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Join and Caching Scheme in Mobile P2P-based Streaming Service

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Abstract

The P2P multicast that has been recently presented as an alternative to the client-server architectures has been getting much persuasion by the system resource and the network bandwidth and the advancement of the network cost. Also, studies on P2P networks for the effective services of VOD streams in the mobile environment have been actively carried out. They however, have failed to consider fully characteristics proper to mobile nodes, such as the constraints of available resources and the variability of service time and location, since their concepts have merely expanded the characteristics of the existing P2P wired networks to mobile nodes. We suggested a scheme for the effective VOD streaming service on the mobile node oriented P2P network. Specifically, our scheme prevents the overconsumption of resources for a parent node when it uploads streams for other node, and enables a child node to keep downloading streams effectively even after its parent node exits the network. Our simulation showed the favorable performance of our system compared to the existing systems, in terms of resource utilization for nodes joining the P2P service and the utilization of shared cache.

Keywords: *P2P network, P2P service, Mobile P2P, Precaching strategy, VOD*

1. Introduction

Internet web service based on high performance network traffic, which includes various application services such as Digital Video, Quality of Service (QOS) for multimedia resource transmission, Multi-casting, Video phone, Home network, Secure Systems of Internet Electronic Commerce, and contents service etc., grows upon the basis of broadband transport networks. Mobile P2P VOD Service provides multi-media stream on mobile phones using traditional P2P network. However, since Mobile P2P should accept all the features of mobile device and multimedia contents service, it is different from former P2P service - mobility and transmission range, the limitation of transmission power and capacity, VOD stream of continuous service, rating popularity. For more effective streaming of mobile device and stream service, methods of utilizing centralized scheduling server and techniques of expanding traditional P2P systems have been proposed. First, on Mobile Opportunistic Video-on-demand (MOVi), centralized operator grasps ‘Opportunity’ that can do network between all the nodes in P2P network and controls transmission of contents which are divided as segment unit.[1,2] The research that extended e-DONKEY service into mobile P2P added both indexing server that manages resources in mobile node and caching server for popular resource.[3] Power saving methods were also suggested in order to solve the restrictive problems of common resource usage of mobile device.[4] As we can see from the early studies, for more effective mobile P2P service, a new strategy that is distinguished from existing P2P stream service on contents transmission among mobile nodes and on caching strategy is required.[5-7].

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2. Concept of Mobile P2P Service

Existing wired P2P service node connected to a wired network using the IP address of a data communication path between nodes, a distance (cost), bandwidth and join in consideration of time, and the nodes interconnected to appropriate content download service. However, Mobile P2P service is inferior to wired P2P system in terms of storing capacity, processing speed, power supply. Thus, advanced strategy is required to solve the problems mentioned above and share contents effectively. In Figure 1, we described by referring general models of mobile P2P. Index server saves nodes which are in the wireless P2P and the list of contents that caching nodes have. When mobile nodes request resources, it provides the list of contents and information of nodes. Index server stores contents information upon internet P2P when it is needed.

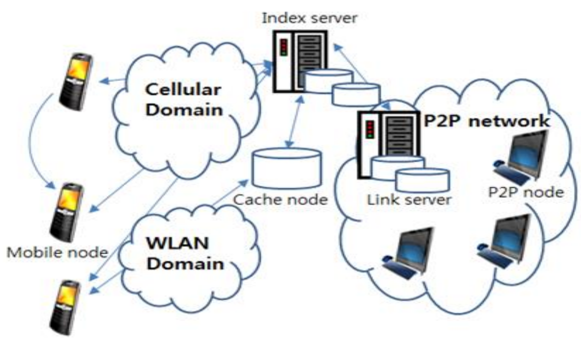

Figure 1. Conceptual Mobile P2P Network

Cache nodes save segment of contents which are frequently required, and they share the resource directly. In addition, the link server stores the most popular downloaded contents at a server located on a wired network, and provides the relevant contents on behalf of wireless terminal, in case of request for them.

