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# A Study on Stable Data Transmission Using Hierarchical Share Group in Mobile Ad Hoc Network

**Hwan-Seok Yang[1] · Jae Hoon Sun[2,3]**

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**Abstract** Recently, various services providing various contents using them have emerged while mobile devices such as smartphone has spread widely. As a result, network traffics are increasing rapidly and various problems such as QoS degradation have occurred. P2P is the technique that can reduce network bandwidth and computing resources. P2P technique in a wireless network environment gained a lot of popularity and MANET-based P2P technique among them has been studied actively. However, MANET has many problems by a stable connectivity between nodes and low bandwidth because it is consisted of only mobile nodes. In this paper, we proposed a hierarchical sharing group configuration techniques in order to provide a stable connection between the mobile nodes and reduce the load of network traffic and overhead of sharing group reconfiguration. Sharing Group Member Node was applied sub-sharing group generation techniques with neighboring nodes of 1-hop distance to reduce traffic for file sharing. We did comparative experiment with PDSR technique to evaluate the performance of proposed technique and confirmed the excellent performance by experiments.

**Keywords** MANET · Data transmission · Hierarchical structure · QoS

✉ Jae Hoon Sun
rdsa4@naver.com

Hwan-Seok Yang
yanghs@joongbu.ac.kr

[1] Department of Information Security Engineering, Joongbu University, 101, Majeon-ri, Chubu-myeon, Geumsan-gun, Chungnam, South Korea

[2] Department of General Education, Dong-Ah Institute of Media and Arts, Dong-Ah yedae Rd. 47 Samjuk-myeon, Anseong-si, Gyeonggi-do 456-717, Republic of Korea

[3] 105-dong 307-ho, 43, Tongil-ro 34-gil, Seodaemun-gu, Seoul 150-754, Republic of Korea

## 1 Introduction

The computing environment has been changed significantly by the rapid development of wireless network technology and the wide spread of mobile devices. Many services providing a variety of contents such as Social Network Service (SNS), Video On Demand (VOD) using these wireless network is increasing [1–3]. This causes the contents server and data traffic of network is increasing rapidly and a variety of problems such as QoS degradation come up by an overload of communication equipment that mobile operators provide [4, 5]. The service contents provided to the user is gradually expanded to a variety of multimedia data such as the audio, video pictures of high-quality and high-volume and the burden on contents server and network traffic providing this has become more and more accelerated [6, 7]. Mobile Ad Hoc Network (MANET)-based Peer to Peer (P2P) file sharing technique with the development of IT technology and popularization of mobile terminals has been studying in various fields such as real time streaming sharing technique, mobile node search technique, file transmission routing technique, sharing group management technique, mobile P2P sharing system and frameworks [8–10]. Recently, MANET-based P2P file sharing technique has been studied a lot. It is not suitable that P2P technique of wired environment is applied as it is because various network which peers can connect are not considered and it is difficult to maintain the transmission link between the mobile nodes in the existing wired network P2P technique. The mobile nodes must perform the role of router to transmit and receive data because MANET consist of only mobile nodes without a fixed infrastructure. There are many difficult in the route setting because a topology change dynamically by movement of nodes. And it has low bandwidth due to characteristic of wireless network. For this reason, it is difficult to transmit a variety of multimedia data of large scale voice, video, etc. non text. P2P technique is needed in order to save computing resources while reducing the network bandwidth in MANET [11, 12].

However, it is needed many requirements for a stable data exchange with a neighboring node in MANET environment. Among them, the seamless connection with mobile nodes and the load occurrence of nodes is caused to big problem.

In this paper, we propose the hierarchical sharing group structure in order to provide continuous streaming service through a secure connection between the mobile nodes and reduce the reconstitution overhead of sharing group while reducing the load of traffic. The network is consisted of cluster form in order to form the hierarchical sharing group proposed in this paper and the node that connectivity is the highest is elected to Sharing Group Header (SGH). The node which has the most sharing group node among the SGH is designated as Highest Sharing Group Header (HSGH) and the node searching management module is managed for the location searching of a specific node. The SGH performs relay role of continuous monitoring of sharing group nodes and streaming data. The streaming data transmission technique is applied using buffer state measurement of mobile node. In addition, Sharing Group Member Node (SGMN) applies sub-sharing group generation technique with nodes of I-hop distance from the own in order to share file quickly while reducing the network traffic.

This paper is organized as follows. We inspect the characteristics of P2P technique in the mobile environment in Sect. 2 and describe the sharing group configuration technique to provide efficient P2P proposed in this paper in Sect. 3. In Sect. 4, the performance evaluation of proposed technique is performed through experiments. Finally, conclusions are given in Sect. 5.

## 2 Data Transmission Technique in MANET

### 2.1 Wireless Data Transmission Architecture

The existing wired P2P service uses the IP address of terminal without considering transmission unit by each transmission period because it provides service for fixed PC connected to the wired network. It focus on the Traffic Localization which estimates distance of data transmission path transmitting between terminals and transmits contents between terminals in close distance. However, it is difficult to calculate accurately the transmission distance between terminals having IP address because Network Address Translator (NAT) is used widely. Therefore, we need the technique that internet service provider provides network topology information to P2P service platform in order to compensate for this problem and the shortest transmission path between terminals based this information is found. The transmission cost in a wireless network become different largely depends on which terminal is connected to which wireless network than transmission distance. P2P connection is provided by considering the type and traffic condition of wireless network which terminal can connect in order to minimize the load of wireless network and also provide service to many user [13].

Mobile P2P function can be divided into a terminal and network function [14]. Network function has Mobile P2P Service control Function (MPSF) for control of P2P service, Meta Information Processing Function (MIPF) for user contents information management, User Equipment status Monitoring Function (UEMF), Access network Traffic Monitoring Function (ATMF) to monitor traffic condition of wireless access network, and Supper Peer Function (SPF) that stores popular content doing many download to server located in the wired network and provides contents instead of a wireless terminal when there is a request for the content.

