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M.S. THESIS

Design of Internet Forum Based Hybrid P2P Network for Contents Sharing

컨텐츠 공유를 위한 인터넷 포럼 기반의 하이브리드
P2P 네트워크 설계

BY

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DEPARTMENT OF ELECTRICAL ENGINEERING AND
COMPUTER SCIENCE
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이 논문을 공학석사학위논문으로 제출함

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Abstract

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Internet forums provide a varied and graceful stage for those who have hobbies or interests in common and want to share their contents of interest with each other. Traditionally they use Client-Server (CS) model. A distinct characteristic of a Internet forum is that some registered nodes periodically visit the forum. It implies that those nodes are regular visitors and can be considered relatively stable for some duration of time. The efficient use of these relatively stable nodes is very useful in a P2P network design, especially when the forum server is with limited bandwidth. In this paper, we propose a hybrid P2P network structure which is targeted for Internet forums. In the proposed system, the forum server maintains a list of registered nodes and classifies some nodes that are regularly visiting the forum with high probability as stable nodes. The P2P network created by these stable nodes is triggered when the forum server is highly demanded due to a special event. To resolve the bandwidth shortage problem, the forum server selects stable nodes in advance, according to each node's activity history. For the stable P2P node selection, we consider two types of mechanisms; a time period mechanism and a valid date window (VDW) mechanism, according to the considered time period. Then, we confirm that our proposed P2P model outperforms the traditional CS model through simulations.

Keywords: P2P, Hybrid Networks, Internet Forums Based Network,

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1 Introduction

Currently, Internet forums are all over the place. People share their own contents of interest such as short videos, high resolution images, MP3s and other contents in Internet forums. A traditional Internet forum is based on Client-Server (C-S) model. The C-S model operates well when there are not many nodes in the network. However, due to the limited bandwidth of the forum server, it is inevitable for nodes to experience QoS degradation (e.g. service delay). In order to solve the problem of the server's bandwidth limitation, a P2P network, which have emerged as one of the most successful ways to share resources in a decentralized and scalable way, can be a solution.

Many methodologies of P2P networks, such as structured[1], unstructured [2], super-peer [3], have been proposed so far. However, all the existing P2P protocols suffer from the churn problem; dynamics of peers' participation. Some existing works on understanding churn behaviors are found in [4] and [5], and show that there is little correlation between each peer. The uptime (or downtime) duration of an individual peer tends to be exponentially distributed if its connectivity (or disconnectivity) is primarily interrupted by peers arrival and departure events [6].

Handling churn is a challenging issue because it requires precise and unbiased information about arrival and departure events of peers. Therefore, we focus on an important property of Internet forums to apply the P2P network for them efficiently. That is, registered nodes will have a high probability of visiting their forum of interest in a long term and their arrival events tend to be periodic. From this property, it can be inferred that some

nodes can stay in the forum somewhat steadily because the usage pattern of the Internet forum users is different from that of common Internet service users such as web surfing and file sharing. We call this type of nodes stable nodes in this paper. Based on these observations, we propose a novel hybrid network for Internet forums that combines the P2P network with the traditional C-S model.

In our design, when there are a lot of nodes visiting the forum at a time for an event, i.e. rush hours, the server will trigger an extra P2P network created by stable nodes whose departure rates is relatively low. Common nodes probably get contents they need from this extra P2P network. In this mechanism, the most important thing is how to select stable nodes to create the P2P network. To count flexibility and fairness in the selection process, we propose two mechanisms; time period and valid date window (VDW). The time period mechanism makes the forum server select stable nodes more accurately, while the VDW mechanism avoids potential unfairness in node selection.

A scheme named MBoard similar to our mechanism has been proposed in [7]. The MBoard uses the replying time of each node in the forum to decide its stability. There may be some trickers in the MBoard system, where a tricker indicates a node that replies a certain number of times in a given short time period and departs the forum site. In this case, the MBoard has the possibility of misunderstanding the behaviors of nodes and choosing wrong nodes as stable nodes.

The rest of this paper is organized as follows. Section II explains the overview of a forum based P2P network. In Section III, some details of useful

mechanisms are followed. In Section IV, the simulation results will be demonstrated. The final section presents conclusions and future works.