3. Mobile P2P Service Model

3.1. Relay Join Strategy

The typical methods for forming a P2P multicast tree include the Bandwidth-Ordered(BO) tree and the Time-Ordered(TO) tree[8]. For example, suppose that the time when Node 1, Node 2, Node 3, … Node 7 join a network is t1, t2, t3, … t7, and that an interval between their joining time is Δt1, Δt2, Δt3, .. and Δt6, respectively. A TO tree and a BO tree expected in case of using the above supposition to construct a P2P tree, with the bandwidth between nodes being three times the video traffic requirements, are as shown in Figure 2 and Figure 3. In Figure 2, while Node 1 is downloading contents i via a certain parent node at t1, Node 2 requests the same contents and joins Node 1 after $\Delta \boldsymbol{t1}$. Again after $\Delta \boldsymbol{t2}$, Node 3 joins Node 1, requesting the same contents. Lastly, Node 7 joins Node 2 (Node 4 in Figure 3), $\Delta \boldsymbol{t6}$ after Node 6 joins. Let the total sum of time needed for Node 1 to download its own necessary contents from mobile P2P (T_i) and time needed to upload contents for its child nodes be T_t, and then T_t can be calculated as follows:

First, let the total time for downloading contents i be T_i, and then Tt = $Ti + \Delta \boldsymbol{t1} + \Delta \boldsymbol{t2} + \Delta \boldsymbol{t3}$. Therefore, if nodes that join Node 1 are {2, 3 ,4, ...N} and the time of starting download for each node is $\{\boldsymbol{t1}, \boldsymbol{t2}, \boldsymbol{t3}, \boldsymbol{t4} \ldots \boldsymbol{t_{n-1}}\}$, Node 1 spends $\sum_{\mathbf{i=1}}^{\mathbf{n-1}}(\mathrm{t_{i+1}} - \mathrm{t_i})$, that is, $\sum_{\boldsymbol{i=1}}^{\boldsymbol{N-1}} \Delta \boldsymbol{ti}$ in addition to time for downloading its own contents. Such a phenomenon is not desirable from the part of a mobile device whose resources are limited.

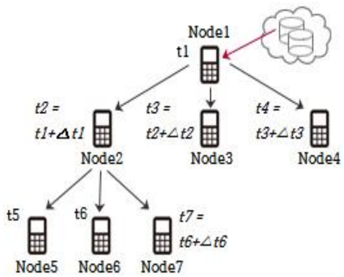

Figure 2. TO Join Tree

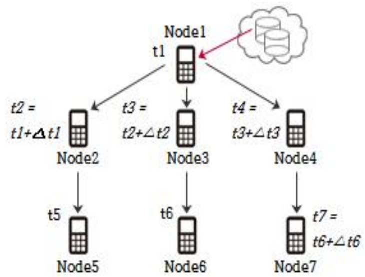

Figure 3. BO Join Tree

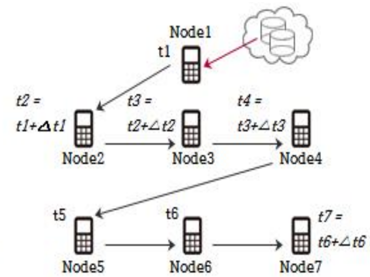

Figure 4. RO Join Strategy

Relay Ordered (RO) Join Strategy allows nodes within a P2P mobile group to share the burden of resource use, and prevents the phenomenon that resource consumption converges on a particular node. Figure 4 and Figure 5 illustrate a relay join tree and the state of resource utilization, respectively. The RO Join does not depend solely on the super node (Node 1), but distributes the use of resources to child nodes in order. Figure 5 shows that upload time to service a child node is added by $\{\Delta\, \mathbf{t1},\ \Delta\, \mathbf{t2},\ \Delta\, \mathbf{t3}\}$ for {Node 1, Node 2, Node 3}, respectively. In general, if there are N nodes and the number of nodes with a child node is SN, the average service time of nodes with a child node, TSM, is $\mathbf{t} + (\sum_{\boldsymbol{i=1}}^{\boldsymbol{n-1}} \Delta \boldsymbol{t(i)})$/ SN, where if BW is the size of bandwidth between nodes and TR is a required video traffic amount, for the TO tree, $\mathbf{SN_T}$ = (N+1)/(BW/TR); for the BO, $\mathbf{SN_B}$ ≈ (N+1)/(BW/TR); and for RO, $\mathbf{SN_R}$=N-1. Therefore, it may be said that $\mathbf{SN_R} > \boldsymbol{SN}_\mathbf{B} \geq \mathbf{SN_T}$. The characteristics of RO are that it distributes loads to every node within a network and that it has a simple structure compared to BO and TO, and thus link to a parent node is easily established in case of a failure in an intermediate node.

