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Enhance QoS by Learning Data flow rates in Wireless Networks using Hierarchical Docition

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Abstract

Wireless Wireless network finds application in military environments, emergency, rescue operations and medical monitoring due to its self-configuring nature. As the availability of resources such as processing power, buffer capacity and energy are limited in wireless networks; it is required to devise efficient algorithms for packet forwarding. Due to the dynamic nature of the wireless environment, the traditional packet forwarding strategies cannot guarantee good network performance every time. This paper proposes a method for learning data flow rates in wireless network to improve quality of service in the network. Each node in the network learns the environment using reinforcement learning approach and selects appropriate neighbours for packet forwarding. In order to improve the learning capacity of nodes, the hierarchical docition technique is employed. Docition applied to each layer of network, which selects a set of special nodes which has more information about the environment and share this information with less informative nodes. The algorithm is tested in a geographical routing protocol and the results indicate improved network performance.

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*Keywords:*Wireless network, Reinforcement learning

1. Introduction

In wireless multi-hop environment, the traffic characteristics are often influenced by the dynamic data flow rates in the multi-hops. This can have a serious impact on the Quality of service of the network. The conventional routing protocols1 are categorized as table-driven and on-demand. Table-driven routing protocols relied on table information updated periodically at each of the nodes. This resulted in high message overhead, high memory requirements and slow adaptation to the dynamic wireless environment. Also the connectivity among the network nodes is affected by the availability of its resources such as energy of the nodes, its processing power, data rate or

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interferences. One of the major challenges in the dynamic wireless environment is to develop intelligent routing algorithms that can ensure QoS in terms of throughput, delay and packet loss.

In a wireless network, group of nodes communicate with each other and forward packets to the destination. Each node in the network needs to identify a neighbour node which forwards its packets to final destination. The selection of neighbours is an important factor that affects the performance of the network. The proposed learning algorithm gives a method to rank the neighbours of a node and generate best topology for communication by interacting with the environment. Each node in the network learns the dynamically varying environment conditions of the node using Q learning algorithm. To improve the learning rate of each node, a hierarchal docition technique is applied. The network topology is logically divided into different layers starting from destination to the multiple sinks. In each layer, the algorithm identifies an expert node based on the learned q value. This expert node shares its experience with neighbouring nodes in the layer and improves the learning rate. The simulation results shows that the algorithm improve the performance of packet forwarding.

The remainder of the paper is organized as: Section 2 which elaborates of the existing algorithms and the reinforcement learning applied in wireless network. Section 3 describes the model and algorithm of the learning scheme based on docition. Section 4 deals with the experimental results followed by conclusion.

2. Related work

One of the major issues in wireless ad hoc networking is to provide good the quality of service in the dynamically varying environment. Many algorithms have been employed to improve the quality of service in wireless communication. In2, authors describe a method for rate adaptation in a congested wireless network using two real time measurements of the network and achieved throughput improvement. Diego Passos3 et al. proposed a joint rate adaptation technique in wireless mesh network. To compute optimal rate for each wireless link, the algorithm uses values collected by the routing algorithm. These algorithms are not able to adapt with the dynamicity of the wireless links quickly. Reinforcement learning4 is a machine learning technique in which the agent can interact with the environment and using the feedback signal obtained from the environment the agent can learn the characteristics of the environment. Reinforcement learning is applied to a wide variety of wireless networking problems and many algorithms are available improve routing decisions.

Recent works explores the possibility of applying machine learning for optimal control problems such as routing in wireless networks. One of the most popular reinforcement learning techniques, Q-learning was the first to venture the routing problem in static networks5. But this work ignored the dynamic nature of networks when factors such as mobility and connectivity are considered. The advantage of Q-learning is that it can adapt to the dynamic environment through continuous interactions. There is no need of a teacher; instead a critic in form of reward signal can help the agent itself to judge its actions. Each agent with its limited knowledge of the environment can learn or gain more information about the network through many trial-errors. Independent Q-learning thus accounts for slow convergence and less accuracy.

In6 an opportunistic routing using reinforcement learning is proposed based on success probability. This work uses receiver diversity gain in the distributed algorithm but not considers the congestion control aspect of the routing scenario. Xianfu Chen7 et. al used the Q learning approach for power adaptation in a cognitive wireless mesh network. In 8 authors proposed a collaborative reinforcement learning to improve the manet routing performance. It uses feedback models to understand changes in environment but not guarantees the convergence to suboptimal solutions. In9 authors use q learning technique to adress routing issue in underwater sensor network. To select packet forwarders, they consider the residual energy of the nodes and it is used in reward function computation. This resulted in improvement of the lifetime of the network. Multiagent Q-learning10 is proposed to solve water resource management problem where multiple q learning units compute the potimal policy.

The proposed work looks into how the exchange of information learned independently by the nodes (or agents) through docition among the hierarchy of nodes can lead to efficient routing followed by improved network performance. Hierarchy is defined based on the distance of nodes to the destination