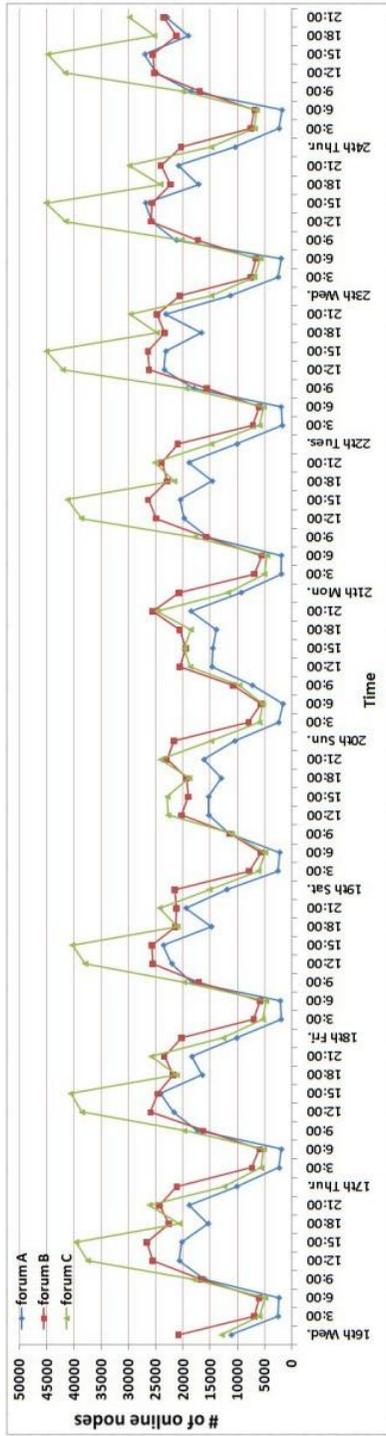


Figure 2-1 Cross-tier Interference Scenario (DL)

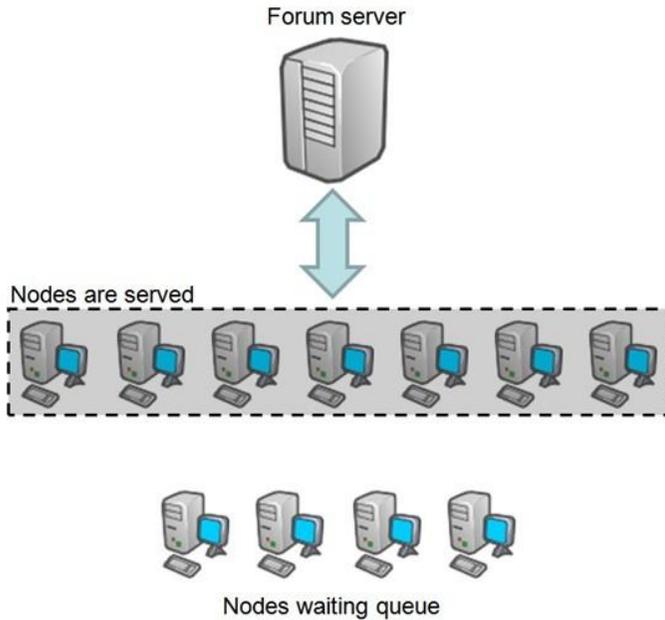


Figure 2-2 Traditional client and server based Internet forum service model. (Nodes within the rectangle box are to be served first and the other nodes in the bottom should wait until the nodes within the box are served completely.)

2 Overview: Forum Based P2P Network Protocol

Figure 2-1 shows the monitoring results for 9 days from Nov. 16th through Nov. 24th, 2011 for 3 different Internet forums [8], [9], [10]. The results represent that the maximum and minimum numbers of online nodes are very different. The number of online nodes during the daytime is roughly 5 times more than that during the midnight. According to the measurement results, it can be inferred that the traditional C-S service model (figure 2-2) operates well during the midnight or dawn because the bandwidth for the

forum server is sufficient to serve all the online nodes. On the contrary, the forum server is heavily utilized during the daytime, so a large number of nodes will experience unwanted extra service delay. An easy solution to this problem is to install more servers in extra, which incurs high management cost to the service provider. This motivates us to design a forum based P2P service model that is scalable and requires low management cost.

