Peer-to-Peer Netw. Appl. (2014) 7:53–65
DOI 10.1007/s12083-012-0175-1

A novel method for delivering multimedia e-advertisement data base on use multi-path and multi-seed peer-to-peer-like approach

Yu-Hsin Cheng · Deng-Jyi Chen

Received: 29 November 2011 / Accepted: 8 October 2012 / Published online: 19 October 2012

Abstract With the fact that digital signage are characterized for the variable and abundant multimedia visual and audio expressions and exhibit advantages of multiplicity, locality, real-time, segmentation, and existence, they have been predicted to emerge as the major trend in the future advertising in various surveys. Focused on the characteristics of disseminating the multimedia electronic advertisements through the network, there will be an enormous amount of data transmitted and various electronic advertising distributed in accordance with the regions. To specifically address these needs, we will propose a multi-path, multi-seed dissemination approach suitable for the delivery of the multimedia electronic advertisements. In this paper, within a peer-to-peer network structure, the network cluster will be first formed in accordance with the locality. Based on each cluster's locality, the electronic advertisements designated for dissemination into a specific cluster can then be determined. We then apply the seed concept formed by BitTorrent to segment the entire multimedia electronic advertisement into myriad seeds. At the same time, this paper adopts the Optimal Multi-Path Routing proposed by Guoliang Xue to design a peer-to-peer-like multiple multi-path framework, followed by the distribution of myriad seeds into each node within the cluster. Each node's bandwidth will also be utilized to complete the re-transmission of the multimedia electronic advertisement for achieving the objective of establishing multimedia electronic advertisement on each node. The NCTUns Network Simulator and Emulator was utilized to simulate the transmission status for variable number of node. The approach proposed by this manuscript can be applied to different set-up parameters and data size. The experimental results indicate that the key determining factor of transmission time under the multi-path and multi-seed dissemination approach is the data size. Transmitting the same data size under a multi-path and multi-seed approach does not increase the transmission time as the number of nodes increase. Simulations demonstrate that the multi-path and multi-seed dissemination approach is suitable for the delivery of the multimedia electronic advertisements.

Keywords Digital signage · Electronic advertisement · Multi-path · Multi-seed · Peer-to-peer

Y.-H. Cheng (✉)
Department of Information Networking and System Administration, Ling Tung University,
1 Ling Tung Road,
Taichung, Taiwan
e-mail: hsin@teamail.ltu.edu.tw

D.-J. Chen
Department of Computer Science and Information Engineering, National Chiao Tung University,
1001 University Road,
Hsinchu, Taiwan
e-mail: djchen@cs.nctu.edu.tw

1 Introduction

When you walk into MRT stations, bus stops, airports, elevators, supermarkets, hypermarkets and even fast food stores one very readily sees a variety of digital signage (examples are shown in Fig. 1). This means of signage has gradually replaced the traditional marquee or other advertisement means as such a means of displaying a product adds a pleasing increase to consumer browsing. Moreover, such an advertising platform can display product content and characteristics with more flexibility and diversity. Digital signage is tied with newspapers, journals, television and the Internet as the major media. Digital signage is also an innovative media formed to cope with the new mode of transmitting information and the current trend in shifting from mass media to a focus on quality communication. Therefore, to attract attention from the public with digital signage there must be a new appeal to advertisers in terms of media selection and use [1, 2].

Fig. 1 Diverse application of digital signage

The unique characteristics and advantages of digital signage are described as follows [1–5]:

1. Audio/Video: Multimedia digital signage is a platform that uses a digital display as the media with which to convey information to target customers located at different places and at specific times through high-quality video, animation, image and text.
2. Multiplicity: Advertisers may set up a program to be broadcast through a central system and the digital signage will follow the predetermined schedule and broadcast the requisite video and/or message. System managers ubiquitously and rapidly update all digital signage by connecting to the system via LAN or WLAN.
3. Locality: Digital signage is versatile enough to be used at locations near where the product or service is actually available. Thus, the electronic advertisement offered can completely meet the public demand. Moreover, the latest product information can be directly delivered to target customers in real-time and customers can be attracted and inspired to purchase through the dynamic media presentation. Consequently, customers are stimulated with the immediate effect of impulse buying.
4. Real-time: Traditional signage cannot be modified in terms of content after installation. Any modification would require a complete reproduction of the signage, which consumes both time and money. In comparison with the fixed nature of tradition signage, digital signage offers greater variability. In the event that any modification is needed after the installation of digital signage the staff simply must reset the configuration and not undertake a completely new installation.
5. Segmentation: Different from the mass media of general television, digital signage is compatible with small media designed for niche markets. It is a marketing tool that can achieve site-specific, real-time, interactive, and 'last mile impact' for exclusive objects.
6. Existence: Digital signage is ubiquitous and can properly provide a variety of information and advertisements by continuously giving consumers to new stimuli and to impress them with product images.

The market is quite optimistic about the availability of digital application platforms. Thus, the future need for digital signage is growing rapidly. Due to the vastness of market and the fact that the product is customized yet requires diversity there remains areas for potential improvement as described as follows:

1. Data: Due to the fact that electronic advertisement is presented via multimedia, the content of the advertisement includes a large about of data that is incomparable with general text files. The characteristics of mass transmission must be emphasized when disseminating this information via the network.
2. Segmentation: As the main focus of communication penetrates into the outdoor and commercial market, digital signage becomes the best choice for outdoor media. However, due to its regional and demographic characteristics, advertisements should take into consideration the regional culture, religion and background factors. Hence, the mass transmission of electronic advertisements does not necessarily apply to all people viewing the advertisement. Such information needs to be distributed with different electronic advertising according to the region.
3. Repeatability: Compared with the focus on electronic advertising, some electronic advertising is required for all advertising sites. For example, weather forecast and current events are all applicable to each advertising site.

Taking into consideration of the aforementioned requirements, using the traditional transmission approach to transmit multimedia e-advertisements (i.e. in batches) could result in prolonged transmission time due to excessive amounts of data. This is not favorable in the transmission of multimedia e-advertisements. From the perspective of advertisement broadcasting, the approach of peer-to-peer can potentially raise some real-time issues if one only searches online when broadcasting. Hence, one approach alone cannot solve the issues with the transmission of multimedia e-advertisements. This paper then proposes a multi-path and multi-seed approach to transmit multimedia based on the requirements and issues relevant to multimedia e-advertisement. The approach is described as follows:

1. Network clusters are formed according to regional characteristics and such characteristics are used to distribute relevant electronic advertising into the cluster terminal.
2. We use the concept of seeding from BitTorrent [6] to divide a large number of multimedia e-advertisement into different seeds.
3. We distribute these massive seeds into the various ends of the cluster to fully utilize the transmission power at each endpoint of the cluster. Hence, the multi-path approach will form a multi-path end-to-end transmission in networks in an attempt to expand the network bandwidth and to reduce transmission time.

The remainder of the paper is organized as follows. Section 2 provides background and related work. Section 3 elaborates on the architecture proposed by this paper and how the multimedia e-advertisement data completes data transmission occurs through the multi-seed and multi-path architecture. Section 4 demonstrates how multimedia electronic data is transmitted within the cluster utilizing a NCTUns network simulator [7] to simulate the different situations as well as demonstrating the details of the implementation and the experimental results. Finally, Section 5 presents the conclusions drawn from this work.

