EFFICIENT PACKET DELIVERY APPROACH FOR AD-HOC WIRELESS NETWORKS

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Abstract: A wireless ad-hoc network is a collection of nodes which are self-configuring, connected by wireless links. The nodes are free to move randomly and organize themselves arbitrarily; thus, the network's topology may change rapidly and unpredictably. These kinds of networks are very flexible and they do not require any existing infrastructure. Therefore, ad-hoc wireless networks are suitable for temporary communication links. The biggest challenge in these kinds of networks is to find a path between the communication end points of nodes that are mobile. Due to the limited transmission range of wireless interfaces, the communication traffic has to be relayed over several intermediate nodes to enable the communication between two nodes. Therefore, these kinds of networks are also called multi-hop ad-hoc networks. The proposed model is designed to improve the problems of real-time event-based communication. It improves the packet delivery ratio by prior prediction and reduces end-to-end packet delay. This in turn improves performance of the routing process significantly and increases the Quality of Service (QoS).

Keywords: Ad-hoc Wireless Networks, QoS, Lagrange Interpolation, Power, Predictive Preemptive approach

1. Introduction

Ad-hoc wireless networks comprise of sets of nodes connected by wireless links that form arbitrary wireless network topologies without the use of any centralized access point. Ad-hoc wireless networks are inherently self-creating, self-organizing and self-administering. The nodes are free to move randomly and organize themselves arbitrarily. Thus the network's topology may change rapidly and unpredictably. The biggest challenge in these kinds of networks is to find a path between the communication end points of nodes that are mobile. Due to the limited transmission range of wireless interfaces, the communication traffic has to be relayed over several intermediate nodes to enable the communication between two nodes. Therefore, these kinds of networks are also called multi-hop ad-hoc networks. Every node acts as both, a host and as a router. Another limitation associated with wireless devices is the power constraint of the nodes i.e. each node has only limited battery power which should be used judiciously for the node to survive longer and to provide its services within the network.

Nodes cooperate with their neighbors to route data packets to their final destinations. As intermediate nodes may fail, routes between sources and destinations need to be determined and adjusted dynamically. Routing protocols for ad-hoc networks typically include mechanisms for route discovery and route maintenance. The route discovery mechanism is invoked to determine a route between a sender and a receiver. The performance of these protocols depends on the route maintenance mechanism they use. Schemes that use Global Positioning System (GPS) information for detecting and handling expected link failures early have been proposed [1].A node on a route from a source to a destination may become unreachable from its predecessor node because of node movement or node failure. In this paper, route maintenance is initiated

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when a link break is expected rather than waiting for the break to happen. The route maintenance mechanism finds new valid routes as substitutes for broken active routes. Several approaches to route maintenance have been proposed. In this paper, a predictive preemptive local route repair strategy is used [2] [3] [4]. Its aim is to find an alternative path before the cost of a link failure is incurred. A link is considered likely to break when the power of either of the nodes that it connects is close to the minimum detectable power. Route repair (finding sub-path to the destination) is the responsibility of a source node after receiving a warning about the imminence of a link break on an active route to a destination.

Quality of Service (QoS) is the performance level of a service offered by the network to the user. It is the collective set of service performance which determines the degree of satisfaction of the user of the service.Providing QoS in MANETs is a challenging and difficult task where nodes may leave or join the network and move around dynamically. Our approach aims to improve the QoS by predicting a link failure before its occurrence thereby routing packets through an alternative path.