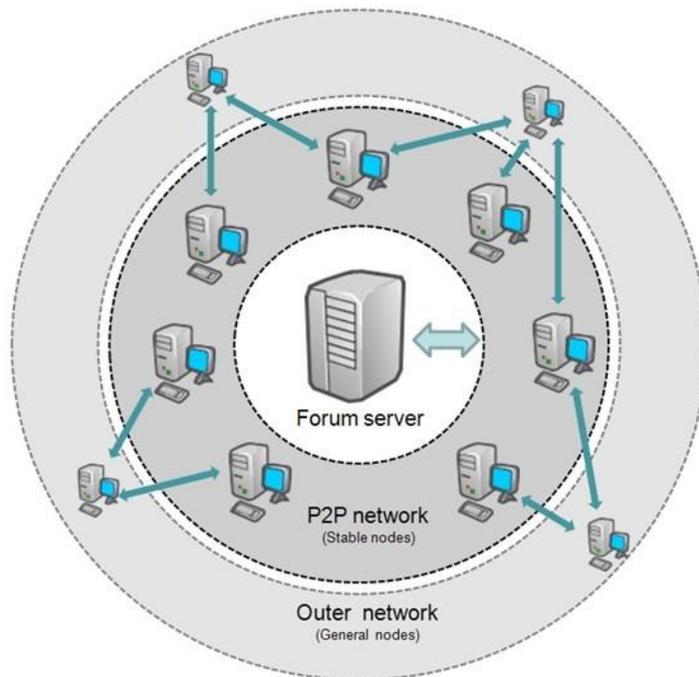


Figure 2-3 Forum based P2P network service model. (The concentric inner circle indicates a part of the P2P network created by stable nodes, and the outer circle represents the other part of P2P network created by other common participating nodes.)

Figure 2-3 illustrates the proposed forum based P2P service model. Stable nodes in the P2P network function as service agencies for the forum when common nodes want to participate in the forum. The function of the stable nodes is similar to that of super-peers [3], but the selection process for stable nodes is much simple. A simple parameter to be considered is the service duration of each node. That is, some nodes whose online times are longer than those of other nodes will be chosen as stable nodes. The longer a node is online, the higher probability it stays in the DHT table (P2P network)[11].

In this approach, the forum server automatically chooses nodes whose online times are highly ranked for some period, which is a certain threshold value. When the server notices that the network is crowded, it forms a P2P network by selecting stable nodes according to the ranking. After that, when some common node wants to download contents, these stable nodes will look for contents for common nodes through the P2P network.

If the contents of interest are not found in the P2P network, the stable nodes turn to the forum server to get those. In the end, the stable nodes will get the contents of interest from either the P2P network or the forum server, and send them to the common node. If the P2P network is not triggered properly due to some reason, the common node visits the forum server to get the contents of interest only if it does not cause any difficulty to the forum server at that time. The flow chart is depicted in figure 2-4.

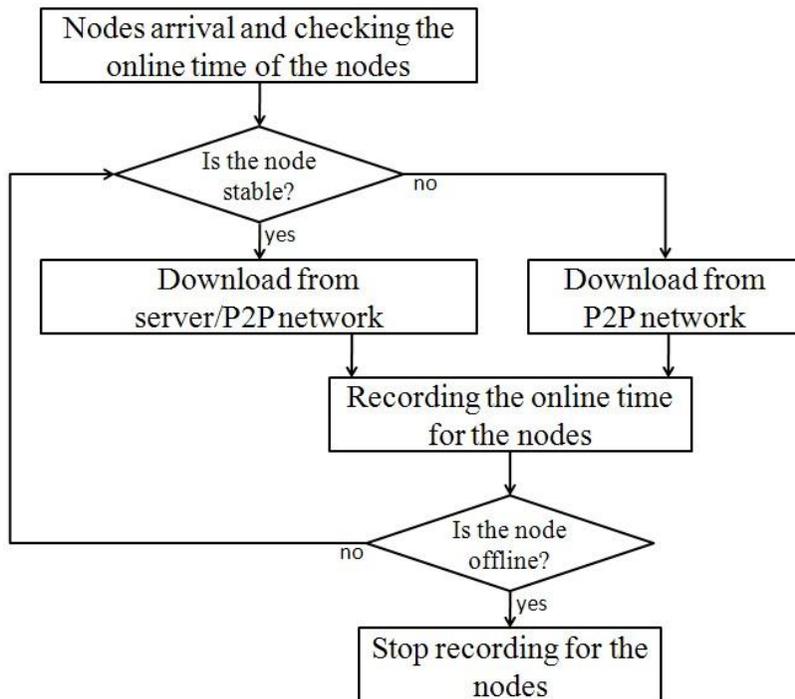


Figure 2-4 Flow chart of the proposed forum based P2P network.