2 Related work

2.1 Data transmission path routing problem

Much of the literature proposes relevant studies on the path routing problem of end-to-end data transmission including single path and multi-path routing problem. For example, the minimum hop algorithm only takes into account of the number of path nodes passing through without taking into consideration of the actual path distance of the transmission. The single path yielded is not necessarily the transmission path with the shortest time [8]. Also, the shortest path algorithm only takes into consideration of the overall propagation delay path passing through without considering the data size transmitted. Hence, the shortest path is not necessarily the transmission path with the shortest time [9].

The maximum capacity algorithm focuses on whether the available capacity of path is the maximum path with the available capacity in the network [10]. All possible solutions are listed to delete a large number of possibilities using sufficient conditions to reach the final results [11]. This approach does not take into consideration the propagation delay of the path and the results do not necessarily yield the shortest transmission time.

The quickest path algorithm [12] not only takes into consideration propagation delay [13] but also the data size. In other words, the path that requires the minimum time to transmit data, known as the 'quickest path', is determined by considering the path propagation delay and the available maximum capacity of that path calculation based on the amount of data transmitted [12].

The multi-path data transmission algorithm can be used to improve quickest path algorithm. Although the quickest path algorithm can find a single path with the shortest transmission time there are still likely to be other idle and unused paths in the entire network that could be utilized [14]. Using these idle and unused multi-paths [15, 16] in addition to dividing the data intended for transmission [17] followed by transmission to destined nodes via different paths will expand the available transmission bandwidth of the path and shorten the time required for transmission [18]. Optimal multi-path routing [19] as proposed by Guoliang Xue uses multi-path for transmitting data online of a known size and applies a polynomial time algorithm to calculate a set of multi-path with the shortest transmission times. The multi-path approach could be used to determine the idle paths in the network and to expand the bandwidth. Nonetheless, the discussion of such an approach is limited at a couple of points.

2.2 Client/server structure

The client/server structure is made up of a client and a server that belongs to a centralized management structure. The server is the node that provides services while the client is the node that requests the services. These roles never change. Resources are stored and controlled by the server. Common applications are seen in WWW website services and FTP services [20, 21].

The advantages of client/server structure include:

- Simple protocols.
- Enjoying a more stabilized transmission speed in general.
- The server can effectively control access to restricted files.

The disadvantages of client/server structure include:

- A fixed server is always subject to hacking. Once the server is hacked or malfunctions the client will be unable to retrieve resources from the server.
- Only the server can provide service sharing. The client must acquire agreement from the server and upload files to the server in order to share resources. This limits the ease of file sharing.
- Client must know connection information related to the server.
- Heavy loading for server, which includes query and responsibility for data transmission.

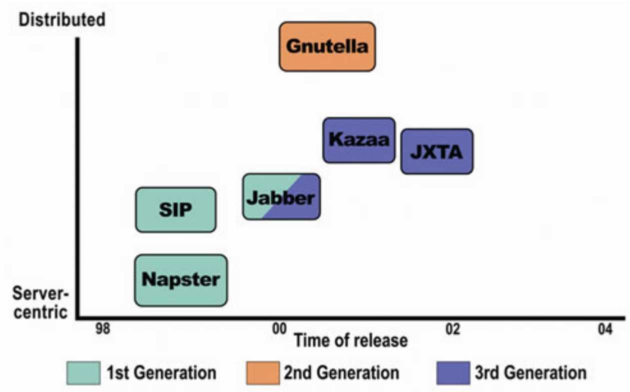


Fig. 2 The evolution of P2P [24]

2.3 Peer-to-peer (P2P) architecture

A peer-to-peer (P2P) network is composed of distributed network based on many computers online. P2P architecture differs from the centralized management method of client/server in that computers in a P2P Network are all peers with equal roles. Any computer can serve as the client or server according to different requirement. Sometimes the computer can even serve both as the client and the server concurrently, sharing each other's resources [22, 23] .

According to the development chronicle, peer-to-peer (P2P) network architecture is divided into three generations [24, 25] as described in Fig. 2 where time is the x axis and the level of distribution is the y axis. This figure demonstrates the sorting of P2P applications in a simple arrangement.

Studies that analyzed first generation peer-to-peer transmission architecture emerged in the1990s where the architecture was comprised of some index server and subsequent peers requesting for service. The system is divided into several clusters and an index server exists within each

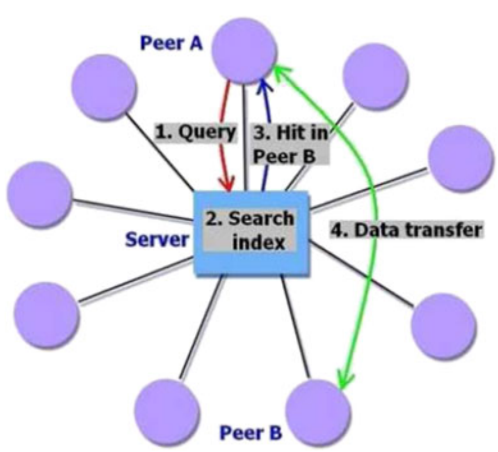


Fig. 3 The operating principle of Napster [24]

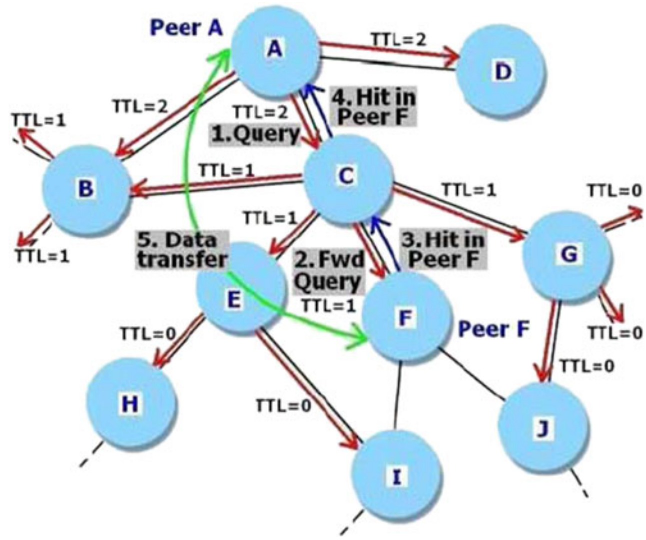


Fig. 4 The operating principle of Gnutella [24]

cluster to manage all of the data resources available for sharing. Moreover, the index server exchanges content with the index server to obtain more information. When a peer makes a request the index server notifies the peer of the other peer that has the file or service location so that these two peers can initiate peer-to-peer communication with each other. Napster [26] is a example of 1st-generation P2P transmission architecture. Its principles of operation are shown in Fig. 3, where the peer requesting the service makes a query to the index server and the index server makes a subsequent query to its file content and returns notice to the peer concerning the whereabouts of the file being sought after. The peer requesting the service then proceeds with a peer-to-peer transmission [24].

