The Effect of Using XCAST Based Routing Protocol in Wireless Ad Hoc Networks

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***Abstract*— Wireless ad hoc networks are a type of wireless network that can be easily created without the need of network infrastructure or central administration. Unfortunately, wireless ad hoc networks suffer from some limitations related to the bandwidth leakage. So a proper data flow mechanism should be used to save the bandwidth consumption. So we proposed an XCAST based routing protocol (P-XCAST) to be used in wireless ad hoc networks, but XCAST was initially designed for wired network and there is an absence of software implementation. Our P-XCAST routing protocol is based on modifying route request control packets mechanism to build the network topology and route the data packet which hold the list of destination by classify the P-XCAST list of destinations according to similarity on their hop count number, to minimize the bandwidth consumption by sending one data packet instead of sending n packets equal to n destinations. In this paper, we have tested P-XCAST QoS parameters using background many-to-many applications under different groups' size and compare these results with AoDV and WRP routing protocols. The results of simulation reflect a better QoS performance parameters compared with AoDV and WRP routing protocols.**

Keywords-component; AODV, MANETs, ODMRP, PDR, PTT, P-XCAST, QoS , WRP, XCAST.

I. Introduction

Push to Talk (PTT) is "a wakie-talkie-type" half-duplex n near real time voice service that can be viewed as instant messaging services, enhanced with voice functionality. PTT provides fast access, two-way communication between two or more communicating parties .PTT were previously implemented using dedicated radio equipment. With the move towards IP-based converged network access, the implementation of PTT services and other group-based communications using IP becomes crucial. Since such group-based communications are characterized by multiple small-sized teams operating within a geographical area of interest, effective team or group-based routing protocols are necessary to support the effective use of limited wireless bandwidth.

In this paper, we propose a new XCAST based protocol (P-XCAST) to minimize the bandwidth consumption in wireless ad-hoc network. We develop a group request method to discover network topology and build a routing table for each node in the desired network, then we develop an XCAST based routing algorithm to send a data packets to their required list of destinations, and compare the obtained results with AoDV and WRP routing protocols under many-to many scenarios using GloMoSim network simulator. This paper is structured as follows: Section II provides an overview of related work for XCAST, a small-group based routing algorithm, and the use of XCAST in wireless ad hoc networks. A new P-XCAST routing algorithm design is described in Section III. Performance evaluation using QoS metrics for comparison between P-XCAST and other routing protocols under different group sizes are presented in Section IV. Finally, Section V summarizes the results.

II. RELATED WORK.

A. *Wireless Ad Hoc Networks*

Wireless and Mobile Ad hoc Networks (MANETs) consist of multiple mobile devices spread out in a fixed area that establish peer-to-peer communications among themselves. Mobile Ad hoc Networks (MANETs) can support multi-hop communications through IP routing, via two classes of MANET routing protocols: Reactive or On-Demand protocols and Proactive protocols. Reactive protocols decrease overheads by only initiating a request when required, so they are more suitable for dynamic topologies; however this mechanism creates a setup delay when building new routes [1]. Ad-hoc On-Demand Distance Vector (AODV), Location Aided Routing (LAR), and Dynamic Source Routing (DSR) protocols are examples of reactive protocols [12] [3]. The main difference between AODV and DSR is that AODV is a distance vector routing protocol that only stores the next hop information in its routing table.

Proactive protocols periodically broadcast a control information message across the network in order to build or update routing table for every node. Wireless Routing Protocol (WRP) is an example on proactive protocols that maintains routing information through the exchange of triggered and periodic updates [13].

B. *Group Communications Protocols*

Since QoS is a crucial features of multimedia group applications such as PTT, and since wireless bandwidth is a

978-1-4244-4547-9/09/$26.00

scarce resource, efficient use of bandwidth is critical to support Quality of Service (QoS) for these applications. One approach is to adopt multicast in MANETs, using protocols such as On-Demand Multicast Routing Protocol (ODMRP) [4] and Multicast Ad hoc On-Demand Distance Vector (MAODV). For example, QS-AODV [5] adds new QoS features to AODV, by modifying RREQ, RREP and RERR messages by adding the Session ID and the required bandwidth for a given QoS flow. Two major goals for QS-AODV were: path selection that satisfies the QoS.

