DEMAND PREDICTION FOR SRI LANKAN URBAN FIXED WIRELESS TELECOMMUNICATION SECTOR

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INTRODUCTION

Fixed wireless telephone systems, commonly known as the wireless local loop (WLL) systems have been a solution to many issues arising in deploying wired local loop connections. Easy deployments with high scalability together with comparatively low capital and operational costs have made fixed wireless services to be preferred over conventional wired lines. Currently, three fixed wireless operators are operating in Sri Lanka, namely Dialog, Sri Lanka Telecom (SLT) and Lankabell who rely mainly on CDMA2000 wireless system to provide voice and data services (TRCSL, 2013).

Meanwhile, in wireless communication systems, demand for communication may vary both in the short term as well as in the long term. In a conventional wireless mobile communication system, if the demand exceeds the capacity of the network segment, the new subscribers have the liberty to move to the coverage of a different segment which has free resources. However in fixed wireless systems, the movement is restricted and demands exceeding the capacity would result in blocking. This affects the service quality. On the other hand, the service providers are interested in maintaining the network resources at the minimum level, just sufficient to maintain the threshold service quality and are finding it cost ineffective to maintain the capacity always above the peak demand. Therefore, a constant alert is required to identify both the long and short term demand variations to take necessary actions to alter the capacity as required. This will allow forecasting the future demand in a particular segment both in the short and in the long term.

Telecommunication demand prediction is the activity of estimating the amount of a voice and broadband service that subscribers will utilize during a given future time. Demand forecasting involves techniques including both qualitative methods such as getting expert opinions and quantitative methods such as the analysis of historical traffic volumes (Lee, 1988 & Li, et al, 2010). In this paper a quantitative demand prediction is presented for forecasting the demand for a CDMA2000 fixed wireless system segment deployed in Sri Lankan urban areas, using time series analysis. Even though the presented results are for a short term analysis, extending the same forecasting for long term would be very similar.

METHODOLOGY

In this study, half hourly recorded past call traffic data were collected from the performance monitoring server databases of two live fixed wireless systems and was analyzed, where these two systems service more than **60%** of the total fixed wireless subscriber base in Sri Lanka. Further, a demand prediction was carried out for a network segment centered on Nawala, Koswaththa, Narahenpita, Kirimandala Mawatha, Polhengoda and Nugegoda area base stations.

Before analyzing the results, two different trends were predicted for weekdays and weekends considering the fact that the human behavior changes greatly from weekdays to weekends. Hence, the analysis was carried out for the weekdays and weekends separately. Furthermore, the traffic patterns during special holidays were observed to be very much different from those of other days.

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Even the traffic patterns during different special holidays were seen to be different from each other. Hence, to maintain the uniformity, the traffic data of special holidays were excluded from this analysis. Autoregressive Integrated Moving Average (ARIMA) model (Juan, 2008) was employed to predict future daily traffic utilization. Note that in order to utilize the ARIMA model, the data series must be stationary without any seasonality.

During this prediction process, first the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the traffic data were calculated for different lags (sets of data points) to find the lag size which exhibits a stationary series behavior. Second, the prediction was carried out for the two series of data, separately. Finally, the residual plots were generated to investigate the accuracy of the prediction system.
Minitab statistical software was employed for the analysis and forecasting (Amari, 2003).

RESULTS AND DISCUSSION

Figure 1 shows the time series plots of past call traffic data. Weekdays' and weekends' traffic patterns clearly show different trends which justifies the prior assumption.

