Maintainability of Object- Oriented Software Metrics with Analyzability

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Abstract

Design and Analysis places crucial role in establishing the models of the software Maintainability. Understandability, Modifiability and Analyzability are the Maintainability factors with UML specifications of the class diagrams in object-oriented design (OOD). In this paper we include two more levels one is at the lowest and another one is at the highest level for judging the levels of Maintainability factors effectively. With the help of total 9 levels we estimated the models for Understandability, Modifiability, Analyzability and Maintainability. Two-tailed t-test was used in these models for identifying the significant metrics for the model estimation.

Keywords: *Software Maintainability, Analyzability, Modifiability, Understandability, OOD, t-test.*

1. Introduction

Software Quality is a major quantifier to design the quality software product in general. Software Maintainability is an external attribute that shows its effect on the software product which is completely or nearly finished. As per the standard of ISI-9126 Maintainability is major attribute among the other attributes like functionality, efficiency, usability, portability….etc. which has the considerable effect on the quality of the software product.Maintainability can be measured with several attributes like Understandability, Analyzability, Reusability, Modifiability, Complexity, Durability, Expandability,…etc [1], [2],[9].The definition of the software maintainability as per IEEE standard is to correct the faults of software system can be modified, changed environment adoption and performance improvement.

In the OOD the design size and structural complexity metrics play the key role in the selection of the maintainability factors like as Understandability, Modifiability and Analyzability.

As per the standard of ISO/IEC 9126-1[27] Understandability and Modifiability were defined as follows. Understandability defined as the capability of the software product to enable the user to understand whether the software is suitable and how it can be used for particular tasks and conditions of use. Modifiability means corrections, improvements or adaptions of the software to changes in environment and in requirements and functional specifications. As per the standard of ISO/IEC TR 9126-3[3] Analyzability definition is a set of attributes for predicting the maintainer's or user's spent effort or spent resources in trying to diagnose for deficiencies or causes of failure, or for identification of parts to be modified in the software product.

In this paper we used the regression approach to estimate the model between the dependent and independent variables.The significant (important) variables are taken into the consideration of model estimation and remaining variables eliminated from the total variables. Here we used the non-linear Log-normal transformation for representing the Maintainability and its factor models. The Weighted-sum method is also used paper for the purpose of finding the maintainability level with the help of Understandability, Modifiability and Analyzability levels.

The structure of the paper follows as. Section1 deals with the importance of the software maintainability feature. Section2 deals with the related work of various maintainability models by different authors by using the regression. The brief note about the size and structural metrics which were used in this paper in Section3. Maintainability factors estimated using the sample data displayed in Section4. Section5 contains research work regarding different models and statistical

importance of their models and also discussed in this section. Section6 gives the conclusion and future scope of our research paper.

2. Related Work

Maintainability was predicted by so many authors [2], [9], [10], [11], [14], [15], [22], [30], [33] towards good system maintainability. Among the above authors some used lines of code as factor, completion time of the variables and other measures were taken but no one was found the correct methodology to find the system maintainability. Regression process is applied in some situations on the maintainability factors to achieve the better estimation model of the maintainability.

Muthanna *et al.*[12] utilized the polynomial regression for the purpose of developing the Maintainability models. This published model would applicable to the procedural software not for the purpose of object-oriented software. Kiewkanya *et al.* [28] used regression approach to develop Maintainability model, Modifiability model and Understandability model. These models were developed with the help of Weighted –sum [29], Metrics-discriminant and weighted dependent methods and measured in only three levels of models namely low, medium and difficult. The drawback of this models is the application of three levels need a lot of time to calculate the factors and number of independent variables are taken.

Rizvi *et al*. [20] used the Back-ward step wise regression model to predict the estimation models of the Understandability, Modifiability and Maintainability. Here much more regression steps need in this process because every time large significant valued independent variable was removed from next regression step until finding the zero significance attributes. The draw backs of that paper is regression can be applied many more times and each model also taken the large number of attributes to establish the model. Here Understandability and Modifiability models were estimated on the one data [19] and maintainability was developed for the different data [28].