3 Proposed Forum Based P2P Network Protocol

In this section, we consider two types of stable node selection mechanisms; Time Period based Mechanism and Valid Date Window (VDW) based Mechanism. The time period based mechanism uses the accumulated service time and visiting frequency, and the valid date window based mechanism considers the total online time for some recent period.

3.1 Time Period Based Mechanism

In [7], Shen *et al.* proposed an approach that counts the number of replies during a day to decide whether the node of interest is a stable node. However, their approach has a drawback of not considering the timeliness of the P2P network. The timeliness is an important factor in the design of a P2P network design, and it is critical selecting ‘real’ stable nodes properly. For instance, one day of time may be too long in updating the list of stable nodes. The server should be able to select stable nodes more flexibly.

Assume that there is a node, say *A*, that always visits an Internet forum during 1:00AM~5:00AM (midnight). Another node *B* visits the same forum during 8:00AM~11:00AM. From the monitoring results shown in figure 2-1, the forum server can serve all the nodes during the midnight without any difficulty. There is no need to build a well performing P2P network during the midnight time, i.e. when the network is idle. In this case although node *A* has more online time (4 hours) than node *B* (3 hours), its contribution is less beneficial to the forum server compared to node *B*’s contribution.

For this reason, we can consider to divide a day into several time periods. For instance, period 1 for 8:00 to 13:00, period 2 for 13:00 to 18:00, and period 3 for 18:00 to 24:00. Then the forum server simply measures online time of each user for each period, and ranks the accumulated online time of each user. According to this online time history and ranking of each user, our algorithm selects stable nodes for each period.

3.2 Valid Date Window (VDW) Mechanism

The selection of stable nodes based on the accumulated online time history may not work properly. For instance, assume that a certain node finds an Internet forum of interest and begins to visit the forum every day. In general, it deserves to become a stable node. However, if the forum server selects stable nodes based only on the accumulated online time history, it may select some nodes that had visited the server long time ago. This situation may occur even when these nodes have not visited the forum recently. The time period based stable node selection may not consider each node's actual contribution properly. To avoid having such cases, the forum server needs to count the online time of each node for some recent period, named valid date window (VDW). This implies that recent online time is more meaningful in the proposed system. Considering the monitoring results shown in figure 2-1, we choose the VDW of 7 days which is the shortest period that shows each user's behaviors appropriately. A choice of VDW is highlighted in figure 3-1.



Figure 3-1 Example of a Valid Date Window having 7 days.

3.3 Weighting Factor and Forgetting Factor

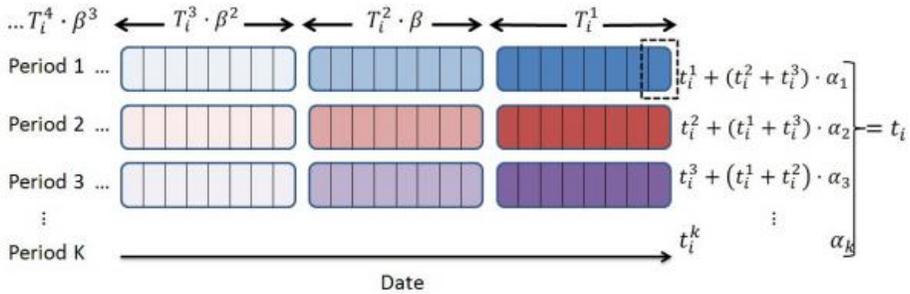


Figure 3-2 Relationship between time period, VDW, weighting factor and forgetting factor. (Each small rectangle stands for a time period.)

