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Near-Hidden Link Interference Minimization In IEEE 802.11 Adhoc Multi-Radio Multi-Channel Wireless Mesh Networks

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ABSTRACT

Wireless Mesh Network is very promising and a novel communication technology. The purpose of WMN is to provide broadband access, flexibility, and ease of deployment. Wireless mesh network faces several issues i.e. routing, node deployment and channel assignment. In case of channel assignment there are chances of interference among frequency channels from IEEE 802.11b spectrum that degrade the overall capacity of a network. One of the well-known interference types is Near Hidden interference that is caused by the near hidden terminals in WMN topology. In this paper, Near-hidden interference problem is minimized by proposing an optimal channel assignment model called OCAM. The simulations are conducted with the help of OPNET simulator. The simulation results show that the network capacity of the proposed model gives more effective results over the existing model. The performance of proposed channel assignment scheme OCAM is 10% better than the existing model.

Keywords— Wireless mesh network; MRMC-WMN; optimization; Near-hidden interference, channel assignment

Introduction

Wireless mesh networks (WMNs) deliver wireless services in personal, local, campus and metropolitan areas for a large variety of application. In mesh network all nodes are directly communicated with each other for the purpose of sharing network connection across a vast area. Nodes only use the WLAN standards 802.11 b/g to

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connect wirelessly with the users, and to other nodes within a network. According to [1], a node can send and receive messages and functions as a router. The routing protocols provide paths to permit communication between non-neighbour nodes and the best routes are used.

Wireless mesh network comprises three types of nodes WMN router, WMN client and WMN gateway. The complete architecture is shown in Figure 1. WMN clients are the devices used by end-users that include laptops, PDAs, smart phones and other devices. WMN client have limited power, they have routing capability. WMN routers can route the network traffic. Some of the routers (mesh) acts as a gateway to the whole internet and are connected through the internet by high speed wired links. The nodes in a network could be assigned single or multiple radios [2]. In multi-radio multi-channel each node has more than one radio interface card. Multiple radio interfaces operate on various dissimilar radio channels using single mesh router that forms a multi radio wireless mesh network. Wireless Mesh Networks (WMNs) is developed by the combination of mobile and fixed nodes that are linked with the help of wireless links in order to build a multi-hop ad hoc network.

Each and every node is connected to all other nodes within a network for communication. The interconnection among each node is referred to as a link [3]. As the nodes are increased in number, the number of links also increases. A node can send and receive messages and functions as a router. The routing protocols provide paths to permit communication between non-neighbor nodes and the best routes are used.

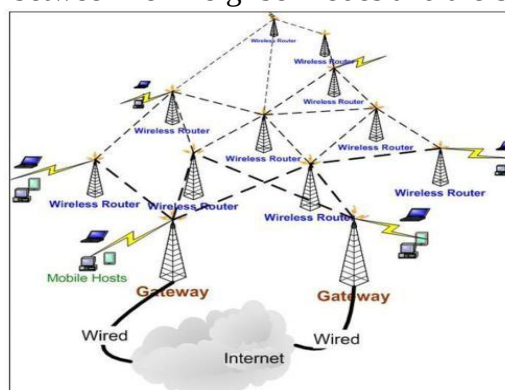


Figure 1. Architecture of WMN

From the sources to destination, there are a number of paths. The advantage of WMN is that the alternative routing increases network reliability. The main aim of wireless mesh network is providing internet access with high speed to end users.

1.1 Channel Assignment exploiting Non-Overlapping channels

Channel Assignment (CA) in a multi radio wireless mesh network environment that consists of allocating channels to radio interfaces to carry the flow of data. The number of channels that could be allocated to a node cannot surpass the number of interfaces (radios) present on the node. In case of assigning channels to multiple radios interference may occur. Interference among channels degrades the throughput of

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wireless mesh networks. Interference among the channels present in neighborhood results in a rise in the point-to-point delay, decrease in overall throughput and a rise in retransmission. It is not easy to protect a wireless network, since the medium of transmission is available to everyone inside the geographical range of a transmitter.

The Non-Overlapped Channels (NOCs) are those channels that have no spectrum overlap with other working channels. In the well-known IEEE 802.11b wireless standard the largest orthogonal (non-overlapping) channel set includes channel 1, 6 and 11 that could be consecutively used within neighborhood. Channels of non-overlapping frequency can be assigned to radios in a carrier sensing range that increase actual bandwidth available to a network. In this paper the non-overlapping frequency channels are utilized for channel assignment purpose.

Each mesh node in WMN has its own Carrier sensing Range (Cr) and Transmission Range (Tr). Transmission range is that range, inside which nodes can communicate on the same frequency channel. Whereas carrier sensing range is the range inside which the nodes are capable of sensing the signal even though the availability of correct packet reception may not possible. Interference can occur if nodes inside carrier sensing range operate on the same frequency channel.

