Chapter 5
Traffic Prediction over Wireless Networks

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ABSTRACT

The predictability of network traffic is an important and widely studied topic because it can lead to the solutions to get more efficient dynamic bandwidth allocation, admission control, congestion control and better performance of wireless networks. In this chapter, firstly, the authors briefly describe a number of traffic models that include time series models, artificial neural networks models, wavelet-based models, and support vector machine-based models. Secondly, they give the prediction method and metrics of measuring the accuracy of a prediction. Finally, they examine the feasibility of applying support vector machine into the prediction of actual traffic in WLANs and evaluate the performance of different prediction models such as ARIMA, FARIMA, and artificial neural network, wavelet-based and support vector machine-based models for the prediction of the real WLANs traffic.

INTRODUCTION

The predictability of network traffic is of significant interest in many areas including network design, management, control, and optimization (Stemm & Seshan & Katz, 2000; Kim & Noble, 2001). Prediction on long time scale is the base of long-term planning of Internet topology (Ostring, 2000; Shah, 2003). Prediction on short time scale is necessary for congestion control, admission control, bandwidth allocation and buffer management (Yi, 2004; Qiu, 2004; Chisci, 2006). The goal is to forecast future traffic variations as precisely as possible based on the measurements of the traffic history. An accurate traffic prediction model should have the ability to capture the prominent traffic characteristics. Therefore, highly accurate traffic prediction can help to make the maximum usage of bandwidth while guaranteeing the quality of service (QoS) for real-time applications which have stringent requirements on delay or packet rate.

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loss. An accurate traffic prediction is, therefore, critical in preventive control scheme in order to utilize its resources efficiently.

The widespread deployment of IEEE 802.11 wireless local area networks (WLANs) as a fundamental approach for enabling ubiquitous wireless networking is mainly due to their easy installation, flexibility and robustness against failures. WLANs traffic prediction plays a fundamental role in the design and analysis of WLANs (Papadopouli, Shen, Raftopoulos, Ploumidis & Campos, 2005). For example, the bandwidth utilization at an access point (AP) can affect the performance of the wireless clients in terms of throughput, delay, and energy consumption. The traffic prediction can help the AP to perform better load balancing, admission control, and QoS provisioning. Specifically, an AP can use the expected traffic estimations to decide whether to accept a new association request or advise a client to associate with a neighboring AP. Thus, it can improve wireless network throughput and ensure the QoS requirements from different traffic types.

Recently, there has been a significant change in the understanding of network traffic. A number of studies of traffic measurements in wired and wireless networks have convincingly demonstrated that the Internet traffic is self-similar or long-range dependent (LRD) in nature (Park & Willinger, 2000; Jiang, Nikolic, Hardy & Trajkovic, 2001). It implies the existence of concentrated periods of low activity and high activity (i.e., burstiness) at a wide range of time scales. Self-similarity traffic cannot be captured by classical models. Predicting the future traffic from the past observations is an important way to obtain traffic control under self-similar traffic loads. Under the long-range dependent network traffic and with their slow convergence properties, it becomes more difficult to design rigorously effective predictors with desirable properties. Effective optimal prediction remains a technical challenge (Beran, 1994). Hence the new fundamental problem in the network traffic prediction is to find efficient self-similar models to predict future traffic variations precisely and produce good predictability.

BACKGROUND

In the past several decades, many models have been proposed for the prediction of traffic in wired networks. In the earliest work, some researchers have proposed autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models to predict network traffic (Sang & Li, 2002; Adas, 1997; Krithikaivasan, Deka & Medhi, 2004). All these models are linear time series models that can capture short-range dependence. Although ARIMA models are proved to be quite powerful to model a class of non-stationary data traffic, it can’t capture long-range dependent characteristics.

Currently, self-similarity and LRD features have been observed in the Internet traffic over the wired and wireless networks. Traditional linear time series models cannot explain and capture self-similarity and LRD features of the traffic. To deal with the self-similar nature of the network traffic, some researchers (Shu, Jin, & Zhang, 1999; Corradi, Garroppo, Giordano, & Pagano, 2001) have proposed using fractional autoregressive integrated moving average (FARIMA) to model and predict the traffic in the networks. Since FARIMA is a self-similar model with the capability to capture both the short-range dependent (SRD) and LRD characteristics, the FARIMA model has shown its prediction ability in admission control and dynamic bandwidth allocation (Shu, Jin, Wang & Yang, 2000; Sadek, Khotanzad & Chen, 2003). Another non-stationary and non-linear threshold autoregressive (TAR) model has also been introduced to model and predict network traffic (You & Chandra, 1999). The TAR model is also non-linear and behaves as long memory. It can capture self-similarity and LRD well. Both FARIMA and TAR models do improve the performance of prediction for self-similar time series with the cost of com-