A Survey of Coverage-Based Broadcast for Reducing Routing Overhead in Mobile Ad Hoc Networks

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Abstract:

The MANET is a special type of wireless mobile network in which mobile hosts can communicate without any aid of established infrastructure and can be deployed for many applications such as battlefield, disaster relief and rescue, etc. Broadcasting is to transmit a message from a source to all the other nodes in the network. A neighbor coverage-based probabilistic rebroadcast protocol for reducing routing overhead in MANETs. In order to effectively exploit the neighbor coverage knowledge, the rebroadcast delay to determine the rebroadcast order, and then we can obtain the more accurate additional coverage ratio by sensing neighbor coverage knowledge. And also define as connectivity factor to provide the node density adaptation. By combining the additional coverage ratio and connectivity factor, we set a reasonable rebroadcast probability. The advantages of the neighbor coverage knowledge and the probabilistic mechanism, which can significantly decrease the number of retransmissions so as to reduce the routing overhead, and can also improve the routing performance. Mobile ad hoc networks (MANETs) are multi hop wireless networks with mobile nodes that can move freely. Due to a dynamic topology and limited resources, developing a dynamic routing protocol that can efficiently find a routing path with low control overhead is crucial to MANETs. This propose a novel route discovery mechanism based on the estimated distance to reduce the control overhead of routing protocols in MANETs.

1. Introduction:

Ad hoc On Demand Distance Vector Routing (AODV) a novel algorithm for the operation of such ad hoc networks. Each Mobile Host operates as a specialized router and routes are obtained as needed, on demand with little or no reliance on periodic advertisements [1].

On-demand routing protocols construct a path to a given destination only when it is required. When a source node needs a route to some destination, it broadcasts a RREQ packet to its immediate neighbours. Each neighbouring node rebroadcasts the received RREQ packet only once if it has no valid route to the destination. Increasing control traffic could further lead into less packet delivery ratio and increase in delay. Under the worst case, it could result in "broadcast-storm" problem and the whole network will be congested. It is thus essential to understand the intricate relations between routing overhead and topology evolutions, for the design of routing protocols in MANETs. In sensor-networks, routing protocols, resource discovery, and network-integrated database systems all depend on flooding to construct efficient data collection trees [6].

Broadcasting is to transmit a message from a source to all the other nodes in the network. Probability-based approach is depends upon pre-defined fixed probability to determine whether it rebroadcast the packets or not. This value does not seem globally optimal for different node density and relative location from the sender. The coverage area can be estimated from the distance between sender and receiver node, and the distance can be estimated by signal strength or global positional system (GPS) [2].

MANETs are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using an existing fixed network infrastructure or centralized administration. The design of MANETs in a multi-hop environment is the design of dynamic routing protocol that can efficiently establish routes to deliver data packets between mobile nodes with minimum communication overhead while ensuring high throughput and low end-to-end delay. Each mobile node is required to periodically discover and maintain routes to every possible destination in the network [5].

Mobile ad hoc networks (MANETs) are multi hop wireless networks with mobile nodes that can move freely. Due to a dynamic topology and limited resources, developing a dynamic routing protocol that can efficiently find a routing path with low control overhead is crucial to MANETs. Thus, we combine the position-based routing features into on-demand routing protocols and propose an EstD-based routing protocol (EDRP) in the absence of positioning service to improve the route discovery [7].

2. Different Approaches and Algorithms

2.1 Ad Hoc on-Demand Distance Vector (AODV) Routing

Approach: Ad hoc On Demand Distance Vector Routing (AODV) a novel algorithm for the operation of such ad hoc networks. Each Mobile Host operates as a specialized router and routes are obtained as needed, on demand with little or no reliance on periodic advertisements. New routing algorithm is quite suitable for a dynamic self starting network as required by users wishing to utilize ad hoc networks. AODV provides loop free routes even while repairing broken links [1]. Because the protocol does not require global periodic routing advertisements, the demand on the overall bandwidth available to the mobile nodes is substantially less than in those protocols that do necessitate such advertisements [1].