The terminal function has Contents Upload Function (CUF) for sending contents and Contents Download Function (CDF) for receiving contents [15]. The one of the most important factors in providing the mobile P2P service is that provides P2P connection according to what is the wireless network that a terminal can connect. If multiple terminals with the same content exist, it is preferable that terminal being able to connect to a Wi-Fi network provides contents if possible and terminal being able to connect to the WiBro network than mobile communication network provides contents. Also, if terminals having the same contents can connect to the same wireless network, it is preferable that terminal located to coverage of wireless base station which a wireless data user is not many than many.

### 2.2 Wireless Data Exchange Technique

The tit-for-tat algorithm used for data exchange between peers in P2P transmits a piece to the uploaded peer and is the piece exchange algorithm used widely in many P2P system [16]. Goalbit use Unchoking algorithm based tit-for-tat, Optimistic unchoking algorithm uploading regardless of the amount of upload to one peer selected randomly, and a maximum Unchoked peer number control algorithm in Unchoking algorithm. Therefore, the peer manages a list of peer by Unchoked peer, Optimistic Unchoked peer, and choked peer. Upchoking algorithm transmits INTEREST message indicating that a peer for receiving the download is interested in neighboring peer and the peer determines Unchoked peer in the order peer doing the most uploaded in peer sent INTEREST

message. The peer selects up to four peers basically to Unchoked peer in order the most uploaded peers to their. The peer checks BITFIELD map of partner peer and transmits INTEREST message in case of having a piece to request. The peer receiving INTEREST message transfers Unchoked or Choked message to a response message and Unchoked peer is updated every 10 s. Figure 1 shows the operation process of Unchoking algorithm.

Optimistic Unchoking algorithm selects one peer to Unchoked peer Optimistic Unchoking randomly regardless of the amount of upload in total peer list. Optimistic Unchoked peer is used to improve the effectiveness of the piece exchange. This is because peers doing low upload cannot have P2P participation opportunities if the most upload is allowed to download. The maximum Unchoked peer number control algorithm is classified as increase and decrease operation of the number of peer. The increasing case is a situation doing unchoked the number of the maximum Unchoked peer set currently and the number of Unchoked peer is increased by one if the number of piece that transmission is unsuccessful during 10 s is greater than the number of successful piece. However, the operation is rare because it is difficult that a peer satisfy the condition of the algorithm operation. In order to decrease the number of the maximum Unchoked peer, it should be determined that the peer is uploading to other peers currently and the next piece to transmit should be already made reservation.

### 2.3 Mobile P2P Middleware

The P2P sharing group between mobile terminals is formed in order to provide optimum streaming service between mobile terminals considering several connectable network links with the contents server load and network traffic. The terminals belonging to a sharing group can be connected with global network consisted of Wi-Fi, 3G/LTE and P2P network consisted of Bluetooth, Wi-Fi Direct. The mobile terminals belonging to sharing group can use the reliable and seamless contents through contents sharing between mobile terminals in sharing group when QoS of streaming service is degraded because the bandwidth that global network provides is not enough [17]. Figure 2 shows the structure of network for a mobile streaming service.

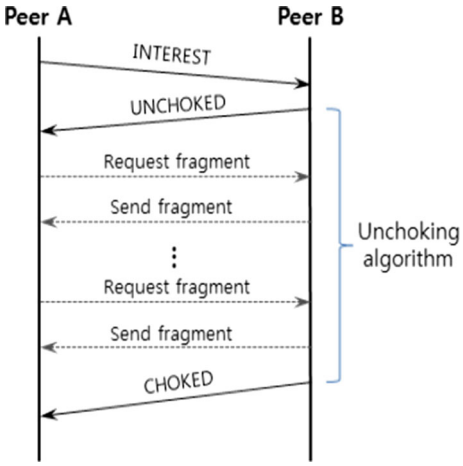


**Fig. 1** Unchoking algorithm operation process

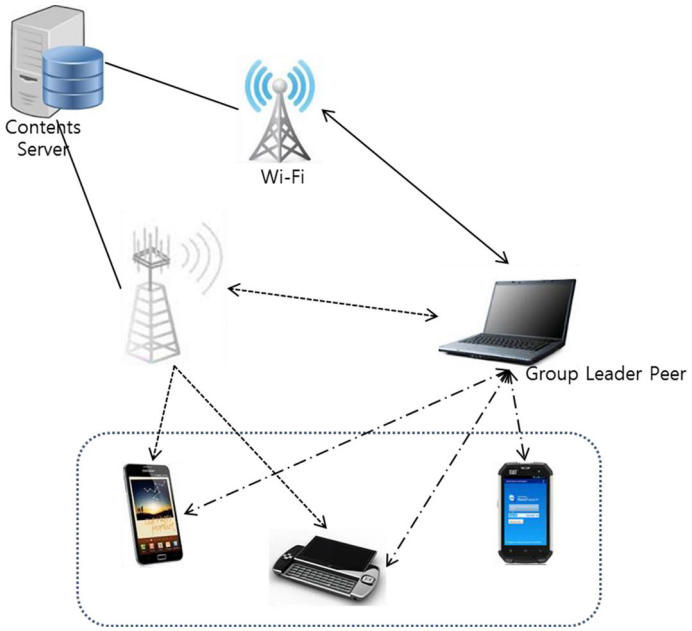


**Fig. 2** Network structure of mobile streaming

The mobile terminals belonging to sharing group should guarantee QoS by connecting to several network such as Bluetooth, Wi-Fi Direct in environment that connection with the network changes by connection on or off with Wi-Fi and 3G/LTE due to migration in the place that people are concentrated. In addition, QoS should be guaranteed through the global network also when the sharing group is configured due to the movement of the mobile terminal. In order to establish P2P overlay network, the local network between mobile terminals is constituted and mobile terminal having sharing contents and the same middleware among mobile terminals to share the stored contents is searched around it. The module that this terminal is consisting of connected P2P network via the optimal link needs. Also, the contents is sent and received on the consisted P2P network. The module reconstructing this again needs as the mobile terminal is disconnected by the signal strength of Wireless Access Point (WAP) and the state of the network [18].

