Centric Performance Evaluation Model for Distributed Software System Architecture

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Abstract - Neural-Fuzzy Performance Evaluation Model [NFPEM] is a user-centric model developed to evaluate the performance of Distributed Software System Architecture [DSSA]. Parameters used for evaluation are contextual organizational variables. The emphasis in this paper is to simulate NFPEM in four different Information Technology oriented environments where Distributed Software System [DSS] is used for service delivery, with the ultimate aim of establishing and evaluating its utility. The results of the simulation point to the responsiveness of the DSSA to the contextual organizational factors during the project life cycle.

Keywords: Neuro-Fuzzy, Distributed Software, System Architecture, Organizational Variables, Performance Evaluation, User Involvement.

I. INTRODUCTION

A review of various models for evaluating the performance of Software System Architecture (SSA) was carried out in [1, 2, 3] with emphasis on the identification and classification of parameters used for evaluation. In addition, [3] did a further review of various models used to measure Information System (IS) success in organizations with the aim of establishing the contextual factors (organizational factors) that were used to measure the IS success, and to determine if the factors were directly or indirectly related with the components of Distributed Software System Architecture (DSSA). The following deductions were made in [3]:

a. "Existing parameters for evaluating DSSA performance are machine centred and they are objective. The machine centric parameters entails variables peculiar to system hardware parameters such as: processor speed, bus and network bandwidth size, RAM size, cache size, server response time, server execution time; and software process parameters such as: message size, event load, time to perform an action, request arrival time, request service time. Therefore the models are machine-centric".
b. "Though in the DSSA performance evaluation models, the contributions of the client organization/end users during software development process were acknowledged but none of the models draws parameters for evaluation from the contextual organizational decision variables".
c. "Performance metrics considered are mostly the following: throughput, response time, and resource utilization".
d. "None of the IS success measurement models show a relationship mapping of the organizational variables and the components of software system architecture. Thus the IS success in organization is not measured at the system architectural design level but rather at the IS implementation and usage levels. Moreover the use of the organizational variables to determine the performance of the system architecture before implementation is not considered".

In view of the above deductions, we developed and presented a framework of Neuro-Fuzzy Performance Evaluation Model (NFPEM) [3]. NFPEM is a user-centric model that can be used to evaluate the performance of DSSA at the architectural level using contextual organizational variables as parameters for evaluation. The performance metric considered is the responsiveness of the system architecture to end-users' requirements as defined in the requirement definition/analysis phase of the System Life Cycle (SLF). The developed framework was not simulated using some real life data; thus in this paper we simulate NFPEM in four different environments where Distributed Software System

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(DSS) is used for service delivery to the customers. The end-users (i.e. staff of client organization and customers that use the DSS) completed Software Performance Assessment Form (SPAF). They were requested to examine each of the performance parameters in the SPAF in terms of suitability and then check the degree of their agreement with each parameter - whether in their opinion, the organization's DSS meets the end-users' requirements. They were equally expected to indicate their rating confidence for each parameter. The rating confidence values ranged between 1 – 10. Highest confidence level is 10 and the lowest is 1. Finally the simulation results were presented and some policy statements were given as recommendations.

II. RELATED WORKS

In the mid-1980's, User-Centric Software Engineering (USE) emerged as an approach to developing software with active involvement of end-users in the phases of the system life cycle. USE is a synthesis of methods that were advocated for and practiced by the leaders in the software engineering discipline. The principal aim of USE is to encourage collaboration between end-users and developers in order to design and develop acceptable application software that efficiently perform the business processes of an organization [4].

According to [5], user-centric architecture is an extension of the conventional service oriented architecture (i.e producer-centric architecture). User-centricity upgrades end-users to prosumers (i.e producer + consumer) and involve them in the process of service creation and therefore both service consumers and service providers can benefit from a cheaper, faster, and better service provisioning [5].

A number of research works have been carried out on the development of user-centric models for solving problems in various domains. Some of the works are presented in Table 1.

Table 1: Description of some research works on user-centricity

Literature	Brief Description of Research Work carried out
[7]	The authors presented algorithms that were built from user-centric data and used the algorithms for data pre-processing of clickstream data. It was established empirically that the algorithms built from user-centric data (classified as complete data) performed better than models built from site-centric data (classified as incomplete data) while both were applied to two prediction tasks.
[8]	A user-centric model was developed for classification of mobile payment system which was able to discover motivations and preferences of consumers about mobile payment system.
[9]	User-centric approach was used to evaluate the performance of semi-automated RoadMAP system against RoadMAP system that runs in a fully-manual mode.
[10]	Presented in this work was a user-centric model, tagged Prudentexposure. It exposes minimal information privately, securely, and automatically for both service providers and users of service discovery protocols. It secures organizational services from illegitimate users.
[11]	A user-centric approach was proposed in taking vertical handover decisions, which are based on the knowledge of the available access networks' characteristics and higher level parameters that fall in the transport and application layers of the network. This approach reflects optimal settings from the point of view of mobile network user regarding running services and applications. Thus based on specific needs of user, convenient handover decision policy could be autonomously applied by each mobile network user.
[12]	Proposed in this work is a User-Centric Story Architecture. It is an interactive narrative model that adapts screenwriting and acting theories. It integrate user model formed by dynamic monitoring and modelling of users' behaviour. The architecture uses user's actions and inferred stereotype based personality to guide its decisions, thus forming a user centric approach to interactive narrative.
[13]	Presented in this article was a multimodal context framework (networked home) which was a user-centric multimedia system that make it possible for users to rest, reflect, interact and communicate their everyday experiences with the communication networks.
[14]	This paper presented a user-centered proactive computing typology for proactive behaviours. This will assist researchers to observe proactive behaviours more from the point of view of users.
[15]	This paper proposed system innovation approach tagged Living Labs with the aim to bringing the stakeholders (users/consumers/citizens) into the system of innovation. Thus ideas, knowledge and experiences of stakeholders are captured in structured form and these are useful for building user-oriented systems.
[16]	This paper established traditional identity management as service-provider centric. That is the service provider solely undertakes the activities involved in managing service users identities. The demerits of the traditional identity management system were established and it was justified that users/clients must be actively involved in managing their identities. In view of this a user-centric identity management framework was proposed and this was established to be cost effective and scalable and also compatible with the traditional identity management systems. Related to this work is [36]

[17]	Carried out a study of how Web pages are scheduled for selective (re)downloading into a search engine repository and thus identified user-centric metrics for search engine's local repository quality. Using the identified metrics, user-centric Web page refresh strategy was proposed with the view to efficiently refresh Web pages already present in the search engine repository. The empirical comparisons of the user-centric method against existing Web page refresh strategies showed that user-centric method requires far fewer resources to maintain search engine quality level for users and thus leave enough resources for incorporating new Web pages into the search repository.
[18]	Developed User Centric Walk algorithm, which is an integrated approach used to model Web users' browsing behaviour. The algorithm generates synthetic data instead of empirically obtained requests.
[19]	Swing & swap user-centric scheme was proposed to maximize location privacy of users of devices and vehicles that are being tracked. Related to this work is [37].
[6]	This paper proposed user-centric service-oriented architecture (UCSOA). UCSOA provides platform for end users to establish their needs including workflows and services and the producers produce the services to meet the users' requirements. It is an extension of consumer-centric service-oriented architecture (CCSOA), which is an extension of conventional SOA (producer-centric). Related to this work are: [33, 38, 39].
[20]	This article emphasized the need for Organizational Development (OD) to be more user-centric rather than management oriented. Thus consumers or users of an organization's product or services should be involved in every stage of design and development process.
[21]	Presented in this article is a user-centric faceted search method for semantic portals. It provides the end-user with intuitive facet hierarchies to conceptualize the content, formulate queries, and classify the search results.
[22]	This paper proposed a framework to evaluate adaptive pervasive systems from two viewpoints: the potential users and the system design. Thus two types of goal models were developed: "system goal models" and "user goal models". Two metrics: "coverage" and "demand"; were used for measuring the difference in the viewpoints and some principles were applied for identifying key features from the comparison between the viewpoints. Related to this work is: [40].
[23]	The user-centric model developed is Home-cell Community-based Mobility Model (HCMM). It is for modelling user mobility in mobile pervasive and opportunistic networks.
[24]	This article described a user-centric wireless network model tagged user-provided network. In this case the end user is both a consumer and a provider of Internet access. Related to this work is: [41].
[25]	This paper presented the initial results of a research project that applies the user-centric approach to the creative combination of Web and network services over next generation networks.
[26]	In this paper, a prototype of user-centric identity-usage monitoring system was developed. This system transparently uses context information of a request to detect anomalous use of online identity. The prototype implemented in an OpenID setting and evaluated in terms of scalability, performance, user-centricity, and security.
[27]	In this article, a user-centric prototype was proposed to facilitate the service consumers on discovering Web services in an easy-of-use manner. This alleviates the consumers from time-consuming discovery tasks and lowers their entry barrier in the user-centric Web environment.
[28]	A user-centric service composition approach was developed in order to provide support to the user in the composition of services and applications on mobile phone. The services are organized around the following resources: time, location, social relations, money. It model the essential user assets handled by mobile services and guide data integration and service composition. Other related works are: [42, 43].
[29]	A video interaction model tagged *SmartPlayer* was proposed. It is an adaptive fast-forwarding model and is user-centric. It makes use of predefined semantic rules and thus assists people to quickly browse videos. A user study was done in order to evaluate the model and it was established that users had a better experience while using *SmartPlayer* to browse and fast-forward videos compared to previous video players' interaction models. Related to this work are: [44].
[30]	In this paper, a framework tagged Collaborative Enterprise Computing was developed with the aim to creating a trusted network for capturing expertise and ideas of enterprise employee in a structured and machine understandable form. This provide the platform for automated inter and intra- enterprise collaboration in an open-controlled environment and thus facilitate the building of user-centric and friendly enterprise informatics.
[31]	*ResQue* (*Re*commender *s*ystems' *Q*uality of *u*ser *e*xperience) was developed. It is a user-centric

	evaluation framework for recommender systems. The model aimed at identifying the essential qualities of an effective and satisfying recommender system and the essential determinants that motivate users to adopt this technology. *ResQue* consists of 15 constructs and 32 user-based which define the important qualities of an effective and satisfying recommender system and also provide practitioners and scholars with a cost-effective way to evaluate the success of a recommender system and identify important areas in which to invest development resources.
[32]	This paper presented content-on-demand (CoD) video adaptation system that considers the preference of users on cognitive content and affective content for video media. The CoD support user' decision during selection of content of interest. It also adaptively deliver video source by selecting relevant content and dropping frames while considering network conditions.
[5]	Semantically enhanced service repository system was developed for user-centric service discovery and management. It supports prosumers (producer + consumer) who are not technically experienced to explore and discover services in an intuitive and visualized manner.
[33]	Using identified human factor, user-centered design methodologies was adopted to develop knowledge-based system for sustainable skill and performance improvement in education.
[34]	This paper presented a community-driven (i.e user-driven) case study by identifying factors supporting or against community-driven technological innovations. It concluded that innovative technology must be community driven, designed and owned in order to have sustainable community empowerment.
[35]	In this article, *ClickRank* was introduced as an efficient and scalable algorithm to evaluate webpage and website importance based on the preference judgement of users that is mined from session context. Thus *ClickRank* is a user-centric algorithm that is based on a data-driven intentional surfer model and empirically shown to be effective for Web search ranking.

