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Interface and results visualization of WMN-GA simulation system: Evaluation for Exponential and Weibull distributions considering different transmission rates

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ABSTRACT

In this paper, we present the interface and data visualization of a simulation system for Wireless Mesh Networks (WMNs), which is based on Genetic Algorithms (GAs). We call this system WMN-GA. As evaluation parameters, we consider Packet Delivery Ratio (PDR), throughput and delay metrics. For simulations, we used ns-3 simulator and Hybrid Wireless Mesh Protocol (HWMP). From simulation results, we found that PDR for Weibull distribution is higher than Exponential distribution. But, the throughput of Exponential distribution is higher than Weibull distribution. The delay of Exponential distribution is smaller than Weibull distribution.

1. Introduction

The Wireless Mesh Networks (WMNs) are currently attracting a lot of attention due to their importance for providing cost-efficient broadband wireless connectivity. The WMNs can be seen as a special type of wireless ad-hoc networks.

WMNs are based on mesh topology, in which every node (representing a server) is connected through wireless links to one or more nodes, enabling thus the information transmission in more than one path. The path redundancy is a robust feature of mesh topology. Compared to other topologies, mesh topology does not need a central node, allowing networks based on it to be self-healing. These characteristics of networks with mesh topology make them very reliable and robust networks to potential server node failures.

There are a number of application scenarios for which the use of WMNs is a very good alternative to offer connectivity at a low cost. It should also mentioned that there are applications of WMNs which are not supported directly by other types of wireless networks such as cellular networks, ad hoc networks, wireless sensor networks, and standard IEEE 802.11 networks. There are many applications of WMNs in Neighboring Community Networks, Corporative Networks, Metropolitan Area Networks, Transportation Systems, Automatic Control Buildings, Medical and Health Systems, Surveillance and so on.

In WMNs, the mesh routers provide network connectivity services to mesh client nodes. The good performance and operability of WMNs largely depends on placement of mesh router nodes in the geographical deployment area to achieve network connectivity, stability, and client coverage.

In this work, we present the interface of WMN-GA system, which is based on Genetic Algorithms (GAs). We evaluate the performance of WMN-GA simulation system for Exponential and Weibull distributions considering different transmission rates. We present the visualization of the simulation results for different generations. As evaluation parameters, we consider the Packet Delivery Ratio (PDR), throughput and delay metrics. For simulations, we use ns-3 simulator and Hybrid Wireless Mesh Protocol (HWMP).

The structure of the paper is as follows. In Section 2, we discuss the related work. In Section 3, we make an overview of HWMP routing protocol. In Section 4, we present the implemented WMN-GA simulation system. In Section 5, we show the description of ns-3 and path loss model. In Section 6, we show the simulation results. Finally, conclusions and future work are given in Section 7.

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2. Related work

Until now, many researchers performed valuable research in the area of multi-hop wireless networks by computer simulations and experiments [1]. Most of them are focused on throughput improvement and they do not consider mobility [2].

Several heuristic approaches are found in the literature for node placement problems in WMNs [3–5].

In [3], the authors investigate the role of gateway placement on network throughput for realistic configurations of WMNs. They show that the position of the gateway significantly bears on network throughput. It is hence important to optimize its placement. The authors propose several heuristics to optimally position a single gateway in WMN and compare their relative performance in terms of network throughput with respect to the exact solution, which is obtained through cumbersome computations.

In [4], the author presents an algorithm for the gateway placement problem in Backbone Wireless Mesh Networks (BWMNs). Different from existing algorithms, the proposed algorithm incrementally identifies gateways and assigns mesh routers to identified gateways. The algorithm can guarantee to find a feasible gateway placement satisfying Quality-of-Service (QoS) constraints, including delay constraint, relay load constraint, and gateway capacity constraint. Experimental results show that its performance is as good as that of the best of existing algorithms for the gateway placement problem. But, the proposed algorithm can be used for BWMNs that do not form one connected component, and it is easy to implement and use.

In [5], the authors deal with the deployment of Mesh Nodes (MNs) in WMNs. They show that because it is difficult to place the MNs in a regular pattern in the real deployment, finding the optimal locations in the deployment environment is of much interest for the service providers. For a given possible location for the MNs and the user density in the deployment environment, they aim to find the locations of the MNs to be used that maximize the coverage and the connectivity of the network together. Due to high computational complexity of the exhaustive searching algorithm, an efficient local searching algorithm is proposed. Numerical results show that, the local search algorithm can give close to optimal performance with much lower time complexity than exhaustive searching.