Applications and Challenges

Commercial scenarios [5] for ad-hoc wireless networks include:

- Conferences/meetings/lectures
- Emergency services
- Law enforcements

Current challenges for ad-hoc wireless networks include:

- Multicast
- QoS support
- Power-aware routing
- Location-aided routing

2. Major Challenges in AD-Hoc Wireless Networks

Major challenges [6] in ad-hoc wireless networks are:

1. **Mobility:** One of the most important properties of ad-hoc wireless networks is the mobility associated with the nodes. The mobility of nodes results in frequent path breaks, packet collisions, transient loops, stale routing information and difficulty in resource reservation.
2. **Bandwidth constraint:** Since the channel is shared by all nodes in the broadcast region, the bandwidth available per wireless link depend on the number of nodes and traffic they handle.
3. **Error-prone and shared channel:** The bit error rate (BER) in a wireless channel is very high, compared to that in its wired counterparts.
4. **Lack of centralized control:** The major advantage of an ad-hoc network is that it can be set up spontaneously without the need for centralized control. Routing and resource management are done in a distributed manner in which all the nodes cooperate to enable communication among them.
5. **Resource constraints:** The constraints on resources such as computing power, battery power, and buffer storage also limit the capability of the network.

3. Quality of Service (QoS)

Quality of Service (QoS) [6] is the performance level of a service offered by the network to the user. 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. QoS is the collective set of service performance which determines the degree of satisfaction of the user of the service.

The dynamic nature of ad-hoc networks makes QoS a challenging and difficult task where nodes may leave or join the network or move around anytime. To support QoS, the link state information such as delay, bandwidth, cost, loss rate, and error rate in the network should be available and manageable [7].

QoS parameters in ad-hoc wireless networks

A service can be characterized by a set of [6] measureable service requirements such as bandwidth, delay, delay jitter, power etc… Military applications have stringent security requirements while emergency operations should operate with minimal overhead.

4. Proposed Algorithm

Step1: Power of the node is computed using the following equation

Pb = P - k – n.x…………………Eqn (1)

Where Pb – Battery Power
P – Power as calculated by Lagrange's equation
k – Constant factor for battery drain
n- No. of packets processed
x- Processing factor

Step2: When the power Pb of a node N is lower than the minimum acceptable power as shown in Eqn (1), a warning message is first propagated to the predecessor node and in case the predecessor node is unable to find an alternative path to the destination [8] [9] [10][11], then the link failure warning message is further propagated to all upstream sources that make use of this node. The routing table is also updated to notify the nodes in the network about the change in the network topology that is expected to take place as a result of node failure.

```
Predict ()
{
        If (Pb <= Min_Acc_Power) then
        {
        Send_ warning (predecessor node);
        Segmentation_Of_Packets ();
```

//transmit only the remaining data packets which had not been transmitted earlier
//through this route, prior to link failure, through an alternative route, to the
//destination
}

}

Step3: The predecessor of node N then initiates a local route repair procedure to find an alternative path to the destination by consulting the updated routing table. The proposed approach also accounts for the segmentation of packets.ie. the source sends only the remaining data packets which had not been transmitted earlier through the path in which the link failure had occurred thereby leading to its abandoning, through an alternative route, to the destination.

Step4: When the power of the node N becomes zero, then the node is removed from the network and all links attached to it are broken.

5. Sequence of Activities

In the Predictive Preemptive Local Route Repair Strategy for improving QoS, we have proposed the following sequence of steps that occur for the routing process as shown in Figure 1.

1. The user requests for the creation of a node in a specified cell of the pre-defined grid.
2. The deploy network option responds by asking the user for the (X, Y) location of the center of the circular node.
3. The user then replies with the (X, Y) location and as a result, the deploy network process successfully creates the node and assigns a node number to it.
4. In this way, the user can deploy several nodes in the network.
5. Upon the creation of every node, the node value is forwarded to the Routing process, which in turn updates the routing table and checks for the presence of nodes which lie within the range of a given node. This is the Route Discovery mechanism.
6. Every node has a pre-defined range, in which it can detect the presence of other nodes. The following strategy is adopted when a node needs to find a path to an unknown destination.
7. We adopt 4 techniques to determine the nodes which lie within the range of the concerned node and can hence be detected by the concerned node,

i.) Check the range of the concerned node in clockwise direction.
ii.) Check the range of the concerned node in Anti- clockwise direction.
iii.) Check the range of the concerned node in down clockwise direction.
iv.) Check the range of the concerned node in down anti-clockwise direction.

