Middle-East Journal of Scientific Research
24 (Special Issue on Innovations in Information, Embedded and Communication Systems): 105-112, 2016
ISSN 1990-9233; © IDOSI Publications, 2016
DOI: 10.5829/idosi.mejsr.2016.24.IIECS.23147

A Survey on Fairness MAC Protocols in Manets

[1]M. Saseekala and [2]P. Kamalakannan

[1]Department of Computer Science, MGR College, Hosur, TN, India
[2]Department of Computer Science, Arignar Anna Govt. College, Namakkal, TN, India

Abstract: Mobile Ad Hoc Networks (MANET) is a collection of self-governing mobile nodes that can communicate with each other using multihop wireless links without depending on any fixed base station infrastructure and centralized management. MANETs are initially proposed for military applications, disaster recovery efforts and emergency/rescue operations. But nowadays, they are used in many non-military and industrial purposes. While the use of wireless networks in civil and military aspects is increasing, the need for quality of service (QoS) becomes necessary. Due to importance of Medium Access Control (MAC) protocols for providing QoS in MANETs, the main purpose of this paper is to survey the QoS mechanisms provided by Medium Access Control protocols for MANETs. A standard survey on MAC mechanisms for providing QOS in ad-hoc networks is already done by MarekNatkaniec *et al*. in [1], but their attention is mainly on multiple-traffic problem of MANETs. Other important aspects in this area such as fairness, power saving and security are out of their scope and they leave these issues as future work. So we have considered those issues in this paper, particularly, fairness supporting media access mechanisms for MANETs are surveyed in detail. The flow of this paper is as follows: an overview of the related work, the definition of QoS and QoS-related metrics,a discussion of the issues affecting QoS of ad hoc networks, as well as a classification of the QoS mechanisms of MAC protocols. Then, each mechanism is briefly reviewed and implementation examples from different protocols are explained in order to guide future protocol designers.

Key words: MANET · QOS · MAC · Fairness

INTRODUCTION

AD-HOC networks have been progressively trendy in recent years. An Ad-Hoc network is an “infrastructureless” multi-hop network without a centralized entity (Access Point), where every node acts as a router. According to the standard IEEE 802.11, MANET is a network composed solely of stations within a mutual communication range of each other via the wireless medium (WM). The term *ad hoc* is often used as slang to refer to an independent basic service set (IBSS) [2]. They are dynamically formed amongst a group of wireless users and not required any existing infrastructure or pre-configuration. They can be usually setup in environments where the deployment of a planned network is difficult or not possible and where the network structure changes dynamically.

In ad-hoc networks, the hosts will move indiscriminately, the network structure may change dynamically; the wireless topology may change unpredictably and as per the network changes, the nodes will organize themselves arbitrarily. The dynamic and self-organizing nature of ad-hoc networks makes them particularly useful in situations where rapid network deployments are required or it is prohibitively costly to deploy and manage network infrastructure. Some of the applications of MANETs are military, armed forces, natural disaster relief areas, mine cite operations, emergency services and urgent business meets [3].

The usage of ad-hoc networks will become even more prominent and popular, when it supports the applications for which the QoS is essential. With an increasing demand for multimedia applications it is expected that ad-hoc networks will provide correct traffic differentiation and support for heterogeneous services. Multimedia traffic is usually delay-sensitive and audio-visual content of the data should reach the destination without any delay or the end-to-end delay should be below a certain limit.

Corresponding Author: M. Saseekala, Department of Computer Science MGR College, Hosur, TN, India.

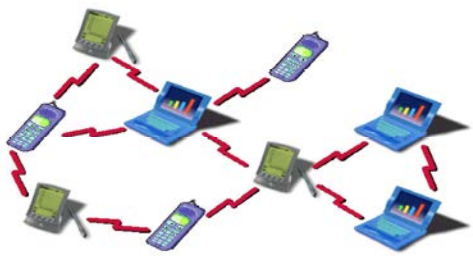

Fig. 1: Ad hoc Networks

Each real-time frame that belongs to a multimedia flow has to reach the final destination within a stipulated deadline, after which it becomes useless. Therefore, an end-to-end QoS assurance is possible in MANETs only if each host in the network offers QoS guarantees.

