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A STUDY ON QoS PROBLEMS IN AD HOC NETWORKS AND THEIR SOLUTIONS

An Ad Hoc Wireless Network (AWN) is a collection of mobile hosts forming a temporary network on-the-fly without using any fixed infrastructure. These hosts are connected together in wireless mode. For there are no access point and infrastructure in these networks, so, AWNs could be developed quickly. Characteristics of AWNs such as lack of central coordination, mobility of hosts, dynamically varying network topology, and limited availability of resources make QoS provisioning very challenging in such networks. In this paper, we describe the issues and challenges in providing QoS for AWNs and review some of solutions and factors that are necessary to support QoS in AWNs.

Key words: *Quality of Service (QoS), wireless ad hoc networks,* QoS *problems, QoS methods, QoS components.*

1. Introduction

Today, establishing computer networks, information sharing and quick access to information are essential. Considering the rapid development of computer devices that also could connect together, creation of computer networks are increasing day to day. However, unlike previous years, devices are connected through wireless links to build a live and on-the-fly network called Ad-hoc Wireless Network (AWN). Due increasing the use of AWNs, need for faster and optimal algorithms, establishing better QoS and providing high level services for network users, are essential. But with regard to the characteristics of AWNs, providing the above cases is difficult and complex task. So, each of the above cases are under review and study in the scientific communities and universities all over the world.

The rest of the paper is organized as follows. QoS parameters in ad hoc networks are described, issues and challenges in providing QoS in ad hoc wireless networks have been explained, some methods for providing of QoS have been also described and at the end we demonstrate necessary components for providing QoS in ad hoc networks.

2. Quality of Service (QoS)

Prioritizing the data, reliability in data sending and creation of communication with higher quality are the main concerns in all the computer systems. The various scheduling algorithms in CPU demonstrate the importance of these issues.

These issues also are discussed in computer networks. But this time, the processor is not only one that decides what package is served in this time. However, some of systems are working together to send a packet on time, with high QoS and with attention to its priority.

QoS is the performance level of a service offerred by the network to the user [1]. The goal of QoS provisioning is to achieve a more deterministic network behavior, so that information carried by the network can be better delivered and network resources can be better utilized. A network or a service provider can offer different kinds of services to the users. Here, a service can be characterized by a set of measurable prespecified service requirements such as minimum bandwidth, maximum delay, maximum delay variance (jitter), and maximum packet loss rate. After accepting a service request from the user, the network has to ensure that service requirements of the users flow are met. In other words, the network has to provide a set of service guarantees while transporting a flow. After receiving a service request from the user, the first task is to find a suitable loop-free path from the source to the destination that will have the necessary resources available to meet the QoS requirements of the desired service. This process is known as QoS routing. After finding a suitable path, a resource reservation protocol is employed to reserve necessary resources along that path. QoS guarantees can be provided only with appropriate resource reservation techniques. For example, consider the network shown in Figure 1. The attributes of each link are shown in a tuple <BW,D>, where BW and D represent available bandwidth in Mbps and delay in milliseconds.

