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Multi-Paths Multicast Overlay Tree in Hybrid Mobile Ad-Hoc Network (HYMANET)

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Abstract

Mobile ad-hoc network(MANET) is a self-organized network over infraless structured radio links. And hybrid mobile ad-hoc network(HYMANET) is a network which is combined with infra(AP) and MANET. In these networks, one of the most critical problems is the deficient network resource for receiving multimedia streams. The other problem is that overlay connection tree shuts down frequently following mobile node(MN)s' movement. For solving these problems, this paper generates multi-paths overlay multicast connection tree using multiple parent-child relationships according to the number of hops towards AP(access point) in hybrid ad-hoc network. The proposed method can be used as service for live-video such as news, sports broadcasting image and movies in HYMANET. And this paper can minimize redundant multimedia streams that could appear when supporting multimedia service using multicast.

Keywords: *Multicast, Multimedia, Routing, WLAN, Ad-hoc network*

1. Introduction

Mobile devices, such as notebook computers, tabular PCs and handphones, enter into general use in wireless network. Internet services using these mobile devices are one of the most popular services. The wireless network to provide connection services for mobile device is divided into infra-structured network and infraless-structured network(ad-hoc network). As they're known, infra-structured wireless network uses access pointer(AP) to connect remote server, but infraless-structured wireless network makes up self-configured network without the aid of AP. The infraless-structured wireless ad-hoc network(ad-hoc network) in general does not provide Internet service. Thus, in mobile ad-hoc network(MANET), a variety of services are being provided in various areas such as battlefields, habitat managements along the seashore, emergency search, collapsed network recovery, rescue sites including collapsed buildings and conventions[1, 2].

Mobile devices configuring MANET that are provided the variety services as mentioned above are growing need to connect remote server through Internet. For this, hybrid mobile ad-hoc network(HYMANET) that is combined MANET and AP is needed in wireless network.

But wireless network has problems of power, connectivity between mobile nodes and deficient network bandwidth, which are the most critical ones [3-5].

Especially in MANET and HYMANET, the overlay tree to support connection between AP and mobile nodes(MN) to solve problems caused by limitation of transmission range of

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MNs and MNs' movement is very important. But it is easily shut down because the MNs move frequently here and there in MANET or HYMANET. Also, the deficient network bandwidth in wire/wireless network is critical for multimedia such as video, audio and images.

The transmission of the same multimedia data consumes excessive network bandwidth especially in wire/wireless network. Multicast technique can improve the efficiency of the deficient wireless link when sending the same multimedia data such as live-video, news and sports broadcasting[3, 6]. A number of researches have progressed to solve the problems such as the overlay tree being cut off easily because of MNs' movement and excessive consumption of deficient wireless link bandwidth is due to the multiple copies of the same multimedia data[7, 8, 9, 10]. But such researches are dealt with only one problem.

This paper presents a novel technique to reduce that the possibility of cutoff for overlay tree by supporting multi-paths and the possibility of redundant multicast streams. The proposed technique adopts addressing method that use the upper MN(1-less hop towards AP) which manages three lower MNs(1-more hop) in HYMANET. The overhead of the proposed addressing method is only 10-bit in case of putting 5-hop overlay tree as acceptable delay limits.

The rest of this paper is as the following: Section 2 describes the operation for multicast overlay connection in HYMANET and address allocation method for MNs. Section 3 deals with the algorithm for generation of overlay tree and establishing multicast group in HYMANET. Section 4 is simulation of proposed algorithms and analysis of the result. Finally, we discuss our conclusion.

2. The Operation for Multicast Connection in Hybrid Ad-Hoc Network

Hybrid mobile Ad-hoc network(HYMANET) for supporting the proposed technique is composed of an access point(AP) and a number of MNs[5, 7]. Providing connectivity among MNs in HYMANET, the connection in this paper limits 5-hops to alleviate the problem of transmission delay. Thus, MNs in this paper are divided into 5 groups to connect AP according to their transmission range.

The 1st group MNs can connect directly to AP. We call these MNs 1-hop away MNs. The 1-hop away MNs are directly assigned IP address by AP. The 2nd group MNs cannot connect directly to AP due to their transmission range, but they can connect to AP by way of 1-hop away MNs. We call these 2nd group MNs to 2-hop away MNs. In this HYMANET, thus there are 5-groups of MNs from 1-hop away MNs to 5-hop away MNs toward AP. Thus the adjacent two groups(n-hop MN and n+1-hop MN) are in the relation of parent-and-child. This connection tree towards AP according to the number of hops is called overlay tree as shown in Figure 1. The Figure 1 is called single-path overlay tree because it has only one-path towards AP. This single-path overlay tree tends to cutoff connection towards AP because of the movements of MNs configuring the tree.