Although much progress has been done in QoS for wireless networks, there are still many unsolved challenges such as limited transmission range, lack of centralized control, restricted channel bandwidth, error prone, hidden, exposed and intruder terminal problems, battery and computational power constraints, frame losses due to collisions and transmission errors, multi-hop operation, unidirectional links and synchronization problems...etc [1]. Obviously, Ad hoc wireless networks present even greater challenges than infrastructure wireless networks at the MAC layer. Therefore a great deal of research and development efforts is under way on the design of medium access control protocol for resolving the above issues of MANETs.

The medium access protocol is one of the most important aspects of any network which has a broadcast channel as the basis of communication. Because MAC protocols are directly responsible for controlling access to the communication resources in an efficient and reliable manner. Medium access control protocols define the rules that should be followed by the nodes of a network to get access to a shared medium in order to transmit or receive data. It defines how each mobile unit can share the limited wireless bandwidth resource efficiently. Generally MAC protocols are addressing the following features:

- Efficient Channel separation and access
- Topology
- Power
- Fairness
- Transmission initiation
- Traffic load and scalability
- Contention and Collision problem [4].

Developing a QoS-aware MAC protocol is not a simple task, because a good balance should be guaranteed between protocol complexities, method of QoS reservation, available traffic classes, signaling overhead, mobility of nodes, unreliable time varying channels, supported QoS metrics, fairness, consumed power-energy and efficient use of resources. We start with a comprehensive survey of the medium access mechanisms recently proposed in the literature that allow for QoS provisioning in ad-hoc networks. To narrow the scope of this survey, we have focused only on those mechanisms which support fairness in MANETs. Other aspects such as multiple traffic, security, channel contention and collision... are out of the scope of this survey.

The rest of this paper is organized as follows: Section II provides a brief overview of existing surveys of MAC protocols for ad-hoc networks as related work. Section III discusses in detail about QoS, its issues and commonly employed MAC layer QoS metrics. In Section IV, an effective classification of QoS-aware MAC protocols have been done. Section V describes the mechanisms which are used in MAC protocols for QoS in MANETs. Most of the latest standardized MAC protocols with QoS support, primarily fairness related access mechanisms are discussed in Section VI. Finally, Section VII identifies the open issues in this area and concludes the paper by highlighting the future research directions of MAC protocols.

Related Work: Adequate numbers of surveys are existing in the past in which the importance of QoS mechanisms provided by MAC protocols for ad-hoc networks has been repeatedly reviewed thoroughly. But only a few of them has focused on the QOS issues of MANETs at MAC layer and particularly none of them concentrates on fairness in MANETs.

A standard survey on MAC mechanisms for providing QOS in ad-hoc networks is done by MarekNatkaniec *et al*. in [1], but their attention is mainly on the multiple-traffic problem of MANETs. Other important aspects in this area such as fairness, power saving and security are out of their scope. An early survey presented by Raja Jurdak *et al*. in [4] contains a clear classification of MAC protocols and a detailed analysis of 34 MAC layer protocols for wireless ad hoc networks, ranging from industry standards to research proposals. Their analysis is based on various key features like channel separation and access, topology, power, transmission, scalability..etc but it doesn't care about the fairness of MANET. In [5], Sylwia *et al*. have classified the MAC protocols as synchronous and asynchronous protocols. Hidden and Exposed terminal problem, congestion, the “false blocking” problem, the pseudo-deadlock, unfairness, multiple fading issues of MANETs are analyzed. Though it is more useful to understand various MAC protocols, they have not concentrated keenly on fairness in MANETs.

In [6], Sunil Kumar *et al*. have deeply discussed about the issues affecting QOS, need for MAC protocols, QOS aware and non-QOS MAC protocols. Due to the space constraints, they have addressed only some of the QOS issues like contention, throughput and power control. Variety of MAC protocols for single, multiple channels, Protocols using directional antennas, power aware protocols are reviewed by Neeraja *et al*. in [7]. But only 4 selected schemes PAMAS, DPSM, PCM, PCMA for power control are listed in this survey.

After perusing various surveys, in this paper, we have made an attempt to consolidate maximum number of medium access mechanisms which support fairness in MANETs. The detailed explanation of the listed mechanisms and their protocol-specific implementation has been done to make this survey as an extra-ordinary effort.

