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QOS improvement in Mesh Network using traffic offloading through 2G/3G Networks

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Abstract

Wireless mesh network is established to provide seamless internet access to users while roaming. Under this, a interact access point also called routers are placed at various points in cities and users can access the internet by connecting to these access points. Access points in turn connect via multi hop to internet gateway. When the load on an access point increases, congestion occurs and quality of service is impacted. Many solutions have been examined previously like increasing the gateways, optimum location of gateways, etc., but all these solutions skill have a constraint on maximum scalability and many times traffic loads is maximum only at a certain period of time and later the load is less, so scaling is not a profitable solution in this case as the access point is not loaded to capacity most of time and cost spent on it is not fruitful. In considering this problem, we propose a hybrid mesh network solution integrating 2G/3G network into a mesh network to handle the momentary load on a mesh network.

I. INTRODUCTION

Wireless Mesh Network (WMN) is emerging as a promising technology for providing internet services in cities and urban area with minimal infrastructure cost and fast deployment.

WMNs are multi-jump base based remote systems that are interconnected by an arrangement of generally stationary wired gateways associated with the Web. The routers that relay traffic and the client may or may not be mobile. Most of the traffic in a WMN flows from the client to the gateways.

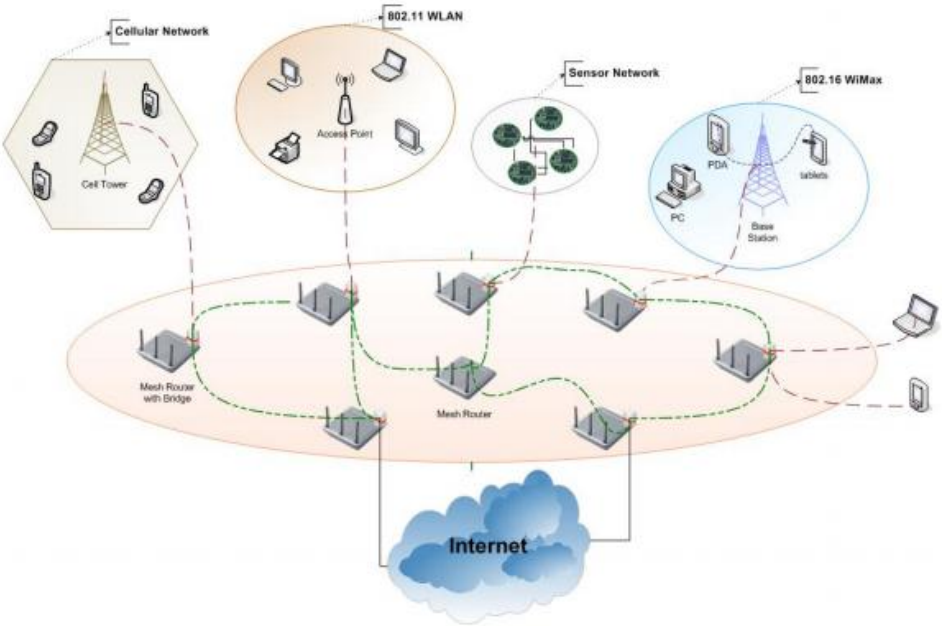

Fig.1: Wireless Mesh Network.

WMN consists of following types of nodes
WMN Clients: These are the end-client gadgets like PDAs, portable workstations, advanced mobile phones, and so on., that can get into the system for utilizing applications like email, web surfing, VoIP, and alike. These gadgets are expected to constrain force, portable, having none or restricted directing abilities, and could conceivably be constantly associated with the system. Versatile Impromptu Systems (MANETs) can be thought to be an exceptional instance of WMNs that are framed simply by WMN customers.

WMN router/Switches: These network components are basically in charge of routing traffic in the network. Traffic does not start or end at a router/switch. The routers/switches are described by restricted portability and moderately high reliability. Compared with conventional wireless routers, a remote wireless mesh router can accomplish the same scope with much lower transmission, power utilization through multi-hop communications. Also, the Medium Access Control (Macintosh) protocol in a mesh router supports multiple-channels and various interfaces that empower adaptability in a multi-hop mesh environment.

