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Review on Scheduling and Resource Allocation Management Techniques in Ad-hoc and Wimax networks

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Abstract
In recent years, wireless networks have got a tremendous growth in the field of communication. Some of the very rapidly growing wireless technology is IEEE 802.11, IEEE802.16, wireless standards. In most of these networks, many technical issues are still facing the wider deployment of these technologies. Scheduling and resource allocation management techniques take the lead among those technical challenges. As the resources in wireless networks are limited, it should be properly and efficiently used, there is a clear absence of a comprehensive performance study that can provide a unified platform for comparing different used algorithms in different wireless networks. In order to provide a better understanding of the scheduling and resource allocation challenges in Adhoc and Wimax wireless networks, this paper presents a detailed investigation of current state-of-the-art in scheduling and resource allocation mechanisms in ADHOC (MANETT) and WiMAX networks. A brief outline of the key concept, metrics used, as well as the advantages and drawbacks of each discussed mechanism are given. Finally, the comparison table is constructed to summarize several scheduling and resources allocation management techniques.

Keywords: - WiMAX wireless networks, Ad-hoc wireless networks, scheduling, Resource Allocation management techniques

1. Introduction
Wireless communications become ubiquitous in this century due to the popularity use of cell phones, smart phones, and smart phones. Wireless networks are less expensive and their installation is very much easier in comparison to the traditional wired networking. Wireless networks can be accessed from the airport, hotel lobbies, a small office, home network and so forth. Wireless networks provide a wide range of communication recently. The most important wireless networks are 802.11 (mobile ad hoc network), 802.16 (Worldwide Interoperability for Microwave Access). Each of these networks is briefly described below:

(i) Mobile Ad hoc Network
A mobile ad hoc network (ADHOC (MANETT)) is an autonomous collection of mobile nodes connected through wireless links. As ADHOC (MANETT) is a self-configuring network of mobile nodes, it does not have/need any centralized coordinator such as base stations (BSs) or access points (APs). The routes for other nodes are exposed and maintained by each node that is used for packet forwarding for other nodes. Storage devices are limited and the computational capabilities are not much stronger in the ADHOC (MANETT) nodes. ADHOC (MANETT) can be applied in various applications such as disaster relief, emergency operations, military service, maritime communications, vehicle networks, casual meetings, campus networks, robot networks, and so forth [1]. However, some of the limitations of Quality of Service (QoS) in ADHOC (MANETT) are bandwidth limitations, vibrant and non-predictive topology, and the limited processing and minimum storage of mobile nodes.

(ii) Worldwide Interoperability for Microwave Access: Worldwide Interoperability for Microwave Access (WiMAX) is a trade name used to group a number of wireless technologies for satisfying the demands of the various end-users. It is deployed to serve all the end users [2]. WiMAX can be suitable for the following potential applications: (a) portable mobile broadband connectivity across cities and countries via a variety of devices, (b) a wireless alternative to cable and digital subscriber line for last mile broadband access, (c) data, telecommunications, and (d) internet connectivity source.

1.1 Resource allocation: Bandwidth is a scarce resource that can be shared either dynamically based on the amount of data to be transferred to or from each node or deterministically by assigning a fixed number of slots to each cell. In ADHOC (MANETT), as inefficient resource allocation causes heavy losses to the service providers and results in inadequate user proficiency, efficient resource allocation techniques can be needed to improve and automate the network QoS. Moreover, it can guarantee successful collision less data transmissions and enhance the channel spatial reuse to maximize the system throughput. However, traditional bandwidth allocation is pre-planned so that it is less adaptive to traffic load variations and network topology changes [3].By resource allocation in WiMAX, it is possible to supply exactly required resources for the transmission by which the network's energy can be conserved. Through resource allocation management we can allocate the resources in an efficient manner and get the desired throughput. Resource allocator is used for allocating the resources required for the transmission for each user in each Mobile WiMAX frame. It is difficult to achieve the maximum throughput in the WiMAX networks as each transmission demands different QoS. This can be possible by using resource allocator in the networks.

