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Congestion-Aware Bandwidth Assignment In Wireless Mesh Networks

Rejoice Raju #1, Dhanyalakshmi R*2
Electronics and Communication, Karunya University

Abstract- **Engineering the network capacity requires a complex cross-layer design in multi-radio multi-channel wireless mesh networks. A decoupling approach that breaks down the entire design space into routing and initial channel assignment, and local channel reassignment and distributed congestion control is done in order to make the complex problem implementable in a distributed manner is proposed. A unified priced-based framework for distributed congestion control and localized channel-link assignment algorithms is thus formulated .The convergence of the proposed algorithms with respect to different fairness objectives like proportional fairness and max–min fairness on both grid and random topologies are also simulated. This algorithm achieves faster convergence with less overhead in the control and forwarding plane compared to other existing algorithms.**

Keywords**—Multi-radio multi-channel wireless mesh networks, QoS guarantees, congestion, price, congestion-aware channel allocation**

I. INTRODUCTION

In the coming generation’s wireless mobile communication will be driven by converged networks which integrate disparate technologies and services. The wireless mesh network is considered to be one of the key components in the converged networks of the future. This provides flexibly high bandwidth wireless backhaul over large geographical areas thus providing ubiquitous and inexpensive last-mile Internet access. The WMN is more promising due to its features like multi hop, self-organizing, self-healing, high robustness and high bandwidth. It consists of a number of wireless mesh routers connected to each other through high speed wireless links. These routers are static and form the backbone of the network. The nodes are equipped with multiple radio interfaces in order to increase the network throughput. The data are transferred in a multi hop manner across the network via these routers. In order to satisfy the increasing need for high quality multimedia applications and real time services, the Quality of Service (QoS) has become a vital requirement in WMN.

In Multi-radio multi-channel wireless mesh networks the adjacent nodes may interfere with each other while communicating with each other. This may reduce the effective data rate resulting in congestion. Congestion occurs when a link is carrying data more than its capacity. It leads to QoS deterioration. Some of the effects include queuing delay, blocking of new connections or packet loss. When the node or link gets over loaded or when the link put in queue for a long time the node may start dropping the packets which causes the QoS deterioration.

Multi-radio multi-channel wireless mesh networks that use IEEE802.11 radios usually include a cross-layered design of all the protocol stacks. That is scheduling in achieved at the medium access control (MAC) layer, channel assignment is done at the link layer, routing in the network layer, and congestion control in the transport layer in order to obtain the effective capacity or throughput. Flow rate is determined based on how much portion of packets in a flow traverses which end-to-end route, which channel is used on each link, and how much portion of capacity of each link and channel pair is utilized for each flow.

II. RELATED WORK

Various layers of the protocol stack face complex design issues in multi-radio multi-channel wireless mesh networks. One of problem scopes in some previous works has dealt with congestion control. Giannoulis et al. [4] deals with the congestion control and channel assignment in multiradio multi-channel wireless mesh networks. The multi-path routing for a flow is consider and formulate all possible sub-paths with different sets of intermediate routers and different sets of channels for links in a utility maximization problem.

An additional outer loop for convergence to optimal fair flow rates is a multipath feature required, and the formulation may become computationally infeasible owing to exponential numbers of possible sub-paths for each flow. Tang et al. [9] deals with formulating various fair rate allocation problems in multi-radio multi-channel networks as linear programming and convex programming.

The problems are shown as NP-hard and they propose a heuristic algorithm which requires global information and is centralized. The algorithm permits multiple sub-paths, which may suffer from exponential complexity during computation. The algorithm does not consider network utility maximization (NUM) framework for convergence, and therefore it does not suffice for distributed implementation. There are also other instances of previous works which do not take congestion control into account in multi-radio multi-channel wireless mesh networks. Ning-et-al. [10] deals with network-layer metrics for routing and devising link-layer metrics for scheduling they try to ensure fairness in links and also give a higher routing priority to links with less congestion and larger queuing for improving the throughput. Their solution is centralized and fairness is considered in terms of links and not flows. Ramachandran et al. [2] deals with dynamic channel assignment which minimizes interference in multi-channel wireless mesh networks.

