Forecasting of Computer Network Performance with Quadratic Equation

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FORECASTING OF COMPUTER NETWORK PERFORMANCE WITH QUADRATIC EQUATION

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ABSTRACT

The computer network service provider has to observe, evaluate and plan continually its services in order to provide reliable systems. One of the efforts in planning process is forecasting. There are many methods in it, and this paper proposes to use Quadratic Equation Formula as a forecasting method. It is used because of the simplicity and it is suitable to solve problems with parabolic characteristic that can not be solved by linier computational method. It also compares characteristic of Quadratic Equation Formula with Linear Regresion forecasting. The result of this research shows that the computer network performance can be forecasted with Quadratic Equation Formula which has similar case characteristic with it. The standard deviation error of forecast value of the Quadratic Equation Formula is 370 of 3080 forecasted throughput maximum value. While the standard deviation error of forecast value of the linear regresion method is 282 of 3518 forecasted throughput maximum value. But in the forecasted throughput of linear regresion methhod, the output value will allways increase as the increasing of the input variable value. As the result, the error distribution calculation is not interesting anymore because there is no peak value for the forecasted result.

Keywords : Forecasting, Computer Network Performance, Quadratic Equation

INTRODUCTION

There are many advantages of computer network system like resource sharing, reliability, economical side, scalability and communication medium. Madura Trunojoyo University that apply computer network system has to takehold and maintain its system in order to gain the advantages especially with good monitoring, evaluation and planning continually. It is very important to give quality of service of network system to the users in university, especially when the users of computer network in campus increase (Achmad Ubaidillah et al, 2014).

The observation, evaluation and planning of computer network performance are very important to be implemented. There are many research that concern about it. For example, the research that make network planning to define QoS Metric based on total delay and packet loss with Calculus Theory approach on zip modeling architecture (salem Nasri, 2011). Dhobale J.V., Kalyankar N.V., and Khamitkar S.D., observe and evaluate the computer network performance using OMNET++ simulation environment with different input variable (Dhobale J.V. et al, 2014). Other research that concerns in computer network performance are the research that makes remaster of Ubuntu to observe the computer network performance (Andi Pebriananta et al, 2011), the research that measures the computer network performance to manage the availibility (Sri Wulandari et al, 2011), and the research that measures and analizes the distributed computer network performance with different properties for administration (Amit Kumar Sahu et al, 2012).

Beside that, the management of computer network performance can be observed by optimizing and improving the performance. For exmple the research that proposes some recomendations that can improve the network performance based on QoS changes (Winarno Sugeng et al, 2015), The research that combines the MBAC and PBAC to improve admission control and network utilization efficiency (Suleiman Y. Yerima,

2011). Other researchs that develop the improvement of network performance are paper that proposes to improve end to end delay of network management system using network coding (El Miloud Ar Reyouchi et al, 2013), the research that proposes to minimize trannsmission cycle delay between mobiles moving by changing the BEB Algorithm (Ibrahim Syed Ahmad et al, 2013), and the research that proposes to improve TCP Performance over wireless network with frequent disconnections (Purvang Dalal et al, 2011).

The observation, evaluation and planning of computer network performance also can be implemented by developing the performance forcasting system with parameters that influence network performance. Paulo Cortez proposes to use Neural Network, ARIMA and Holt Winter to forecast multi-scale internet traffic (Paulo Cortez et al, 2012). While Poo Kuan Hoong proposes to forecast the network computer traffic using ARMA (Poo Kuan Hoong et al, 2012).

Basically, this paper begins from other research especially (Achmad Ubaidillah et al, 2014). It proposes to use linear and multi linear regresion as a forecasting method of computer network performance. But it is just linear computation. It assumes that the output value will increase as the increasing ofinput variable value. It is contradictive compared with characteristic of computer network performance that can increase and decrease after gain the peak value. So this research proposes to use Quadratic Equation Formula to forecast the computer network performance because of the similarity of the output data characteristic.

Network performance can be measured by turn arround time, response time, throughput, goodput, capacity, availability, reliability, delay, jitter, and blocking probability (Mohammad Iqbal, 2012), (Hendrawan, 2006). This research uses sent packets as the input variable and throughput as the output variable.