For online time accumulation and node selection, we can express the time period mechanism by using a weighting factor α_k ($0 \leq \alpha_k \leq 1$), which gives a different weight to each period k in a day. In figure 3-2, we show an example of three periods for a day. $t_{i,l}$ is the accumulative online time in each time period when the date l is among the VDW for node i .

Similarly, we may use a forgetting factor β which is used to count the online time of nodes out of the VDW. Since the old online time of each node will be gradually forgotten by the server. For instance, the accumulative online time of the most recent 7 day period is multiplied by 1, and that of the previous 7 days is by β where $0 \leq \beta \leq 1$, and so on. As β approaches zero, the recent online time is more weighted, It means that the most recent participation time of each node is more important than all the old accumulated online history. Its accumulative online time indicates contribution to the P2P network and the forum server, and can be expressed as following:

$$T_i = \sum_{j=1}^{\infty} T_i^j \cdot \beta^{j-1} = \sum_{j=1}^{\infty} \sum_{l=1}^7 t_{i,l} \cdot \beta^{j-1}, \quad (3.1)$$

where T_i^j stands for the accumulative online time of node i in the j th weekly period. The most recent week period is indicated by $j = 1$.

Figure 3-2 also shows the relationship between time period, VDW, weighting factor α and forgetting factor β .

3.4 Stable Nodes

Clearly the P2P network achieves better performance with the increase of stable nodes in number. Therefore, how the forum server can attract some nodes to spend more time in the forum is a challenging issue. In reality, most of the forum sites are running on some hierarchical structures, where a different hierarchy means assigning a different priority to each group of nodes in the forum. According to the priority of each node, the service provider gives some incentive, such as more personal upload space, higher download

speed, and higher access priority. Such incentives attract more nodes to participate in the forum.

The forum server is able to reduce its load by giving some incentives to the stable nodes; therefore, a key parameter is the stable node ratio in the P2P network. When the forum server sets the ratio threshold high, many nodes should be considered as stable nodes. However, some of these nodes may not contribute to the P2P network as much as desired due to the fact that their online times are not really long. On the contrary, if the stable node ratio is low, stable nodes play important roles in the P2P network. However, as the size of P2P network becomes smaller, less contribution will be obtained in terms of downlink bandwidth saving of the forum server.

Uplink bandwidth [unit*]	Percentile of the number of peers
0	30
1 ~ 10	58
20 ~ 90	5
100	7

*In this paper, one unit is assumed to be 10KB/s.

Table 3-1 Uplink bandwidth distribution of peers

In [12], Ren *et al.* found that the uplink bandwidth of P2P peers follows some distribution as shown in Table 3-1. From this, we can calculate the contribution of a P2P network as follows:

$$\begin{aligned}
 U_{all}(t) \geq & \frac{1}{2}(N_s(t)P_1U_1 + N_s(t)P_2U_2 + \\
 & N_s(t)P_3U_3) \left(\frac{N_s(t)}{\frac{N_s(t)}{2}} \right) P_{contemp},
 \end{aligned} \tag{3.2}$$

where $N_s(t) = R_s \cdot N(t)$, $P_{contemp} = \prod_{i \in S_{id}} \frac{T_i}{T_{period} W_{size}}$ Here $N(t)$ is the number of online nodes including both stable nodes and general nodes and R_s denotes the stable node ratio. $N_s(t)$ stands for the number of stable nodes. $U_{all}(t)$ denotes the total uplink bandwidth required by stable nodes. From [14], U_1, U_2, U_3 are different uplink bandwidths generated by peers in a P2P network. P_1, P_2, P_3 are the fractions of U_1, U_2 and U_3 , respectively. T_i is the accumulated online time of node i during VDW. T_{period} denotes the length of each time period, and W_{size} is the size of VDW, i.e. number of days. In [13], Rowstron *et al.* found that the message delivery in Pastry is guaranteed unless $[L=2]$ nodes in consecutive node IDs fail simultaneously, where L is the size of leaf node set in Pastry protocol. In [14], Stoica *et al.* proved that if each node fails with probability $1/2$, then the expected time to find a successor is $O(\log N)$ in the P2P network using Chord protocol.

