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Comparative Study Between Static Dynamic and Hybrid Channel Assignment Techniques In Multi Channel and Multi Radio In Wireless Mesh Network

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Abstract

A major challenge in multichannel multiradio wireless mesh network is the allocation of channels that optimizes both packet delay and network throughput. We propose a hybrid multichannel multiradio wireless mesh network where each router works on two interfaces, one interface from each router works on statically allocated channel, while the other interfaces works on dynamically allocated channel. The hybrid architecture is implemented by two protocol, they are Adaptive Dynamic Channel Allocation protocol (ADCA) and Interference and Congestion Aware Routing protocol (ICAR). The Adaptive Dynamic Channel Allocation protocol reduces the packet delay in the network without degrading the network throughput and it is suitable for more number of routers while, Interference and Congestion Aware Routing protocol (ICAR) reduces the interference and packet loss by proper utilization of the channels in the network. The hybrid architecture shows much better adaptively to changing traffic and counteracts router failure more efficiently than purely static architecture and dynamic architecture without remarkable increase in overhead .In addition we also examine the quality of service and fairness parameters of hybrid multichannel multiradio wireless mesh network.

Keywords: Wireless Mesh Network, Static, Dynamic, Hybrid, Interference and Congestion Aware Routing protocol, Adaptive Dynamic Channel Allocation protocol.

Introduction
Now a day’s wireless network is foremost used. It should provide better service to all its users. Around a number of application domains such as the mobile networks, ad hoc networks, ubiquitously and pervasive computing, sensor networks and so on. To provide better service Wireless mesh networks (WMNs) is used. WMN are dynamically self-organized and self-configured, with the nodes in the network [1]. A wireless mesh network (WMN) is a mesh network created through the connection of wireless access points installed at each network user's point. Each network user is also a provider, forwarding data to the next node. Another issue is Channel assignment problem in wireless mesh networks. The major task of channel assignment is assigning frequency channels to the users satisfying the interference constraints and using as small bandwidth as possible is known as the Channel Assignment Problem (CAP). Channel assignment schemes are finding a proper mapping between the available channels and the radios at each node such that the network performance is optimized. Channel assignment methods can be categorized according to the frequency of channel assignment. We distinguish different categories: Centralized, Distributed, Static, Dynamic and Hybrid.

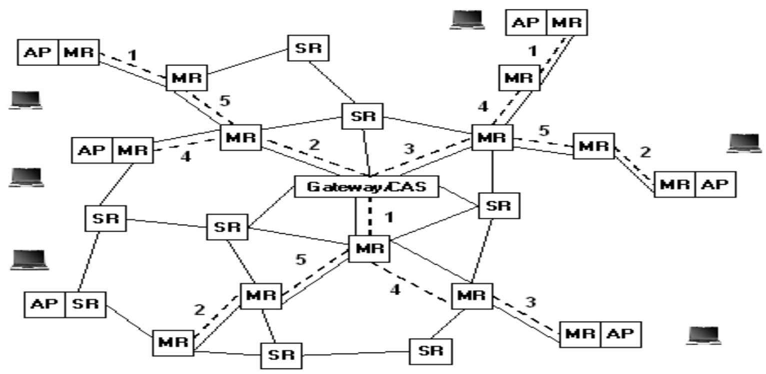

Figure 1: Wireless Mesh Networks

Classification of Channel Assignment Methods In Multi Channel Mutli Radio Wmns
In Channel assignment methods we have (i) Static (ii) Dynamic (iii) Hybrid (iv) Centralized (v) Distributed

Static Channel Assignment Method:
In Static Channel Assignment we have two types i) Fixed Assignment Scheme ii) Varying Channel Assignment Scheme.

Fixed assignment schemes assign channels to interfaces either enduringly or for long time period with respect to the interface switching time. Common Channel

Assignment is the simplest scheme. In this case the radio interfaces of each node are all assigned the same set of channels. [2]

Varying Channel Assignment scheme, interfaces of different nodes may be assigned different sets of channels. The assignment of channels may lead to network partitions and topology changes that may increase the length of routes between the mesh nodes and assignment needs to be carried out carefully. [2]

Dynamic Channel Assignment Method:
Dynamic assignment allows any interface to be assigned any channel, and interfaces can often switch from one channel to another. When nodes need to communicate with any other node, a synchronization mechanism has to make sure they are on a common channel.