8. This approach is particularly useful in determining the shortest path (minimum number of hops) to the destination.
9. Next, the user requests for the transmission of data from the source to the destination.
10. The Deploy network process responds, by asking the user for the source and destination and in Turn, the user specifies the desired source and destination node.

11. The Send Data Process as shown in Fig 2 then finds an optimal path (consisting of least number of hops) between the source and destination by consulting the routing table.
12. Next is the Route Maintenance and Route Failure Handling phase.
13. Link failure may occur due to the crashing of certain nodes because of the depletion of their battery power. Such failures are handled by the route failure handling phase. On reaching the source, route discovery phase is restarted.
14. We propose a predictive preemptive local route repair strategy to increase Quality of Service (QoS) in the network. Its aim is to find an alternative path before the cost of a link failure is incurred.
15. The power of the node is used to estimate when a link is expected to break. A link is considered likely to break when the power of either of the nodes that it connects is close to the minimum detectable power.
16. When the power of a node becomes lower than the minimum acceptable power, a warning message is sent to the predecessor node which then attempts to find an alternative path to the destination. This is the local route repair strategy adopted.
17. If a link should fail, the node whose power has decreased below the pre-defined threshold power is simply removed from the routing table, the next-hop probabilities are recomputed for the remaining set (ie. the routing table contents are updated) and the remaining packets which were not transmitted earlier through the route which has failed are sent through an alternative path.
18. If no nodes lie within the range of the source node or any of the intermediate nodes to route packets, the packet is dropped.
19. Finally, data is successfully transmitted through the alternative path to the destination.

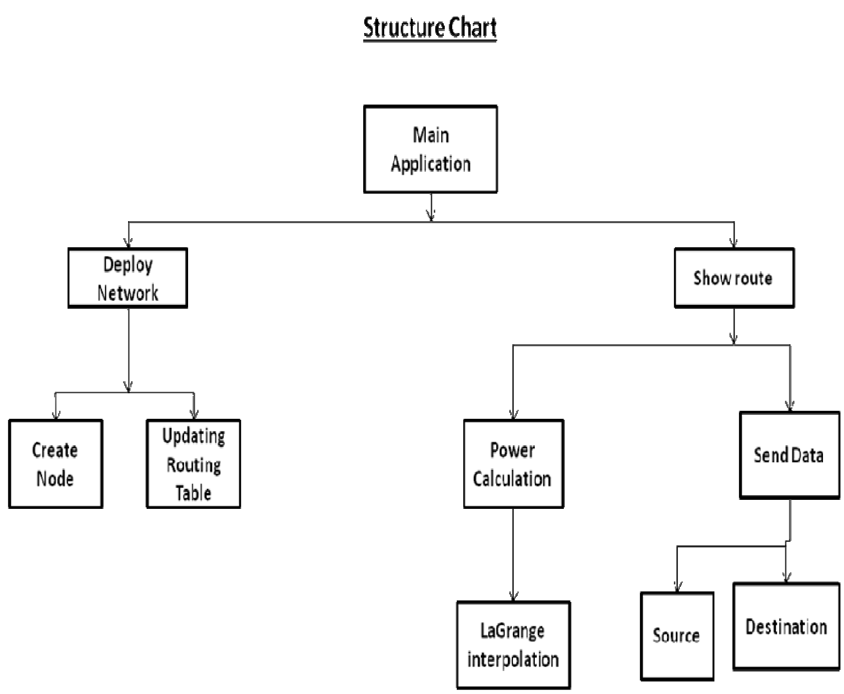

Fig.1Structured Chart for Predictive Preemptive Local Route Repair Strategy

6. Related Route Maintenance Mechanisms

Route failures have a significant negative impact on packet delivery. Packet dropping and higher delays are the main consequences of route failures. The time elapsed between link break detection and alternative path establishment can be high. Therefore, many studies have focused on improving route repair.

