

Survey on Efficient Use of Spatial Reusability in Multihop Wireless Network

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Abstract

The present wireless routing protocols does not increase the end-to-end throughput by reducing the number of hops to deliver a single packet from a source to a destination node. To maintain the proper link among the nodes in multihop wireless ad-hoc networks, the medium access control (MAC) protocol plays a vital role. The spatial reuse and throughput of a multihop network is greatly affected in assessing the level of interference, channel sharing was not expeditiously utilized by the prevailing methodology of the IEEE 802.11. Routing protocols are generally depends on transmission cost, minimizing routing metrics. But they fail to give assurance for increasing end-to-end throughput. The existing protocols don't take spatial reusability of the remote correspondence media into account. This paper overviews numerous techniques to upgrade the effective channel use by enhancing the spatial reuse.

1. Introduction

In multi-hop networks due to confined ability of wireless communication media and lossy wireless links, end-to-end throughput can be increased by proper selection of routing path. number of protocols were proposed for delivering the packet with less transmission time but they failed to achieve maximum throughput. Spatial reusability conscious routing in multi hop wireless network is featured with the aid of considering spatial reusability of the wi-fi conversation media. To develop an efficient routing, we endorse spatial reusability-aware single-path routing (SASR) and any path routing (SAAR) protocols. Multiple antennas are also employed to enable the multiple streams between transmitter and receiver using adaptive interference cancellation technique to increase the throughput in multipath environment. Spatial reuse concept was utilized in millimeter-wave (mmWave) wireless personal area networks (WPANs). Depending on the type of an antenna, configurations and the deployment of nodes ,it produces beam formation. Based on the result one can find how spatial sharing is utilized.

2. Literature Review

2.1. Topology Control

By reducing the number of collisions, there will be more chance for spatial reuse. Here, for every cone of ϕ degree, each node makes its connectivity with at least one neighbour node by maintaining the minimum power. Each node increases its power slowly by sending a Hello message to find its neighbour node having the lowest power A cone based topology control scheme was adopted for this evaluation[1]. Using position-based topology control algorithm they found each node broadcasts its position information periodically and builds a sparse graph called enclosure graph. This graph saves the position information about

the broadcasting packets. To develop a optimal link on the enclosure graph the node assign a cost metric which also includes neighbour node. This was using distributed Bell Ford shortest path algorithm. The minimum power required to establish a link between nodes is called as cost metric[2]. By reducing the power consumption, network connectivity and interference in MAC-level one can increase the spatial reuse. A simple power control MAC protocol called BASIC protocol was introduced. This protocol allows the nodes to vary transmission power on packet basis. Here each node use different power levels for RTS/CTS and DATA/ACK frames[4]. For sending the RTS/CTS frames, maximum transmission power is used and for DATA/ACK packets lower power level is used for proper communication to take place. The main idea of this protocol is used to enhance the energy efficiency; but due to asymmetrical link problems from hidden terminals shown in fig 1, it faces high congestion between the nodes. Because of this problem it reduces the throughput and increases the energy consumption.

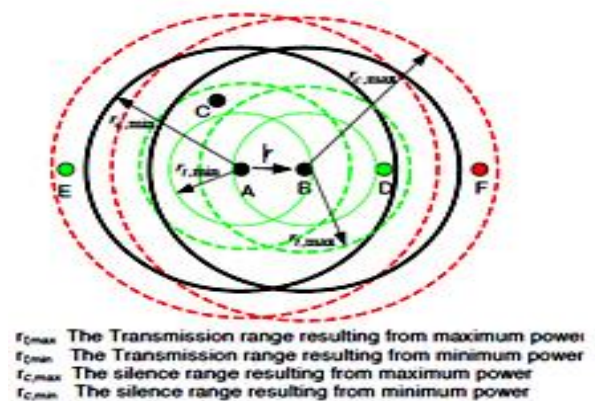


Fig. 1: Asymmetrical link Problem

For accumulative interference measurement they used honey grid model shown in fig 2.