1.2 Scheduling

The process of distributing the available resources among the users is termed as scheduling. Scheduling algorithms are essential in ADHOC (MANETT) to provide Quality of Service. Due to mobility of nodes, topology of network changes dynamically in ADHOC (MANETT). This leads to frequent route changes and packet losses. To reduce these effects, the network works according to an optimal scheduling algorithm. Scheduling algorithms that give higher weight to data packets with smaller numbers of hops or shorter geographic distances to their destinations reduce the average delay significantly and improve the average throughput. Network traffic can be classified into two categories: control packets and data packets [4].For guaranteeing fairness among all the users in WiMAX, this technique helps is attaining the maximum throughput. The five scheduling services which are defined in IEEE 802.16 systems are unsolicited grant service, real-time polling service, extended real-time polling service, non-real-time polling service, and best effort service. The WiMAX scheduling algorithms are categorized into two types: (1) centralized scheduling that involves the estimation of schedule by the BS and transmission of the scheduling packets in a collision-free way and (2) distributed scheduling in which three way handshakes are performed such as requesting, granting and confirming messages while selecting the slots utilized for data transfer. This technique is further classified as coordinated distributed scheduling and uncoordinated distributed scheduling. Due to support of various service levels, fairness and complexities in the implementation, the design of scheduling algorithm are more challenging. The limitations of bandwidth allocation and transmission rate causes difficulty in the designing phase of scheduling algorithm. This is due to limitations of resources in wireless network. An efficient and fair scheduling algorithm should enhance the network throughput and reduce overhead while considering taking bandwidth, delay and jitter needs of different flows. This causes scheduling mechanism more complex [5] [6].

2. Existing Survey on Scheduling and Resource Allocation : Mohammed Sabri Arhaif [2] have presented the comparative study of scheduling algorithms in WiMAX to evaluate the implementation of the various types of scheduling algorithms of WiMAX such as diffserv-enabled, round robin, self-clocked-fair, strict-priority, weighted-fair queuing and weighted-round robin. After that, a detailed simulation study was carried out via QualNet 5.0 to analyze and evaluate the performance of each scheduler to support different QoS classes. Results show that effective scheduling algorithm can provide high service standards to support the QoS requirements to meet the different types of demands by the various end-users. Ala'a Z. Al-Howaide et al. [9] have surveyed the performance evaluation of scheduling algorithm in WiMAX. The performance of strict priority, round robin, weighted round robin, weighted fair queuing, self-clocked fair queuing, and diff-serv scheduling algorithms is measured in terms of size and number of BS output queues. Results showed that the output queue size and number do not affect the server throughput and end-to-end delay for a specific scheduling algorithm. Kanika Garg and RishiPal Singh [4] have studied various scheduling schemes and their effects on network performance. Parameters used in simulation and studies are also specified. The authors have further studied that priority scheduling and weighted-hop scheduling helps in reduction of average delay. Scheduling algorithm which uses short distance metrics results in faster delivery of data packet in congested network.Ronica et al. [10] have compared bandwidth aware routing protocols with various unique features that incorporate QoS metrics in route finding. Various techniques for estimating the available bandwidth are focused. In some protocols, bandwidth estimation is based on channel Idle Time Ratio, whereas in other, bandwidth is estimated using Channel Idle _time/Busy_time * Weighting_fun and TDMA-based timeslot assignment. Further, they discussed about the bandwidth estimation techniques, routing types, Cs-neighbor bandwidth estimation process, mobility and QoS violation detection process, route failure handling method and other features of these protocols. Afolabi, O. Richard et al. [11] Have surveyed a multicast group formation and various forms of group rate determination approaches. They also provide a systematic review of recent channel-aware multicast scheduling and resource allocation techniques for downlink multicast services in OFDMA based systems. These enabling algorithms are studied to evaluate their core characteristics and limitations and classify them using multidimensional matrix. We cohesively review the algorithms in terms of their throughput maximization, fairness considerations, performance complexities, multi-antenna support, optimality and simplifying assumptions. Finally, they discuss the existing standards employing multicasting and highlight some potential research opportunities in multicast systems.Chakchai So-In [12] have discussed the key issues and design factors to be considered for scheduler designers. In addition, they present an extensive survey of recent scheduling research and classify the existing mechanisms based on the use of channel conditions. It is concluded that scheduling is used to achieve the optimal usage of resources, assure the QoS guarantees, maximize good put and minimize power consumption while ensuring feasible algorithm complexity and system scalability.