Our deduction from the review presented in Table 1 above is that there has not being a user-centric model applied in evaluating the performance of distributed software system architecture (DSSA). A framework of user-centric model for DSSA performance evaluation was proposed in our previous paper [3], but it was not simulated. Thus the objective of this paper is to carry out a case simulation of the framework using life data.

III. MODEL DESCRIPTION

The detailed description of NFPEM (including the algorithm) was presented in [3]. This section presents a brief description of NFPEM in order to enhance understanding of this paper. Figure 1 presents the conceptual diagram of NFPEM.

NFPEM is a user-centric model developed to evaluate the performance of distributed software system architecture. It is composed of the following components: (1) Organizational variables and DSSA components (2) Neuro-fuzzy software performance evaluation engine, which consists of (a) Fuzzy engine, (b) matching functions, and (c) Neural Network (NN) engine. The conceptual diagram of the *Perceptron* is presented in Figure 2. The computed values for y_j, $_{j\,=\,1,\,2,\,3,\ldots,10}$ were the inputs to the NN functions. A DSSA performance assessment form was designed for the users to evaluate their organizational DSSA based on the 31 organizational variables ($x_1,x_2 \ldots x_{31}$) described in the form. Users rated each of the variables using the following linguistic values: *strongly satisfied, satisfied, fairly satisfied, dissatisfied, strongly dissatisfied.* The essence of the evaluation was to establish the extent to which the DSSA was able to respond to the users' requirements. NFPEM algorithm is presented below:

NFPEM Algorithm *(Source: [3])*

Algorithm Header: ***User_Centric_PE()***

Step 1: (i) Input values for $\boldsymbol{x_{ij}}$, i = 1, 2, 3, …, 31 and j = 1, 2, 3, …, n (n = total number users sampled to collect data for $\boldsymbol{x_{ij}}$). Values for x_{ij} are gotten from users of DSS using the DSSA performance assessment form, presented in Appendix A.

(ii) Input rating confidence of users, $\boldsymbol{c_{ij}}$. $\boldsymbol{c_{ij}}$ is rating confidence of $\boldsymbol{i^{th}}$ user for $\boldsymbol{j^{th}}$ variable

Step 2: Compute normalized rating confidence of users, $\boldsymbol{\alpha_{ij}}$, using the following procedure

Knowledge Assessment Methodology (KAM) Normalization Procedure

i. Ranks are allocated to all the respondents' rating confidence for variable x_j. Respondents with the same confidence rating are allocated the same rank. Therefore, the rank equals 1 for a respondent that has the highest rating confidence in our sample on a particular variable (that is, it has the highest score), the rank equals to 2 for a respondent that has the second highest, and so on.

ii. For each respondent for variable x_j, the total number of respondents with a higher rank is calculated ($\hat{R}_{i,j}$)

iii. Equation (1) is used in order to normalize the rating confidence for every respondent on every variable according to their ranking and in relation to the total number of respondents in the sample (N) with available data:

$$\alpha_{i,j} = 1 - \frac{\hat{R}_{i,j}}{N} \qquad (1)$$

where: $\alpha_{i,j}$ = Normalized rating confidence

Step 3: Adjust rated values of users for each $\boldsymbol{j^{th}}$ variable using:

$$\varphi_{i,j} = \alpha_{i,j}\{u_{t-1}, u_t, u_{t+1}\} \quad (2)$$

(u_{t-1}) = Defined lower bound of the value of the linguistic rating directly below the actual rating of users
(u_t) = Defined median point of the value of the actual linguistic rating of users
(u_{t+1}) = Defined upper bound of the value of the linguistic rating directly above (if exists) the actual rating of users.

This enables the computation of possible triplets ($\varphi_{i,j}$), whose membership function would be utilized in determining the crisp value.

Step 4: Compute the membership values of the adjusted rated values, $\varphi_{i,j}$, of users, using the functions defined in Table 2

Step 5: Compute the crisp value of $\mu_X\{\varphi_{i,j}\}$ using the defuzzification function:

$$\hat{z}_{i,j} = \frac{\sum \varphi_{i,j}(\mu_X(\varphi_{i,j}))}{\sum \mu_X(\varphi_{i,j})} \quad (3)$$

where $\hat{z}_{i,j}$ = Crisp value obtained; μ_X ($\varphi_{i,j}$) = Fuzzy membership values

Step 6: Compute the mean x_i of $\hat{z}_{i,j}$, i = 1,2,3,…,31 and j = 1,2,3,…,n

$$x_i = \frac{\sum_{j=1}^{n} \hat{z}_{i,j}}{n}$$

Step 7: Compute values of y_j, j = 1,2,3, …, 10 using the following equations (matching function):

$$\begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \\ y_7 \\ y_8 \\ y_9 \\ y_{10} \end{pmatrix} = \begin{pmatrix} -4.48 + 0.56x_1 + 0.44x_2 \\ -5.84 + 0.37x_3 + 0.29x_4 + 0.22x_5 + 0.17x_6 + 0.167x_7 \\ -1.07 + 0.86x_8 + 0.14x_9 \\ -6.16 + 0.55x_{10} + 0.37x_{11} + 0.24x_{12} + 0.06x_{13} \\ -4.03 + 0.90x_{14} + 0.07x_{15} \\ -3.70 + 0.78x_{17} + 0.34x_{18} + 0.20x_{19} \\ -6.71 + 0.61x_{21} + 0.25x_{22} + 0.26x_{23} + 0.15x_{24} \\ -5.15 + 0.59x_{25} + 0.29x_{26} + 0.24x_{27} \\ -5.60 + 0.41x_{22} + 0.45x_{28} + 0.32x_{29} \\ -4.55 + 0.67x_{30} + 0.38x_{31} \end{pmatrix}$$

Step 8: NN process starts
Invoke the NN algorithm: ***NN(y_j) [j=1..10]***
Step 9: Algorithm terminates

Algorithm of the NN engine of NFPEM

The algorithm developed for the NN engine of the model is presented as follows:
Algorithm Header: ***NN(d_j) [j=1..10]***

Step 1: Assign constant values to: **η** (NN learning rate), 0 < η ≤ 1; ***Q*** (defined threshold Performance value), 0.0 ≤ **Q** ≤ 1.0
Initialize w_i (multiplicative weight), 0.0 ≤ w_j ≤ 1.0, j = 1, 2, 3, …, 10

Step 2: Input values of y_j for j = 1 to 10 (y_j is the value computed using the matching function)

Step 3: Execute the summation function: $P = \sum w_j y_j$; j = (1,2,…10) (4)

Step 4: Execute the normalization function:

$$f(P) = P_T = \begin{cases} P & \text{if } (0.0 \le P \le 1.0) \text{ and } (P \ge Q) \\ \dfrac{1}{1 + e^{-P}} & \text{if } P < 0, P > 1.0 \end{cases} \quad (5)$$

if $P_T = P$ then output **P** and Goto **Step 6**; otherwise Goto **Step 5**

Step 5: Delta training rule starts
i. Compute delta, **δ**: **δ** = $Q - P$

ii. Adjust weights w_j using delta weight adjustment function:

$$w^*_j = w_j + \eta\delta y_j,\ j = 1, 2, \ldots, 10 \quad (6)$$

iii. Repeat steps **Step 3** through to **S5** until $(0.0 \leq P \leq 1.0)$ *and* $(P \geq Q)$

Step 6: Algorithm terminates

IV. NFPEM SIMULATION AND DISCUSSION

This section presents the discussions on the results obtained in the course of simulating and evaluating NFPEM.

A. Simulation of NFPEM

The following assumptions were made prior to the model simulation:

a. A uniform initial synaptic weight (w) of 0.4 is assumed for each NN input value ($y_1, y_2, y_3, \ldots, y_{10}$). This is based on the assumption that each input factor has equal strength at the initial stage of the NN processing; thus they influence the DSSA performance equally.

b. A learning rate (η) of 0.2 is assumed in order to prevent the NN from oscillating around the solution, which is the case if a higher value of learning rate is chosen.

c. It is assumed that performance values fall within the range (0.1 – 1.0).

d. The minimum benchmark value (that is minimum expected output), Q, for DSSA performance is assumed to be 0.5. The linguistic labels and values that are assumed to describe DSSA performance are presented in Table 4. It is assumed that the minimum linguistic performance value expected for a DSSA is “Fair” which is equivalent to 0.5.

Table 4. Linguistic Label and Values for DSSA Performance

Linguistic Labels	Excellent	Very Good	Good	Fair	Poor
Values	4.50 - 5.0	4.0 – 4.49	3.0 – 3.99	2.0 – 2.99	1.0 – 1.99

Simulation Data

The data for simulating NFPEM were obtained from the users of distributed software application used in four different Universities in Nigeria: Bells University of Technology, Ota; Covenant University, Ota; University of Lagos, Akoka-Yaba; and Lagos State University, Ojo. Each of these universities has established distributed software system (DSS) that is used for online students’ course registration, examination results processing, online checking and printing of students’ result slip, transcripts and a number of other services. The DSSs run on different platforms based on the Information Technology (IT) infrastructure in each of the universities. The following user categories were sampled: students, faculty, and IT expert technical staff. The essence of the simulation was to ascertain the functionality of the user-centric model on different DSS platforms.

