1. INTRODUCTION

Ubiquitous Computing has become the need of the day. People need high-speed (high-bandwidth) internet anytime and everywhere. This ubiquitous nature is possible only due to Mobile Ad hoc Networks (MANETs) or Wireless Mesh Networks (WMNs). MANETs enable multi hop communications among the nodes where nodes in the network act as routers and forwards the messages to other nodes in the network. The capacity/range of the network is actively increased and varies due to the active co-operation of participating nodes. WMN is a MANET which stands on the basis of static nature or minimal mobility. Internet accessibility can be provided to rural, geographically disadvantaged or remote locations due to the ability of WMNs to extend the coverage areas. Mobile wireless mesh networks (MWMNs) is of dynamic nature that operates in peer-to-peer (P2P) MANET communications where the connectivity of devices also known as mobile clients (MCs) such as laptops, mobiles, wireless sensors, etc. keeps on changing.

This paper is based on the work done by Vardi et al. [1] of estimating the source-destination traffic intensities from link data to obtain end-to-end delay measurements and the extension of work done by Mohammad S. Khan et al. [2] for finding a solution to inverse problem in wireless mesh networks in static environment where the MCs remain in a steady state. Network tomography is a methodology of estimating the source-destination traffic intensities from link data to obtain end-to-end delay measurements where minimal or no co-operation from nodes is expected to estimate the delay incurred at each of the nodes. In this paper, we provide an analysis of network performance using network tomography approach that estimates end-to-end link delays of each and every node in the network in a dynamic environment where the MCs will continuously keeps on changing. This kind of network diagnosis approach will help us to estimate network traffic intensities at each node in the network as well as will let us know shortest possible path (least hop path) with least delay.

Our algorithm is verified using NS2 simulations, which generates the results and give us information about flow delay which helps in choosing low delay end-to-end path. This helps us to achieve better load balance over multiple paths in WMNs. Along with delay information, which includes average delay and absolute delay, our algorithm also provides information about number of hops, overhead and average throughput . Shortest possible path can be calculated only on the basis of information about number of hops. But shortest possible path does not guarantee that the path will have least delay. At times path with least number of hops which will be shortest path and may have more delay than the path with more number of hops. Overhead is another issue that needs to be handled in network traffic. Minimal route overhead should be the prime aim while developing any load balancing algorithm.

Section 2 gives us information about previous and related works in the same area. WMN architecture is described in section 3. Section 4 deals with network tomography application for MWMNs. NS2 simulations and results are carried out and shown in section 5 and 6. Conclusion and future work is mentioned in section 7.

2. RELATED WORKS

Network Tomography as a concept was first mentioned by Vardi et al. [1] while estimating end-to-end node delay parameter with the application of maximum likelihood estimation and EM (Expectation – Maximization) algorithm to calculate source-destination traffic intensities. Network Diagnosis using network tomography with ray tracing concept was implemented on synthetic data using CORE emulation as well as on real data pertaining to a major US based network provider [3].

Several load balancing algorithms also developed with an objective to reduce the delay in the network traffic. Adaptive situation-aware (ASA) load balance scheme for mobile wireless mesh networks helps to maintain an optimal path during the transmissions by using a routing metric for judging the situation of routing paths [4]. Maximum Pseudo Likelihood concept is used for estimation in network tomography where the basic problem is grouped among subproblems ignoring the dependencies among the subproblems to form a product likelihood of the subproblems [5]. Stitching algorithm uses such an approach on mobile ad hoc networks [10]. Weighted cumulative expected transmission time with load balancing (WCETT-LB) for wireless mesh net works is proposed for load balancing in routing metric [7].

Packet Loss rate and delay are two of the inter-related performance parameters and its correlation is described in [6] and [12]. Packet loss predictor technique predicts the packet loss as a function of the available bandwidth and delay [8]. [9] uses the traffic indicator, that can describe the behavior of short-term, long-term or self-similar traffic patterns. Then, approximate the cell loss rate in terms of the indicator parameters using a neural network system which consists of a linear combination of a number of sigmoidal functions. Predictive packet loss rate mechanism is used in [13] and simulations are carried out using NS-2 to compare with other load balancing algorithms. [2] and [10] gives us the exact idea of network tomography application in wireless mesh networks. [11] gives us the information about WMNs in general and issues, troubleshooting and research opportunity in the area.

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