Preliminaries

QoS and its Issues: The first step on mobile wireless ad hoc networks (MANETs) was centered on the design of routing algorithms which create connectivity and maintain or update connections in networks. Then as the field matures, improving QoS considerations becomes of greater importance. However, achieving the desired level of QoS over wireless networks is far more challenging than for wired networks because of unpredictable channels, lack of any central coordination authority, unreliable links, station mobility, scalability, limited bandwidth, limited battery power, computational constraints, multi hop communication, contention for accessing the wireless channel, hidden and exposed stations..etc. That’s why QoS is still an unsaturated and important research area in ad-hoc networks. To insist the importance of QoS, the first part of this section gives a detailed description about QoS and QoS models for MANETs. Second part depicts the medium access based QoS issues of MANETs and the importance of MAC protocols.

According to RFC2386, QoS is a set of service requirements to be met by the network while transmitting data from a source to a destination (unicast or multicast) with an associated QoS. The associated QoS could,

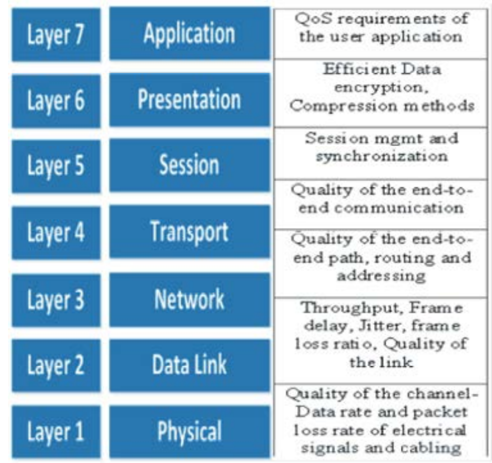

Fig. 2: QOS metrics in OSI layers

in fact, be ‘best effort’ [8]. It is defined as the capability of the cellular service providers to provide a satisfactory service which includes voice quality, signal strength, low call blocking and dropping probability, high data rates for multimedia and data applications etc.

QoS is a collective set of measurable performance metrics which can be directly observed and measured at the point where the user accesses the services of MANETs. Typical QoS metrics include throughput, packet delivery ratio, various delays, routing load, available bandwidth, packet loss rate and out of order packets, error rate, signal-to-noise ratio, scalability, time complexity, security requirements, jitter (delay variability), hop count and path reliability [3]. Achieving the optimum level of various QoS metrics are the responsibilities of the different layers of the OSI model.

QoS Model: A QoS model is a mechanism for achieving and provisioning of QoS based on certain architecture. The main requirements for a QoS model for MANETs [9] are as follows:-

Minimal Overhead: The wireless link capacity, battery and computational resources are quite limited in a wireless multi-hop network. Therefore a QoS model for those networks should minimize the signaling overhead as well as the computational overhead.

Robustness: QoS models should be capable of handling frequent route failures and dynamically changing network. The QoS model should have mechanisms to adapt to the changing topology without creating bottlenecks, in a fast and efficient manner.

Fairness: The QoS resources should be shared in a fair manner among the wireless clients and misbehaving nodes should not be allowed to make use of the network's resources without relaying packets for other nodes.

To facilitate true end-to-end QoS, the Internet Engineering Task Force (IETF) has defined three basic levels of service [10, 11] for QoS based on their fundamental operations:

Best-Effort Service: Standard form of connectivity without any guarantees. This type of service uses first-in, first-out (FIFO) queues, which simply transmit packets as they arrive in a queue with no preferential treatment.

Integrated Services: IntServ, also known as hard QoS, is an absolute reservation of services. In this, the traffic flows are reserved explicitly by all intermediate systems and resources. It follows the signaled-QoS model, where the end-hosts signal their QoS needs to the network and provides explicit reservations for end-to-end host. IntServ supports a set of specific algorithms and scheduling techniques which allow for strict QoS guarantees. The Resource Reservation Protocol (RSVP) was designed as the primary signaling protocol to setup, signal, reserve the desired QoS for each flow in the network and maintain the virtual connection. RSVP is also used to propagate the attributes of the data flow and to request resources along the path. Routers finally apply corresponding resource management schemes to support QoS specifications of the connection. IntServ provides quantitative QoS for every flow.

Differentiated Services: DiffServ, also known as soft QoS, is class-based for traffic management, where some classes of traffic receive preferential handling over other traffic classes. DiffServ works on the provisioned-QoS model, where network elements are set up to service multiple classes of traffic with varying QoS requirements and offers hop-by-hop differentiated treatment of packets. DiffServ operates on the principle of traffic classification, where each data frame is located into a specific number of traffic classes. The most important advantage of DiffServ is that it is easy to setup and it does not require reservations for each traffic flow.