The key issue is to involve channel switching delays and the need for synchronization mechanisms for channel switching between nodes. [2]

Hybrid Channel Assignment Method:
Hybrid channel assignment strategy combines together static and dynamic assignment properties. Some of the interfaces are assigned for Static and remaining interfaces is assigned for Dynamic. [2]

Centralized Channel Assignment Method:
Presumptuous the availability of complete information at a central point, the centralized Channel Assignment approaches are introduced before their distributed counterparts.

The centralized approaches are classified into three categories according to their problem formulations: the graph-based approaches, the network flows approaches, and the network partitioning approaches. [5]

Disturbed Channel Assignment Method:
Distributed CA approaches involve communication and coordination among multiple parties; they are more difficult to design than their centralized counterparts.[5]

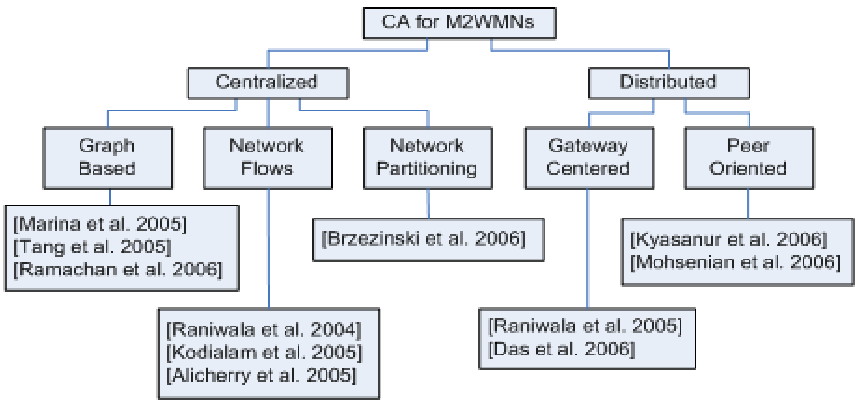

Figure 2: Classification of Channel Assignment

Key Design Issues of Channel Assignment in Multi Channel Mutli Radio WMNs

In Channel assignment we should follow some of major issues while assigning the channel to the users.

Main design issues are as follows.

a) Interference
b) Connectivity
c) Stability
d) Throughput/Delay
e) Routing
f) Fault Tolerance
g) Fairness

Interference

Interference is one of the important issues that causes in channel assignment in WMNs. When two close by nodes assigning similar frequency, they cannot transmit data at the same time. Interference is the prime factor that degrades the network performance. [7]

There are two models:

a) Protocol Model
b) Physical Model

Protocol Model: Each radio has an interference range and a transmission range For example a transmission from radio 1 to radio 2 is successful. If 2 is in the transmission range of 1 and not in the interference range of radios other than 1 that are currently transmitting.

Physical Model: If transmission is active the Signal to Interference and Noise Ratio (SINR) of the transmitter's signal at the receiver is best and the interference and noise power at the receiver consists of the noises generated by other ongoing transmissions and the ambient noise in the network.

Connectivity

The difference between the single-channel and multi-channel networks is that Channel assignment can change the network topology.

Connectivity is defined on graphs, which are used to model computer networks. Two graph concepts are Unit Disk Graph and Network topology. [3]

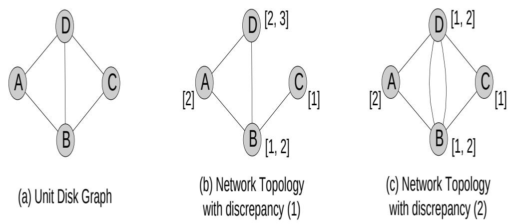

Figure 3: Two Kinds of Discrepancies Between Unit Disk Graph And Topology

Stability
In channel assignment the stability of the network is depend upon two things i) Ripple effect ii) Channel Oscillation.

Ripple Effect: A stretching effect or series of consequences caused by a single action or event. [3]

Channel Oscillation: The channel assignment does not converge and changes back and forth among several choices.

Throughput/ Delay
Throughput: Rate of successful message delivery over a communication channel. Channels should be treated differently when assigning channels.

Delay: The delay of a network specify how long it takes for a bit of data to travel across the network from one to another. [3]

Routing
Routing is the process of selecting best paths in a network. Forwarding network traffic among networks or simply forwarding.

Fault Tolerance
Fault tolerance enables a network to continue working correctly in the event of the failure also.

Fairness
A basic fairness criterion for Channel Assignment is the capability to avoid that the traffic of some nodes only has access to crowded channels shared by many links.