## 2.4 Previous P2P Techniques

Delay/Distribution Tolerant Network (DTN) is the multi-hop MANET-based file sharing technique and is reduced traffic of contents server through file sharing between mobile nodes [19, 20]. The intermediate node stores data and moves even if there are not connectivity between the source node and destination node. It transmits file to the final target node by transmitting to other node. The network delay time is caused because file transmission is started when the connection between the mobile nodes is not established. Therefore, DTN cannot ensure the real time of the service and is not suitable to share file because it shares file using the mobility of the nodes. It is useful for applications that are not largely affected by network latency.

Seven Degrees of Separation (7DS) is XML message-based protocol that allows internet and e-mail transmission through mobile node connected to surrounding internet and data sharing though the mobile node is not connected to the internet [21]. The mobile node which is not connected to the internet writes down the job which wants to perform of internet and e-mail transmission to XML message form and transmits to the neighboring mobile node If 7DS is used. 7DS enables the sharing of data through P2P. But it can transmit when other mobile nodes have directly the necessary data or are connected to the internet. It is difficult to provide equitable service between mobile nodes because P2P configuration is parents–child relationship.

DHT technique is the technique that can find files with less routing in a certain number of hops stochastically when the scalability of the network is creased and the file is searched in P2P overlay network [22]. It is the technique applying hash table to the network and all data are represented by a pair of key and the value. That is, the nodes in the network are part of the entire hash table and overall network is represented as a hash table if they is gathered. All nodes obtain the key by hashing the data which they have and transmit to the node in charge of the area the key is included. The search message is transmitted in the same way using a key value also when node searches the wanting data. These data registration and search message must be transmitted to a specific node in the network. For this, nodes set a logical routing table for routing on the network with routing table of physical network separately and manage information of the logical neighboring nodes. DHT technique has an advantage to improve the P2P scalability mainly because it is easy to find the file through a small number of file routing information. There is disadvantage to know correct name because the overhead is occurred when hash table is made and diffused and date search is performed using the hash function [23, 24].

PSDR is the routing protocol which MANET routing protocol, Dynamic Source Routing (DSR) is improved. It uses naming mechanism of chord system using DHT method and uses routing method of chord when you search the desired node [25]. Each node detects source route of DSR and reflects to the routing method of chord through Next Hop Source Route (NHSR) field to routing table. The nodes on the path in NHSR broadcasts PHELLO message to neighboring node of 1-hop distance using PHELLO similar to HELLO message of AODV and the neighboring node goes to find.

## 3 The Proposed System Model

In this chapter, we propose the technique that can provide seamless streaming service through a stable connection between the mobile nodes while reducing the load on the network traffic using the sharing group structure of the hierarchy form. Especially, the sharing group forming algorithm to reduce the sharing group reconfiguration overhead by the movement of nodes is described.

### 3.1 Network Structure and Components

It is very important that reduces traffic and maintain the connection of the mobile nodes in order to provide stable service of P2P based MANET. In particular, MANET has the disadvantage that the network maintenance overhead occurs greatly as the number of mobile nodes increases. The desired QoS cannot be guaranteed and it is difficult that continuous mobile streaming service is done smoothly because the connection is cut off by

the movement of a mobile nodes and the network bandwidth is variable. In this paper, the hierarchical shared group is used to provide a continuous streaming service between the mobile nodes while reducing the load on the network traffic. For this, the network is configured as a cluster. The cluster configured like this is a sharing group. The node having the highest connectivity among mobile nodes in a sharing group is elected to the SGH because the communication with all mobile nodes in sharing group is possible and the mobile nodes most be monitored continuously to detect the mobile nodes. SGH that has the highest number of connection among each SGH and the highest number of mobile nodes in the group is set to HSGH. HSGH manages information of nodes to detect the mobile node of the overall network.

Figure 3 shows a network structure used in this paper and the role of each mobile node is as follows:

- HSGH: It delivers this information after the location information of the mobile node is searched using the node information management module in case of that the SGH request the location information for a particular mobile node while communicating with each SGH. Therefore, HSGH is transmitted node information in the sharing group from all the SGH periodically and manages.
- SGH: It is monitoring continuously while communicating with all the mobile nodes in the sharing group. And it performs a server role relaying streaming data to the mobile nodes in the sharing group.
- Sharing Group Secondary Node (SGSN): Group withdrawal by the movement of SGH causes a problem receiving continuous streaming data of mobile nodes in the group. The secondary node substitutes for the role of header when SGH cannot perform the role by pre-assigning node which can assist sharing group node.
- SGMN: Member node receives the streaming data from the SGH. It reduces traffic load of SGH by re-formatting sub-sharing group with nodes around 1-hop and transfers the file by reducing the sharing group remodeling overhead.

Figure 4 shows the process of sharing group formation.

