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BitTorrent in a Dynamic Resource Adapting Peer-to-Peer Network

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Abstract

Our previous work proposed a MPEG-21 based P2P network architecture supporting resource adaptation on the basis of usage environment and user preferences. In this paper, we investigate the deployment of a BitTorrent (BT) - like approach in the previous super-peer P2P resource adaptation architecture. In addition, the architecture's peer selection strategy is adopted and evaluated as a way to enhance the peer selection process in BT. The strategy uses super peers as trackers to intelligently select peers according to their capabilities and shared resource segments. Simulation results show that the proposed selection strategy reduces average access time and increases download speed when compared with the existing BT peer selection process with randomly selected peers. The results also show that the deployment of BT in the P2P Adaptation architecture greatly reduces the congested download problem previously reported.

1. Introduction

Recently, a new generation of P2P applications has been gaining popularity for the download of large-sized content such as multimedia resources. In these P2P applications, resources are divided into small segments such that peers can exchange these segment pieces instead of the complete resource. Also a number of central entities – "trackers" are used to select a list of resource senders that can fulfill a request from a peer. The most successful application in this category is BitTorrent (BT) [5]. In this paper, we investigate the feasibility of deploying BT based solutions in a dynamic resource adapting P2P environment using our previously proposed super peer based architecture [6]. The work shows that there are significant benefits to using a combined super-peer / BT peer selection strategy.

2. Related work and motivation

P2P based peer selection strategy has been the topic of various research projects. For instance, Zou et al. [1] proposes a simple greedy scheme that selects serving peers based on their uploading session status and uplink bandwidth. Adler et al. [2] investigates the scenarios of serving peer selection in a parallel downloading or streaming P2P environment, and proposed use of micro-payments as the solution to the peer selection process.

However, these projects focus on pure P2P networks where peers are interconnected and functioning without any central entities; requesting peers must thus select serving peers themselves. Our work is focused on hybrid P2P [4], such as BT, where a central entity (i.e., tracker or super peer) is used to perform some of the tasks. Currently, the only project that addresses peer selection in a hybrid P2P network is the work from Koo et al. [3] which uses a genetic-algorithm-based optimization to maximize the overall disjointedness of content among serving peers in the network. However, there are several limitations to their contribution:

1. A global optimization based approach is used to determine peer selections in the network. However, the approach selects serving peers for each downloading peer based on the assumption that all peers start downloading at the same time. It then calculates the optimal solution for the whole network. This is impractical as in real life situations, peers make requests at different times and also some peers are always idling.
2. A single tracker is deployed in the network to store all peer information and perform peer selections. This is unrealistic and not scalable to a large P2P network.
3. The 'total number of bytes downloaded so far' is the only attribute used to calculate the peer selections. Other important attributes should be considered in the selection process (i.e., bandwidth, terminal capabilities).

The work reported in the current paper addresses these deficiencies using several improvements to our previously proposed dynamic resource adapting P2P architecture.

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3. Dynamic resource adaptation P2P system with BitTorrent

In our previously proposed dynamic resource adaptation P2P architecture [6], peers were grouped into clusters based on similarity of their shared contents and super peers were nominated to be in charge of one or more clusters. On joining the network, a peer must submit information about its shared resources and its related usage environment attributes (i.e., terminal capabilities) to the super peer(s). Super peers then use the registered information to adapt search results and resources for requesting peers.

The proposed architecture was then further improved through a locality-based clustering approach which assigns peers to clusters on the basis of their locality information [8]. By default, the approach requires new peers to register to locality-based super peers but also allows them to be registered to category super peers (i.e., super peers who govern one particular type of content) based on their shared content. The architecture, however, was designed to facilitate only one-to-one resource transfer between peers. This is not scalable to the download of large size resources with limited available copies, as downloads could be congested if there are too many requests at the same time. Therefore, we now incorporate a BT based resource exchange method into the architecture; this allows peers to download/upload resource segments from multiple peers.

The new architecture improves upon the standard BT approach by taking advantage of the existing dynamic resource adaptation architecture by actively adapting resource segments and then transferring them to requesting peers whenever adaptation is feasible. This means that a requesting peer can download resource segments not only from peers holding resource segments of the correct 'variation', but also those capable of dynamically adapting resource segments to the correct variation (i.e., down-sampling of a video file segment). Apart from this improvement and the proposed peer selection strategy detailed in the next section, the standard BT protocol [5] is adopted (i.e., we use a "tit-for-tat" mechanism as an incentive-provisioning scheme etc.).

4. Peer selection strategy

Based on the observations in Section 2, we propose a novel peer selection strategy that intelligently selects peers based on their capabilities as well as the resource segments they hold. The selection strategy adapts the existing P2P architecture [8] by using the super peers in the network as trackers. Therefore each time when a peer requests a resource, it contacts its locality cluster super peer which selects a list of peers from the cluster to exchange resource segments with the requesting peer.

The advantage of this approach is that, in the proposed architecture, super peers store registered peer information for their locality clusters and select the appropriate resource senders for their peers. Thus, the incorporation of trackers upgrades the role of the super peer to select multiple resource senders for each request and this is a minimal modification to the current infrastructure detailed in [8].