In this paper, we assume that if more than a half of stable nodes are online at a time, the P2P network can steadily contribute to the forum server. Under such an assumption, the proposed system guarantees that the contents of interest can be found in the P2P network with high probability. This is a main difference between the proposed system and the MBoard. S_{id} denotes the ID space of stable nodes which size is $N_s(t)/2$, and then $\binom{N_s}{N_s/2} \cdot P_{contemp}$ represents the probability that a half of stable nodes are online in each period simultaneously. From Eq. (3.2), if the stable node ratio R_s is low, the value of $\binom{N_s}{N_s/2}$ is small, and $P_{contemp}$ is high because N_s is small. With the increase of R_s , $P_{contemp}$ dramatically decreases. The decrease in $P_{contemp}$ comes from the low average online time of each stable node. Our goal is to calculate the

value of R_s that maximize Eq. (3.2). In order to simplify the process of Eq.(3.2), we find that $P_{contemp} = \prod_{i \in S_{id}} \frac{T_i}{T_{period} W_{size}}$ can be written as follows:

$$P_{contemp} = \prod_{i \in S_{id}} \frac{T_i}{T_{period} W_{size}} \approx \left(\frac{E[t]}{T_{period} W_{size}} \right)^{\frac{N_s(t)}{2}}, \quad (3.3)$$

where $E[t]$ is the expected online time of stable nodes and $T_{period} W_{size}$ equals to 300×7 minutes. Through simulations, we found that it is appropriate to set the stable node ratio from 25% to 30% to obtain the maximum value of Eq. (3.2).

4 Performance Evaluation

4.1 Parameter Settings and Methodology

There is a statistical analysis site of Chinaz [15] that shows the rank for Chinese web sites and publishes the UV values of web sites where UV stands for Unique Visitor that is a main reference value used to classify web sites. It represents the number of visitors with different IP addresses during a certain time duration. The data are obtained from an authority of web information provider, named Alexa [16]. In simulations, we chose a photography web site forum, named Xitek [17]. We obtained the average daily UV value of this site at Chinaz and Table 4-1 shows the ratio of UV value at each sub site. From this, it is easy to count how many nodes have visited the forum site daily. The next four steps show a method to obtain the average online time of each node for a given forum. We assume that the online time duration of a node in the forum follows an exponential distribution.

- **STEP 1:** Xitek records the number of online nodes throughout a day. The recorded results are provided in figure 4-1.
- **STEP 2:** From reading the average UV value of Xitek in ratio shown in Table 4-2 , calculate the UV value as 126,000 ($\approx 210,000 \times 60.78\%$).
- **STEP 3:** Set the number of node arrivals per day to 126,000.

- **STEP 4:** Slowly adjust the average online time of each node until simulation results (a curve from figure 4-1) closely overlap with monitoring results (real data in figure 4-1). From this, we can get a node's average online time as about 20 minutes during the weekdays and as 22 minutes during the weekends.

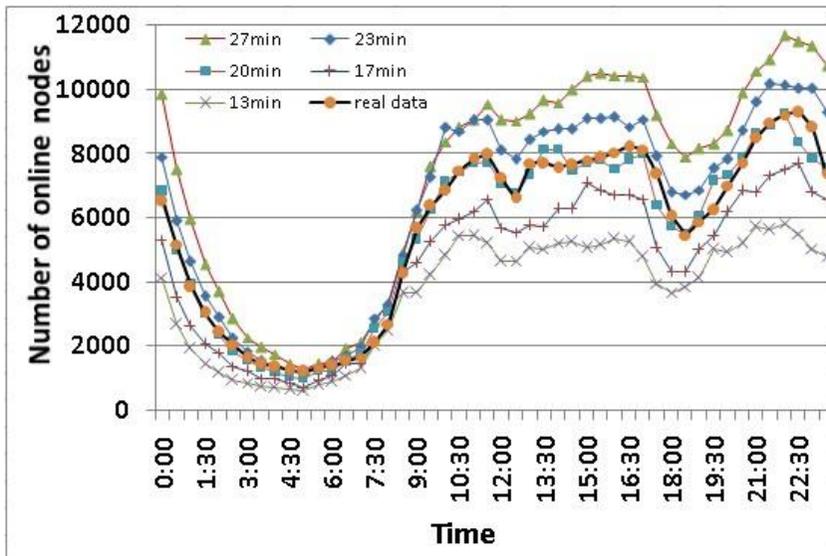


Figure 4-1 The number of online nodes according to the average online time.