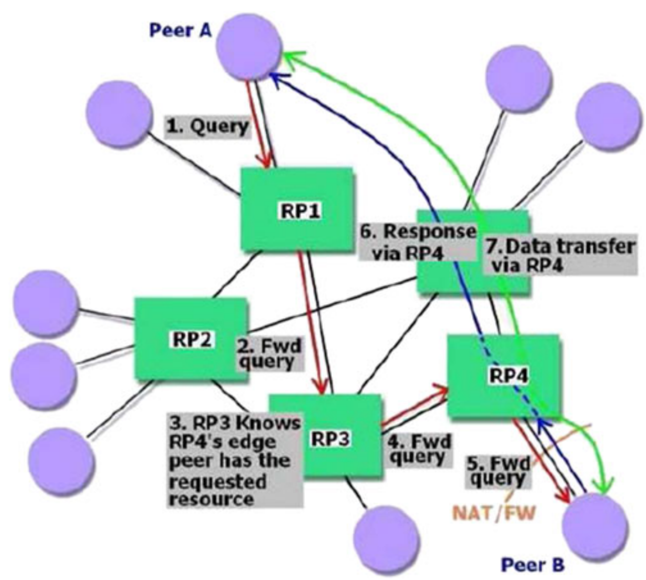


Fig. 5 The operating principle of JXTA [24]

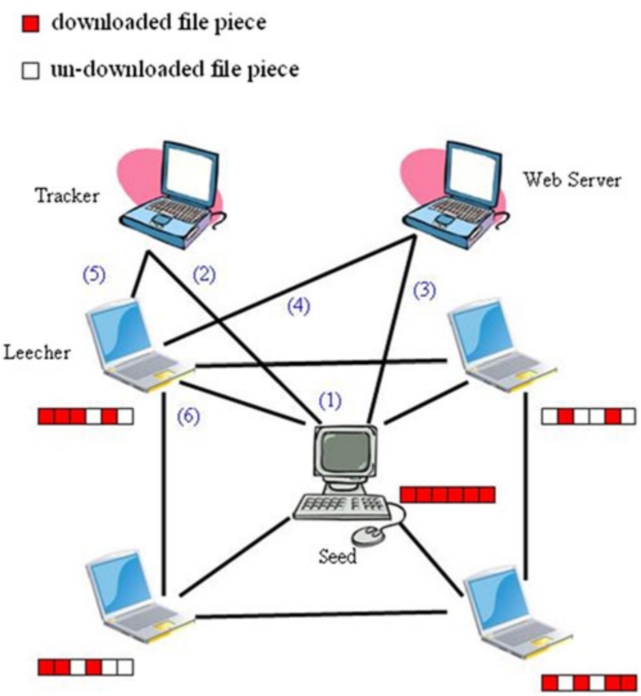


Fig. 6 Operating principles of BitTorrent

The advantages of 1st-generation P2P transmission architecture [24, 25] include:

- The server does not need to process file transmissions and thus is reduces substantial loading.
- The Index server can effectively process a query.
- Peers do not need to maintain data on other peers.

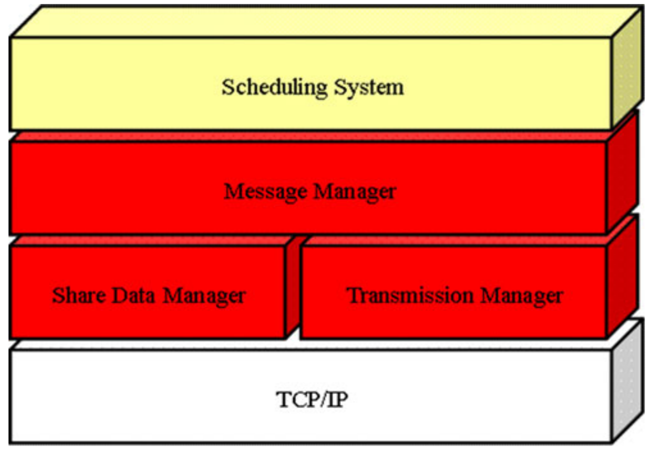
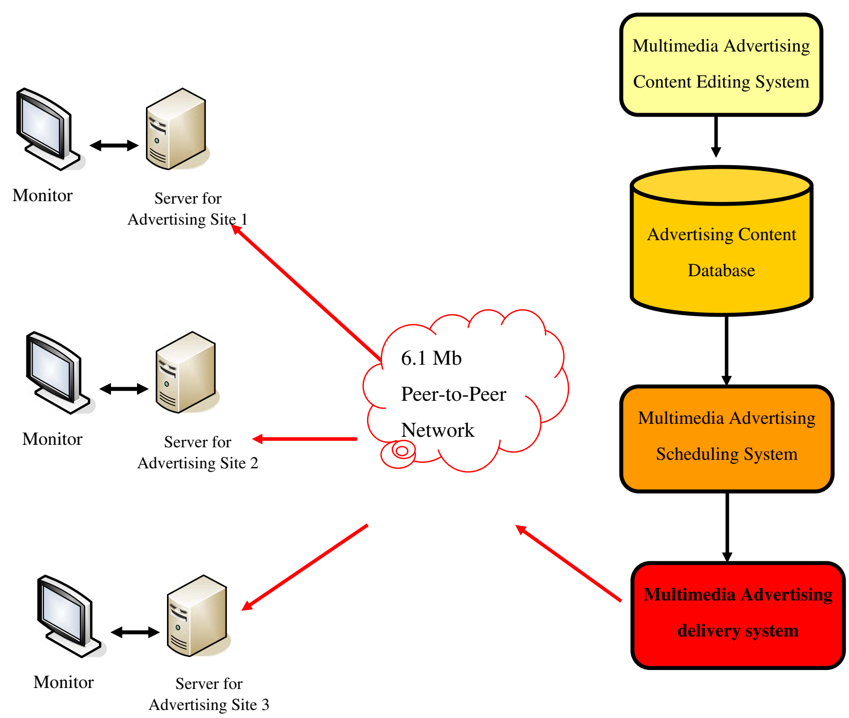


Fig. 8 Component architecture for delivery system

The disadvantages of 1st-Generation P2P transmission architecture [24, 25] include:

- There is a fixed index server that is subject to hacking. Once the index server becomes the target of hacking or malfunctions it will not be able to offer any query function.
- The fixed index server requires maintenance, management, HR resources and updating of its hardware. Hence, the fixed index server requires additional expenditure.
- Once files such as MP3s and movies with copyright issues begin to circulate online an increasing number of legal issues become involved.