Implementation of Static, Dynamic And Hybrid Architecture

Static Architecture
In Static Channel Assignment schemes, a set of channels is permanently allocated to each node in the network.

Entire number of available channels in the system S is divided into sets; the minimum number of channel sets *N* required serving the entire coverage area.

Static Channel Assignment schemes are often not able to maintain high quality of service and capacity attainable with static traffic demands.

Dynamic Architecture
In Dynamic Channel Assignment schemes, all channels are kept in a central pool and are assigned dynamically to new nodes as they arrive in the system.

After each node task is completed, the channel is return to the central pool. It is fairly easy to select the most appropriate channel for any node based simply on current allocation and current traffic, with intend of minimizing the interference.

Dynamic Channel Assignment scheme can overcome the problem of static Channel Assignment scheme.

Hybrid Architecture

Hybrid Channel Assignment schemes are the combination of both Static Channel Assignment and Dynamic Channel Assignment techniques.

The hybrid architecture is designed in such a way that each dynamic interface maintains multiple queues in the link layer with one queue for each neighbor and static interface has a single queue for each neighboring nodes. The data to be sent to each neighbor are buffered in the corresponding queue.

Dynamic interface has data to transmit, it selects a neighbor that it wants to communicate and try to negotiate a common channel with the neighbor.

When there exist a static channel between the source and destination node then the node can transmit some packet through the static channel and the rest through the dynamic channel in order to reduce the delay and to overcome the node failure problem.

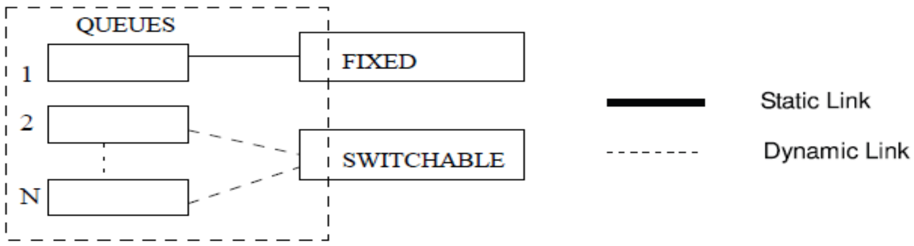

Figure 4: Hybrid Node Architecture

When a node needs to transmit data in a hybrid network then each node informs its neighbors of its fixed channels by broadcasting a message to all the channels of its neighbors. A node needs to transmit some packets to a neighbor; it first switches one of its switchable interfaces to a channel, with the fixed interface of the receiving node, and then sends the packets through the switchable interface. This approach maintains good adaptivity to changing traffic.

There are many criteria for selecting neighbors. If throughput is the only concern, we may select the neighbor with the longest queue. This strategy may cause undernourishment. We enhance it with some fairness considerations, that is, we estimate a neighbor priority by considering both its queue length and how long the queue has not been served. A pair of nodes that have already negotiated a channel, then node which sends data in that channel is the sending node, and the other node as getting node. The node has not succeeded in negotiating a channel with any other node is denoted as pending node. [4]

Adaptive Dynamic Channel Allocation

The adaptive dynamic channel allocation performs a hybrid channel allocation protocol in multi channel multi radio wireless mesh network. In this hybrid network each router have two interfaces, one interface from each router uses the static channel allocation, while the other uses dynamic channel allocation. The static channel allocation provides a fixed channel between the neighboring nodes and improves the network throughput. The dynamic channel allocation maintains a switching channel that switches between the neighboring nodes periodically this switching mechanism reduces the overall packet delay and suitable for varying traffic pattern in the network. The hybrid architecture is also capable of adapting to the changing traffic quite faster, because the dynamic interfaces renegotiate channels every 100ms. Thus the hybrid architecture provides a combined architecture of static and dynamic channel allocation and is capable of improving the network throughput and dramatically reduces the packet delay. [4]

In adaptive dynamic channel allocation when there are N nodes limited channel negotiation is enough that the source node can directly transfer data to the destination node hence this hybrid channel allocation dramatically reduces delay in the network the below Fig 5 shows that node A and node B had already negotiated a common channel between them and node D and node E also had negotiated a channel hence when node A needs to transmit data to node E then it enough that node B and node D negotiates to a common channel then node A transmits data through this route hence reduces delay and improves the performance of the network. [4]

This does not have any effect with network having few number of nodes but when the number of nodes increases then channel negotiation between all the node has to be done and only then the data transfer can take place this causes huge delay and interference in the network.