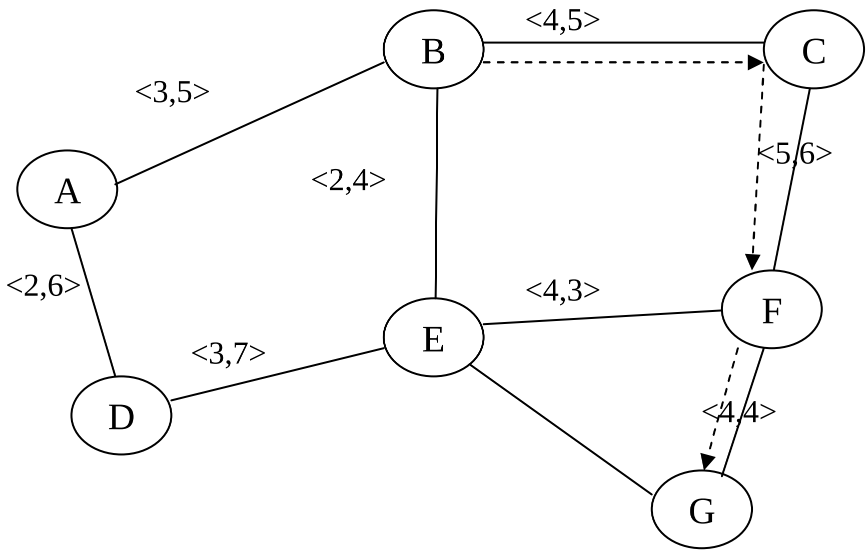

Figure 1. An example of QoS routing in ad hoc networks

Suppose a packet-ow from node B to node G requires a bandwidth guarantee of 4 Mbps. QoS routing searches for a path that has sufficient bandwidth to meet the bandwidth requirement of the flow. Here, 6 paths are available between nodes B and G as shown in Table1. QoS routings selects path 3, because, out of the available paths, path3 alone meets the bandwidth constraint of 4 Mbps for the flow. The end-to-end bandwidth of a path is equal to the bandwidth of the bottleneck link (i.e., link having minimum bandwidth among all the links of a path). The end-to-end delay of a path is equal to the sum of delays of all the links of a path. Clearly path 3 is not optimal in terms of hop count and/or end-to-end delay parameters, while path1 is optimal in terms of both hop count and end-to-end delay parameters. Hence, QoS routing has to select a suitable path that meets the QoS constraints specified in the service request made by the user.

Table1

Available paths from node B to node G

NO	Path	Hop Count	BW (Mbps)	Delay (ms)
1	B-E-G	2	2	9
2	B-E-F-G	3	2	11
3	B-C-F-G	3	4	15
4	B-C-F-E-G	4	3	19
5	B-A-D-E-G	4	2	23
6	B-A-D-E-F-G	5	2	25

3. QoS parameters in ad hoc networks

As different applications have different requirements, the services required by them and the associated QoS parameters differ from application to application. For instance, in case of multimedia applications, bandwidth, delay jitter and delay are the key QoS parameters. For example, the most important factors that are causing delays in sending packets are delayed in the queues at source and intermediate nodes, packet processing at the intermediate nodes and transmission delay [2]. The military applications have stringent security requirements. For applications such as emergency search and rescue operations, availability of network is the key QoS parameter. Applications such as group communication in a conference hall require that the transmissions among nodes consume as minimum energy as possible. Hence battery life is the key QoS parameter here.

Unlike traditional wired networks, where the QoS parameters are mainly characterized by the requirements of multimedia traffic, in AWNs the QoS requirements are more influenced by the resource constraints of the nodes. Some of the resource constraints are battery charge, processing power, and buffer space.

4. Issues and challenges in providing QoS in AWNs

Providing QoS support in AWNs is an active research area. AWNs have certain unique characteristics that pose several difficulties in provisioning QoS. Some of these important difficulties are listed below:

- dynamically varying network topology;
- imprecise state information;
- lack of central coordination;
- error prone shared radio channel;
- hidden terminal problem;
- limited resource availability;
- insecure medium.

Here we describe each of the above challenges.

- *Dynamically varying network topology*:

Since the nodes in an ad hoc wireless network do not have any restriction on mobility, the network topology changes dynamically [3]. Hence the admitted QoS sessions may suffer due to frequent path breaks, thereby requiring such sessions to be re-established over new paths. The delay incurred in re-establishing a QoS session may cause some of the packets belonging to that session to miss their delay targets/deadlines, which is not acceptable for applications that have stringent QoS requirements.

- *Imprecise state information*:

In most cases, the nodes in an ad hoc wireless network maintain both the link-specific state information and flow-specific state information. The link-specific state information includes bandwidth, delay, delay jitter, loss rate, error rate, stability, cost, and distance values for each link. The flow specific information includes session ID, source address, destination address, and QoS requirements of the flow (such as maximum bandwidth requirement, minimum bandwidth requirement, maximum delay, and maximum delay jitter) [4]. The state information is inherently imprecise due to dynamic changes in network topology and channel characteristics. Hence routing decisions may not be accurate, resulting in some of the real-time packets missing their deadlines.

- *Lack of central coordination:*

Unlike wireless LANs and cellular networks, in ad hoc networks, there is no central point of coordination due to the mobility of the nodes [5]. Therefore, the control of the access to the channel must be distributed among them. In order for this to be coordinated, the nodes must exchange information. It is the responsibility of the MAC protocol to make sure this overhead is not a burden for the scarce bandwidth.

- *Error prone shared radio channel:*

The radio channel is a broadcast medium by nature [6]. Therefore, when there is communication going on, no other node should transmit, otherwise there would be interferences.

Access to the physical medium should be granted only if there is no session going on. Nodes will often compete for the channel at the same time; therefore, there is high probability of collisions.