Algorithm: The Ad hoc On Demand Distance Vector Algorithm: The algorithm's primary objectives are: To broadcast discovery packets only when necessary. To distinguish between local connectivity management (neighbourhood detection) and general topology maintenance. To disseminate information about changes in local connectivity to those neighbouring mobile nodes that are likely to need the information [1]. The **Path Discovery** process is initiated whenever a source node needs to communicate with another node for which it has no routing information in its table. The source node initiates path discovery by broadcasting a route request (RREQ) packet to its neighbours. The RREQ contains the following fields: < source_ addr, source_ sequence, broadcast_ id, dest_addr, dest_ sequence, hop _count >. **Reverse Path Setup:** The source sequence number is used to maintain freshness information about the reverse route to the source_ and the destination sequence number species how fresh a route to the destination must be before it can be accepted by the source. **Forward Path Setup:** A RREQ will arrive at a node possibly the destination itself that possesses a current route to the destination .The receiving node first checks that the RREQ was received over a bidirectional link. A route reply packet RREP back to its neighbour from which it received the RREQ RREP contains the following information: < source_addr, dest_ addr, dest sequence, hop _count, lifetime >. **Route Table Management:** The source and destination sequence numbers other useful information is also stored in the route table entries and is called the soft state associated with the entry. **Path Maintenance:** Movement of nodes not lying along an active path does not affect the routing to that path's destination. If the source node moves during an active session it can reinitiate the route discovery procedure to establish a new route to the destination. Alternatively and with far less latency such failures could be detected by using link layer acknowledgments (LLACKS) [1].

2.2 Probabilistic Counter-Based Route Discovery for Mobile Ad Hoc Networks

Approach: **ON-DEMAND ROUTE DISCOVERY MECHANISM IN AODV:** On-demand routing protocols construct a path to a given destination only when it is required. When a source node needs a route to some destination, it broadcasts a RREQ packet to its immediate neighbours. Each neighbouring node rebroadcasts the received RREQ packet only once if it has no valid route to the destination. Each intermediate node that forwards the RREQ packet creates a reverse route pointing towards the source node. When the intended destination node or an intermediate node with a valid route to the destination receives the RREQ packet, it replies by sending a route reply (RREP) packet [6].

Algorithm: **PROBABILISTIC COUNTER-BASED ROUTE DISCOVERY (PCBR):** The hybrid route discovery algorithm which combines the features of fixed probability and counter based approaches. Whenever a copy of the packet is received the counter is increase by 1. A high counter values implies that the node's number of neighbours is high while a low counter value relates to a small number of neighbours. Moreover, the value of packet counter does not necessarily correspond to the exact number of neighbours from the current node, since some of its neighbours may have suppressed their rebroadcasts according to their local rebroadcast probability [6].

2.3 Routing Overhead as a Function of Node Mobility: Modeling Framework and Implications on Proactive Routing

Approach: Mobility brings fundamental challenges to the design of protocol stacks for mobile ad hoc networks (MANET). Increasing control traffic could further lead into less packet delivery ratio and increase in delay. Under the worst case, it could result in "broadcast-storm" problem and the whole network will be congested. It is thus essential to understand the intricate relations between routing overhead and topology evolutions, for the design of routing protocols in MANETs [4]. Due to the inherent complexities, simulation-based approaches have been the major tool to analyze the performance (routing overhead, packet delivery ratio, delays) of MANETs in terms of mobility, power and optimum transmission radios. An analytical view of routing overhead of reactive protocols, assuming static network (manhattan grid) with unreliable nodes and concludes the scalability of reactive protocols with localized traffic pattern. The key insight that can be drawn from the results is that mobility will drive up the overhead by a penalty factor, which is a function of the overall stability of the network [4].

2.4 RBP: Robust Broadcast Propagation in Wireless Networks

Approach: Flooding is an integral part of many protocols and applications in wireless networks. Wireless routing protocols such as DSR, AODV, and ODRMP flood route discovery messages. In sensor-networks, routing protocols (such as in), resource discovery (such as directed diffusion), and network-integrated database systems (such as TinyDB) all depend on flooding to construct efficient data collection trees. Flooding-limitation protocols like SPIN and BARD resort to flooding when query history is not applicable [3].

