Customer Satisfaction based Demand Analysis of Mobile Services

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Abstract – **The rapid technology growth of the mobile networks has led to the situation where the competition for each one customer became a great importance. The customer satisfaction is increasingly attended to the quality, to the performance and to the usefulness of the services. These are in nature different characteristics and their complex evaluation requires implementation of new methods and tools such as fuzzy logic and fuzzy evaluation schemes. The paper proposes an approach for analyzing the customer demand on mobile services according their satisfaction with these services. The demand analysis is object of fuzzy evaluation approach based on the customer value hierarchy.**

Keywords – **Customer Satisfaction, Fuzzy Evaluation, Mobile Services, Significant Attribute Definition.**

I. INTRODUCTION

There are many known attempts for creating a methods and models for meeting the improved customer requirements according the service quality. All of them requires considerable preparation before the evaluation schemes are implemented. The first step of the whole evaluation process is the definition of an appropriate customer experience model in order to find out the customer's goal and purpose, the desired consequences in use situation and the desired products/ services attributes and performances [1]. In the same work an exemplary "mobile customer value hierarchy" was defined. In [2] the author introduces an overall demonstration of the applicability of fuzzy evaluation method for Service Level Management metrics.

There are not many similar researches in the field of the customer centric evaluation. In [3] the authors use the fuzzy similarity approach for clustering the QoS opinions for Web services. In [4] a fuzzy oriented approach for clustering of the services attributes and for definition of the most significant of these attributes is introduced. The research is based on the customer demand in personalized services. In [5] the authors apply fuzzy evaluation of SLA (Service Level Agreement) oriented quality metrics in NGN. All mentioned research works are based on hypothetical values, and not on real data and are only used for proving the applicability of the fuzzy logic in such complex evaluation problems.

This work is an extension of [6]. In the work mentioned, the authors attempt to apply the fuzzy evaluation approach to the customer experience hierarchy in order to evaluate the customer satisfaction with a defined number of services. The experiment included a wide study over three groups of mobile services users, conducted at the Technical University of Sofia. The three target groups were the university teachers, the administration and students. These groups are being chosen because of the differences in age, in job, in activity of service use etc.

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II. CUSTOMER VALUE HIERARCHY AND ATTRIBUTES DEFINITION

A. The mobile customer value hierarchy

Based on the complete chain of customer value layers, the first step in the procedure is to shift the layers from the individual perspective to the aggregate perspective of a group of customers. Based on the mobile customer investigation, an model for constructing the mobile customer value hierarchy is introduced [1].

B. Attributes definition

In order to apply the fuzzy evaluation of the customer satisfaction the following investigation where performed: Three different groups of mobile users where asked about the services mentioned above – teachers, administration staff and students. Each group covers 100 people. The questionnaire includes four questions according each of the services:

1. Do You use the service …….?
2. How could You evaluate the service?
3. Could You evaluate service parameters?

The answers on the questions 1 and 3 are "Yes" and "No". The answers on the question 2 include different evaluation levels. The evaluation is defined with 5 evaluation levels – from 1 to 5. Table I shows the results of the answers on the first question and the corresponding coding for each service. The values give the number of the group members which are engaged with the corresponding service.

In [6] these definitions were used for calculating the customer satisfaction score - S. For the three groups being studied it was obtained:

Satisfaction Score S (Teachers) = 3.0333;
Satisfaction Score S (Administration) = 2,994157;
Satisfaction Score S (Students) = 3,005901.

That means – the group "Teachers" has the higher satisfaction score with the services have being studied.

