Multimedia Push-to-Talk Service over Wireless Mesh Networks

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Abstract—With the explosive growth of multimedia service, mobile computing network is necessary to satisfy with several requirements of multimedia service. Especially, session management is the core technology for supporting reliable multimedia communication. As a session management protocol, the Session Initiation Protocol (SIP) has been a very popular solution. Also SIP includes Push-to-Talk service mechanism that is well suited for one-to-many multimedia transmission. However, a centralized server based SIP architecture makes it hard to adapt directly to the mobile computing environment where network is generally self-constructed in an ad hoc fashion. To solve these challenges, this paper proposes a multimedia push-to-talk service system architecture over wireless mesh network. The proposed architecture is confirmed through the implementation and test.

Keywords – PTT service, mesh network, distributed sip system

I. INTRODUCTION

Wireless mobile communication is one of the most important features for supporting ubiquitous computing. A number of studies suggested these days have focused on ability to use networking technologies while moving with portable small devices. Mobility support mechanisms generally assume that packet can be lost and delays are also introduced over network. Thus, such a scenario is not suitable for a session based multimedia communication but for a command and response service. Communication method based on session is critical to allow ubiquitous mobile user to communicate with each other without any restriction of time and place.

Recently, as a session management protocol, the Session Initiation Protocol (SIP) [1] has emerged in IETF and it was also chosen as the signaling protocol in the 3GPP framework. SIP relies on centralized entities, namely servers, maintained by service providers. SIP servers handle users’ registration, their location, and forward SIP messages to the location(s) where the recipient is reachable. The centralized SIP protocol system is therefore suitable for an infra-structured network environment. However, the server based centralized structure of SIP is not feasible for self-organized mobile networks created on-demand in the absence of infra-structured networks such as ad-hoc network. SIP end devices (user agents) in an ad-hoc network do not have the means to contact with other nodes because the assistance of the servers is missing. So distributed session management system over ad hoc network is required.

To support SIP in ad-hoc networks, S. Leggio et al. [2] proposed the decentralized SIP system over ad hoc network using SLP (Service Location Protocol) which is used for SIP message routing. A shortcoming of the work is flooding problem of SLP message introducing traffic congestion in ad-hoc network. Such a flooding greatly influences on network performance owing to lack of wireless resources. Consequently, a mechanism to efficiently deliver control message is necessary for a distributed SIP system.

SIP is originally designed and standardized for voice communications. The initial standard of SIP is difficult to support one-to-many multimedia communications. However, SIP is used for IP communication for the core of PTT (Push-to-Talk) service, thereby multimedia multicast is possible.

In wireless network, session based group communication is preferred to general IP multicast communications owing to several limitations of wireless communications. These include lack of network resources, low computing power, path losses, interferences and others. Especially, these challenges are more difficult to solve for a self-organized ad-hoc network, which is a promising solution for ubiquitous mobile computing from the aspect of networking technology. For this reason, we have studied on how to support session based group communication over the new trends of networking (i.e. ad-hoc network and mesh network).

As a related work, J. Lin et al.[3] proposed iPTT to support efficient PTT service over ad-hoc network. The iPTT logically organizes clusters by using a super node which manages PTT clients and provides call determination on behalf of the ordinary node. The iPTT provides optimal service in comparison to the client-server model in terms of scalability and reliability. However, the iPTT continues to introduce significant signaling costs caused by hierarchical architecture. To solve the problem, S. Jun et al.[4] proposed ePTT serving signaling cost efficient PTT service mechanism that uses a proxy node. However, The problem of both of the above mechanism is that the load is concentrated into specific node which acts as the super node or proxy node.

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In this paper, we propose an architecture for enabling decentralized multimedia PTT (Push to Talk) service over mesh network which is a semi-infrastructure ad-hoc network to solve above mentioned problem which is issued when distributed SIP and PTT service system is deployed over ad hoc network. And the appropriated signaling procedure is also proposed. The main idea of our work is that a set of the basic functionalities of a SIP proxy, registrar server and PTT server are embed into every mesh router which is more stable and powerful than ordinary nodes.

The rest of the paper is divided as follows. Section II explains the Push-to-Talk service in more detail. Section III describes proposed network architecture and SIP signaling procedure for PTT service among the elements and the adaptable service scenario. Finally, section IV describes our implementation architecture for the decentralized PTT system and shows a test result.