3. Review

3.1 Resource Allocation: In this section, resource allocation techniques in two different types of networks, ADHOC (MANETT) and WiMAX, are discussed. These analyses encompass the key concept, performance metrics used, advantages and limitations of the existing resource allocation mechanism. Analyses can help to understand how the techniques are implemented in both networks.

3.1.1 ADHOC (MANETT)

3.1.2 WiMAX

3.2. Scheduling: In order to obtain the basic concept how the scheduling and resource allocation management techniques can be implemented in various networks, several existing works in different types of networks are analyzed. The networks considered are as follows: MANET, WiMAX. These analyses encompass the key concept, performance metrics used, advantages and limitations of the existing scheduling and resource allocation mechanism in AD-HOC, WiMAX.

3.2.1 ADHOC (MANETT)

3.2.2 WiMAX

4. Comparison Table

Table1: the analyzed techniques.

Techniques	Network	Metrics Used	Advantages	Disadvantages
1.Bandwidth resource Allocation				
1.Cross-Layer TDMA-Based Routing Protocol	Ad hoc	Throughput, network load	Increased throughput and more flows are admitted.	Not suitable for less dense network.
2.Distributed Slots Reservation Protocol for QoS Routing	Ad-hoc	Call success rate, network throughput, control overhead, average delay time, and the storage	Better call success rate and throughput	Less scalable.
3.Distributed Bandwidth Reservation Protocol	Ad-hoc	Request success rate and overhead	Better performance in denser networks and heavier traffic conditions	Not appropriate for less dense network and network with less traffic
4.Race-Free Bandwidth Reservation Protocol for QoS Routing	Ad-hoc	-	Solve parallel reservation problem in QoS routing	There is no performance analysis.
5.Agent based Bandwidth Reservation Routing Technique	Ad-hoc	Aggregated bandwidth, fairness index, and total bandwidth	Reduce losses and improve performance	More energy consumption.
6.Interference-aware Multi-path Routing and Bandwidth Allocation	Ad-hoc	Packet throughput, packet delay, request success rate, and packet delivery ratio	Increase the network throughout, request success ratio and packet delivery ratio	More overall time complexity.
7.Quality of Service Through Bandwidth Reservation on Multi rate Ad Hoc Wireless Networks	Ad-hoc	Packet loss and end-to-end delay	Achieving the QoS requirement	Various other QoS parameters are not considered.

8.Two-way Admission Control and Resource Allocation for Quality of Service Support	Ad-hoc	Energy, bandwidth	Minimize the need of retransmission.	Did not support multiple traffic classes.
9.Dynamic slot assignment protocol for QoS support	Ad-hoc	Throughput, call blocking probability, and delay	Improve channel throughput and achieve lower call blocking probability.	Energy consumption is more
10. Routing in Multi-Radio, Multi-Hop Wireless Mesh Networks.	Ad-hoc	Throughput,CDI	Provide network connectivity.	It might not utilize all non overlapping channels
11.A topology control approach for utilizing multiple channels in multi-radio wireless mesh networks	Ad-hoc	Maximum link conflict weight, throughput and Average Delay	Apply connectivity graph and conflict graph for assigning the channels.	It does not take the traffic patterns in channel assignment
12.Centralized Channel Assignment and Routing Algorithms for Multi-Channel Wireless Mesh Networks	Ad-hoc	Throughput,	The traffic load is considering known for allocating the channels in their algorithm, each link will visited in decreasing order based on its expected traffic load and greedily assigns to channel.	The method of assignment channel it may cause a ripple effect, such that already assigned links have to be revisited, so the time complexity will increase.
13. A Channel Allocation Algorithm for Reducing the Channel Sensing/Reserving Asymmetry in 802.11ac Networks	Ad-hoc	Throughput, PER(i.e. packet error rate),CDF (i.e. Cumulative Distribution Function).	Address the problem of 'Hidden Channel' in 802.11ac, tried to improve the fairness performance among transmission pairs with various channel bandwidths.	End to end delay has not been evaluated in proposed work.
14. A Distributed Multi-Channel MAC Protocol for Ad Hoc Wireless Networks	Ad-hoc	Throughput, Expected number of nodes.	Address of congestion issue and improve the performance of network	Hello message might be increase overhead in the network; also, they use both interfaces, for broadcast packets, it is better to use one interface.
15.Joint multi-radio multi-channel	Ad-hoc	End-to-end delay, jitter and network	Avoid co-channel interference , use Latin	The coloring information has

