Fuzzy Evaluation of Service Level Management Metrics

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Abstract – **SLM (Service Level Management) metrics, according the ITIL (Information Technology Infrastructure Library) framework, are the building blocks of the Service Level Management procedures. These metrics are the quantitative measure of the successful implementation of the SLM by the IT service providers. The evaluation of the whole SLM process is a complex problem that could not be fulfilled in regular way, such visual evaluation, because of the huge amount of process metrics. Moreover these metrics are different by the nature and are measured in different units (%, time, amount etc.) This paper introduces an appropriate fuzzy based approach for evaluating the SLM process metrics.**

Keywords – **Information Technology Infrastructure Library, Service Level Agreement, Service Level Management, Fuzzy logic, Customer Experience.**

I. Introduction

The quick development of new standards for delivery and support of IT services challenges the growth of the role of SLM generated and proposed according to the higher customer demand. From the other side that challenges the enterprises to look for new efficient approaches for delivering high quality service and higher level of ROI (Return of investments). Most of the enterprises have implemented the standards for design, delivery and support of managed services to their customer and now they search the most appropriate business conditions for itself in order to reduce cost and enhance the revenue [1],[2],[3].

In the field of the Information Technologies such an approach is the mapping of ITIL Procedures over known business process frameworks – such as eTOM [4]. Within that mapping the ITIL procedure metrics are well known, but the eTOM framework is being depicted only in three levels and only a small part of the business process metrics are conclusively defined. Until now the metrics according the SLM (Service Level Management) are not clarified. The difficulty ensues from the huge amount of services delivered and from the different points of view for the quality of these services – the technological characteristics (from the enterprise side) and perception level (from the customer side). Both views on one and the same service characteristics should be met on an interface between the enterprise and the customers where the technical parameters of the quality could be easy adopted to the customer perception and vice versa – the SLA.

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The main goal of this work and next works as well, is to propose a fuzzy similarity based approach for evaluation and clustering the Service Level Management parameters of the services in mobile networks. The approach moves toward two threads – service centric (evaluation) and customer centric (clustering) of the SLM metrics. This work will represent the first of these processes – the fuzzy evaluation of the SLM metrics.

The nature of the requirements and the defined metrics for evaluation of the IT Service management is the precondition for choosing the Fuzzy set theory for solving such complex problems.

II. Evaluation of SLM Metrics

A. The SLM process

The SLM Process is responsible for negotiating Service Level Agreements, and ensuring that these are met. SLM is responsible for ensuring that all IT Service Level Agreements, Operational Level Agreements, and Under Pinning Contracts, are appropriate for the agreed Service Level targets [1],[2]. SLM monitors and reports on Service levels, and holds regular Customer reviews – Fig 1.

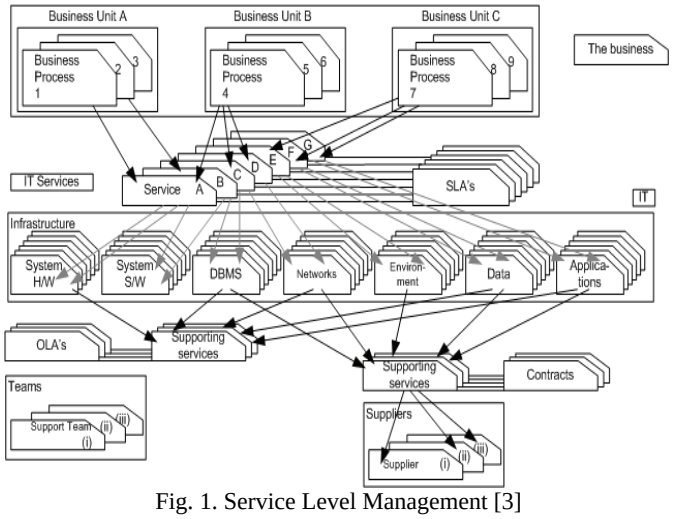

Fig. 1. Service Level Management [3]

Service Level Management (SLM) negotiates, agrees and documents appropriate IT service targets with representatives of the business, and then monitors and produces reports on the service provider's ability to deliver the agreed level of service. SLM is a vital process for every IT service provider organization in that it is responsible for agreeing and documenting service level targets and responsibilities within SLA's and SLR's (Service Level Requirements), for every activity within IT Service Delivery Process.