Also, in this paper, we propose that the upper MNs(parent MN: 1-less hop MN towards AP) can manage up to 3 lower MNs(child MN: 1-more hop towards AP) to protect possibility of cutoff connection towards AP. As an example, in Figure 2 an 1-hop away MN(number 1 MN) can manage up to three 2-hop away MNs(number 3, 4, 5 MNs) and they may have managed by another 1-hop away MNs(number 2 MN). Thus the proposed method in Figure 2 provides multi-paths(redundant path) overlay tree available to multicast transmission that the lower MNs can have multi-path towards upper MN(or AP). As shown in Figure 2, the proposed technique has multi-path overlay trees because the 3-hop away MN 7 is connected to 2-hop away MN 4 and may have connected to another 2-hop away MN 5. Thus, the 3-hop away MN 7 can use dashed-line path when the 2-hop away MN 4 moves out of transmission boundary from it.

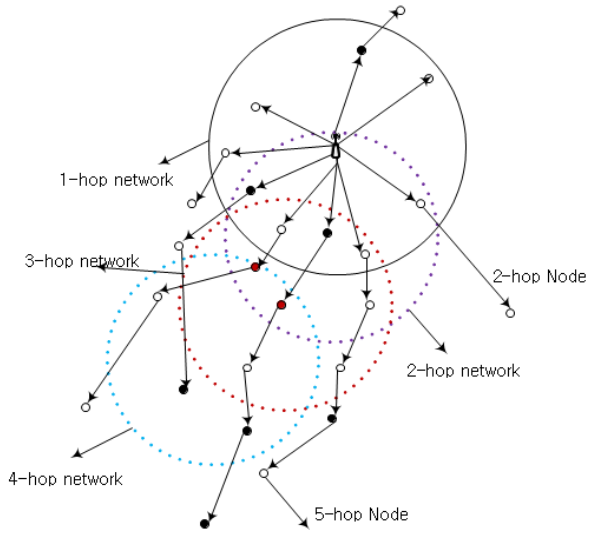

Figure 1. The Single-path for Multicast Overlay Tree in Hybrid Ad-hoc network

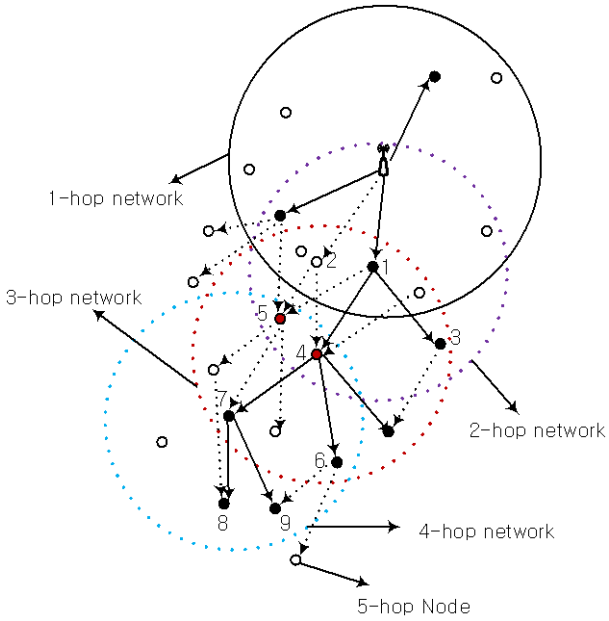

Figure 2. The Multi-paths for Multicast Overlay Tree in Hybrid Ad-hoc Network

Figure 3 shows multicast Acknowledgement(ACK) path towards upper MNs after lower MNs receive multicast streams from upper MN in hybrid Ad-hoc network. This path is the reverse path of Figure 2 except only path 4-hop away MN 9. If 4-hop away MN9 sends ACK to 3-hop away MN 7, the MN 6 sends the same multicast streams to MN 9 because the MN 6 recognizes that MN9 does not receive multicast streams. Thus, MN 9 receives redundant multiple copy of multicast streams. But MN 7 never sends the same multicast streams when MN 7 receives ACK from MN 9. This case the MN 9 does not receive multiple copy of multicast streams, thus the proposed method protects redundant multiple copy of it.

