A Simple Statistical Methodology for Testing Ad Hoc Networks

Makoto Ikeda[1], Giuseppe De Marco[2], and Leonard Barolli[1]

[1] Department of Information and Communication Engineering,
Fukuoka Institute of Technology (FIT)
3-30-1 Wajiro-Higashi-ku, Fukuoka 811-0295, Japan
mgm05001@ws.ipc.fit.ac.jp, barolli@fit.ac.jp
[2] Toyota Technological Institute,
2-12-1 Hisakata, Tenpaku-Ku, Nagoya 468-8511, Japan
demarco@toyota-ti.ac.jp

Abstract. Real-life tests of ad hoc networks are invaluable in order to assess models used in simulation. However, the number of factors affecting the performance of an ad hoc network is high. There are, for example, system factors, such as routing protocols, MAC and physical layer protocols, as well as environment factors, such as the presence of walls, foliage and moving objects. In this regard, it is important to design repeatable experiments of the network, in order to identify the parameters which really affect the system behavior. Here, we leverage methods of statistical testing theory to identify these parameters in a compact manner. In particular, we use OLSR as a routing protocol. Results from real experiments confirm the horizon effect of ad hoc multi-hop networks and shown that there is a treatment effect caused by the window size of OLSR.

1 Introduction

Ad hoc networks are infrastructureless networks, where a number of nodes can interconnect to each other in a decentralized manner. Applications of such networks range from emergence or spontaneous networking to space extension of Internet connections, which is commonly known as mesh networking. So far we can count a lot of simulation results on the performance of ad hoc networks, e.g. in terms of end-to-end throughput, delay and packet loss. However, in order to assess the simulation results, real-world experiments are needed and a lot of testbeds have been built to date [1]. The baseline criteria usually used in real-world experiments is guaranteeing the repeatability of tests. This requirement is very stringent, because in ad hoc networks there are a lot of uncontrollable parameters. Let us think at the wireless channel only. It might happen that in some days the channel is "better" than in other days. Also, effects such as multipath fading may vary along the experiment. Various solutions have been proposed in order to overcome these difficulties. One of the most active project on experimental analysis of ad hoc networks is that of the group at Uppsala University, which implemented a large testbed of 30 nodes [2,3]. They presented

T. Enokido, L. Barolli, and M. Takizawa (Eds.): NBiS 2007, LNCS 4658, pp. 1–10, 2007.

an automatic software called APE which can set and run measurements in an ad hoc network with a particular routing protocol, e.g. AODV, OLSR or LUNAR. The authors of the experiments suggested to use a particular metric to solve the repeatability problem. Here, we propose to use another way to solve this problem which does not need in principle additional metrics. This solution take advantage of the hypothesis test theory, which is often used whenever the experimenter wishes to identify true difference in performance of the system when tested under different scenarios. A scenario in a statistical parlance is a treatment. The results presented here are taken from a real-world testbed of five ad hoc nodes, which was run both in indoor and outdoor scenario. In particular, we used the Open Link State Routing (OLSR) as routing protocol, because it is the most evolving protocol worldwide, especially from the point of view of its software implementation [4,5].

The rest of paper is structured as follows. In Section 2, we review the basic properties of OLSR. In Section 3, we describe the components of our testbed and the methodology used to analyze the data. The application of this methodology is given in Section 4. Conclusions are presented in Section 5.

2 Routing: OLSR

By means of dedicated control messages, OLSR modifies the routing tables of the node it runs on. Its main tasks are neighbors sensing, Multi-Point Relaying (MPR) calculation and Topology Control (TC) messages dissemination. Neighbor sensing is performed by sending periodic broadcast HELLO messages with rate T_{HELLO}^{-1}. In OLSR, there are cross-layer operations to some extent. For example, in order to check the presence of a neighbor, OLSR has to compute a quality metric of all links towards neighboring nodes. According to the value of this metric for both directions of links, OLSR can judge upon the symmetry of links. Asymmetric links are discarded. It is well known [6] that hop-cont based metrics do not result in high throughput, because the routing protocol could choose a worse path (e.g. high delay) even if it has the minimum hop-count. A better metric is based on the Expected Transmission Count (ETX). Every node computes the forward and backward packet loss rate for every neighbor link. The backward packet loss rate is the packet loss "seen" by the neighbor. Then, the ETX is computed as $ETX = \frac{1}{p_f p_r}$ where p_f is the estimate of the forward packet loss rate and p_r is the reverse packet loss rate. This quantity is the mean number of re-transmissions per packet we have to wait for successful transmission over a particular link. The latter quantities are computed within a normalized time window whose default value is $w = 10$. For example, if $T_{\text{HELLO}} = 0.5\text{s}$, we have to wait 20s in order to compute a sample of ETX. Since we used single-radio NICs, we did not use more advanced metrics, like the Weight Cumulative Expected Transmission Time (WCETT) [7]. For instance, WCETT is conceived for multi-radio mesh networking.

There are several implementation of OLSR. However, the most known and update open project is OLSRd [4], originally implemented by Andreas Tønnesen.