The algorithm requires interference estimation at each distributed mesh router and is centralized .Some recent works focus on other aspects of multi-radio multi-channel networks than throughput and network utility maximization. Avallone et al. [11] focuses on energy efficiency in addition to network utilization. A novel energy efficient channel assignment and routing problem is formulated and a heuristic algorithm for maximizing the number of radios turned off while achieving the best total utilization is proposed. The algorithm is not based on the NUM framework and is centralized. Jahanshahi et al. [12] considers a multicast transmission problem in multi-radio multi-channel networks. They introduce a novel binary integer programming model with an objective to minimize the total number of links together with the total interference. In this model, multicast tree construction and channel assignment are jointly considered in order to minimize interference. The approach is not based on the NUM framework, and so centralized linear programming solver should be used.

III. PRELIMINARIES

A wireless mesh network is a communication network made up of radio nodes organized in a mesh topology. It is a form of wireless ad hoc network. The Wireless mesh networks often include mesh routers, mesh clients and gateways. The mesh clients are often devices like laptops, cell phones and other wireless devices. The mesh routers forward traffic from and to the gateways which is, connected to the Internet. The coverage area of the radio nodes working as a single network is often called a mesh cloud. Access to this cloud is dependent on the radio nodes working in sync with each other to create a radio network. A mesh network is reliable and provides redundancy. When one node can no longer function, the remaining nodes can still communicate with one another, directly or through one or more intermediate ones. Wireless mesh networks are self-organizing and self-healing. Wireless mesh networks can be implemented with various wireless technology, cellular technologies or combination of more than one type.

A. *Congestion in mesh networks*

In data networking and queuing theory, network congestion occurs when a link carries so much data that its quality of service deteriorates. Some of the effects are packet loss, queuing delay, or the blocking of new connections. The result is that there is an incremental increase in the load offered which can lead either to a small increase in network throughput, or to a reduction in network throughput.Network protocols that use aggressive retransmissions to compensate for packet loss keep systems in network congestion, even after the initial load has been reduced to a level which would not normally have induced network congestion. Thus, networks utilizing these protocols exhibit two stable states under the same level of load. The stable state of low throughput is known as congestive collapse.

B. *Types of fairness*

Maintaining fairness in WMNs is quite important but has been given less attention compared to other aspects such as capacity maximization and maintaining connectivity. IEEE 802.11 MAC protocol is used as the default standard for WMNs although it was initially designed to be operated in wireless local area networks. It is known to be quiet unfair in multi-hop networks. This unfairness is evident in bursty conditions.

1) *Max-min fairness:* In communication networks, multiplexing & the division of scarce resources, max-min fairness is achieved by an allocation if and only if the allocation is feasible and an attempt to increase the allocation of any participant necessarily results in the decrease in the allocation of some other participant with an equal or smaller allocation. Fair queuing is one of the examples of a max-min fair packet scheduling algorithm of statistical multiplexing and the best effort packet-switched networks, as it gives scheduling priority to users that achieve lowest data rate once they became active. In equally sized data packets, round-robin scheduling is an example of max-min fair. Max-min fairness in communication networks consider that resources are allocated to flows in advance, as opposed to other best-effort networks. The name “max-min” comes from the notion that it is the rate of the small flows that is made as large as possible.
2) *Proportional fairness*: Proportional fairness refers to a compromise between fairness and throughput. It is compromise-based scheduling algorithm maintaining a balance between two competing interests is the base, thereby trying to maximize total throughput while at the same time allowing all users at least a minimal level of service. This is achieved by assigning each data flow a data rate or a scheduling priority that is inversely proportional to its anticipated resource consumption.

IV. DESIGN METHODOLOGY

This approach facilitates to make the complex problem implementable in a distributed manner, a decoupling approach that breaks down the entire design space into initial channel assignment and routing, and distributed congestion control with local channel reassignment. A priced-based framework for distributed congestion control and localized channel-

link assignment algorithms is used to accomplish it.

A. *Decoupling approach*

A simplifying approach decouples the network throughput problem into two sub-problems: routing and initial channel assignment upon flow admission, and channel re-assignment and congestion control. Upon admission of a flow into a WMN, a route and a set of channel links or equivalently a set of channels of topological links that belong to the route are determined. The initial channel assignment is done such that exactly one channel for a topological link of the route for a flow is determined. This multi-flow diversity enables high channel utilization without resorting to such a fine granularity that path and channel link pairs need to be determined individually for every packet of a given flow. The multi-flow diversity can contribute to reducing the implementation complexity of the problem in terms of paths and channel links by keeping the problem not over simplified in that throughput is still involved with multiple paths of multiple flows and multiple channel links of multiple flow. Once routing and initial channel assignment is complete, the network throughput problem is reduced.