Fig. 7 Architecture of multimedia e-advertisements system



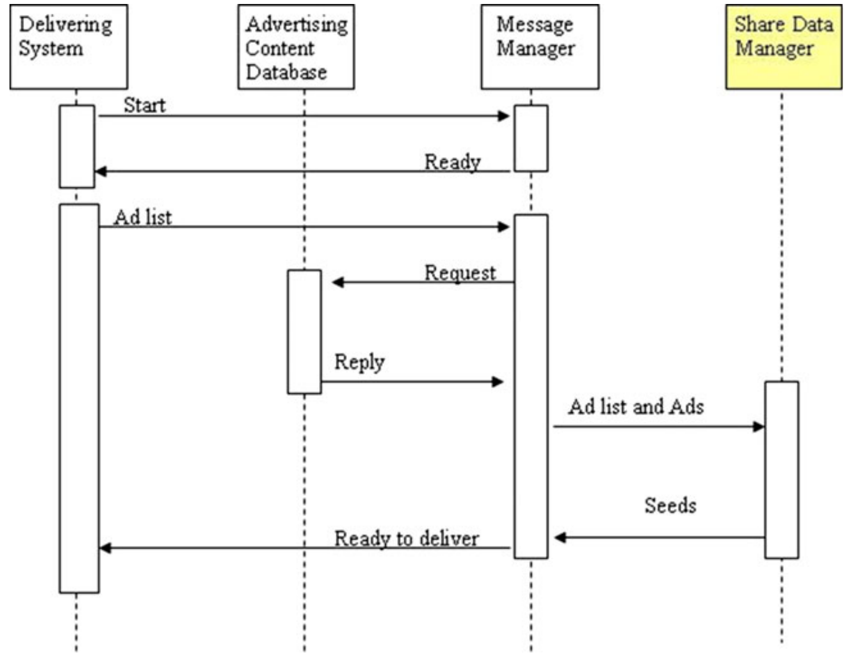


Fig. 9 Sequence diagram for share data manager

The 2nd-generation P2P transmission architecture is completely decentralized (Pure P2P) and studies on this topic have emerged since 2000. This architecture aims to solve the various problems inherent in the index server of the 1st-generation. This architecture does not contain any server; all queries, responses to requests and other communications are achieved by a mutual collaboration of peers. The peers in this type share identical statuses serving both as server and client. Hence, a peer is also known as servant. Gnutella [27] is a example of 2nd-generation P2P transmission architecture and its operating mode is shown in Fig. 4. When a peer requires some file or service it will make a request and broadcast this to its neighboring peers. In the event of no compliance for this request, neighboring peers would continue to expand this request outward until other peers have located information on this file and have responded. The request ceases delivery when the time-to-life (TTL) has come to an end. When a response is returned

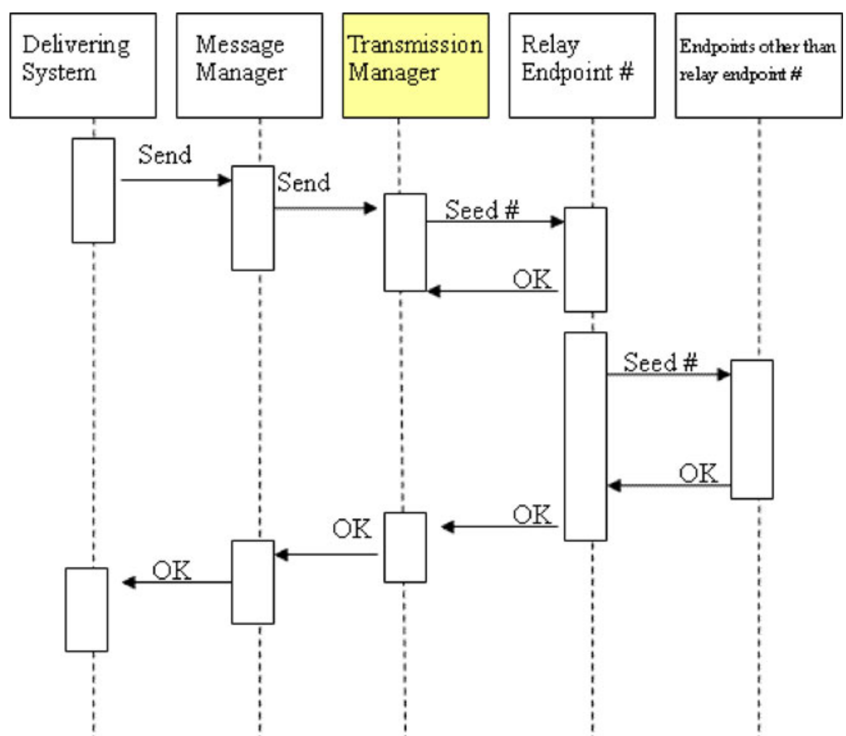


Fig. 10 Sequence diagram for the transmission manager

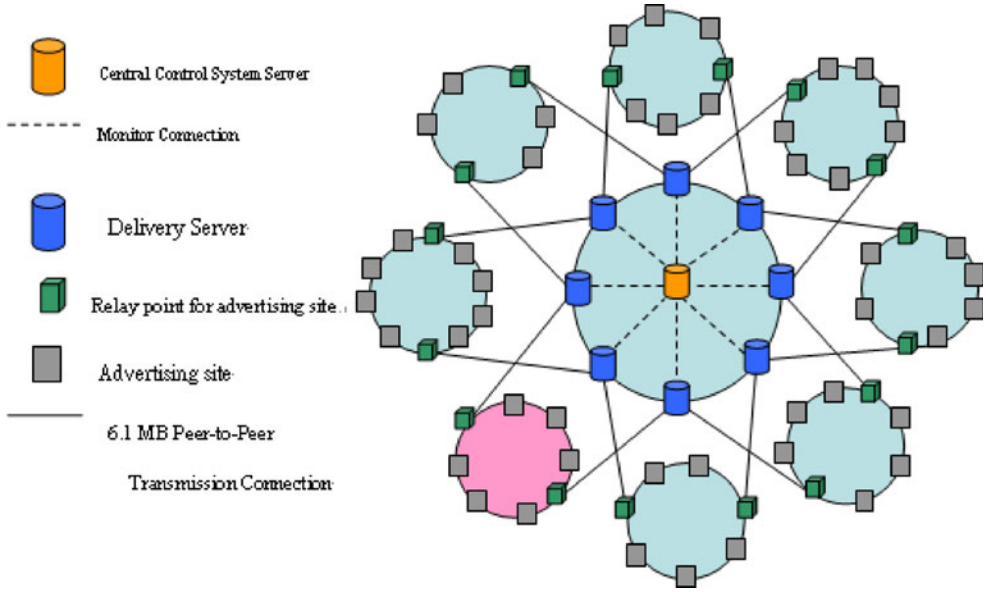


Fig. 11 Logical topology of delivery system

to the peer making a request, the peer and the peer owning this file can proceed with their own point-to-point communication and transmission [24].

The advantages of 2nd-Generation P2P transmission architecture [24, 25] include:

- The absence of a server means that the architecture is truly a decentralized network that would not become paralyzed should the server encounter a malfunction.
- The architecture offers fault tolerance. When the peer providing the file and service suddenly disappears from the network, other peers are likely to provide similar service and files. Such methods reduce the probability of a service failure.

The disadvantages of 2nd-Generation P2P transmission architecture [24, 25, 28, 29]include:

- Although depth-limited search has been applied, it could still cause network congestion.
- Worse search efficiency: the research speed of Gnutella is far slower than Napster.
- All research, responses to requests and communication are collaborated between the peers. The loading of the peer becomes more heavy.

