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Interference Reduced Channel Assignment and Routing Algorithm for Energy Harvesting Multiradio Wireless Mesh Networks

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Abstract— Wireless Mesh Networks (WMNs) provide connection to the Internet and it carries data generated by several services. Multiple radios are used in Wireless Mesh Networks to improve the network performance and to reduce the power consumption. To achieve this, proper channel assignment with best routing algorithm such as Dynamic channel assignment is used with the help of multi radios arrangement. The main concept is to route the traffic demands by turning radios on and off when not in use to save energy. Here we proposed a Minimum Power Channel Assignment and Routing Algorithm (MP-CARA) which gave better utilization and minimum power consumption. Proposed work gives better power consumption and improved throughput with dynamic channel assignment.

Keywords— WMNs, Multiradio, MP-CARA, Channel assignment.

1. INTRODUCTION

Wireless Mesh Networks (WMNs) are the backbone of mesh routers which collect and transmit the traffic generated by mesh clients. Mesh routers have limited mobility and are usually connected through wireless links. In wireless transmissions interference is a major concern in order to mitigate the effects of interference mesh routers are being equipped with multiple radio interfaces, which allow simultaneous transmissions which is help to reduce the interference arising among wireless transmissions which each node consists with multiple radios. One of the key challenges in multi-radio environment involves channel switching delay which is typically in the order of several milliseconds. Centralized channel assignment which generated the traffic by mesh clients. Each mesh router often captures packets generated by the mesh clients and measures the number of senders and per second utilization for each channel. Each link is assigned the highest ranked channel that does not variance with the channel assignment of its neighbors. Distributed channel assignment together with a distributed routing protocol. Radios are set to various channels and there is no need for the channel switching. Thus each node can simultaneously communicate over different channels, which has been reduce the interference and increase the network

throughput. The performance of networks depends on throughput and stability maintenance when access the channel. Routing and channel assignment are interdependent. A routing protocol selects a path from the source to the destination, and forwards traffic to each link along the path, while channel assignment determines the individual channel, channel assignment determines the connectivity between two nodes as two radios can only communicate when they are tuned to a common channel. Hence channel assignment at last determines the network topology. In order to avoid transmission collisions and improve network performances in wireless mesh networks (WMNs), a good channel allocation is needed. Allowing multiple channels use in the same network, it is a possible way to improve the network capacity. As IEEE 802.11 standards provide more than one channel, thus a trivial way to improve the network performances is to allow transmission on multiple channels in each network node.

2. RELATED WORK

In [2], the author proposed the cost-effective wireless network and it is practical to design network devices with multiple radios which can transmit and receive more different frequency channels. By using multiple radios per node increases the throughput of multi-hop wireless mesh networks. However it creates several research challenges. This joint problem is NP-complete. Proper solution is developed by solving the channel assignment and the routing problems separately. The channel assignment problem is given set of flow rates are schedulable and it also be NP-complete. The problem is not only the channels but also the transmission rates of the links have to be properly selected to make a given set of flow rates schedulable. Further the channel and rate assignment problem is developed.

Algorithms to schedule the resulting set of flow rate which require synchronization among nodes and hence modified coordination functions. To overcome this problem forwarding paradigm is developed to achieve the resulting set of flow rates. A bi-dimensional Markov chain model of the forwarding paradigm is used to analyze its behavior. Thorough

performance studies are conducted to: a) compare the proposed greedy heuristic to other channel assignment algorithms b) analyze the behavior of the forwarding paradigm through numerical simulations c) simulate the operations of the forwarding paradigm and evaluate the achieved network throughput.

In [4], the author proposed the wireless mesh networks are being deployed all around the world both to provide ubiquitous connection to the Internet. In those cases where fixed power connections are not available, mesh nodes operate by harvesting ambient energy for this reason they can calculate on a limited and time varying amount of power to accomplish their functions. Since we consider mesh nodes equipped with multiple radios power savings and network performance can be maximized by properly routing flows assigning channels to radios and identifying nodes/radios that can be turned OFF. Thus, the problem we address a joint channel assignment and routing problem with additional constraints on the node power consumption. we proposed a heuristic named minimum power channel assignment and routing algorithm (MP-CARA), which is guaranteed to return a local optimum for this problem.