1.2 Near Hidden interference in WMN

Interference degrades the throughput of wireless mesh networks. Wireless links may interfere with each other, resulting in performance degradation. It is not easy to protect a wireless network, since the medium of transmission is available to everyone inside the geographical range of a transmitter. Degradation of performance could occur when the sources send much traffic than the capacity of the network [4]. Interference among the channels present in neighborhood results in a rise in the point-to-point delay, decrease in overall throughput and a increase in retransmission.

Near hidden interference is the type of non-coordinated interference. The non-coordinated interference is that interference in which source node are outside the carrier sensing range of each other. Near hidden interference is caused by near hidden terminals in WMN. In case of Near-Hidden (NH) interference both the nodes of source *D* and *A* are not in the carrier-sensing range of each other. But the receivers of both the links are inside the sensing range of each other's source node. Both these connections interferes one another in a situation of transmission on the similar frequency channel.

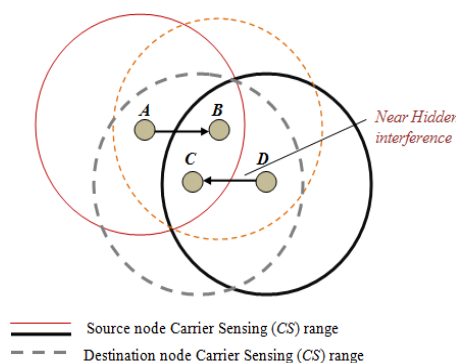


Figure. 2. Near Hidden interference in Wireless mesh network.

Online ISSN

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Print ISSN

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As shown in the Figure 2, two links (A, B) and (C, D) are taken as mesh links. the source node A has a Transmission range (Tr) shown by the left solid line circle, every node in this range can listen to any signal transmitted by node A . Source node D has a transmission range displayed by the right solid line circle. It shows that every node located in this range can listen any signal transmitted by D . Node D is outside the transmission range of A same as node A is outside the transmission range of D . Destination nodes B and C are in the area covered by both A and D , both B and C can hear signal transmitted by A or D . Assuming that node A is sending data to node B . In the middle of this transmission, node D has also some data to send to node C . Node D is out of A 's range and transmissions from B cannot reach D . Node D finds the medium free and starts transmission on the same frequency channel to C . Node D sends its data to C , results in a collision. The nodes A and D are unknown from each other with respect to the destination node. Hidden nodes can decrease the capacity of the network because of the possibility of interference.

The rest of the paper is organized as follows. The section 2 provides related works, while Section 3 describes the proposed model formulation. Section 4 describes the simulation results of the proposed scheme and optimized model Section 5 conclusion and future work.

2 Literature Survey

Researchers have proposed different algebraic channel assignment models for solving the near hidden inference issue. Many optimization models are intended to achieve the optimal channel assignment and decrease near hidden interference. [2] presented an overview of wireless mesh network in detail. Many methods have been proposed to increase the capacity and springiness of wireless system, the cantered objective of wireless mesh network is discussed. The author described different features which made worse effect on the routing process in WMN. Network management function like power management, mobility management and network monitoring issues are examined. WMNs are exposed to security occurrences in different protocol layers. At the end it was concluded that are certain issues i.e the scalability and security exists that reduces the performance of wireless mesh network.

[5] divided the interference links into two parts. The coordinated (CO) and the Non-coordinated (nCO) interfering links. The author categorized the nCO links as the Near-Hidden (NH), Information Asymmetric (IA), and Far-hidden (FH) interference links. The authors formulated the conditional loss of packets probabilities of different links for each kind of interference. After certain comparisons the author has demonstrated that non-coordinated link results in significant higher transmission losses as compare to the coordinated (CO) interference. The author provided the behavior of Carrier Sensing Multiple Access protocols in multi hopping networks and gave the new visions that can lead the study and design of the distributed Medium Access Control (MAC) schemes.

In [6], an optimization model is proposed that focuses on maximization of the network capacity and minimization of Non Coordinated interference utilizing the effectiveness of non-overlapping CA in MRMC WMNs by proposing an optimized CA approach. The author compared both the sparse and dense channel assignment in MRMC WMN

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topologies through simulation. Three non-overlapping channels of 802.11b technology were used for channel assignment strategy. At the end model result of both sparse and dense topologies were concluded through *OPNET* simulator. In the sparse environment, where *NCO* interference is more, it showed that the performance of optimized model is 19% improved than the dense network environment. [4] discussed the extend problem of interference between nodes in WMN. Interference causes throughput degradation when it is compared to a pair-wise interference of the links. An analytical model referred to ripple effect problem is discussed. It is a formal model of interference which estimates the maximum rate of the flow that can safely send traffic without overloading network. The interference is spread towards other neighbouring nodes. The channel reassignment, route scheduling and fair scheduling are overviewed. Author in [7] proposed that the numbers of non-overlapping channels that are obtainable are less than the wireless mesh nodes, so the same channels will repeatedly assigned and shared among these nodes. This insufficiency of the channels causes interference and degrades the performance of the network. The author has presented a group based channel assignment method to minimize the interference. This model defines the channel assignment strategy for the reduction of interference. The Discrete Particle Swarm Optimization (*DPSO*) is used for solving the optimization function.