As node placement problems are known to be computationally hard to solve for most of the formulations [6,7], GAs have been recently investigated as effective resolution methods. However, GAs require the user to provide values for a number of parameters and a set of genetic operators to achieve the best GA performance for the problem [8–10].

In our previous work [11–13], we considered the application of GAs for scheduling and resource allocation in grid systems, and the mesh router nodes placement in WMNs. In [11] and [12], we considered the tuning struggle strategy in Genetic Algorithms for scheduling in computational grids and carried out an experimental study on GAs for resource allocation on grid systems. In [13], we proposed and evaluated the GAs for near-optimally solving problems. We considered two-fold optimization: the maximization of the size of the giant component in the network and the user coverage. Several GA operators have been considered in implementing GAs in order to find the configuration that works best for the problem. We have experimentally evaluated the proposed GAs using a benchmark of generated instances varying from small to large size. The experimental results showed the efficiency of the GAs for computing high quality solutions of mesh router nodes placement in WMNs.

3. Overview of HWMP routing protocol

The IEEE 802.11s draft defines a default routing protocol called the Hybrid Wireless Mesh Protocol (HWMP). Every IEEE 802.11s compliant device is required to implement HWMP and to be capable of using it. HWMP is located on layer 2, this means, it uses MAC addresses.

The nodes of a WMN are called Mesh Points (MPs) in IEEE 802.11s. A MP is an IEEE 802.11 station that has mesh capabilities in addition to the basic station functionality. This means that it can participate in the mesh routing protocol and can forward data frames on behalf of other MPs according to the IEEE 802.11s standard. The MPs can be end customer devices such as laptops as well as infrastructure devices such as Access Points (APs).

The MPs with additional AP functionality are called Mesh AP (MAPs). Conventional WLAN clients, which are non-mesh IEEE 802.11 stations (STAs), can connect through the MAPs to the WMN. The MPs with additional portal functionality are called Mesh Portal Points (MPPs). They can bridge data frames to other IEEE 802 networks, especially to a wired network such as an Ethernet.

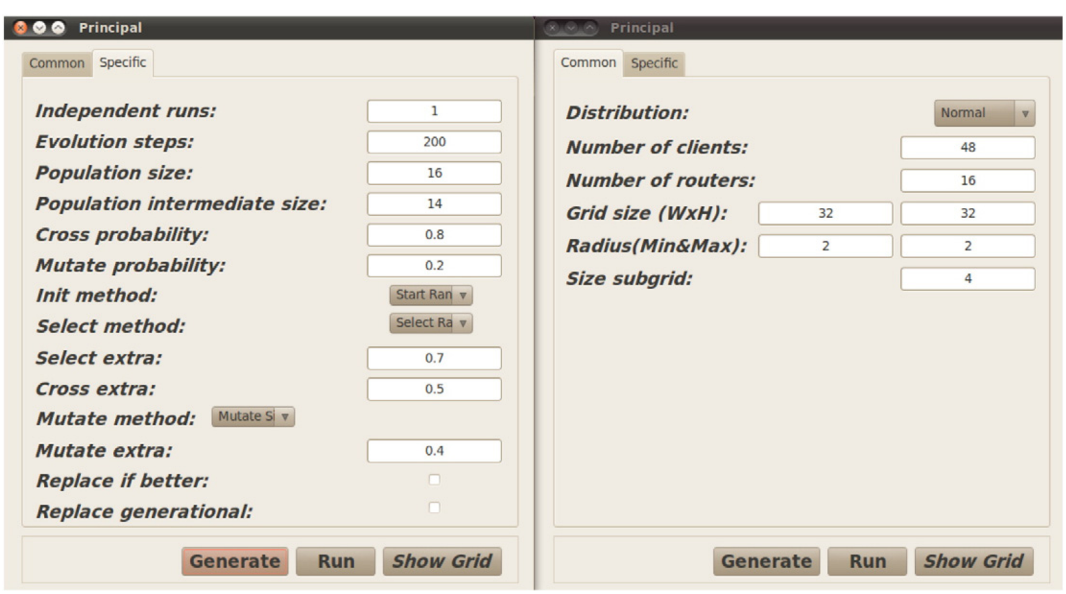

Fig. 1. GUI of WMN-GA simulation system.