# 모든 peer가 송수신자인 Ad Hoc 네트워크에서의 자료 분배 방법에 대한 고찰

# Content Distribution Mechanism in an All-Sender-All-Receiver Ad Hoc Network

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요 약

Mobile device users are sensitive to pay telecommunication charge for downloading Internet data, because the cost is proportional to the amount of data received. If there are device users who want to download the same content, they may cooperate each other to form an ad hoc network and share the partially downloaded content in order to reduce the amount of data downloaded. Each mobile device, called a peer, downloads a specific portion of the whole content using fee-based telecommunication channel, and exchanges the portion with other peers with free ad hoc channel in order that all participating peers are able to reconstruct the whole content. In this situation, all participating peers become senders and receivers at the same time. In order to distribute the partial content to other peers, the ad hoc network requires a controlled distribution mechanism. This paper introduces the per-peer-based distribution method in which one designated peer can transmit partial data to its neighbors at a time. Simulation results show that 90% of the telecommunication cost is saved with as few as 10 peers.

## 1. Introduction

It's getting popular to use mobile devices to access Internet thanks to wireless communication technology such as 3G and Bluetooth. Fig. 1 displays a situation in which many nearby mobile devices connect to the Internet via their wireless telecommunication links to their ISPs and then access their favorite content. This paper proposes a low-cost sharing schemes in which mobile devices download in parallel their assigned portions of the target file via their 3G connections, and then construct an ad hoc network (that has no fee for data transferred) to exchange the remaining portions of the file. Fig. 2 illustrates the mechanism for partitioning the target file and downloading the assigned portions by the mobile devices. Suppose, users of the mobile devices wish to download a mobile game program in order to play interactively with each other. Each mobile device is assigned a portion of the target file to download. Each device connects to its favorite ISP with its 3G link and contacts the CP with the aid of its associated server in order to request its assigned portion of the file. The main difference between Fig. 1 and

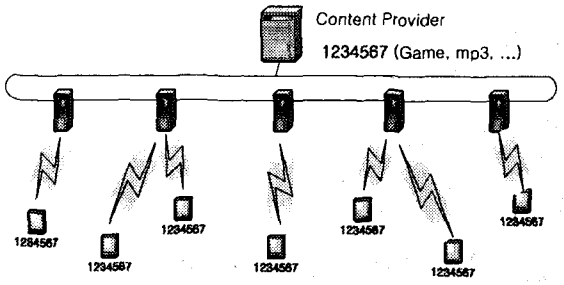


Fig 1. Each peer downloads a whole content

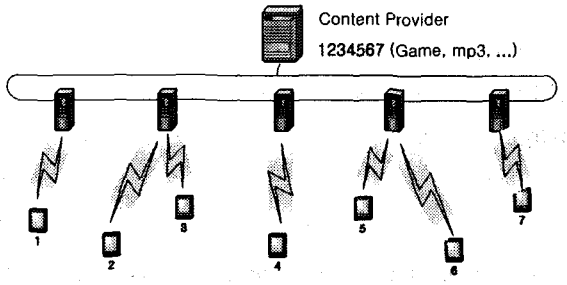


Fig 2. Each peer downloads an assigned portion of the whole content

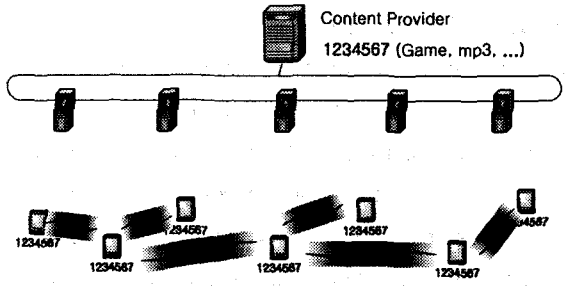


Fig 3. The remaining portion can be acquired by distributing their downloaded portions

Fig. 2 is the amount of data downloaded using 3G connection, which represents the amount of data downloaded for each mobile device. In Fig. 1, each mobile device downloads the entire content from the CP. However, In Fig. 2, each device downloads only a portion of the target file. Upon completion of downloading the specified portion of the file, the mobile devices use their ad hoc connections to exchange their content with other members. Fig. 3 shows that all mobile devices participate by exchanging their partial content with others in order to reconstruct the target file.