The number of users sampled in each university is as follows:

a. Bells University of Technology- 75 users
b. Covenant University - 65 users
c. University of Lagos - 46 users
d. Lagos State University - 51 users

Where: y_1 = Business Entity, y_2 = Preparedness of the Client Organization, y_3 = Service Agent, y_4 = Process and Presentation Logic, y_5 = Users Interest and IT Expertise, y_6 = User Involvement, y_7 = User Interface, y_8 = Data Access and Security, y_9 = Business Workflow, y_{10} = Service Layer; x_1 = Communication rules with external organizations (CRE1), x_2 = Data communication rules and semantics within the client organization (DCRO), x_3 = Willingness of users for IT training (WUIT), x_4 = IT infrastructure available in client organization (ITIF), x_5 = Budget of the client organization for software project (BSPJ), x_6 = Feasibility study done by the project team in client organization (FSTU), x_7 = Expected size of the organization database (SODB), x_8 = Policies for interoperability (PIN1), x_9 = Defined mapping of data with external business entity and services (DMEB), x_{10} = Users definition for input data and the format for input (UDI1), x_{11} = Data input validation strategy/procedure defined by client organization (DVSC), x_{12} = Developers’ understanding of the organization’s goal and task (DUOG), x_{13} = Internal services of the client organization and their relationships (ISO1), x_{14} = Professional qualification of users (PQUS), x_{15} = Academic qualification of users (AQUS), x_{17} = Involvement of users in system design (USDE), x_{18} = Involvement of users in system operation (USOP), x_{19} = Population of users expected to use/operate the system (PUOS), x_{21} = Information requirements of users and the format in which it expected (UIRF), x_{22} = Organization goals and tasks (OGTS), x_{23} = Organization policies/procedure for transaction flow (OPTF), x_{24} = Organization defined functions required in the user interface (ODFI), x_{25} = Organization defined access right for users of applications (DUAR), x_{26} = Business rules associated with the data to be processed (BRDP), x_{27} = Data security measures put in place by the organization (ODS1), x_{22} = Organizations goals and tasks (OGTS), x_{28} = Data flow procedure (DFP1), x_{29} = Defined timeout for services/operations (DTSO), x_{30} = External services requested by the client organization from external organizations (ESEO), x_{31} = Message contract for communication between organizations (MCC1).

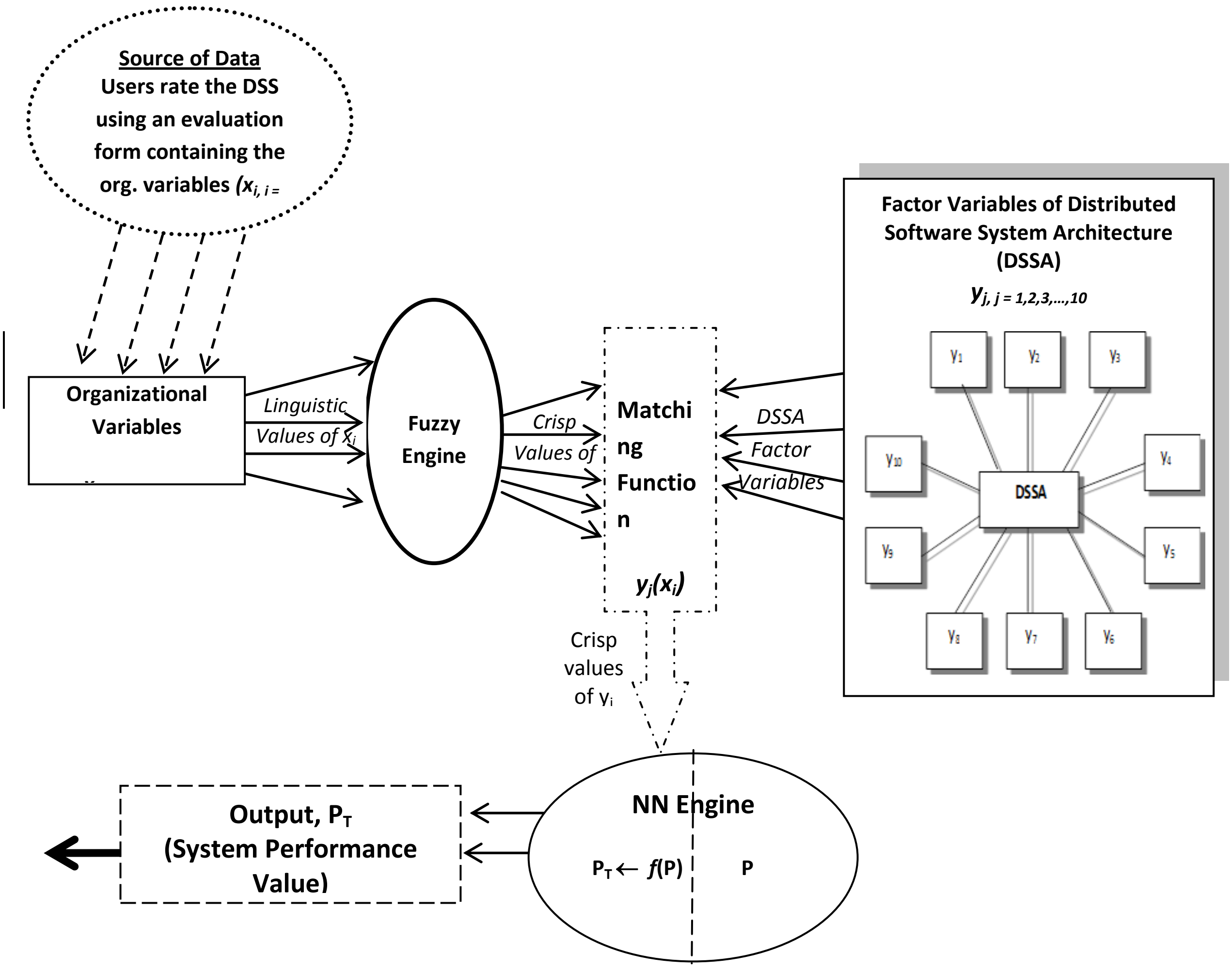

Figure 1: Conceptual Diagram of Neuro-Fuzzy Based User-Centric Performance Evaluation Model (NFPEM) *(Source: [3])*

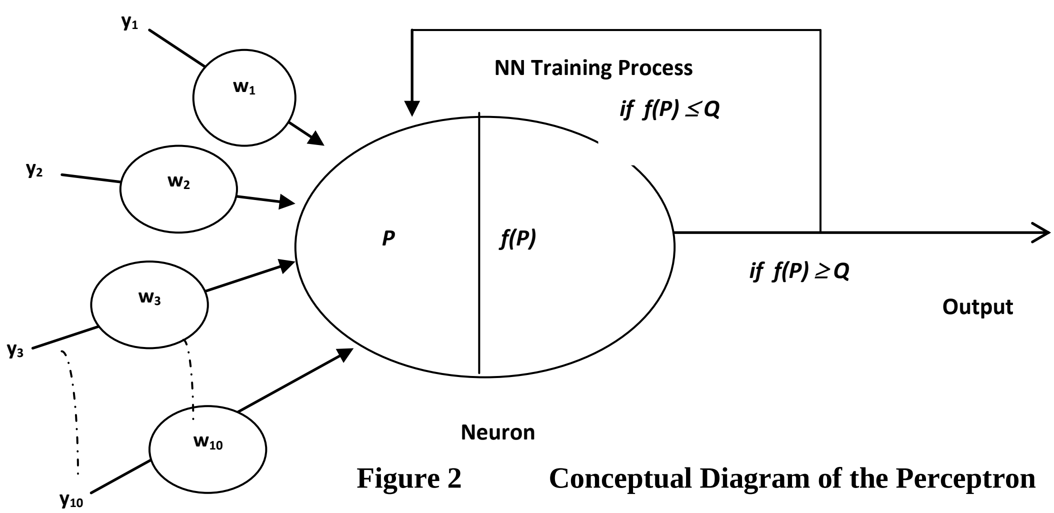

Figure 2 Conceptual Diagram of the Perceptron

where: **y_i** is the value of the i^{th} DSA factor that results from the solution of the matching functions, that is, $y_i = f(x_1, x_2, x_3 \ldots x_k)$ and this is fed into the neuron; **w_i** = *multiplicative weight*, **Q** = *Defined Threshold Value of DSSA performance (ranges from 0.0 – 1.0)*

Table 2: Triangular Fuzzy Membership Functions for Fuzzification of the Adjusted Variables *(Source: [3])*

	Lower bound (*l*)		Median point (*m*)		Upper Bound (*u*)	
	Value	**Condition**	**Value**	**Condition**	**Value**	**Condition**
Strongly Dissatisfied ($\varphi_{i,j}$)	0	($\varphi_{i,j}$) < 0	1.0 - $\varphi_{i,j}$	$0 < \varphi_{i,j} < 1$	1	$\varphi_{i,j} = 1$
Dissatisfied ($\varphi_{i,j}$)	0	($\varphi_{i,j}$) < 1	(4 - $\varphi_{i,j}$) / 5	$1 < \varphi_{i,j} < 2$	1	$\varphi_{i,j} = 2$
Fairly Satisfied ($\varphi_{i,j}$)	0	($\varphi_{i,j}$) < 2	(6 - $\varphi_{i,j}$) / 5	$2 < \varphi_{i,j} < 3$	1	$\varphi_{i,j} = 3$
Satisfied ($\varphi_{i,j}$)	0	($\varphi_{i,j}$) < 3	($\varphi_{i,j}$ - 1) / 4	$3 < \varphi_{i,j} < 4$	1	$\varphi_{i,j} = 4$
Strongly Satisfied ($\varphi_{i,j}$)	0	($\varphi_{i,j}$) < 4	($\varphi_{i,j}$ - 0.2) / 5	$4 < \varphi_{i,j} < 5$	1	$\varphi_{i,j} = 5$

Table 3: Matrix of the Weight Attached to Linguistic Values *(Source: [3])*

	Strongly Satisfied	**Satisfied**	**Fairly Satisfied**	**Dissatisfied**	**Strongly Dissatisfied**
Upper bound (u_{t+1})	5.5	4.5	3.5	2.5	1.5
Median Point (u_t)	5	4	3	2	1
Lower bound (u_{t-1})	4.5	3.5	2.5	1.5	0.5

A sample of the performance assessment form distributed to the users is presented in Appendix A. The assessment form contains the established 31 significant organizational variables. The established organizational variables are the parameters used for evaluation. The users express their feelings about the responsiveness of the DSSA to the organizational factors described in the assessment form by using the following linguistic values: *'Strongly Satisfied', 'Satisfied', Fairly Satisfied', 'Dissatisfied' and 'Strongly Dissatisfied'.*

Each user indicated the rating confidence level for each variable responded to. The essence of the rating confidence is to assess the overall bias of users for each of the variables and also show the level of assurance for the value given to each variable. The rating confidence ranges from 1 (lowest) to 10 (highest). In the course of implementing the model, the rating confidence was divided by 10 in order to make it range between 0.1 and 1.0. It was further normalized using the KAM normalization procedure as stated in NFPEM algorithm. Thus the normalized rating confidence value was used to adjust (inflate or deflate) the rated values of each variable. Presented in Figure 3 is the graph of the average normalized rating confidence for the variables.