B. *Price-Based Approach*

To improve the network capacity constrained in the suboptimal setting, a priced-based local channel assignment algorithm in a way that a critical channel link limiting the end-to-end flow throughput is forced to change its current channel to another channel with more available throughput is enhanced. Focus on re-routing and channel re-assignment in response to dynamic link quality in multi-radio multi-channel WMNs. In sum, it enhances the prior work with fair congestion control and link scheduling to be able to determine fair rates for individual flows in a distributed manner.

C. *Proportional Fair Congestion Control*

The proportional fairness in congestion control is obtained by using the lagrangian multipliers λ. The price information is calculated using the formula.

$$H(x, \lambda) = \sum_s U_s(X_s) - \sum_{l€L}\sum_{c€C}\lambda_{lc}(\sum_{s,k}F_{lk}R_{kcs}X_s \ -1) = \sum_s(U_s(X_s)-X_s(\sum_{l,c}\lambda_{lc} \sum_k F_{lk}R_{kcs})) \ +\sum_{l,c}\lambda_{lc}$$

Max-min fair congestion control

In the case of max–min fairness, each source s determines X_s by the following rule.

$$Xs(t+1) = [\ X_s(t) + \gamma\ (1 - X_s(t)\ \max_{l,c}\lambda_{lc}\sum_k F_{lk}R_{kcs})\ ]^+$$

Then source s will inform all nodes on its route of newly updated $X_s$value. Prices for link and channel pair's k are updated in the same way.

V. RESULTS AND DISCUSSION

In this chapter, the results of each technique have been discussed and the functionality of all techniques is simulated. The technique is implemented and functionality is verified by using Network Simulator-2.

The fig 4.1 shows the throughput variation of single channel flow for dynamic network. The graph is plotted across normalized flow rate and the single channels obtained after the routing and initial channel assignment for a dynamic network of random topology. This shows the throughput for each of the selected channels and the drop in throughput shows the channel has higher congestion.

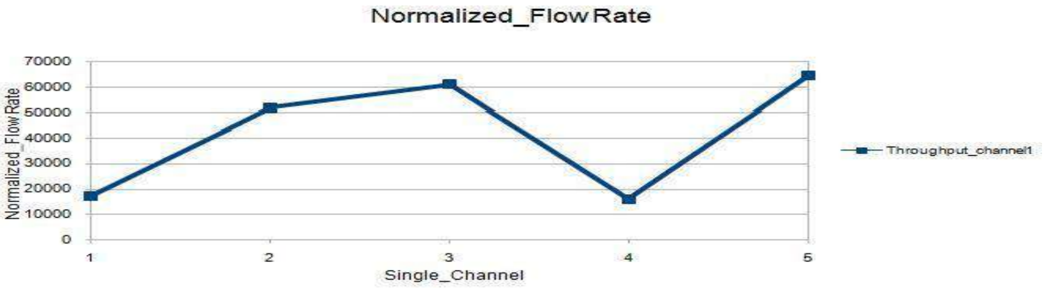

Fig 4.1 single channel flow for dynamic network

Fig 4.1 The graph is plotted across normalized flow rate and the single channels obtained after the routing and initial channel assignment for a dynamic network of random topology. The graph shows the throughput for each of the selected channels. The drop in the throughput shows the channel has higher congestion.