Linear Regresion As Forecasting Method

Regression is one of statistical development model that is used to predict a value of response variable

based on the variable explanatory (Hendrawan, 2006). Linear regression is the most simple model of regression as linear equation. Basically, linear regression equation is,

$$y = a + bx + e \tag{1}$$

with,   *x:* input variable

a : intercept
b : slope
e : random error

the correlation value between input variable and output variable must be known before determining the linear regression equation in order to know the relation and the influence of input variable to output variable. The correlation value is shown as,

$$r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{x_i-\bar{x}}{S_x}\right)\left(\frac{y_i-\bar{y}}{S_y}\right) \tag{2}$$

with, r : Correlation value between input and output variable

n : event
x_i: input variabel
$\bar{x}$: mean of input variable
S_x : standard deviation of input variable
y_i : output variable
$\bar{y}$: mean of output variable
S_y : standard deviasion of output variable

The next step after calculating the correlation value is calculating the slope or gradient value of equation with,

$$b = r\left(\frac{S_y}{S_x}\right) \tag{3}$$

Afterwards, the intercept value can be calculated after knowing the slope value with,

$$a = \bar{y} - b\bar{x} \tag{4}$$

Quadratic Equation Formula As Forcasting Method

The formula of Quadratic Equationproduces parabolic graph, and it is the main contemplation of this research. According to (Frank Ayres, JR., 2006), The main formula is,

$$y = ax^2 + bx + c \tag{5}$$

The steps to make (5) to become forecast formula:

1. begin from input variable and output data
2. take 3 samples of its coordinate, 1 sample before peak value, 1 sample at the peak and 1 sample after the peak
3. obtain 3 equations in a, b and c by making substitution the 3 samples to (5)
4. compute the 3 equations with elimination and substiution method to obatain the values of a, b and c
5. obtain a new Quadratic Equation whit them
6. make computational forecasting with it

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

$$MSE = \left[\frac{\sum_{i=1}^{n} e_i^2}{n-2}\right] \tag{6}$$

$$S_e = \sqrt{MSE} \tag{7}$$

with   MSE : *Mean Square Error*

S_e : *Unbiased of error standard Deviation*

METHODOLOGY

First, this research simulates a computer network system (figure 1) with Network Simulator 2 (NS2). The system is built as a bottle neck network, all nodes (0, 1, 4, 6, 7) send packets to node 3 over node 2. The traffic types are mixed between TCP and UDP. The variable input is total sent packets, while terminal throughput in node 3 is set as network system performance output. Then, the input and output variable values are computed into Linear Regresion Forecasting method and Quadratic Equation Forecasting Formula. The performance computation result of them are compared each other to be concluded which the better is.
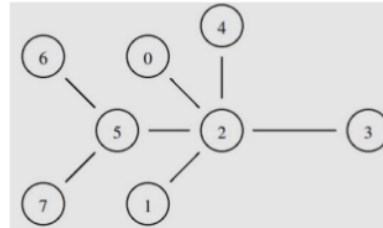

Figure-1. Simulation of computer network system observed

RESULTS

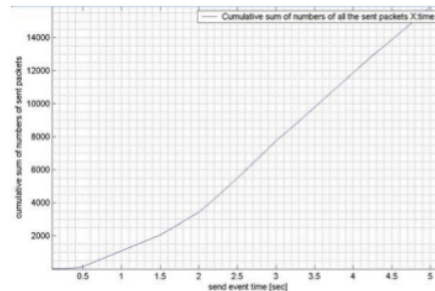The simulation results are shown in figure 2 and figure 3.

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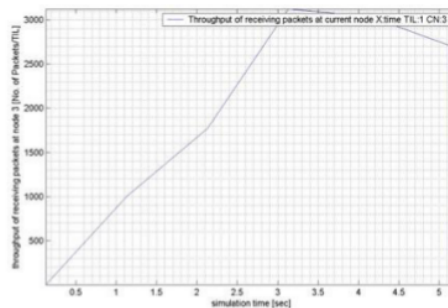

Figure-3. Graph of event time terminal throughput in node 3 of simulation result

Then, the performance resultsare sampled in some node samples shown in table 1. It shows the correlation between total packets sent and terminal throughput values in node 3.