These two principal approaches to assure QoS in wireless networks have defined at the MAC layer: prioritized, based on DiffServ and parameterized, based on IntServ [1].

QoS aware MAC protocols for ad-hoc networks mostly utilize the prioritized approach as the default service differentiation method due to the distributed nature of ad-hoc networks.

Importance of MAC Protocol: The MAC protocols for MANETs need to be distributed, QoS assured, fair to all flows and should work in a multihop environment.

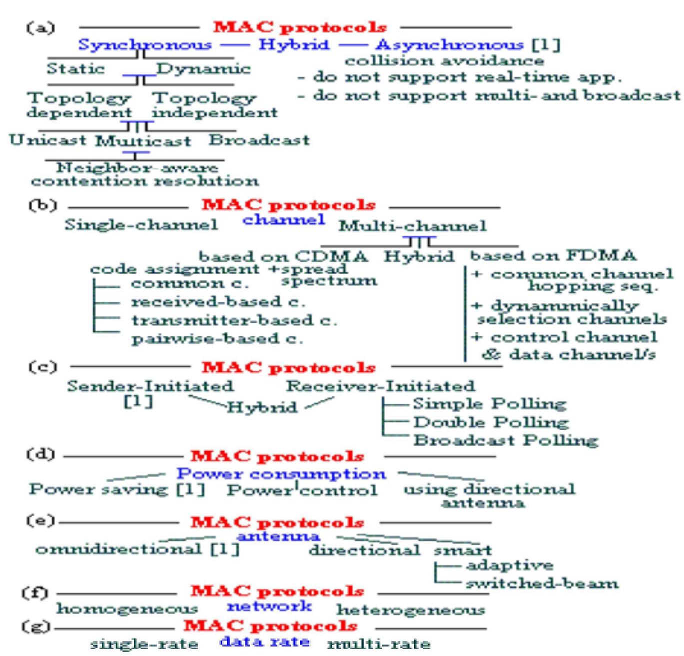

Fig. 3: Basic classification of MAC Protocols based on different views

Apart from resolving unreliable wireless channel, technology based issues, multi-hop topology, mobility, limited energy supply and computational power, MAC protocols are designed with the following goals:

- Bandwidth Efficiency
- Fairness-A channel is said to be fair if it is able to provide each and every individual nodes without giving preference to one node over the others when there is no service differentiation.
- Synchronization
- Low control overhead
- Hidden and Exposed Terminal Problems
- Error-Prone Share Broadcast Channel
- Distributed Nature/Lack of Central coordination
- Mobility of Nodes
- Selfish nodes
- Power control
- Signaling

Medium Access Mechanisms for QoS: Several QoS-aware mechanisms are proposed in the literature. Most basic two components are considered here: Distributed Coordination Function (DCF) and Point Coordination Function (PCF).

DCF: DCF is a technique where a node reserves a channel for data transmission by exchanging RTS (Ready to Send) messages and CTS (Clear to Send) messages with the target code. Whenever a node intends to transmit packets to other nodes, first it must send an RTS packet to the destination. The receiving node replies with a CTS packet. Both the RTS packet and the CTS packet include an estimate of the time the channel will be occupied. All the other nodes that hear these packets must postpone their transmissions for a while, as specified in the packets. Hence, every node keeps a variable called NAV (Network Allocation Network), which is a record of the time interval that transmissions should be postponed. This whole process is commonly known as carrier virtual detection and allows reserving the area around transmitter and receiver for proper communication, thus avoiding the hidden terminal problem [12]. DCF is a distributed protocol which is mainly aimed to minimize the numbers of collisions caused by hidden stations.

In order to minimize the probability of collisions during contention between multiple wireless stations, DCF combines CSMA/CA with a random back off procedure.

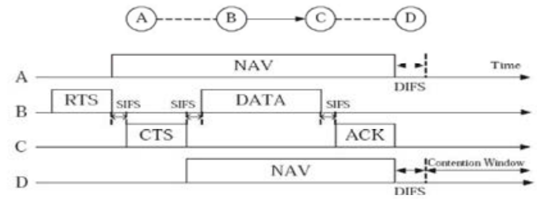

Fig. 4: Operation of IEEE 802.11 DCF

IEEE 802.11 defines four time intervals (called InterFrame Spaces, IFSs) in order to provide priority levels for access to the wireless channel.

