Finding the Pulse on Value of Pulse-Jamming Wireless Attacks Based on Time Series Forecasting Using the ARIMA Model

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***Abstract* - The objective of this research is to find the pulse on value of pulse-jamming wireless attacks and use it to forecast the time intervals. To simulate the time series-forecasting model, a simulation model using jamming attacks in the 802.11 wireless network was conducted to collect and evaluate the time intervals in the form of a dataset. In order to achieve more satisfactory and accurate forecasts, the ARIMA framework was used to model the time series. In this research, the alternative ARIMA (2, 0, 0) model was selected from the comparison results. Generated forecasting was at 98.825 percent accuracy.**

***Keywords* - ARIMA Model, Pulse On, Pulse-Jamming, Wireless Network**

I. INTRODUCTION

Today's wireless networking technology plays a significant role in diverse areas such as education, communication and other services. There are many advantages from wireless technology such as flexibility and ease to install and use. Moreover, acceptable speeds and inexpensive costs are wildly spread nowadays. However, security issues have become significant for communication over wireless networks. The jamming of a wireless network is one of the attacks that effects efficiency of communication devices connected. There are many types of wireless attack, one of the most effective wireless attacks is Denial-of-Service (DoS). The pulse-jamming wireless network attack is one of the DoS attacks that attempts to send sine-pulse waveforms to interrupt other communication devices. This pulse-jamming attack is hard to detect and discover the source of jamming [1]. Moreover, the throughput of the wireless devices, which are disturbed from jamming, also degrades at around 30 percent.

This research presents the process of modeling a ARIMA model to find time intervals of pulse-jamming attack (pulse-on) and without pulse-jamming attack (pulse-off). Therefore, the developed ARIMA model will be able to forecast the throughputs and react against pulse-jamming attacks.

The rest of the paper is organized as follows. Section 2 provides background knowledge and definition of the ARIMA model. The research methodologies are described in Section 3. The results and discussion are given in Section 4. Section 5, finally, covers the conclusion of this research.

II. BACKGROUND KNOWLEDGE

A. Objective

The objective of this research is to find the pulse on value of pulse-jamming wireless attacks over a wireless network.

B. Definition

The ARIMA model is a univariate time series model, which aims to find the relation of single observations and records sequentially through time. The ARIMA model or Box-Jenkins is a famous model that combines

Autoregressive (AR) model and Moving average (MA) model together [2].

Pulse On is time interval of the pulse-jamming wireless attack.

III. METHODOLOGGY

This section describes the process used to collect and evaluate the information to find the pulse on value, as shown in Fig. 1.

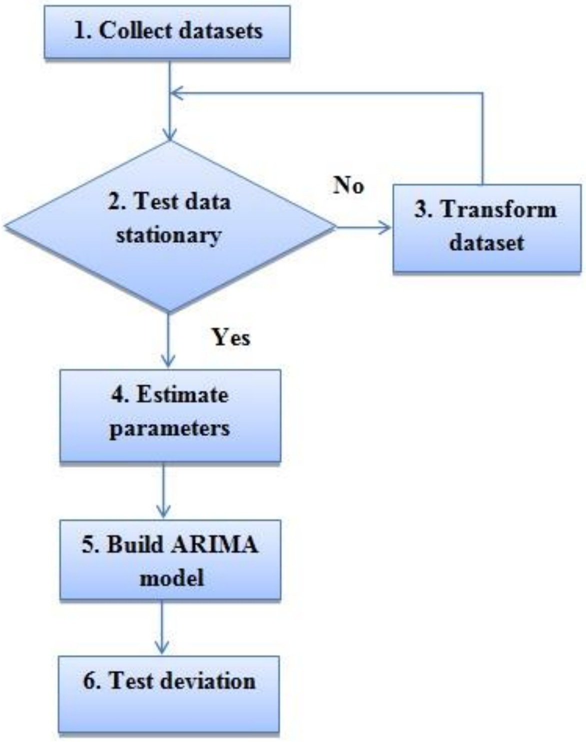
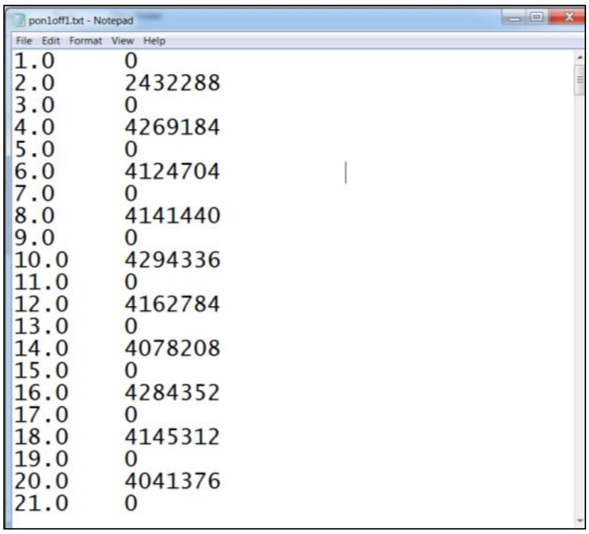