Sub site	Visit ratio
forum.xitek.com	60.78%
travel.xitek.com	17.60%
xitek.com	35.94%
info.xitek.com	16.38%
vision.xitek.com	13.24%
auto.xitek.com	5.64%
photo.xitek.com	21.16%
ww.xitek.com	24.07%
mail.xitek.com	1.22%
lohas.xitek.com	0.51%
image.xitek.com	0.99%
mall.xitek.com	0.93%
carnival.xitek.com	0.46%
OTHER	0

Table 4-1 Statistical list of Xitek published by Chinaz.

Daily Site Visits	Daily Page View
≈ 210,000	≈ 2,664,000

Table 4-2 Unique visitors and page views of xitek published by Chinaz.

Parameter	Default Value
Number of nodes	160000
Trace duration	17 days
Stable nodes ratio	30%
Stable nodes uplink bandwidth	550KB/s(5%), 1000KB/s(7%), 55KB/s(58%)
Forum server downlink bandwidth	2GB
VDW size	7 days
Number of period	3
Period duration	5, 5, 6 hours
Online time distribution	Exponential
Weekday online time duration	20 minutes
Weekend online time duration	22 minutes
Factor α, β	0.0, 0.0

Table 4-3 Simulation parameters

4.2 Simulation Results

We developed a C++ based simulator, and the simulation parameters are provided in Table 4-3. Figure 4-2 shows the impact of time period mechanism and VDW mechanism on 3 different nodes in 3 time periods. The forum server simply accumulates the online time for each node when the day is within the VDW. Because of the existence of VDW mechanism the ranks of the accumulative online time of nodes in each period always change. Comparing proposed system with the MBoard we note that the threshold for selecting stable nodes in MBoard (M-SNTH) is lower than the threshold of proposed system (Proposed-SNTH) since the stability in MBoard is measured by 5 replies/posts (50 minutes). On the other hand, the measurement of stability is based on the rank of accumulative online time in proposed system. The interval part which between 2 threshold lines (Proposed-SNTH, M-SNTH) in figure. 4-2 mean that nodes can be chosen as stable nodes in MBoard that

cannot be selected as stable nodes in proposed system due to lack of real stability. Without considering the real stability, the contribution of P2P will be amplified distortedly.

Figure. 4-3 shows the contribution of proposed P2P network to the forum server. Assume that the forum server is with a link of 2 GB bandwidth, indicated by the dotted line. The simulation results show that when the stable node ratio is 30%, our proposed system contributes to the creation of an average of 31% bandwidth in extra. This extra bandwidth can be used to serve more nodes in rush hours.

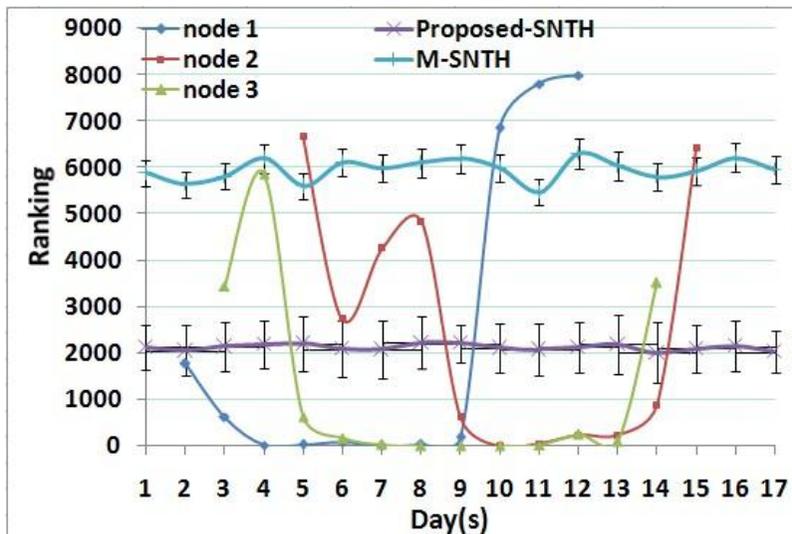


Figure 4-2 Ranking of 3 randomly chosen nodes in each period and the threshold of stable node in the proposed system and MBoard. Proposed-SNTH represents the proposed stable nodes threshold, and M-SNTH stands for the MBoard stable node threshold.