Adjustment of Users' Rated Value for Each Variable

A sample of the raw data collected from the users in Bells University of Technology was used to illustrate NFPEM implementation. The users' rated value for each variable (that is, $x_{i,j}$, i^{th} user's rated value for j^{th} variable), was adjusted using the normalized rating confidence, $\alpha_{i,j}$, either to the left or right of the linguistic rating scale defined in Table 3. The rated values of users for each variable are adjusted using Equation (2) as stated in NFPEM algorithm.

For Example, for variable CRE1 (communication rules with external organization), represented as $x_{i,j}$, with $i = 17; j = 1$; from the raw dataset, the i^{th} respondent rated value for j^{th} variable ($x_{17,1}$ = *CRE1)* is 5 (that is Strongly Agree), and the normalized rating confidence, $\alpha_{17,1}$ = 0.61; therefore, applying Equation (2):

$$\varphi_{17,1} = \alpha_{17,1}\{u_{t-1}, u_t, u_{t+1}\} = 0.61\{5.5, 5, 4.5\} = \{3.36, 3.05, 2.75\}$$

This process is repeated for all the variables, $x_{i,j}$, with $i = 1, 2, 3, \ldots, 75$, $j = 1, 2, 3, \ldots, 31$ in order to adjust the rated values either to the left or right of the linguistic rating scale using the corresponding normalized rating confidence value. The dataset of the adjusted rated values of $x_{i,j}$ is large, so a sample of the dataset is presented in Table 5.

Fuzzification and Defuzzification of Linguistic Values of the Decision Variables

a. Fuzzification

The fuzzification functions in Table 2 were used to compute the membership values for each variable. The fuzzification functions were applied to the adjusted rated value of each variable.

Applying the fuzzy function to $\varphi_{17,1}$ = {3.36, 3.05, 2.75}: 3.36 is within the median condition of "Satisfied"; 3.05 is within the median condition of "Satisfied" and 2.75 is within the median condition of "Fairly Satisfied". Therefore, $\mu_x(\varphi_{17,1})$ is evaluated based on the following median conditions:

[Satisfied, Satisfied, Fairly Satisfied]

Thus:

$\hat{\varphi}_{17,1} = \mu_x(\varphi_{17,1}) = \mu_x(3.36, 3.05, 2.75) = [(\varphi_{i,j} - 1) / 4; (\varphi_{i,j} - 1) / 4; (6 - \varphi_{i,j}) / 5] = [0.59, 0.51, 0.65]$

$\hat{\varphi}_{17,1} = \mu_x(\varphi_{17,1}) = [0.59, 0.51, 0.65]$

This process is repeated for all the user-centric variables in order to compute the fuzzy membership values of the linguistic variables. The dataset of the membership values for variable x_{ij} is large, thus presented in Table 6 is a sample of the dataset.

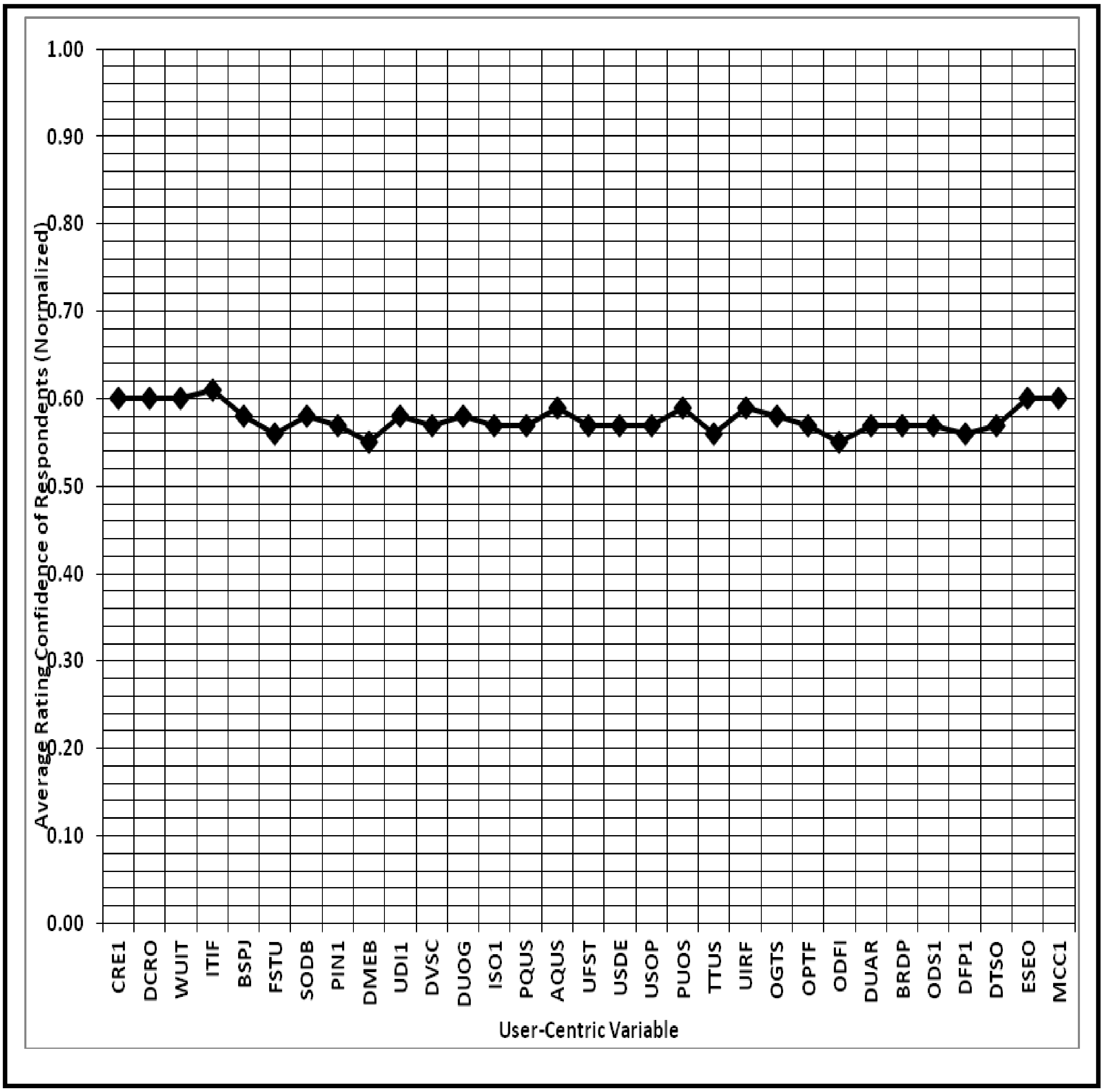

Table 5: Adjusted Rated Values of Some Decision Variables

Respondent	Decision Variables														
	CRE1			DCRO			WUIT			ITIF			BSPJ		
	u_{t+1}	u_t	u_{t-1}	u_{t+1}	u_t	u_{t-1}	u_{t+1}	u_t	u_{t-1}	u_{t+1}	u_t	u_{t-1}	u_{t+1}	u_t	u_{t-1}
1	3.50	3.00	2.50	5.50	5.00	4.50	3.50	3.00	2.50	4.50	4.00	3.50	3.50	3.00	2.50
2	3.50	3.00	2.50	5.50	5.00	4.50	3.50	3.00	2.50	4.50	4.00	3.50	5.50	5.00	4.50
3	4.50	4.00	3.50	4.50	4.00	3.50	5.50	5.00	4.50	3.50	3.00	2.50	5.50	5.00	4.50
4	3.50	3.00	2.50	5.50	5.00	4.50	3.50	3.00	2.50	5.50	5.00	4.50	4.50	4.00	3.50
5	3.50	3.00	2.50	3.50	3.00	2.50	4.50	4.00	3.50	3.50	3.00	2.50	3.50	3.00	2.50
6	2.70	2.31	1.93	4.35	3.95	3.56	4.50	4.00	3.50	5.50	5.00	4.50	4.51	4.10	3.69
7	3.47	3.08	2.70	3.56	3.16	2.77	5.50	5.00	4.50	5.50	5.00	4.50	3.69	3.28	2.87
8	3.47	3.08	2.70	3.56	3.16	2.77	5.50	5.00	4.50	5.50	5.00	4.50	4.51	4.10	3.69
9	4.24	3.85	3.47	2.77	2.37	1.98	4.50	4.00	3.50	3.50	3.00	2.50	4.51	4.10	3.69
10	4.24	3.85	3.47	4.35	3.95	3.56	4.50	4.00	3.50	3.50	3.00	2.50	4.51	4.10	3.69
11	2.70	2.31	1.93	4.35	3.95	3.56	4.02	3.65	3.29	4.07	3.70	3.33	4.51	4.10	3.69
12	4.24	3.85	3.47	3.56	3.16	2.77	2.56	2.19	1.83	3.33	2.96	2.59	3.69	3.28	2.87
13	3.47	3.08	2.70	4.35	3.95	3.56	4.02	3.65	3.29	3.33	2.96	2.59	3.69	3.28	2.87
14	2.14	1.83	1.53	2.79	2.48	2.17	1.83	1.46	1.10	3.33	2.96	2.59	2.88	2.56	2.24
15	2.14	1.83	1.53	3.41	3.10	2.79	4.02	3.65	3.29	4.07	3.70	3.33	2.24	1.92	1.60
16	2.14	1.83	1.53	2.79	2.48	2.17	4.02	3.65	3.29	4.07	3.70	3.33	2.88	2.56	2.24
17	3.36	3.05	2.75	3.41	3.10	2.79	2.56	2.19	1.83	4.07	3.70	3.33	2.88	2.56	2.24
18	2.75	2.44	2.14	2.79	2.48	2.17	4.02	3.65	3.29	3.33	2.96	2.59	2.88	2.56	2.24
19	2.14	1.83	1.53	2.17	1.86	1.55	3.29	2.92	2.56	3.33	2.96	2.59	2.88	2.56	2.24
20	2.75	2.44	2.14	2.79	2.48	2.17	4.02	3.65	3.29	3.33	2.96	2.59	2.88	2.56	2.24
21	2.75	2.44	2.14	3.41	3.10	2.79	3.29	2.92	2.56	4.07	3.70	3.33	2.88	2.56	2.24
22	2.75	2.44	2.14	3.41	3.10	2.79	1.96	1.68	1.40	4.07	3.70	3.33	2.88	2.56	2.24
23	3.36	3.05	2.75	2.79	2.48	2.17	3.08	2.80	2.52	4.07	3.70	3.33	2.88	2.56	2.24
24	2.14	1.83	1.53	3.41	3.10	2.79	3.08	2.80	2.52	1.93	1.65	1.38	2.88	2.56	2.24
25	2.14	1.83	1.53	2.79	2.48	2.17	1.96	1.68	1.40	2.48	2.20	1.93	3.52	3.20	2.88
26	2.75	2.44	2.14	2.37	2.15	1.94	3.08	2.80	2.52	3.03	2.75	2.48	2.03	1.80	1.58
27	3.36	3.05	2.75	1.51	1.29	1.08	2.52	2.24	1.96	3.03	2.75	2.48	2.03	1.80	1.58
28	1.26	1.08	0.90	1.94	1.72	1.51	1.98	1.80	1.62	2.48	2.20	1.93	2.48	2.25	2.03
29	1.26	1.08	0.90	1.94	1.72	1.51	1.26	1.08	0.90	3.03	2.75	2.48	2.03	1.80	1.58
30	1.62	1.44	1.26	1.08	0.86	0.65	1.62	1.44	1.26	1.23	1.05	0.88	2.03	1.80	1.58
31	1.62	1.44	1.26	1.08	0.86	0.65	1.98	1.80	1.62	1.93	1.75	1.58	2.03	1.80	1.58

b. Defuzzification

The crisp value of each variable is computed using Equation (2). Using the example above;