- Short InterFrame Space (SIFS)-the shortest IFS, used prior to transmissions of ACK frames and Clear To Send (CTS) frames, as well as before a response to polling by the Point Coordination Function (PCF).
- Point Coordination Function InterFrame Space (PIFS)-used to give priority to PCF channel access over DCF channel access.
- DCF InterFrame Space (DIFS)-used by stations operating under DCF to transmit DATA and RTS frames.
- Extended InterFrame Space (EIFS)-used after erroneous transmissions of frames.

The QoS-aware MAC protocols frequently implement this mechanism, e.g., in order to reserve bandwidth or a transmission period, negotiate the data channel, transmit additional QoS-related information (e.g., transmission power, additional acceptable noise).

PCF: PCF is a centralized protocol in which stations are polled by an AP (Access Point). PCF provides contention-free access through a polling procedure. It was designed for infrastructure network configurations, in which one of the stations acts as a coordinator (AP) and polls other station for data

MAC Protocols for Fairness: Wireless channel is a shared scarce resource. The MAC protocols used over ad-hoc networks are distributed protocols which try to avoid collisions and provide the nodes in a network with an access to the channel in a fair manner. The efficiency of MAC protocols can be measured using two parameters: i) Probability *of collision ii) Fairness*in the allocation of channel to competing nodes.

A medium access protocol (MAC) is termed to be fair when multiple nodes in a network are competing with each other for channel access, the probability of each node winning the contention should be equal. This section gives an overview of existing MAC mechanisms which support fairness in ad-hoc networks. A common technique to construct mechanisms for implementing various fairness policies is to

- Assign priorities to data packets
- Manipulate the priorities dynamically to implement a specific policy
- Ensure channel access to be ordered in terms of the priorities.

Fairness mechanisms are supported by priority resolution (PR)-mechanisms to implement the prioritized access of packets. We classify such MACs supporting PR into three categories based on the way they perform PR and identify three representative schemes for each of the three categories.

- Differentiated backoff based-represented by 802.11e
- Beacon-based-represented by EY-NPMA
- Scheduling-based-represented by DWOP

In this section, we describe these categories and their representative schemes used for our evaluation [13].

Differentiated Backoff-Based Schemes: In such schemes, nodes access the channel with a backoff period which is a function of the priority of their head-of-line(HOL) packet, e.g. a node A with higher priority2 will access the channel with a shorter backoff compared to neighboring node B with lower priority. This ensures that A captures the channel with high probability compared to B, with the exact probability of channel capture being a function of the relative backoff periods of A and B. This mechanism has non-overlapping backoff periods for each priority, DIFSi= DIFSi-1+CWi-1, where CWiis the backoff window for priority level I.

Beacon-Based Schemes: In beacon-based schemes, nodes rely on bursts of energy to inform their neighbors of their priority. The actual priority is encoded in the length of the beacon or the time at which they are sent. A subset of such schemes also relies on an additional channel to send beacons. We focus our evaluation on EY-NPMA which uses short beacons sent at predefined moments in time to encode priority information. The reason for choosing EY-NPMA is twofold. First, encoding the priority in the length of the beacon wastes energy. Second, using a separate channel for beacon transmissions is not possible in contemporary single transceiver radios.

EY-NPMA Elimination-Yield Non-Pre-emptive Priority Multiple Access (EY-NPMA) is the MAC protocol which employs CSMA technique. In this, each node goes through a PR phase followed by a contention resolution (CR) phase. The PR phase is as follows. As soon as the channel becomes idle, a node with aback-logged packet with priority i waits for i *beacon periods* which is defined to be the time to fully transmit a short *beacon*. At the end of i beacon periods, if the channel is idle, the node transmits the beacon and enters contention for the medium. If more than one node with the same highest priority exist, they will all transmit beacons simultaneously and will enter the CR phase together. At the end of the PR phase, one or more nodes with the highest priority are left in contention and they contend for the medium in the CR phase. There are four channel access phases: the prioritization, elimination, yield and data transmission phase. In the prioritization phase a station, with a channel access priority *n*, should listen for *n* prioritization slot intervals. If the channel is sensed idle in the *n*-th prioritization slot interval, the station transmits a channel access burst of the duration of a priority assertion interval. Only stations which have the highest channel access priority move to the next phase. Therefore, in the next, elimination phase, only stations with the same, highest priority contend for channel access. Each station selects a random number of slots, which follows a truncated geometric distribution. Next, the station transmits these slots as a channel access burst. As soon as a station finishes its transmission, it checks the medium. If the medium is busy it defers. If it is idle, the station can proceed to the yield phase. There is the possibility that two or more stations having the same priority frame will choose the same length of elimination pulse and be unable to detect one another even at the end of the second phase. In this case the final contention is done in the yield phase. The yield phase is similar to the backoff procedure used by IEEE 802.11 DCF. EY-NPMA assures strict fairness guarantees and time bounded delivery of frames.