Figure 4 indicates the structure of the address packet according to the number of hops for the proposed technique. The 1st row of Figure 4(Figure 4 (1)) shows the whole address packet

format of acquired MNs' address from AP or the upper(parents) node. The address packet format is divided into 5-fields that indicate four hop-counts fields(8-bits long) assigned from AP or parent-node and assigned MN's address from AP or parents node. Each hop-counts field is allocated 2-bits. And as shown in (1) of Figure 4, the initial state of the four hop-counts fields and the IP of 1-hop away MN are all 1s as shown in (2) of Figure 4.

The Figure 4 (3) shows three 2-hop away MNs address assigned by 1-hop away MN and three 2-hop MNs are 111111**00**MN's ID, 111111**01**MN's ID and 111111**10**MN's ID. Thus these three 2-hop away MNs are managed by 1-hop away MN (11111111MN's ID). This managed system may have overload for connection establishment, but it is not critical problem because MNs are moved freely.

The Figure 4 (4) shows three 3-hop away MNs address assigned by 2-hop away MN and three 3-hop MNs are 1111**00**00MN's ID, 1111**01**01MN's ID and 1111**10**10MN's ID. Thus these three 3-hop away MNs are managed by 2-hop away MN (111111**00(01 or 10)**MN's ID).

The Figure 4 (5) shows three 4-hop away MNs address assigned by 3-hop away MN and three 4-hop MNs are 11**00**0000MN's ID, 11**01**1101MN's ID and 11**10**1110MN's ID. Thus these three 4-hop away MNs are managed by 3-hop away MN.

The Figure 4 (6) shows three 5-hop away MNs address assigned by 4-hop away MN and three 5-hop MNs are **00**000000MN's ID, **01**011101MN's ID and **10**101110MN's ID. Thus these three 5-hop away MNs are managed by 4-hop away MN.

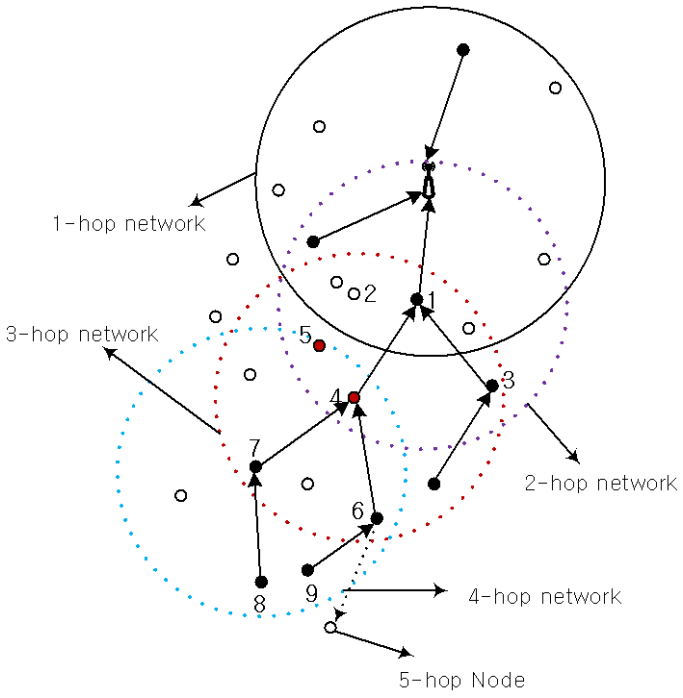

Figure 3. Multicast Acknowledgement (ACK) Path in hybrid Ad-hoc Network

The 7th row of Figure 4 shows the MN having the 3rd 5-hop away MN's(10) address is controlled by the 2nd 4-hop MN(01), the 1st 3-hop away MN(00), the 3rd 2-hop MN(10) and 1-hop away MN with address 01001011($4B_h$).