II. PUSH-TO-TALK SERVICE

Push-to-talk (PTT) is a promising service for group-based multimedia communications [5]. PTT is a half-duplex multimedia transmission service that supports both user-to-user and user-to-group communications. It is suitable to solve limited power consumption challenges introduced by mobile devices. The Open Mobile Alliance (OMA) PoC WG [6] specified a basic procedure and protocol for the PoC server and PTT clients. Fig. 1 shows a PTT service system architecture and connectivity among the comprising elements.

A straightforward way to support PTT service is to install PTT server to SIP network. It allows SIP based networks to easily support PTT service, where SIP sets up sessions for PTT service. Such PTT sessions including RTP session for media data transportation and RTCP session for control are established between a mobile device and PTT server. PTT server makes copy of the data to send the copy to multiple members in PTT group. A main function of MBACP is floor control performed by PTT server. It determines and authorizes data receivers of PTT group communication, thereby restricts useless transmissions. In addition, PTT server does not need to establish an additional session for flow control because it uses a RTCP session to transport MBACP control data for the floor control.

III. MULTIMEDIA PTT SERVICE OVER MESH NETWORK

In this section, network architecture for enabling a PTT service and message flows for signaling are presented to show the feasibility of our PTT over mesh network system.

A. PTT Network Architecture

Fig. 2 shows our network model to support PTT service over wireless mesh network. The PTT network comprises three elements; mesh router, inter mesh router connection, ordinary nodes. For supporting decentralized PTT service over mesh network, we embed a set of basic functionalities of a SIP proxy, registrar server and PTT server in every mesh router forming a PTT service network. In addition, all the mesh routers maintain group overlay network connections among the mesh routers to share the group information of the nodes. The ordinary nodes can build a session among the group members through mesh router using the SIP semi-infrastructure.
Especially, if two nodes are located within areas covered by different mesh router, a PTT connection is connected by not peer-to-peer but mesh router-to-peer style. Such a communication style enables efficient packet transmission for group communication in a limited resource environment.

A floor control is the process to determine who has the chance to talk. The efficiency of floor control has a great influence on the performance of PTT service. Large determination latency makes the PTT group communications “un-smooth,” and the conversations between group members are not real-time. In centralized PTT system, the chance is given to the user of floor request that is arrived earlier at the PTT server. But distributed PTT system based on mesh network has a lot of variations in terms of transmission delay and traffic condition that can lead to unfairness of floor control due to the node location and network traffic condition, which therefore should be considered for floor determination. More details are mentioned in section 4.

B. Signaling Procedure

Fig. 3 shows the signaling procedure of initial group overlay connectivity creation, and PTT call initiation.

For node 1 and 2, mesh router A informs it’s ID as a floor control router by using SIP INFO message

Step2) after receiving registration message, mesh router A and B construct overlay connection each other and PTT group peer table.

PTT session initiation procedure could be divided into SIP session initiation and Floor determination procedure. At first, SIP session initiation is started by one of the member nodes sending INVITE message to the mesh router and then a session of inter mesh router is established. During SIP session initiation, a floor control router which is responsible for performing final floor determination is elected. Second phase of Fig. 3, which is for PTT session initiation procedure, is proceeded as follows:

Step 3) (SIP session ignition) node 1 sends INVITE message to mesh router A to start PTT communication. If PTT group is not on communicating, a mesh router A which includes a starting member is elected as floor control router by itself. And in turn, mesh router A establish session with mesh router B which has PTT group member.

Step4) (floor control router notification) After finishing session initiation, mesh router A informs it’s ID as a floor control router by using SIP INFO message

Step5) (Initial floor owner notification) At the begging of PTT communication, the node 1 which initiates PTT session should have a talking chance. For notifying result of floor determination to all group members, the mesh router A sends RTCP floor grant message to node 1 and RTCP floor taken message to mesh router B which in turn, sends it to node 2.

Step6) (data transmission) Packet from node 1 to another group member node 2 is transmitted through each section session.

As mentioned above, for floor determination at the one point, Floor control router should be selected. The floor control router collects floor request message from members who want to be the talking owner, and then determines who should be talking owner. But except the floor control router, other mesh routers also perform floor control for the area where they supervising. The difference between the floor control router and the ordinary mesh router is that the floor control router performs floor determination for not only local area members but also other group members who is located in another mesh router area. More specific flow is shown at the third section of Fig. 3.