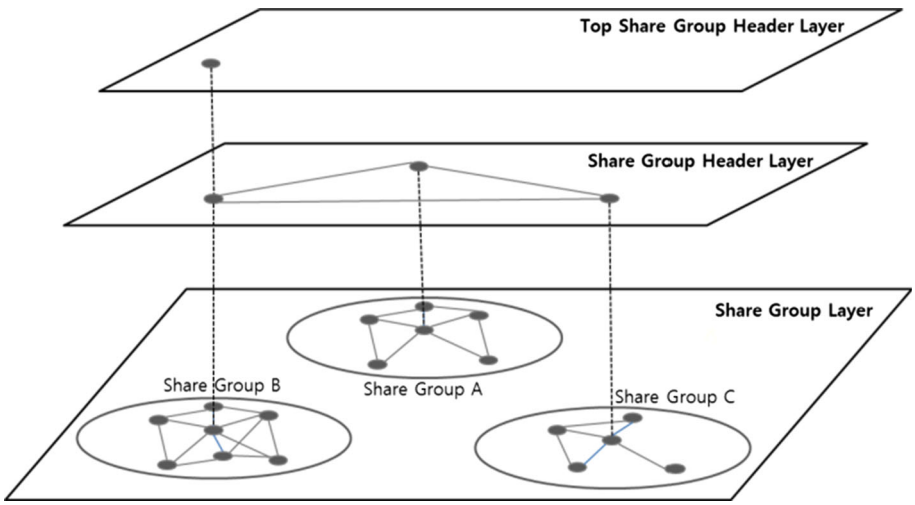


**Fig. 3** Network structure

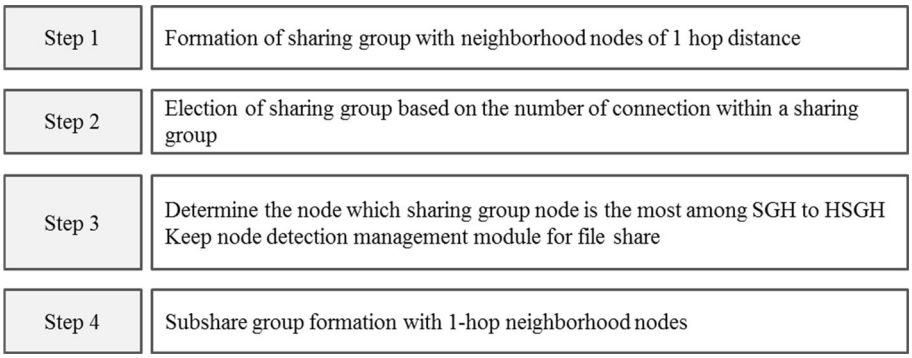


**Fig. 4** The process of sharing group formation

## 3.2 Sharing Group Formation

### *3.2.1 Hierarchical Sharing Group Formation*

The hierarchical sharing group is composed to transfer files between mobile nodes effectively and reduce traffic. It is suitable structure for providing stable streaming service. First, the nodes consisting the overall network configures cluster of sharing group. Nodes in the sharing group configured like this are based on the number of their connections. The node with the highest number of connection becomes the SGH. The reason using the highest number of connections when SGH is elected is because monitoring can be done while SGH communicates with the mobile nodes in group. The node of sharing group among SGH elected in each sharing group elects the most SGH to HSGH. It has node detection management module which stores information about the nodes participating in the overall network. If it receives search request of a specific mobile node for file sharing from SGH, it provides the location information for the mobile node by searching node searching management module. Figure 5 shows the node searching management module managing in the HSGH. In Fig. 5, the current group id field stores sharing group information of each nodes and group history field keeps sharing group information that the nodes move. The sharing file list field stores file list information sharing in mobile node.

SGH performs server role relaying streaming data to nodes in the sharing group and has group node management module managing monitoring information for each mobile nodes. Group node management module has file information that nodes in the sharing group share

| Node ID | Current Group ID | Group History | Share FileList |
|---|---|---|---|
| D | 3 | 1->6->3 | P2p.avi |
| A | 7 | 2->4->1->7 | Mobile.avi |
| ... | ... | ... | ... |
| F | 1 | 5->1 | Test.mp3 |

**Fig. 5** Node search management module structure

and time information that comes and go out to the sharing group. This information is stored and managed in a table of same structure with Fig. 6.

The elements such as size of transmission file, bandwidth and the number of nodes which transmit and receive must be considered for file sharing of nodes in group and mobile P2P in SGH. That is, bandwidth of SGH is not able to support this if the number of the mobile node transmitted specific file is too many or the size of the file is too large. Therefore, streaming data transmission can be done smoothly through SGH only when Eq. (1) is satisfied.

$$\frac{GH_{bandwidth}}{\sum_{i=1}^{n} Node_i} \times r \tag{1}$$

Here GH means the bandwidth of the group header and $r_{\text{means}}$ the ratio of the bandwidth allocated when GH transfer the file. Therefore, group header calculates using Eq. (1) every regular time after streaming data is transmitted. It checks whether the number of mobile node participating network bandwidth and file sharing exceeds the maximum value or not.

#### *3.2.2 Sub-sharing Group Formation*

The file request packet is broadcasted to neighbor mobile nodes of 1-hop distance if mobile node A in sharing group wants to share file. Among the mobile nodes receiving the file request packet, the nodes which can provide a file transmits a response message to this and sub-sharing group with only mobile nodes responded like this is reformed. This sub-sharing group nodes include a packet number that itself holds and is transmitted. And a mobile node A broadcasts the file request packet to the neighboring mobile nodes at regular intervals until all the files are transmitted. In this way, sub-sharing group is disbanded if the transfer of file that themselves need is complete. It has advantages that traffic of SGH is reduced the quick file sharing is done by forming a sub-sharing group with the neighboring mobile node and sharing the file. Figure 7 shows the forming process of sub-sharing group.

### 3.3 Streaming Data Transmission Technique

SGH is applied streaming data transmission control technique through real time buffer status measurement of mobile terminal in order to transmit a seamless streaming data to the mobile nodes in group. SGH always does buffering streaming data than sharing SGMN because streaming data in sharing group transmits to SGMN through SGH. The playback point of streaming data must be synchronized in order that SGMN is able to play the same

| Node ID | Entrance Time | Out Time | Share FileList |
|---|---|---|---|
| C | 15:10:08 | 15:11:38 | P2p.avi |
| G | 15:11:50 | - | Mobile.avi |
| ... | ... | ... | ... |
| D | 15:12:30 | - | Test.mp3 |