Scheduling-Based Schemes: In scheduling-based schemes, nodes disseminate priority information well before the actual packet transmissions and then co-ordinate their transmissions in such a way that the order of packet transmissions matches the advertised priorities. Distributed priority scheduling and DWOP follow this scheme. Distributed Wireless Ordering Protocol (DWOP) is based on the DSP, ensure that packet access the medium according to the order specified by an ideal reference schedule such as FIFO. Each node builds up a scheduling table (ST) ordered according to the overheard arrival times. A node is made eligible to contend for the channel only if its locally queued packet has a smaller arrival time compared to all other arrival times in its ST. In both schemes, nodes piggyback their packet priorities onto RTS, CTS, DATA and ACK messages, which are overheard by neighbors. Thus each node builds a database of priorities of all its neighbors within a two-hop communication range. RTS and CTS messages of a node inform its immediate neighbors and potential two-hop interferers respectively about its priority. DATA and ACK messages inform the neighbors that the packet has been successfully transmitted so that they may update their database. In addition, DATA and ACK messages also inform neighbors about the priority of the next packet in its queue. Some MAC protocols that support fairness in MANETs are briefly explained as follows:

Distributed Fair Scheduling (DFS): Distributed Fair Scheduling is a protocol which allows the stations to contend for the channel with the contention window in proportion to the weight assigned to them. The stations with higher weight set the contention window of less size compared to the other stations. Although the DFS protocol deals with fairness issue, it is not clear how the channel shares are assigned to each node. It provides node based fairness. That means all node should be fairly served. Node based fairness may cause problem when it is to be applied to a multihop adhoc network. Hence in such situation, flow based fairness is the best choice.

Faired QOS Assured MAC Protocol: In the Faired QoS assured MAC Protocol [14], each station along the path from the source to the destination counts the number of successful frame transmissions, separately for each flow. If two frames of the same priority but from different flows are stored in a single queue the one which belongs to the less frequently served flow can be dequeued. Such behaviour is obtained by changing CWs according to the ratio of the number of successful frame transmissions for the current flow to the number of successful frame transmissions for any better served flow of the same priority. This protocol provides a better level of fairness in MANETs.

Prioritized Binary Countdown (PBC): In the Prioritized Binary Countdown (PBC) [15] protocol, the jamming signals are transmitted as binary numbers. These numbers consist of a priority number (for QoS support) and a random number (for fairness and collision control). In the binary countdown period, the station sends a signal if the individual bit of the chosen binary number is set and remains silent if the bit is not set. The station which remains silent senses the channel. If the channel is not idle the station loses the competition. The winning station is allowed to transmit.

Fairness Supporting Protocol (FSP): This protocol is supporting flow based fairness. It employs the IEEE 802.11 as a subroutine for channel contention. FSP has the following key features: (1) QoS support (2) Flow based fairness-exhibits fairness to different flows with same priority (3) Works in a multihop adhoc network. In order to provide service differentiation to different types of traffic different priority level is assigned. In this work, three types of traffics are involved: voice traffic (constant bit rate), video traffic (variable bit rate) and datagram traffic. The priority level assigned to voice, video and data are 2, 1 and 0 respectively. Hence voice traffic will contend the channel with less contention window size and data traffic with larger window size.

FAP-Fair Cooperative Protocol: To perform fair resource allocation in energy-constrained cooperative ad-hoc networks, a novel multiuser cooperative protocol, the FAir cooperative Protocol (FAP) is developed. In FAP, a *power reward* is adopted by each node to evaluate the power contributed to and by others. In particular, each node has to *pay* for cooperative transmission by subtracting the amount of transmission power contributed by its relays from its power reward. On the other hand, each node can also boost its power reward by helping others.