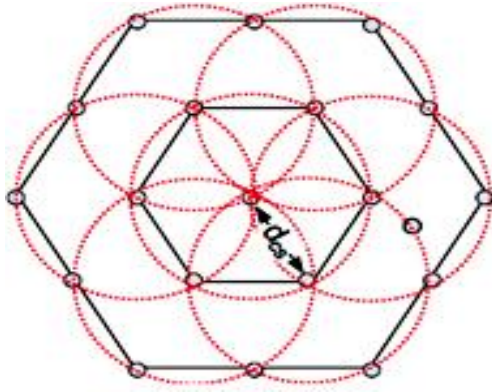


Fig. 2: Honey Grid Model

Another enhancement to the BASIC scheme is that each node should know about the success and failure of its own transmissions. To achieve this, a node creates a record of all the previous RTS/CTS-DATA-ACK transmission power level in a table, so that it helps in communicating with each of its neighbors [6]. This algorithm yields higher throughput by reducing the energy consumption. Another solution for the BASIC scheme, after receiving the signal pattern, a node should check whether the signal belongs to a transmitted CTS packet or not. Then the node sets its NAV. So that it will not interfere with the upcoming DATA packet reception [7]. The solution to the asymmetric link problem of the BASIC scheme is by allowing nodes in the carrier sensing zone of an RTS/CTS transmission [8], they can find the time taken by the information of the upcoming DATA packet. During the process, it finds a problem to decode correctly the RTS/CTS packet, whether the physical carrier is sensed or not, but still they can detect the time duration. The RTS/CTS frame duration can be increased by adding a few bits.

2.2. Transmit Power Control

By proper selection of sense range r_c , the interference from hidden terminals is eliminated, since it covers the interference range. Optimal CS_{th} was derived for grid topologies to increase the throughput and to enhance the spatial reuse, but they didn't consider the MAC overhead [9]. The optimal CS_{th} depends not only on the packet size but also on the degree of channel contention, and they also considered the MAC overhead on the basis of optimal carrier sense range for increasing the throughput [10]. To increase the network capacity, the CS_{th} should allow a less number of hidden terminals to exist. Then CS_{th} determines the number of contending nodes (nc) which is used to maximize the throughput. The algorithms which were proposed tune CS_{th} to adjust nc [11]. To obtain an optimal nc , first the node checks whether the channel is idle, busy, and then captured for receiving and finally the node adjusts its CS_{th} .

2.3 Rate Adaption

The rate starts increasing after a number of consecutive frame transmissions and it starts decreasing the rate after a frame loss. ARF becomes the best standard for IEEE 802.11 for rate adaptation [12]. For channel estimation, a *Sample Rate* selection algorithm was proposed [13]. To check the rate's loss ratio which transmits a DATA packet continuously with different rates to update the record. If the throughput estimation becomes higher than the current throughput, *Sample Rate* then transmits the data packets with a different rate. Hybrid Rate Control algorithm is used to adjust the transmission rate using the physical layer information (e.g. SINR) and MAC layer information (e.g. FER) [14]. Two algorithms called Adaptive Auto Rate Fallback (AARF) and Adaptive Multi-Rate Retry (AMRR) for high and

low latency systems. Based on the concept of ARF, they proposed AARF while AMRR depends on ONOE. These methods help in rate increase [15]. When the channel quality is good, it transmits multiple back-to-back packets. The observed value is based on the rate adaptation process which treats bad channel conditions as transmission failures [16]. Either due to collisions or channel errors, transmission failures may occur. Errors in the channel due to collisions, to evaluate it, various rate adaptation methods are proposed. When jamming occurs, the rate starts decreasing during transmission. To avoid this, the authors introduced "loss differentiation" schemes [17]. While transferring packets, if the system faces failure, a node first finds the solution for the transmission failure. If the failure is due to collisions, then the transmission rate decreases. The transmission rate gets fixed if it is due to channel error. The best way to enhance the throughput by proper adjustment of thresholds. The proposed rate adaptation scheme [18], shown in fig. 3, based on link-layer measurement, they start adjusting the rate parameters. They considered the variable transmission power and different receiver sensitivities for multi-hop wireless networks [19].