TABLE I
EVALUATION METRICS SERVICE USAGE

No.	Attributes	Votes	Code
1	Voice mail box	Teachers – 57 Administration – 76 Students - 87	S1
2	SMS	Teachers – 78 Administration – 89 Students - 92	S2
3	Voice call	Teachers – 100 Administration – 100 Students - 100	S3
4	Conference call	Teachers – 14 Administration – 2 Students - 34	S4
5	Routine Services	Teachers – 82 Administration – 91 Students - 89	S5
6	E-Bank	Teachers – 8 Administration – 11 Students - 13	S6
7	Data Service	Teachers – 23 Administration – 8 Students - 47	S7
8	Mobile Purchase	Teachers – 26 Administration – 18 Students - 55	S8
9	Internet browsing	Teachers – 42 Administration – 32 Students - 70	S9
10	Mobile movie	Teachers – 4 Administration – 28 Students - 65	S10
11	Mobile games	Teachers – 4 Administration – 12 Students - 75	S11
12	MMS	Teachers – 34 Administration – 52 Students - 78	S12
13	Travel Info	Teachers – 5 Administration – 11 Students - 23	S13
14	Entertainment Info	Teachers – 6 Administration – 14 Students - 19	S14
15	Finance Info	Teachers – 9 Administration – 32 Students - 11	S15

In this work we will follow other way – further decomposition of the attributes defined above into most important quality parameters of each one service, represented as attribute in the value hierarchy. The number of parameters for each service is limited on 5, but it can be higher or respectively lower.

Table II represents 5, randomly chosen services and their quality characteristics. We choose only 5 services in order to make the work more understandable and clear. We suppose that when the approach is proven with smaller number of services, it will become applicable for great amount of services too. Each characteristic is presented with unique code.

TABLE II
SERVICE QUALITY PARAMETERS

No.	Objectives	Attributes	Code
1	Voice mail box (S1)	Message duration Number of messages to be stored Number of rings before start VoiceMailBox Broken messages Speech quality	S11 S12 S13 S14 S15
2	SMS (S2)	Message length Message validity Number of messages to be stored Multi-user send message Service coverage	S21 S22 S23 S24 S25
3	Voice call (S3)	Service coverage Speech quality Second voice call during conversation	S31 S32 S33
4	Conference call (S4)	Service coverage Speech quality Number of participants Service control	S41 S42 S43 S44
5	Data Service (S7)	Down speed Up speed Lost data Service coverage	S71 S72 S73 S74

Table 2 is produced with applying the proposed in this work Attribute – objective map. This means: uncover the relationship between quality parameters that the customers engaged (attributes layer) and the used services (objective layer). That approach enables the mobile provider to identify the customer's goal from their consume history. So we reduce the layers in the customer value hierarchy to an attribute – objective map. We discovered attributes that are equal to more than one objective – for example: Speech quality.

So we obtained 21 service quality parameters. The main goal of the following analysis is to find out the most important parameters that are significant not only for the corresponding service but for the overall quality grade of the delivered services too.

C. Significant Attributes Analysis

The significant attributes of customer value hierarchy are the key attribute variables of the attribute layer which distinctly correlate to the objective layer. Because of the large numbers of mobile telecommunication products/services and the relatively small percentage of the mobile services/products engagement, the original data of customer value hierarchy is high dimensional sparse feature data. This paper adopts the fuzzy cluster analysis method [7] to find the significant attribute.

According to the rough set theory, data of the customer value objective layer and attribute layer can be defined as $S=(U, A, V, f)$. Here: $U=\{u_1, u_2, \ldots, u_n\}$: the set of customers where n is the total number of customers. $A=\{a_1, a_2, \ldots, a_m\}$: the set of variables of the objective layer and of the attribute layer. $A = C \cup D$, where C is the characteristics set of the attribute layer, and D is the characteristics set of the objective layer. V is the set of the customer attribute parameters. The value of $f(u_j, a_i)$ indicates the value of u_j about a_i.

The significant attributes analysis is solved by fuzzy clustering [8]. The process of the analysis includes the following steps:

Step1. Calculate the similarity matrix for the attributes. The pair-wise comparison method is used to obtain the values of the corresponding element a_{ij}, where ($i=1,2, \dots,k$ and $j=i+1, i+2,\dots,i+(k-1)$). The values of a_{ji} are obtained as $1-a_{ij}$. Here k is the number of the attributes for the corresponding objective.