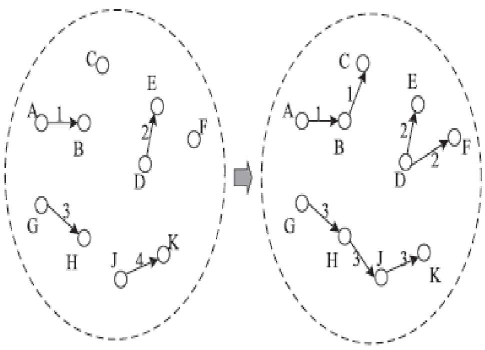

Figure 5: Adaptive Dynamic Channel Allocation

Assigning Interfaces To Channel

Fixed Interface:
In wireless mesh network when there are K interface, then M interface has to be assigned statically between the nodes.

Switchable Interface:
The remaining K-M interfaces are dynamically assigned to any of the remaining K interface, based on data traffic and is made to switch between the remaining interface.

The Fig.6 shows the basic hybrid channel allocation, where all the nodes are connected through one static channel and multiple dynamic channels with the neighbouring nodes.

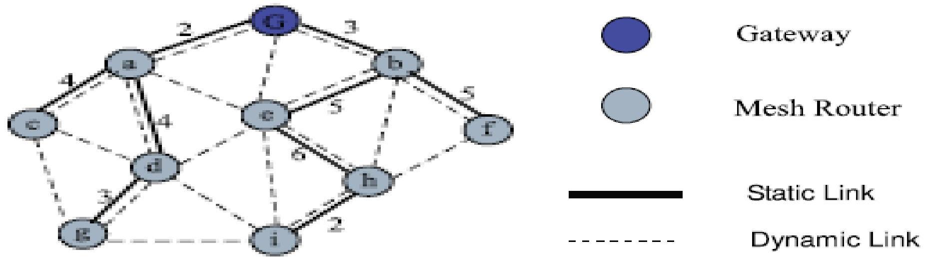

Figure 6: Hybrid Channel Allocation

Channel Negotiation Algorithm

The channel negotiation algorithm provide a procedure to the nodes for negotiating a common channel the node that had not negotiated a common channel with any other node is the pending node. The node that has a common channel and sends data to that channel is the sending node and the node that receives the data is the receiving node. [4]

Pending Node:

It broadcast PNODE REQ message to notify its neighbors that it is a pending node and if receives SWITCH CHNL then switch to channel c indicated in the message and ends the connection.

Sending Node:

If its queue length for the receives node < QT then it broadcast SNODE REQ message to notify its neighbours that it is a sending node and the traffic load is below saturation. If it receives SWITCH CHNL and the receiving node (r) is not negotiating with any other sending nodes then switch to channel c indicated in the message. Notify r to switch to channel c and ends the connection establishment.

Receiving node:

If the queue length of the sending node < QT and if receives PNODE REQ then it sends SWITCH CHNL message to the pending node including its own channel c and ends the connection else if it receives SNODE REQ then it send SWITCH CHNL message to the sending node including its own channel c and ends the connection.

Advantages of Adaptive Dynamic Channel Allocation Protocol

There are quite a few reward of using this hybrid channel allocation.

If purely static channel allocation strategies are used, the connectivity will be degrading. By using one dynamic interface in each mesh node, the connectivity of the network can be improved.

Purely static channel allocation strategies cannot adapt to the frequently changing network traffic. The use of one or more dynamic links is able to direct traffic around the congested areas and therefore achieve better load balance in the network.

The hybrid channel allocation provides improved network throughput and capable of counteracting node failure and loss of packet it improves the fairness of the network and provides better quality of service.

Interference and Congestion Aware Routing Protocol

The multi channel multi radio wireless mesh network consist of more than one channel assigned to each routers hence interference and congestion is the major parameter which determines the performance of the network. In order improve the throughput and to reduce the packet loss in the network the interfering links and congestion occurrence must be considered while selecting the route to the destination router.[4]

The dynamic routing protocols, routes based on the shortest path and switching channel and does not considers the interfering links and proper utilization of bandwidth therefore the congestion and interference in the network is more this eventually reduces the throughput and fairness of the network.

In order to improve the channel consumption and network throughput in the multi channel multi radio wireless mesh network it is very important that the routes of different flows to be selected efficiently such that channel usage is balanced at each node and links are selected for routing based on the probability of interference.