C. *XCAST Routing*

eXplicit Multicast (XCAST) is a multicast scheme designed to support networks with a large number of groups, where each group only has a small number of members (receivers). This is achieved by encoding the list of destinations in the XCAST header [6]. XCAST was initially proposed for use in wired networks; several proposals to adapt XCAST for MANETs were mentioned in [7], since XCAST minimizes the traffic load in the link from the source to the rest of network topology. So the use of XCAST as a group routing algorithm helps reduce the traffic load in the links, since XCAST packets are only duplicated when the network route branches, to reach specific receivers. Fig. 1 shows the mechanism of XCAST.

III. P-XCAST FOR GROUP BASED APPLICATION

A. *Group Membership Management*

The first step for applying the P-XCAST protocol in MANETs starts with determining the destinations that the sender wants to send data to, by defining a list of destinations for the source application. Hence applications must be P-XCAST enabled to manage the group membership list. Data packets are then sent to the transport layer (typically UDP) [11], which is also modified to enable the use of P-XCAST as the network layer protocol.

B. *P-XCAST Routing Algorithm*

It was noted that source advertising is more efficient and controllable than destination advertising [8]. The proposed P-XCAST protocol for MANETs is based on source advertisement. We propose the combination of source advertisements and on demand routing requests to reduce overhead, based on the AODV routing protocol. P-XCAST operates in the following three phases:

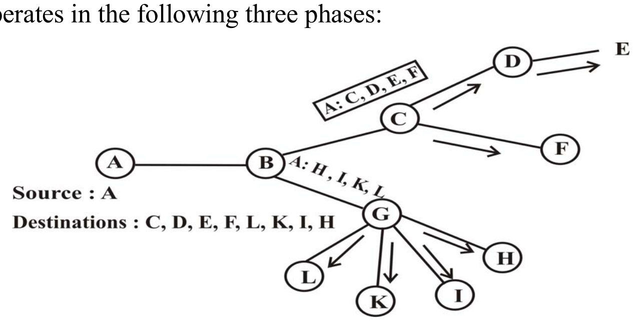

Figure 1. XCAST packets delivery mechanism

1) *Route Request Phase*

The Route Request packet consists of the following fields: Packet Type, Source Address, Destination Address, Sequence Number, Destination Number, Flow Id, and Time To Live (TTL) (Figure 2). This control packet is sent periodically by the sender nodes to discover the route to the receiver nodes for the group-based application.

TYPE	SRC. ADDRESS	DEST. ADDRESS	SNO	DEST. NO.	FID	TTL

Figure 2. P-XCAST route request control packet

2) *Route Reply Phase*

The Route Reply packet is the response generated by each destination for every source that send a Route Request packet, and consists of the following fields: Packet Type, Source Address, Destination Address, Destination Number, and Hop Count see Fig. 3.

TYPE	SRC. ADDRESS	DEST. ADDRESS	DEST. NO.	HOP COUNT

Figure 3. P-XCAST Route Reply Control Packet

3) *Data Forwarding Phase*

Data packets to be sent to a particular group are passed to the P-XCAST network routing layer, where the P-XCAST routing algorithm would perform the following actions to classify and build the correct XCAST header for subsequent transmission. This is illustrated in

Figure 4.