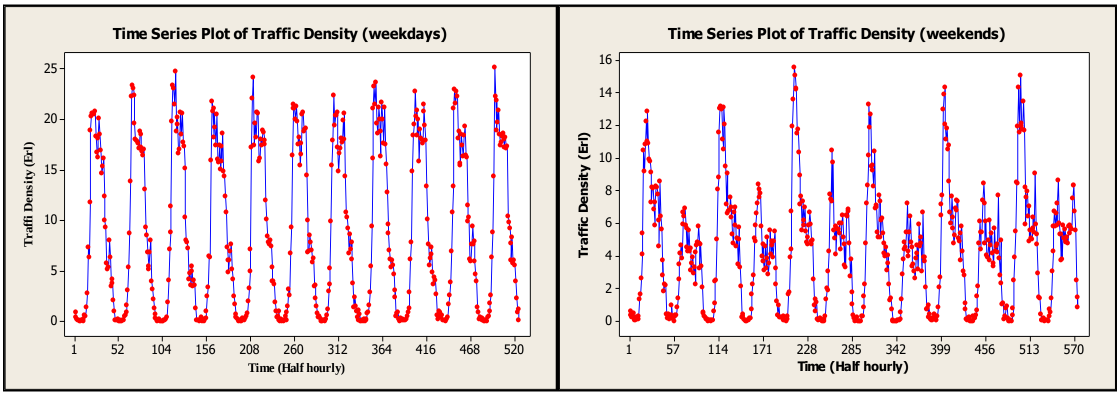

Figure 1: Time series plots for traffic density

Both series have seasonality; therefore difference was calculated to make the traffic data series to be converted to a stationary series. Using the ACF and PACF plots, the optimum lag sizes were selected to be 48 for weekdays and 96 for weekends.
The ACF and PACF of stationary data (lag size 48) for the weekday series are shown in Figure 2 where the ACF is with large spikes at initial lags and decay to zero during later lags and the PACF is with large spikes only at the first and second lags. This clearly indicates that the traffic generation process is an autoregressive moving average process with stationary behavior. The weekend series was having a similar behavior in its ACF and PACF with a lag size 96.

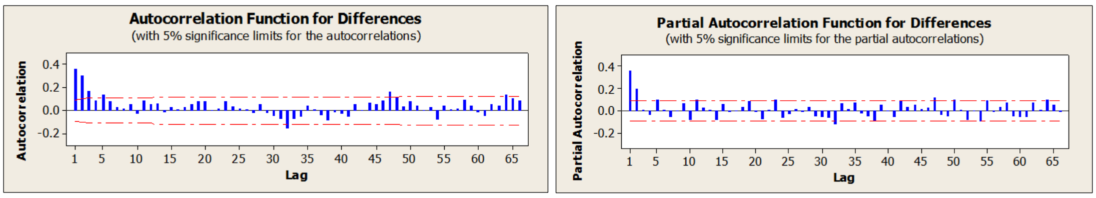

Figure 2: Auto correlation function and partial autocorrelation function

With ARIMA model, the short term prediction for the coming three days with a 95% confidence level is as shown in Figure 3 together with past eleven days' traffic data. It is clearly visible that when the prediction duration increases the error associated is also increased.

Extracted prediction results without error bars are presented in Figure 4.