II. RELATED WORK

We categorize the existing works on QOS improvement as below

1. MAC Layer optimization
2. Optimized Routing Protocols

3. Optimized Gateway Placement
4. Optimized Router Placement
5. Cross Layer Protocols

2.1 MAC Layer Optimization

In [1], S-TDMA (spatial-TDMA) based Macintosh was proposed for remote cross section system in which ceaseless power control is done to decrease the noise interference and rate allocation is done to increase the capacity. This solution relies on conflict free scheduling, to increase the throughput by avoiding collisions, but the solution does not address delay due to conflict free scheduling, Mesh Routers and Mesh clients have to wait in turn for time schedule and as delay increases buffer overflow occurs in routers and QOS are affected. So it is not a scalable solution.. So it is not a scalable solution or an adaptable arrangement.

In [2], solution based on increasing the contention window size to lower the collision is proposed. By decreasing the impactor collusion throughput can be increased. A spatial augmentation of the TXOP(transmission opportunity) idea called 'express sending' to clear multi-bounce streams sooner, and another instrument called 'express re-transmission' to diminish crashes on retransmission were additionally proposed.

In [3], use of smart antenna for directional transmission and link scheduling algorithm to activate the links in such a way to increase the network capacity was proposed. But this is not a scalable approach as new routers are deployed to existing network; placement becomes a difficult operation and has to place with the path of another router. Also the use of smart antenna will increase cost of Routers.

In [4], STDMA based scheduling was done at the Macintosh layer of affirmation control. Confirmation control guarantees clients to have a base certification of data transmission, bandwidth and maximum delay. It works for VOIP administrations. However, it is not beneficial to apply this arrangement as clients will change to an alternate administrator if strict affirmation control is implemented or enforced.

2.2 Optimized Routing Protocol

In [5], the routing protocol in WMN is adopted to choose the relay nodes in the path of estimation of wireless link quality, bandwidth and transmission capacity. In any case, with no control on the rate of transfer, this methodology is not helpful as a path found efficient or productive in view of link, connection quality, bandwidth and data transmission can later be congested because of a variable rate of usage from clients.

In [6], Weighted Contention and Interference routing Metric (WCIM) is proposed. Based on interference, bandwidth available, quality of link, etc., a metric is calculated for each node. Routing is done in such a way next node with the highest value of the metric is caused as a relay node in the route. The problem with these approaches is that it requires frequent exchange of information between nodes to calculate the metric and also it is not end to end decision. When end to end is considered there may be a better path with more WCIM value than the current chosen path and solution converges in local minima.

In [7], routing based on opportunistic method is proposed.Each hub catching different hubs in remote medium can help in routing in case of break down.But this technique has may sensible difficulties in deciding the collaboration and also enhance the network communication overhead.

2.3 Optimized Gateway Placement

In [8], the controller is put ideally in the system utilizing Molecule Swarm enhancement strategy for boosting the imperfections in system discovered by utilizing Passage Fulkerson calculation. Be that as it may, this technique requires incessant development of controller taking into account movement perception over a time frame.

In [9] remote cross section system is bunched in view of the degree/number of WMRs associations, while guaranteeing Delay, Hand-off burden and Group size requirements**.**

In [10], a genetic algorithm based solution is proposed for gateway placement. This arrangement optimized variation of MR-IG- hop counts (VAR-MRIG-Jump) among MRs to ensure that the Gateways are placed in the appropriate positions. But during loading, the solution cannot maintain QOS.

2.4 Optimized Router Placement

In [11], a heuristic solution, called PRACA (Placement, Routing And Channel Assignment) was proposed to find the optimal position for the router in the Mesh Network. The solution jointly considers and routing, channel assignment and placement get the optimal solution for placement. By this way it tries to eliminate interference and improve QOS.

In [12], response for arrangement of multi rate routers in the cross section system was considered. It exhibited a heuristic arrangement computation called IL Seek which considers both numerous transmission rates and co-channel impedance. The IL Seek comprises of two segments: (1) Coverage MR determination which greedily exploits the capability of each selected MR to cover mesh clients (MCs); and (2) Relay MR determination that incrementally chooses the additional MRs for traffic relaying through the local search.

In [13], the closest cell affiliation calculation was proposed to reassign clients to routers in various times and an avaricious quest to discover ideal positions for the routers. They demonstrated QOS is enhanced because of exchanging clients between routers along these lines.

