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Enhancement of Forecasting Value with Quadratic Equation Method on Computer Network Performance

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Quadratic equation formula is suitable to be used as forecasting method on computer network performance because they have similar characteristic especially in the form of graph. The performance of this forecasting can be enhanced with wide possibility. This paper proposes to enhance the forecasting value of quadratic equation method of computer network performance especially by choosing the most appropriate input values that optimize and enhance the forecast accuracy. The result of this research shows that the choosing input value with the lowest up and the highest down value (M2) produces the best and the most optimal forecasting value with error standard deviation 80. While the choosing input value with random up and down value (M1) produces error standard deviation 370, the highest up and the lowest down value (M3) produces error standard deviation 227, and the mean of up and down value (M4) produces error standard deviation 230.

Keywords : Enhancement Forecasting value, Computer Network Performance, Quadratic Equation

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1. INTRODUCTION

Computer network is widely used by almost all people from all level in the world. It gives challenge to the computer network service provider in giving best service to the subscribers. So the computer network service provider has to maintain the performance of it by planning, observing and evaluating continually. It becomes very important especially to face the increasing of computer network users with still serves the reliable network to them[1]. The research activities of planning, observing and evaluating the network performance are widely done and published at many journal. For example, the research of Nasri S.[12] that makes QoS metric model especially based on total delay and packet loss as metrics with Calculus Theory approach on chip modeling architecture. The research of Dhobale J.V., et. al.[4,5,6] makes simulation of computer network performance using OMNET++ with data packet size, data rate and number of clients per server as metrics and than makes analysis and evaluation from it.

Beside doing observation and evaluation, the maintenance efforts of good computer network performance can be applied by improving or optimizing and forecasting the network performance. In improving and optimizing the network performance, the research of Jingeng W., et. al.[13] proposes some recomendations of network performance improvement based on QoS changes. Ar Reyouchi E.M., et. al.[7] proposes to improve end to end delay of network management system using network coding. In forecasting network performance, the research of Cortez P., et. al.[10] makes forecasting of the multi-scale internet traffic using Neural Network, ARIMA and Holt Winter, while the research of Hoong P.K., et. al.[11] uses ARMA to forecast network traffic.

Other advance step to plan good computer network performance is how to improve and enhance the forecast result[9]. There are many ways to improve and enhance forecast result and forecast accuracy, for example improving the input data[3]. The research of Leau Y.B. and Manickam S.[14] proposes to enhance prediction capability of Grey Verhulst model using enhanced adaptive Grey Verhulst prediction model in incoming network security situation.

In the same mindset with that description, this research was started from Ubaidillah A., et. al.[1] that proposes to forecast the computer network performance using Linear and Multi Linear Regresion Method. The main problem of the reasearch is the linearity of forecast result. While computer network performance has non-linear characteristic of graph. In other word, it is not appropriate to use linear forecasting for computer network performance that has parabolic characteristic. The research of Ubaidillah A. and Kholida I.[2] proposes to improve the minus side of the earlier research[1]. It uses Quadratic Equation to forecast computer network performance. The main reason is both of them has same parabolic characteristic of graph. As the advance next step, forecast result can be enhanced especially it's accuracy. One of the ways to enhance the forcast result and accuracy is improving it's input data. This research proposes to enhance it by choosing the most appropriate input values that optimize and enhance the forecast accuracy.

2. FORCASTING METHOD WITH QUADRATIC EQUATION FORMULA

There are many methods that that can be used as forecasting method. Generally, they are linear and non-linear method. The linear method is apropriate to be used in linear cases or cases that the output value increases as the increasing of the input value. While non-linear method is appropriate to be used in non-linear cases. Quadratic Equation Formula is included into non-linear forecasting method because it produces parabolic graph.

The main formula of Quadratic Equations[8],

$$y = ax^2 + bx + c \quad (1)$$

There are some steps to make (1) to become forecast formula. The first, take 3 points coordinate (x1,y1), (x2,y2) and (x3,y3), where (x1,y1) is sample of coordinate before peak value, (x2,y2) is sample of coordinate at peak value and (x3,y3) is sample of coordinate after peak value. Then, obtain 3 equations in a, b and c by making substitution the 3 samples to (1). Compute the 3 equations with elimination and substiution method to obtain the values of a, b and c. Obtain a new Quadratic Equation with a, b and c, then it can be used as forecasting method.