In 2019 [9], Li et al. proposed an interference-aware routing and channel allocation scheme that jointly optimizes routing paths and channel selection. Their results showed improved Quality of Service (QoS) in dense WMN environments. With the advancement of artificial intelligence [10], Reinforcement Learning-based methods have been widely adopted. Chen et al. (2020) applied Q-learning for adaptive channel assignment, enabling nodes to dynamically select optimal channels based on network conditions. In [11], Wang et al. introduced deep reinforcement learning (DRL)-based channel allocation for MRMC-WMNs. Their model improved network capacity and reduced interference by learning optimal policies in real-time. A study by Kumar et al. [12] explored hybrid optimization techniques combining genetic algorithms and machine learning for interference minimization. Their approach demonstrated better scalability and performance in large-scale WMNs. Recent work by Ahmed et al. [13] focused specifically on near-hidden interference mitigation using interference-aware scheduling and channel assignment. Their findings showed significant reduction in packet collisions and delay. In [14], emerging research trends emphasize AI-driven and software-defined networking (SDN)-based WMNs. These approaches enable centralized control and intelligent channel allocation, further improving network efficiency and reliability.

3. Proposed Model Formulation

In this section near-hidden interference is minimized by formulating a linear programming (LP) model. The proposed model is termed as an Optimal Channel Assignment Model called OCAM. The OCAM consists of a binary decision variable, one objective function and a set of constraints.

3.1. Problem Formulation

In this section Linear Optimization model is formulated. The model comprises of

Online ISSN

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Print ISSN

3007-3189

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decision variables, set of constraints and objective functions.

Let M be a set of all available frequency channels and E representing set of all the mesh links. Number of total channel i.e. 11 is shown by K . The symbol $\lambda(e_i)$ represents fraction of traffic flow on each link whereas e_i represents a single link and c_j represents a single channel v . The capacity of each frequency channel is represented by C_{c_j} . The variable k represents the set of non-overlapping channels i.e. 1,6,11. $C(e_j)$ shows channel assigned to link e_j . $NH(e_j)$ represents set of all NH interfering links of a link e_j . The variable $CO(e_j)$ shows set of all the coordinated interfering link of e_j .

3.2. Proposed OCAM Model

The proposed model that is Optimized Channel Assignment Model (OCAM) comprises of Near-Hidden interference constraint. The proposed model aims to optimize the channel assignment mechanism. In the proposed model three non-overlapping channels of 802.11b technology are used for channel assignment strategy OCAM minimizes interference and improves the overall capacity of a network.

3.2.1. Decision Variable

In this optimization model an IEEE 802.11 b spectrum the decision variable assigns channel c_j to e_i that is a link. It states that if any intended link e_i operates on any channel c_j then it is equal to 1 and if not then value will be 0. Such a kind of decision variable is also known as binary variable that can be represented by either 1 or 0. The binary variable is shown in equation (1);

$$x(e_i, c_j) = \begin{cases} 1 & \text{Directed link } e_i \text{ operates on channel } c_j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

3.2.2. Objective Function

The objective of this model is to maximize the *MRMC-WMN* capacity. Getting the objective all the constraints must be considered. Objective function is used to collect objective and all the constraints must be measured. The objective function is shown in equation (2). All the link flows fulfilled over all the links and channels are added.

$$\max \sum_{e_i \in E} \sum_{c_j \in M} x(e_i, c_j) \cdot \lambda(e_i) \cdot f(e_i) \quad (2)$$

Here an E represents non overlapping channels which are 3 (1, 6, 11) and M is the set of all existing frequency channels.

3.2.3. Constraints

Constraints are limitations on an optimization model, which explains the obnoxious results. In this research there are few restrictions that must be observed. Following are the set of constraint of the channel assignment model.

3.2.3.1. Single channel per link constraint.

First constraint in the optimization model confirms that every link in the set E (edges) should be assigned to only one channel. Single channel per link constraint states that if

Online ISSN

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Print ISSN

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<http://amresearchreview.com/index.php/Journal/about>

e_i is a link and c_j is a channel assigned to a link than the summation of all channels evaluates to 1 [8]. Equation (3) shows the single channel per link constraint.

$$\sum_{c_j \in M} x(e_i, c_j) = 1 \quad \forall e_i \in E, c_j \in M \quad (3)$$

3.2.3.2 Coordinated Interference constraint

Coordinated links which does not cause any severe interference and network performance will not be affected if multiple corresponding links working on the same frequency channel. Meanwhile channel capacity is absolutely dispense between all the corresponding interfering links. However the capacity of a channel is shared when multiple corresponding links are active on same channel, which is shown in the following constraint. The coordinated constraints is represented through equation (4) by [6].