$\varphi_{17,1}$ = [3.36, 3.05, 2.75]; $\mu_x(\varphi_{17,1})$ = [0.59, 0.51, 0.65]

Therefore:

$$\hat{z}_{17,1} = \frac{(3.36 * 0.59) + (3.05 * 0.51) + (2.75 * 0.65)}{0.59 + 0.51 + 0.65} = \quad = 3.05$$

The crisp value of linguistic variable, $x_{17,1} = 3.05$

This process is repeated for all the user-centric variable, $x_{i,j}$, with $i = 1, 2, 3, \ldots, 75$, $j = 1, 2, 3, \ldots, 31$ in order to obtain the crisp values of the variables. Presented in Table 7 is the sample of the crisp values of some of the variables.

The results generated for all the variables after applying the adjustment function, fuzzy and defuzzification functions are large datasets and therefore will be too voluminous for this paper. However few samples are presented in Appendix B.

Execution of the Matching Function

The matching function was executed using the mean value (crisp), $x_{i,\ i = 1, 2, 3, \ldots, 31}$, of each variable. The mean values were computed using mean equation stated in Step 6 of NFPEM algorithm. Table 8 presents the mean values for the organizational variables for BELLSTECH, CU, UNILAG and LASU. The values for $y_{j,\ j = 1, 2, 3, \ldots, 10}$; were obtained after the execution of the matching functions.

Computed Performance Values of DSSA

The NN algorithm of NFPEM was executed in order to complete the computation of the performance value for the DSSA of each university. The input values to the NN are $y_1, y_2, y_3, \ldots, y_{10}$ and they are computed using the matching function stated in NFPEM algorithm. Using the mean of crisp values of the variables, $x_1, x_2, x_3, \ldots, x_{31}$ presented in Table 8, the values of $y_1, y_2, y_3, \ldots, y_{10}$ were computed.

The NFPEM simulation results showing the computed performance value for each DSSA is shown in Tables 9 to 12. The iterative process of the NN algorithm terminates after satisfying the condition: $\mathbf{0.0 \leq P \leq 1.0}$ **and** $\mathbf{P \geq Q}$. The NN was trained with the computed delta value and adjusted synaptic weights during the iterative process.
The users evaluated the DSSA performance based on the organizational variables in order to establish the extent to which the organizational (end user) requirements are satisfied by the DSSA. As presented in Tables 8 to 11, the performance values of 0.8640, 0.5672, 0.8820 and 0.8680 were computed for the DSSAs of BELLSTECH, CU, UNILAG and LASU respectively in the last iteration. This shows that the users ascertained by their rating that the responsiveness of the DSSA of BELLSTECH, CU, UNILAG and LASU to the organizational requirements is about 86.40%, 56.72%, 88.20% and 86.80% respectively.

Table 6: Triangular Fuzzy Membership Values of Some Decision Variables

Respondent	Decision Variables														
	CRE1			DCRO			WUIT			ITIF			BSPJ		
	u_{t+1}	u_t	u_{t-1}	u_{t+1}	u_t	u_{t-1}	u_{t+1}	u_t	u_{t-1}	u_{t+1}	u_t	u_{t-1}	u_{t+1}	u_t	u_{t-1}
1	0.63	1.00	0.70	1.00	1.00	0.86	0.63	1.00	0.70	0.86	1.00	0.63	0.63	1.00	0.70
2	0.63	1.00	0.70	1.00	1.00	0.86	0.63	1.00	0.70	0.86	1.00	0.63	1.00	1.00	0.86
3	0.86	1.00	0.63	0.86	1.00	0.63	1.00	1.00	0.86	0.63	1.00	0.70	1.00	1.00	0.86
4	0.63	1.00	0.70	1.00	1.00	0.86	0.63	1.00	0.70	1.00	1.00	0.86	0.86	1.00	0.63
5	0.63	1.00	0.70	0.63	1.00	0.70	0.86	1.00	0.63	0.63	1.00	0.70	0.63	1.00	0.70
6	0.66	0.74	0.42	0.83	0.74	0.64	0.86	1.00	0.63	1.00	1.00	0.86	0.86	0.78	0.67
7	0.62	0.52	0.66	0.64	0.54	0.65	1.00	1.00	0.86	1.00	1.00	0.86	0.67	0.57	0.63
8	0.62	0.52	0.66	0.64	0.54	0.65	1.00	1.00	0.86	1.00	1.00	0.86	0.86	0.78	0.67
9	0.81	0.71	0.62	0.65	0.73	0.41	0.86	1.00	0.63	0.63	1.00	0.70	0.86	0.78	0.67
10	0.81	0.71	0.62	0.83	0.74	0.64	0.86	1.00	0.63	0.63	1.00	0.70	0.86	0.78	0.67
11	0.66	0.74	0.42	0.83	0.74	0.64	0.76	0.66	0.57	0.77	0.68	0.58	0.86	0.78	0.67
12	0.81	0.71	0.62	0.64	0.54	0.65	0.69	0.76	0.44	0.58	0.61	0.68	0.67	0.57	0.63
13	0.62	0.52	0.66	0.83	0.74	0.64	0.76	0.66	0.57	0.58	0.61	0.68	0.67	0.57	0.63
14	0.77	0.43	0.50	0.64	0.70	0.77	0.44	0.51	0.58	0.58	0.61	0.68	0.62	0.69	0.75
15	0.77	0.43	0.50	0.60	0.53	0.64	0.76	0.66	0.57	0.77	0.68	0.58	0.75	0.42	0.48
16	0.77	0.43	0.50	0.64	0.70	0.77	0.76	0.66	0.57	0.77	0.68	0.58	0.62	0.69	0.75
17	0.59	0.51	0.65	0.60	0.53	0.64	0.69	0.76	0.44	0.77	0.68	0.58	0.62	0.69	0.75
18	0.65	0.71	0.77	0.64	0.70	0.77	0.76	0.66	0.57	0.58	0.61	0.68	0.62	0.69	0.75
19	0.77	0.43	0.50	0.77	0.43	0.49	0.57	0.62	0.69	0.58	0.61	0.68	0.62	0.69	0.75
20	0.65	0.71	0.77	0.64	0.70	0.77	0.76	0.66	0.57	0.58	0.61	0.68	0.62	0.69	0.75
21	0.65	0.71	0.77	0.60	0.53	0.64	0.57	0.62	0.69	0.77	0.68	0.58	0.62	0.69	0.75
22	0.65	0.71	0.77	0.60	0.53	0.64	0.41	0.46	0.52	0.77	0.68	0.58	0.62	0.69	0.75
23	0.59	0.51	0.65	0.64	0.70	0.77	0.52	0.64	0.70	0.77	0.68	0.58	0.62	0.69	0.75
24	0.77	0.43	0.50	0.60	0.53	0.64	0.52	0.64	0.70	0.42	0.47	0.53	0.62	0.69	0.75
25	0.77	0.43	0.50	0.64	0.70	0.77	0.41	0.46	0.52	0.71	0.76	0.42	0.63	0.55	0.62
26	0.65	0.71	0.77	0.73	0.77	0.41	0.52	0.64	0.70	0.51	0.65	0.71	0.80	0.44	0.49
27	0.59	0.51	0.65	0.50	0.54	0.59	0.70	0.75	0.41	0.51	0.65	0.71	0.80	0.44	0.49
28	0.55	0.58	0.00	0.41	0.46	0.50	0.40	0.44	0.48	0.71	0.76	0.42	0.71	0.75	0.80
29	0.55	0.58	0.00	0.41	0.46	0.50	0.55	0.58	0.00	0.51	0.65	0.71	0.80	0.44	0.49
30	0.48	0.51	0.55	0.59	0.04	0.26	0.48	0.51	0.55	0.56	0.59	0.03	0.80	0.44	0.49
31	0.48	0.51	0.55	0.59	0.04	0.26	0.40	0.44	0.48	0.42	0.45	0.49	0.80	0.44	0.49

Table 7: Crisp Values of Some Decision Variables

Respondent	**CRISP VALUES**								
	CRE1	**DCRO**	**WUIT**	**ITIF**	**BSPJ**	**FSTU**	**SODB**	**DMEB**	**DVSC**
1	2.98	4.77	2.98	4.05	2.98	4.05	4.05	4.77	4.05
2	2.98	4.77	2.98	4.05	4.77	4.05	4.05	4.77	4.77
3	4.05	4.05	4.77	2.98	4.77	2.98	2.98	4.05	4.77
4	2.98	4.77	2.98	4.77	4.05	4.05	4.77	4.77	2.98
5	2.98	2.98	4.05	2.98	2.98	4.77	4.77	2.98	4.77
6	2.36	3.98	4.05	4.77	4.13	3.07	3.88	1.69	4.34
7	3.07	3.16	4.77	4.77	3.29	2.36	2.36	4.03	2.33
8	3.07	3.16	4.77	4.77	4.13	2.36	2.36	3.20	3.83
9	3.88	2.42	4.05	2.98	4.13	3.07	3.07	3.20	3.83
10	3.88	3.98	4.05	2.98	4.13	3.88	3.07	4.03	2.33
11	2.36	3.98	3.69	3.73	4.13	3.07	2.36	3.20	3.83