In [5], the author proposed the wireless mesh networks are an efficient and low-cost solution for providing last-mile broadband Internet access. They face numerous challenges related to intrinsic characteristics of the multi-hop and flow of traffic. An energy-efficient and load-aware strategy is proposed for the unified management of radio resources of multi-radio nodes, combining channel assignment, rate adaptation, and power control. It exploits 100% of the network capacity, achieving the maximum throughput, minimizing spectrum and power usage.

In [6], the author proposed the Medium Access Control (MAC) protocols for wireless sensor networks (WSNs) has been conventionally tackle by assuming battery-powered devices and by adopting the network lifetime. Wireless Sensor Networks operated by energy-harvesting (EH) devices are not limited by network lifetime. New challenges due to the uncertain amount of energy that should be harvested from the environment. Novel design are thus required to capture the trade-offs between the potentially infinite network lifetime and the energy availability. Here we addresses the analysis and design of WSNs with energy harvesting devices by focusing on conventional MAC protocols, namely TDMA, FRAMED-ALOHA (FA) and dynamic-FRAMED ALOHA (DFA) and by accounting for the performance trade-offs and design issues arising due to energy harvesting. A novel metric referred to as delivery probability is introduced to measure the capability of a Medium Access control protocol to deliver the measurement of any sensor in the network to the destination. By using markov models the delivery efficiency and time efficiency is analytically calculated.

In [7], the author proposed the scheduling problem in multi-hop wireless networks has been extensively investigated. Throughput optimal scheduling solutions have been developed but they are inappropriate for multi-hop wireless systems

because they are usually centralized and have very high complexity. Therefore we develop a random-access based scheduling scheme that utilizes local information. The significant features of this scheme include constant-time complexity and a provable performance guarantee. Analytical results show that it guarantees a larger fraction of the throughput performance than the state of the art it is based on the simulations with both single-hop and multi-hop traffics, we observe that the scheme provides high throughput and highly efficient centralized greedy solution called the greedy maximal scheduler.

In [8], the author proposed the routing scheme and the network expends the minimum energy satisfying with the minimum constraints of flows. Under certain assumptions on how links are scheduled, we can show that our proposed algorithm in time optimal in terms of minimizing the average energy consumption. Our algorithm automatically found congested area in the network which helps moderate network congestion and improves the network performance. By using simulations we show that the routes chosen our algorithm centralized and distributed are more energy efficient than the state of the art.

In [9], the author proposed the wireless transmitter which is limited by its finite battery resource. Our objective is to design a transmission schedule that maximized battery lifetime. To attain this, we exploit two previously unconnected ideas: (i) channel coding can be used to save energy by transmitting at reduced power levels over longer durations; (ii) electro-chemical mechanisms in batteries permit them to recover energy during idle periods. While the first method is to extending transmission durations, the second method requires the transmitter to be idle to allow for recovery. In other words burst packet transmissions interspersed with idle periods extend battery life. For that reason a strategy which is based entirely on either one or the other idea is not optimal. We present a framework to merge the two ideas. We consider two kinds of delay constraints, one is a deadline constraint and the other an average delay constraint it will show that the energy aware scheduling strategies for energy harvesting.

3. PROBLEM STATEMENT

The channel assignment problem in multi-radio has been investigated in the literature recently. Many proposal aims is to minimize the network interference and do not learning the channel assignment problem and the routing problem. Mesh routers with multiple radios is a recent solution to improve the performance of Wireless Mesh Networks (WMNs). The problem how to route flows and assign channels to radios in multi-radio WMNs has involved a lot of attention in the recent years. However, the approach is proposed so future has mainly focused on reducing interference and maximizing the throughput. At the same time we focused on the energy consumption of wireless mesh networks. However the energy consumed by communication infrastructures, it makes logic to consider the minimization of the energy consumption in the channel assignment and routing problem. Our work is an idle

radio simply consumes nearly the same power as the radio. Hence, energy may be saving by turning off a number of radios if the performance of the network is not impaired. In this paper, we define the minimum power channel assignment and routing algorithm. Finally, we show the results of general simulation studies and the effectiveness of the proposed algorithm.