B. The SLM process metrics

The SLM process metrics are captured in the form of Critical Success Factors (CSFs), Key Performance Indicators (KPIs) and activity metrics for the service management processes [2], [3]. CSF would use these metrics as input in identifying improvement opportunities for each process. Some important metrics used for the evaluation process proposed in this work, are shown in Table 1.

TABLE 1
SLM EVALUATION METRICS FOR THE MOBILE NETWORKS SERVICES

No.	Characteristics	Description	Code
1	% of services covered by SLA	SC = ServCovered/AllServ x 100%	SL1
2	OLA's and UC's to support all SLA's	Contracts = OLA's + UC's	SL2
3	Service improvement measures	SIM = technical improvements + process&procedures+ "Quick wins"+ Training + dialogue	SL3
4	% of SLA targets being met	SLAm = SLAtargMet/ AllSLAtarg x 100%	SL4
5	Number of SLA targets on risk	SLAr = SLAtargRisk/ AllSLAtarg x 100%	SL5
6	Number of breaches per period	BR=1/T x ∑Br	SL6
7	Customer perceptions improvement	CustPercCurent = $CustPerc_{i+1}$ – $CustPerc_i$	SL7
8	Number of Service Improvement Plans (SIP's) Opened	SIPOp = ∑OpenedSIP	SL8
9	Number of SIP's closed	SIPCl = ∑ClosedSIP	SL9

The characteristics mentioned in the above Table 1 have the meaning as follows: "% of services covered by SLA" gives the coverage of the services with SLA. By most of the mobile network operators there are services which are delivered to the customers by default and aren't a part of the contract between the operator and the customer; "OLA's and UC's to support all SLA's" are the internal contracts (for the enterprise) and the contracts with external suppliers; "Service Improvement Measures" represents a number of activities fulfilled in order to evaluate the service improvement degree of the management process; "% of SLA targets being met" is a criterion for the accomplishment of the SLA have being contracted; "Number of SLA targets on risk" these are SLA targets not fulfilled for a definite time period and look like not feasible within the corresponding service delivery process; "Number of breaches per period" represent all breaches aroused in a period of time; "Customer perceptions improvement" gives the improvement of the satisfactory degree for each customer during the use of the service; "Number of Service Improvement Plans (SIP's) Opened" and "Number of Service Improvement Plans (SIP's) Closed" are measures for the reaction of the service provider in order to change the service characteristics in response to the customer demand.

In the following analysis, we simplify the description of the formula of the metrics – in most cases each characteristic includes a number of sub-characteristics. This simplification will not affect the method and conclusions of fuzzy evaluation method.

III. FUZZY EVALUATION OF SLM METRICS

A. The Fuzzy evaluation method

The following section describes the basic steps of the proposed fuzzy evaluation approach [5],[6]:

1. In an element set $U=\{u_1,u_2,u_3,\ldots,u_n\}$ each element denotes each characteristics in evaluation metrics of SLM process. The n means the number of characteristics in evaluation metrics.
2. Suppose that Evaluation set is $V=\{v_1,v_2,v_3,\ldots,v_m\}$. The m means the number of the evaluation levels. The value of evaluation is the degree of u_i to v_j.
3. Suppose that fuzzy matrix is $R=(r_{ij})_{mxn}$. The element r_{ij} means that the membership degree of the i-th element in set U to the j-th element in set V.
4. Suppose that set $A=\{a_1,a_2,a_3,\ldots a_n\}$ is the fuzzy matrix set of the weight of each characteristics – a_i means the weight of the element u_i in the set U. Set A is the calculation of the membership degree. This paper chooses the Pair-wise Comparison [5] method to calculate set A. The elements in set A satisfy normalization condition:

$$\sum_{i=1}^{n} a_i = 1 . \quad (1)$$

5. Suppose that the effect degree of evaluation set V element – a fuzzy matrix set is $B=\{b_1,b_2,b_3,\ldots b_m\}$. b_j means the weight of the evaluation decision in set V. The calculation of set B is by the equation: $b=a\circ R=\{b_1,b_2,b_3,\ldots,b_m\}$. "$\circ$" means compound algorithm operator (Adamar multiplication [7]).
6. The evaluation results of S is calculated in the following steps: In order to get the accurate calculation, the weight of each evaluation is calculated first by the following equation:

$$\delta_j = \frac{b_j}{\sum_{i=1}^{m} b_i}, j = 1,2\ldots m . \quad (2)$$

Then for each evaluation level v_j the total evaluation S is got from the following Equation:

$$S = \sum_{j=1}^{m} \delta_j v_j . \quad (3)$$

B. A practical example

The characteristics in Table 1 are evaluated according to the above fuzzy evaluation method. The key is how to get the membership degree set *A*. There are several known methods to calculate *A* [5]. The proposed approach concerns to a very new problem and therefore the Pair-wise Comparison method is chosen. That means – every two characteristic's membership degree is being compared to create the membership sequence with which fuzzy set *A* is abstracted.