The idea of the cooperating ad hoc network concept is often described as peer-to-peer computing[1]. In [2], the peers download an assigned portion of a target file and distribute their portions to all other peers based on the per-packet based method. The authors in [3] investigated the performance improvements of the multiple description (MD) Content Delivery Network (CDN) over the single description (SD) CDN. Fairness issues of the multiple sources to single receiver multipoint-to-point is studied in [4]. SplitStream[5] allows a source peer to split a file into $k$ stripes and to multicast each stripe using k multicast trees. In BitTorrent [6], when many downloaders try to download a file(s) from a URL-specified location, the downloaders upload to each other concurrently to help reducing the load of the source. The authors in [7] proposed an approach for computing a schedule for coordinated data collection with avoiding congested links and maximizing the network resource utilization.

## 2. Data Distribution Method

The special ad hoc network in this paper focuses on the distribution scheme in which all peers download partial content in parallel with their own 3G connections, and exchange them with other peers using their shared cost-free ad hoc connection until all peers receive the complete content. Each peer downloads only a portion of the target file, but needs to acquire complete content. In order to reconstruct the file, every peer becomes a sender as well as a receiver. However, if all peers, as senders, transmit their content in an uncontrolled manner, the broadcast storm problem[8] may arise. Each peer needs a controlled way of broadcasting its received data to other member peers.

In the per-packet distribution method[2], one packet from one peer is forwarded to all other peers at a time. Then the next scheduled peer takes a turn to transmit its next unit-sized packet. In the per-peer based distribution, only one peer has a chance to transmit some number of unit-sized data packets to its neighbors at a time. In addition, the data packets are not immediately forwarded, which reduces the possibility of packet collision. Each

peer decides which unit-sized data to broadcast depending on the reception status of its neighbors. The neighbors do not rebroadcast any packet immediately, but wait for their transmission turn. When the current transmitting peer has finished broadcasting a given number of packets, it broadcasts a DONE packet. If a scheduled next peer is directly connected with the current peer, the next peer resumes its transmission after selecting which data to send. If the next peer is out of range from the current peer, the DONE packet contains a list of rebroadcasting peers that forward the DONE packet toward the next-scheduled transmitting peer.

One improvement on the per-peer based distribution is to provide additional opportunities for data transmission to peers that have substantial data with a positive benefit value. As the data distribution proceeds, the peers in the central area of the network receives more data than that of edge peers. Many edge peers do not have data with a positive benefit value except the data downloaded from the Internet itself. If each peer broadcasts one data packet at a time, several consecutive DONE packets may exchanged in the middle of data distribution, which increases the completion time. As more data packets transmit at a time per each peer, it will take a smaller completion time and reduces the overall DONE packet transmission frequency.

## 3. Simulation Result

The *ns2* network simulator [9] is used in this simulation. The simulation model assumes each peer downloads portions using its 3G connection that the master server schedules to download, while it exchanges the portions with other peers using its ad hoc network. The peers do not experience buffer underrun when they transmit their portions to other peers. The unit packet size of the 3G connection is set to 500 bytes. The ad hoc network uses the same size of data packets. The peers download the target file size of 1 Mbytes that consists of 2048 unit packets. Each peer has the 802.11 MAC with the transmission range of 250 meters. The number of peers varies from 2 to 10. Because of the short amount of completion time described in [2], the mobility of peers is not considered. All peers are located in a 400 meter by 400 meter grid unless specified otherwise. Each peer transmits the maximum of 90 packets at a time because the packet buffer size is set to 100 in the simulation. Each peer uploads its new neighborhood information in a second. In all cases, the ad hoc network is connected.