12	3.88	3.16	2.24	2.94	3.29	3.07	3.07	3.20	3.83
13	3.07	3.98	3.69	2.94	3.29	3.07	3.07	2.85	3.83
14	1.88	2.46	1.43	2.94	2.54	2.05	2.00	3.15	3.83
15	1.88	3.09	3.69	3.73	1.97	2.64	3.26	1.94	2.42
16	1.88	2.46	3.69	3.73	2.54	2.64	2.58	3.15	2.42
17	3.05	3.09	2.24	3.73	2.54	2.64	3.26	3.15	2.42
18	2.42	2.46	3.69	2.94	2.54	2.64	3.26	1.94	3.04
19	1.88	1.91	2.90	2.94	2.54	2.64	3.26	3.15	3.04
20	2.42	2.46	3.69	2.94	2.54	3.38	2.58	3.15	2.42
21	2.42	3.09	2.90	3.73	2.54	3.38	2.58	2.50	3.04
22	2.42	3.09	1.66	3.73	2.54	1.66	2.00	1.94	3.04
23	3.04	2.46	2.77	3.73	2.54	1.66	3.26	3.15	2.42
24	1.88	3.09	2.77	1.63	2.54	2.77	2.58	1.94	3.04
25	1.88	2.46	1.66	2.24	3.20	2.28	3.26	1.94	3.04
26	2.42	2.19	2.77	2.72	1.84	1.84	1.37	1.25	2.34
27	3.04	1.28	2.28	2.72	1.84	1.47	1.37	2.13	2.34
28	1.15	1.71	1.79	2.24	2.24	1.47	1.37	1.67	1.92
29	1.15	1.71	1.15	2.72	1.84	1.89	1.37	1.67	2.34
30	1.43	0.91	1.43	1.11	1.84	1.47	1.88	2.13	1.40
31	1.43	0.91	1.79	1.74	1.84	1.47	1.88	1.67	1.35

Table 8: Mean Values of the Decision Variables

Variables	MEAN VALUES			
	BELLSTECH	**CU**	**UNILAG**	**LASU**
CRE1-x_1	3.08	3.15	3.40	3.50
DCRO-x_2	3.27	3.13	3.19	3.48
WUIT-x_3	3.55	3.45	4.01	4.27
ITIF-x_4	3.37	3.17	4.08	4.04
BSPJ-x_5	3.47	3.14	3.96	3.93
FSTU-x_6	3.22	3.09	3.45	3.88
SODB-x_7	3.58	3.23	4.17	4.10
PIN1-x_8	3.26	2.97	3.61	3.54
DMEB-x_9	3.04	2.87	3.37	3.56
UDI1-x_{10}	3.35	3.07	3.77	3.83
DVSC-x_{11}	3.23	3.07	3.54	3.52
DUOG-x_{12}	3.62	3.31	3.95	4.02
ISO1-x_{13}	3.30	3.09	3.85	3.94
PQUS-x_{14}	3.23	3.03	3.66	3.80
AQUS-x_{15}	3.22	3.00	3.77	3.84
UFST-x_{16}	3.23	2.92	3.67	3.77
USDE-x_{17}	2.90	2.78	3.73	3.64
USOP-x_{18}	3.32	2.94	3.74	3.94
PUOS-x_{19}	3.28	3.18	3.84	3.93
TTUS-x_{20}	3.36	2.83	3.73	3.66
UIRF-x_{21}	3.26	3.10	3.55	3.46
OGTS-x_{22}	3.40	2.98	3.79	3.82
OPTF-x_{23}	3.42	3.15	3.87	3.81
ODFI-x_{24}	3.40	3.04	3.76	3.81
DUAR-x_{25}	3.03	2.52	3.43	3.54
BRDP-x_{26}	3.52	3.12	3.85	3.89
ODS1-x_{27}	3.41	3.01	3.77	3.82
DFPI-x_{28}	3.18	3.09	3.44	3.61
DTSO-x_{29}	3.42	3.04	4.16	4.01
ESEO-x_{30}	3.39	3.16	3.86	3.91
MCC1-x_{31}	3.33	3.16	3.72	3.72

Table 9: DSSA of BELLSTECH (Simulation Result)

1st Iteration							2nd Iteration					
y	**Initial w**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
-1.32	0.4	-0.528	-4.028	0.017498	0.017498	0.482502	0.272619	-0.359858	-1.47378	0.186369	0.186369	0.313631
-1.64	0.4	-0.656					0.241739	-0.396453				
2.16	0.4	0.864					0.608441	1.314232				
-2.05	0.4	-0.82					0.202174	-0.414457				
-0.89	0.4	-0.356					0.314115	-0.279562				
0.35	0.4	0.14					0.433775	0.151821				
-2.47	0.4	-0.988					0.161644	-0.399261				
-1.52	0.4	-0.608					0.253319	-0.385045				
-1.68	0.4	-0.672					0.237879	-0.399637				
-1.01	0.4	-0.404					0.302535	-0.30556				

3rd Iteration						4th Iteration						
Adj. Weight	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj.Weight**
0.189821	-0.250564	0.186489		0.186489	0.313511	0.107022	-0.141269	1.846758	0.863746	0.864		
0.138868	-0.227744					0.035997	-0.059036					
0.743929	1.606888					0.879418	1.899543					
0.073585	-0.15085					-0.055	0.112757					
0.258288	-0.229877					0.202462	-0.180191					
0.455729	0.159505					0.477683	0.167189					
0.00671	-0.016574					-0.14822	0.366112					
0.157976	-0.240123					0.062632	-0.0952					
0.132499	-0.222599					0.027119	-0.04556					
0.239181	-0.241573					0.175828	-0.177586					

Table 10: DSSA of CU (Simulation Result)

1st Iteration							2nd Iteration					
y	**Initial w**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
-1.34	0.4	-0.536	-5.1	0.00606	0.00606	0.49394	0.267624	-0.358616	-1.82754	0.138532	0.138532	0.361468
-1.88	0.4	-0.752					0.214278	-0.402844				
1.88	0.4	-0.752					0.585722	1.101156				
-2.35	0.4	-0.94					0.167848	-0.394443				
-1.09	0.4	-0.436					0.292321	-0.31863				
0.11	0.4	0.04					0.410867	0.045195				
-2.79	0.4	-1.116					0.124381	-0.347024				
-2.04	0.4	-0.816					0.198472	-0.404884				
-2.02	0.4	-0.808					0.200448	-0.404905				
-1.23	0.4	-0.492					0.278491	-0.342544				

3rd Iteration					
Adj. Weight	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
0.170751	-0.228806	0.567268		0.567268	
0.078367	-0.147329				
0.721633	1.356671				
-0.002042	0.004798				
0.213521	-0.232738				
0.418819	0.04607				
-0.077318	0.215717				
0.050993	-0.104027				
0.054415	-0.109918				
0.18957	-0.233171				

Table 11: DSSA of UNILAG (Simulation Result)

1st Iteration							2nd Iteration					
y	**Initial w**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
1.18	0.4	0.472	-1.28	0.21755	0.21755	0.28245	0.466658	0.550657	-0.14216	0.46458	0.46458	0.03548
-1.01	0.4	-0.404					0.342945	-0.346375				
2.5	0.4	1					0.541225	1.353062				
-1.6	0.4	-0.64					0.309616	-0.495386				
-0.48	0.4	-0.192					0.372885	-0.178985				
1.18	0.4	0.472					0.466658	0.550657				
-2.04	0.4	-0.816					0.28476	-0.580911				
-1.21	0.4	-0.484					0.331647	-0.401293				
-1.17	0.4	-0.468					0.333907	-0.390671				
-0.55	0.4	-0.22					0.368931	-0.202912				

3rd Iteration						4th Iteration					
Adj. Weight	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
0.475031	0.560537	0.000774		0.000774	0.499226	0.592849	0.699562	2.011896	0.88204	0.88204	
0.335778	-0.339136					0.234935	-0.237284				
0.558965	1.397412					0.808578	2.021445				
0.298262	-0.47722					0.13851	-0.221616				
0.369479	-0.17735					0.321553	-0.154345				
0.475031	0.560537					0.592849	0.699562				
0.270285	-0.551381					0.0666	-0.135865				
0.323061	-0.390904					0.202248	-0.24472				
0.325604	-0.380957					0.208786	-0.244279				
0.365028	-0.200765					0.310113	-0.170562				

Table 12: DSSA of LASU (Simulation Result)

1st Iteration							2nd Iteration						
y	**Initial w**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
-0.99	0.4	-0.396	-1.9	0.130108	0.130108	0.369892	0.374239	-0.370496	-1.40916	0.196367	0.196367	0.303633
-0.87	0.4	-0.348					0.377361	-0.328304				
2.47	0.4	0.988					0.464274	1.146756				
-1.55	0.4	-0.62					0.359666	-0.557483				
-0.34	0.4	-0.136					0.391153	-0.132992				
1.27	0.4	0.508					0.433048	0.54997				
-2.08	0.4	-0.832					0.345875	-0.71942				
-1.01	0.4	-0.404					0.373718	-0.377455				
-1.13	0.4	-0.452					0.370595	-0.418773				
-0.52	0.4	-0.208					0.386469	-0.200964				

3rd Iteration						4th Iteration					
Adj. Weight	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
0.314119	-0.310978	-0.26369	0.434457	0.434457	0.065543	0.301142	-0.29813	-0.01643	0.495893	0.495893	0.004107
0.324529	-0.28234					0.313125	-0.272418				
0.614268	1.517243					0.646647	1.597217				
0.26554	-0.411587					0.245222	-0.380094				
0.370506	-0.125972					0.366049	-0.124457				
0.51017	0.647916					0.526818	0.669059				
0.219564	-0.456692					0.192298	-0.399979				
0.312384	-0.315508					0.299145	-0.302136				
0.301974	-0.341231					0.287162	-0.324493				
0.354891	-0.184543					0.348074	-0.180999				

5th Iteration						6th Iteration					
Adj. Weight	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
0.300328	-0.297325	-0.000936	0.499766	0.499766	0.000234	0.300282	-0.297279	-0.000053	0.499987	0.499766	0.000234
0.31241	-0.271797					0.312369	-0.271761				
0.648675	1.602228					0.648791	1.602514				
0.243949	-0.37812					0.243876	-0.378008				
0.365769	-0.124362					0.365753	-0.124356				
0.527861	0.670384					0.527921	0.670459				
0.190589	-0.396425					0.190492	-0.396223				
0.298315	-0.301298					0.298268	-0.30125				
0.286234	-0.323444					0.286181	-0.323384				
0.347647	-0.180777					0.347623	-0.180764				
7th Iteration						**8th Iteration**					
Adj. Weight	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**	**Adj. Weight**	**y.w**	**∑(y.w)**	**P normalized**	**P**	**Error**
0.300236	-0.297234	0.000829		0.000829	0.499171	0.2014	-0.199386	1.883972	0.868067	0.868067	
0.312328	-0.271726					0.225473	-0.196161				
0.648906	1.602799					0.895497	2.211877				
0.243804	-0.377896					0.089061	-0.138044				
0.365738	-0.124351					0.331794	-0.11281				
0.52798	0.670535					0.65477	0.831557				
0.190395	-0.396021					-0.017261	0.035902				
0.29822	-0.301203					0.197388	-0.199362				
0.286128	-0.323324					0.173315	-0.195846				
0.347599	-0.180751					0.295685	-0.153756				

B. Evaluation of the Developed Model (NFPEM)

NFPEM is evaluated by drawing a comparison between it and the existing models that are used to evaluate the performance of DSSA. Parameters used to draw the comparison are based on the facts deduced in the course of reviewing the research works on DSSA performance evaluation models for over a decade (1999 – 2011) and this review has been presented in [1, 2, 3]. The comparison is presented in Table 9.