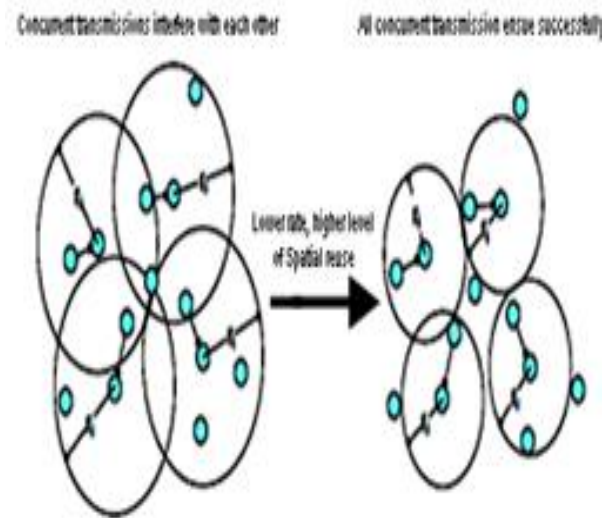


Fig. 3: Enhancement of spatial reuse by Rate adaption

2.4. Directional Antennas

Directional antennas also help in increasing the network capacity by increasing spatial reuse. It allows the sender to transmit in the direction of the receiver. Thereby, it reduces the level of collisions with other nodes, allowing more simultaneous transmissions to occur. Moreover, directional antennas can increase the transmission range by saving power and accordingly, some receivers outside the omni-directional range may be reached in one hop transmission [20]. Throughput increases with a less number of hops. Transmission power control scheme along with directional antennas can further give more benefits to enhance the spatial reuse. For millimeter-wave (mmWave) wireless personal area networks (WPANs) with directional antennas, they adopted a spatial reuse concept [23]. The main objectives of this paper are mentioned below:

- A spatial reuse technique was applied to mmWave WPANs based on BF information.
 - For implementation, they designed the algorithm for spatial reuse condition.
 - Analysis differentiates idealistic and realistic antennas shown in fig 4 and 5.
 - Results proved the achieved spatial multiplexing gain and efficiency shown in i.
- Simulation results proved that based on the type of an antenna, configuration and topology of a network, the spatial multiplexing gain can be increased.

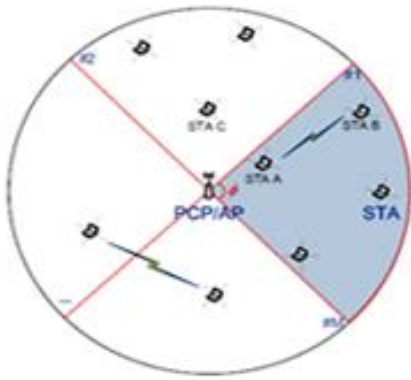


Fig. 4: A mmWave WPAN and directional antenna model.