Steps In Interference And Congestion Aware Routing Protocol.

The routing in interference and congestion aware routing is performed by

- Route discovery.
- Route maintenance.
- Interference and congestion based routing.
- Rediscovery and switching of channel.

Route Discovery

The route discovery is the process involved for finding the routes for an efficient data transmission which provides better quality of service and bandwidth usage. Route discovery process is initiated by source router which broadcast a Route Request (RREQ) packet. All the routers looks into its routing table and send route reply message (RREP) the ICAR protocol selects the best route which provides better utilization of network bandwidth and reduces the interference and congestion in the network.

Route Maintanance

The route maintenance is the process involved to check and maintain the performance of the link in the network. It periodically checks and evaluates the bandwidth utilization and state of congestion in the network to perform channel switching to reduce the interference. In case of congestion or interference in the network the routing protocol selects a different route.

Interference and Congestion Aware Routing

The interference and congestion aware routing performs evaluation of congestion occurrence in the network and when there is a possibility of congestion occurrence the ICAR protocol selects a new route that provides congestion less and interference free route with low bandwidth utilization.

Rediscovery and Switching of Channel

The ICAR protocol performs switching of link to another router based on rediscovery of routes with minimum consideration of congestion less and interference less route with queue length less than queue threshold.

Interference Reduction In Wireless Mesh Network

The interference and congestion aware routing protocol aims to reduce interference by proper selection of channels based on the state of congestion occurrence in the links. In order to determine the state of congestion each link is categorized into three states they are,

- Congested state.
- Low congestion state.
- Median congestion state.

Congested state is the state of a link where the transmission through that link had already resulted in congestion and therefore it is not the desirable route for transmission of data. Median congested state is where the link has considerable amount of load but still it is able to transmit considerable amount of data based on the data rate. Low congested state is the state where the link has very low load and the link is more suitable for heavy load hence preferred for additional traffic.

The ICAR protocol considers the congestion state and bandwidth availability for routing where the number of links connected to each router is taken into account to define the occurrence of interference and performs two determinations they are, [4]

- Determining of the links states.
- Determination of interfering links.

The link state can be inferred from the queue length and the interfering links can be determined from the number of interfaces working on that router and based on the congestion state and bandwidth the link is selected for routing.

The total bandwidth consumed for routing in a network of routing path R with a data rate of d and link l belongs to the path R and interfering links be IE(l) and ETX(l) be the expected transmission count of link l. is calculated by, [4]

Total Bandwidth = $\sum$ [IE (l)] * ETX (l)*d , where l € R.

Where,

l – Links in the network.

R – Routing path.

ETX (l) – expected transmission hop count.

IE (l) – interfering links.

The bandwidth metric reflects the resource consumed by routing the flow through the network. In order to support as many as flows in the network as possible the routing of each flow must consider the bandwidth and congestion occurrence with interference in the network. In order to provide better quality of service and fairness the ICAR protocol routes to suitable links which considers efficient utilization of the bandwidth and selects channel based on the occurrence of congestion and interference in the network.

Advantages of Interference And Congestion Aware Routing Protocol
It improves the network throughput and reduces the packet delay in the network.

It reduces switching latency and packet loss in the hybrid multi channel multi radio wireless mesh network.

It provides proper utilization of channel and bandwidth of the network thereby improves the quality of service and fairness of the network.

Performance Evaluation

The parameters are to be found are

- Network Throughput
- Packet Delay
- Fairness
- Quality of Service

Network Throughput
It can be seen from the Fig 7 that the throughput of the dynamic channel allocation increases as the data rate increases and when the data rate reaches 5Mbps the network throughput increases slowly and on further increases in data rate results in decreases of network throughput. But in static channel allocation the network throughput increases with data rate and can support data rate up to 25Mbps with unnoticeable change in the performance of network.

It can be seen from the Fig 7 that in hybrid channel allocation protocol the network throughput increases as the data rate increases up to 15Mbps beyond which constant network throughput occurs and provides better throughput performance.

