A Probability-based Method for Resources Advanced Reservation in Wireless Ad Hoc Networks

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Abstract- Ad hoc networks are wireless networks composed of mobile devices with limited power and transmission range. Advance reservations are a useful method to allocate resources of various kinds in many different environments, and especially be useful for wireless ad hoc networks that require network quality of service, which need advance reservation to support handovers for streaming video. It is key in guaranteeing that enough resources will be available in the wireless ad hoc network when a new flow is to be set between a source and a destination. In this paper, we evaluate several methods for supporting advanced reservation in wireless ad-hoc networks, and propose a probability-based method for resources advanced reservation (PMRAR). This method can provide resource reservation more efficiently and cost-effectively, and make the resource management more powerful and practical for wireless ad-hoc networks.

Key words: ad hoc networks, advanced reservation.

1.0 Introduction

Ad hoc networks are wireless networks composed of mobile devices with limited power and transmission range. These networks are rapidly deployable as they neither require a wired infrastructure nor centralized control [1]. Because of the lack of fixed infrastructure, each node also acts as a relay to provide communication throughout the network. Applications of ad hoc networks include coordination between various units, search and rescue missions, rapidly deployable networks, and vehicular networks, among others. Although research on wireless ad hoc networks has attracted a lot of attention lately, little attention has been given to resource reservation in large-scale wireless ad hoc networks.

In wireless ad-hoc networks, multi-media flows need to satisfy certain performance requirements such as, bandwidth guarantees and upper bounds on packet losses and end-to-end delay in order to function properly. These requirements are generally known as Quality of Service (QoS) guarantees. Satisfaction of QoS guarantees has been an active area of research in wireline networks for several years. The same issue becomes more challenging in wireless ad-hoc networks where capacity is a scarce resource and packet transmissions are more prone to errors, noise and interference than wireline networks[2]. This is especially true in wireless ad-hoc networks, where packets are much more relayed by wireless ad-hoc nodes, rather than a base station in cellular systems.

Two common mechanisms for providing quality of service guarantees are, admission control and resource reservation. When a new flow is to be set between a source and a destination, the source examines whether there are enough resources in the network so that the flow can be admitted and be provided with the required QoS, without affecting the already admitted connections (Admission Control). If these resources can be found, they are reserved for the flow (Resource Reservation) and transmission begins.

A further challenge in wireless ad-hoc networks is supporting dynamic resource reservation as required by nodes that join or leave the network at run-time, or by changes in the communication requirements. This is necessary for an efficient use of the communication bandwidth and for flexibility with respect to the operational environment. This paper proposes a probability-based method for resources advanced reservation (PMRAR) strategy which reserves bandwidth for each user based on the real-time movement parameters, and allows select available routes for the flow. The remainder of this paper is organized as follows. In section 2, background and a brief survey of related works are reviewed. The details of PMRAR are explained in Section 3. Finally we present our conclusions in section 4.

2.0 Related Work

Wireless communication technology has recently become pervasive in many application domains, enabled by a gradual enhancement in quality and security of the communication, together with a substantial decrease in the related costs. The resulting wireless networks are normally classified in two categories: structured, i.e., based on fixed access points; and ad-hoc. A further classification divides the latter category into mobile ad-hoc networks and sensor networks [3]. An important component of this architecture is the reservation protocol used to reserve resources at the routers along the data flow path. Paper [4] has described a protocol, RSVP, which sets up resource reservation for real-time traffic in the Internet and can be used to reserve resources for both unicast and multicast flows in the Internet. In this protocol, reservation is receiver-initiated and aggregation of reservations is supported depending on application needs.

As portable computers become more powerful and the accessibility of a fixed network from a mobile host becomes easier, the number of mobile users will grow and additionally the mobile users will demand the same real-time services available to fixed hosts. The existing system architecture for real-time services in a network with wireline networks is not adequate for supporting wireless networks and a new system architecture is required to handle the effects of mobility. Paper [5] has presented an "adaptive reserved service" framework for use in integrated services networks to support mobile connections carrying multimedia traffic. Paper [6] have proposed resource allocation and admission control schemes based on a new concept, to improve the QoS of mobile calls by reducing the number of dropped calls in an wireless-ATM network. However, in the solutions presented in these works wireless networks may suffer significant degradation in QoS due to mobility. Paper [7] described a resource reservation protocol, MRSVP, for a wireless network with mobile hosts.