Sequence relation in Table 2 is got from element set $U=\{u_1,u_2,u_3,u_4,u_5,u_6,u_7,u_8,u_9\}$. The result of the comparison of every two characteristics is shown. Because the most characteristics have different values for different services, Table 2 gives just an instance of relationships. The same method may be used for different situations as well.

TABLE 2
MEMBERSHIP DEGREE OF SLM EVALUATION METRICS

Item	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8	SL9
SL1	=	≥	≥	≤	≥	≥	≤	≤	≤
SL2	≤	=	≤	≤	≥	≥	≤	≤	≤
SL3	≤	≥	=	≤	≥	≥	≤	≤	≤
SL4	≥	≥	≥	=	≥	≥	≤	≤	≤
SL5	≤	≤	≤	≤	=	≤	≤	≤	≤
SL6	≤	≤	≤	≤	≥	=	≤	≤	≤
SL7	≥	≥	≥	≥	≥	≥	=	≥	≥
SL8	≥	≥	≥	≥	≥	≥	≤	=	=
SL9	≥	≥	≥	≥	≥	≥	≤	=	=

In the table "=" means that membership degrees to A of two characteristics are the same; "≥" means that the membership of SL_i to A is higher than that of SL_j to A; "≤" means that the membership degree of SL_i to A is lower than that of SL_j to A.

Set A is calculated from Table 2: $\forall u_i$, $u_i \in U$, let p_{ij} denotes the membership degree of u_i/A to u_j/A.

The rules to get p_{ij}:

$$0 \le p_{ij} \le 1; i, j = 1,2,... n; \quad (4)$$

$$p_{ij} + p_{ji} = 1; \forall i \ne j. \quad (5)$$

The fuzzy relation matrix (Eq. 6) is calculated according to Table 2 and Equations (4) and (5):

$$\begin{bmatrix} 1 & 0.6 & 0.6 & 0.4 & 0.6 & 0.6 & 0.4 & 0.4 & 0.4 \\ 0.4 & 1 & 0.4 & 0.4 & 0.6 & 0.6 & 0.4 & 0.4 & 0.4 \\ 0.4 & 0.6 & 1 & 0.4 & 0.6 & 0.6 & 0.4 & 0.4 & 0.4 \\ 0.6 & 0.6 & 0.6 & 1 & 0.6 & 0.6 & 0.4 & 0.4 & 0.4 \\ 0.4 & 0.4 & 0.4 & 0.4 & 1 & 0.4 & 0.4 & 0.4 & 0.4 \\ 0.4 & 0.4 & 0.4 & 0.4 & 0.6 & 1 & 0.4 & 0.4 & 0.4 \\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 1 & 0.6 & 0.6 \\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.4 & 1 & 1 \\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.4 & 1 & 1 \end{bmatrix} \quad (6)$$

The fuzzy set *A* is calculated by average method and for the given values for the p_{ij} the following values are obtained:

A = {0.556, 0.511, 0.533, 0.578, 0.467, 0.489, 0.644, 0.667, 0.667}.

The following set *A'* is the result to satisfy the normalization method:

A' = {0.108, 0.099, 0.105, 0.114, 0.091, 0.096, 0.125, 0.131, 0.131}.

According to the steps 1-3 of Section III.A and to the above calculations for the fuzzy set *A*, the following three SLM metric sets are evaluated:

U1 = {98, 97, 97, 98, 97, 97, 100, 99, 99};
U2 = {98, 98, 98, 98, 98, 98, 98, 98, 98};
U3 = {97, 96, 97, 98, 95, 96, 99, 98, 98}.