$$x(e_i, c_j) \cdot \lambda(e_i) \cdot f(e_i) + \sum_{e_k \in co(e_i)} x(e_k, c_j) \cdot \lambda(e_k) \cdot f(e_k) \leq C c_j \quad \forall e_i \in E, c_j \in M \quad (4)$$

3.2.3.3 Near-Hidden interference constraint

This equation shows that if there are multiple Near-Hidden (NH) interfering links then only one channel c_j will be assigned to them. Equation (5) shows the near-hidden constraint. Hence e_k and e_i are different links which works on the same channel c_j . On the channel c_j , only one among them would be active in the range of interference.

$$x(e_i, c_j) + \sum_{e_k \in NH(e_i)} x(e_k, c_j) \leq 1 \quad \forall e_i \in E, \forall c_j \in M, e_k \in E \quad (5)$$

Figure 3 shows that links e_1, e_2 and e_3 are *Near-Hidden* links. The receiver node r_2, r_3 and r_4 are inside the carrier-sensing range of source node s_1 which cause near-hidden interference. The main objective is to decrease the near-hidden interference. If a specified channel c_j is allocated to e_i then it can't be allocated to e_4 or e_3 . It means that at one time we can assign only one IEEE 802.11b frequency channel to near-hidden interfering links. In the next section results are discussed in detail.

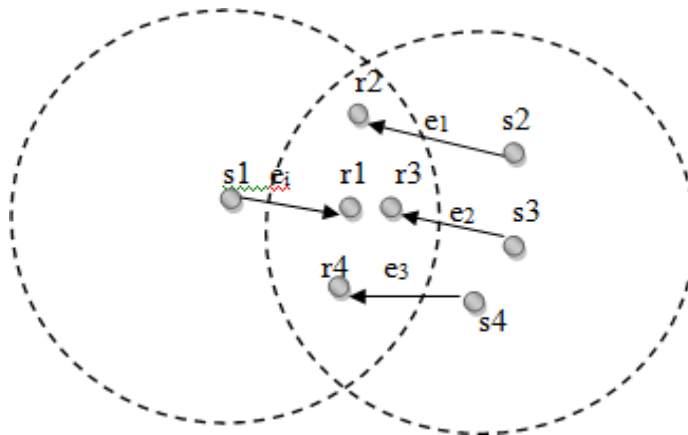


Fig. 3. Near Hidden links

Online ISSN

3007-3197

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3007-3189

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4 Results and Discussion

This section is divided into three main parts. In the first part *MATLAB* is used for the purpose of constructing different *MRMC* wireless mesh topologies. Second section comprise of Linear Programming (*LP*) model results that are taken in *AMPL*. *LP* uses mathematical notations to describe a model. An ideal channel assignment proposed scheme is grounded on *LP* modeling. This model gives results based on ideal channel assignment using Mathematical Programming Language tool. In section third the extensive OPNET simulations have been done to verify the model results.

4.1. WMN topology construction

In Figure 4 four different *WMN* topologies have been generated, each topology consists of 25 nodes respectively. The effect of interference of *NH* is to be checked in topologies having 25 nodes each. We have assumed that maximum transmission range of every node Tr is 10 meter while the carrier-sensing range that is represented by Cr is considered 26 meters that is 2.6 times of Tr . The terrain area is taken $100 \times 100 \text{ m}^2$. Near-Hidden links and coordinating interference links are recognized after the construction of the four topologies.

In Figure 4 (a) link (12,13) is the considered link. Node 12 is taken as source node while 13 is destination node of source 12. The set of coordinated links for (12,13) are (3,4) (4,5) (5,6) (13,14) (14,15) (15,16) (8,9) (9,10) (10,11) while the set of Near-Hidden (*NH*) links are (2,3) (7,8). The source node of link (12, 13) is in Carrier Sensing range of the links (2,3) and (7,8). Apart from this, such kind of interference is identified for all the remaining *MRMC-WMN* topologies that are shown in Fig 4.

Similarly in Figure 4(b) link (24, 25) is a considered link. Node 24 is a source node while 25 is a destination node. The set of coordinated links for (24,25) are (1,2) (2,3) (5,6) (6,7) (7,8) (10,11) (11,12) (16,17) (17,18) (21,22) (22,23) (23,24) while the set of Near-Hidden (*NH*) links are (9,10). The source node of link (24, 25) is in carrier sense range of the links (9, 10). If the channel assigned to link (12, 13) is same as that assigned to the link (9, 10) and in this case they can sense each other and the chances of Near-Hidden interference is high. To minimize *NH* interference optimal channel scheme is proposed in this paper. In Figure 4(c) link (1,2) is a considered link. Node 1 is a source node while 2 is a destination node. The set of coordinated links for (1,2) link are (2,3) (3,4) (8,9) (9,10) (11,12) (12,13) (16,17) (17,18) (18,19) while the set of Near-Hidden (*NH*) links is empty () which means that there is no near-hidden link for link (1,2).