Although many protocols are proposed in the literature [3-7], neither energy efficiency nor support for real-time streaming media are completely solved issues in wireless ad-hoc due to their highly dynamic topologies an limited network resources.

Therefore, we propose a new advanced reservation method for wireless ad-hoc networks, which reserves bandwidth for each user based on the probability and real-time movement parameters.

3.0 Probability-based Method for Resources Advanced Reservation (PMRAR)

3.1 Wireless ad-hoc networks Architecture

The wireless ad-hoc networks can be modeled as a graph G(V,E). The number of nodes is $N_n = |V|$ and that of links is $N_l = |E|$ .Link (i,j) means that nodes i and j can communicate. Let N_i be the neighbors of node i, Denote by N_i (h) the set of nodes that are at most h hops away from node i (including node i), for example, $N_i(1)=\{\{i\} \cup \{N_i\}$, Node i has bandwidth C_i, i.e., it can send a message to its neighbors at rate C_i.

A transmission interferes with nodes that are within a number of hops, H_i, from the transmitter and receiver, depending on the signal to noise ratio required for a correct reception. In the general case, for a successful transmission from node i to node j, it must be ensured that no node within H_i hops from receiver j are transmitting at the same time. Moreover, in order to ensure that the transmission of node i does not interfere with other ongoing transmissions, it must be ensured that no nodes within H_i hops from node i are receiving at the same time. Therefore reserving a unit of bandwidth for transmission from i to j requires the reservation of a unit of bandwidth from all receiving nodes within H_i hops from node i and all transmitting nodes within H_i hops from j.

To simplify the bandwidth reservation process, one can impose the rule that whenever node i transmits to node j, the nodes in $N_i(H_i) \cup N_j(H_i)$ can neither transmit nor receive packets - this is the basic mode of operation in a CSMA-CD system. Therefore, transmitting b units of bandwidth from i to j, requires the reservation of b units of bandwidth on the nodes in $N_i(H_i) \cup N_j(H_i)$. Determining the minimal units that need to be reserved is complicated and depends on the selected end-to-end flow path. Instead, we first consider a simplified bandwidth reservation process determined by the following rule: Whenever b units of bandwidth need to be transmitted between nodes i and j, reserve b units of bandwidth on all nodes in $N_i(H_i) \cup N_j(H_i)$.

3.2 Definitions

Following are some terminology definitions we use throughout this method.

1).*Vicinity of a node $N_i(h)$*: all nodes within a particular number of hops (H) from the node. H is the radius of the vicinity.

2).*Neighbors of node N_i*: $N_i = N_i(1)$.

3).*Maximum transmit distance (R)*: the maximum distance (in hops) from the source node within which a transmitter is selected.

4).*Availablilty of node i's bandwidth $A_b(i)$*: When bandwidth b is not available, $A_b(i)=0$, and when bandwidth b is available, $A_b(i)=1$.

5).*Probability of node i choosing to be transmitted PB(i)*: be defined as $\frac{d-H}{R-H}$, where d is the number of hops transmitted from S_{node} to D_{node}. From the above equation, when d = H, PB(i) = 0, and when d = R, PB(i) = 1.

3.3 The PMRAR Reservation Model

In PMRAR model, an advance reservation request is typically characterized with a source node (S_{node}), a destination node (D_{node}), the bandwidth demand, the starting time(T_s)and the duration time(T_d). Once a request is received, the central controller performs an PMRAR algorithm to find a feasible route for the request based on the specified requirements as well as the current wavelength availability in the network. Since there is no wavelength conversion at each node, a route is feasible in the sense that an identical wavelength must be available on all links along the route. If a feasible route can be found, an available wavelength is selected and reserved on all links along the route, and a lightpath will be established at the specified starting time for the specified duration.