In our previous non-linear maintainability model [38] uses the Two-tail t-test for the degrees of freedom (df) establishes the Understandability, Modifiability and Maintainability models. Here only seven levels for the individual factors were included. Analyzability factor was not included. In this new model we include the two more levels for Understandability, Modifiability, Analyzability and Maintainability to improve the observation of the user on the class diagrams and to develop better estimation models rather than previous one. Here in this paper also we used the Two-tailed t-test for estimating the Understandability, Modifiability and Analyzability models.

3. Metrics Selection

Many authors produced their research work on the topic of the Object-oriented metrics[4],[5],[6],[7], [8],[13],[16],[17],[21],[23],[24],[26],[32],[34],[36] for the purpose of the various applications. In the area of software maintainability few members produced the metrics [18], [25], [37] to apply on UML specifications with the help of number of class diagrams. In this research paper we used total 3 size and 8 structural complexity metrics which were empirically validated [35] and correlated with Modifiability, Understandability and Analyzability [19] that measure the factors of maintainability.

The 3 size related metrics used in this paper are named as Number of Classes (NC), Number of Methods (NM) and Number of Attributes (NA). The remaining 8 structural metrics utilized in our paper were named as Number of Associations (NAssoc), Number of Aggregations (NAgg), Number of Aggregation Hierarchies (NAggH), Maximum HAGG (MaxHagg), Number of Dependencies (NDep),Number of Generalizations (NGen), Number of Generalizations Hierarchies (NGenH), Maximum DIT (MaxDIT). These 11 size and structural metrics were developed with the help of UML specifications on the specified class diagrams.

4. Sample Data

In the phase of sample data identification for the Maintainability factors i.e. Understandability, Modifiability and analyzability levels we want to improve two more levels including with previous suggested seven levels by M.genero *et al*.[19].Here we observed that there is some more levels needed to include in the previous results. By including these two levels users can grab the more command on the given class diagrams in the process of identifying the maintainability factors.

In this paper we proposed two more levels named as Trivial for lowest level and Consequential for highest level. Here the level of Trivial indicates un-Important or minor means less noticeable efforts to put in this level to find out the factors of the maintainability. Another level is Consequential which would positioned at the highest level indicates too much difficult but not impossible to

detect the maintainability and its factors. These 9 levels were placed in an order as shown in below.

1	Trivial
2	Extremely Easy
3	Very Easy
4	Quite Easy
5	Neither Difficult Nor Easy
6	A bit Difficult
7	Very Difficult
8	Extremely Difficult
9	Consequential

With the help of above 9 levels from Consequential to Trivial we took 45 class diagrams which were almost equal to the class diagrams represented by M.Genero *et al.*[19] . The Pseudo-Completion method is used in the process of developing 1-9 levels of sample data for the 45 class diagrams to represent the acceptable projected values in Appendix-A.

The above table states that more levels of data would be taken for the Understandability, Analyzability and modifiability factors helps in better way to find out the Maintainability levels of the system. The above table data was used in the following estimation models through converting the data into lognormalized form and then utilized in various models estimation.

5. Non-Linear Models Estimation

In this research paper our utilized methodology in identifying the model for the factors is Two-tail t-value with 0.05 level of confidence (95%) would be taken as degrees of freedom (df) as a table value indicator. In single regression process we identified the significant or important independent variables (metrics) for the dependent variable (factor) by using the Two-tail t-value with 95% power of confidence. Here is no need to go for the second attempt of the regression process, because in the first attempt only identified the significant variables which were having greater values than Two-tail t-value for the given degrees of freedom (df). The remaining in-significant variables would be removed from our consideration of preparing the model for individual model estimation. The definition to the degrees of freedom states that subtraction between the number of samples and number of independent variables with one.

In this paper the Non-linear model estimation process Log-Normal (Ln) model was used to represent the estimation of different models. The multiplicative process is utilized in the non-linear representations. The form of the multiplicative representation is

$X=P\ Y_1^a\ Y_2^b\ Y_3^c\ Y_4^d$ ---------- →**(1)**

By applying Discriminant function [31] with log transformation on two sides of the above Multiplicative representation.

$Ln(X) = Ln(P) + a * Ln(Y_1) + b * Ln(Y_2) + c * Ln(Y_3) + d * Ln(Y_4)$ ---------- →**(2)**

We represented the understandability, Modifiability, analyzability and Maintainability models in the form of above Log-Normal transformation representation by using Appendix-A and B. In the total 45 samples of data in the Appendix-A and B, we used 35 samples for the models estimation and remaining 10 samples were utilized to find the comparison between the actual and estimated values of the factors.