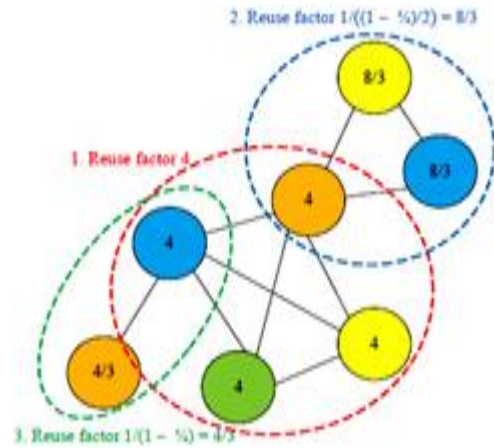


Fig. 7: Reuse factor

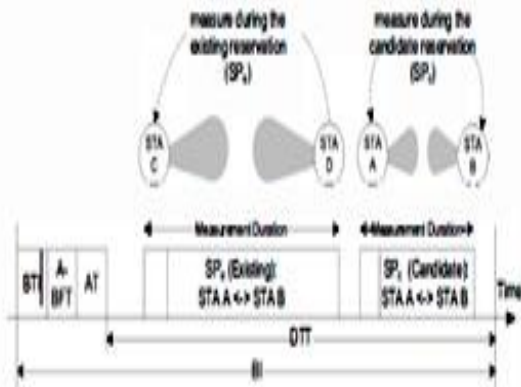


Fig. 5: An example of spatial sharing measurement

Based on the interference graph, the computational prerequisites of the algorithm that computes the ideal spatial reuse figure of each user are diminished to quasilinear time complexity, ideal for viable execution. They performed a resource allocation method that can maximize the proficiency of spatial reuse. The proposed spatial reuse plot provides advantages in beam forming frameworks, where in the interference with neighbour. Millimetre wave system test bed shown in fig 6.and 7 system environment hubs can be relieved by using directional bars. Based on the framework level measurements performed to demonstrate the physical interference from down to earth millimeter wave remote links[35].

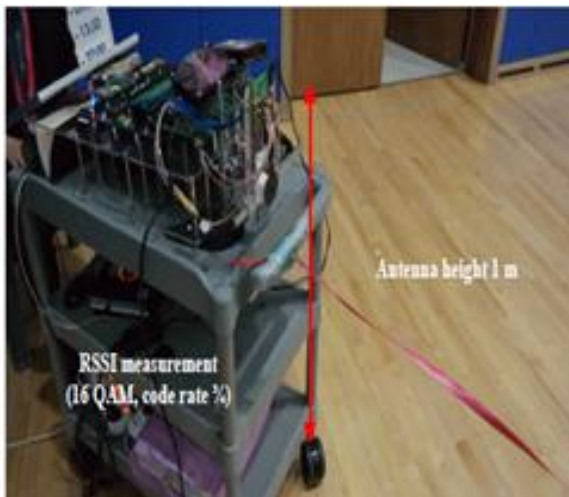


Fig. 6: A Millimetre wave system test bed and system environment

2.5. Interference Aware

As the channel gain exceeds a threshold γ it affects the resulting spatial reuse. By proper tuning of channel-aware MAC can increase spatial reuse by 40% relative to simple ALOHA[21]. Even though O-ALOHA significantly increase spatial reuse by checking nodes selecting good channels, but it still suffers from congestion thereby limiting its performance. To overcome this problem they developed Carrier Sense based Medium Access (CSMA) protocols to attain high spatial reuse by proper transmissions coordination among the neighbouring nodes to reduce congestions.

Increase in spatial reuse for wide range of node densities is achieved by QT-CSMA[22] than O-CSMA. The dominated sets of spatial fairness-reuse pair under QT/O-CSMA shows the relationship between joint spatial reuse and fairness performance to understand the interactions between the nodes. QT0- CSMA is very difficult to configure but it gives high performance. Using the logic of mutually independent links, they maximize spatial reuse in CSMA-based networks. They increased the number of independent links through power control and also by asymmetric links[24]. The protocol defines the independence among the links. Pt and CSth adjustments shows the proposed algorithm achieves higher throughput compared to fixed Pt and CSth .Multi-radio Unification Protocol or MUP coordinates the operation on a single node for Multiple wireless network by tuning without overlapping the existing frequency range. They used multiple nodes to direct the transmission to reach a particular channel based on the load[25]. But the drawback is that the neighbouring nodes cannot be able to communicate when those neighbours are chosen by orthogonal to the channel. Algorithm used Striping Algorithm and Round Robin O Algorithm.