3.2. Precaching Strategy

The procedure to provide contents to descendant nodes may be complicated and the service may be delayed when the candidate nodes which save requested contents cannot be found and when there is no requested contents. When a node uploads and downloads at the same time, precaching strategy makes an estimated time. This strategy saves contents segment in advance that the node has to upload after that. Figure 6 shows the concept of precaching strategy. A segment block marked by patterns of each node should be pre-stored before being downloaded. For example, after node1 downloads its contents and leaves from mobile P2P network, child node 2 is not able to download segment {7, 8} from parent node (node 1). Therefore, before node 1 downloads all the contents, mobile P2P manager should do precaching segment {7, 8}. Stream PreCaching Strategy includes the following cases.

(1) when parent node secures bandwidth for precaching, and child node can download multi stream
(2) when parent node secures bandwidth for precaching, but child node cannot download multi stream
(3) when parent node does not have bandwidth for precaching, and child node can download multi stream

(4) when parent node does not have bandwidth for precaching, nor can child node download multi stream

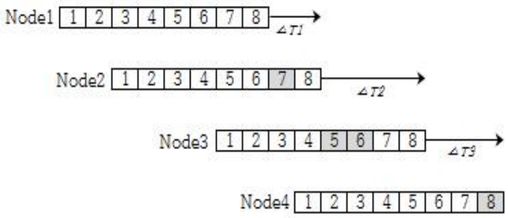

Figure 5. Utilization of Resources

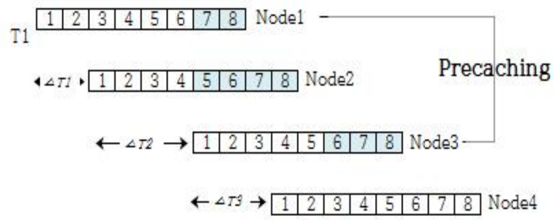

Figure 6. PreCaching Strategy

4. Performance Evaluation

The tool for evaluating the performance of this paper is Process-based Discrete Event Oriented Kernel, also known as SSFNet [9]. Comparing experiment network is composed with 2000 nodes. Every node can compose more than one client. Relay Join Strategy has one child node per each node, and relay join degree is limited up to 10 nodes. We simulate 100 video streams and each playing time is 360 seconds. Packet arrival rate of each client is the main indicator for the file's popularity. And as soon as the download of desired video stream was completed after a node had joined its parent node, we made the node leave the relevant P2P even when it had a child node. The formula 1 that was based on Zipf distribution shows the popularity of the videos. Here, 'i' is assumed to be the number of the entire video. Formula 2 is a modification of Formula 1, which represents the request rate of the video user's.

$$f(i) = C / i \text{ here } C = 1/\sum (1/i) \quad < \text{for } i = 1 \text{ to } I > \quad (1)$$

$$f(i) = C / i\,(1-\theta) \text{ where } C = 1/\sum (1/i\,(1-\theta)) < \text{for } i = 1 \text{ to } I > \quad (2)$$

The other details were defined in Table 1.

Table 1. Simulation Parameters

type	contents	value	type	contents	value
Video demand patterns	Zipf Distribution	-	λ(Poisson distribution)	Service arrival rate	10/sec
V_no	Number of videos	100	V_play_time	Video running time	360sec
N	Number of nodes	2000	Ch_size	Cache size	0~60Gbyte

In this section, we will compare the improved performance of the algorithm suggested by this paper. We will use a modified FIFO system. The modified FIFO system replaces one least referenced among the oldest blocks within a fixed interval of time. Also, the LRU system is a method for replacing a block left unused for the longest time within a cache. And the performance of the suggested algorithms of replacement will be compared, using the hit rate and the cache utilization ratio. The hit rate means the ratio of the number of references hit in a cache to the total number of references; and the cache utilization ratio means the ratio of information hit in a cache to the total amount of referenced information. And it is assumed that there is a cache of s in size, and that a user does not know the sequence of future references to an object requested from a cache, but only knows the requested object.

· The size of an object i : S_i · The total number of requests for an object i : R_i
· The number of hit for an object that already existed in a cache : H_i

· HR(hit rate) : $\sum H_i \div \sum R_i$ · UOC(utilization of cache) : $\sum (S_i \times H_i) \div \sum (S_i \times R_i)$

Figure 7 plots the popularity of videos used in the simulation. It is clearly seen that requests for video are concentrated in 10% of the videos (videos 1-10). Figure 8 shows the mean time of upload service by parent node. Relay, time, and band refers to the RO tree, the TO tree, and the BO tree, respectively.