5.1 Understandability Model Estimation

In the development of Understandability model 3 size and 8 structural metrics were behaved as independent variables of the dependent variable Understandability.Here degrees of freedom (df) value is df = 35-11-1=23. The Two-tail t-value with 95% level of confidence for the degrees of freedom 23 is 2.07. In the single step regression process out of the 11 independent variables only 2 metrics named as NAssoc and MaxDIT maintains the greater Two-tail t-values rather than 2.07. Hence NAssoc and MaxDIT metrics are significant and these two metrics show the significant effect on the Understandability. The t-values and other values related to those two variables and the constant associated with model was displayed in the below table.

5.1.1. Statistical Significance of the Understandability Model

Table-1- Understandability Model Coefficient Values.

	Coefficient	St.error	t	Sig.
Constant	0.527	0.348	1.512	0.144
Ln(NAssoc)	0.198	0.094	2.114	0.046
Ln(MaxDIT)	0.192	0.056	3.46	0.002

Based on the t-values of the NAssoc and MaxDIT as shown in the Table-1 the model estimation for the Understandability in Non-linear Log-Normal representation is as follows.

$Ln(U) = 0.527 + 0.198 * Ln(NAssoc.) + 0.192 * Ln(MaxDIT)$ ---------- →**(3)**

Table-2- Model Summary for Understandability.

	R	R^2	Adj.R^2	Std.Error
UND	0.978	0.956	0.934	0.10851

From the above Table-2 better values of Coefficient of Determination (R^2) and Adjusted R^2 shows how much effect on the total variance of the Understandability model. The ANOVA model of the Understandability model gives more than 99% statistical significance level in the Table-3.

Table-3- ANOVA for Understandability.

	Sum of Squares	df	Mean Square	f	Sig.
Regression	5.819	11	0.529	44.926	0
Residual	0.271	23	0.012		
Total	6.09	34			

5.1.2. Understandability Model Validation

In the validation process of the Understandability model, comparison made between the actual values of the understandability levels in Log-Normal form and calculated the Understandability values by applying the model(3). Table-4 shows the comparison between the actual and calculated values of the Understandability model. Calculated values were very so near to the actual values of the Understandability model.

Table-5 shows the Pearson's Correlation between the actual and calculated values of the Understandability model. The observation of the table says that strong correlation possible between the actual and calculated values of the Understandability. These correlation values were calculated at 99 %(0.001) level of significance. In the below tables UA indicates that Actual Understandability and UC indicates that Calculated Understandability.

Table-4- Actual and Calculated values for Understandability.

	CLASS DIAGRAMS									
	1	2	3	4	5	6	7	8	9	10
UA	1.8	1.8	1.1	1.6	1.4	0.7	1.8	2.1	2.2	2.2
UC	1.2	1.3	0.7	1.1	1	0.7	1.3	1.3	1.4	1.3

Table-5- Correlation between Actual and Calculated values of Understandability Levels.

	UA	UC
UA	1	0.959
UC	0.959	1

5.2. Modifiability Model Estimation

In the modifiability model estimation Modifiability variable taken as dependent on the 11 size and structural independent variables of the various class diagrams. The degrees of freedom (df) value here is also 23.So, Two-tail t-value for the df value 23 is again 2.07. NAssoc and MaxDIT two independent variables had t-values are greater than 2.07.NAssoc and MaxDIT are the two significant most dependent factors of the Modifiability. The Modifiability model t-values and other statistical values were shown below.

5.2.1. Statistical Significance of the Modifiability Model

Table-6- Modifiability Model Coefficient Values.

	Coefficient	St.error	t	Sig.
Constant	0.804	0.321	2.5	0.02
Ln(NAssoc.)	0.281	0.086	3.244	0.004
Ln(MaxDIT)	0.239	0.051	4.659	0

By considering the coefficient values displayed on the above Table-6 the model estimation for the Modifiability in form as below.

Ln (M) = 0.804 + 0.281 * Ln (NAssoc.) + 0.239 * Ln (MaxDIT) ----------→ **(4)**

Table -7-Model Summary for Modifiability.