In Figure 4(d) link (1,2) is a considered link. Node 1 is a source node while 2 is destination node. The set of coordinated links for (1,2) link are (2,3) (3,4) (4,5) (11,12) (12,13) (13,14) (14,15) while the set of Near-Hidden (*NH*) link is (19,20). The source node of link (1,2) is in Carrier Sensing range (Cr) of the links (19,20). Table 1 shows the interference links created for *WMN* topology given in Fig. 4 d).

4.2 AMPL implementation and results

The *AMPL*, gurobi solver assigns channel to numerous network nodes. A gurobi solver is designed to solve *LP* problems. The solver solves the model and it sends the result back to *AMPL* which in turn shows a result in a standardized form. The single link path has been taken for all the paths between mesh nodes.

Online ISSN

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Print ISSN

3007-3189

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The channel assignment results obtained from proposed model are near optimal. The entire paths among mesh node are taken single link paths. Each link flow demand has been varied from 100 to 500 packets per second on each source node.

Table 2 consists of channel assignments results for the figure given in Fig 4 d). First column represents the link between nodes and the second column represents channel assigned to each link. There are 25 nodes. Three IEEE 802.11b non-overlapping channels (1,6,11) are used for channel allocation.

4.3 Simulation results

The channel assignment results given by OCAM model are simulated in OPNET for further verification. The four scenarios with different network sizes are presented to compare the OCAM model results with the existing model [6]. The optimized channel assignment result that is given by *AMPL* is used by *OPNET* modeler for creating an optimized model. The links have been divided into coordinated and near hidden links and for each link the non-overlapping channels are assigned. The parameters used during the entire simulation are shown in Table 3. In WMN each node in a network is connected to another node. The traffic sinks from source node to the destination node. Every node has three radios and it consists of specific attributes. The non-overlapping channel is assigned to each radio interface. A unique *IP* address is assigned to each node and different *MAC* address are assigned to each radio interface of a node.

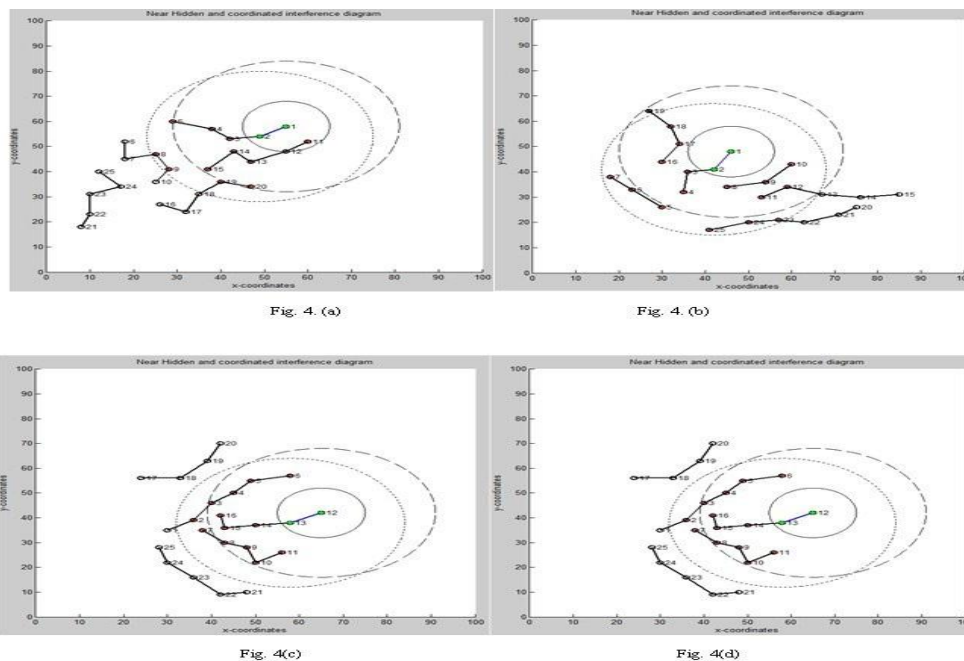


Fig. 4. The MATLAB generated MWN Topologies

In WMN each node in a network is connected to another node. The traffic sinks from source node to the destination node. Every node has three radios and it consists of specific attributes. The non-overlapping channel is assigned to each radio interface. A unique *IP* address is assigned to each node and different *MAC* address are assigned to each radio interface of a node.