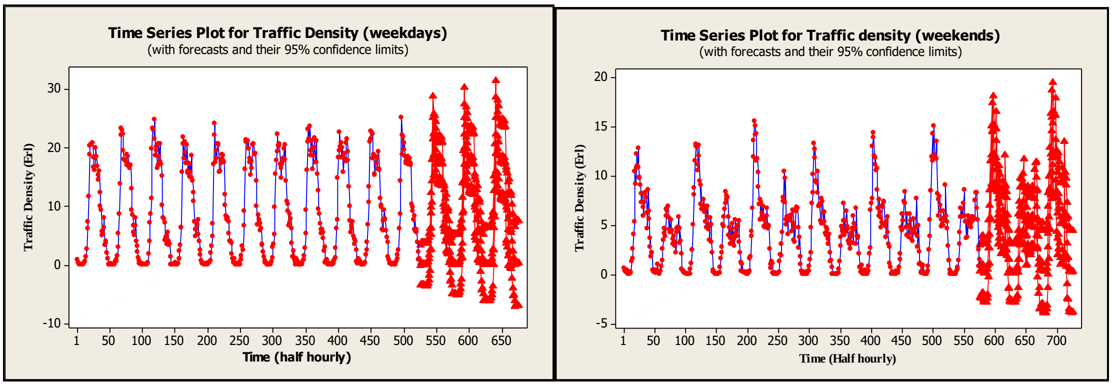

Figure 3: Time series forecasting with error margins

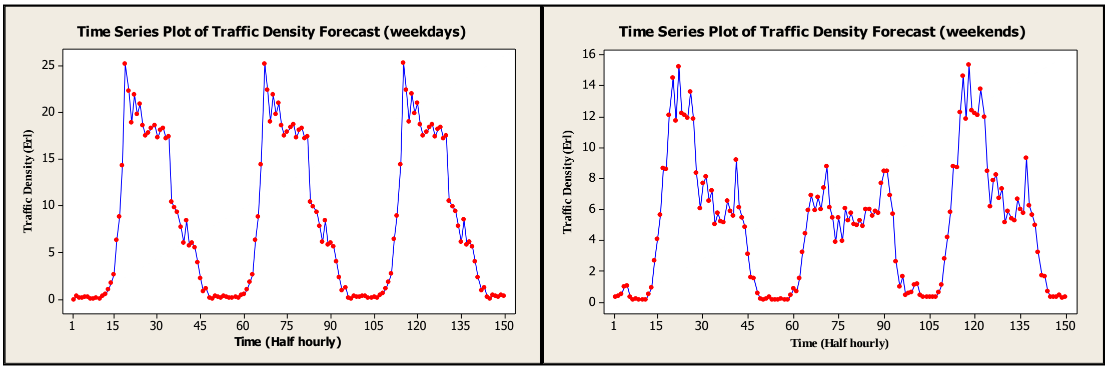

Figure 4: Time series forecasts for weekdays and weekends

According to the prediction, on weekdays 10.00am to 11.30am, the peak traffic density is to be observed which is over *20 Erlangs*. Then, traffic density varies around *15-20 Erlangs* between 2.30pm to 3.00pm. Traffic density changes around *5-10 Erlangs* at 8.00pm during night time. Saturday traffic variation is predicted as *6-14 Erlangs* while on Sunday, it is almost *6 Erlangs*.

Further, weekday total daily traffic utilization at an urban base station is predicted to be around 400 *Erlangs* while it is predicted to vary between *200* and *250 Erlangs* on Saturday. On Sunday it is predicted to go down to *150 Erlangs*. These predictions closely agree with the stationary pattern seen over the past, as shown in Figure 3.

Normal probability plot and histogram of residuals in Figure 5 shows a Gaussian behavior while theversus fit and order show randomly distributed residuals which verifies the accuracy of our prediction.

CONCLUSIONS/RECOMMENDATIONS

With the use of Minitab statistical software tool and based on ARIMA model, a time series prediction for a Sri Lankan urban fixed wireless sector has been presented. The results clearly demonstrate two patterns for weekdays and weekends. Moreover, the predictions have agreed very closely with the past patterns.

With the presented prediction system, while maintaining a 95% confidence level, prediction can be carried out only to predict for one third time as past time considered. However, a further prediction can be carried out with less accuracy. On the other hand, use of a larger past data set would allow prediction further in to the future maintaining the same 95% confidence level.

Using forecasted demand, network planners would be able to decide how much equipment to purchase and when and where to place them to ensure optimum management of traffic loads. This will in turn give an operator a competitive advantage in the telecommunication business while maintaining a tradeoff between the capital expenditure and the quality of service.

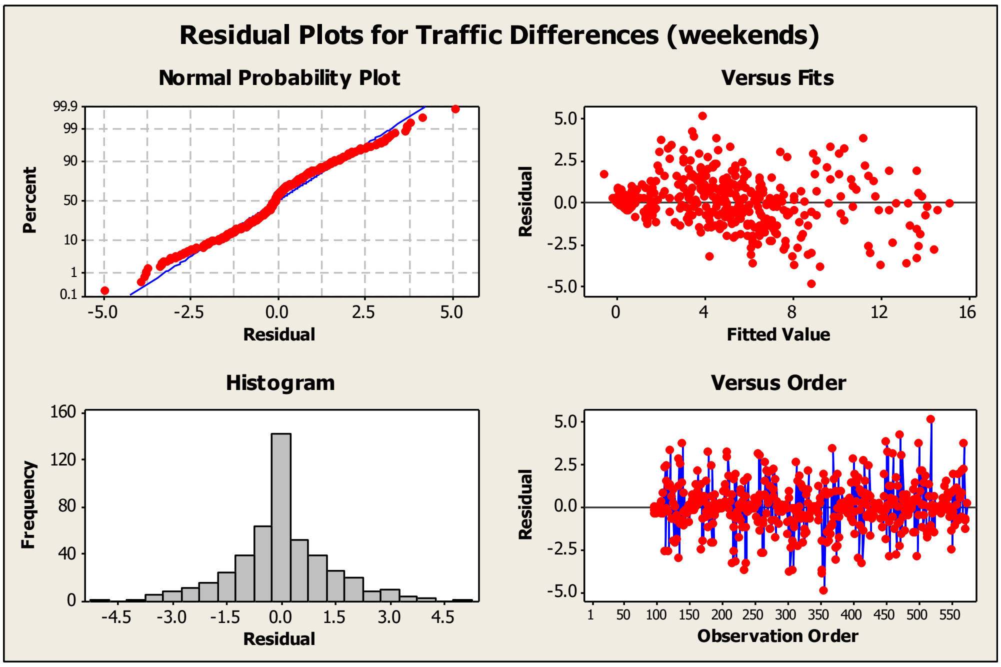

Figure 5: Residual plots for weekends

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