ROBUST Broadcast Algorithm: RBP addresses the problem of poor reliability for broadcasting in low power wireless networks of non-uniform density. First, RBP requires that a node know the identity of its one-hop neighbours. This definition eliminates distant and weak neighbours, as well as neighbours with strongly asymmetric links. Second, RBP uses a simple algorithm for retransmission. Third, a key optimization in RBP is that both retransmission thresholds and the number of retries are adjusted for neighbourhood density. Higher density neighbourhoods require lower thresholds with fewer retries, since other neighbours are likely to broadcast as part of the same flood. Finally, an additional important improvement is directional sensitivity by detection of important links [3].

2.5 Probabilistic Broadcasting Based on Coverage Area and Neighbour Confirmation in Mobile Ad Hoc Networks

Approach: MANET is a special type of wireless mobile network in which mobile hosts can communicate without any aid of established infrastructure and can be deployed for many applications such as battlefield, disaster relief and rescue, etc. Broadcasting is to transmit a message from a source to all the other nodes in the network. It is widely used to resolve many network layer problems. Probability-based approach is depends upon pre-defined fixed probability to determine whether it rebroadcast the packets or not. This value does not seem globally optimal for different node density and relative location from the sender. The coverage area can be estimated from the distance between sender and receiver node, and the distance can be estimated by signal strength or global positional system (GPS) [2].

Algorithm: **DYNAMIC PROBABILISTIC BROADCASTING WITH COVERAGE AREA AND NEIGHBOR CONFIRMATION**: Probability based methods use certain predefined rebroadcast probability p ($0 < p \leq 1$) to decide whether to rebroadcast or not. **Shadowing Effect**: The goal of our protocol is to achieve high reach ability of broadcasting and reduction of rebroadcast. The distance from a node to the sender can be calculated from the signal strength or GPS (Global Positioning System). It is better for a node that is farther away from the sender to have high retransmission probability. This means that a node geographically further from the sender may potentially act as a relay node on behalf of a node closer to sender. **Dynamic Probabilistic Rebroadcast with Coverage Area**: The scheme is based on the shadowing effect. When a node receives a broadcasting packet, it refers to its distance from sender to determine its rebroadcast probability. **Dynamic Probabilistic Rebroadcast with Coverage Area and Neighbour Confirmation**: An important problem is how to minimize the number of rebroadcast packets while retransmission latency and packets reach ability are maintained appropriately [2].

2.6 Neighbour Coverage: A Dynamic Probabilistic Route Discovery for Mobile Ad Hoc Networks

Approach: MANETs are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using an existing fixed network infrastructure or centralized administration. The nodes are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. One of the fundamental challenges in the design of MANETs in a multi-hop environment is the design of dynamic routing protocol that can efficiently establish routes to deliver data packets between mobile nodes with minimum communication overhead while ensuring high throughput and low end-to-end delay. Each mobile node is required to periodically discover and maintain routes to every possible destination in the network [5]. In the on-demand routing protocols, such as AODV and DSR, routes are discovered only when they are needed. In conventional on-demand routing protocols, a node that needs to discover a route to a particular destination, broadcasts a Route Request control packet (RREQ) to its immediate neighbours. If the destination node is reached, the maximum number of rebroadcasts is about $N - 2$, where N is the total of number of nodes in the Network. This can potentially lead to excessive redundant retransmissions and hence causing considerable collisions of packets in a contention-based channel, especially in dense wireless networks. Such a phenomenon induces what is known as broadcast storm problem, which has been shown to greatly increase network communication overhead and end-to-end delay. In conventional probabilistic broadcast schemes, every mobile node rebroadcasts a packet based on a predetermined fixed forwarding probability p. This paper proposes a new probabilistic route discovery approach, called Dynamic Probabilistic Route Discovery (or DPR for short) which addresses the broadcast storm problem in existing on-demand routing protocols [5]. In this approach, each node, upon receiving a broadcast packet, forwards the packet with probability p determined by the neighbourhood coverage and the local density of the node. The aim of this method is to keep the routing overhead low while achieving high reach ability in order to ensure high overall network connectivity.