2.6. Othe Related Works

Comparing the performance of different multi-hop routing protocols such as DSDV,TORA, DSR, and AODV, these protocols cover the range according to their design. Among these DSR has the lowest overhead. The author uses DSDV protocol that guarantees loop freedom. But they didn't considered the capture effects, propagation delay, MAC-layer collisions, and the effects of congestion due to large packet sizes [26].The broadcast and unicast packets were delivered with the same probability, and, as noted in this is not a realistic assumption. Based on DSR's AODV-LL uses a Route Discovery mechanism. Hop-by-hop routing state is created in each node to overcome the overhead of source routing from data packets. Temporally Ordered Routing Algorithm was proposed by the author. MORE, a MAC-independent opportunistic routing protocol was proposed ,it shuffles the packets before forwarding them. The recent opportunistic routing protocol, establish a strict schedule on

routers to access the medium. Even though the scheduler delivers opportunistic gains, but it prevents spatial reuse. Disadvantages - forwarding maximum packet in this system is not possible[27]. Even the host moves is frequent, this protocol responds faster to the changes in routing. If host movement is less frequent, it may or not require overhead. No periodic routing is required. Reducing the network band width overhead when there is no host movement. Draw back are the piggybacked data .It would be lost if the route request is received by another host and acknowledged. Algorithm used is Distance vector algorithms[28].DSDV allows a collection of mobile computers, to exchange the data's along the arbitrary paths of interconnection, which may not be close to any base station .Separate route tables are used in to two distinct structures, so that updation in the route can be done in an order to receive the poorer metric routes first and then the best metrics due to large populations of mobile hosts. Shortest-path algorithm, Distributed Bellman-Ford (DBF) algorithm[29] and distant -vector routing algorithm was proposed .The proposed DSDV, uses the mobile computers as routers, which are about to forward packets as needed to each others. A new routing technique in wireless mesh networks that generalizes opportunistic routing is any path routing, for reaching the destination each node uses both a set of next hops and a selected transmission rate. To implement this, the author used any path routing protocol[30].This approach presents two major drawbacks. First, utilizing the available bandwidth resource ,it uses a single rate over the entire network . Secondly, at a higher bit rate the network may become disconnected. For maximizing the throughput in wireless networks, they introduced optimal routing, scheduling, and network coding strategies. It introduces k-tuple coding[31], with next-hop decodability, and fully characterize the region of arrival rates for network queues which can be stabilized. They evaluated the LCM Frame policy via packet simulation and LP evaluation for pair wise and 3-tuple coding.The ad-hoc routing runs over heterogeneous link layers and the higher layer software runs unrestricted over the ad-hoc network. Currently they have proposed LQSR protocol[32] in the MCL framework. It supports any ad-hoc routing protocol. Algorithm used was shortest path algorithm. Using PRC algorithm [33] they proved the improvement in the throughput. This algorithm utilises less power so that it can induce low interference, better spatial reuse and data rates can be achieved..There are many routing protocols have been proposed but they never give assurance to select a path with minimum transmission for delivering a single packet. The proposed protocol improves the end-to-end throughput. The median throughput gain for single-path routing increases up to 60%, for any path routing it increases up to 13.2%.Most routing algorithms were based on min-hop count metric, which is a metric that assumes perfect wireless links and tends to minimize the number of hops on the path. However, in the case of lossy links in wireless environment, protocols using min-hop metric does not perform well because they may include some poor links with high loss ratios.

3. Conclusion

From the above review we found that, the authors have proposed many protocols to make use of efficient spatial reusability in wireless network. But some protocols gives minimum throughput since they projected their work with minimum number of nodes. Some have done research such that transmission should take place without overlapping the existing frequency range. In rate adaption technique has to avoid the collisions between nodes. Authors also shown the relationship between physical layer and MAC layer .Directional antennas also helps in increasing the throughput for mmwave propagation. For long distance communication the signals may fade causing interference. In this case they do not take spatial reusability in to account. Tong Meng et al, proposed two protocols for efficient spatial reusability. He is the one who uses multiple nodes to select the efficient path for lossless transmission. Using SASR and SAAR algorithm he proved that median throughput gain for single-path routing increases up to

60%, for any path routing it increases up to 13.2%. Future work can be extended to interflow spatial reusability in wireless network. We can also link the result with physical layer by using omni directional antennas for interference free transmission to occur at Ghz frequency range.

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