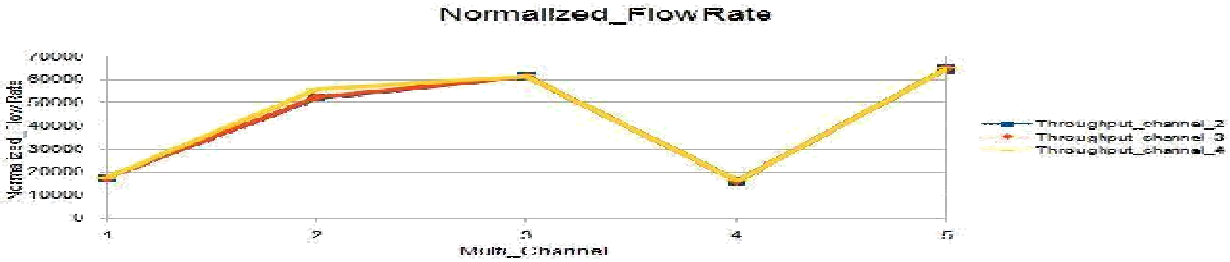

Fig 4.2 multiple channel flow for dynamic network

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The single channel network is now extended to the multi channel network. The different colours show the multiple channels. The blue colour denotes the throughput of channel 2, red denotes throughput of channel 3 and yellow denotes the throughput of channel 4. The plot shows similar result as that of single channel. The drop shows the increase in congestion for multiple channels in the dynamic network. Scenario 1: Taking into consideration 30 nodes in dynamic network Scenario 1: Taking into consideration 30 nodes in dynamic network

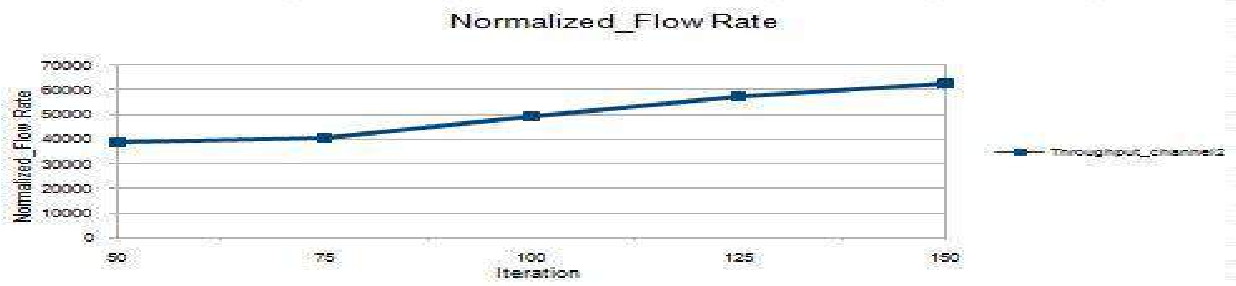


Fig 4.3 throughput in channel 2

Fig 4.3 Scenario 1: Taking into consideration 30 nodes in dynamic network.

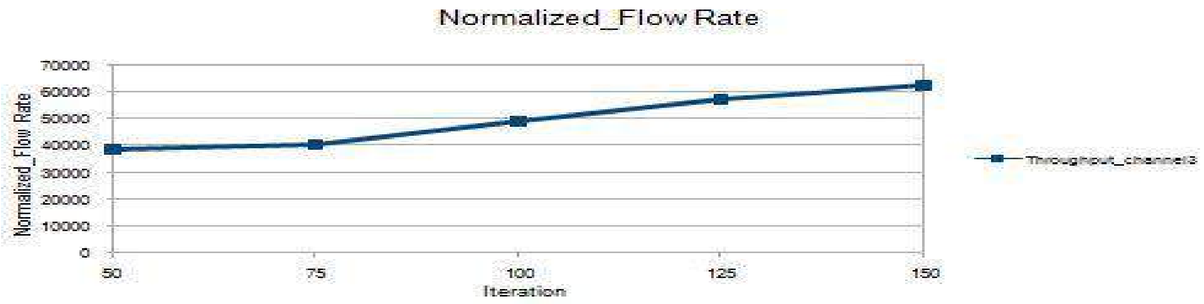


Fig 4..4 throughput in channel 3

Fig 4.4 Scenario 2: Taking into consideration 40 nodes in dynamic network

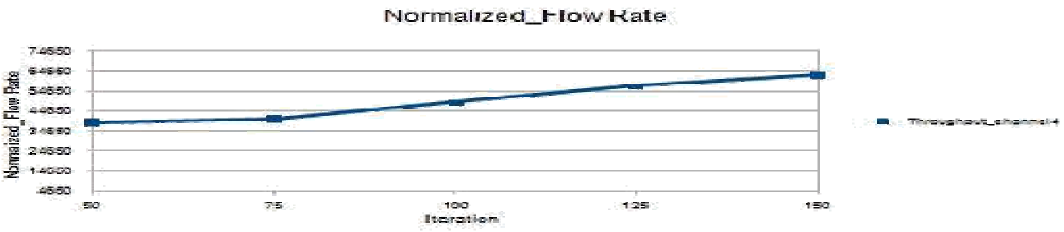


Fig 4.5 throughput in channel 4

Fig 4.5 Scenario 3: Taking into consideration 50 nodes in dynamic network.

