The Effect of Transmission Range in Multi-hop Wireless Networks

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***Abstract*—Transmission or communication range is an important factor for successful data delivery in wireless communications including multi-hop wireless networks. Typically, transmission range can be technically adjustable by configuring the transmitting power (Tx Power) or changing the antenna height. For the same antenna height, if transmission range is minimized or adjusted to be shorter by lowering Tx power, there is less energy consumption but the networks are likely to be unconnected which consequently degrades the network performance such as throughput and delivery ratio. In the case that range of nodes is maximized or extended for connectivity by increasing Tx power, networks become connected and a node may reach the others by using just a hop. This beneficially affects network performance but these nodes with range extension consume more energy for data transmission. Hence, there is trade-off between energy consumption and network performance when adjusting transmission range. In addition, in multi-hop wireless networks where nodes are usually mobile and network topology are highly dynamic, transmission range has lots of impact on network performance. Hence, to study the effect of transmission range is very important and required. In this work, various scenarios (i.e. load-, speed- and density-varying scenarios) are constructed to investigate both energy consumption and network performance with different transmission ranges.**

I. Introduction

In multi-hop wireless networks or mobile ad hoc networks, node a can directly transmit data to node b if distance between these two nodes (d_{ab}) is shorter than node a's transmission range r_a; otherwise, $d_{ab} > r_a$, it relays data through one or more intermediate nodes along the communication path p. Hence, data is consequently sent from one node to another using one or more hops without requiring any fixed network infrastructure to process this data. Furthermore, a node in these networks behaves as a router in the sense that it has to find the best paths to destinations including both in-range and out-of-range nodes and consequently store them in its routing table for future use. This means that communicating nodes are not necessary to be located within the transmission range of each other, they can share or exchange data by relying on multi-hop communication path.

By extending the transmission range r_a, a node a can possibly use fewer hops to reach a destination node b if there exists at least a path p_{ab} between them. This range extension can be carried out by increasingly adjusting Tx power or antenna height. However, adjusting Tx power is a lot easier to be achieved since raising/relocating antenna may require additional mechanical elements or be limited by physical constraints. In addition, connectivity of this multi-hop wireless networks also become enhancing which may consequently improve network performance i.e. better throughput and higher packet delivery ratio with the cost of more energy consumption. Moreover, in dense networks where more number of nodes share the same wireless channel, increasing transmission range may reduce available bandwidth and possibly cause interference and collision.

However, to improve capacity by increasing Tx power may not be the effective solution for some specific networks (i.e. Wireless Sensor Networks-WSNs, a specific type of multi-hop wireless networks) or areas (i.e. search & rescue and battlefield areas) where most of nodes rely on battery or another exhaustible source of energy because it can possibly shorten node lifetime. Hence, to decrease transmission range can reduce Tx power required for data transmission and results in less energy consumption, but probability of link break in disconnected networks become increasing which typically lowering throughput and delivery ratio.

According to the reasons explained above, increasing or decreasing transmission range to control network connectivity/topology has to be carefully planned. However, in multi-hop wireless networks where nodes are usually portable devices, they are free to move in any direction with different movement speeds. This situation causes these networks to be highly dynamic topology networks. Then, to study/investigate the effect of transmission ranges in these networks is required for efficient and effective network performance and management. In this work, various scenarios (i.e. load-, speed- and density-varying scenarios) are constructed to study the performance of multi-hop wireless networks as well as their energy consumption.

II. Related Work and Motivation

As discussed in the previous section that transmission range adjustment has a directly effect on connectivity and network performance; hence, in decades, many research works [1]–[10] were conducted to study the effect of transmission range and its optimization in multi-hop wireless networks including both mathematical analysis and computer simulation. In [1], Ramanathan and Rosales-Hain proposed algorithms to control network topology by adjusting Tx power in both static and dynamic networks. In static networks, Tx Power is iteratively increased until the networks are connected; whereas, in dynamic networks, Tx power can be effectively adjusted to