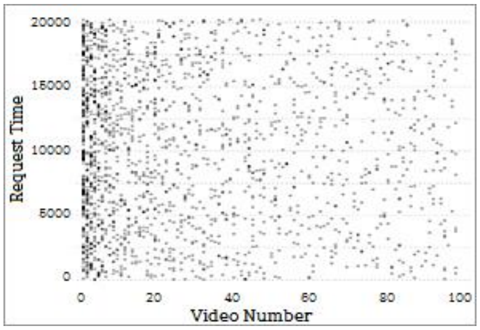

Figure 7. Distribution of Video Popularity

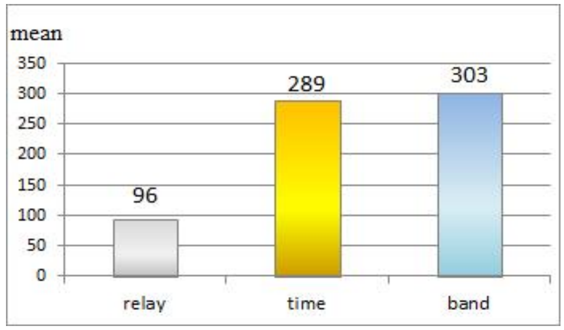

Figure 8. Mean Service Time of Parent Node

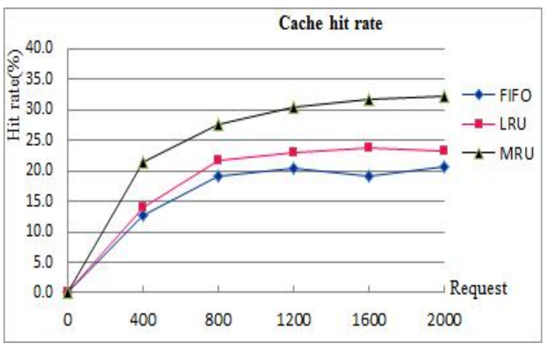

Figure 9. Cache Hit Rate

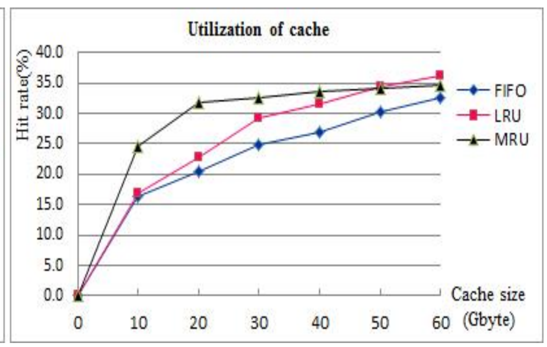

Figure 10. Utilization of Cache

As shown in Figure 9, the FIFO system is easy to implement, but has the shortcoming of too frequent replacement even for a block access to which is expected to occur soon. Therefore, low values for both hit rate and byte hit rate are distributed. As for the LRU system, it is quite probable that a recently referenced object exists within a cache, for the system uses referenced time. On the other hand, as for the suggested system, the hit rate improved about 5%, for the segment of a requested object is accessed in a cache; and the byte hit rate is shown to be high, for a requested object is divided by the time and only a segmented object is stored in a cache, if necessary. As for the system proposed in Figure 10, the cache hit rate per memory improves greatly at the early stage, for it does not rely only on a cache for requested objects, but accesses them from related nodes; however, the hit rate per memory drops somewhat after a certain level due to its characteristics of not depending solely on a cache. The cache utilization ratios of BO and TO shown for cache sizes over 50Gbytes, which lie in the extreme right part on the horizontal axis of the graph, represent cases where almost all sample video streams are stored at cache memory; it is not realistic to use such great cache sizes; and thus it may be said that the cache utilization ratios of the extreme right part have no great significance. In view of this, overload of a cache on the entire network can be reduced; and in case of operating multiple cache modes on the P2P network, a small cache memory is required, and so it is very effective also in terms of cache memory utilization.

5. Conclusion

Mobile devices are characterized by mobility, available time constraints when characteristics of the poor resources available to configure wired P2P network nodes are compared to a PC or server-class, they can be poor in terms of the availability of resources. In this paper, the existing P2P concept is fulfilled faithfully and the characteristics of mobile devices are considered. By these results, we propose strategies that prioritize the joining between the mobile nodes. This prediction is also being used only when absolutely necessary was to run a caching policy. Thus, the caching strategy is proposed in this paper is relatively high, but the hit rate, cache utilization is low. This P2P network can be used more small means that the cache.

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