Algorithm: **ON-DEMAND ROUTE DISCOVERY (AODV)**: On-demand routing protocols construct a path to a given destination only when it is required. They do not maintain topological information about the whole network, and thus there is no periodic exchange of routing information. Since the focus of our study is on the route discovery part of the protocol. **DYNAMIC PROBABILISTIC ROUTE DISCOVERY (DPR)**: In traditional AODV, an intermediate node rebroadcasts all RREQ packets that are received for the first time. Assuming no intermediate node has a valid route to the destination and N is the total number of nodes in the network, the number of possible rebroadcast in AODV is $\mathbf{N} - 1$. The basic probabilistic route discovery is simple. A source node sends an RREQ to its immediate neighbours with probability $\mathbf{p} = 1$. When an intermediate node first receives the RREQ packet, with probability $\mathbf{p} < 1$ it rebroadcasts the packet to its neighbours and with forwarding probability $1 - \mathbf{p}$ it simply drop the packet. Since the decision of each node to rebroadcast a packet is independent, the possible number of rebroadcasts is $\mathbf{p} \times (\mathbf{N} - 1)$. **Local Density:** To estimate the density of a region in the network, we use the local neighbourhood information of the region. A node is considered to be located at a dense region of the network if its number of neighbours is more than the average number of neighbours in the network. In the hello protocol, nodes exchange hello packets periodically. The size of hello packets and the rate at which they are transmitted can drastically consume the communication bandwidth and thus degrade the overall network throughput. **Covered Nodes:** The goal of our protocol is to reduce the transmission redundancy incurred in disseminating the REEQ packet without degrading the overall network throughput. Our dynamic probabilistic route discovery allows each node to determine its forwarding probability according to the characteristic of its local density and the set of neighbours which are covered by the broadcast. When a node is ready to forward an RREQ packet, it appends its most recent neighbour list [5].

2.7 An Estimated Distance Based Routing Protocol for Mobile Ad Hoc Networks

Approach: Mobile ad hoc networks (MANETs) are multi hop wireless networks with mobile nodes that can move freely. Due to a dynamic topology and limited resources, developing a dynamic routing protocol that can efficiently find a routing path with low control overhead is crucial to MANETs. In view of this, we propose a novel route discovery mechanism based on the estimated distance (EstD) to reduce the control overhead of routing protocols in MANETs [7]. The directed route discovery may restrict the propagation of RREQ packets within a narrow region, which includes the destination, and avoid the region that is far away from the destination. Thus, we combine the position-based routing features into on-demand routing protocols and propose an EstD-based routing protocol (EDRP) in the absence of positioning service to improve the route discovery. The contributions of this paper are as follows. (1) We propose an algorithm to estimate the distance of two nodes without positioning service. The EstD includes two parts: a) the estimated geometrical distance (EGD), which is based on the change regularity of the received signal strength (RSS) at the contact time of two nodes to estimate the future geometrical distance after the nodes have parted from each other, and b) the estimated topological distance (ETD), which is a topology-based EstD to refine the inaccurate estimation of the EGD when it grows large. By using the EstD, we divide the entire network area into three zones: (a) src-Zone; (b) dst-Zone; and (c) other-Zone. In each different zone, we adopt a different strategy to forward RREQ packets; (2) This propose a method utilizing the computational process of the EGD to evaluate the quality of link between neighbors and then exclude the weak links. This is very important for routing protocols because it can reduce the frequency of path failures and route discoveries; (3) The combination of exclusion of weak links and utilizing the EstD (EGD and ETD) to steer the propagation direction of RREQ packets to the general direction of the destination, the protocol can significantly reduce the routing overhead and improve the routing performance in dense or high-mobility networks [7].