2.5 Cross Layer Protocols

In [14], cross layer blended predisposition calculation was proposed. The cross-layering will give data on connection quality and separation between hubs. Join quality will be given from the physical layer while separation can be given from numerous points of view. The separation could be processed by the quantity of jumps between two focuses, by measuring the deferral or by utilizing genuine directions if the hubs are outfitted with Worldwide Situating Frameworks (GPS). In this paper author utilized the amount of hops. A portion of the scheduling resources will be biased according to a set of heuristics that penalize nodes for various “bad behaviors” such as distance from the gateway, overuse of traffic, poor link quality and so on. Each heuristic will be assigned a different proportion of the network resources which will be determined experimentally. Another portion of the resources will be left for absolute fairness in order to ensure that none of the links are starving and that some minimum level of service is maintained. Then the collective system will be optimized to produce high throughput fair scheduling for wireless mesh networks.

In [15], two cross layer steering were proposed an inexactly coupled cross-layer plan and a firmly coupled cross-layer plan. In the approximately coupled cross-layer plan, directing is figured first and after that the data of steering are utilized for connection layer booking; in the firmly coupled plan, directing and interface planning are illuminated in one advancement model. The two cross-layer plans include obstruction displaying in multihop remote systems with omnidirectional reception apparatus. An adequate state of contention free transmission is built up, which can be changed to polynomial-sized direct requirements and a straight program in view of the adequate condition, is produced.

In [16], the authors proposed a new routing metric for wireless mesh network—CAETT (Congestion Avoidance Expected Transmission Time). With the queue’s utilization rate and the transmit situation of control frames in 802.11 protocol’s MAC layer, a reasonable path is chosen in terms of the channel competition status, link data frame delivery rate and the node’s queue utilization rate.

From the survey we notice that each solution tries to achieve maximum QOS by reducing interference, parallel data rate, smart antenna, network component placements etc.

One of the most important points noticed in all the solutions suffers from scalability issues and gateway can get overloaded soon with internet service requests. To reduce the overload on the gateway, multi gateway is suggested, but still there is a scalability problem.

III. PROBLEM DEFINITION

Given a wireless mesh network with mesh nodes, access points and gateways and some of the mesh nodes have internet connectivity through their 2G/3G and when the load on mesh network is high and some of access points in the network are congested, the objective of the work is a offload network load though some of mesh nodes using their 2G/3G interfaces.

IV. Hybrid Mesh Network with 2G/3G

The architecture of the proposed offloading scheme is given below in figure 2.

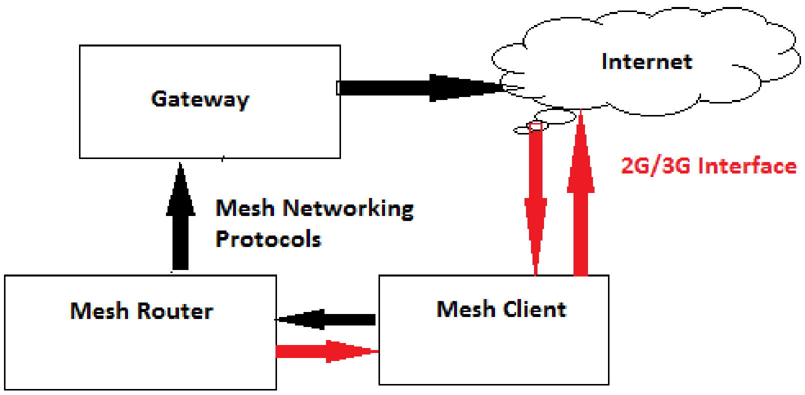

Fig. 2: Hybrid Mesh network with 2G/3G Interface.

From the traditional architecture, we introduce a offloading facility at Mesh Client for sharing its unused 2G/3G interface to wireless mesh network.
The mesh router's routing protocol is modified to enable the 2G/3G offloading capability.
Mesh clients who are interested in offloading their traffic must register their interest to the mesh router. Also Mesh client at any point of time when it needs the additional bandwidth can unregister its interest for offloading to mesh router.

To do this we provide two new messages OFFLOAD_REGISTER and OFFLOAD_UNREGISTER.

OFFLOAD_REGISTER is sent by the mesh client when it wants to provide its unused bandwidth for offloading. In the message, it sends the amount of bandwidth it wants to offload. The Mesh router cannot use more than this bandwidth for offloading.

OFFLOAD_UNREGISTER is sent by the mesh client when it wants to reclaim its bandwidth given for offloading.

Mesh Router maintains a table OFFLOAD_TABLE which maintains the registered mesh clients or customers and their bandwidth available when

OFFLOAD_REGISTER is received and removes this entry when OFFLOAD_UNREGISTER is received.

