A Ring-Oriented Multicast Architecture over Mobile Ad Hoc Sensor networks

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Abstract

Detecting environmental hazards and monitoring remote terrain are among many sensor network applications. In case of fire detection, it is significantly valuable to monitor fire-spot's shape and trend in time. Mobile ad hoc sensor nodes right round are responsible for sensoring, processing and networking packets, or even launching extinguisher. In this paper, we proposed a ring-oriented Multicast architecture based on "Fisheye State Routing" (MFSR) to organize a group of mobile ad hoc sensor nodes in a multicast way. It is familiar with traditional mesh-based multicast protocol [1] in mobile ad hoc network, trying to concentrates on efficiency and robustness simultaneously. Certain applications-based solution for hazards is proposed, quantitative results including architecture and recovery algorithms of MFSR are also investigated in this paper.

Keywords: Multicast, Ring-oriented, Mobile ad hoc, Sensor networks.

1.Introduction

A sensor network is composed of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. With the development of modern industry, sensor nodes become to have more sophisticated computation, wireless communication, and mobile ability. Unfortunately, traditional sensor nodes usually can not afford peer-to-peer communication for lack of IP address. Herein we employ mobile ad hoc node that have routing ability instead of traditional sensor node. As defined in [5], they are called multihop ad hoc sensor network, in which each node plays the dual role of data originator and data routers.

Detecting environmental hazards and monitoring remote terrain are among many sensor network applications. In case of fire detection, it is significantly valuable to monitor fire-spot's shape and trend in time. Mobile Ad hoc sensor nodes right round are responsible for sensoring, processing and networking packets, or even taking actions to launch extinguishers.

We proposed a ring-oriented Multicast architecture based on "Fisheye State Routing" (FSR) [2] to organize a group of mobile ad hoc sensor nodes in a multicast way. It is familiar with hybrid multicast protocol and tries to address efficiency and robustness simultaneously.

The rest of this article is organized as follows. In section 2, background of Fisheye State Routing (FSR) is introduced. In section 3, ring-oriented Multicast architecture based on "Fisheye State Routing" (MFSR) is proposed in detail. Our conclusion and future work are presented in section 4.

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2. Fisheye State Routing Protocol (FSR)

The concept of fisheye, originated by Kleinroch and Stevens in 1971, is to reduce the size of information in graphical data.

Fisheye State Routing (FSR) is proposed as a mobile ad hoc network protocol by [2] in 2000. FSR introduces the notion of multi-layer fisheye scope to reduce routing update overhead in large-scale networks. Nodes exchange link state entries with their neighbors with a frequency that depends on distance to destination. From link state entries, nodes construct the topology map of the entire network and compute optimal routes. The background of FSR is briefly introduced below.

2.1 Overview for FSR

The goal of FSR is to provide an accurate routing solution while the control overhead is kept low. “Fisheye Routing” gets its name from a novel ‘fisheye’ updating mechanism. Similar to Link State Routing, Fisheye Routing generates accurate routing decisions by taking advantage of the global network information. However, this information is disseminated in a method to reduce overhead control traffic caused by flooding. Instead, it exchanges information about closer nodes more frequently than farther nodes. So, each node gets accurate information about neighbors and accuracy of information decreases as the distance from the node increases. Fig.1 illustrates the application of fisheye in a mobile wireless network. The center node defines a scope within which nodes cab be reached within certain link state entries. The center node has most accurate topology information about inner circle, and becomes less accurately known outer ones. Even though a node does not have accurate information about distance nodes, the packets could be routed correctly because the route information becomes more and more accurate as the packet moves closer to the destination. So we could predefine the scale by trading off overhead.