Table 9: Comparison of NFPEM with Existing DSSA Performance Evaluation Models *(Source: [3]).*

S/N	Parameters used for comparison	Existing DSSA Performance Models	Proposed Model (NFPEM)
1.	Variables used for evaluation	Machine variables	Organizational variables
2.	Nature of evaluation variables	Objective	Subjective
3.	Evaluation Techniques	Hard computing and soft computing techniques	Soft computing techniques
4.	Involvement of users	No user involvement	Users are actively involved
5.	Source of data	DSS processes and the computer systems that runs the software system processes	Users of the DSS
6.	Performance metrics	System throughput, response time of system, resource utilization, turnaround time, latency of system, error rate. The listed metrics are tied to the machine conditions).	System responsiveness. This metric is tied to the organizational services defined during requirement definition stage of the software life cycle.
7.	Goal	To establish the extent to which the DSSA satisfies machine requirements defined for it to run.	To establish the extent to which the DSSA respond to the organizational (end user) services.
8.	Mapping DSSA components with organizational variables	None of the models does this.	This was done: $\boldsymbol{y_j} = f(x_1, x_2, x_3 ... x_k)$; where $\boldsymbol{y_j}$ is the j^{th} DSSA component mapped with the organizational variables; $x_1, x_2, x_3 ... x_k$

V. CONCLUSION AND POLICY IMPLICATIONS

In developing a software system, the software developers do not only have to develop the system in a professional manner, but also need to ensure that the software system satisfies the performance requirements of the client and all users of the software. The users' requirements definition guides the software architect in the course of designing the system architecture. However, in practice, total involvement of end users in all phases of software development process is not given utmost priority. Various empirical research works had established the gap between software developers and end users and the negative effect on system acceptability and usability.

In this research work, we did case simulation of NFPEM, which permits the users to evaluate the DSSA performance based on the organizational variables in order to measure the extent to which the DSSA respond to the organizational (end user) requirements. This is unlike the existing machine-centric performance evaluation models that evaluate DSSA performance using machine parameters in order to establish the extent to which the DSSA meet the defined machine requirements needed for it to run efficiently on the machine. NFPEM was simulated using JAVA programming language and the assessment data were collected from the users of DSS in four universities, which produced performance values of 0.8640, 0.5672, 0.8820 and 0.8680 respectively. This implies that, the users ascertained by their rating that the responsiveness of the DSSAs of the universities to the organizational requirements was about 86.40%, 56.72%, 88.20% and 86.80% respectively.

Evaluating performance of DSSA on the bases of the user requirement parameters and other management input parameters produces results that could serve as guides for the software performance engineers to advise the client organization and also advise the software system developer before implementing the architecture. Therefore, the significant contributions of this research are as follows: i). The use of organizational variables in DSSA performance evaluation model has been established; ii). The developed neuro-fuzzy based user-centric model can be used to evaluate the DSSA of any given organization.

Since users' decision variables are significant to designing software system architecture, it is recommended that the performance of software architecture is also evaluated based on the decision variables of the users in the client organization with the view of establishing if the software system satisfies the needs of the users. Therefore, the model developed in this work is made to be user-oriented and is recommended as a tool for the software performance engineers (SPE). Evaluating software system architecture using this model enables the SPE know the extent to which the system architecture can carry out the operations of the client organization. This information will guide the SPE in advising the management of the client organization accordingly as regards the software system project.

The general guidance on specifying user and organizational requirements and objectives in system development is provided in ISO 13407. This states that the following elements should be covered in the specification [45]:

a. Identification of the range of relevant users and other personnel in the design.
b. Provision of a clear statement of design goals.
c. An indication of appropriate priorities for the different requirements.
d. Provision of measurable benchmarks against which the emerging design can be tested and evaluated.
e. Evidence of acceptance of the requirements by the stakeholders or their representatives.
f. Acknowledgement of any statutory or legislative requirements, for example, for health and safety.
g. Clear documentation of the requirements and related information. Also, it is important to manage changing requirements as the system develops.

User-Centric Model (UCM) is a process that takes account of the end-users of a system. It conforms to the human-centered design process defined in ISO 13407. Brief description of ISO 13407 is presented in Appendix C. System modelling using user-centered approach increases user acceptability of system, improves the productivity of users and reduces the time and cost of training and also cost of documentation and support are minimized.

This research work embraced human-centered paradigm and thus developed a user-centric model that emphasized the direct involvement of users in the evaluation of DSSA performance. Listed below are the ways that the developed model conforms to the international policy defined in ISO 13407 as per the involvement of the end users in the evaluation of system design:

a. Development of performance assessment form that contains the identified significant organizational variable. The form is to be completed by the DSS users and this shows an active involvement of users in the evaluation exercise.
b. The organizational variable defined in the model state the significant organizational requirements that pertains to the end users, government policy on information flow and exchange internally and externally, information and system security issues.
c. The use of fuzzy functions handles the subjectivity that comes with human judgement of the system performance.
d. The model produces a definite result for system performance.
e. The model evaluates the system design against the requirement of the client organization. This involves the real end users assessing the system design.

ISO 13407 standard provides the guide for system development policy makers, the system developers and the users in human-centered design paradigm.

Appendix A

SOFTWARE PERFORMANCE ASSESSMENT FORM

As an end-user of Distributed Software System (DSS), you are requested to examine each item in terms of suitability and then to tick the degree of your agreement to each item whether, in your opinion, your organization's DSS meets your requirements. You are also expected to indicate your confidence level (rating confidence) for each item. Your rating confidence value range between 1 – 10. Highest valua of rating confidence level is 10 and the least confidence level is 1. Your in-time response will be appreciated. Please, use the scale below to mark (√) your response in the area provided.

	Items	**Strongly Satisfied**	**Satisfied**	**Fairly Satisfied**	**Dissatisfied**	**Strongly Dissatisfied**	**Rating Confidence (1 – 10)**
1	The DSS of your organization satisfies all communication rules that are established to relate with external organizations						
2	The DSS of your organization satisfies the laid down communications rules and semantics for the units within the organization to relate						
3	The DSS of your organization provides friendly features that gear the willingness of the users to embrace its usage						
4	The DSS of your organization supports the IT infrastructure that are available in the organization						
5	The DSS of your organization is developed within the limit of the organization’s budget for it						
6	The feasibility study done by the DSS project team in your organization is adequate						
7	The DSS of your organization supports the expected size of the organization database						
8	Your organization’s policies for interoperability are meet by the DSS						
9	Your organization’s data structure is well mapped with the business entities and services						
10	The DSS of your organization meets the users’ data input format and also the report format						
11	The data input validation procedure defined by your organization is satisfied by the DSS						
12	Your organization’s DSS developers have a good understanding of the organization’s task and goal.						
13	The DSS of your organization adequately represents the organization’s defined internal services and their relationships						
14	The Professional qualifications of the users are put into consideration in the course of developing your organizations’ DSS						
15	The Academic qualification of the users are put into consideration in the course of developing your organization’s DSS						
16	The users are involved in the feasibility study carried out for the DSS project of your organization						
17	The users are involved while designing the DSS						
18	The users are involved in the DSS operations						
19	The DSS of your organizations supports the expected number of users						
20	The DSS satisfies the expected thinking time of users						
21	The DSS meets the information requirements of the users						
22	The DSS meets the goal and objectives of the organization						

23	The DSS satisfy the organization laid down rules/policies for transaction flow						
24	The DSS satisfies the organization's requirements for the user interface						
25	The user's access right is well implemented by the DSS						
26	Business rules associated with your organization's data are implemented by the DSS						
27	The DSS implements all the data security measures put in place in your organization						
28	The DSS implements your organization's data flow procedure						
29	The DSS implements the defined timeout for all the services in your organization						
30	The DSS carries out the services requested by your organization from other external organizations						
31	The DSS implements the message contract for communication between organizations						

Appendix B

1. BELLS UNIVERSITY OF TECHNOLOGY, OTA, OGUN STATE, NIGERIA (BELLSTECH)
   Organizational Variable: Validation procedure defined for input data by the organization (DVSC)

Respondents	Rated Values (DVSC-x_{11})	Normalized Rating Conf. (□ □_DVSC)	Adjusted Rated Values			Fuzzy Values			Defuzzified Value
			□c	□b	□a	U(□c)	U(□b)	U(□a)	
1	4	1.00	4.50	4.00	3.50	0.86	1.00	0.63	4.05
2	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
3	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
4	3	1.00	3.50	3.00	2.50	0.63	1.00	0.70	2.98
5	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
6	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
7	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
8	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
9	3	1.00	3.50	3.00	2.50	0.63	1.00	0.70	2.98
10	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
11	3	1.00	3.50	3.00	2.50	0.63	1.00	0.70	2.98
12	4	1.00	4.50	4.00	3.50	0.86	1.00	0.63	4.05
13	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
14	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
15	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
16	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
17	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
18	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
19	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
20	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
21	3	0.91	3.19	2.73	2.28	0.55	0.65	0.75	2.68
22	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
23	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
24	3	0.76	2.66	2.28	1.90	0.67	0.74	0.42	2.33