Step 7) (Floor request from members) node 2, 3 which is located in the area of mesh router B sends Floor request message.

Step 8) (Floor determination and relay at the intermediated mesh router) when receiving floor request message from members, the mesh router B determines which one is arrived earlier and then relays the request message from node 3 while notifying node 2 of failing to get a chance to be talking owner.
Step 9) (Floor determination and notification at the floor control router) The mesh router A collects floor request from all group members as a floor control router and finally determines floor owner.

C. service scenario

An attractive scenario could take place in a fire prevention system. The fire prevention system could be comprised of a camera which is scattered over the area, the monitoring center that is fixed and monitors all of camera, personnel for a security who patrols the area. Fig. 4 shows the flow of the scenario.

![Sample scenario](image)

1) The camera locating on the mesh network area detects the fire and notifies the fire event to monitoring center. (According to SIP subscribe/notify procedure)

2) The monitoring center commands all security agents to move to fire area while sending image from camera. (Through a PTT session on which monitoring center and all security agents are involved)

3) Security agent A is arrived earlier near the fire area. Agent A start to send more detail image by using his mobile handset equipping camera. (According to the PTT floor owner changing procedure)

IV. IMPLEMENTATION AND TEST

A. Implementation Architecture

![Implementation modules](image)

The implementation architecture of a mesh router comprises several modules communicating with each other according to a layered structure. Fig. 5 depicts the structure and the connection between the modules.

The modules comprising mesh router could be grouped into session control block, multimedia data control block and mesh networking block. SIP transaction layer and SIP transport layer belong to the session control block. SIP module provides primitives and functions for exploiting higher level functionalities, such as building SIP messages. SIP transaction layer maintains transaction state per session. SIP transport layer just performs sip message relation between upper and lower layer. The multimedia block includes not only multimedia data transmission function but also floor control function (i.e. MBCP). The reason why MBCP should be placed under multimedia control block is that MBCP utilize RTCP control message as a floor control message. The mesh routing protocol modules belonging to mesh networking block maintain topology information of overall mesh network in proactive fashion. They are implemented at the kernel layer for providing standard socket API to other modules which is implemented at the user space.

![GUI of client PTT application](image)

The client implementation structure includes almost same modules with mesh router except the group manager and the mesh networking block. Because clients communicate with mesh router in AP mode like ordinary WLAN, they don’t need to have mesh network functions. And also because client doesn’t manage group overlay connection, the group manager module is omitted. Fig. 6 shows GUI of the client PTT application.

B. Test and results

As above mentioned, the efficiency of floor control has a great influence on the performance of PTT service. Especially, in our proposed system, call determination fairness of members could be influenced by the location and traffic condition of floor control router which is responsible for final call determination. For verifying call determination fairness depending on floor control router environment, we tested on real mesh network environment that is comprised of 8 mesh router equipping PPT service related functions. Actually, at the user terminal, the floor_request_message asking to be a talking owner is issued by push the button. However, because there is
personal difference about pushing speed, in our test, the floor_request_message of all group members is automatically issued when they receive floor_release_message meaning that floor is on not busy state. Fig. 7 shows the test result. In the Figure, hop count value 0 on the horizontal axis means that a node is located under floor control router’s area.

![Figure 7](image)

According to the test results, as a node is located more far from floor control router, the probability to be a floor owner is decreased. Especially, under the condition of data traffic jam near the floor control router, the chance to be floor owner lean too much towards on the node locating near the floor control router. This result is due to the multi-hop networking feature of mesh network. The multi-hop feature causes a lot of variations in terms of transmission delay depending on traffic condition.

V. CONCLUSION

In this paper, architecture for enabling decentralized SIP over wireless mesh was proposed. Especially, for supporting efficient multimedia data communication, PTT service system architecture and the appropriated signaling procedure was also proposed. In the proposed architecture, the mesh routers contain distributed PTT service system including a set of the basic functionalities of a SIP proxy, registrar server and PTT server. Each mesh router manages PTT group information in proactive fashion and using this information PTT group overlay connectivity is organized among them. This group overlay connection enable mesh routers to perform faster session initiation procedure without member discovery.

The proposed architecture was implemented and tested. In test results related to the call determination fairness, we could find that the call determination fairness of members could be influenced by the location and traffic condition of floor control router which is responsible for final call determination. Hence, as our future work, we are going to propose the optimal floor control router selection algorithm.

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