Fig. 1 The Six Main Process of Research

There are six significant steps as follows.

Step 1: Collect the dataset derived from the simulation model of an 802.11 wireless network for about 300 seconds. In the simulator, setup pulse on and pulse off are equal to 1 second.

Fig. 2, presents the 802.11 wireless network simulation model used to simulate the pulse-jamming attack for approximately 5 minutes. At that time, the 300 lines of acquired datasets, throughputs and times, are collected.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1.0	0
2.0	2432288
3.0	0
4.0	4269184
5.0	0
6.0	4124704
7.0	0
8.0	4141440
9.0	0
10.0	4294336
11.0	0
12.0	4162784
13.0	0
14.0	4078208
15.0	0
16.0	4284352
17.0	0
18.0	4145312
19.0	0
20.0	4041376
21.0	0

Fig. 2 The Example of Dataset to Model ARIMA

To simulate the ARIMA model, the obtained datasets are then adjusted to form the input of the statistical program (SPSS).

Step 2: Use the PACF function to test the stationary of data.

In this step, the stationary of data series are determined. The ARIMA model can only be applied to the stationary data series. If the data series is not stationary, it must be transformed to stationary [3].

Generally, the stationary datasets imply that the data should contain no trend and seasonal patterns. If the data series is non-stationary, differencing or square root function are applied. However, the order of the differencing value could affect the number of discrete spikes. Usually, the maximum number of spikes, in PACF, should not be more than 2 spikes.

Therefore, the PACF function is created to identify patterns from the above data series, which can be stationary, or not.

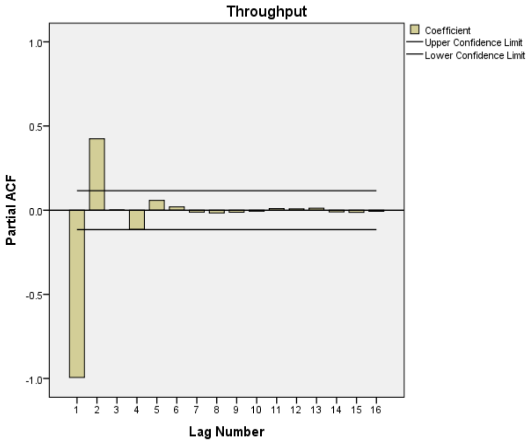
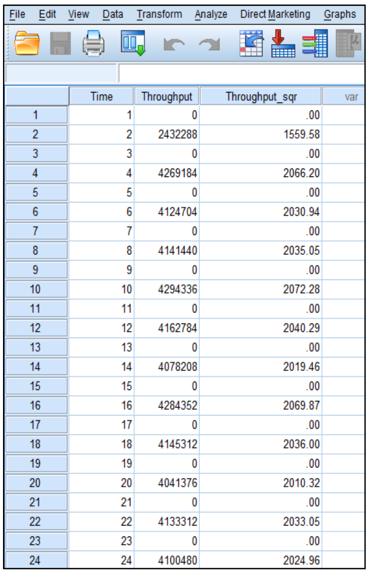


Fig. 3 The Stationary of Data Using PACF

Fig. 3, presents the patterns from the above data series which are not stationary since the excess number of spikes. Therefore, the square root function is successively applied in step 3.

Step 3: Use of square root function to adjust the stationary of data.