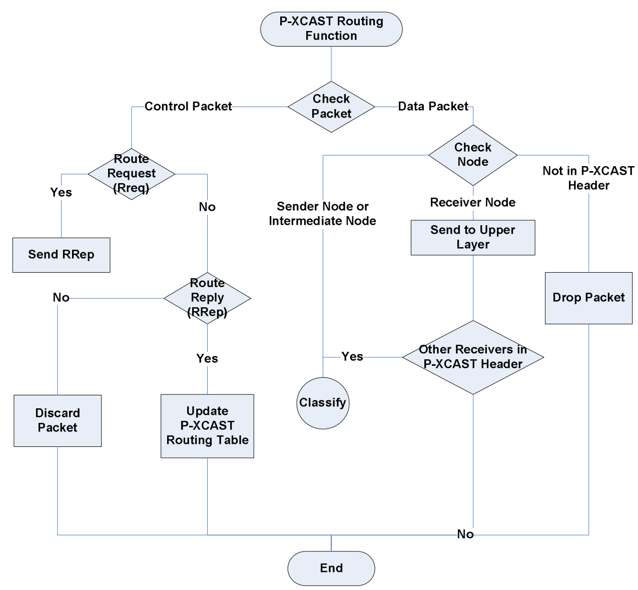

Figure 4. P-XCAST routing function

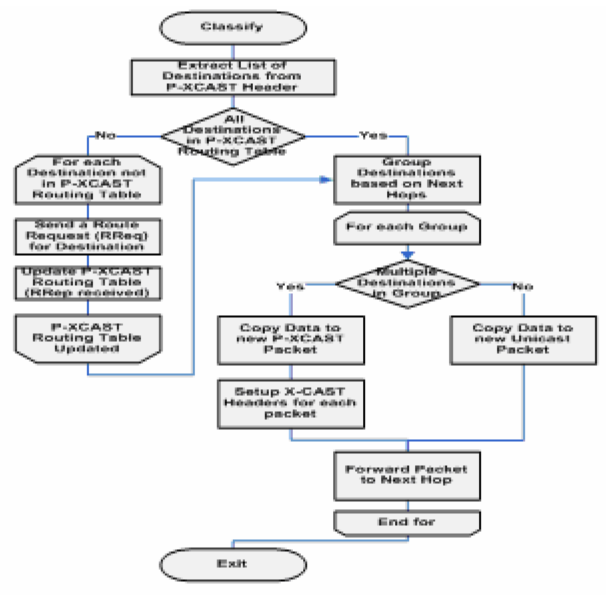

Figure 5. P-XCAST destination classification

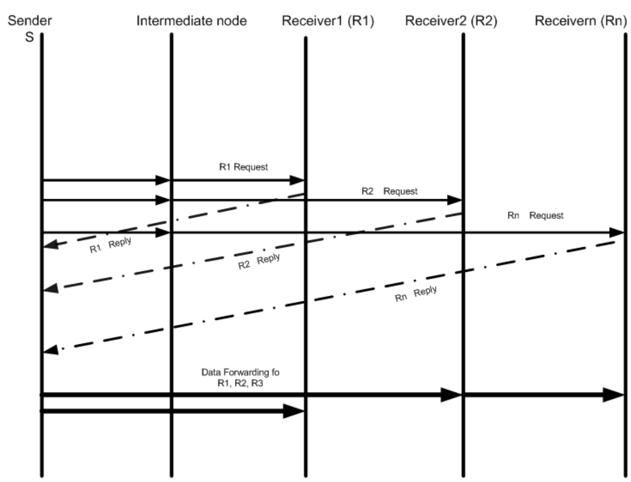

Figure 6. RREQ and RREP messages passing diagram

The P-XCAST data packet contains the list of all destination that the sender wants to send data packet to, some of these destinations may already exist in the routing table of the node. Other destinations not found in the routing table would trigger a Route Request, until all nodes have been updated in the P-XCAST routing table as shown in Fig. 5.

After the routing table is updated, then the list of destinations is grouped into P-XCAST sub-lists according to the next hop information. A number of P-XCAST packets equal to the number of sub-lists are created and the XCAST header information updated for each of the packets. Finally the new packets are forwarded to the next hops toward the destinations. If the list of destinations for a subgroup is a single destination, it is sent as a Unicast packet. For example, R1 is the only destination in the subgroup, while R2 & R3 both have a common Next Hop (Fig. 6).