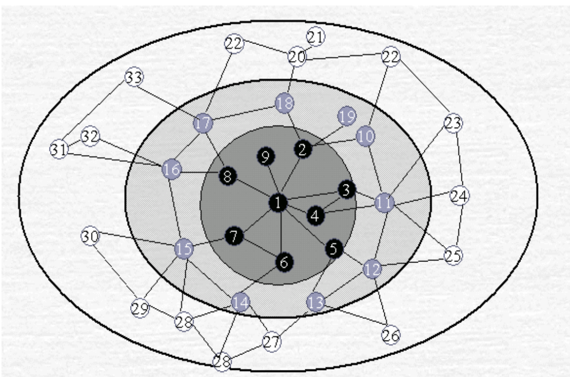

Fig. 1. Application of fisheye in a network

2.2 Table-Driven Design in FSR

Fisheye Routing determines routing decisions using a table-driven routing mechanism similar to link state. The table-driven ad hoc routing approach uses a connectionless approach of forwarding packets, with no regard to when and how frequently such routes are desired. It relies on an underlying routing table update mechanism that involves the constant propagation of routing information. Table-driven mechanism was selected over on-demand mechanism based on the following properties:

. On-Demand routing protocols on the average create longer routes than table driven routing protocols. The relative communication delay in sensor networks is significantly larger than that in traditional computational systems. In modern deep sub-micron (DSM) chip designs, delay on a single system- chip will be up to 20 clock cycles. However, even the fastest communication protocols will have delays in millions of cycles due to technological and physical limitations as well as system software overhead.

. Table-Driven routing accuracy is less sensitive to topology changes. Since every node has a ‘view’ of the entire network, routes are less disrupted when there is link breakage (route reconstruction can be resolved locally). Fortunately node in ad hoc sensor network usually has a less mobility rather than that in mobile ad hoc network.

For these reasons, a table driven scheme for the ad hoc sensor routing protocol was chosen as the basis of our multicast architecture. Link state was chosen over distance vector because of faster speed of convergence and shorter-lived routing loops. Link state topology information is disseminated in special link-state packets where each node receives a global view of the network rather than the view seen by each node’s neighbor. Fisheye routing takes advantage of this feature by implementing a novel updating mechanism to reduce control overhead traffic. The procedures for fisheye routing are described below.

2.3 Procedures in FSR

There are 3 main procedures in the FSR routing protocol:

1) Neighbor Discovery: responsible for establishing and maintaining neighbor relationships.

2) Information Dissemination: responsible for disseminating Link State Packets (LSP), which contains neighbor link information, to other nodes in the network.

3) Route Computation: responsible for computing routes to each destination using the information of the LSPs. Each node initially starts with an empty neighbor list and an empty topology table.

After its local variables are initialized, it invokes the Neighbor Discovery mechanism to acquire neighbors and maintain current neighbor relationships. LSPs in the network are distributed using the Information Dissemination mechanism. Each node has a database consisting of the collection of LSPs originated by others in the network. According to database, the node uses the Route Computation mechanism to yield a routing table for the protocol. The process is periodically repeated.

3. Multicast based on FSR

The motivation of MFSR lies in the unique application of mobile ad hoc sensor network which range from early forest fire detection to sophisticated earthquake monitoring in dense urban areas. In case of fire detection, it is significantly valuable to monitor fire-spot's shape and trend. Mobile ad hoc sensor nodes right round are responsible for sensoring, processing and networking packets, or even taking actions to launch extinguishers. Since the fire usually occurs in a state of art of irregular shape, surrounding polygon should be carefully monitored. Precise polygon detection is NP-hard and we use a ring topology instead. Thus we propose a ring-based multicast architecture to organize a group of mobile ad hoc sensor nodes located nearby to monitor the polygon in a multicast way. Thus the ring-oriented Multicast architecture based on "Fisheye State Routing" (MFSR). It is familiar with mesh-based multicast protocol who tries to address efficiency and robustness simultaneously, but is more suited for certain applications.

3.1 Invoking Ring-based Multicast Request

There are 2 main way of invoking ring-based multicast group: the center-spot based and the sink-based.