Table 1. The set of Coordinated (CO) and Near Hidden (NH) links of 25 nodes WMN topology of Figure 4(d)

Link	Near Hidden links	Coordinated links
1,2	(19,20)	(2,3)(3,4)(4,5)(11,12)(12,13)(13,14)(14,15)
2,3	(7,8)(18,19)	(1,2)(3,4)(4,5)(8,9)(9,10)(11,12)(12,13)(13,14)(14,15)(19,20)
3,4	(17,18)	(1,2)(2,3)(4,5)(6,7)(7,8)(8,9)(9,10)(11,12)(12,13)(13,14)(14,15)(18,19)(19,20)
4,5	(18,19)	(1,2)(2,3)(3,4)(6,7)(7,8)(8,9)(9,10)(11,12)(12,13)(13,14)(14,15)(19,20)
6,7	(2,3)(13,14)(22,23)	(3,4)(4,5)(7,8)(8,9)(9,10)(14,15)(23,24)(24,25)
7,8	(2,3)(13,14)(21,22)	(3,4)(4,5)(6,7)(8,9)(9,10)(14,15)(16,17)(17,18)(18,19)(19,20)(22,23)(23,24)(24,25)
8,9	(1,2)(12,13)(22,23)	(2,3)(3,4)(4,5)(6,7)(7,8)(9,10)(13,14)(14,15)(16,17)(17,18)(18,19)(19,20)(23,24)(24,25)
9,10	(1,2)(12,13)(21,22)	(2,3)(3,4)(4,5)(6,7)(7,8)(8,9)(13,14)(14,15)(16,17)(17,18)(18,19)(19,20)(22,23)(23,24)(24,25)
11,12	(18,19)	(1,2)(2,3)(3,4)(4,5)(12,13)(13,14)(14,15)(19,20)
12,13	(18,19)	(1,2)(2,3)(3,4)(4,5)(11,12)(13,14)(14,15)(19,20)
13,14	(7,8)(16,17)	(1,2)(2,3)(3,4)(4,5)(8,9)(9,10)(11,12)(12,13)(14,15)(17,18)(18,19)(19,20)
14,15	(17,18)	(1,2)(2,3)(3,4)(4,5)(6,7)(7,8)(8,9)(9,10)(11,12)(12,13)(13,14)(18,19)(19,20)
16,17	(6,7)(14,15)	(7,8)(8,9)(9,10)(17,18)(18,19)(19,20)(21,22)(22,23)(23,24)(24,25)
17,18	(6,7)(12,13)(14,15)	(7,8)(8,9)(9,10)(13,14)(16,17)(18,19)(19,20)(21,22)(22,23)(23,24)(24,25)
18,19	(2,3)(6,7)(12,13)(22,23)	(3,4)(7,8)(8,9)(9,10)(13,14)(16,17)(17,18)(19,20)(14,15)(23,24)(24,25)
19,20	(1,2)(6,7)(23,24)	(2,3)(3,4)(4,5)(7,8)(8,9)(9,10)(11,12)(12,13)(13,14)(14,15)(16,17)(17,18)(18,19)(24,25)
21,22	(9,10)	(16,17)(17,18)(22,23)(23,24)(24,25)
22,23	(6,7)(8,9)	(7,8)(9,10)(16,17)(17,18)(21,22)(23,24)(24,25)
23,24	Nil	(6,7)(7,8)(8,9)(9,10)(16,17)(17,18)(18,19)(21,22)(22,23)(24,25)
24,25	(14,15)	(6,7)(7,8)(8,9)(9,10)(16,17)(17,18)(18,19)(19,20)(21,22)(22,23)(23,24)

Table 2. Simulation Parameters for the proposed model

Parameter	Value
Radio Technology	IEEE802.11b
Transmission Capacity	11Mbps
Transmission Range	30 meters
Carrier Sensing Range.	2.6*30 meters
Number of Nodes	25
Radios per Node	3
Poisson flow generation	0.02,0.01,0.005
Simulation time	3 minutes
Terrain area	100x100 meters

Table 3.Existing model simulation results

Network Capacity-packets/sec(25 nodes)					
Flow	Flow	Flow	Flow	Flow	Flow
50	50	50	50	50	50
100	100	100	100	100	100
150	150	150	150	150	150
200	200	200	200	200	200
250	250	250	250	250	250
300	300	300	300	300	300
350	350	350	350	350	350
400	400	400	400	400	400
450	450	450	450	450	450
500	500	500	500	500	500

The data in every column represent the throughput of 25 node topologies respectfully. The last column represents the average value of the network capacity for the flow demand ranging from 50 to 500 kbps. The table shows that as the flow demand increases the network capacity also increases. The traffic flow varies from 50 to 500 packets per second for each topology. The last column represents the average value of the network capacity for the flow demand ranging from 50 to 500 kbps for the existing model. The network capacity of the existing model is lower than the overall throughput of proposed optimized model. The data in every column represent the throughput of 25 node topologies respectfully. The last column represents the average value of the network capacity for the flow demand ranging from 50 to 500 kbps. The table shows that as the flow demand increases the network capacity also increases. Table 3 represents the results obtained and the total network capacity for every topology of the existing model. The traffic flow varies from 50 to 500 packets per second for each topology. The last column represents the average value of the network capacity for the flow demand ranging from 50 to 500 kbps for the existing model. The network capacity of the existing model is lower than the overall throughput of proposed optimized model.