Error calculations of this paper are RMSE (Root Mean Square Error) that is implemented as standard deviation of the error.

$$MSE = \left[\frac{\sum_{i=1}^{n} e_i^2}{n-2}\right] \quad (2)$$

$$S_e = \sqrt{MSE} \quad (3)$$

MSE : Mean Square Error

Se :Unbiased of error standard deviation

3. METHODOLOGY

This paper is the next research of Ubaidillah A. and Kholida I.[2]. It means, the forecast data that will be computed in this research is from it. The data that will be computed is taken from simulation result of bottle neck computer network performance as shown in figure-1. The simulation result graph is shown in figure-2, and figure-3. The computer network performance of simulation result is depicted as a relationship between number of sent packet as input data to throughput at node 3 as output data and it is shown in table-1.

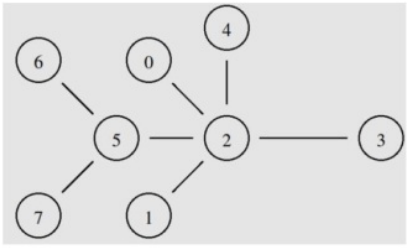

Fig-1. Simulation topology of bottle neck computer network system that is observed

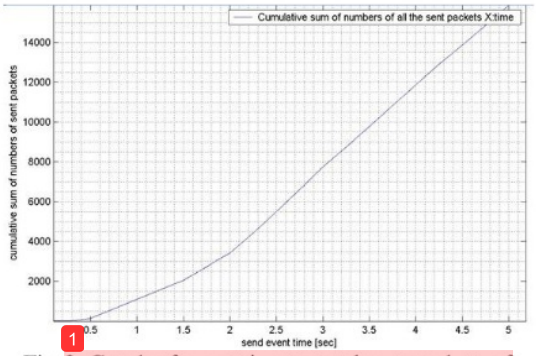

Fig-2. Graph of event time to total sent packets of simulation result

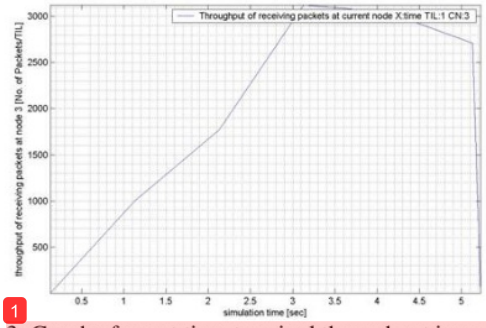

Fig-3. Graph of event time terminal throughput in node 3 of simulation result

From input and output data of table-1, 3 samples of coordinate (x,y) are chosen to be computed until a, b and c are obtained. Then they are used to form the forecasting formula of Quadratic Equation. This research proposes to enhance the forecast accuracy of Quadratic Equation method by choosing one of four rules in finding the most appropriate input values.They are :

M1 : Random up and random down
M2 : The lowest up and the highest down
M3: The highest up and the lowest down
M4 : Mean of up value and mean of down value

Table 1. Samples of network performance of the simulation and the forecasted value with Linear Regresion method

Sent_Pckt (Packets)X	Trhoughput (Packets/second)Y
305	370
1230	890
2215	1297
3490	1680
5510	2295
7750	2944
9726	3102
11981	3005
13833	2928
15752	2720

Then, four Quadratic Equations are obtained from the four rules, and they are used in the forecasting. The final step is to compute the error standard deviation of each forecast result. Then the most appropriate rule that can improve and enhance the forecast accuracy is known.

4. RESULT

The research computational result is shown in table-2.

Table-2. The 3 samples of chosen coordinate, Quadratic Equation and error standard deviation of each rule of choosing input value.

INPUT TYPE	(x_1,y_1)	(x_2,y_2)	(x_3,y_3)	QUADRATIC EQUATION
M1	(5510, 2295)	(9726, 3102)	(13833, 2928)	$y=-0{,}000031x^2$ +0,66373x -442,5
M2	(305, 370)	(9726, 3102)	(15752, 2720)	$y=-0{,}00002298x^2$ +0,5196x +214
M3	(7750, 2944)	(9726, 3102)	(11981, 3005)	$y=-0{,}00002907x^2$ +0,5879x +133
M4	(3417, 1579)	(9726, 3102)	(13855, 2884)	$y=-0{,}00002817x^2$ +0,6116x -181

Input type M1, M2, M3 and M4 are rules of choosing input value. M1 means the rule to choose input data with random before peak and random after peak. M2 is for the rule to choose input data with the lowest value

before peak and the highest value after peak. M3 is for the rule to choose input data with the highest value before peak and the lowest value after peak. While M4 means the rule to choose input data with the average value before peak and the average value after peak. Where (x1,y1) is sample of coordinate before peak value, (x2,y2) is sample of coordinate at peak value and (x3,y3) is sample of coordinate after peak value.

