A Testing Architecture for Designing High-Reliable MANET Protocols

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Abstract. In future ubiquitous communication environments, broadband wireless communication will become popular. Also, wireless LAN devices such as IEEE802.11a/b/g and wireless PAN devices such as Bluetooth and ZigBee may be integrated into mobile terminals with reasonable cost and complementarily used with existing cellular networks. This means that mobile ad-hoc networks (MANETs), which are composed between these narrow range communication devices without fixed network infrastructures will be seamlessly connected to global networks (IP networks). For future deployment of MANET protocols, we discuss their testing issues with some experimental results.

1 Introduction

MANETs are getting recognized as one of key infrastructures to realize future ubiquitous communication environments. However, testing functional and performance validity of MANET applications and protocols is not an easy task. Even if given IUTs (Implementation Under Test) of mobile nodes have independently passed general conformance tests, they might not work correctly (or might not achieve reasonable performance) if they work together collaboratively to provide services and functionalities such as distributed content search and routing. Additionally, mobility of nodes makes the problem much more difficult. It is known that mobility models strongly make influence for their performance and correctness [1].

In this paper, we focus on functional and performance testing for MANET protocols. We discuss what properties should be validated in testing, and accordingly how we model the environments of target protocols. Then we propose a testing architecture for MANET protocols. The architecture is based on our network simulator MobiREAL [2,3]. We basically use passive testing methods where we observe sequences of data transmission between IUTs. Given IUTs to be tested and properties to be validated, the environments including mobility models and underlying wireless transmission layers can be virtually provided to IUTs as if they are executed on real mobile terminals. The architecture supports not only to provide environments but also to observe the results of passive testing visually. Some experimental results are also shown in this paper.

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2 Passive Testing of MANET Protocols

When we consider passive testing in the higher layer (layer 4 and the above) of MANET protocols, we may simply abstract the communication channel between them as single unreliable channel. On the other hand, testing the network layer protocols of MANETs needs much consideration mainly because of (i) mobility modeling and (ii) upper/lower layer modeling.

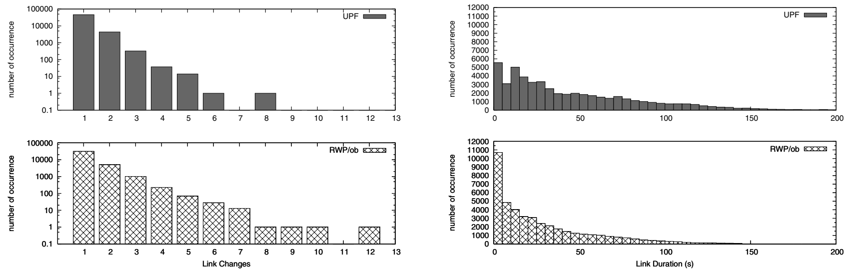
Let us consider DSR (Dynamic Source Routing) [4] as an example. DSR finds multiple potential routes at the route request phase. Then one of them is selected and the others are kept in route cache of the nodes for some period. If the current route is broken, the route is re-established using the cache at the nodes. In this situation, if we would like to validate such property that the route can be re-established *in any situation of node mobility, topology and density*, we have to test given IUTs in many cases, giving many types of mobility models with different numbers of nodes. We may refer to Ref. [1] where several mobility models have been introduced. However, it is hard for designers to imagine mobility patterns of mobile nodes and choose ones that generate node mobility, topology and density that totally generates the desired situations. To cope with this problem, we may use several metrics to characterize the mobility [5–7].

The modeling of the upper/lower layers of the target layer might make some influence. In the lower layers, packet delay by collision avoidance and/or retransmission might make some influence to the performance of the network layer. The packet duplication by retransmission and packet regulation by rate control in the upper layers also might make some influence. Here, we assume that the implementation in the lower layers is correct. Also, we assume that we use general functions and applications in the upper layers (*e.g.* we assume that we use CBR (Constant Bit Rate)).

Under these assumptions, we assume that IUTs are provided as executable codes (thus they are black-boxes), and provide an architecture for passive testing. For given properties to be validated (*e.g.* communication between source and destination nodes can take place correctly in DSR), we observe communications between IUTs. We use a mobile ad-hoc network simulator called MobiREAL[2,3] which can control the mobility of each mobile node using a set of events with pre- and post-conditions. For macroscopic control of mobile nodes, mobility scenarios can be given. The simulator can provide implementation of the other layers such as CBR, TCP, IEEE802.11 MAC, and radio propagation. We are now planning to provide a virtual environment in the MobiREAL simulator where given IUTs can be executed as if they are executed on the real terminals. But actually these terminals are emulated using implementations of the other layer protocols of MobiREAL simulator.

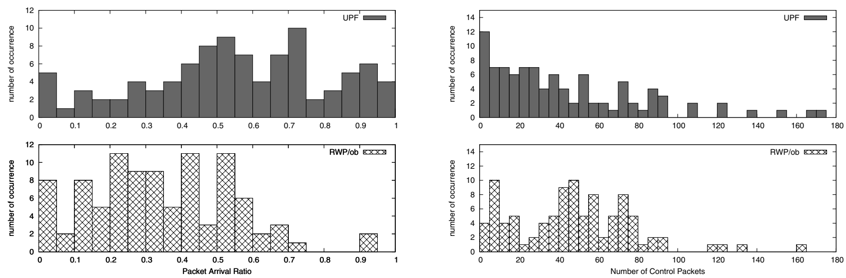
3 Impact of Mobility – Experimental Results –

In this section, we present the experimental results of performance evaluation of DSR using MobiREAL. The results will show the difference of performance depending on mobility, and encourage us to provide our testing architecture.



(a) Distribution of link changes (b) Distribution of link duration

Fig. 1. Mobility Metrics



(a) Distribution of packet arrival ratio (b) Distribution of number of DSR control packets

Fig. 2. DSR Performance

We have used different mobility models to see the impact of mobility models to MANET protocols. We have modeled a real 500m×500m region including buildings in downtown Osaka city. We have used two mobility models, (i) UPF (Urban Pedestrian Flow) mobility[8] which represents realistic movement of pedestrians in city sections, and (ii) a modified version of RWP (random way point) mobility denoted as RWP/ob ("ob." stands for obstacles). In RWP/ob, each node moves between intersections. At each intersection, the node randomly decides the next direction, avoiding to go backward. Then we have measured the metrics presented in Ref. [7] that characterize mobility. (i) link changes (*i.e.* the number of link creations between two nodes) and (ii) link duration (*i.e.* the longest time interval during which two nodes are in the transmission range of each other).

The distributions of these metrics are shown in Fig. 1. Clearly, RWP/ob model has several cases with larger link changes (*e.g.* 9 and the above) compared with UPF mobility. This is natural because in the UPF mobility, more neighboring nodes are going to the same destination than RWP mobility and thus link changes do not occur many times. This observation is endorsed by the link duration result, where UPF has longer durations clearly.

Then we have measured several metrics that show the performance of DSR. We have selected two application users in the same pedestrian flow but away from each other. The results are shown in Fig. 2.

In the UPF mobility, DSR route was established along the flow. Therefore, the route is stabler than RWP/ob. This observation is endorsed by Fig. 2(a) and Fig. 2(b). The packet arrival ratio becomes lower and the number of control packet is larger if the route is instable, since there are many disconnections of the route.

4 Conclusion

In this paper, we have discussed a passive testing architecture of MANET protocols, and have presented a future direction to design high-reliable MANET protocols. Our ongoing work is to design the presented architecture.

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