4. DYNAMIC CHANNEL ASSIGNMENT SCHEMES

Dynamic channel assignment allow any interface to be assigned any channel and interfaces can frequently switch from one channel to another. Therefore when nodes need to communicate with each other a coordination mechanism has to make sure they are on a common channel. For example such mechanisms may require all nodes to periodically visit a predetermined channel to agree channels for the next phase of transmission. In the Slotted Seeded Channel Hopping (SSCH) mechanism, each node switches channels synchronously in a pseudo- random sequence so that all neighbours meet periodically in the same channel. The benefit of dynamic channel assignment is the ability to switch an interface to any channel, thereby offering the potential to use many channels with few interfaces. However the key challenges involve channel switching delays and the need for coordination mechanisms for channel assignment between nodes

5. PERFORMANCE EVALUATION

The number of simulation studies to evaluate the performance of the centralized channel and rate assignment algorithm in the Flow-based Channel and Rate Assignment(FCRA).The channel assignment algorithms which is the one part of the method for the joint channel assignment and routing problem. The problem is to assign channels to radios in order to make a given set of pre-computed flow rates schedulable, at the same time the channel assignment problem is NP-complete and the minimum scaling factor which yield a set of flow rates satisfying the sufficient condition for the maximum among the total utilization of all the collision domains. The flow based channel and rate assignment are only considered the new set of traffic demands.

Each router is configured with the set of schedulable flow rates associated with its links. Such values are used to take forwarding decisions as follows. Each router x sets a timer which expires at regular intervals and records the amount of bytes $b(y)$ sent to each node y . Every time x has to take a forwarding decision it computes the value for each node.

$$\Delta x(y) = f(x-y) \div \sum_{\forall x \rightarrow i} f(x \rightarrow i) - b(y) \div \sum_{\forall x \rightarrow i} b(i) \quad (1)$$

Where

$x(y)$ → Represents the gap between the desired and the current utilization of link $x \rightarrow y$

$f(x \rightarrow i)$ → Router will send the packet to the neighbour node i

To keep the transmission rate on its entire links proportional to the corresponding flow rate x will send the packet to the node having the largest $x(y)$ value.

In energy efficient channel assignment and routing algorithm they turn off the maximum number of radios in a wireless mesh network while ensuring that the maximum total utilization is below a given threshold λ_0 . They keep the total utilization of all the collision domains below the threshold λ_0 and they switch off as many radios as possible while not increasing the total utilizations that are already above λ_0 .

$$f \leftarrow \min \left\{ \min_{m=0} \lambda_0 - \mathbf{u} \div \sum_{\substack{tot(e) \\ l \in m(P)}} 1 \div c(j), f(x \rightarrow v) \right\} \quad (2)$$

6. MINIMUM POWER CHANNEL ASSIGNMENT AND ROUTING ALGORITHM

The main aim of the minimum power channel assignment and routing algorithm are switching channels on the performance of a wireless mesh network and to identify the causes of the observed interruptions in the connectivity among nodes. It requires full details of the current network status to send the actual information. The proper channel assignment schemes that can maximize the overall network .Throughput are often regarded as the primary standard to estimate the efficiency of a new scheme. However throughput is maximized by increasing the number of parallel transmission in a network. So channel assignment algorithms should focus on throughput maximizing. The IEEE 802.11 standard specifies multiple non-overlapping channels, so the channel assignment scheme should aim into exploiting channel diversity to maximize spectrum utilization and also we focused on the partially overlapped channels with proper interference model can further improve the channel utilization to maximum level. The power consumption and energy model would be mentioned as

$$(x) = \rho_b(x) + |\{r \in R(x) \mid (r) = 0\}| \rho_{sleep} + [\tau_{tx}(r) \rho_{tx} + \tau_{rx}(r) \rho_{rx} + \tau_{idle}(r) \rho_{idle}]_{r \in R(x) \mid (r) \neq 0}$$

Where

$\rho(x)$ → Power consumed by a node x in the sleep State

$\rho_b(x)$ → Power consumed by each radio interface

$\rho_{tx}, \rho_{rx}, \rho_{idle}$ → Power consumption of a radio in the Transmitting, Receiving, idle and sleep mode.

$\tau_{tx}, \tau_{rx}, \tau_{idle}$ → Fraction of time spent by radio in the Transmitting, receiving and idle mode.