**Fig. 6** Group node management module structure

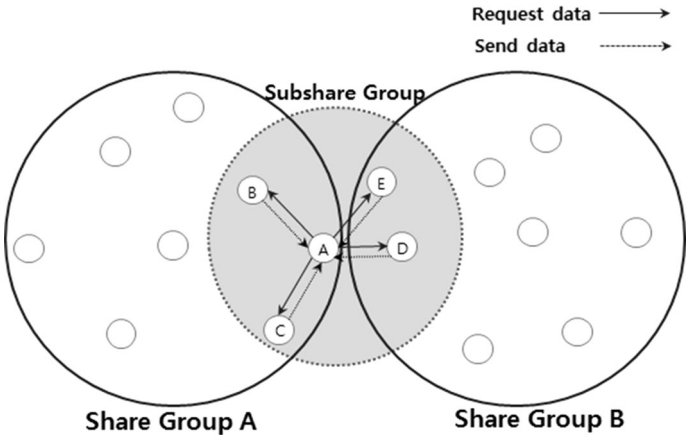


**Fig. 7** The process of subshare group formation

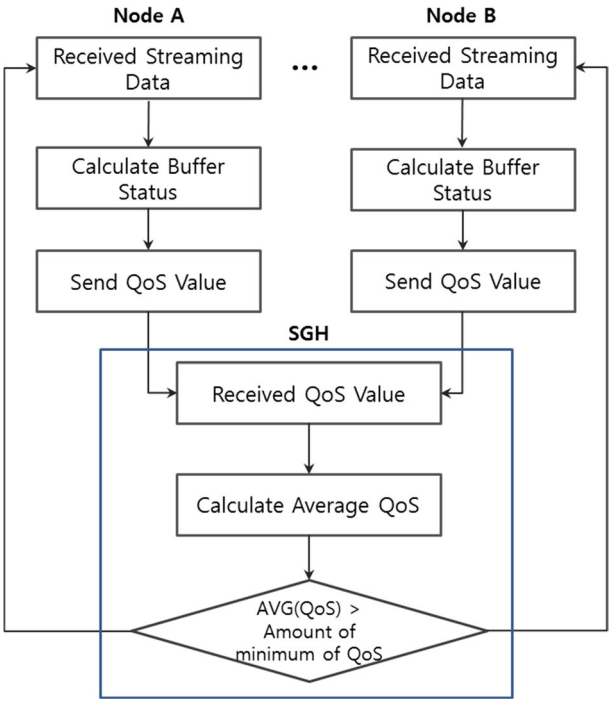


**Fig. 8** QoS calculation and the streaming data transmission process

streaming data at the same time. SGMN receiving streaming data from SGH check the own buffer. That is, QoS of network is calculated and transmitted to SGH using location value of streaming data received and played back recently, and streaming playback speed. SGH is calculated the average QoS by Eq. (2) using QoS received from SGMN.

$$Avg(QoS) = \frac{\sum_{i=1}^{n} Node_i\left(\frac{rp-pp}{playspeed}\right)}{Count(TotalNode)} \quad (2)$$

The minimum value that can ensure the QoS of streaming data is measured after SGH calculates average QoS. If the network bandwidth become low and cannot guaranteed QoS because of a variety of reasons, streaming data transmission is converted using SGSN and streaming data transmission service can be performed. Figure 8 shows calculation of SGH, SGMN and QoS, and the process of streaming data server switching technique. Their buffer state is measured and QoS value is transmitted to SGH while the streaming data is received by SGH in the mobile node A. In the SGH received this, the streaming data transfer is controlled after the average QoS is measured and the minimum QoS is compared.

## 4 The Performance Analysis

### 4.1 Experimental Environment

The ns-2 simulator is used in order to evaluate the performance of the sharing group constitution and streaming data transmission technique proposed in this paper. The performance evaluates while joining and withdrawal of sharing group is repeated by changing the position of each mobile nodes at random. The experiment time was 600 s and communication distance between mobile nodes was set to 100 m in consideration of the maximum communication distance of Bluetooth. And the moving speed of the mobile node was set to 0–20 m/s. However, the battery consumption of the mobile nodes did not consider in experiment of this paper. The environment variables used in the experiments for performance evaluation is shown in Table 1. Here, the performance evaluation and the load of all network traffic and SGH is measured.

### 4.2 The Performance Evaluation

This chapter describes the performance measurement results of the proposed hierarchical sharing group formation and streaming data transmission technique and the performance measurement is performed through comparative experiment with PSDR technique. The reason that comparative experiments with PSDR technique for the performance evaluation of proposed technique in this paper is because many experimental environment such as routing protocols is most similar. The criteria of the performance evaluation used for performance measurements is set to the number of mobile node, transmission delay time by

**Table 1** Simulation parameters

| Parameter | Value |
|---|---|
| Network size | 1000 × 1000 |
| Number of nodes | 50, 100, 150, 200 |
| Pause time (s) | 10 |
| Data size | 4 MB |
| Mobility model | Random way point |
| MAC protocol | IEEE 802.11 DCF |

data size, the average time of receive data, disconnection rate of data transmission and overall network traffic.

Figure 9 shows the measurement result of data transmission delay time by the number of mobile node. It was confirmed that the transmission time is shortened because the more the number of mobile node increases, the more density increased. The transmission delay time was long because the more the moving speed of nodes is fast, the more neighboring nodes 1-hop distance are changed frequently in the PDSR technique. The proposed technique showed excellent performance than the PDSR technique because sub-sharing group that SGMN configure has fewer changes even if the nodes belonging to sharing group change. The more the number of nodes is many, the more it also showed excellent performance in the delay time by configuration of sub-sharing group.

Figure 10 shows the measurement result of delay time by the data size. The data size was changed from 1 to 4 M and the other setting were same. It was confirmed that the more the data size is big, the more the delay time by movement of nodes is long. As shown in Figure, the proposed technique was shown a stable results that were affected significantly to data size.