- *Hidden terminal problem:*

The hidden terminal problem is inherent in AWNs [7]. This problem occurs when packets originating from two or more sender nodes, which are not within the direct transmission range of each other, collide at a common receiver node (figure 2). It necessitates retransmission of packets, which may not be acceptable for flows that have stringent QoS requirements. The RTS/CTS [8] control packet exchange mechanism, IEEE 802.11standard [9], reduces the hidden terminal problem only to a certain extent. BTMA [10] and DBTMA [11] provide two important solutions for this problem.

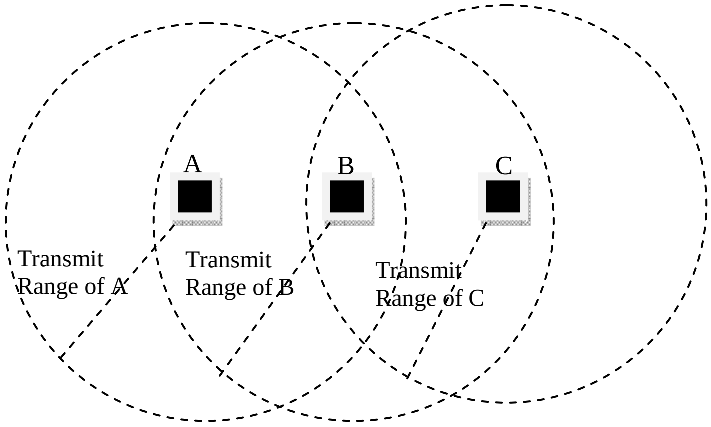

Figure 2. Hidden terminal in ad hoc networks

- *Limited resource availability:*

Resources such as bandwidth, battery life, storage space, and processing capability are limited in AWNs. Out of these, bandwidth and battery life are very critical resources, the availability of which significantly affects the performance of the QoS provisioning mechanism [12]. Hence efficient resource management mechanisms are required for optimal utilization of these scarce resources.

- *Insecure medium:*

Due to the broadcast nature of the wireless medium, communication through a wireless channel is highly insecure [13]. Hence security is an important issue in AWNs, especially for military and tactical applications. AWNs are susceptible to attacks such as eavesdropping, spoofing, denial of service, message distortion, and impersonation. Without sophisticated security mechanisms, it is very difficult to provide secure communication guarantees.

5. Some methods for providing QoS

In this section we have explained some methods that we can use them to provide QoS in ad hoc networks.

- *Hard state vs soft state resource reservation:*

QoS resource reservation is one of the very important components of any QoS framework (a QoS framework is a complete system that provides required/promised services to each user or application). It is responsible for reserving resources at all intermediate nodes along the path from the source to the destination as requested by the QoS session. QoS resource reservation mechanisms can be broadly classified into two categories, hard state and soft state reservation mechanisms [14].

Hard State: Once the reservation is made, the resources stay in the disposal of the flow until the source receives an acknowledgement of receipt (Ack) from the destination. This implies a waste of time and a wasting of the network resources especially in the case of a break of link which engenders the fact that even the message indicating this cut cannot be sent.

Soft State: When the reservation is made, a timer is activated and will be updated in a permanent manner. In this way the reservation will have a lifetime. When the timer is sold, and even if we have not yet received an acknowledgement of receipt from the destination, the reserved resources are going to be released and can be so used for the other flows.

The resources reservation with the Hard State method is the simplest because it requires less path marking for the update of the state of the reservations, besides, it is not limited in the time.

As even, it seems to us, within the AWNs, that the Soft State's reservation is the most interesting to be integrated because the links radio are unstable and can be broken at any moment. Thus, the use of this method of reservation (Soft State) allows a better optimization of the use of the available resources.

- *Stateful vs stateless approach:*

In the stateful approach, each node maintains either global state information or only local state information, while in the case of stateless approach no such information is maintained at the nodes. State information includes both the topology information and the flow-specific information. If global state information is available, the source node can use a centralized routing algorithm to route packets to the destination. The performance of the routing protocol depends on the accuracy of the global state information maintained at the nodes. Significant control over head is incurred in gathering and maintaining global state information.On the other hand, if mobile nodes maintain only local state information (which is more accurate), distributed routing algorithms can be used [15]. Even though control over-head incurred in maintaining local state information is low, care must be taken to obtain loop-free routes. In the case of stateless approach, neither flow-specific nor link specific state information is maintained at the nodes. Though the stateless approach solves the scalability problem permanently and reduces the burden (storage and computation) on nodes, providing QoS guarantees becomes extremely difficult.