Sum of the flow to capacity ratios to all the links that enter the radio

$$\tau_{tx}(r) = \sum_{l \in (r)} \frac{f(l)}{c(l)} \tag{3}$$

$$\tau_{rx}(r) = \sum_{l \in (r)} \frac{f(l)}{c(l)} \tag{4}$$

Average power consumed by an active radio expressed as

$$\tau_{tx}(r) \rho_{tx} + \tau_{rx}(r) \rho_{rx} + (1 - \tau_{tx}(r) - \tau_{rx}(r)) \rho_{idle} = \tau_{tx}(r) \cdot (\rho_{tx} - \rho_{idle}) + \tau_{rx}(r) \cdot (\rho_{rx} - \rho_{idle}) + \rho_{idle}$$

To find the initial load estimation, first derived the estimation of the expected link load

$$C_1 = \frac{Q * C_Q}{L} \tag{5}$$

Where

$Q \rightarrow$ Number of available channels

$C_Q \rightarrow$ Capacity per channel

$L \rightarrow$ Number of used links

Expected load on link capacity estimation and it can be calculated by the equation

$$\gamma_1 = \frac{P(a, b)}{\sum_{a,b} P(a, b)} * B(a, b) \tag{6}$$

Let the number of the accepted path between a pair of nodes is denoted by $P(a, b)$, and the number of the accepted path between the pass link is $P_1(a, b)$, where $B(a, b)$ is the estimated load between the node pair in the traffic profile

Routing algorithm when the channel is not overloaded the channel divide available to a link to its expected load.

$$dw = \gamma_1 * C_1 \tag{7}$$

To find the traffic and the arrival of the packet should be mentioned as

$$C(T) = \frac{(T-1)L}{\Delta(T)} \tag{8}$$

$\Delta(T) \rightarrow$ Difference in the arrival time of last and first packet

$(T-1) \rightarrow$ Time gap between the packets

6.1 FLOWCHART

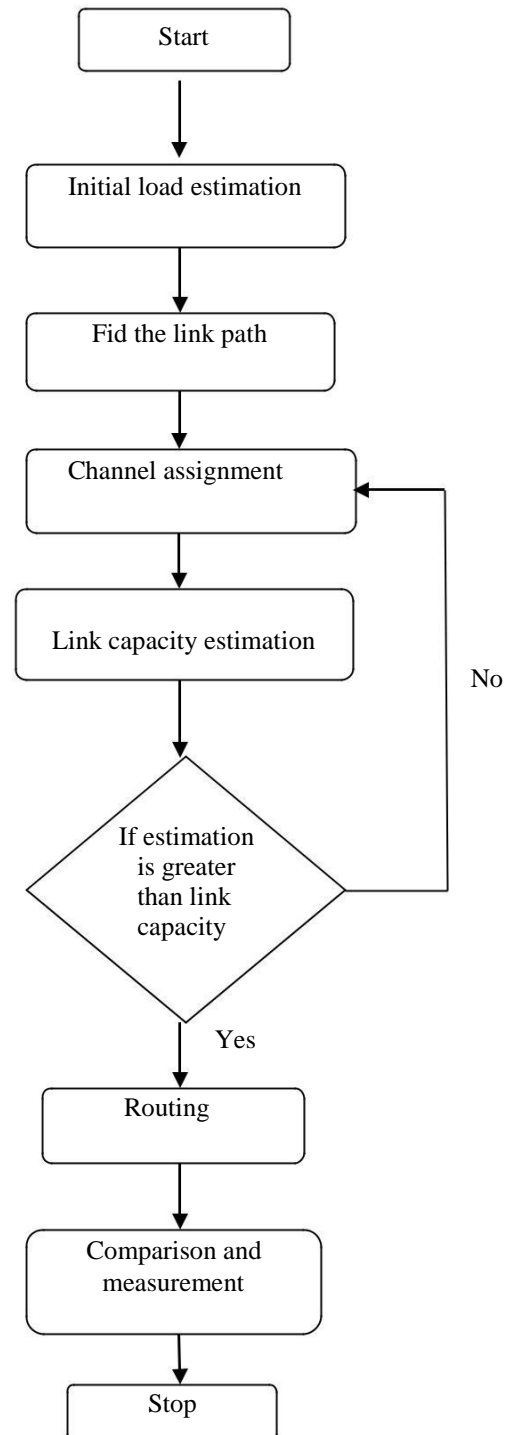


Fig 1. Channel assignment and routing algorithm

The above flowchart discusses various aspect of traffic loads in multi-channel wireless mesh network architecture. Link loads will be estimated with the traffic.

7.2 MAXIMUM UTILIZATION

Network utilization is the ratio of current network traffic to the maximum traffic that the port should handle. While

By turn radios on in the attempt to find a solution with a better maximum total utilization or a solution that meets the power constraints for all the nodes. All the nodes having radios currently switched off are inserted into a priority queue.

Channel assignment and routing problem typically consists of the following three steps:

A pre-computed flow rate is determined for every link Based on the given optimization objective.