In [2], Crisòstomo et al. propose a Preemptive Local Route Repair (PLRR) extension to AODV. Nodes trigger the preemptive local route repair procedure when they predict that a link on the route to a destination is about to break. All packets are modified so as to contain node positions and motion information obtained using GPS receivers that nodes are equipped with. The problems with this approach are the cost associated with using a GPS and the need for synchronization between the internal clocks of nodes.

Cahill et al. [1] propose the use of node position and mobility information in the route discovery mechanism of DSR. When multiple routes to a destination exist, route selection is based on route stability and hop count. Moreover, nodes upstream of links that are predicted to break carry out preemptive local repair. This proposal uses DSR caching. Therefore, it is not applicable to AODV. Moreover, a GPS is used.

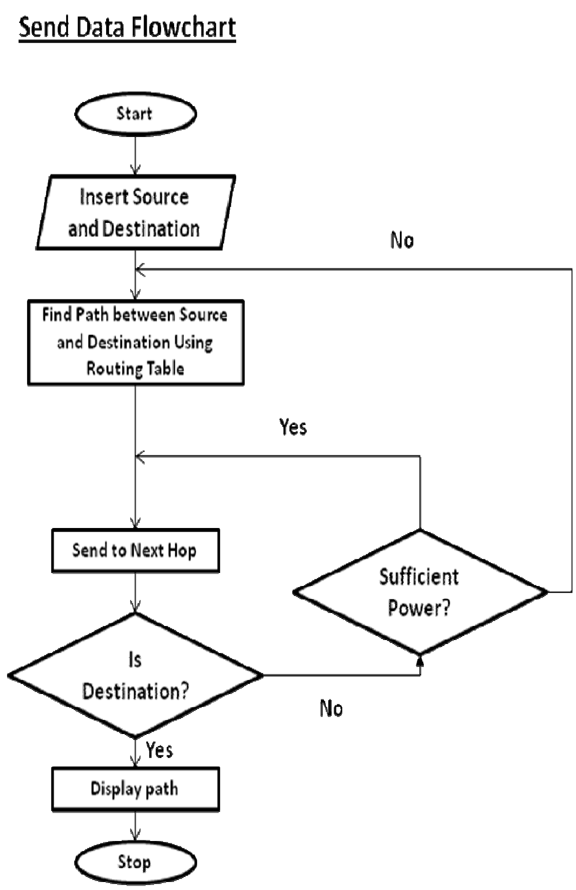

Fig 2 Send Data Flowchart

In [12], Goff et al. propose a preemptive route maintenance extension to on-demand routing protocols. Its aim is to find an alternative path before the cost of a link failure is incurred. The received transmission power is used to estimate when a link is expected to break. A link is considered likely to break when the power of the signal received over it is close to the minimum detectable power. Route repair is the responsibility of a source node after receiving a warning about the imminence of a link break on an active route to a destination. This mechanism has been applied to DSR; AODV is also considered, but only superficially.

7. Scope and Motivation

Routing in wireless ad-hoc networks has always been a challenging task, mainly due to the high degree of the dynamic nature involved in the network. The basic algorithms involve a lot of overhead due to exchange of routing tables among the nodes and every node maintaining the routing information about every other node. Predictive Preemptive Local Route Repair algorithm was chosen to be implemented due to following reasons:

- The application is designed for best effort delivery of data (higher packet delivery ratio).
- The aim of the application is to build an optimal path from the source to the destination (based on least hop count) and maintain it.
- It results in minimum overhead as it does not propagate unnecessary warning messages in the network to upstream nodes.
- It results in fewer broken active links due to prior prediction of link failure based on the power calculation for each node.
- It results in lower end-to-end delay.

Conclusion

We have proposed a protocol with a prediction mechanism that anticipates link breaks, and repairs them before they happen, thereby avoiding unnecessary warning messages and reducing control overhead. We also provide for segmentation of data packets that need to be transmitted from the source to the destination i.e. we transmit only the remaining data packets through an alternative path to the destination which had not been transmitted earlier prior to link failure through the failed route.

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