The 3rd-generation P2P transmission architecture is a mix of the 1st-generation and the 2nd-generation. In view of the advantages and disadvantages associated with the first two generations, studies on 3rd-generation P2P transmission architecture emerged beginning in 2002. This architecture is comprised of a peer and a super-peer where the peer is the terminal device on the network that is requesting the service and whose technical capabilities are of lesser quality. This is also known as the edge-peer. The notion of a super-peer refers to the server node with a higher level of capability. It is usually the service node that provides delivery for other peers or super-peers. JXTA [30] is an example of third-generation P2P transmission architecture and its operation

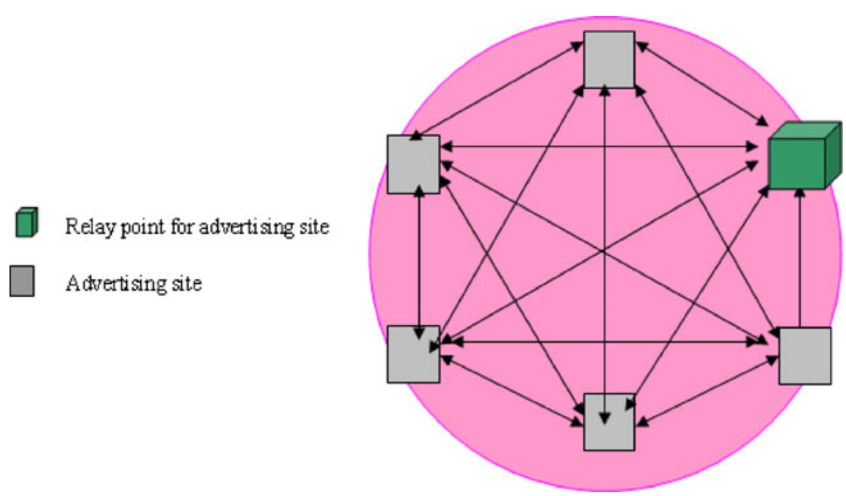


Fig. 12 Logical topology of multi-path

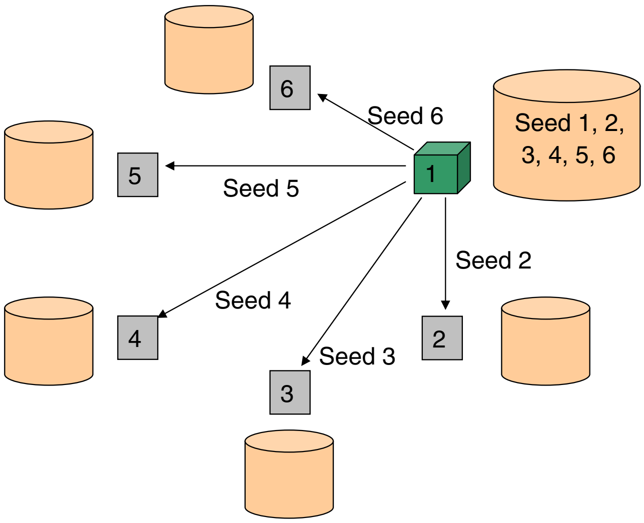


Fig. 13 The first pass: distribution of seeds

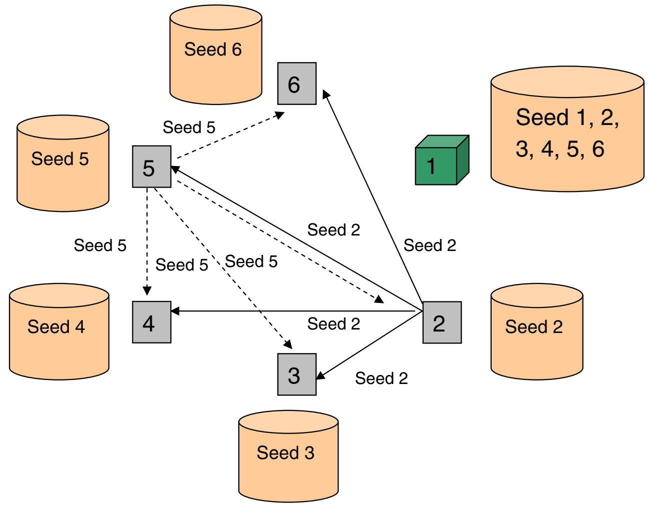


Fig. 15 During the second pass each endpoint receives seeds through multi-path

mode is shown in Fig. 5. When any one peer makes a request it will first be sent to the super-peer attributed to the peer. Super-peers will search for file content and in even that there is no result the request will be passed on to other super-peers nearby to continue with the query. After exchanging data on file directory content, the response will be returned to the peer who made the initial request and the peers will then communicate with each other and transmit the information. However, when peer B in Fig. 5 is located behind the a firewall or NAT, a super-peer will be required to assist with the job of data transfer [24].

The advantages of 3rd-generation P2P transmission architecture [24, 25, 31, 32] include:

- The super-peer is replaceable and thus users do not face the issue of a disappearing server that occurs with the 1st-generation of P2P.
- With assistance and management from a super-peer, the search speed will be accelerated and hence solves the issue associated with 2nd-generation P2P.

The disadvantages of 3rd-generation P2P transmission architecture [24, 25] include:

- Some architecture is equipped with other techniques such as tree search and cache methods for accelerating the search. However, this also increases the need for maintenance.

Aside from the aforementioned architecture, the efficacy of BitTorrent's architecture is also highly recognized. BitTorrent is a P2P file exchange technology developed by Bram Cohen whose architecture compositions include (1) a seed (the peer that owns the file), (2) a leecher (a peer that needs the file), (3) a tracker (someone responsible for

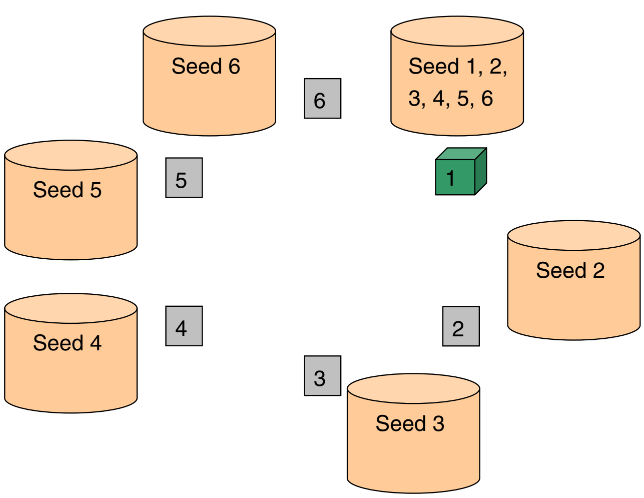


Fig. 14 At the end of the first pass each endpoint receives the seed

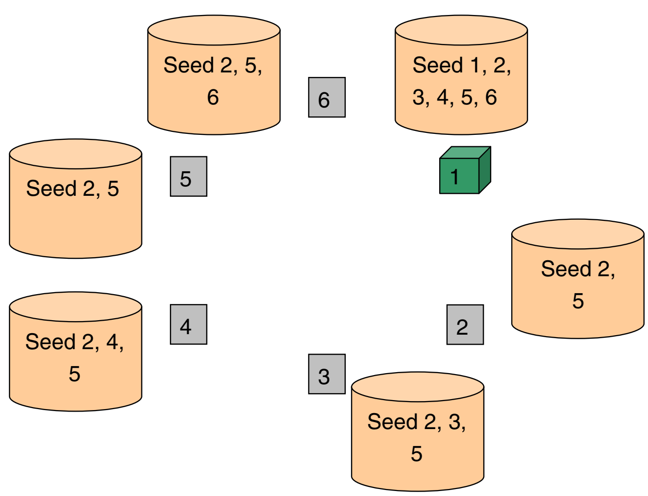


Fig. 16 At the second pass the seeds are received at each endpoint after endpoint 2 & endpoint 5 have transmitted their seeds