IV. PERFORMANCE EVALUATION

The GloMoSim network simulator [10], was modified to implement the P-XCAST algorithm and conduct various simulation experiments to compare its results with the other routing protocols. These simulation experiments were performed for an open area of 2000 m × 2000 m, for over 900 seconds of simulation time. The group application was represented by a P-XCAST enabled Constant Bit Rate (CBR) source which generates data to its group members at the rate of 1 packet / s with packet size of 512 byte. Nodes in the simulation were placed in static topology with different sources representing foreground many-to-many applications, as shown in Fig. 7. Different group sizes, starting from five members per group (small group size) to larger group sizes of thirty members per group were studied. The experiments were run ten times using different initial random seeds value and averaged to give the recorded value in the graphs.

The efficiency of the P-XCAST is evaluated through the following QoS performance metrics:

- Throughput: defined as the data rate (bps), which is calculated as the total number of bit received divided by the difference between the reception time of the last packet and the reception time of the first packet.
- Latency or end-to-end Delay: defined as the difference between the generation time of a packet in the source node and the reception time for this packet at each node.

$$\overline{D} = \frac{1}{n}\sum_{i=0}^{n} Di \qquad (1)$$

- Jitter: the variation of end-to-end transient or absolute data packet transfer delay [9].

$$V^2 = \frac{1}{n-1}\sum_{i=0}^{n}(Di - \overline{D})^2$$

$$J = \sqrt{V^2} \qquad (2)$$

- Packet Delivery Ratio: defined as the ratio of number of packets received to the number of packet that should be received, and this factor is calculated to measure the efficiency of routing protocols in delivering packets to all group members.

$$\overline{PDR} = \frac{\sum \text{No. of (P.received)}}{\text{Nx} \times \text{No. of (P.sent)}} \qquad (3)$$

Where:

$\overline{PDR}$ = Average Packet Delivery Ratio

P.received = Packets received

P.sent = Packets sent

Nx = the number of destinations in P-XCAST header.

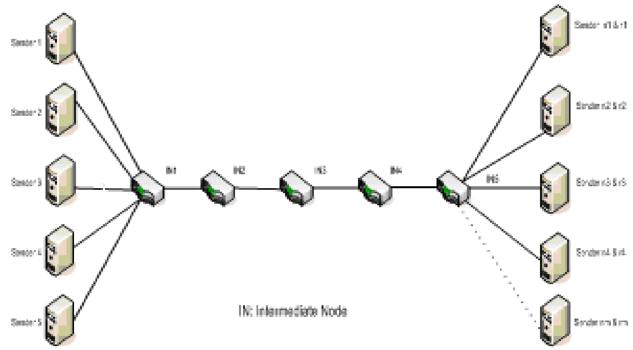

Figure 7. Network topology for many-to-many applications

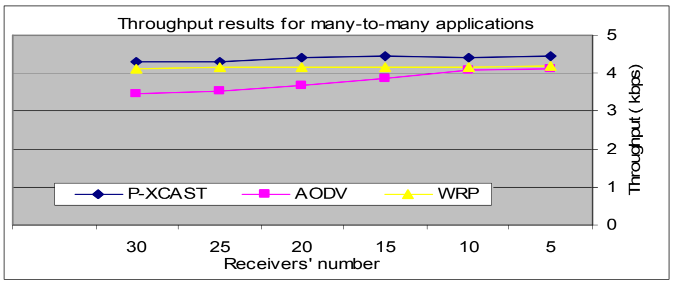

Figure 8. Throughput for many-to-many applications

A. The Effect of Varying Group Size on Throughput

In this scenario the QoS metrics were studied by investigating the effect of group size on throughput results using many-to-many applications. The size of group is varying from five until thirty receivers see Fig. 7. It is noted from the results there is no effect of increasing the number of receivers on P-XCAST Throughput, and it is almost identical and constant for P- XCAST and WRP. While it is less for AODV as shown in Fig. 8.

B. The Effect of Varying Group Size on Average Delay

The major constraint on real time applications is the Average Delay, which should be minimized. The average delay for P-XCAST is less than that for AODV and WRP even that WRP is a proactive routing protocol that doesn't incur any delay for topology discovering (Fig. 9). So, the use of P-XCAST is recommended to be used in real time applications that need a little amount of latency or delay.