Channels are assigned to radios in the attempt to make the pre-computed flow rates returned by the previous step schedulable.

The pre-computed flow rates returned by the first step may be adjusted in order to obtain a set of schedulable flow rates.

7. SIMULATION RESULT AND ANALYSIS

We perform a number of simulation studies to compare MP-CARA to E2CARA and FCRA in terms of maximum total utilization, network throughput and energy consumption.

7.1 THROUGHPUT

In this section we estimate the performance of the channel assignment algorithms in multichannel access point networks through simulations. The figures show the achieved throughput normalized to the sum of the traffic demands in MP-CARA. In both FCRA and E2CARA-TD traffic scenarios the highest throughput is achieved by MP-CARA.

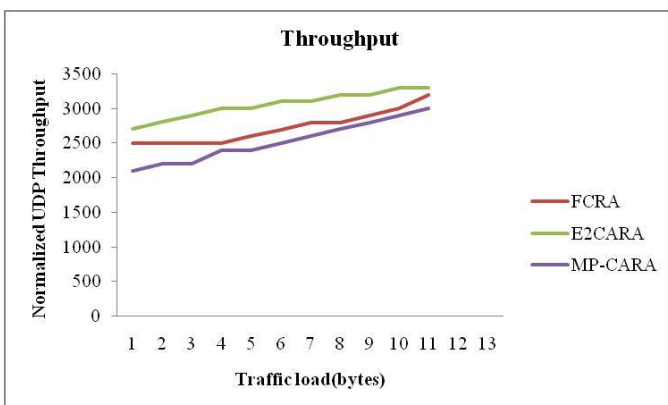


Fig 2: Throughput

examine the network utilization we can understand whether the network is busy, normal or idle. When the traffic load decrease MP-CARA achieves lower values than E2CARA-TD and FCRA in all the scenarios.

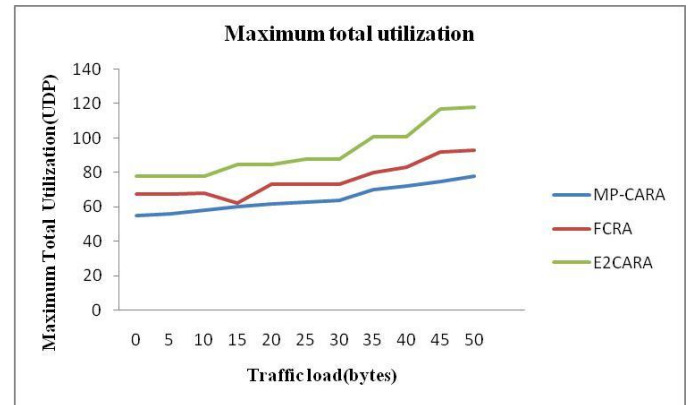


Fig 3. Maximum total utilization

7.3 ENERGY CONSUMPTION

The figures show the energy consumed by each algorithm. In both FCRA and E2CARA-TD traffic scenarios the highest energy is achieved by MP-CARA.

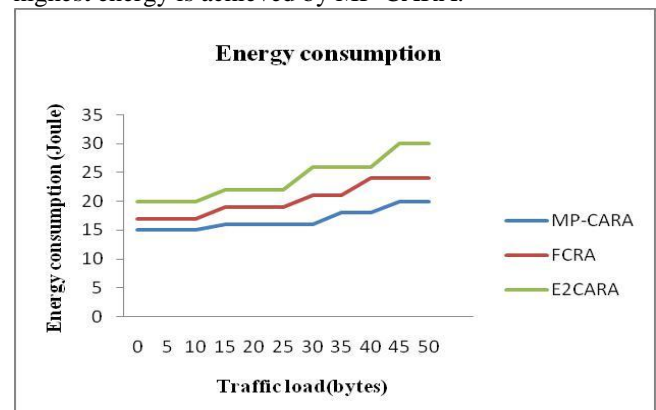


Fig 4. Energy consumption

8. CONCLUSION

We addressed the minimum power channel assignment and routing problem. The goal is to minimize the power consumption of multi-radio wireless mesh networks where nodes have constraints on their power consumption and improve the network performance. To find the traffic demands, turns off some radios and turns on some other radios to find the best solution possible. Simulation results are shown here for the Minimum Power Channel Assignment and Routing Algorithm. In future the interference will be avoided by using the channel assignment and routing algorithm.

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