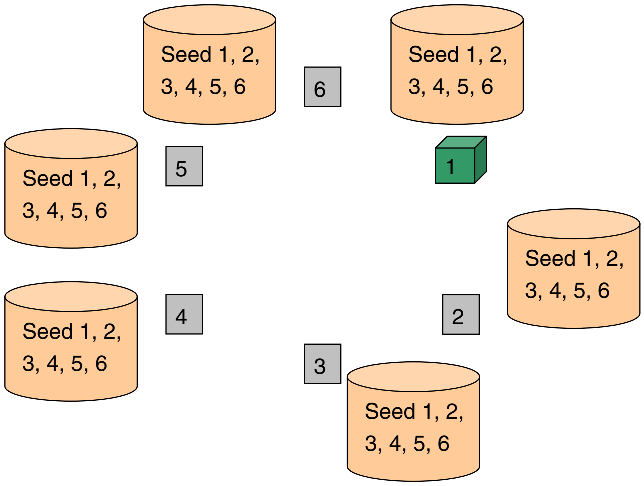


Fig. 17 At the end all endpoints have received all of the seeds

the leecher who locates the seed owning the file so file sharing can proceed) [6, 33]. The operating principles of BitTorrent are shown in Fig. 6 and the procedures are described below [33].

First the seed will convert the file to be released into a torrent file. Next, the seed registers the released file with the tracker and the torrent file will include the location data of the tracker. The seed then searches for a web server and publishes torrent file into that website so that it can be downloaded by a leecher. The leecher then searches for that same file published on the web server by the seed and then locates the torrent file published by seed. The leecher then connects with the location of the tracker through information contained within the torrent file and notifies the tracker of the file to be downloaded, the web address and the network port used. Later the tracker will randomly select a peer with the same file to form a list and then return that list to the peer as well as the network port used by the peer. Finally, the leecher will begin downloading and sharing files according to the peer data in the list.

3 System design

3.1 Architecture of multimedia e-advertisements system

Multimedia e-advertisements system contain editing subsystem which can alter the advertising content, the scheduling subsystem, the delivery subsystem and the monitoring and management subsystem as shown in Fig. 7. This paper explores the delivery subsystem. The delivery subsystem delivers the advertising content for each advertising site according to the results determined by the scheduling subsystem.

3.2 Delivery system architecture

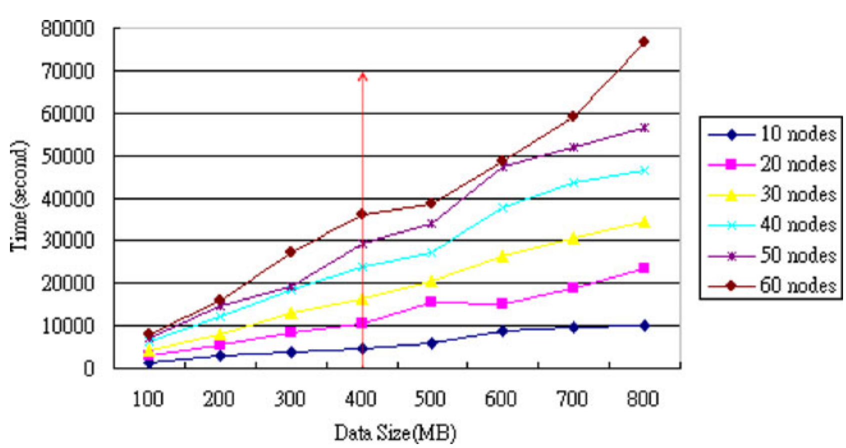
The positioning of the delivery system falls into place between the scheduling system and TCP/IP. The delivery system is divided into three major management components including the Message Manager that controls all transmissions, the Share Data Manager that generates seeds and the Transmission Manager that transmits seeds. All of this is shown in Fig. 8. The collaboration of these three management components accomplishes massive data transmission to each endpoint.

The Message Manager commonly receives status messages; after receiving such messages the control component will analyze the message and transmit it to the proper management components to initiate new action. With the exception of incorrect situations, the Message Manager will also store messages in log for back tracing and debugging.

Figure 9 describes the process of Share Data Manager when generating seeds. The delivery system transmits the advertisement retrieved from the selected advertising list and corresponding advertising content database to the Share Data Manager via the Message Manager. Different seeds are generated by the Share Data Manager according to the different bandwidth and they undergo multi-path seed propagation through the Transmission Manager.

The Transmission Manager is responsible for all physical transmission of data. The delivery system notifies the

Fig. 18 Changes in transmission time under the different number of nodes and same data size



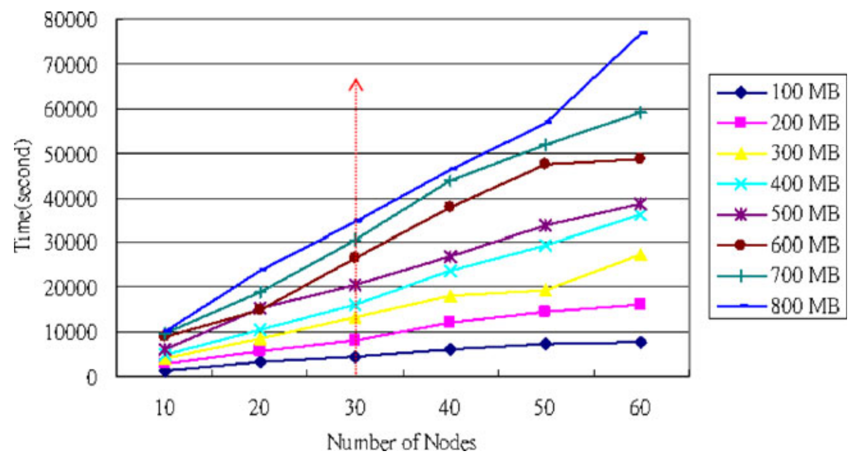


Fig. 19 Changes in transmission time under the same number of nodes and different data size

Transmission Manager through the Message Manager of the need to transmit seeds to certain relay endpoints. The seed is then transmitted from the relay endpoint through a multi-path and multi-seed transmission mechanism to other endpoints within the cluster. This is shown in Fig. 10.