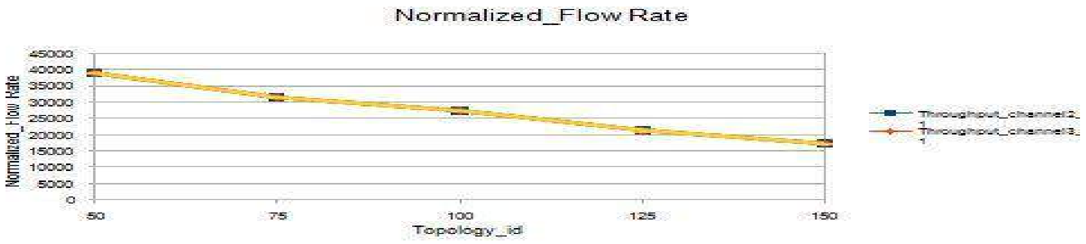


Fig 4.6 flow rate for topology id [1]

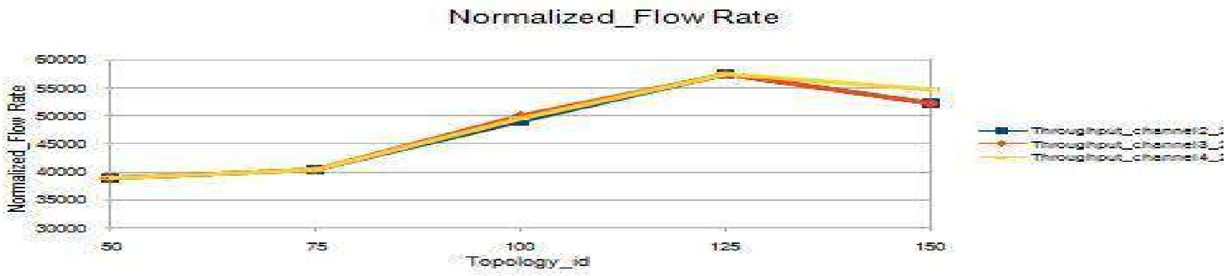


Fig 4.7 flow rate for topology id [2]

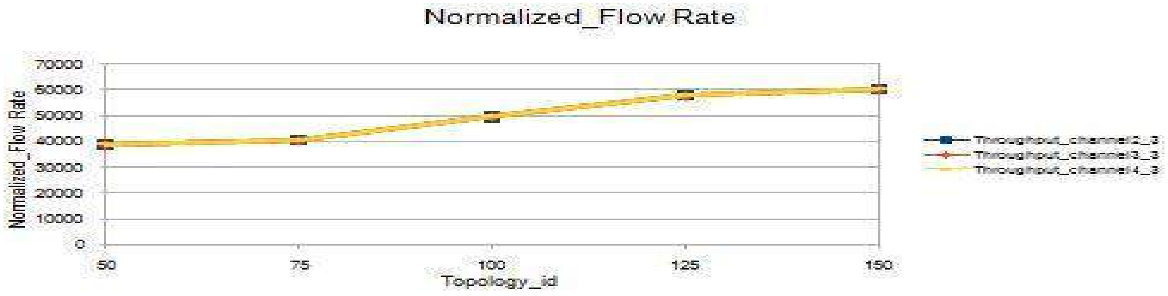


Fig 4.8flow rate for topology id [3]

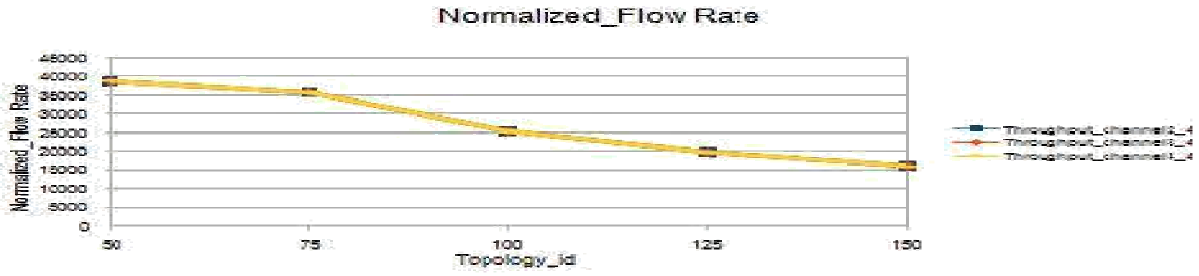


Fig4.9 flow rate for topology id [4]