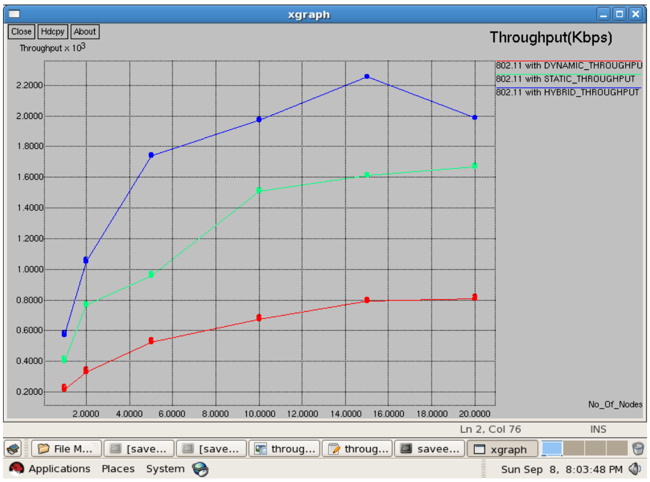

Figure 7: Throughput In Static, Dynamic And Hybrid Architecture

It can be seen from the Fig 8 that the throughput performance of the hybrid architecture is better than static and dynamic channel allocation.

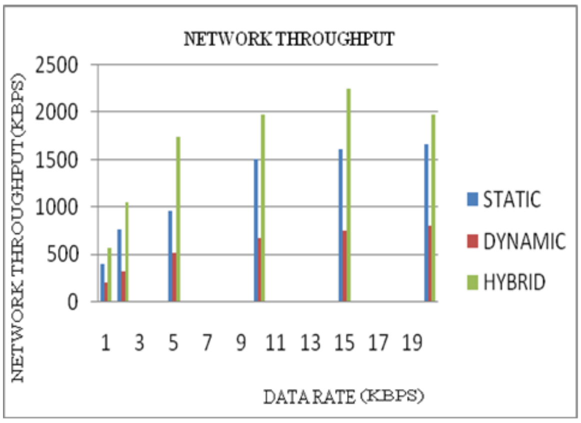

Figure 8: Bar graph for Network Throughput

Packet Delay

It can be seen from the Fig 9 that the average packet delay in the dynamic channel allocation increases steeply as the data rate increases and between the data rate of 3Mbps to 4Mbps the delay is almost constant beyond 10Mbps the delay increases slowly and the static channel allocation provides unnoticeable change in delay up to 25Mbps. In static channel allocation average packet delay is high for 1Mbps and increases as the data rate increases.

It can be seen the Fig 9 that the hybrid channel allocation provides an optimized delay and throughput and improves the performance of the network better than static and dynamic channel allocation. A delay increase up to 4 Mb further increases in data rate does not have a noticeable change in the average packet delay in the network.

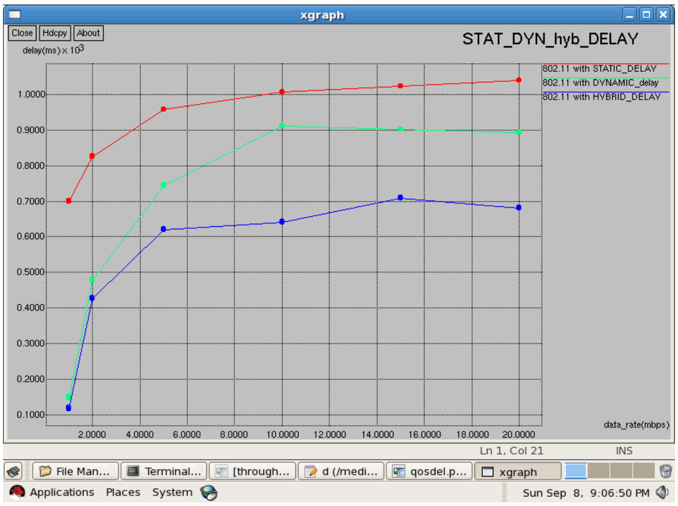

Figure 9: Packet delay in Static, Dynamic and Hybrid architecture

It can be seen from the Fig 10 that the hybrid architecture reduces the average packet delay in the network than static and dynamic channel allocation.