Table 4.WMN topology: Channel assignment given by proposed OCAM model

Mesh Links	
1,2	1
2,3	6
3,4	1
4,5	6
5,6	11
7,8	1
8,9	11
9,10	6
10,11	1
12,13	11
13,14	6
14,15	1
15,16	1
18,17	11
19,18	6
20,19	1
21,22	6
22,23	11
23,24	11
24,25	1

Table 4 represents the results obtained and the total network capacity for every topology of the existing model.

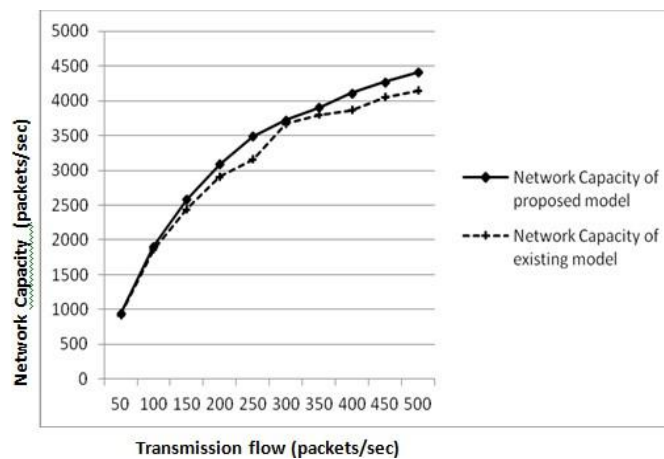


Fig. 5. Capacity comparison of. 25 nodes for topology 1

Figure 5 represents the comparison among first topology of the proposed model and the existing model. Both models consist of 25 nodes each. The horizontal axis shows flow demand which is represented by packets/ sec varying from the range of 50 to 500, likewise the vertical axis displays the overall throughput for the optimized model and the existing model. The above solid line graph shows the network capacity of the proposed model, while the below dotted line graph shows the capacity of network of existing model.

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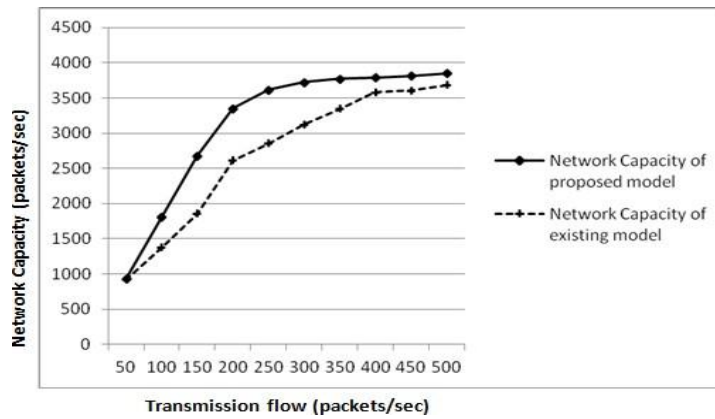