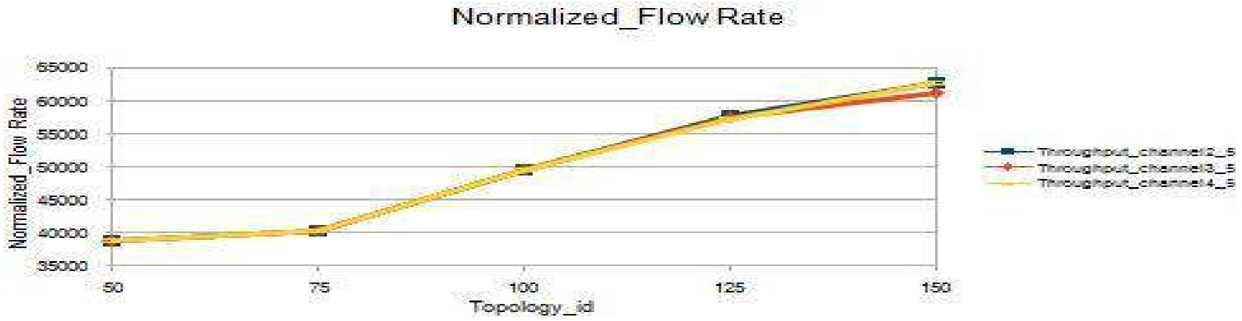


Fig 4.10 flow rate for topology id [5]

Fig 4.6-10The graphs are plotted for different topologies. The topologies are changed by considering different number of nodes in each case randomly. The blue colour denotes the throughput of channel 2, red denotes throughput of channel 3 and yellow denotes the throughput of channel 4. Each of these topologies is iterated for specific number of iterations and the plot is done. Each plot shows the variations in the throughput. The graph is plotted across the normalized flow rate and topology id in each case.

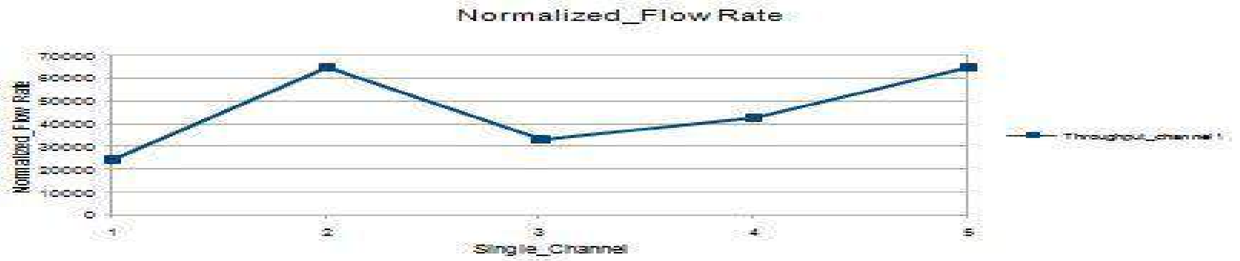


Fig 4.11single channel flow for static network

Fig 4.11The graph is plotted for single channel for static network. The throughput is found to be dropping at channel 3. The channel 2 shows high throughput. The single channels in the table show various levels of throughput.