	R	R^2	Adj.R^2	Std.Error
MOD	0.982	0.965	0.948	0.1

Coefficient of Determination (R^2) and Adjusted R^2displayed on the aboveTable-7 model summary of the Modifiability says that influence of the significant factors NAssoc and MaxDIT in the total variance of the Modifiability. The below Table-8 shows that significance levels at above 99 % (0.001) level of ANOVA model of the Modifiability model.

Table 8- ANOVA for Modifiability.

	Sum of Squares	df	Mean Square	f	Sig.
Regression	6.261	11	0.569	56.921	0
Residual	0.23	23	0.01		
Total	6.491	34			

5.2.2. Modifiability Model Validation

In the validation of the modifiability model we compare the actual values of the Modifiability levels with non-linear Log-Normal values and calculated Modifiability values by using the Modifiability model(4). The resultant values of the actual and calculated values of the Modifiability were shown in the below Table-9.Here MA denotes that Actual Modifiability and MC denotes that Calculated Modifiability. The resultant values much closer to the actual values.

The Table-10 shows that Pearson's correlation between the actual and calculated values of the Modifiability. The correlation value of the correlation indicates that there is a strong correlation between the actual and calculated values of the Modifiability.

Table-9- Actual and Calculated values for Modifiability.

	CLASS DIAGRAMS									
	1	2	3	4	5	6	7	8	9	10
MA	1.8	2	1.1	1.6	1.4	0.7	2	2.2	2.2	2.2
MC	1.7	1.8	1	1.5	1.5	1	1.8	1.8	2	1.9

Table-10- Correlation between Actual and Calculated values of modifiability Levels.

	MA	MC
MA	1	0.968
MC	0.968	1

5.3 AnalyzabilityModel Estimation

Here in Analyzability model estimation we used total 11 size and structural metrics as independent variables for dependent variable Analyzability. The degrees of freedom (df) value here also 23. The Two-tailed t-value is 2.07 same as for the understandability and modifiability factors. Out of total 11 independent variables only two variables are named as NDep and NGenH which have the t-values more than 2.07. Hence these two variables are significant (important) for developing the analyzability model. The statistical values of the Analyzability model were shown in the below tables.

5.3.1. Statistical Significance of Analyzability Model

Table-11- Analyzability Model Coefficient Values.

	Coefficient	St.error	t	Sig.
Constant	0.237	0.311	0.762	0.454
Ln(NDep)	0.208	0.053	3.911	0.001
Ln(NGenH)	0.235	0.05	2.444	0.959

The form of the Analyzability model by consider the Table-11 coefficient values

Ln (A) = 0.237 + 0.208 * Ln (NDep) + 0.235 * Ln (NGenH) ---------- →**(5)**

The Adjusted R^2 and Coefficient of Determination values displayed in the below Table-12 says that portion of the NDep and NGenH variables on the total variance of the Analyzability model. Table-13 Shows the ANOVA for the Analyzability model taken at the 0.001(99%) level of significance.

Table-12- Model Summary for Analyzability.

	R	R^2	Adj.R^2	Std.Error
ANL	0.979	0.959	0.939	0.09688

Table-13- ANOVA for Analyzability.

	Sum of Squares	df	Mean Square	f	Sig.
Regression	5.049	11	0.459	48.906	0
Residual	0.216	23	0.009		
Total	5.265	34			

5.3.2. Analyzability model Validation

In the analyzability model validation comparison made between the Actual values of Analyzability (AA) and Calculated values of Analyzability (AC). The calculated values of Analyzability displayed in Table-14 were calculated using the model (5). Table-15 shows the strong correlation between calculated and actual values of the Analyzability model.

Table-14- Actual and Calculated values for Analyzability.

	CLASS DIAGRAMS									
	1	2	3	4	5	6	7	8	9	10
AA	1.8	1.8	1.1	1.6	1.6	1.1	1.8	2.1	2.2	2.1
AC	0.6	0.8	0.2	0.4	0.6	0.2	0.8	0.8	1	1

Table-15- Correlation between Actual and Calculated values of Analyzability Levels.