In the previous step, the data series was not stationary so, these data must be transformed using square root function, as shown in Fig. 4.



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	Time	Throughput	Throughput_sqr	var
1	1	0	.00	
2	2	2432288	1559.58	
3	3	0	.00	
4	4	4269184	2066.20	
5	5	0	.00	
6	6	4124704	2030.94	
7	7	0	.00	
8	8	4141440	2035.05	
9	9	0	.00	
10	10	4294336	2072.28	
11	11	0	.00	
12	12	4162784	2040.29	
13	13	0	.00	
14	14	4078208	2019.46	
15	15	0	.00	
16	16	4284352	2069.87	
17	17	0	.00	
18	18	4145312	2036.00	
19	19	0	.00	
20	20	4041376	2010.32	
21	21	0	.00	
22	22	4133312	2033.05	
23	23	0	.00	
24	24	4100480	2024.96	

Fig. 4 The Result of Adjusting Data Using Square Root Function

Fig. 4 shows, the result of transforming the data series to stationary using the square root function. The stationary of data series is then estimated by checking the number of spikes in the plotted graph, as shown in fig. 5.

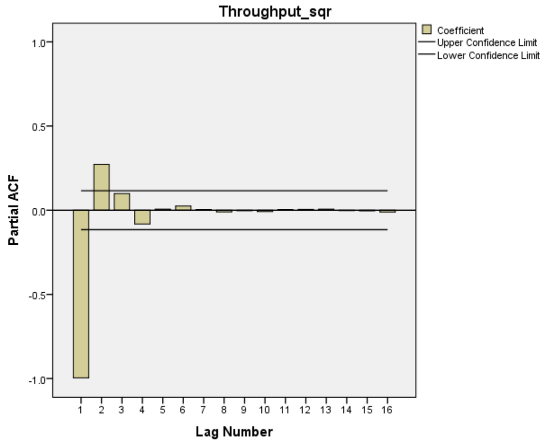

Fig. 5 The Graph Using PACF to Estimate the Stationary Data Series Using Square Root

Step 4: Use of the ACF function to estimate parameters of the ARIMA model.

In this step, the parameters of the ARIMA model are evaluated by using the ACF function to estimate and choose suitable parameter values.

After adjusting the data series to stationary, parameters of the ARIMA model are appropriately selected to produce an accurate forecast.

In general, the ARIMA model is identified with the notation ARIMA (p, d, q) whereas p, d and q denote the order of autoregressive, differencing and moving average respectively.

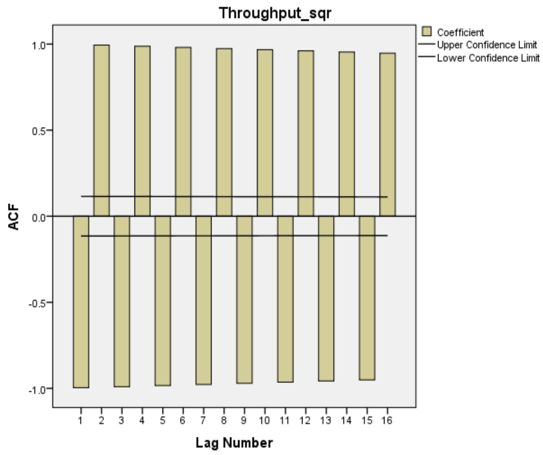

Fig. 6 The Graph Using ACF by Adjust the Dataset with Square Root Function

The previous graph was re-calculated using the ACF function via the statistical program (SPSS), as shown in Fig. 6. The pattern of graph is a sine graph. Therefore, a suitable ARIMA model should be selected, one can see the ARIMA (2, 0, 0) is acceptable from the AR(2) model [4].

Step 5: Model the time-series forecast using the ARIMA.

A univariate time series analysis is provided to find the relation of single observations recorded sequentially through time. Although, there is single value recorded in the univariate time series model, the time value is actually hidden. Generally, the ARIMA model or Box-Jenkins is a well-known univariate time series model that combines Autoregressive (AR) model and Moving average (MA) model together. Moreover, the total number of observations recorded as satisfactory should be at least 50 records.