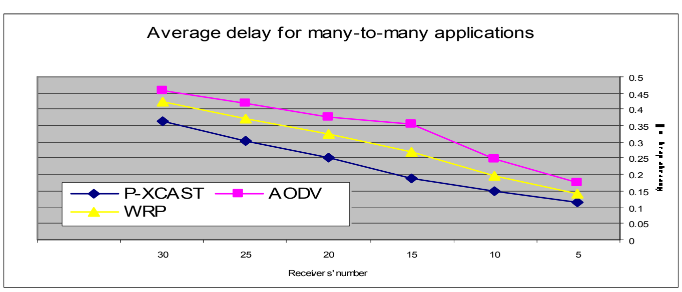

Figure 9. Average Delay for many-to-many applications

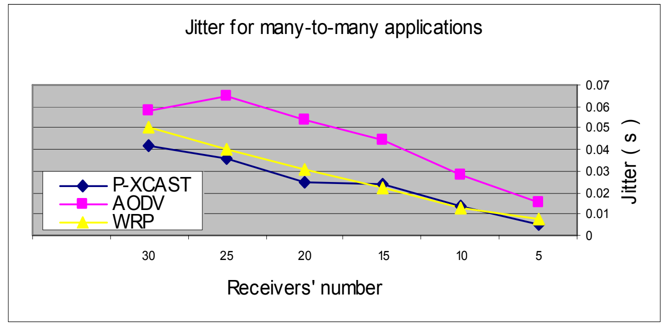

Figure 10. Jitter for many-to-many applications

C. The Effect of Varying Group Size on Jitter

Fig. 10 describes the effect of varying group size starting from five receivers until thirty receivers using foreground many-to-many applications as jitter, or delay variation should also be minimized, since it affects the behavior of real time applications, especially Voice over IP (VoIP) applications. The measured values in P-XCAST are less than the values obtained using AODV and WRP. This indicates that P-XCAST can provide better performance for applications as Voice over IP (VoIP) or PTT.

D. The Effect of Varying Group Size on PDR

As shown in Fig. 11, P-XCAST has better PDR performance than other protocols. PDR values for P-XCAST is fairly constant and does not change too much with increasing group sizes, while values for AODV fall sharply when the number of receivers exceeds fifteen. PDR for P-XCAST is better than WRP PDR for all number of receivers.

PDR is an indication of the effectiveness for any routing protocol as it measures the number of packets that are received correct without any loose. P-XCAST has a good PDR and it is almost equal to one.

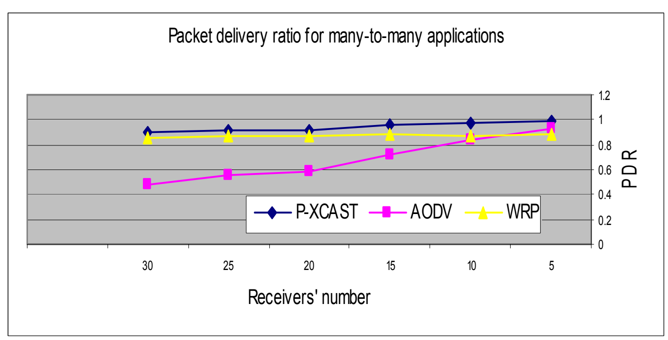

Figure 11. Packet Delivery Ratio for many-to-many applications

V. CONCLUSION

In this paper, P-XCAST, a new protocol based on the XCAST routing mechanism, has been adapted for group-based applications in MANETs, and evaluated using various QoS performance metrics to investigate its effectiveness in foreground many-to-many applications, in which different groups sending and receiving at the same time, then it is compared with AODV and WRP routing protocols. Different group sizes were evaluated. The results showed that the P-XCAST protocol is efficient in reducing network overheads and improving QoS performance. Our final goal is to test this protocol under different scenarios and to apply it towards dynamic topologies to support different mobility speeds, as well as to apply P-XCAST towards new IP Multimedia Services subsystems (IMS), so an effective group management protocol will be proposed over P-XCAST routing protocol.

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