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	Forecasted Throughput Y'
305	370	1047
1230	890	1195
2215	1297	1352
3490	1680	1556
5510	2295	1880
7750	2944	2238
9726	3102	2554
1198 1	3005	2915
1383 3	2928	3211
1575 2	2720	3518

From X and Y oftable 1, some parameters that can be calculated :

- $n = 10$ (8)
- $\bar{x} = 7179$ (9)
- $S_x = 5490$ (10)
- $\bar{y} = 2123$ (11)
- $S_y = 995$ (12)

Using (2),
$$r = 0,86 \qquad (13)$$
Using (3),
$$b = 0,16 \qquad (14)$$
Using (4),
$$a = 998 \qquad (15)$$
So, the Linear Regrasion equation that will be used as forecasting equation is,
$$y = 998 + 0,16x \qquad (16)$$
The Forecasting values (Y') is obtained by using (16). Then the next step is to calculate error distribution with equation (6) and (7). The MSE value is 79.664 and the standard deviation of error (S_e) is 282.

Then, this research proposes to use Quadratic Equation formula as forecast method. Three nodes (X,Y) are taken as samples of the network performance, (5510, 2295), (9726, 3102) and (13833, 2928). By inserting them to Quadratic Equation then it obtains,
$$30360100a + 5510b + c = 2295 \qquad (17)$$
$$94595076a + 9726b + c = 3102 \qquad (18)$$
$$191351889a + 13833b + c = 2928 \qquad (19)$$
From (17), (18) and (19), value of a, b and c can be obtained by using Elimination and Substitution computational method. Then,
$$a = -0,000031 \qquad (20)$$
$$b = 0,66 \qquad (21)$$
$$c = -442,5 \qquad (22)$$
So, the forecasting Quadratic Equation is,
$$y = -0,000031x^2 + 0,66x - 442,5 \qquad (23)$$
The result of forecasted throughput Y' is shown in table 2.

Table-2. Samples of network performance of the simulation and the forecasted Throughput with Quadratic Equation Formula

Sent_Pckt (Packets)X	Trhoughput (Packets/second)Y	Forecasted Throughput Y'
305	370	-243
123 0	890	327
221 5	1297	876
349 0	1680	1496
551 0	2295	2273
775 0	2944	2839
972 6	3102	3080
119 81	3005	3060
138 33	2928	2807
157 52	2720	2321

DISCUSSIONS

It is interesting to watch forecasted throughput Y' in table 1, that the value will always increase as the increasing of the input variable value. It becomes the main problem and the main weakness of forecasting with linear regresion method. It is not appropriate to be implemented to computer network performance that has parabolic characteristic. Beside that, the error distribution like MSE and S_e is not important anymore. While the real throughput value will decrease after peak value, but the forecasted throughput value will always increase. It will cause the error valeu is getting higher and higher as the increasing of input variable.

On the opposite, the result of forecasted throughput Y' of Quadratic Equation shown in table 2, shows that the forecasted throughput Y' values increase, obtain the peak value then decrease like parabolic graph. It has similar characteristic with values of Y. As the result, error distribution becomes important to be observed. The MSE value is 136.622 and the standard deviation of error (S_e) is 370 of 3080 maximum forecasted throughput value.

CONCLUSION

From the analysis of the computational result before, it is clearly proven and concluded that Linear Regresion method is not appropriate to be used as forecasting method for computer network performance because of the linearity problem, while network performance has parabolic characteristic. Even, calculation of error distribution is not important anymore because of it. In the other side, Quadratic Equation Formula can be used as forecasting method for computer network performance because of the characteristic similarity. So, for the case like this, Quadratic Equation Formula is better than Linear Regresion method.It can be said the research of this paper

The error standard deviation of forecasted throughput Y' with Quadratic Equation Formula is not to bad, 370 of 3080 maximum forecasted value or about 12%. It means, there is wide possibility to make it better. So, the suggestion for next research is how to make it better.

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