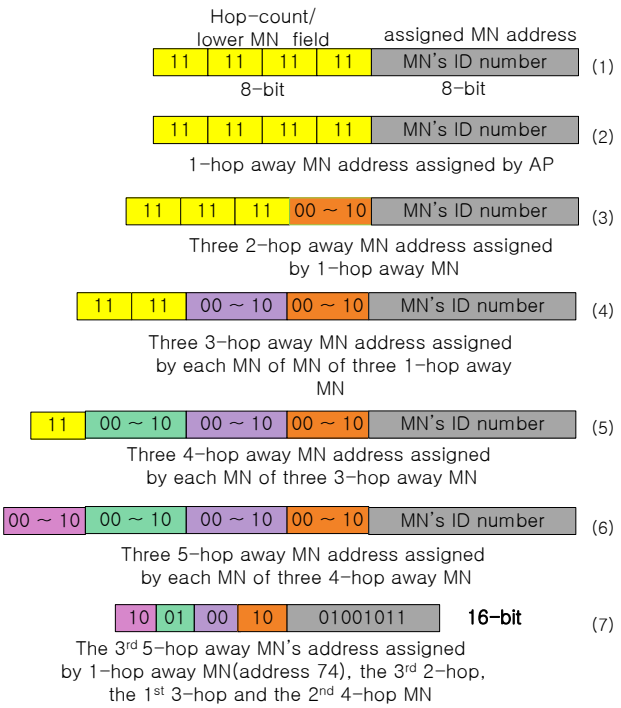

Figure 4. The Proposed Addressing Assigning Method for Manage the Upper (n-hop Away Towards AP) MN and the Lower(n-1 hop Away Towards AP) MN Relationship According to the Number Hops

3. The Algorithm for Multicast Overlay Tree in Hybrid Ad-Hoc Network

This paper presents 2-algorithms for establishing multi-path multicast overlay tree in hybrid ad-hoc network (HYMANET). The 1st algorithm is assigning a new address to each MN to generate an overlay connection tree just like reference paper 2 and 5. And the 2nd algorithm is for establishing multicast group and transmitting multicast streams in HYMANET.

3.1. The Algorithm is for receiving a New Address from AP or Upper MNs

i) MNs send solicited packet to AP for acquisition a new address or AP sends packets for allocation IP address to MNs in HYMANET

ii) AP sends 1-hop away address to each MN that can send a solicited packet directly to AP

iii) MNs that can't receive 1-hop away address send a solicited packet to 1-hop away MNs for acquisition a new address.

iv) 1-hop away MN sends 2-hop away address to each MN that can send a solicited packet directly to 1-hop away MN.
(At this time 1-hop away MN can manage up to three 2-hop away MNs These three 2-hop away MNs may have managed by other 1-hop away MNs at the same time)

v) Repeat step iii) and iv) until the farthest MNs receive a 5-hop away address from a 4-hop away MN.

Thus the 1st algorithm generates multi-path overlay tree through the acquisition of a new address from the upper(1-less hop towards AP) MN. The step iv) of the algorithm for

receiving a new address is for multiple(redundant) connection paths and those can be used when one of the upper(parents) node connected is moved away out of transmission range from the lower(child) node or the upper(parents) node is experienced overload of the lower(child) nodes' connection request.

The reason of the limit that the farthest MNs are 5-hop away from AP in step 5 minimizes the connection delay and service delay.

3.2. The Algorithm is for Establishing Multicast Group and Transmitting Multicast Streams

i) MNs request the same live-video service to server along with the multi-path overlay tree which is established through the 1st algorithm

ii) The server sends a multicast group address for live-video to the corresponding MNs along with the overlay tree.

iii) The server transmits live-video streams with a multicast group address(Mcast streams).

iv) The MNs(n+1 hop away) having multicast group address join multicast group (n-hop away MNs) along with overlay tree

v) If the n-hop away MN that has already joined a multicast group is receiving Mcast streams, then it retransmits them n+1 hop away MNs
else n-hop away MN sends multicast group join message to n-1 hop away MN until reaching AP

vi) If the n-hop away addressed MNs manage n+1-hop addressed MNs regardless of the request of the same video service, they retransmit Mcast streams as soon as they receive Mcast streams

vii) If (n+1)-hop away MNs are Multicast group members, then they receive Mcast streams, send Ack to the managing n-hop(upper) MN and goto step ix)

viii) The same-hop away MNs are listening whether the other same-hop away MNs retransmit Mcast streams or not.
They do not retransmit Mcast streams if they listen to Mcast streams from other same-hopped away MNs.

ix) The n-hop away(upper) MNs in step vii) retransmit Mcast streams if they do not receive Ack from the (n+1)-hop away (lower) MN

x) If the n-hop away MNs in step ix)do not manage (n+1)-hop away(lower) MNs or receive multicast join message from the lower MNs then they do not send Mcast streams

xi) Repeat step iv) until the 5-hop away addressed MNs receive Mcast streams if they request a Mcast stream.

In the algorithm for establishing multicast group and transmission Mcast streams, the step viii) and ix) indicate the reason which MN 9 has to send ACK to MN 6 as shown in Figure 1(b). If MN 9 sends ACK to MN 7 instead of MN6, the MN 6 will retransmit the same Mcast streams for MN 9. Thus the step viii) and ix) are to protect redundant Mcast streams.