assignment, scheduling, and routing in wireless mesh networks		throughput.	squares to achieve efficient channel access , and guarantee fairness of radio and channel allocation to clusters and nodes	included the header of data frames, as two fields, each one is 32 bit in length, it causes increase in overhead.
16.A Distributed Cross-layer Routing Protocol with Channel Assignment in Multi-Channel Ad-hoc	Ad-hoc	Average throughput, Average delay.	Categories the channels into two categories on is control channels and other is data channels	Synchronization between nodes during channel switching is difficult to be adapted, especially if the node is share in more than one path.
17.An end-to-end channel allocation scheme for a wireless mesh network	Ad-hoc	Throughput, complementary cumulative distribution function, Total latency.	Divided into two channels types, one type for transmission and other reception of packets. Classify the channel as transmitting, receiving, interfered, free, or parity. Allocating the channel on basis of channel state	Their work has tested for two flows only, switching delay from channel to channel, will increase as number of flows is increased.
18.Channel Allocation and Routing in Hybrid Multichannel Multi radio Wireless Mesh Networks	Ad-hoc	Average Packet Delay, Throughput	Propose a hybrid channel allocation , that have take the advantages of static and dynamic allocation, and propose a routing protocol based on a awareness of interference and congestion	One interface might not sufficient for dynamic channel; routing protocol only can apply only on static allocation.
19.Analysis and enhancement of multi-channel MAC protocol for ad hoc networks	Ad hoc	Throughput	Analytical model has proposed for control channels, and a novel multi-channel MAC protocol for single-hop scenario has present.	For better work analytical model should also consider data channels.
20.Improving Channel Assignment in Multi-radio Wireless Mesh Networks with Learning Automata	Ad hoc	packet drop, end-to-end delay, average goodput, jitter	Apply learning automata to solve the channel assignment problem	It was better if the comparison has done with other algorithm than AODV. Because the CA problem it is not related with routing protocol.
21.On the impact of interference models on channel assignment in multi-radio multi-channel wireless mesh networks	Ad hoc	Throughput.	The proposed work depended on the SIR model with shadowing. Minimum number of non-overlapping channels.	End to end delay not testd, the model should be tested in case of increase number of nodes, where the density has significant impact in network performance.
22.Efficient rate allocation, routing and channel assignment In wireless mesh networks supporting dynamic traffic flows.	Ad hoc	Flow duration-time elapsed, Flow throughput, Flow throughput fairness-rates	The heuristic algorithm called JRCAR to optimize performance of the instantaneous traffic (current set of Internet flows) with a proportional fairness objective	Routing protocol does not test efficiencies and effectiveness with other routing that used in wireless mesh network.
23.A hybrid multi-channel MAC protocol	Ad hoc	aggregate throughput,	Adopts the IEEE802.11 power saving mechanism	Switching over head from channel to other