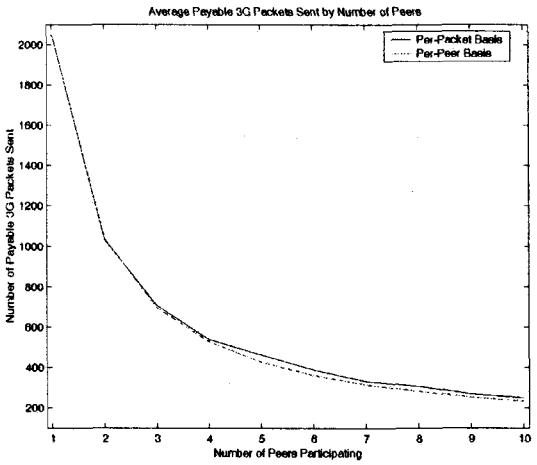


Fig 4. Number of Packets on the 3G link

Fig.4 displays the average number of packets used by the peers that may have a fee charged by a telecommunication provider. Each value in the figure is the average of 30 runs. As the number of peers increases, the number of fee-based packets decreases substantially. However, an additional peer only reduces a marginal cost when there are already several peers, whereas, the new peer receives the same cost reduction. Approximately 90% of the telecommunication cost is saved with as few as 10 peers.

The completion time of each simulation is shown in Fig.5. Both horizontal lines are the average of 30 runs and the short vertical lines represent the standard deviation of the 30 results. The average completion time increases slowly as more peers participate. This is due to the increasing number of hops in the network.

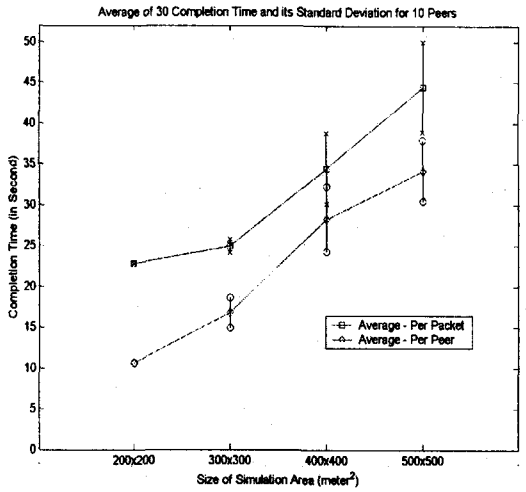


Fig 5. Completion time by varying # peers

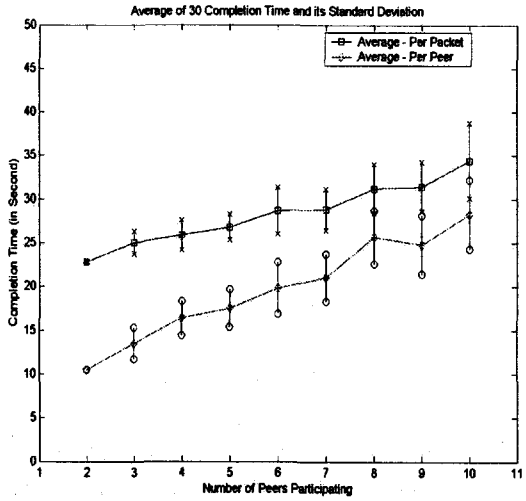


Fig 6. Completion time by varying size of simulation area

Fig. 6 shows the completion time by varying the simulation area size. The largest number of hops was 3 among 120 different topologies used in the figure. As the simulation size increases, so does the number of hops, which causes longer completion time. Overall, the per-peer based distribution method outperforms the per-packet based method in terms of the completion time, and uses less packets on the 3G link.

## 5. Conclusion

This paper describes a special ad hoc network in which mobile peers save telecommunication cost by sharing their partially downloaded data with other peers. Each peer agrees to download a specified portion of the target file located in the Internet using its fee-based WWAN connection. Each participating peer distributes its downloaded portion to all other member peers over the cost-free ad hoc connection so that all participated peers can generate the completed target file. The per-peer based distribution method utilizes the reception status of its neighbors. In addition, approximately 90% of the telecommunication cost is saved with as few as 10 peers in this distribution method.

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