The average data received time measured in the mobile node is shown in Fig. 11. The measurement results as an indicator that measures the quality of the streaming service show that the streaming service how much the quality is good is available in the mobile node. And these were proportional to the moving speed of the nodes. As shown in Fig. 11,

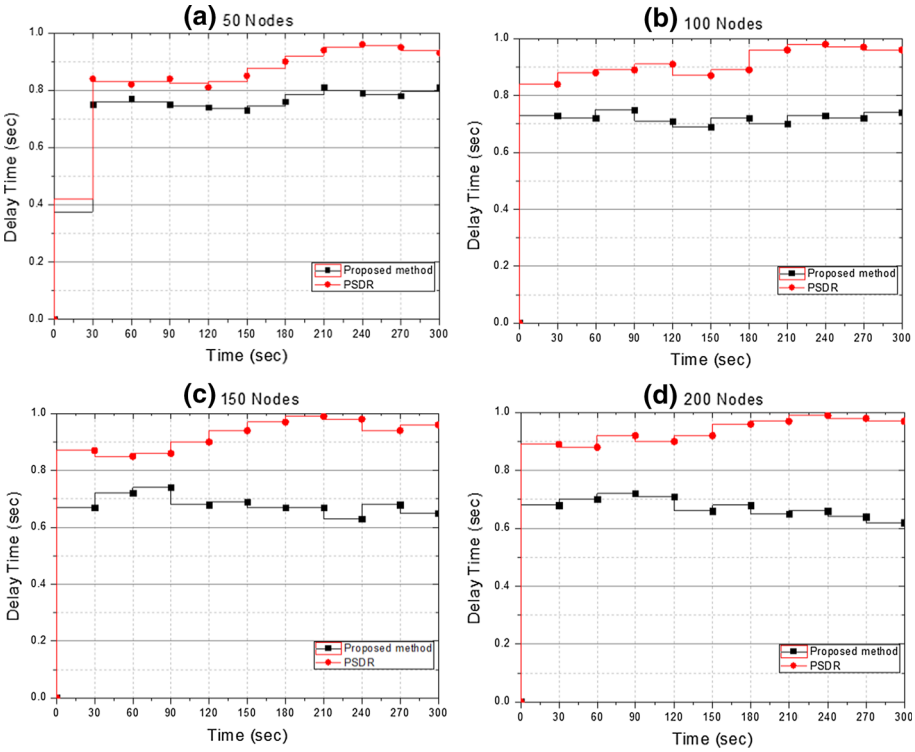


**Fig. 9** The result of data transmission delay time

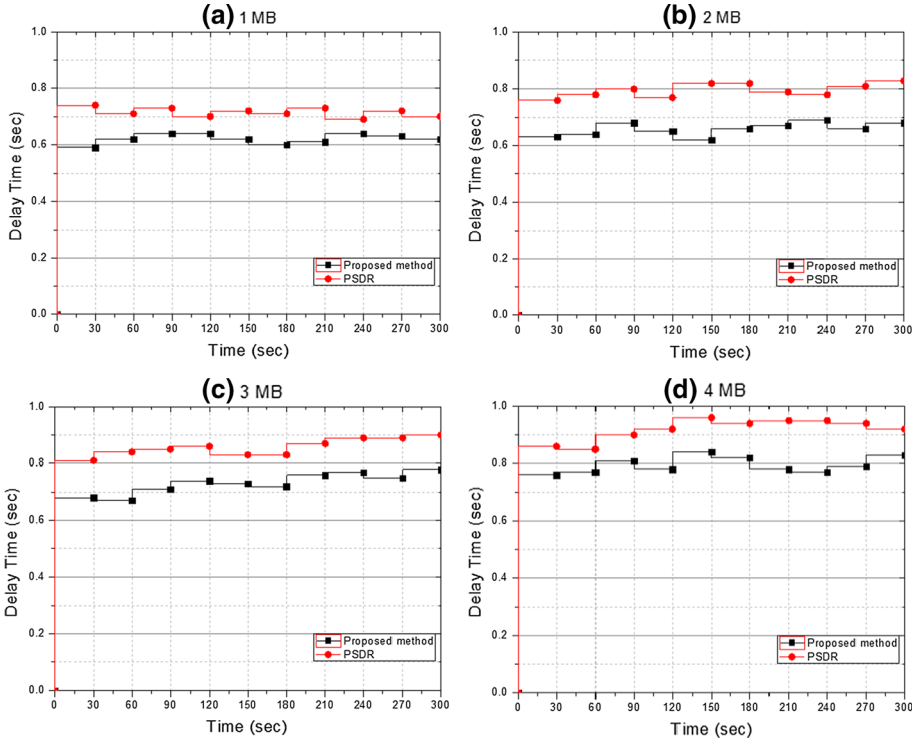


**Fig. 10** The result of delay time by the data size

PDSR technique has long received time of the average data because it is difficult to maintain data transmission path by moving speed. In the proposed technique, the data was transmitted continuously without a significant effect of moving speed and it was shown excellent performance in the average data received time because SGH manages streaming data transmission of mobile nodes.

Figure 12 shows the data transmission disconnection rate by moving data. This measurement results mean the reliability of P2P and represent how much provide reliable P2P in a wireless environment. It is not easy to set route by fast moving of nodes though PSDR uses NHSR routing and it was confirmed that a high traffic was occurred because it broadcasts to neighboring nodes. In the proposed technique, it can be confirmed that data transmission disconnection rate is quite low though the high traffic is occurred because sharing group member nodes form sub-sharing group.

Figure 13 shows the measurement results of overall network control packet. The overall network traffic includes also a control packet for setting a route between mobile nodes. The performance of network is reduced as a control packet contains a lot. As you can see in the figure, we can confirm that the proposed technique than PDSR technique show low traffic result in data transmission of same condition because it shows excellent connectivity between the mobile node.