for wireless ad hoc Networks		Average delay, fairness and energy efficiency.	For sending data by some nodes, try to negotiate the data channel during the Ad hoc Traffic Indication Message window based on the network traffic Load.	channel might increase in case of increase the traffic load. Selection criteria of channels should be on basis of physical environment.
24.Multi-channel MAC protocol with Directional Antennas in Wireless Ad hoc Networks	Ad hoc	Throughput, Packet Delivery Ratio, Energy Efficiency	Exploit directional antenna and adopts IEEE 802.11 power saving.	Further messages, increase overhead, channel, that use for exchange control packets should not for exchange data packets.
25.Architecture and Algorithms for an IEEE 802.11-Based Multi-Channel Wireless Mesh Network	Ad hoc	goodput, HTTP response time	Incorporate channel assignment with routing protocol.	The proposed work may cause a ripple effect.
26.Multi-Channel MAC for Ad Hoc Networks: Handling Multi-Channel Hidden Terminals Using A Single Transceiver	Ad hoc	Average Packet Delay, Aggregate Throughput	The authors consider one channel is dedicated for sending control packets like RTS and CTS and others use for sending data channels [39], each node maintain a list of preferable channels which can be used for sending a data. The RTS and CTS utilize for negotiating the channel selection.	It is difficult to achieve global synchronization when number of nodes are large and hops, Use RTS/CTS can generate exposed nodes.
27.Routing and Link-layer Protocols for Multi-Channel Multi-Interface Ad Hoc Wireless Networks	Ad hoc	Throughput	They categorized the interfaces into two types as follows. 1. Fixed interface, which is assigned a static channel for long time intervals, 2.Switchable interface, this interface can be switchable the channels dynamically over short timescales among non-fixed channels.	The proposed work does not consider traffic load in assigning the fixed channels.
28. Channel Allocation and Routing in Hybrid Multichannel Multi radio Wireless Mesh Networks.	Ad hoc	throughput and delay	proposed adaptive dynamic channel allocation protocol (ADCA), which considers Both throughput and delay in the channel assignment.	One interface for dynamic allocation, might not sufficient for utilizing all non-overlapping channel.
29.Efficient Resource Allocation for Energy Conservation in Uplink	WiMAX	Energy consumption and satisfaction ratio	Solve EURA problem	Most of the QoS metrics are not considered that may

Transmissions				reduce the network performance
30.Dynamic Resource Allocation for IEEE802.16e	WiMAX	User throughput, sector throughput, average packet drop rate, packet delay, and transfer delay	Have capacity to increase the delivered QoS within WiMAX while utilizing spectrum efficiently	Energy consumption is considerably high
31. Generalized Weighted Fairness and its Application for Resource Allocation.	WiMAX	System goodput and system throughput	Achieve better throughput	Did not consider the overhead such as MAC header and other sub-headers
Techniques	Network	Metrics Used	Advantages	Disadvantages
2.Scheduling				
32. Fair Data Flows Scheduling Schema.	Ad-hoc	Network bandwidth, network throughput	Maximum usage of network bandwidth and improved total network throughput	Delay is increased.
33. Optimal Scheduling for Fair Resource Allocation	Ad-hoc	Deficit size, queue length, average service, and dropping probability	Better performance in both elastic and inelastic traffic	When the channel state varies from time slot to time slot, it is difficult to solve
34.Proportionally Quasi-Fair Scheduling Optimization	Ad-hoc	Throughput, fairness, and data rate	Fairness and efficiency is achieved	More overhead
35.Channel-aware Packet Scheduling	Ad-hoc	Delay, overhead	Performance is better.	It does not considered the fairness issues
36.Joint Per-Flow Scheduling and Routing	Ad-hoc	Average delay, average throughput per connection, network capacity and total utility	Increases the average throughput, and the degree of satisfaction	Energy consumption is more.
37. Cross-Layer Fair scheduling with 802.11 CDMA Channels.	Ad-hoc	Latency	Average latency is always consistent	Bandwidth as a metric or a parameter for scheduling the resources