Mesh Router is an important component for enabling offloading. In a mesh network, the mesh router always directs the traffic to Gateway either directly or through multi hop via other Mesh Router. To enable offloading, we modify this behavior. Mesh Router continuously monitors the QOS of mesh network and when it finds the QOS will drop before allowing a new traffic from a mesh client or traffic from a mesh router, it will check the OFFLOAD_TABLE if enough bandwidth is available for a mesh client for offloading and offloads the new traffic to the offloading mesh client and it updates the OFFLOAD_TABLE with the information of bandwidth used. When the mesh client session ends, it updates the OFFLOAD_TABLE with the status of bandwidth.

When the offloading mesh client unregisters during the session, the mesh router finds if enough bandwidth is available on mesh router and if not available, it chooses the next mesh client from the OFFLOAD_TABLE.

To choose the best mesh client to offload, we propose a offload select algorithm. The algorithm works as follows

For each mesh client registered for offload, a trust score is calculated and kept in the mesh client's permanent memory. The score is calculated using the formula

Trust = W*Avg offload time + (1-W)*No of times /times of offload success

Avgerage offload time is the sum of (Unregister time - Registered time) / no of times of offload.

The mesh router chooses from OFFLOAD_TABLE the node with the highest trust for offloading.

V. Mathematical Model

We model the drop ratio in our proposed solution.

Let there be, Nr mesh router in the network and Nc be a number of mesh clients in the network, No be the number of mesh clients who want to offload

Nrc = Nc-No

Out of the remaining Nrc mesh clients, at each interval of time, each mesh client decides with a probability to launch a session or not

So the total session in a period of time is

$$T=\sum_{i=1}^{Nr} P(S(Ni)=1$$

Of these sessions, if the mesh network capacity on number of sessions is Mc then remaining Mr would have been drooped

Dr = T - Mr

If the Dr can be also handled, drop ratio would be lower.

If the No and Dr are distributed uniformly, then the drop ratio would be reduced as

ODr = Dr – No

So the drop ratio is dependent on the number of offloaded mesh clients and its distribution with respect to the remaining session capacity not handled in the mesh network

VI. RESULTS

We simulated the proposed solution on the wireless mesh network jprowler simulator where some of the nodes are randomly chosen for offloading. Service requests are generated from the node with Poisson distribution over the simulation duration configurable by user.

We varied the number of offloaded nodes and measured the QOS of the system with and without offloading, the results are as follows

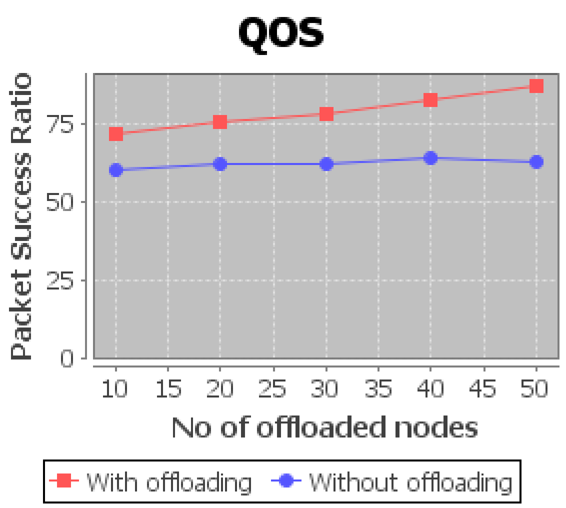

Fig. 6.1: Packet Success ratio vs no of offloaded nodes

From the graph in fig 6.1 we see that the QOS of the system in terms of the packet success ratio is increased by the network because of offloading.

We varied the duration of offload between register and unregistered clients and measured the QOS of the system with and without offloading and the result is shown below the graph in figure 6.2.

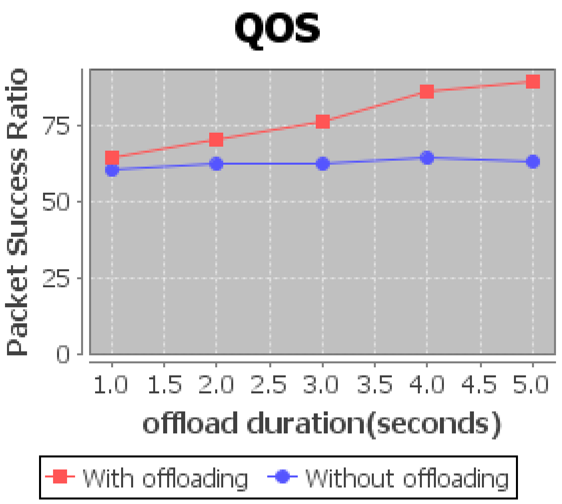

Fig. 6.2: Packet Success ratio vs no of offloaded duration.