	AA	AC
AA	1	0.944
AC	0.944	1

5.4. MaintainabilityModelEstimation

In the Maintainability model estimation we taken Maintainability can be depend on the Understandability, Modifiability and analyzability independent factors. Based upon the levels of the three factors displayed on the Appendix-A calculated the Maintainability levels by using the well-known Weighted-Sum method [29] displayed on the Appendix-B. Here also 35 samples were utilized for the purpose of maintainability model development and remaining 10 samples were taken for the purpose of validation of the resultant Maintainability model. In this regression process total three factors treated as the significant variables of the maintainability. The statistical significance, coefficients and others values were displayed below.

5.4.1. Statistical significance of the Maintainability Model

Table-16- Maintainability Model Coefficient Values.

	Coefficient	St. Error	t	Sig.
Constant	-0.01	0.016	-0.647	0.522
Ln(UND)	-0.105	0.074	-1.43	0.163
Ln(ANL)	1.005	0.032	31.344	0
Ln(MOD)	0.107	0.063	1.706	0.098

Table-16 shows that the maintainability model coefficients and other values related to the statistical importance of the model. The Maintainability model with the three significant factors Understandability, Modifiability and Analyzability is of the form as below.

Ln(MAIN)= -0.01 - 0.105 * Ln(UND) + 1.005 * Ln(ANL) + 0.107 * Ln(MOD)--------→(6)

The values of the Coefficient determination (R^2) and Adjusted R^2 in the Table-17 shows the strong influence of the three factors namely Understandability, Modifiability and Analyzability on the total variance of the Maintainability factor. Table-18 shows that ANOVA model which would states that more than 99% level of significance of the maintainability.

Table-17- Model Summary for Maintainability.

	R	R^2	Adj.R^2	Std.Error
MAIN	0.999	0.997	0.997	0.02174

Table-18- ANOVA for Maintainability.

	Sum of Squares	df	Mean Square	f	Sig.
Regression	5.363	11	1.788	3782.588	0
Residual	0.015	23	0		
Total	5.378	34			

5.4.2. Validation of the Maintainability

The Maintainability validation involves with the comparison of the actual and calculated values of the Maintainability denoted by MAIN-A and MAIN-C respectively in the below two tables. The Table-19 shows the resultant values of the actual values of the Maintainability by applying the non-linear Log- Normal transformation on the Table-19.The calculated Maintainability values were calculated with the help of the model (6).The calculated values are almost near to the actual values of the maintainability.

Table-20 shows the Pearson's correlation between the actual and calculated values of the maintainability model. The resultant values show that strong correlation between the values of actual and calculatedmaintainability.

Table-19- Actual and Calculated values for Maintainability.

	CLASS DIAGRAMS									
	1	2	3	4	5	6	7	8	9	10
MAIN-A	1.8	1.8	1.1	1.6	1.6	1.1	1.8	2.1	2.2	2.1
MAIN-C	1.7	1.7	1.1	1.5	1.6	1.1	1.7	2	2.1	2

Table-20- Correlation between Actual and Calculated values of Maintainability Levels.

	MAIN-A	MAIN-C
MAIN-A	1	1
MAIN-C	1	1

Table-21- Correlation between Maintainability, Understandability, Modifiability and Analyzability.

	MAIN	UND	MOD	ANL
MAIN	1	0.971	0.972	0.945
UND	0.971	1	1	0.946
MOD	0.972	1	1	0.947
ANL	0.945	0.946	0.947	1

Table-21 shows the correlation between the maintainability, Understandability, Modifiability and Analyzability. The above table says that Understandability, Modifiability and Analyzability are much strongly correlated with Maintainability factor. The correlation between the Understandability, Modifiability and Analyzability are also strongly correlated themselves. This shows the effectiveness of the Maintainability model (6) for the future usage.

6. Conclusion & Future Scope

In this paper we mentioned two more levels named as Trivial at first level and Consequential at the last level to improve the observation of the user on the class diagram in object-oriented (OO) software in effective manner. The Two-tailed t-values were used for judging the models in regression process because it identifies the significant factors in the single regression process only. The coefficient of Determination (R^2) and Adjusted R^2 values show the good portion of participation in the total variance of the various models. The correlation values of the all model estimations show the strong correlation among the calculated and actual values of the Understandability, Modifiability, Analyzability and Maintainability.