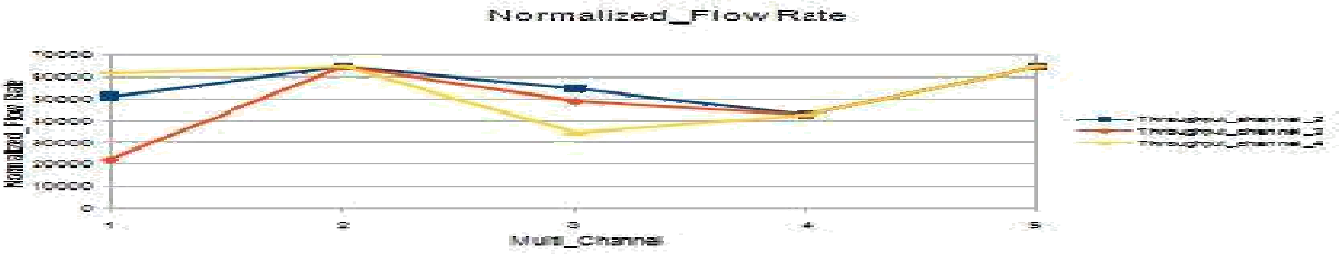


Fig 4.12 multiple channel flow for static network

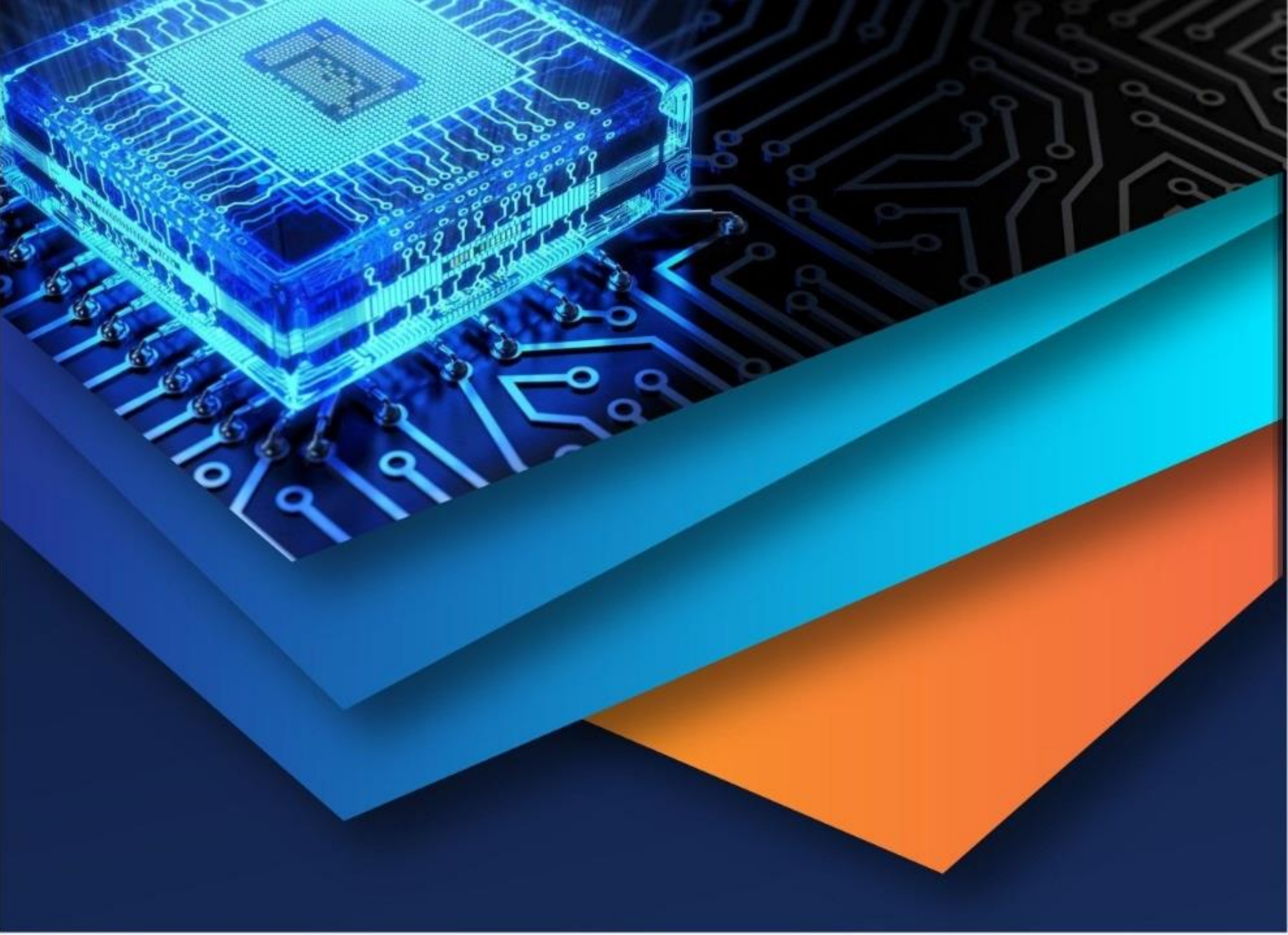
Fig 4.12 The single channel network is now extended to the multi channel network. The different colours show the multiple channels. The blue colour denotes the throughput of channel 2, red denotes throughput of channel 3 and yellow denotes the throughput of channel 4. The plot shows similar result as that of single channel. The drop shows the increase in congestion for multiple channels in the static network.