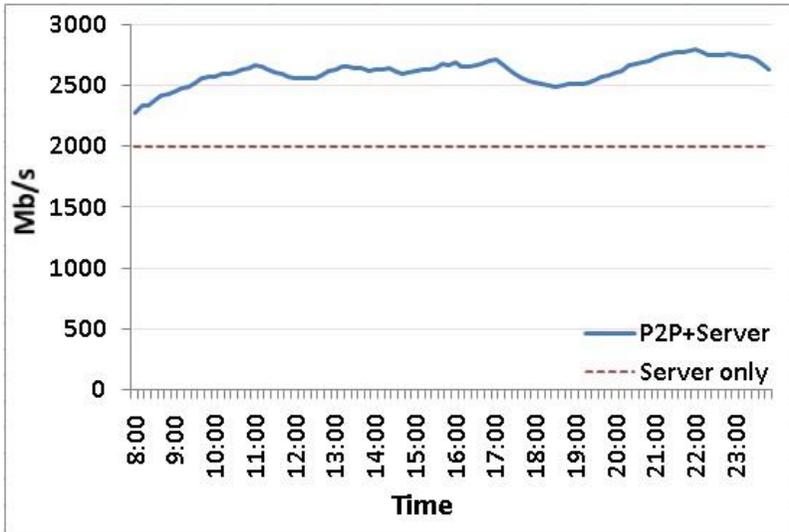


Figure 4-3. P2P network's contribution to the forum server.

5 Conclusions

In this paper, we designed an Internet forum based P2P network that can support a large number of nodes in busy hours. For the creation of a P2P network, we take advantage of some stable nodes that visit the network more frequently and are connected for a longer time. The created P2P network gives the effect of loading the forum server off especially during busy hours. We consider an online time accumulation mechanism by adopting a forgetting factor, which gives more weight on recent visits compared to the old ones. It gives some effectiveness in flexibility and fairness in spite of churning effect of the P2P network. The simulation results show that the proposed system is practical enough to be applied in a real forum environment.

The future work will include the investigation on nodes' behaviors in detail and the precise setting of simulation parameters.

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초록

지금 인터넷 포럼은 사용자 (가입자)를 위하여 무한무궁한 내용물들을 제공 할수있다. 같은 포럼 가입자들은 같은 관심분야 또는 흥취를 가질수 있어 이런것들을 남들에게 공유하고자 한다. 기존의 인터넷 포럼은 C-S 모드로 동작하고 있다. 인터넷 포럼의 하나의 특징은 어떤 가입자들의 방문시간이 주기적이거나 일정한 규칙성이 있는것이다. 우리가 이런 주기적으로 찾아오는 가입자들을 상대안정노드라고 이름 달았고 이런상대안정노드를 활용하여 효율 높은 P2P 네트워크를 구현할수 있어 S-C 모드에서의 서버의 부담을 감소하고 모든가입자한테 더욱 많은 밴드위스를 제공할수 있게 될것라고 추측한다.

위의 추측을 근거하여 이 논문에서는 하이브리드 형식인 P2P 네트워크를 제안하게 되었고 제안된 시스템에서 각 포럼 서버가 일종 특수한 가입자 리스트(상대안정노드 리스트)를 시간에 따라 관리하게 된다. 결과적으로 볼때 상대안정노드 리스트에 남아 있는 노드가 바로 주기적으로 오래동안 찾아온 가입자들이고 머문시간 순위대로 배열된 상태이다. 상대안정노드 리스트상의 노드로 구현한 P2P 네트워크는 서버에 많은 가입자의 방문에 의하여 성능저하 발생시에 동작하게 된다. 상대안정노드 리스트의 정확한 관리를 위하여 하루를 여러개 구간으로 나누어서 처리하는 메커니즘과 유효 날짜 메커니즘 등을 제안하였다. 시뮬레이션을 통하여 제안한 시스템이 우수한 성능을 보이고 있음을 증명할수 있다.

키워드: P2P, 하이브리드 네트워크, 인터넷 포럼

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