The column of Quadratic Equation of table-2 is quadratic equation formula that is raised from the computational result of coefficient a, b and c of each rule. Then the four quadratic equation are used in forecasting the computer network performance. And Se is the error standard deviation of forecast result.

5. DISCUSSION

The first discussion is about which rule (M1, M2, M3 or M4) that obtains the best accuracy of forecast result. The accuracy quality of forecast value in this paper is determined from the error standard deviation value of the forecast results. The decreasing of the error standard deviation value (Se) causes the forecast accuracy quality to be better. While the increasing of the error standard deviation value (Se) causes the forecast accuracy quality to be worse.

For the case of this research, M2 with the rule in choosing input data is the lowest value before peak and the highest value after peak, obtains the best accuracy of forecast value with Se =80 or the lowest one if it is compared with the others. M3 with Se = 227 and M4 with Se =230 are the second and the third in sequence. While M1 with Se = 370 is the worst. It can be analized first, because the chosen input data of M2 is extremely the lowest before peak value and extremely the highest after peak value. It means that it's quadratic equation construction can cover other input data. So, it can forecast other input dataautomatically more accurate than the others. while the quadratic equation construction of M3 and M4 can not cover all input data, especially the lower input data before peak value and the higher input data after peak value. As the result, it causes the possibility of error greater than M2 and worse in forecast accuracy. While the forecast accuracy of M1 is the worst because it's random effect of the chosen input data.

Other discussion of the research result is correlation of the coefficient a and b to error standard deviation Se. Coefficient is gain factor of variable. It means that coefficient gives direct influence to variable. Shown in table-2 that M1 obtains the smallest coefficient a=-0,000031 and the greatest coefficient b=0,66373, and it results the greatest Se or the worst accuracy of forecast value. M2 obtains the greatest coefficient a=-0,00002298 and the smallest coefficient b=0,5196, and it results the smallest Se or the best accuracy of forecast value. While M3 and M4 obtain coefficients a and coefficient b between M1 and M2. As the result, their forecast value accuracy are also between M1 and M2. In other word, they are better than M1 but worse than M2. Beside that, the coefficient a of M3 is smaller that M4, but the coefficient b of M3 is also smaller than M4. So, they have almost same Se. The correlation graph of coefficient a and coefficient b to error standard deviation of the forecast value is shown by figure-4 and figure-5.

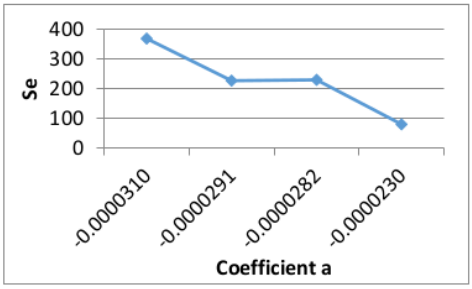

Fig-4. The correlation of coefficient a of quadratic equation for forecasting to error standard deviation of forecast value

figure-4 describes that the error standard deviation value of forecast result leans to decrease linearly as the increasing of coefficient a. As a notice, all the value of coefficient a in this paper are negative. In the opposite, if that values are positive, than it will increase as the increasing of coefficient a. While figure-5 describes that the error standard deviation value of forecast result leans to increaselinearly as the increasing of coefficient b.

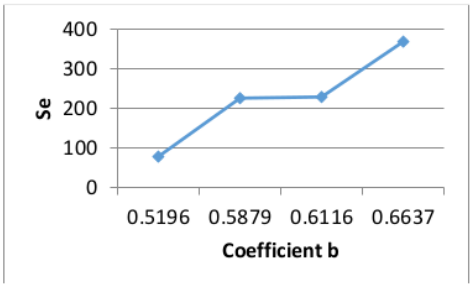

fig-5. The correlation of coefficient b of quadratic equation for forecasting to error standard deviation of forecast value

6. CONCLUSION

From the discussion, the conclusion is M2 obtains the best accuracy of forecast value because it's quadratic equation construction can cover all other input data. So, it can forecast other input data automatically more accurate than M1, M3 and M4.

The second point is about correlation of coefficient a and b to error standard deviation of forecast value Se. In the case of positive value, the greater

coefficient of forecasting quadratic equation causes increasing in Se, so the Se is getting worse. while in the case of negative value, the greater coefficient of forecasting quadratic equation causes decreasing in Se or it causes the Se is getting better.

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