4. Simulation and the Result

The simulation environment to execute the proposed algorithms is that 100 mobile nodes are randomly placed in the area of $1km^2$, the 30% of mobile nodes are fixed nodes and 70% of them are moving 3m/sec. We compare the ratio of connectivity of the whole mobile nodes between multi-paths (3-way) overlay tree and single-path(1-way) tree.

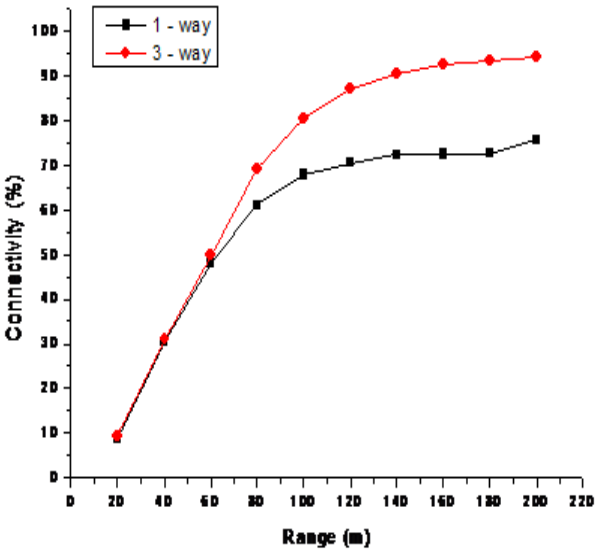

Figure 5. The Connectivity of Mobile Nodes According to the Communication Range of them

Figure 5 shows the connectivity of mobile nodes according to the communication range of mobile nodes. Although there is little difference between the transmission range of up to 60m between 1-way and 3-way method as a simulation result, the ratio of connection for the 1-way and 3-way in the remnant communication ranges has a difference of about 20% as the maximum increase the transmission range thereafter(more than 80m). Increases as the transmission range, which ensures the connection of the mobile nodes, it is possible to make sure that it will converge the value equal to or greater than a certain range(90% connectivity of mobile nodes having 120m transmission range). It is important to determine the appropriate transmission range to account for size and power consumption of the node.

Figure 6 is a result obtained by measuring the connection mobile nodes corresponding to the rate of multicast service requests. The rate of the movement of the mobile nodes is set to 70% in the same environmental conditions as in Figure 5. The multicast service request rate is the probability that a mobile node requests communication among distributed nodes. We have measured based on the rate of service requests from the interval 80m 120m section connection according to the communication range of Figure 1 will now be a difference significantly. We confirm that this proposed 3-way multi-paths technique has a high connectivity up to about 20-25% when compared to 1-way technique according to the multicast service request rate (more than 30%).

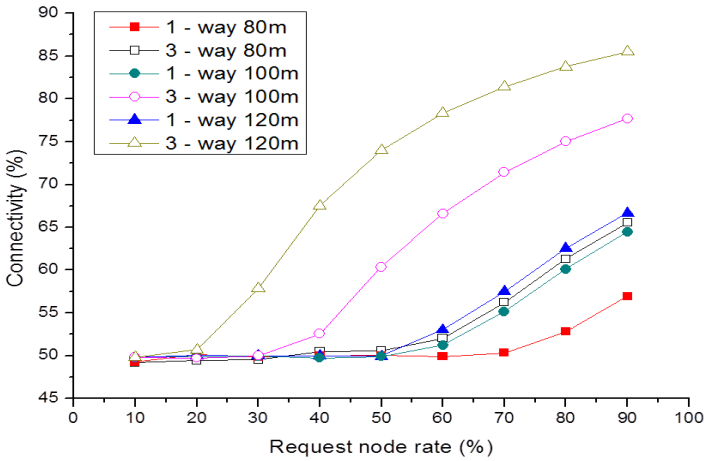

Figure 6. The Connectivity According to the Number of Multicast Service Requesting Mobile Nodes

5. Conclusion

This paper proposes a novel addressing technique to generate multi-paths multicast overlay trees using multiple parent-child(*n-hop away MN - (n+1)-hop away MN)* relationships according to the number of hops towards AP(access point) in hybrid ad-hoc network. Thus this technique can provide robust overlay tree in spite of movement of MNs. And the proposed algorithm is designed to minimize redundant multicast streams. The overhead for supporting multi-path multicast overlay tree is only 8-bit except MN's ID number. We confirm that the proposed technique ensures 90% connectivity for MNs that have 120m transmission range in HYMANET. The proposed algorithm can be used as multicasting service for live-video such as news, sports broadcasting image and movies at the lowest cost without multiple copies of multicast streams in HYMANET.

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