1) Center-spot based invoking request: this is the common mood for fare presentiment. Node located at the center-spot (the red node in Fig.2) is prone to find or estimate fire-hazard a little earlier than others and invokes

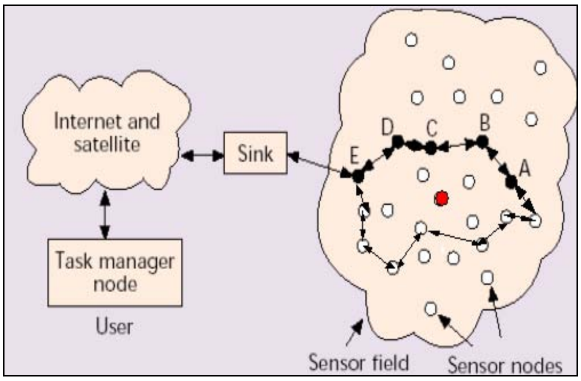

Fig. 2. Invoking ring-based multicast

multicast request. As aforementioned, it already has topology knowledge within certain scale by the help of FSR, a lower routing protocol. In order to access the surrounding border of polygon, a contact-based [3] method is employed. Herein we define contact radius and contact node. Contact radius means how far the border of safe region is away from the center, measured by hops. Contact nodes are those located at the border of polygon from the view of center spot.

2) Sink based invoking request: in case of center-spot failure, some node outside the fire-region will invoke the multicast request, thus called sink. Searching packets will explore the border containing the fire-spot in a loop-searching way [4] using flood or geocasting [6] method if the nodes equipped with GPS. Then, through comparing Link State Table of some certain nodes (E, D, C, B, A), we could calculate the center-spot and construct multicast ring.

It should be noted that ring may not be suited the fire-region at first. More precise adjustments are supposed to be executed to monitor fire-region in a better way.

3.2 Multicast Agent (MA)

Each ad hoc sensor node would establish a Multicast Agent (MA) [7] (shown in Fig.3). MA has two extra elements than traditional multicast agent: status table (ST) and token demon. ST keeps the information of its neighboring member nodes who share the same multicast group such as successor, predecessor; Token demon manages token that flows along the ring. In case of node failure or link breakage, some certain tokens such as recovery-REQ will be released to launch recovery procedure.

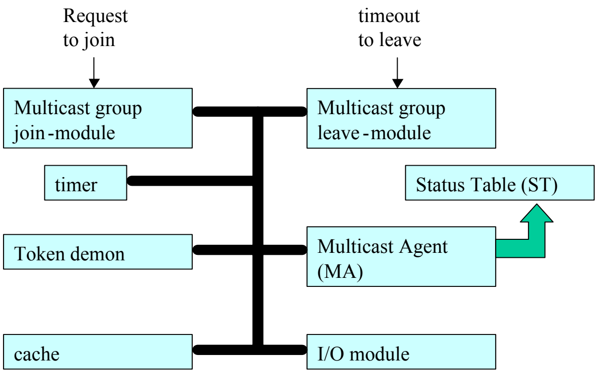

Fig. 3 Multicast Agent (MA) in mobile ad hoc sensor node

3.3 Recovery Algorithm of MFSR

The topology of ad hoc sensor network changes from time to time and ring-based topology of MFSR is prone to be broken by the fire spreading. Thus we develop recovery algorithm from [8]:

```
Flood recovery-REQ message and start the
timer after detecting failure
If (time-out expired & bridge not found)
      {Send recovery-fail to sink along
      reverse path;
      The neighboring nodes repeat Recovery
      algorithm;}
If (time-out not expired & bridge not found)
    {Again flood recovery-REQ;
     At each node hop-counter++;
    Hop-Counter's value is contained by
    recovery-REQ transmitted along flood
    path;}
If(time-out not expired & bridge found)
    {if (number of bridges>=2)
        {Select one with min-hops}
     Send back recovery-REP;
    Send recovery-success to sink along
    multicast loop;
     }
    Break;
}
```

4. Conclusion

In this paper, we proposed a ring-oriented Multicast scheme based on "Fisheye State Routing" (MFSR) to organize a group of mobile ad hoc sensor nodes in a multicast way. Architecture including invoking request, multicast agent and recovery algorithm are introduced. We hope our scheme could shed a little light on certain applications over mobile ad hoc sensor environment. In the future our work will focus on the simulation and optimizing recovery algorithms.

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