25	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
26	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
27	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
28	2	0.76	1.90	1.52	1.14	0.42	0.50	0.57	1.48
29	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
30	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
31	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
32	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
33	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
34	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
35	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
36	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
37	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
38	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
39	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
40	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
41	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
42	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
43	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
44	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
45	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
46	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
47	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
48	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
49	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
50	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
51	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
52	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
53	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
54	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
55	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
56	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
57	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
58	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
59	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
60	4	0.61	2.75	2.44	2.14	0.65	0.71	0.77	2.42
61	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
62	4	0.61	2.75	2.44	2.14	0.65	0.71	0.77	2.42
63	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
64	4	0.61	2.75	2.44	2.14	0.65	0.71	0.77	2.42
65	4	0.61	2.75	2.44	2.14	0.65	0.71	0.77	2.42
66	3	0.47	1.65	1.41	1.18	0.47	0.52	0.57	1.40
67	4	0.34	1.53	1.36	1.19	0.49	0.53	0.56	1.35
68	5	0.34	1.87	1.70	1.53	0.43	0.46	0.49	1.69
69	3	0.34	1.19	1.02	0.85	0.56	0.60	0.15	1.07

70	4	0.34	1.53	1.36	1.19	0.49	0.53	0.56	1.35
71	4	0.34	1.53	1.36	1.19	0.49	0.53	0.56	1.35
72	4	0.34	1.53	1.36	1.19	0.49	0.53	0.56	1.35
73	4	0.34	1.53	1.36	1.19	0.49	0.53	0.56	1.35
74	5	0.34	1.87	1.70	1.53	0.43	0.46	0.49	1.69
75	5	0.34	1.87	1.70	1.53	0.43	0.46	0.49	1.69

2. COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA (CU)
Organizational Variable: Validation procedure defined for input data by the organization (DVSC)

Respondents	Rated Values ($DVSC-x_{11}$)	Normalized Rating Conf. □ □_DVSC)	Adjusted Rated Values			Fuzzy Values			Defuzzified Value
			□c	□b	□a	U(□c)	U(□b)	U(□a)	
1	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
2	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
3	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
4	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
5	3	1.00	3.50	3.00	2.50	0.63	1.00	0.70	2.98
6	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
7	3	1.00	3.50	3.00	2.50	0.63	1.00	0.70	2.98
8	4	1.00	4.50	4.00	3.50	0.86	1.00	0.63	4.05
9	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
10	4	1.00	4.50	4.00	3.50	0.86	1.00	0.63	4.05
11	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
12	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
13	3	0.91	3.19	2.73	2.28	0.55	0.65	0.75	2.68
14	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
15	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
16	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
17	3	0.91	3.19	2.73	2.28	0.55	0.65	0.75	2.68
18	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
19	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
20	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
21	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
22	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
23	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
24	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
25	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
26	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
27	4	0.76	3.42	3.04	2.66	0.61	0.51	0.67	3.03
28	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
29	4	0.76	3.42	3.04	2.66	0.61	0.51	0.67	3.03
30	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
31	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
32	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
33	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94

34	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
35	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
36	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
37	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
38	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
39	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
40	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
41	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
42	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
43	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
44	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
45	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
46	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
47	4	0.61	2.75	2.44	2.14	0.65	0.71	0.77	2.42
48	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
49	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
50	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
51	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
52	4	0.61	2.75	2.44	2.14	0.65	0.71	0.77	2.42
53	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
54	4	0.61	2.75	2.44	2.14	0.65	0.71	0.77	2.42
55	5	0.61	3.36	3.05	2.75	0.59	0.51	0.65	3.04
56	4	0.22	0.99	0.88	0.77	0.01	0.12	0.23	0.81
57	5	0.22	1.21	1.10	0.99	0.56	0.58	0.01	1.15
58	4	0.22	0.99	0.88	0.77	0.01	0.12	0.23	0.81
59	4	0.22	0.99	0.88	0.77	0.01	0.12	0.23	0.81
60	4	0.22	0.99	0.88	0.77	0.01	0.12	0.23	0.81
61	3	0.09	0.32	0.27	0.23	0.69	0.73	0.78	0.27
62	2	0.09	0.23	0.18	0.14	0.78	0.82	0.87	0.18
63	4	0.09	0.41	0.36	0.32	0.60	0.64	0.69	0.36
64	5	0.09	0.50	0.45	0.41	0.51	0.55	0.60	0.45
65	5	0.09	0.50	0.45	0.41	0.51	0.55	0.60	0.45

3. UNIVERSITY OF LAGOS, AKOKA, LAGOS STATE, NIGERIA (UNILAG)
Organizational Variable: Validation procedure defined for input data by the organization (DVSC)

Respondents	Rated Values (DVSC-x_{11})	Normalized Rating Conf. □ □_DVSC)	Adjusted Rated Values			Fuzzy Values			Defuzzified Value
			□c	□b	□a	U(□c)	U(□b)	U(□a)	
1	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
2	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
3	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
4	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
5	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
6	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
7	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69

8	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
9	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
10	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
11	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
12	5	0.86	4.73	4.30	3.87	0.91	0.82	0.72	4.33
13	5	0.86	4.73	4.30	3.87	0.91	0.82	0.72	4.33
14	5	0.86	4.73	4.30	3.87	0.91	0.82	0.72	4.33
15	4	0.86	3.87	3.44	3.01	0.72	0.61	0.50	3.49
16	3	0.76	2.66	2.28	1.90	0.67	0.74	0.42	2.33
17	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
18	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
19	3	0.76	2.66	2.28	1.90	0.67	0.74	0.42	2.33
20	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
21	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
22	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
23	2	0.76	1.90	1.52	1.14	0.42	0.50	0.57	1.48
24	5	0.76	4.18	3.80	3.42	0.80	0.70	0.61	3.83
25	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
26	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
27	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
28	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
29	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
30	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
31	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
32	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
33	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
34	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
35	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
36	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
37	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
38	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
39	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
40	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
41	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
42	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
43	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
44	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
45	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
46	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94

4. LAGOS STATE UNIVERSITY, OJO, LAGOS STATE, NIGERIA (LASU)
Organizational Variable: Validation procedure defined for input data by the organization (DVSC)

Respondents	Rated Values (DVSC-x_{11})	Normalized Rating Conf. □ □_DVSC)	Adjusted Rated Values			Fuzzy Values			Defuzzified Value
			□c	□b	□a	U(□c)	U(□b)	U(□a)	

1	4	1.00	4.50	4.00	3.50	0.86	1.00	0.63	4.05
2	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
3	4	1.00	4.50	4.00	3.50	0.86	1.00	0.63	4.05
4	5	1.00	5.50	5.00	4.50	0.00	1.00	0.86	4.77
5	4	1.00	4.50	4.00	3.50	0.86	1.00	0.63	4.05
6	5	0.96	5.28	4.80	4.32	0.00	0.92	0.82	4.57
7	4	0.96	4.32	3.84	3.36	0.82	0.71	0.59	3.89
8	4	0.96	4.32	3.84	3.36	0.82	0.71	0.59	3.89
9	4	0.96	4.32	3.84	3.36	0.82	0.71	0.59	3.89
10	5	0.96	5.28	4.80	4.32	0.00	0.92	0.82	4.57
11	5	0.96	5.28	4.80	4.32	0.00	0.92	0.82	4.57
12	5	0.96	5.28	4.80	4.32	0.00	0.92	0.82	4.57
13	5	0.96	5.28	4.80	4.32	0.00	0.92	0.82	4.57
14	4	0.96	4.32	3.84	3.36	0.82	0.71	0.59	3.89
15	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
16	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
17	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
18	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
19	5	0.91	5.01	4.55	4.10	0.00	0.87	0.78	4.34
20	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
21	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
22	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
23	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
24	4	0.91	4.10	3.64	3.19	0.78	0.66	0.55	3.69
25	5	0.86	4.73	4.30	3.87	0.91	0.82	0.72	4.33
26	5	0.86	4.73	4.30	3.87	0.91	0.82	0.72	4.33
27	4	0.86	3.87	3.44	3.01	0.72	0.61	0.50	3.49
28	4	0.86	3.87	3.44	3.01	0.72	0.61	0.50	3.49
29	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
30	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
31	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
32	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
33	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
34	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
35	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
36	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
37	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
38	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
39	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
40	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
41	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
42	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
43	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94
44	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
45	4	0.74	3.33	2.96	2.59	0.58	0.61	0.68	2.94

46	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
47	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
48	5	0.74	4.07	3.70	3.33	0.77	0.68	0.58	3.73
49	5	0.09	0.50	0.45	0.41	0.51	0.55	0.60	0.45
50	4	0.09	0.41	0.36	0.32	0.60	0.64	0.69	0.36
51	5	0.09	0.50	0.45	0.41	0.51	0.55	0.60	0.45

Appendix C
ISO 13407: Human Centred Design Process for Interactive Systems

(URL Sources: http://www.ash-consulting.com/ISO13407.pdf; http://www.userfocus.co.uk/resources/iso9241/iso13407.html; http://www.usabilityfirst.com/glossary/iso-13407-human-centered-design-process/; http://zonecours.hec.ca/documents/A2007-1-1395534.NormeISO13407.pdf)

Definition:

ISO 13407 is a description of best practice in user centered design. It provides guidance on design activities that take place throughout the life cycle of interactive systems. It describes an iterative development cycle where product requirements specifications correctly account for user and organizational requirements as well as specifying the context in which the product is to be used. Design solutions are then produced which can be evaluated by representative users, against these requirements.

The goal of the standard is to ensure that the development and use of interactive systems take account of the needs of the user as well as the needs of the client organization (owner of system) and the system developer.

The standard applies to software products, hardware/software systems, websites and services.

Status: International Standard.

Lifecycle Phase:

The standard specifies an iterative cycle of these 4 activities:

a. specify the context of use
b. specify the user and organizational requirements
c. produce design solutions
d. evaluate designs against requirements

Type of Guidance: Principles and general recommendations.

Scope:

This influential standard is "aimed at those managing the design process" and is now increasingly used to ensure software quality.

The standard describes four principles of human-centered design:

a. Active involvement of customers (or those who speak for them).
b. Appropriate allocation of function (making sure human skill is used properly).
c. Iteration of design solutions (therefore allow time in project planning).
d. Multi-disciplinary design (but beware overly large design teams).

The standard also describes four key human-centered design activities:

a. Understand and specify the context of use (make it explicit – avoid assuming it is obvious).
b. Specify user and socio-cultural requirements (note there will be a variety of different viewpoints and individuality).
c. Produce design solutions (note plural, multiple designs encourage creativity).
d. Evaluate designs against requirements (involves real customer testing not just convincing demonstrations).

The standard itself is generic and can be applied to any system or product.

Audience: Anyone that wants to introduce usability processes into a project or organization.

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