Algorithm: **ESTIMATING GEOMETRICAL DISTANCE BASED ON CHANGE REGULARITY OF RECEIVED SIGNAL STRENGTH IN CONTACT TIME**: The computation of EGD and analyzes the properties of the EGD. **Computation of EGD**: To estimate the future geometrical distance of a two-node pair after the two nodes left each other's transmission range, the change regularity of the distance when they are in contact time. The regularity of the relative motion of two nodes in contact time is expected to continue for a while, and the future distance called EGD has some relation with its change in contact time. This idea is related to the signal-stability-based adaptive (SSA) routing protocol and the distinctive feature of the SSA are to use the signal strength to find and maintain stable routes. However, our idea is to use the change of signal strength to obtain the correlation of distance and time. The researchers in positioning have taken into account the error of RSS and have obtained many valuable results that can be used in our routing mechanism. We assume that nodes Ni and N_j move at velocities of v_i and v_j. If we consider node N_i as a reference frame, then node N_j moves at a relative velocity of $v = v_j - v_i$. According to the locality feature, node N_j keeps this relative velocity in some distance. The calculation of the EGD as follows: When node N_j is in node N_i's transmission range, assuming at times T_0, T_1, andT_2, node *Ni* receives packets from N_j with signal strengths P_0, P_1, and P_2, then N_i can use a radio propagation model to calculate the distances D_0, D_1, and D_2 from N_j. Using the six values of T_i and D_i, i = 0, 1, 2, node N_i can obtain the relative velocity v of N_j with itself. We assume that at time T ($T > T_2$), node N_j still keeps the relative velocity v with N_i, and the distances between nodes N_j and N_i are represented by the following equations:$D^2_1 = D^2_0 + (vt_1)^2 – 2D0\ (vt_1) \cos \theta$, $D^2_2 = D^2_0 + (vt_2)^2 − 2D0\ (vt_2) \cos \theta$, $D(t)^2 = D^2_0 + (vt)^2 − 2D0\ (vt) \cos \theta$, where $t_1 = T_1 − T_0$, $t_2 = T_2 − T_0$, and $t = T − T_0$. According to the first two equations, we can solve v and θ, and derive $D(t) = \sqrt{(At^2 + Bt + C)}$, where $A = (1/t_1t2)\ D^2_0 – 1/t_1\ (t_2–t_1)\ D^2_1 + 1/t_2\ (t_2–t_1)\ D^2_2$, $B = −(1/t_1 + 1/t_2)\ D^2_0 + t_2 / t_1\ (t_2–t_1)\ D^2_1 − t_1/t_2\ (t_2–t_1)\ D^2_2$, $C = D^2_0$. Note that D_0, D_1, and D_2, as well as T_0, T_1, and T_2, are iteratively calculated. That means when node N_i receives the k^{th} ($k > 2$) packet from N_j, we do the following iterative calculation: $T_0 \leftarrow T_{k−2}$, $T_1 \leftarrow T_{k−1}$, and $T_2 \leftarrow T_k$; and $D_0 \leftarrow D_{k−2}$, $D_1 \leftarrow D_{k−1}$, and $D_2 \leftarrow D_k$. Thus, T_i and D_i, i = 0, 1, 2, are always the last three packet's transmission times and distances. Then, each node needs a table to store the encounter information such as T_i and D_i, i = 0, 1, 2, and the size of the table is O (n), where n is the number of nodes. Now, $EGD(t) = D(t) = \sqrt{(At^2 + Bt + C)}$ is represented as a function of time t, and t is the difference between the current time and the time of the third to the last packet received from node N_j [7].

Properties of EGD: To observe the relationship between the EGD and the actual distance, we plot the empirical conditional mean of the actual distance between node pairs, conditional on their EGD. $E\{L\} = \{1/15[1/k^2 + k^3 + \sqrt{1} + k^2 (3- 1/k^2- k^2)] + 1/6[k^2 \operatorname{arcosh} \{(\sqrt{1} + k^2)/k\} + 1/k \operatorname{arcosh} \sqrt{1} + k^2]*a\}$.

Dividing Network Area Into Zones Based on E-Radius: A node can effectively estimate the distance to other nodes that are in its E-Zone. Then, we define the E-Zone of the source node as src-Zone and the E-Zone of the destination node as dst-Zone. Except for src-Zone and dst-Zone, at most, three E-Zones can cover any node pairs, and thus, the rest area other-Zone is only one of the three situations: (1) mid-Zone, which is in the middle of src-Zone and dst-Zone; (2) src-Bound, which is the bound zone in the side of src-Zone; (3) dst-Bound, which is the bound zone in the side of dst-Zone [7].

3. Conclusion:

A neighbor coverage-based probabilistic rebroadcast protocol for reducing routing overhead in MANETs. In order to effectively exploit the neighbor coverage knowledge, the rebroadcast delay to determine the rebroadcast order, and then we can obtain the more accurate additional coverage ratio by sensing neighbor coverage knowledge. And also define as connectivity factor to provide the node density adaptation. By combining the additional coverage ratio and connectivity factor, we set a reasonable rebroadcast probability. The advantages of the neighbor coverage knowledge and the probabilistic mechanism, which can significantly decrease the number of retransmissions so as to reduce the routing overhead, and can also improve the routing performance.

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