The hypothesis of a ARIMA model is that current observation values must be a linear equation of previous observations and error, as shown in Eq. 1.

$$\boldsymbol{y_t = \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-q}} \quad (1)$$

Where:

y_t is the observation value.
p is the order.
$\alpha_1, \ldots, \alpha_p$ are the parameters or coefficients (real numbers).

TABLE I
THE PARAMETERS OF A ARIMA MODEL DERIVED BY SPSS

ARIMA Model Parameters

				Estimate
Throughput_sqr	No Transformation	Constant		1015.257
		AR	Lag 1	-.199
			Lag 2	.801

From table I, the ARIMA equation can be written as follows:

$$\boldsymbol{y_t = 1015.257 - 0.199\, y_{t-1} + 0.801 y_{t-2}} \quad (2)$$

The ARIMA equation from Eq. 2 can forecast the time interval without a jamming attack.

Step 6: Test the ARIMA model to find out the deviation.

After the suitable ARIMA model is selected, accuracy of the forecasting model must be tested using MAPE [5].

The Mean Absolute Percentage Error (MAPE) methodology is a measure of the accuracy of statistical forecast. MAPE can be defined as shown in Eq. 3.

$$\boldsymbol{MAPE = \frac{100}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|} \quad (3)$$

Where:

A_t is the actual value.
F_t is the forecast value.
n is the number of forecast data.

Model Statistics

Model	Number of Predictors	Model Fit statistics			Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	R-squared	MAPE	Statistics	DF	Sig.	
Throughput_sqr-Model_1	0	.995	.995	1.175	58.937	16	.000	0

Fig. 7 The Statistic Values of ARIMA Model

Fig. 7, presents the percentage of Mean Absolute Percentage Error (MAPE), which equaled the model at 1.175 percent. In other words, accuracy of the ARIMA model is at 98.825 percent which is greater than 95 percent, generating a good result for accurate forecasting. This means that the alternative ARIMA (2, 0, 0) model is much more accurate.

IV. RESULTS AND DISCUSSIONS

According to the selective ARIMA model, ARIMA (2, 0, 0), accuracy for time series forecasting equals 98.825 percent. The comparison to the pulse-jamming attack simulation is shown in Fig. 8.

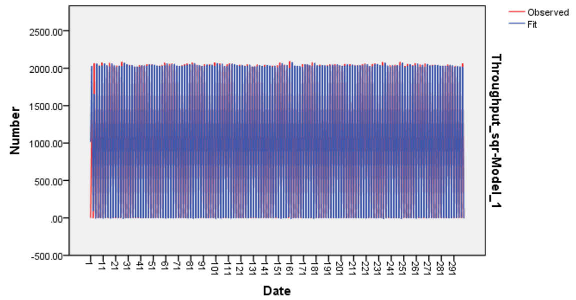

Fig. 8 The Comparison of Output between the ARIMA Forecasting Model and Pulse-Jamming Attack Simulation

V. CONCLUSION AND FUTURE WORK

The objective of research was to find the pulse on value of pulse-jamming wireless attacks. Forecasting was achieved by using a time series-forecasting model, ARIMA (2, 0, 0). This model accurately forecasted at 98.825 percent and could be applied the process of pulse-jamming attack prevention in wireless networks successfully. In this research, however, the alternative parameters of ARIMA model were at different time intervals. Therefore, the total number of parameters should be adjusted in the same time, making it easy to evaluate the forecasting model.

VI. ACKNOWLEDGMENT

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REFERENCES

(Arranged in the order of citation in the same fashion as the case of Footnotes.)

[1] Hall, M., Silvennoienn, A., and Haggman, S. (2005). "Effect of Pulse Jamming on IEEE802.11 Wireless LAN Performance". MILCOM 2005. IEEE Military Communications Conference.

[2] Box, G. and Jenkins, G. (1976). "Time Series Analysis: Forecasting and Control". Holden Day, San Francisco.

[3] The Pennsylvania State University. (2017). "Applied Time Series". <https://onlinecourses.science.psu.edu/stat510/>.

[4] Zucchini, W. and Nenadic, O. "Time Series Analysis with R-Part I".

[5] Khashei, M., Bijari, M., and Hejazi, S.R. (2012). "Combining Seasonal ARIMA Models with Computational Intelligence Techniques for Time Series Forecasting". Springer-Verlag, Berlin, Heidelberg.