From the graph we see that the QOS of the system is increased if the offload duration in increased.

We measured the drop rate of sessions by varying the number of session requests from mesh clients and plotted below

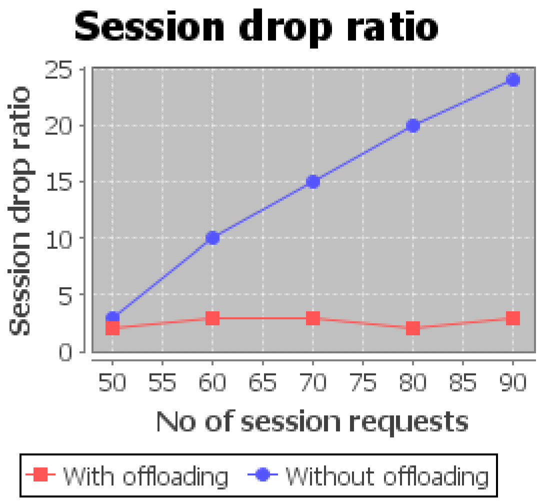

Fig. 6.3: Session drop ratio vs No of session requests.

From the graphin fig 6.3 we see that drop rate of the session is reduced because of the offloading.

We measured the drop rate of session by varying the offload duration of mesh clients and plotted the graph shown in figure 6.2.

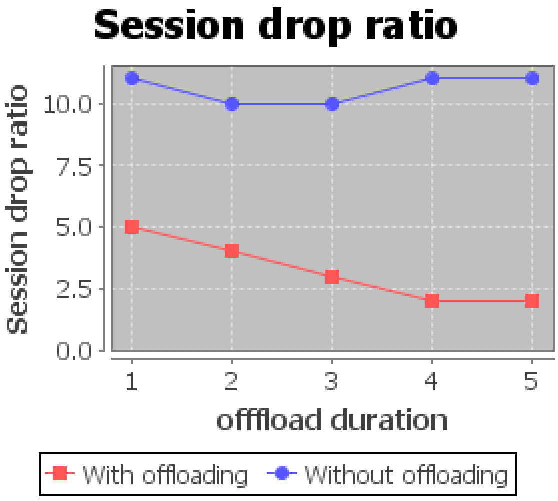

Fig. 6.4: Session drop ratio vs offload duration.

If the offload duration in increased, the drop rate of the session is increased.

We measured the number of network congestion routers in the network by varying the number of offloaded nodes and result is shown in figure 6.4.

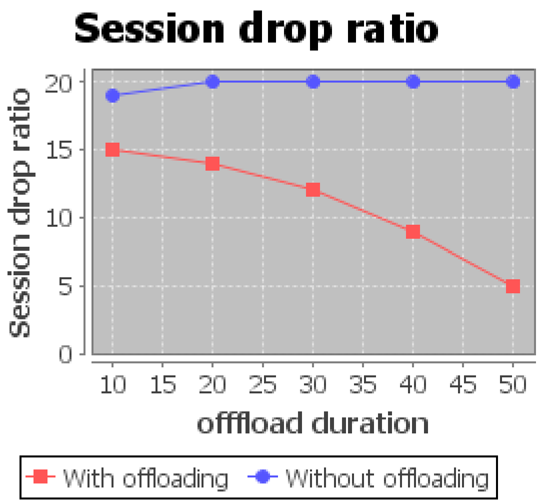

Fig. 6.3: Number of congestion routers reduction.

The number of congestion routers is reduced because of off loading.

VII. CONCLUSION

The proposed offload solution was implemented and through jprowler simulation, we have proved that the capability of the network is increased to handle more incoming requests because of it. Also congestion in the network is reduced by offloading. Though offloading is proposed in this work, the mesh clients do offloading only for revenue gain and since revenue becomes an important part, then choosing across the multiple mesh clients with the least cost and highest quality of service must be selected. This becomes the scope of our future work.

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