Step2. Calculate the fuzzy similarity matrix R. As shown in equation (1) the research adopts the cosine distance measure as the method of similarity measurement of the study objects.

$$r_{ij} = \sum_{k=1}^{m} (a_{ik} a_{jk})^2 \Big/ \sqrt{\sum_{i=1}^{m} a_{ik}^2 \sum_{j=1}^{m} a_{jk}^2} \qquad (1)$$

During the study the calculation of the fuzzy similarity matrix R using Euclidian Distance measure was performed as well. The results obtained where almost the same and will be not shown here.

Step3. Calculate the fuzzy transitive closure $t(R)$ of the fuzzy similarity matrix R with the square method [9]. If the fuzzy similarity matrix can be expressed as $R = (r_{ij})_{nxn}$, then

$$R \circ R = (t_{ij})_{nxn} \qquad \max_{k=1 \text{ to } n}(\min(r_{ik}, r_{kj})) \qquad (2)$$

If $[R]^{2^k} \circ [R]^{2^k} = [R]^{2^k}$, then the fuzzy transitive closure $[t(R)] = [R]^{2^k}$.

Use the cluster method to analyze $t(R)$ with intercept λ and determine the significant attributes set.

III. DATA ANALYSIS

The investigation gave 300 questionnaires out to the individual mobile customers. The questionnaire enumerates the quality parameters of the attribute layer corresponding to a given service of the objective layer. For each service on of the objective layer the number of the customers that use the service is given and on the attribute layer - the number of users that have evaluate the corresponding attribute. The results obtained by the investigation of all three groups are shown in the following Table III. The number of answers for each attribute gives the relative importance of the corresponding attribute in the group. This relative importance is used as a weight of the attribute for the calculation of the fuzzy set values.

The calculation procedure is as follows:

Step 1. For each one group, after partitioning A into C and D the membership degree of each one attribute is calculated. For example: For the service 1 (S1) in group "Teachers" and the corresponding service attributes the following set A is obtained: There are 57 (N = 57) positive answers on the above question 1. This is equal to 0,19 ($K = N/N_{all}$) of all participants in this study. Then the number of the positive answers on question 3, related to K is calculated. So the weight of each one attribute value is defined.

The elements in set A are calculated according the pair-wise[10] comparison of the attribute value with respect to the

TABLE III
INVESTIGATION RESULTS – GROUPS "TEACHERS", "ADMINISTRATION", "STUDENTS"

	Teachers		Administration		Students	
No.	Objectives	Attributes	Objectives	Attributes	Objectives	Attributes
1	S1 - 57	S11 – 31 S12 – 11 S13 – 5 S14 – 24 S15 – 55	S1 - 76	S11 – 44 S12 – 21 S13 – 31 S14 – 25 S15 – 48	S1 - 87	S11 – 54 S12 – 43 S13 – 56 S14 – 44 S15 – 48
2	S2 - 78	S21 – 77 S22 – 65 S23 – 71 S24 – 45 S25 – 76	S2 - 89	S21 – 69 S22 – 75 S23 – 77 S24 – 58 S25 – 82	S2 - 92	S21 – 88 S22 – 74 S23 – 70 S24 – 66 S25 – 87
3	S3 – 100	S31 – 99 S32 – 93 S33 – 45	S3 – 100	S31 – 90 S32 – 75 S33 – 80	S3 – 100	S31 – 100 S32 – 98 S33 – 100
4	S4 - 14	S41 – 7 S42 – 11 S43 – 8 S44 – 6	S4 - 2	S41 – 1 S42 – 2 S43 – 0 S44 – 1	S4 - 34	S41 – 13 S42 – 12 S43 – 14 S44 – 12
5	S7 - 23	S71 – 15 S72 – 16 S73 – 21 S74 – 19	S7 - 8	S71 – 5 S72 – 8 S73 – 4 S74 – 3	S7 - 47	S71 – 31 S72 – 30 S73 – 18 S74 – 42

weight of the attribute values:

$$a_{ij} = \frac{e^{\delta_j - \delta_i}}{1 + e^{\delta_j - \delta_i}} = \log it^{-1}(\delta_j - \delta_i), \qquad (3)$$

where δ_k is the scale location of object k and $logit^{-1}$ is the inverse $logit$ function.