3.3 Logical topology of the delivery system

The data source for this system is mainly an advertising content database generated from a multimedia e-advertisement content editing system. After the advertising content database is selected by the multimedia advertising scheduling system and completed with the play list it is stored into the ring topology constructed by delivery servers. This is followed by initiation of the driving and delivery work from the central control system. The data is then transmitted to the relay point of the regional cluster via the network. A variety of clusters are constructed using regional characteristics to ensure that they remain next to each other. There are at least one to two relay points in any cluster network and the relay points and endpoints connect with each other to form a logical topology with a multi-path delivery system. This is shown in Fig. 11.

3.4 Multi-path and multi-seed transmission scheme

This paper uses regional characteristics to generate a closely connected cluster network using one or two endpoints as the relay point, where the relay point and the endpoints connect with each other to form a multi-path topology diagram. This is shown in Fig. 12. Multi-path and multi-seed transmission schemes are completed in two passes. At the first pass the relay point is responsible for downloading all of the data from the delivery network and generating a large number of seed. This is followed by a distribution of the seeds to the database at different endpoints where each endpoint contains only a part of the entire data from the first pass. At the second pass the seeds are re-transmitted to other endpoints using the networking capability of each endpoint. Upon transmitting seeds between the endpoints, each will own a complete multimedia e-advertisement.

The algorithm of proposed multi-path and multi-seed transmission scheme can be described as follows:

```
Procedure Scheme()
BEGIN{
// first pass //
the relay point divides the multimedia e-advertisement into different
seeds and distributes these seeds to each endpoint
// second pass //
each endpoint delivers its seeds to other endpoints. Meanwhile, the
endpoint also accepts different seeds from other endpoints.
}
END
```

The following example describes the operating process of a multi-path and multi-seed transmission scheme. At the first pass the relay point divides the multimedia e-advertisement into different seeds and distributes these

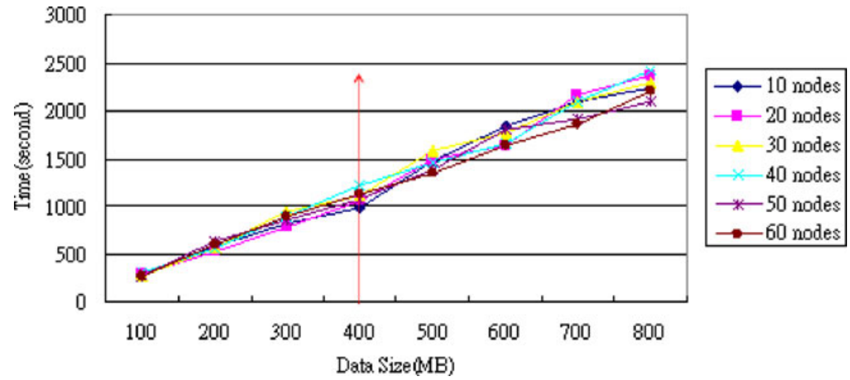


Fig. 20 Changes in transmission time under the different number of nodes and same data size

seeds to each endpoint through the network. This is shown in Fig. 13.

At the end of the first pass the relay point will complete the transmission of seeds while the other endpoints will receive only a portion of their own seeds. This is shown in Fig. 14.

At the end of the first pass each endpoint contains only a portion of the entire data. Each endpoint from the second pass delivers its seeds to other endpoints. Meanwhile, the endpoint also accepts different seeds from other endpoints. Figure 15 shows an example of endpoint 2 and endpoint 5. In fact, nearly all of the endpoints are concurrently transmitting to each other.

After endpoint 2 and endpoint 5 of the second pass have transmitted their seeds, other endpoints will receive new seeds. This is shown in Fig. 16. Consequently, each endpoint receives seeds from the other while its own seeds are transmitted to other endpoints through the bandwidth given by the endpoint. Finally, all seeds are collected and the entire multimedia e-advertisement is shown in Fig. 17.

4 Experimental result

This paper applies a NCTUns network simulator [7] to simulate the desired experiment. The advertising content that is transmitted in this simulated experiment is placed under a T2 leased line with a bandwidth of 6.1 Mbps. The cluster is generated using regional characteristics thus simulating the increase in the number of nodes from 10 to 60 (ascending in increments of 10 nodes) while the data size increases from 100 to 800 MB (ascending in increments of 100 MB). We observe what type of impact the number of nodes and the data size has on the time of transmission.

4.1 Experimental result of single-path data transmission

When transmitting the same data size in a single-path environment, increasing the number of nodes will increase the time to transmit the data in an incremental proportion. The experimental results is shown in Fig. 18.

When we transmit data in a single-path environment, maintaining the same number of nodes will cause the transmission time of data to increase in proportion to the increase in the data size. The experimental result is shown in Fig. 19.

The previous two experimental results show that when transmitting data in the single-path environment the data size and the number of nodes affect the time required for data transmission. The transmission time will rapidly increase when both the number of nodes and data size increase concurrently.

4.2 Experimental results of data transmission through multi-path and multi-seed approach

Transmitting the same amount of data under a multi-path and multi-seed approach does not increase the transmission

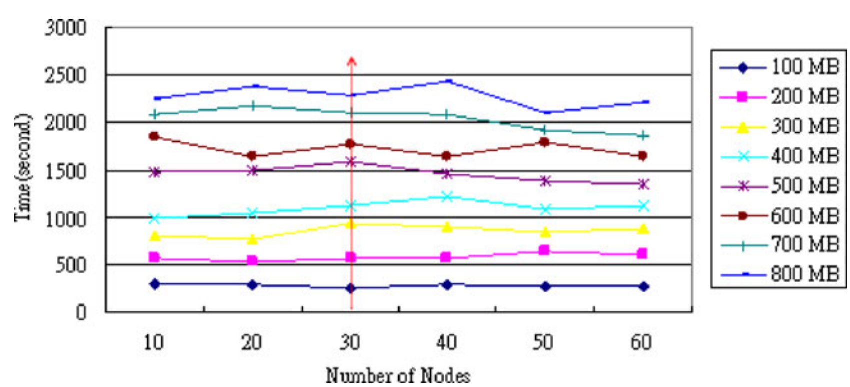


Fig. 21 Changes in transmission time under the same number of nodes and different data size

time as the number of nodes increase. The experimental result are shown in Fig. 20.

In a data transmission under a multi-path and multi-seed environment, the increase of data size while keeping the number of nodes constant will results in an increase in the time for transmitting the data. The experimental results are shown in Fig. 21.

The previous two experimental results indicate that the key determining factor of transmission time under the multi-path and multi-seed is the data size.

4.3 Analysis of experiment results

As compared to other improved schemes, the experiment results demonstrate that the transmission time of a multi-path and multi-seed approach proposed in this paper does not increase due to the increase at the endpoint, which stabilizes when faced with expansion in endpoints. At the same time, when the data size increases, the multi-path approach is used to expand the characteristics of bandwidth, which are particularly suitable for a massive data transmission for the multimedia e-advertising.

5 Conclusion

Due to the diverse presentation of multimedia video and audio for digital signage, as well as the advantage of locality, real-time, segmentation, existence and multiplicity, a number of surveys show that digital signage is becoming a significant aspect of future advertising. Broadcasting multimedia e-advertisements via the network is subject to a variety of issues such as transmitting a massive amount of data and delivering different digital advertising according to the region. We hereby propose a multi-path and multi-seed approach that is applicable to multimedia e-advertisement transmission.