Coming to the future scope of this paper is to establish more improved models of the maintainability with more number of factors listed in [19]. Understandability, Modifiability and Analyzability metrics need to develop the metrics based on the sample data [19], [38]. Other non-linear representations like exponential, polynomial…..etc., need to be tested in the Maintainability models estimation. In future we want to work on the other external attributes of the software quality rather than Maintainability and develop the effective models for those factors to improve the software quality of the product.

Appendix-A

CLASS	NC	NA	NM	NAssoc	NAgg	NDep	NGen	NAggH	NGenH	Max Hagg	Max DIT	U	M	A
1	8	22	35	3	2	1	2	1	1	2	1	3	3	3
2	20	42	76	10	6	2	10	2	3	2	2	6	6	6
3	21	45	94	6	6	1	20	2	2	4	4	6	6	5
4	23	50	73	9	7	2	11	3	4	4	1	5	5	6
5	23	41	88	10	6	2	16	2	3	4	3	6	6	6
6	29	56	98	12	7	3	24	3	4	4	4	6	7	6
7	9	18	36	3	3	1	2	1	1	2	1	3	3	3
8	8	20	36	3	2	1	4	1	1	1	1	3	3	3
9	4	9	16	1	1	1	11	1	1	1	1	2	2	2
10	5	10	20	1	1	1	2	1	1	2	1	3	3	3
11	3	6	12	1	2	1	2	1	1	1	1	2	2	2
12	21	42	84	11	6	2	12	3	3	2	3	6	6	6
13	22	38	56	7	6	2	18	2	3	4	4	6	6	6
14	24	36	72	5	8	1	22	2	2	4	4	6	6	5
15	21	31	60	4	6	1	12	2	2	2	2	4	4	4
16	24	42	81	8	7	2	12	3	3	3	1	5	5	6
17	23	42	81	5	5	1	16	2	2	3	3	5	5	5
18	21	45	90	12	6	2	8	3	2	2	1	5	5	6
19	23	36	70	8	8	1	9	3	3	3	1	4	4	5
20	16	28	51	4	5	1	6	2	2	2	1	3	3	4
21	18	32	54	3	4	1	5	3	2	2	1	3	3	4
22	8	14	20	1	3	1	14	1	1	1	1	2	2	3
23	23	32	64	9	8	2	14	3	3	2	3	6	6	6
24	28	52	86	10	7	3	26	4	4	4	4	6	7	6
25	31	40	94	12	9	2	20	3	5	3	4	8	9	8
26	41	45	98	14	10	6	40	5	6	6	6	9	9	9
27	42	51	92	10	8	5	35	4	5	4	6	9	9	8
28	21	29	58	6	11	2	10	3	2	2	3	6	6	6
29	29	50	92	12	6	3	23	3	3	4	4	6	7	6
30	27	46	84	10	5	4	18	3	3	3	3	6	7	6
31	28	42	81	8	7	4	16	3	2	3	3	6	7	6
32	9	20	36	2	2	1	2	1	1	2	1	3	3	3
33	14	20	32	5	4	1	10	2	3	2	1	4	4	4
34	21	35	52	6	6	1	12	3	2	2	2	4	5	4
35	24	34	68	6	8	1	12	2	3	5	5	6	6	6
36	9	20	42	2	3	1	3	1	1	2	1	3	3	3
37	24	38	52	8	6	2	12	2	2	3	1	5	5	6
38	31	41	84	12	6	4	24	4	4	5	5	7	8	7
39	33	54	98	10	8	5	32	5	5	5	5	8	8	8
40	30	42	86	12	9	4	29	4	5	4	5	8	8	7
41	22	41	81	10	6	1	10	3	4	4	1	4	4	5
42	9	15	30	2	3	1	4	1	1	1	1	2	2	3
43	26	48	74	11	8	4	14	3	5	4	3	8	8	9
44	42	41	109	15	10	6	40	5	6	6	6	9	9	9
45	28	32	81	12	9	3	14	3	5	4	3	8	8	8

Above table shows the summary of data utilized in the models of the maintainability factors i.e. Understandability, Modifiability and Analyzability. The first column shows the class diagram number and remaining columns indicates the 3 size and 8 structural metrics and Maintainability factors.