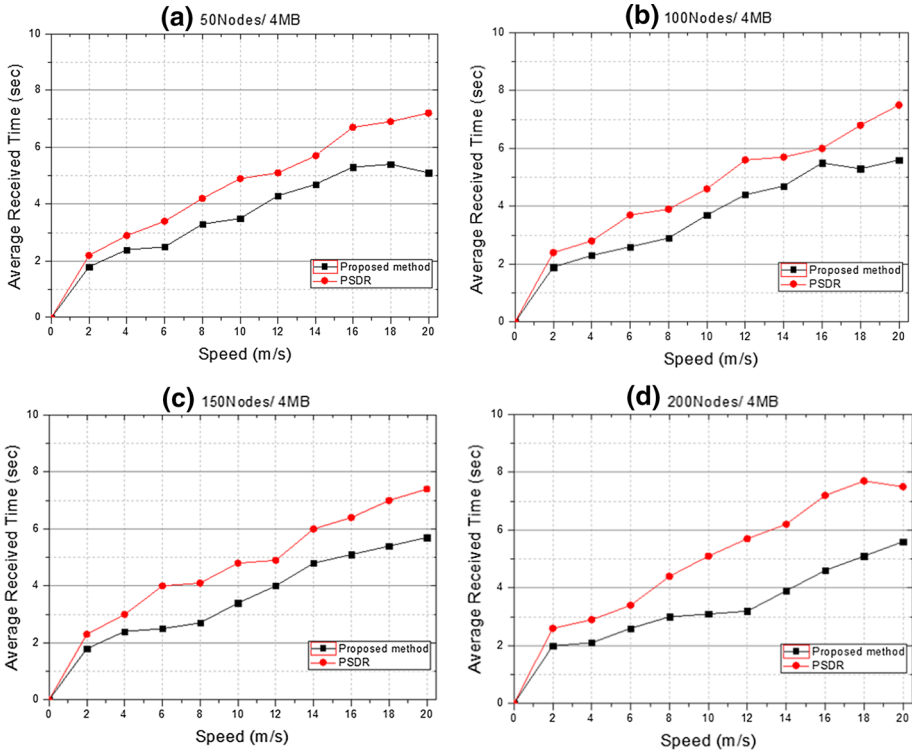


**Fig. 11** The result of delay time by the number of nodes

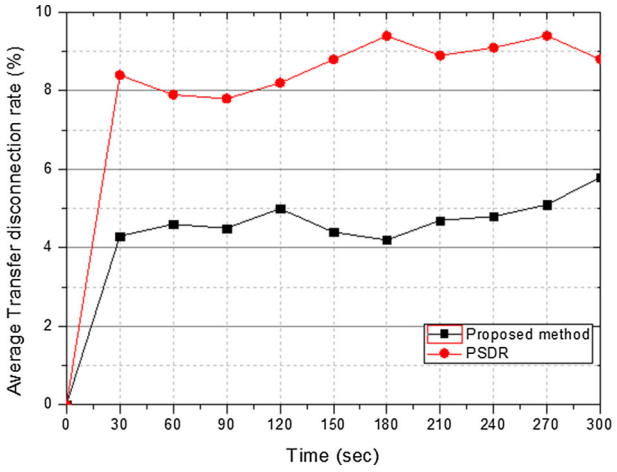


**Fig. 12** The result of data transmission disconnection rate

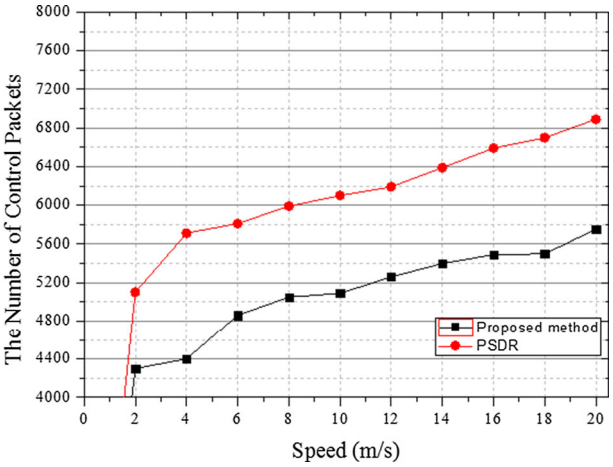


**Fig. 13** The result of control packets

## 5 Conclusions

Rapid development of a wireless network and spread of a mobile terminal such as smart phone has made extensively. In such a mobile environment, network traffic is increasing rapidly as the application providing a variety of multimedia content is increased. P2P is the technique solving the overload according to this content transmission. The popularity of P2P technique in MANET that can build network quickly by consisting of only mobile nodes is increasing day by day. However, many problems is caused due to unreliable data transmission and low bandwidth by moving nodes.

In this paper, we tried to solve the problem of stable streaming service between the mobile nodes while reducing the load of the network traffic using a hierarchical sharing group technique. For this, network was consisted to cluster as a sharing group. SGH and HSGH was elected using the connectivity. HSGH managed node detection information module for searching location of mobile nodes and SGH performed the relay role of streaming service. The technique measuring buffer status of SGMN in SGH was applied in order to provide stable streaming service. Also, we proposed sub-sharing group forming technique with neighboring nodes of 1-hop distance when SGMN transmitted data in order to reduce traffic. In this paper, we performed comparative experiment with PSDR technique using transmission delay time, the average data received time, data transmission disconnection rate, and performance evaluation criteria of overall network traffic by the number of mobile node and data size through experiment. The proposed technique was achieved excellent results of 3.6 % than PSDR technique in transmission delay time, 4.1 % in the average data received time, and 4.9 % data transmission disconnection rate.

## References

1. Kim, J. H., & Chung, K. (2014). Ontology-based healthcare context information model to implement ubiquitous environment. *Multimedia Tools and Applications, 71*(2), 873–888.
2. Jung, H., & Chung, K. (2015). Sequential pattern profiling based bio-detection for smart health service. *Cluster Computing, 18*(1), 209–219.