Evaluation set is *V* = {*Excellent, Very good, Good, Poor*} = {*100, 80, 60, 40*}. In Eq. 7, 8 and 9, the *R* matrices of the three systems, defined above by their SLM metrics, are described. Each matrix *R* is got from a method of expert's evaluation. We suppose that 100 experts give scores for each system. The number of experts for each evaluation level works as the element of matrix *R*. For instance: 0.99 in the first column means that 99 of the 100 expert gave "Excellent" to the corresponding metric.

$$\begin{bmatrix} 0.98 & 0.01 & 0.01 & 0.0 \\ 0.97 & 0.01 & 0.01 & 0.01 \\ 0.97 & 0.02 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \\ 0.97 & 0.01 & 0.01 & 0.01 \\ 0.97 & 0.01 & 0.01 & 0.01 \\ 1 & 0.0 & 0.0 & 0.0 \\ 0.99 & 0.01 & 0.0 & 0.0 \\ 0.99 & 0.0 & 0.01 & 0.0 \end{bmatrix} \quad (7)$$

$$\begin{bmatrix} 0.98 & 0.01 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \\ 0.98 & 0.02 & 0.0 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \end{bmatrix} \quad (8)$$

$$\begin{bmatrix} 0.97 & 0.01 & 0.01 & 0.01 \\ 0.96 & 0.02 & 0.01 & 0.01 \\ 0.97 & 0.02 & 0.01 & 0.0 \\ 0.98 & 0.02 & 0.0 & 0.0 \\ 0.95 & 0.02 & 0.02 & 0.01 \\ 0.96 & 0.01 & 0.02 & 0.01 \\ 0.99 & 0.0 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \\ 0.98 & 0.01 & 0.01 & 0.0 \end{bmatrix} \quad (9)$$

The calculation results of the corresponding sets B are as follows:

B1 = {0.98121, 0.00849, 0.00744, 0.00286};
B2 = {0.98000, 0.01096, 0.00904, 0.00000};
B3 = {0.97429, 0.01284, 0.01073, 0.00394}.

The three systems evaluation gene δ is calculated by set *B* and Eq. (2), then the total evaluation score ***S*** is calculated according the Eq. (3):

S1= 0.98121*100+0.00849*80+0.00744*60+0.00286*40 =
= **99,361**
S2= 0.9800*100 +0.01096*80+0.00904*60+0.0000*40 =
= **99,4192**
S3= 0.97429*100+0.01284*80+0.01073*60+0.00394*40 =
= **99,0776**

The conclusion from evaluation result of S is {**System-2, System-1, System-3**} in the sequence of service management quality from the best to the worst.

The same conclusion may be obtained through a visual analysis, but only if the score of metrics is not very complex. In this example we show that when the score of metrics is more complex, it is easier to get the evaluation result of service management quality using fuzzy evaluation algorithm than using direct analysis. In addition – in this example we have used only nine Service Level Management metrics. Actually the number of the SLM metrics, according the ITIL best practices, is much higher.

In this work we didn't made any classification of the metrics being evaluated. The fuzzy based approaches allow clustering of the metrics according common characteristics of the metrics (for example: unit of measurement). Such clustering will improve the complexity of the evaluation and therefore the use of fuzzy based handling is almost obligatory.

The proposed approach is open for future enhancement – firstly: there is no limitation of the number of the metrics to be evaluated, and secondly – it is possible to implement other methods for producing the relation matrices, such as cosine distance, Euclidean distance etc.

IV. Conclusion

Service management is very important for service provision in correct, effective and economic way. This paper analyzes the increasing service management requirement and points out that the evaluation metrics of service management quality is valuable and useful to improve and evaluate service management.

Based on the analysis and reference of SLA service management content, the evaluation metrics of SLA-oriented service management quality is presented. Then fuzzy evaluation method is used to evaluate service management quality. The process of fuzzy relation matrix *A'* calculation based on Pair-wise Comparison and the calculation of evaluation result is also illustrated. A simple example is explained to illuminate that fuzzy evaluation method is valid and correct. The metrics evaluation is a foundation to extend and to improve for different requirements and the evaluation algorithm can be amended to adapt multiple complexities.

Because the research to the evaluation of Quality of Service Management just begins, a lots of research work is required to do. Moreover the customer – centric evaluation is also required in order to "translate" the customer satisfaction into service quality parameters. So the service providers will be able to monitor and manage the service quality in response to the customer experience.

Acknowledgement

This work is established within a frame-contract between the Faculty of Telecommunications at the Technical University of Sofia and Mobiltel AD – Bulgaria.

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