To resolve the issues present in transmission of multimedia e-advertisement, this paper uses the seed concept of BitTorrent and divides data contained with multimedia e-advertisements into different seeds. A P2P-like multi-path designed with an optimal multi-path is used to broaden the bandwidth and to transmit a variety of seeds via many different paths. Such an approach can fully utilize the transmission capabilities of all endpoints inside the cluster and assist with the transmission of multimedia e-advertisements.

The experimental results indicate that the key determining factor of transmission time under the multi-path and multi-seed is the data size. Transmitting the same data size under a multi-path and multi-seed approach does not increase the transmission time as the number of nodes increase.

This paper uses regional characteristics to construct the cluster; however, this paper does not take into consideration a comprehensive protection scheme for network security. Hence, future studies will need to take such online security issues into consideration.

Acknowledgments The authors would like to express our thanks to Wei-Lung Huang for the discussions which helped us develop the ideas and help with experimental design, and the editor and anonymous reviewers for the helpful comments.

References

1. Newman A, Dennis C, Wright LT, King T (2010) Shoppers' experiences of digital signage-a cross-national qualitative study. Int J Digit Content Technol Appl 4(7):50–57
2. Suqiura K, Dayarathna M, Withana A (2010) Design and implementation of distributed and scalable multimedia signage system. In: IEEE 2010 Second International Conference on Ubiquitous and Future Networks (ICUFN), pp 273–278
3. Dennis C, Newman A, Michon R, Brakus J, Wright L (2010) The mediating effects of perception and emotion: Digital signage in mall atmospherics. J Retail Consum Serv 17(3):205–215
4. Yu KM, Yu CY, Yeh BH, Hsu CH, Hsieh HN (2010) The design and implementation of a mobile location-aware digital signage system. In: IEEE 2010 Sixth International Conference on Mobile Ad-hoc and Sensor Networks (MSN), pp 235–238
5. Chen Q, Malric F, Zhang Y, Abid M, Cordeiro A, Petriu E, Georganas N (2009) Interacting with digital signage using hand gestures. In: ICIAR '09 Proceedings of the 6th International Conference on Image Analysis and Recognition, pp 347–358
6. Liu Z, Chen C (2006) Modeling bittorrent-like peer-to-peer systems. IEEE Commun Lett 10(7):513–515
7. NCTUns Network Simulator and Emulator website. http://nsl.csie.nctu.edu.tw/nctuns.html
8. Fredman ML, Tarjan RE (1987) Fibonacci heaps and their uses in improved network optimization algorithms. J ACM 34(3):596–615
9. Doe N, Pang CY (1984) Shortest–path algorithms: Taxonomy and annotation. Networks 14(2):275–323
10. Ahuja RK (1988) Minimum cost-reliability ratio path problem. Comput Oper Res 15(1):83–89
11. Hu TC (1961) The maximum capacity route problem. Oper Res 9 (6):898–900
12. Chen YL, Chin YH (1990) The quickest path problem. Comput Oper Res 17(2):153–161
13. Martins EQV, dos Santos JLE (1997) An algorithm for the quickest path problem. Oper Res Lett 20(4):195–198
14. Xue GL, Sun SZ, Ben Rosen J (1992) Minimum time message transmission in networks. In: IEEE Fourth International Conference on Computing and Information, pp 22–25
15. Rosen JB, Sun SZ, Xue GL (1991) Algorithms for the quickest path problem and the enumeration of quickest paths. Comput Oper Res 18(6):579–584
16. Chen YL (1994) Finding the k quickest simple paths in a network. Inf Process Lett 50(2):89–92
17. Chen YL (1993) An algorithm for finding the k quickest paths in a network. Comput Oper Res 20(1):59–65
18. Xue G, Sun H, Ben Rosen J (1998) Fast data transmission and maximal dynamic flow. Inf Process Lett 66(3):127–132
19. Xue G (2000) Optimal multi-path end-to-end data transmission in networks. In: Fifth IEEE Symposium on Computers and Communications, pp 581–586

20. Nishida H, Ngugen T (2011) Optimal client–server assignment for internet distributed systems. In: IEEE 2011 Proceedings of 20th International Conference on Computer Communications and Networks, pp 1–6
21. Kolahi SS, Chand N, Soorty BK, Qu Z (2010) Performance comparison of IPv4 and IPv6 in peer-peer and client server local area networks. In: 2010 IEEE 10th International Conference on Computer and Information Technology, pp 41–45
22. Kang C (2011) Survey of search and optimization of P2P networks. Peer-to-Peer Netw Appl 4(3):211–218
23. Ganjam A, Rao SG, Sripanidkulchai K, Zhan J, Zhang H (2010) On-demand waypoints for live P2P video broadcasting. Peer-to-Peer Netw Appl 3(4):277–293
24. Harjula E, Ylianttila M, Ala-Kurikka J, Riekki J, Sauvola J (2004) Plug-and-play application platform: Towards mobile peer-to-peer. In: Proceedings of 3rd international conference on Mobile and ubiquitous multimedia, pp 63–69
25. Schollmerier R (2001) A definition of peer-to-peer networking towards a delimitation against classical client–server concepts. In: Proceedings of the IFIP Workshop on IP and ATM Traffic Management (WATM'01)
26. Napster website. http://www.napster.com
27. Gnutella website. http://www.gnutella.com
28. Day M, Rosenberg J, Sugano H (2000) A model for presence and instant messaging. RFC 2778, Internet Engineering Task Force
29. Kwok SH, Chan KY (2004) An enhanced Gnutella P2P protocol: A search perspective. In: IEEE 18th International Conference on Advanced Information Networking and Applications, pp 599–604
30. JXTA website. http://www.sun.com/software/jxta
31. Liscano R, Jost A, Dersingh A, Hu H (2004) Session-based service discovery in peer-to-peer communications. In: Proceedings of International Conference on Electrical and Computer Engineering, pp 1477–1481
32. Maibaum N, Mundt T (2002) JXTA: A technology facilitating mobile peer-to-peer networks. In: IEEE International Mobility and Wireless Access Workshop, pp 7–13
33. Cohen B (2003) Incentives build robustness in BitTorrent. In: Workshop on Economics of Peer-to-Peer systems, pp 68–72

Yu-Hsin Cheng is currently an Assistant Professor in the Department of Information Networking and System Administration, Ling Tung University, Taiwan, R.O.C. His research interests include computer networks and data management.

Deng-Jyi Chen received the B.S. degree in Computer Science from Missouri State University (cape Girardeau), U.S.A., and M.S. and Ph.D. degree in Computer Science from the University of Texas (Arlington), U.S.A. in 1983, 1985, and 1988, respectively. He is now a professor at Computer Science and Information Engineering Department of National Chiao Tung University (Hsinchu, Taiwan). Prior to joining the faculty of National Chiao Tung University, he was with National Cheng Kung University (Tainan, Taiwan). So far, he has been publishing 130+ referred (journal 50+ conference 70+) papers in the area of performance and reliability modeling and evaluation of distributed systems, computer networks, fault-tolerant system, software reuse, object-oriented systems, and multimedia application systems.