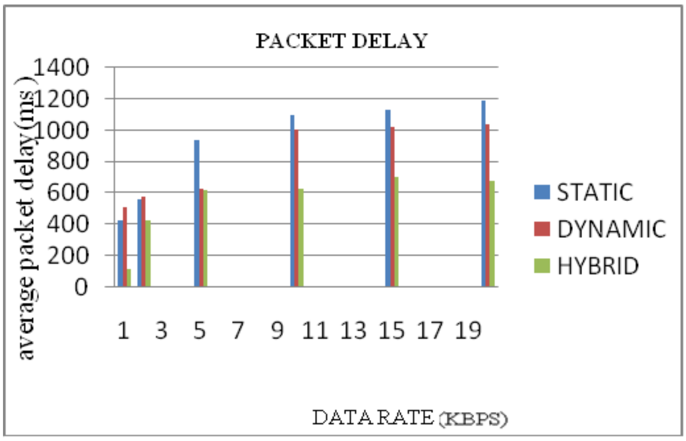

Figure 10: Bar graph for average packet delay

Fairness

The fairness of the network is examined where we vary the data rate and focus on the rate of packet loss in the network. It can be seen from the Fig 11 that the lossless packet delivery ratio in the dynamic channel allocation is better than the static channel allocation.

From the Fig 11 it can be seen that the amount of packet loss in hybrid architecture is less compared with the static and dynamic channel allocation and hence the fairness of the hybrid architecture is better than the static and dynamic channel allocation. Often to improve the throughput and reduce the delay in the network the fairness of the network is sacrificed but in hybrid architecture the fairness is also considered and improved.

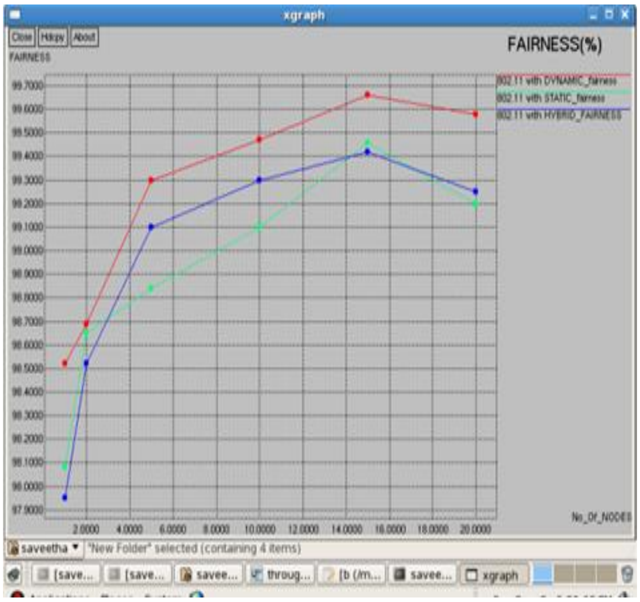

Figure 11: Fairness in Static, Dynamic and Hybrid architecture.

It can be seen from the Fig 12 that the fairness of the hybrid architecture is optimized, counteracting average packet delay and network throughput better than static and dynamic channel allocation.

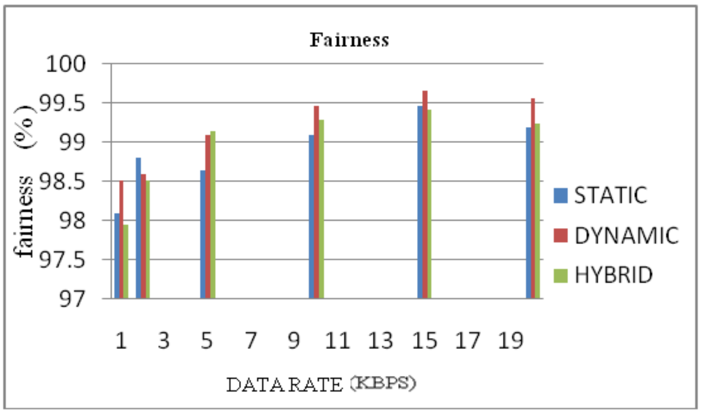

Figure 12: Bar Graph For Fairness

Quality of Service

The quality of service is a priority based approach where each specific service is prioritized differently and the network provides different service to the flow.