Here the calculations for the group "Teachers" are shown:

So the fuzzy set A is obtained:

$$A = \begin{bmatrix} 1 & 0.56218 & 0.57444 & 0.54157 & 0.37754 \\ 0.43782 & 1 & 0.51250 & 0.47918 & 0.32082 \\ 0.42556 & 0.48750 & 1 & 0.46672 & 0.31003 \\ 0.45843 & 0.52082 & 0.53328 & 1 & 0.33924 \\ 0.62246 & 0.67918 & 0.68997 & 0.66076 & 1 \end{bmatrix} \qquad (4)$$

Then, on Step 2, the fuzzy similarity matrix R is calculated:

$$R = \begin{bmatrix} 1 & 0.95463 & 0.94595 & 0.95094 & 0.92991 \\ 0.95463 & 1 & 0.98009 & 0.96527 & 0.92442 \\ 0.94595 & 0.98009 & 1 & 0.95725 & 0.90856 \\ 0.95094 & 0.96527 & 0.95725 & 1 & 0.92817 \\ 0.92991 & 0.92442 & 0.90856 & 0.92817 & 1 \end{bmatrix} \qquad (5)$$

After that the transitive closure $[t(R)]$ for the set of parameters is calculated according equation (2). In all cases, being studied, the intercept λ is chosen from the values obtained for [t(R)].

$$[t(R)] = \begin{bmatrix} 1 & 0.95463 & 0.95463 & 0.95463 & 0.92991 \\ 0.95463 & 1 & 0.98009 & 0.96527 & 0.92991 \\ 0.95463 & 0.98009 & 1 & 0.96527 & 0.92991 \\ 0.95463 & 0.96527 & 0.96527 & 1 & 0.92991 \\ 0.92991 & 0.92991 & 0.92991 & 0.92991 & 1 \end{bmatrix} \qquad (6)$$

Here we can have the following values for **λ**. For each **λ** we can define the corresponding clusters of parameters:

λ=1 {S11},{S12},{S13},{S14},{S15}
λ=0.98009 {S12, S13},{S11},{S14},{S15}
λ=0.96527 {S12, S13, S14},{S11},{S15}
λ=0.95463 {S11, S12, S13, S14},{S15}
λ=0.92991 {S11, S12, S13, S14, S15}

Then we build the dynamic cluster diagram, from which the most significant parameters can be obtained. As shown on the figure below, for the group "Teachers", the most significant parameters of the service S1 – Voice mail box are the parameters coded as S12 and S13. All others parameters are concatenated one after another to the base cluster, built from these two parameters.

This dynamic cluster diagram can be implemented later as a model of deductive database for easier search of significant attributes also in cases of greater amount of parameters or in case of deeper investigation of the significant service parameters. An appropriate method for cost effective search in such database structures is the 2P-Method introduced in [11].

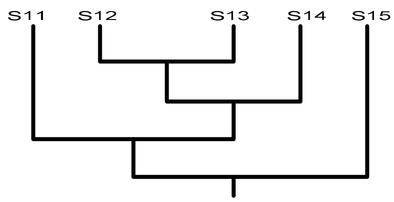

Fig. 1. Dynamic cluster diagram

Following the same steps the following calculation and results are achieved for all other services in correspondence to the services being studied.

TABLE IV
SIGNIFICANT PARAMETERS

Service	Group	λ	Parameter clusters	Significant Parameters
S1	Teachers	0.91577	{S11},{S12,S13},{S14},{S15}	S12, S13
	Administration	0.96807	{S11},{S12,S14},{S13},{S15}	S12, S14
	Students	0.95929	{S11},{S12,S14},{S13},{S15}	S12, S14
Final				**S12, S14**
S2	Teachers	0.96113	{S21},{S22,S24},{S23},{S25}	S22, S24
	Administration	0.96956	{S21,S24},{S22},{S23},{S25}	S21, S24
	Students	0.95954	{S21},{S22},{S23,S24},{S25}	S23, S24
Final				**S24**
S3	Teachers	0.93725	{S31, S33},{S32}	S31, S33
	Administration	0.85246	{S31}, {S32, S33}	S32, S33
	Students	0.86190	{S31, S33}, {S32}	S31, S33
Final				**S31, S33**
S4	Teachers	0.95469	{S41, S44}, {S42}, {S43}	S41, S44
	Administration	0.98709	{S41, S43, S44}, {S42}	S41, S43, S44
	Students	0.94694	{S42, S44}, {S41}, {S43}	S42, S44
Final				**S41, S44**
S7	Teachers	0.95217	{S71, S72},{S73},{S74}	S71, S72
	Administration	0.95968	{S71},{S72},{ S73, S74}	S73, S74
	Students	0.86853	{S72},{S71, S73},{ S74}	S71, S73
Final				**S71, S73**