CONCLUSION AND FUTURE DIRECTIONS

This paper has outlined some of the MAC protocols and mechanism that support fairness in MANETs. This survey highlighted the importance of Fairness to achieve QoS in ad-hoc networks. Based on the presented survey, three general comments related to the future research directions concerning QoS mechanisms can be derived. Mechanisms which alternate contention and contention-free periods seem to be a promising solution for ad-hoc networks. Contention based periods should be used for bursty traffic, reservation based periods for real-time traffic and broadcast periods for the dissemination of important information (e.g., reservation status). As this survey shows, it is impossible to provide strict QoS relying only on the MAC layer. A cross-layer solution is more complex, but may be unavoidable due to the nature of ad-hoc networks.

ACKNOWLEDGMENT

The author would like to thank the anonymous referees for their comments that greatly helped to improve the paper quality.

REFERENCES

1. Marek Natkaniec and Szymon Szott, 2013. A Survey of Medium Access Mechanisms for Providing QoS in Ad-Hoc Networks. IEEE Communications Surveys and Tutorials, 15(2): 592-620.
2. IEEE Computer Society LAN MAN Standards Committee: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications. ANSI/IEEE Std. 802.11, 1999 Edition. The Institute of Electrical and Electronic Engineers, New York.
3. Saseekala, M. and P. Kamalakannan, 2014. A Survey on the QoS Impact Factors Of MANETs, ISBN:9788192660615
4. Raja Jurdak, Cristina Videira Lopes and Pierre Baldi, 2004. A Survey, Classification and Comparative Analysis of Medium Access Control Protocols for Ad Hoc Networks. IEEE Communications Surveys and Tutorials, 6: 1-16.
5. Van den Heuvel-Romaszko, S. and C. Blondia, 2004. A survey of MAC protocols for ad hoc networks and IEEE 802.11, www.pats.ua.ac.be/publications/2004/Nissi.pdf.
6. Sunil Kumar, Vineet S. Raghavan and Jing Deng, 2004. Medium Access Control protocols for ad hoc wireless networks: A survey. Ad Hoc Networks, 4: 326-358.
7. Neeraja, Y., Dr. V. Sumalatha and Sd. Muntaz Begum, 2013. Comprehensive Survey of Medium Access Control Protocols for MANETs, International Journal of Emerging Trends and Technology in Computer Science (IJETTCS), 2(3): 211-219.
8. Crawley, E., R. Nair, B. Rajagopalan and H. Sandrick, 1998. A Framework for QoS Based Routing in the Internet. RFC 2386.
9. Shivanajay Marwaha, Jadwiga Indulska and Marius Portmann, Challenges and Recent Advances in QoS Provisioning, Signaling, Routing and MAC protocols for MANETs, School of ITEE, University of Queensland and NICTA Queensland Research Laboratory Brisbane, Australia.
10. CISCO WEBSITE.
11. JianboXue and Gustavo Alonso, 2003. Quality of Service for Mobile Ad Hoc Networks. Swiss Federal institute of Technology, Zurich.
12. Luis Fernando Pedraza, Ingrid Patricia Paez and Felipe Forero, 2012. An evaluation of MAC protocols running on a MANET network. 3rd International Conference on Ambient Systems, Networks and Technologies, pp: 86-93.
13. Kopal Gangrade, Pawan Patidar and Anshu Tiwari, 2013. Performance Evaluation of IEEE 802.11 MAC DCF Using Various Schemes Towards: Throughput, Delay and Reliability. International Journal of Advanced Research in Computer and Communication Engineering Vol. 2.
14. Seth, D.D., Srikanta Patnaik and Srikanta Pal, 2011. A Faired Quality of Service Assured Mac Protocol for Mobile Adhoc Network and its Performance Evaluation. International Journal of Wireless and Mobile Networks (IJWMN) Vol. 3.
15. Lin Dai, Wei Chen, Leonard J. Cimini, Jr. and Khaled B. Letaief, 2009. Fairness Improves Throughput in Energy-Constrained Cooperative Ad-Hoc Networks. IEEE Transactions On Wireless Communications, Vol. 8.