- *Hard QoS vs soft QoS approach:*

The QoS provisioning approaches can be broadly classified into two categories, hard QoS and soft QoS approaches. If QoS requirements of a connection are guaranteed to be met for the whole duration of the session, the QoS approach is termed as hard QoS approach [16]. If the QoS requirements are not guaranteed for the entire session, the QoS approach is termed as soft QoS approach. Keeping network dynamics of AWNs in mind, it is very difficult to provide hard QoS guarantees to user applications. Thus, QoS guarantees can only be given within certain statistical bounds. Almost all QoS approaches available in the literature provide only soft QoS guarantees.

6. Necessary components for providing QoS in ad hoc networks

Due to the lack of centralized control in an ad hoc network, distributed resource allocation must be used to allocate resources along the routes of flows to provide flow-based QoS guarantees. Since an ad hoc network has no fixed infrastructure, every node in the network must participate in distributed resource allocation and hence must be equipped with QoS support, which requires three necessary components: admission control, QoS-aware scheduling and conflict resolution [17].

- *Admission Control*

This component is used to ensure that the total resource requirements of admitted flows can be handled by the network. If there are not enough resources for all realtime flows, some realtime flows must be rejected to maintain the guarantees made to other realtime flows.

- *QoS-aware scheduling*

This component allocates resources to admitted realtime flows and guarantees their QoS under the condition that admission control is properly performed. The QoS-aware scheduling also regulates the sending rate of best effort flows to prevent them from degrading the QoS of realtime flows.

- *Conflict Resolution*

The conflict resolution deals with QoS violations and selects victim flows to be rejected to maintain the QoS of the remaining flows.

7. Conclusion

Considering the comfortably establishing ad hoc networks, the use of this type of network is increasing day to day. Ad hoc networks are used by various users. These users want to have efficient QoS in ad hoc networks. By considering the properties of ad hoc networks, for providing high level QoS, the algorithms should not be sensitive for packet loss, and should be reached the packets to the destination at minimum time. As mentioned in the paper, the packet collision is inherent problem in ad hoc networks, so, for providing best QoS, we need to smart and accurate algorithms for calculating back-off time of nodes. Because the packet collision is important factor in decreasing/increasing of QoS in ad hoc networks, we can improve the QoS of network by using smart algorithms in calculating back-off time of nodes.

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Ad hok şəbəkələrdə QoS problemlərinin və onların həlli yollarının analizi

Simsiz *Ad hok* şəbəkələr dinamik və özütəşkillənən şəbəkələrdir, müəyyən sayda mobil qovşaqlardan (stansiyalardan) ibarət olurlar. Bu stansiyalar bir-biri ilə simsiz əlaqədədirlər. Belə şəbəkələr heç bir sabit və müəyyən infrastrurktur olmadan sürətlə yarana bilərlər. *Ad hok* şəbəkələrində mərkəzi kontrollerin olmaması, stansiyaların yerinin qeyri-sabitliyi, şəbəkənin topologiyasının dəyişkənliyi və şəbəkədə mövcud olan mənbələrin məhdudluğu səbəbindən xidmət keyfiyyətinin (Quality of Service, QoS) idarə edilməsi bir sıra problemlər və maneələrlə qarşılaşır. Bu məqalədə belə problemlər araşdırılır və qeyd olunan şəbəkələrdə xidmət keyfiyyətini dəstəkləmək üçün zəruri olan faktorlar analiz olunur.
Açar sözlər: *xidmət keyfiyyəti (QoS), simsiz Ad-hok şəbəkələri, xidmət keyfiyyətinin problemləri, xidmət keyfiyyətinin metodları, xidmət keyfiyyətinin komponentləri.*

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Анализ проблем QoS в сетях Ad hoc и пути их решения

Беспроводные сети *Ad hoc* представляют собой динамичные и самоорганизующиеся сети, состоящие из определенного количества мобильных узлов (станций). Эти станции связаны друг с другом в беспроводном режиме. Такие сети могут образовываться и без наличия установленной и определенной инфраструктуры. В связи с характерными особенностями сетей *Ad hoc*, а именно отсутствие центрального контроллера, неустойчивость местонахождения станций, изменчивость топологии сети и ограниченное количество источников (серверов) в сети, управление качеством обслуживания сталкивается с рядом проблем и препятствий. В данной статье исследуются такого рода проблемы и проведен анализ факторов, необходимых для поддержки качества сервиса в сети.
Ключевые слова: *качество* обслуживания *QoS, беспроводные сети Ad hoc, проблемы QoS, методы QoS, компоненты QoS.*