3. Park, R., Jung, H., Chung, K., & Yoon, K. H. (2015). Picocell based telemedicine health service for human UX/UI. *Multimedia Tools and Applications, 74*(7), 2519–2534.
4. Schollmeier, R., Gruber, I., & Niethammer, F. (2003). Protocol for peer-to-peer networking in mobile environments. In *Proceedings of the 12th international conference on computer communications and networks*, *2003. ICCCN 2003* (pp. 121–127). 20–22 Oct. 2003.
5. Matuszewski, M., Beijar, N., Lehtinen, J., & Hyyrylainen, T. (2006). Mobile peer-to-peer content sharing application. In *2006 3rd IEEE consumer communications and networking conference, 2006. CCNC 2006* (Vol. 2, pp. 1324–1325), 8–10 Jan 2006.
6. Kim, S. H., & Chung, K. (2014). 3D simulator for stability analysis of finite slope causing plane activity. *Multimedia Tools and Applications, 68*(2), 455–463.
7. Jung, H., & Chung, K. (2014). Discovery of automotive design paradigm using relevance feedback. *Personal and Ubiquitous Computing, 18*(6), 1363–1372.
8. Kortuem, G., Schneider, J., Preuitt, D., Thompson, T., Fickas, S., & Segall, Z. (2001) When Peer-to-Peer comes face-to-face: collaborative Peer-to-Peer computing in mobile ad-hoc networks. In *Proceedings of the first international conference on Peer-to-Peer computing* (pp. 75–91). 27–29 Aug. 2001.
9. Hakkarainen, T., Savikko, V., & Lattunen, A. (2005). Generic engine for collaborative mobile applications. In *Proceedings of the IADIS international conference WWW/internet 2005 (ICWI2005)*, pp. 243–246.
10. Kotilainen, N., Weber, M., Vapa, M., & Vuori, J. (2005). Mobile Chedar—A Peer-to-Peer middleware for mobile devices. In *Third IEEE international conference on pervasive computing and communications workshops, 2005. PerCom 2005 workshops* (pp. 86–90). 8–12 March 2005.
11. Hsieh, H.-Y., & Sivakumar, R. (2004). On using peer-to-peer communication in cellular wireless data networks. *IEEE Transactions on Mobile Computing, 3*(1), 57–72.
12. Datta, A. (2003). Mobigrid: P2P overlay and MANET rendezvous—A data management perspective. In *CAiSE 2003 Doctoral Symposium 2003*.
13. Karp, B., & Kung, H. T. (2000). GPSR: Greedy perimeter stateless routing for wireless sensor networks. In *The 6th annual ACM/IEEE international conference on mobile computing and networking* (*MobiCom'00*) (pp. 243–254). Aug 2000.
14. Yu, Y., Govindan, R., & Estrin, D. (2001). Geographical and energy aware routing: A recursive data dissemination protocol for wireless sensor networks. Technical Report UCLA/CSD-TR-01-0023, UCLA, May 2001.
15. Kulik, J., Heinzelman, W., & Balakrishnan, H. (2002). Negotiation-based protocols for disseminating information in wireless sensor networks. *Wireless Networks, 8*, 169–185.
16. Xu, B., & Wolfson, O. (2004). Data management in mobile P2P networks. In *Springer Verlag Lecture Notes in Computer Science*, *Proceedings of the 2nd international workshop on databases, information systems, and P2P computing (DBISP2P'04), Toronto, Canada*, Aug 2004.
17. Mauve, M., Widmer, A., & Hartenstein, H. (2001). A survey on position-based routing in mobile ad-hoc networks. *IEEE Network, 15*(6), 30–39.
18. Parvez, N., Williamson, C., Mahanti, A., & Carlsson, N. (2008). Analysis of BitTorrent-like protocols for on-demand stored media streaming. In *Proceedings of the 2008 ACM SIGMETRICS, New York, NY, USA*, pp. 301–312.
19. Catarci, T., de Leoni, M., Marrella, A., Mecella, M., Vetere, G., Salvatore, B., et al. (2008). Pervasive software environments for supporting disaster responses. *IEEE Internet Computing, 12*(1), 26–37.
20. Juszczyk, L., Psaier, H., Manzoor, A., & Dustdar, S. (2009). Adaptive query routing on distributed context—The COSINE framework. In *MDM 2009: Proceedings of the 10th international conference on mobile data management* (pp. 588–593). Washington, DC: IEEE Computer Society.
21. de Leoni, M., Mecella, M., & Russo, R. (2007). A bayesian approach for disconnection management in mobile ad hoc networks. In *WETICE'07: Proceedings of the* 16th *IEEE international workshops on enabling technologies: infrastructure for collaborative enterprises* (pp. 62–67). Washington, DC: IEEE Computer Society.
22. Battista, D., de Leoni, M., Gaetanis, A., Mecella, M., Pezzullo, A., Russo, A., & Saponaro, C. (2008). ROME4EU: A web service-based process-aware system for smart devices. In *ICSOC'08: Proceedings of the 6th international conference on service-oriented computing* (pp. 726–727). Berlin: Springer.
23. Hadaller, D., Keshav, S., Brecht, T., & Agarwal, S. (2007). Vehicular opportunistic communication under the microscope. In *MobiSys'07: Proceedings of the 5th international conference on mobile systems, applications and services* (pp. 206–219). New York: ACM Press.
24. Kusy, B., Sallai, J., Balogh, G., Ledeczi, A., Protopopescu, V., Tolliver, J., et al. Radio interferometric tracking of mobile wireless nodes. In *MobiSys'07: Proceedings of the 5th international conference on mobile systems, applications and services* (pp. 139–151). New York: ACM Press.

25. Papanastasiou, S., Mackenzie, L. M., Ould-Khaoua, M., & Charissis, V. (2006). On the interaction of TCP and routing protocols in MANETs. In *AICT-ICIW'06: Proceedings of the advanced Int'l conference on telecommunications and Int'l conference on internet and web applications and services.* Washington, DC: IEEE Computer Society.

**Hwan-Seok Yang** is holding Assistant Professor position in Information Security at Joongbu University. In 2007–2010, he worked as a Research Professor in Dept. of Cyber Investigation Police at Howon University. He received the Ph.D. degree in Computer Science and Statistics from the Chosun University in 2005. He conducts research in the general areas of security analysis of computer system and mobile networks.

**Jae Hoon Sun** received his Ph.D. degree in Department of Information Security from Kyonggi University, Republic of Korea, in 2010. Now, he is an adjunct professor in Department of General Education, Dong-Ah Institute of Media and Arts, Republic of Korea. Dr. Sun has research interests in Mobile Network Security and Information Security Management Methodology.