38. Joint Topology-Transparent Scheduling and QoS Routing.	Ad-hoc	Violation rates and aggregate throughput	Reduce QoS violation rates and improve aggregate throughput over two representative QoS routing protocols	Better performance cannot be achieved under a realistic radio model
39.Packet Scheduling with QoS and Fairness for Downlink Traffic	WiMAX	Fairness, latency	Achieve better fairness.	They have used more scheduling schemes to differentiate service flows, which may lead to overhead.
40.Modified Weighted Round Robin Scheduling Algorithm	WiMAX	Average end-to-end delay, average throughput	Decrease the average end-to-end delay and improve the average throughput	Variable Bit Rate (VBR) application and the effectiveness of network density are not considered.
41.Enhanced Scheduling Scheme for QoS Guarantee using Channel State Information	WiMAX	Throughput, delay	Better performance	Different layers with cross layer mechanism based on the QoS requirement of a connection are not discussed.
42.Persistent Scheduling For Non-Periodic Real-Time Service	WiMAX	Average delay, maximum allocation period, average occupied resources, and overhead.	Efficient performance for non-periodic real-time services with small-sized packet	Performance is poor in case of real time service
43.Variable-Length Burst Scheduling Algorithm	WiMAX	Network throughput, service ratio, and average utilization ratio.	Better performance in terms of network throughput, service ratio, and average utilization ratio.	Delay and overhead is more.
44.Adaptive Cross-Layer Design for Multiservice Scheduling	WiMAX	Delay, packet loss	Outperform other schemes in term of delay for ertPS SF and packet loss for rtPS SF	Whole capacity of the system is less
45.Design and Test bed Implementation of Adaptive MPLS Diffserv-enabled Virtual Private Networks	WiMAX	Latency, average jitter, and delay	Deliver low latency along with guaranteed service	Performance is less due to high end-to-end delay time

46.Adaptive Radio Resource Allocation in Hierarchical QoS Scheduling	WiMAX	Average packet delay and delay outage probability	Improve the spectral efficiency while satisfying the diverse QoS requirements in each service class	More delay and packet loss
47.Adaptive Power Efficient Packet Scheduling Algorithm	WiMAX	Channel utilization, throughput, average end-to-end delay, and average energy	Achieve better channel utilization while minimizing the delay and power consumption	Overhead is more
48. An optimized scheduling scheme in OFDMA WiMAX networks.	WiMAX	Throughput, outrage ratio, delay, packet loss and bandwidth	Meet the various QoS requirements for different types of traffics from each user	Energy consumption is more
49.Block Scheduling for Low-Rate, Real-Time Traffic in the Downlink Mobile WiMAX System	WiMAX	MAP overhead, user capacity and signaling overhead	Reduce the MAP overhead and perform better in terms of user capacity and signaling overhead	Energy consumption is considerably high that degrades the performance
50.Group Scheduling for Improving VoIP Capacity	WiMAX	Overhead and capacity	Reduces the signaling overhead and provide flexibility in resource allocation avoiding resource holes	End-to-end packet delay is increased
51.Uplink and downlink scheduling for point to multipoint WiMAX Networks	WiMAX	Simulation time, average delay bound, throughput, packet loss, and transmission rate	Provide efficient QoS scheduling without starving the connections of the BE class	There is no energy conservation technique
52.WiMAX/OFDMA Burst Scheduling Algorithm to Maximize Scheduled Data	WiMAX	Throughput	Achieve high frame throughput	Several other QoS metrics are not considered in analysis

5. Conclusion

In this paper, a broad range of bandwidth reservation, and scheduling protocols designed for wireless networks like AD-HOC (MANET), WiMAX have been studied. There are some common limitations in the research for the two different technologies such as not considering all QoS metrics in the analysis which leads to reduce the network performance and also unconsidering the power consumption issue which is considered as an important factor to evaluate any wireless network efficiency .For each protocol study in terms of scheduling and resource allocation management techniques is completed. We can conclude that Fairness, scalability, synchronization is very common issues in Ad-hoc network .While in Wimax network MAP overhead and delay is always the main challenge. We discuss the properties, describe the operation, performance metrics, and list the advantages and disadvantages. Finally, from the comparison of existing works done on bandwidth reservation and scheduling, we have identified their problems. This can be helpful in developing new techniques by understanding the limitations in existing techniques.

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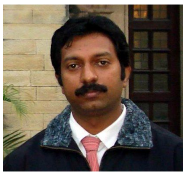

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