Quality of Service Performance on Throughput

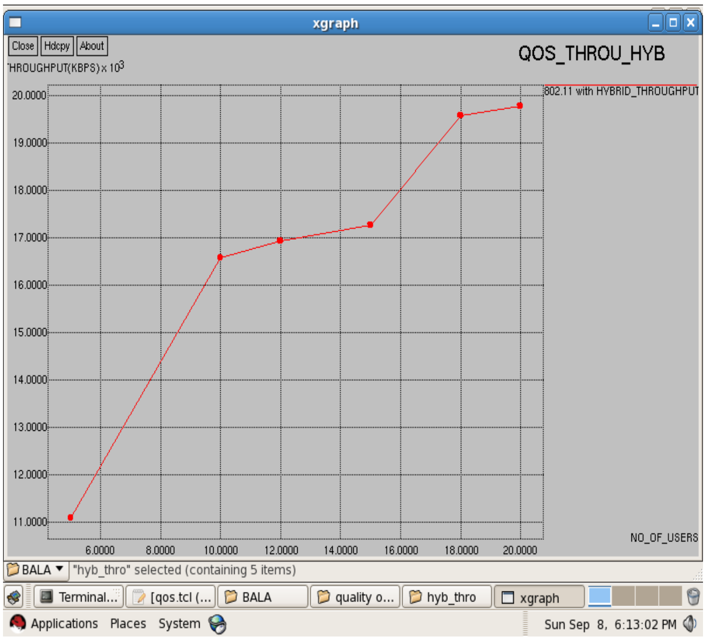

Figure 13: Quality of Service performance on throughput when number of user varies

Quality of Service Performance With Packet Delay

The packet delay is moderate for number of users between 10 and 18 and as the number of user's increases the bandwidth is utilized at the maximum and hence the network is entirely utilized and hence the delay in the network is increased beyond 20 users, as shown in Fig 14.

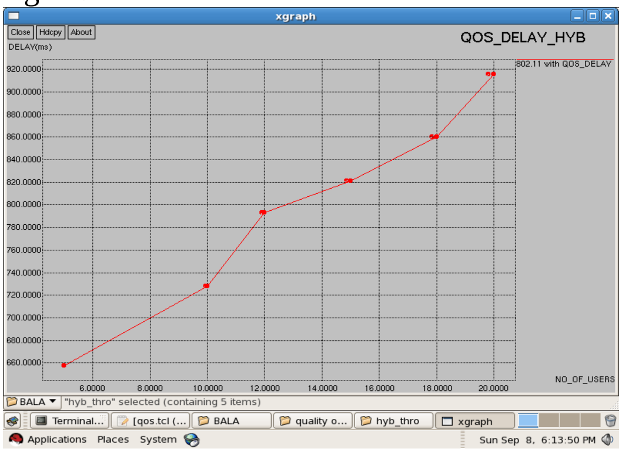

Figure 14: Quality of Service Performance on Delay When Number of Users Varies

Conclusion and Future Enhancement

The main aim is to increase the overall network throughput and average packet delay in the multichannel multiradio wireless network. Here performance of the hybrid channel allocation strategy and interference and congestion aware routing protocol for reducing congestion and interference in the network thus improving the overall network throughput and reduces the packet delay in the network more effectively and efficiently than the static and dynamic channel allocation. Along with the network throughput and packet delay analysis in the network, we also examined the fairness and quality of service provided by the hybrid architecture and it can be seen that the fairness performance of the hybrid architecture is better than the existing method and the hybrid architecture provides a varying throughput and packet delay processing for varying number of user in the network since the bandwidth is equally shared between the different flows and to different number of users in the network.

In future the same performance analyzing strategy on hybrid architecture can be extended by including the parameter such as the energy used by each node and the power consuming efficiency of the hybrid multichannel multiradio wireless mesh network can be used for providing better and efficient quality of service and fairness.

References

[1] I.F. Akyildiz and X. Wang, "Wireless Mesh Networks: A Survey,"Computer Networks, vol. 47, pp. 445-487, 2005.

[2] Tinku Rasheed and Massimiliano Slongo. "Channel Assignment in Wireless Mesh Networks" CREATE-NET TECHNICAL REPORT CN-TR-200800022. 2008.

[3] WEISHENG SI and SELVADURAI SELVAKENNEDY "A Survey on Channel Assignment Approaches for Multi- Radio Multi-Channel Wireless Mesh Networks" August 2007.

[4] Y. Ding, K. Pongaliur, and L. Xiao, "Hybrid Multichannel Multiradio Wireless mesh network ",(icnp) , 2009.

[5] K.N. Ramachandran, E.M. Belding, K.C. Almeroth, and M.M. Buddhikot, "Interference-Aware Channel Assignment in Multi-Radio Wireless Mesh Networks," Proc. IEEE INFOCOM, 2006.

[6] P. Kyasanur and N. Vaidya," Routing in Multi-Radio Multi-Hop Wireless Mesh Networks" (ispan), 2006.

[7] GUPTA, P. and KUMAR, P.R. 2000. The capacity of wireless networks. Information Theory, IEEE Transactions on 46 (2), 388-404.

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