To support advance reservations, the time domain is divided into a series of timeslots of fixed length, which are denoted by TS_k, $\{k = 1,2,..\}$. The length of a slot τ depends on the minimum duration of an advance reservation. PMRAR algorithm assigns wavelengths at the granularity of a timeslot and for an integer number of timeslots. An advance reservation can only start at the beginning of a timeslot. Furthermore, let N_b be the number of bandwidth on each link. For each Link (i, j)$\in$ E , a series of vectors $\{PB_{L\,(i,j)}(k); k = 1,2,\ldots\}$ are defined, where $PB_{L\,(i,j)}(k)$ denotes the bandwidth availability on Link (i, j) during TS_k , which is updated dynamically and is defined as follows:

$$PB_{L\,(i,j)}(k) = \{A_b(k) \times P_b(k);\ b = 1,2,\ldots, N_b\}$$

3.4 The PMRAR Reservation Algorithm

For An PMRAR reservation request is characterized by S_{node}, D_{node} , T_s , T_d, then, the ending time T_e is equal to $T_s + T_d$. Since a reservation can only start at the beginning of a timeslot and the duration is an integer number of timeslots, we assume that $T_s = K_s\tau$ and $T_d = d\tau$, where both K_s and d are a positive integer. Accordingly, the objective is to find a feasible route that has an identical wavelength available on all links along the route during interval $[T_s , T_s + T_d]$. The procedures can be described as follows.

1) For each link Link(i, j)$\in$E , examine $PB_{L\,(i,j)}(k)$ for each slot TS_k during interval $[T_s , T_s + T_d]$. If $PB_{L\,(i,j)}(k) = 0$ for any of these slots, delete link(i, j) .

2) For the residual network, if S_{node} and D_{node} is not connected, the request is blocked.

3) If S_{node} and D_{node} is still connected, compute a route from S_{node} to D_{node} . Suppose that the computed route r consists of a set of nodes (N_r) and a set of directed links (E_r) that connect these nodes, which is denoted by $r = (N_r , E_r)$.

4) For each link Link(i, j)$\in E_r$ (i, j $\in N_r$) , calculate

$$PB_{L\,(i,j)} = \prod_{TS(k)\,\in[Ts,Ts+Td]} (PB_{L\,(i,j)}(k) \times 1_{Nb\times Nb})$$

If $PB_{L\ (i,\ j)} = 0$, it implies that no identical bandwidth is available for all slots during interval $[T_s , T_s + T_d]$ on Link(i, j) . In this case, go to (3) to compute the next possible route.

5) If $PB_{L\ (i,\ j)} \neq 0$, calculate

$$PB_r = 1_{1\times Nb} \times \prod (PB_{L\ (i,\ j)}$$

where PB_r is a $1\times N_w$ vector that reflects the bandwidths availability on route r ,$1_1 \times N_w$ is an $1\times N_w$ vector with all of its elements equal to 1, and $1_{Nw \times Nw}$ is an $N_w \times N_w$ unit matrix.

6) If $PB_r \neq 0$, it implies that at least one identical bandwidths is available on all links along the route. In this case, one of the available bandwidths is selected and is reserved on each link along the route during interval $[T_s , T_s + T_d]$.

7) If $PB_r = 0$, it implies that no identical bandwidths is available on all links along the route. In this case, go to (3) to compute the next possible route.

8) The above procedures will continue until a feasible route is found or all possible routes from S_{node} to D_{node} are examined. If no route can be found, the reservation request is blocked.

4.0 conclusion

This paper has presented a probability-based method for resources advanced reservation (PMRAR) in wireless ad-hoc networks. The proposed PMRAR solutions can effectively provide the typical quality of service for wireless ad-hoc networks reservations. To achieve good reservation performance, it is important to have a good evaluation of the increased complexity and make significant optimization of the proposed reservation solutions. We are currently carrying out this work.

5.0 Reference

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