VI. CONCLUSION

The network utility maximization framework is adequately extended to multi-radio multi-channel WMNs based on quasi-static channel assignment. Price based distributed congestion control is the technique used to break down the complex network design into various small component and thereby creating a congestion aware channel assignment. With the price information, the congestion control algorithm and the local channel assignment algorithm collaborate to achieve better use of multi-channel radio resources. Distributed and localized implementation to the price-based approach which involves network nodes only with a set of nodes whose price information is relevant in a link dimension and a channel dimension is thus attributed.

REFERENCES

[1] Kodialam M, Nandagopal T. Characterizing the capacity region in multi-radio multi-channel wireless mesh networks. In: ACM 8th annual international conference on mobile computing and networking (MobiCom); 2005. p. 73–87.
[2] Ramachandran KN, Belding EM, Almeroth KC, Buddhikot MM. Interference-aware channel assignment in multi-radio wireless mesh networks. In: IEEE 25th conference on computer communications (Infocom); 2006. p. 1–12.
[3] Kyasanur P, Vaidya NH. Routing and link-layer protocols for multi-channel multi-interface ad hoc wireless networks. ACM SIGMOBILE MC2R 2006;10(1):31–43.
[4] Giannoulis A, Salonidis T, and Knightly E. Congestion control and channel assignment in multi-radio wireless mesh networks. In: IEEE 5th conference on sensor, mesh and ad hoc communications and networks (SECON); 2008. p. 350–8.
[5] Shi Y, Hou YT, Zhou H,Midkiff SF. Distributed cross-layer optimization for cognitive radio networks. IEEE Trans Vehicular Technol 2010;59(8):4058–69.
[6] Tang J, Xue G, ZhangW. Cross-layer design for end-to-end throughput and fairness enhancement in multi-channel wireless mesh networks. IEEE TransWireless Commun 2007;6(10):3482–6.
[7] Shin B, Han S, and Lee D. Dynamic link quality aware routing protocol for multi-radio wireless mesh networks. In: IEEE 26th international conference on advanced information networking and applications (AINA); 2012. p. 44–50.
[8] Tan L, Zhang X, Andrew L, Chan S, Zukerman M. Price-based max–min fair rate allocation in wireless multi-hop networks. IEEE Commun Lett2006;10(1):31–3.
[9] Tang J, Xue G, Zhang W. Cross-layer design for end-to-end rate allocation in multi-radio wireless mesh networks. Wireless Networks 2009;15(1):53–64.
[10] Ning Z, Guo L, Peng Y, Wang X. Joint scheduling and routing algorithm with load balancing in wireless mesh network. Comput El ectri Eng 2012;38(3):533–50.
[11] Avallone S. An energy efficient channel assignment and routing algorithm for multi-radio wireless mesh networks. Ad Hoc Networks 2012;10(6):1043–57.
[12] Jahanshahi M, Dehghan M, Meybodi MR. A mathematical formulation for joint channel assignment and multicast routing in multi-channel multi-radio wireless mesh networks. J Network Comput Appl 2011;34(6):1869–82.
[13] Anil Kumar VS, Marathe MV, Parthasarathy S. Algorithmic aspects of capacity in wireless networks. In: ACM international conference on measurement and modeling of computer systems (SIGMETRICS); 2005. p. 133–44.
[14] Shi Y, Hou YT, Liu J, Kompella S. How to correctly use the protocol interference model for multi-hop wireless networks. In: ACM international symposium on mobile ad hoc networking and computing (MobiHoc); 2009. p. 239–48.
[15] Yoon W, Vaidya NH. Routing exploiting multiple heterogeneous wireless interfaces: a TCP performance study. Comput Commun 2010;33(1):23–34.
[16] Yoon W, Vaidya NH. A link layer protocol and link-state routing protocol suite for multi-channel ad hoc networks. Wireless Commun Mobile Comput2012;12(1):85–98.
[17] Srikant R. The mathematics of Internet congestion control. Birkhauser; 2003.



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