Fig. 6. Capacity comparison for 25 nodes in WMN topology

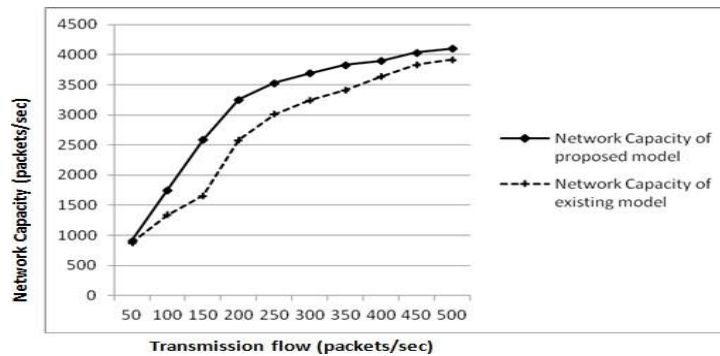


Fig. 7. Capacity comparison for nodes 25 for the topology 3

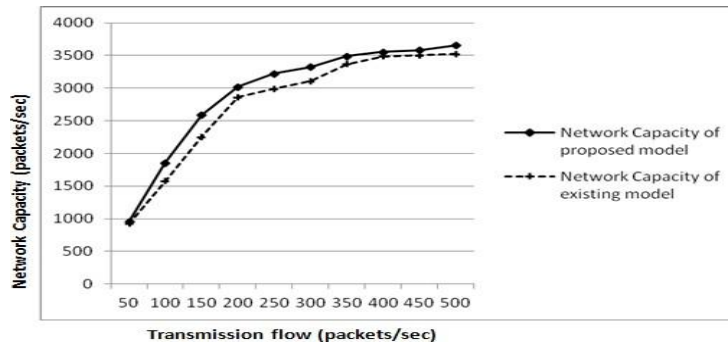


Fig. 8. Comparison of capacity of 25 nodes for topology 4

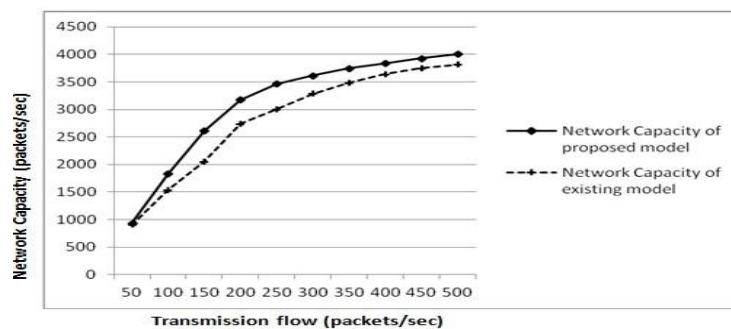


Fig. 9. Average Comparison of network capacity of 25 nodes WMN

The graph shows that when flow demand is 50 packets/sec the proposed model throughput is 941.98 packet/sec and existing model throughput 920.42 packet/sec. As flow increases the network capacity also increases. The flow demand rises from 50 to 500 packet/sec gradually, the network capacity also increases to 4414.52 packets/sec for the proposed model and the network capacity reaches to 4143.56 packets/sec for the existing model. When the flow of demand for the flow increases, the capacity of the OCAM model delivers a maximum value over the existing model. Fig. 6, 7 and 8 illustrates the comparison of remaining all the three topologies (topology 1, topology 2 and topology 3). Here the x-axis displays sender traffic demand on every node, whereas y-axis displays the WMN capacity of network in packets/sec. The solid line represents in the graph shows result for the OCAM model and the dotted line presents the result of existing model. For the traffic demand, the figures are fluctuating from 100 to 500 packets/sec. The graphical represents presents that the proposed optimized model gives improved performance than the existing model.

Figure 9 represents overall capacity comparison between existing model and the proposed models. The upper solid line in graph represents average capacity taken from all the WMN topologies of an OCAM model discussed in this paper and the lower dotted line shows the average capacity of existing model. Table 6 shows the average and percentage capacity packets per sec for the topology of 25 nodes. Similarly the vertical line in the graph shows the average network capacity for those models i.e. consist of existing and proposed model. Increase in transmission flow causes increase in the overall network capacity of the network. Comparison of existing and proposed models. The horizontal value shows transmission flow in Fig. 7. Capacity comparison for nodes 25 for the topology 3.

The average throughput of the proposed model is 4005.61 and for the existing model is 3816.10 for the flow of 500 packets per second. The results clearly show that *NH* interference has been minimized by the proposed model, the performance of proposed model gives better result than the existing model. The graphical presentation illustrate that the average throughput of proposed model gives more effective results over the existing model.

Table 6 shows that the average network capacity of the proposed model is 66% and the network capacity of the existing model is 59%. The percentage improvement between existing and proposed model is 7% that shows, the Optimized Channel Assignment Model (OCAM) provides better capacity improvement over the existing model.

Table 6. Network Capacity improvement of proposed model over existing model

Flow	Network Capacity		Percentage capacity		% age increase
	existing model	OCAM model	existing model	OCAM model	
50	910.11	936.68	91%	94%	3%
100	1539.25	1831.82	77%	91%	14%
150	2050.40	2611.44	68%	87%	19%
200	2741.84	3178.8	68%	79%	11%
250	3003.04	3465.01	60%	69%	9%
300	3286.30	3616.70	55%	60%	5%
350	3481.41	3750.45	50%	54%	4%
400	3641.18	3839.51	45%	47%	2%
450	3747.27	3925.82	41%	43%	2%
500	3816.10	4005.61	38%	40%	2%

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5 Conclusion

The Near Hidden (NH) interference is minimized to maximize the overall network capacity of wireless mesh network. An optimization model has been proposed that intends to minimize near hidden interference, thus enhancing the throughput of the network. The Optimized Channel Assignment Model (OCAM) is evaluated with the existing model, without having the Near Hidden interference constraint.

The simulation results in OPNET shows that the Optimized Channel Assignment Model (OCAM) gives better performance than existing model. Both the models consist of 25 nodes each. Where the Near Hidden (NH) interference is high between the nodes, the proposed optimization model gives better results. The average network capacity of the proposed model is 66% and the network capacity of existing model is 59%. Through the simulation results it is verified that the Optimized Channel Assignment Model (OCAM) provides capacity enhancement over the existing models.

A model may generate which will give much better performance for both the non-overlapping and Partial Overlapping Channel (POC) assignment. Far hidden and information asymmetry interference will be minimized. In the proposed model the number of nodes in each topology is taken as 25 nodes, the number of nodes may exceed to 100 and 200 nodes and it will give better result and capacity improvement.

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