Appendix-B

			W1	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.6	0.5	0.4	0.3	0.2	0.1	0.5	0.4	0.3	0.2	0.1	0.4	0.3	0.2	0.1	0.3	0.2	0.1	0.2	0.1	0.1	
			W2	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.1	0.2	0.3	0.4	0.5	0.6	0.1	0.2	0.3	0.4	0.5	0.1	0.2	0.3	0.4	0.1	0.2	0.3	0.1	0.2	0.1	
			W3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	
NO	U	MO	A																																				M
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
3	6	6	5	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.6	5.6	5.6	5.6	5.6	5.5	5.5	5.5	5.5	5.4	5.4	5.4	5.3	5.3	5.2	5
4	5	5	6	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.8	6
5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
11	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
12	6	6	5	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.6	5.6	5.6	5.6	5.6	5.5	5.5	5.5	5.5	5.4	5.4	5.4	5.3	5.3	5.2	5
13	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
14	5	5	6	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.8	6
15	5	5	6	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.8	6
16	4	4	5	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.4	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.6	4.6	4.6	4.7	4.7	4.8	5
17	3	3	4	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.4	3.4	3.4	3.4	3.4	3.5	3.5	3.5	3.5	3.6	3.6	3.6	3.7	3.7	3.8	4
18	3	3	4	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.4	3.4	3.4	3.4	3.4	3.5	3.5	3.5	3.5	3.6	3.6	3.6	3.7	3.7	3.8	4
19	2	2	3	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	3
20	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
21	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
22	6	7	6	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.1	6.2	6.3	6.4	6.5	6.6	6.1	6.2	6.3	6.4	6.5	6.1	6.2	6.3	6.4	6.1	6.2	6.3	6.1	6.2	6.1	6
23	6	7	6	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.1	6.2	6.3	6.4	6.5	6.6	6.1	6.2	6.3	6.4	6.5	6.1	6.2	6.3	6.4	6.1	6.2	6.3	6.1	6.2	6.1	6
24	6	7	6	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.1	6.2	6.3	6.4	6.5	6.6	6.1	6.2	6.3	6.4	6.5	6.1	6.2	6.3	6.4	6.1	6.2	6.3	6.1	6.2	6.1	6
25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
26	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
27	4	5	4	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.1	4.2	4.3	4.4	4.5	4.6	4.1	4.2	4.3	4.4	4.5	4.1	4.2	4.3	4.4	4.1	4.2	4.3	4.1	4.2	4.1	4
28	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
29	5	5	6	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.8	6
30	7	8	7	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.1	7.2	7.3	7.4	7.5	7.6	7.1	7.2	7.3	7.4	7.5	7.1	7.2	7.3	7.4	7.1	7.2	7.3	7.7	7.7	7.8	8
31	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
32	8	8	7	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.3	7.3	7.2	7
33	8	8	9	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.3	8.3	8.3	8.3	8.3	8.3	8.4	8.4	8.4	8.4	8.4	8.5	8.5	8.5	8.5	8.6	8.6	8.6	8.7	8.7	8.8	9
34	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
35	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
36	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
37	6	7	6	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.1	6.2	6.3	6.4	6.5	6.6	6.1	6.2	6.3	6.4	6.4	6.1	6.2	6.3	6.4	6.1	6..2	6.3	6.1	6.2	6.1	6
38	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
39	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
40	4	4	5	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.4	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.6	4.6	4.6	4.7	4.7	4.8	5
41	2	2	3	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	3
42	6	7	6	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.1	6.2	6.3	6.4	6.5	6.6	6.1	6.2	6.3	6.4	6.4	6.1	6.2	6.3	6.4	6.1	6..2	6.3	6.1	6.2	6.1	6
43	8	9	8	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.1	8.2	8.3	8.4	8.5	8.6	8.1	8.2	8.3	8.4	8.5	8.1	8.2	8.3	8.4	8.1	8.2	8.3	8.1	8.2	8.1	8
44	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
45	9	9	8	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.7	8.7	8.7	8.7	8.7	8.7	8.6	8.6	8.6	8.6	8.6	8.5	8.5	8.5	8.5	8.4	8.4	8.4	8.3	8.3	8.2	8

Above table shows the maintainability levels from the Understandability, Modifiability and Analyzability levels with the help of weighted-Sum Method.

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