Here, from all other calculations, only the highest grade of **λ**, the corresponding parameter clustering and the final result– the most significant parameters for all groups and services will be shown (Table IV).

IV. CONCLUSION

In this paper a fuzzy evaluation approach is introduced, used for definition of significant service parameters, that defines the customer satisfaction with the mobile services. The study has to be continued in order to evaluate the already defined significant attributes from the mobile operator point of view.

The correspondence of the evaluation results will be a good starting point for development of appropriate approaches, methods and tools for improving the grade and the effectiveness of the Customer Relationship Management and the Customer Experience Management.

REFERENCES

[1] Al. Tsenov, "Customer Experience Hierarchy Model", Proceedings of the XLV-th International Scientific Conference ICEST 2010, Ohrid, Macedonia, June 24 – 26, vol.1, pp. 77-80, 2010.

[2] Al. Tsenov, G. Yoncheva, E. Stoyanova and Al. Pavlov, "Fuzzy Evaluation of Service Level Management Metrics", XLVI-th International Scientific Conference ICEST 2011, Nish, Serbia, June 29 – July 01, presented paper, 2011

[3] W. Lin, C. Lo, K. Chao, and N. Godwin, "Fuzzy Similarity Clustering for Consumer-Centric QoS-aware Selection of Web Services", in Proc. CISIS 2009, pp. 904-909, 2009

[4] S. Yajing et al., "Customer Value Hierarchy Based Customer Demand Analysis In Personalized Service Recommender System", International Journal of Simulation, Vol. 7 No 7, ISSN 1473-0831 print, pp. 77-84, 2007

[5] Y. Danfeng, Y. Fangchun, "Fuzzy evaluation of SLA-oriented QoSM (The Quality of Service Management) in NGN", Proceedings of IC-BNMT, ISBN 978-1-4244-4591-2, pp. 301-305, IEEE, 2009

[6] Tsenov Al., I. Ivanov, T. Poparova, S. Neykov, L. Ivanova, M. Gadjeva, "Fuzzy evaluation of customer satisfaction with mobile services", 10th International Conference TELSIKS 2011, vol. 2, pp. 665 – 668, October 5-8, Nish, Serbia,

[7] H. Jiang, "Fuzzy Evaluation on ERP System Implementing Risk Based on Membership Degree Transformation New Algorithm", Second International Symposium on Electronic Commerce and Security, Nanchang, China, May 22-May 24, pp 409-416, 2009

[8] Jordanova and V. Mladenov, "Fuzzy sets and computational intelligence", Lecture notes, Sofia University, 2005

[9] Sun Peide, " Novel Fuzzy Clustering Algorithm to Predict Gas Outburst Zone". Proceedings of the 2006 International Symposium on Safety Science and Technology, October 24-27, 2006 Changsha, Hu'nan, China

[10] David, H.A. (1988). The Method of Paired Comparisons. New York: Oxford University Press.B. Milovanovic, Z. Stankovic, S. Ivkovic and V. Stankovic, "Loaded Cylindrical Metallic Cavities Modeling using Neural Networks", TELSIKS'99, Conference Proceedings, pp.214-217, Nis, Yugoslavia, 1999.

[11] Iltchev V., Cost Evaluation of Methods for Query Processing in Deductive Database Systems, Information Technologies and Control, Vol. 5, No 1, 2007, pp. 10-20, ISSN:1312-2622, Bulgarian Union of Automation and Informatics, Sofia, Bulgaria,