The tracker selection strategy is performed in three steps:

Step1: A peer sends a resource request to its locality super peer, which searches through the locality cluster to return a list of peers with higher or equal capabilities than the requesting peer. We assume that peers store resource variations based on their capabilities. This means that resource variations from a certain peer class can only be consumed by peers of that class (i.e., similar terminal capabilities) and obtained from peers of equal or higher classes (i.e., higher terminal capabilities). If a resource is transferred from a higher class to a lower class peer, it is dynamically adapted during the process.

Step2: Next, the initially filtered peers are separated into various class groups according to the number of different peer classes within the returned peer list. Each class group is then subdivided on the basis of 'total download/upload connections' and the 50% of peers with the highest numbers are ousted from the group. This only leaves peers with the least connections in the list for the final selection step.

Step3: The final step is to select an equal number of peers from each peer class to be included in the final list of selected peers. Hence, the required number of peers from each peer class is determined by the maximum number of peers allowed in the final selected peer list divided by the number of peer classes found in the initial list. A 'content value' is then calculated to determine the most suitable subset of peers within each peer class group. The content value includes three components:

1. The total volume of content held by peers in bytes.
2. The disjointedness of the content which the peers hold in terms of the content segments the requesting peer has. For a new request, this value is not calculated as there are no segments from the requesting peer to compare.

3. The completeness of the file in terms of the file segments the peer holds including file segments already held by the requesting peer.

Each value is calculated as a percentage of its maximum value and the super peer calculates the sum of these values for all possible combination of peers in the peer class group. This returns the list of peers who hold the highest sum of the values as the selected peer senders for that class. If the number of peers in a peer class group is smaller than the required number of peers from each class group, then all peers are simply returned as the selected choices for the group. Once all the selected peers are returned from each class group, the super peer sends them as separated lists to the requesting peer. Here we assume that each locality cluster is of a reasonable size (i.e., 100 peers) and thus the overhead of calculating all possible peer combination is not large.

During the download of a resource, the requesting peer chooses an equal number of peers from each selected peer list for different peer classes to exchange with the peers. The total number of simultaneous connections to exchange resource segments are determined by the pre-defined maximum number of downloads. When the exchange peers are to be reselected periodically, the requesting peer simply contacts its locality super peer which uses the proposed peer selection strategy to return a new peer list.

5. Simulation results

A P2P network simulator was created in our previous work to evaluate the performance of the dynamic resource adaptation architecture and the details of the simulation can be found at [6]. We modified that simulator to allow resource download based on BT and to evaluate the performance of the proposed peer selection strategy.

The simulation is initialized by preloading the network with a specified number of normal peers, super peers and resources. Normal peers are further classified into provider peers and freeloaders. To simulate heterogeneous devices, three classes of device and bandwidth are currently used in the simulation. For resources, we preload the simulation with one resource type in a predefined number of copies. The reason for using only a singular resource type at this stage is to concentrate on the performance evaluation of peer downloading and reduce possible side effects from having multiple resources. The system settings and programmed peer behaviors conform to the findings in the survey from [9]. During the simulation, requests are generated by peers in the system at random time intervals and the simulation terminates when a certain number of requests are completed.

Table 1. Simulation settings

Total no. of peers	3000
No. of super peers (including locality super peers)	60
No. of locality super peers	30
No. of provider peers	240
No. of freeloaders	2700
Resource size	400 Mbs
Percentage of total resources owned by freeloaders	30%
Percentage of total resources owned by provider peers/super peers	70%
No. of new peers joined the network while running	500
No. of peers left the network while running	500
Initial copy of resources	20
BT optimistic unchoking time interval	30 seconds
BT peer list reselect time interval	2 minutes
Total no. of requests	10000

We have also made several improvements to the simulation so as to create a more realistic P2P simulation environment. These include allowing a predefined number of peers with resources to join/leave the network at random time intervals.

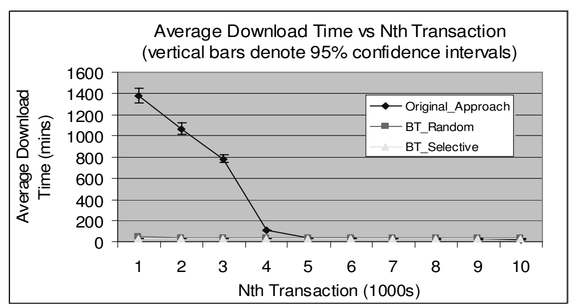

Figure 1 average download time comparison of different approaches

In the tests we compared three architectural approaches: the proposed peer selection strategy (*BT_Selective*), the random peer selection approach used by BT (*BT_Random*), and the previously proposed dynamic resource adaptation architecture (*Original_Approach*) where resources are simply adapted and downloaded on a one-to-one basis. Simulation settings in Table 1 were used to obtain the results and we have also simulated other peer compositions which have shown similar trend in the results.

Average download time was used as a performance metric to compare the three systems and results are shown in Fig. 1. *Original_Approach* shows a much higher average download time for the first 4000 requests as most downloads were congested by peers downloading from the same sources. This problem gradually eased as more resources became available. Conversely, both *BT_Selective* and *BT_Random* show that, by adapting BT, peers were able to download from not only peers with completed files (i.e. seeders) but also each other; this significantly reduced the average download time from the beginning of the simulation. It is also notable that in the simulation, *Original_Approach* effectively hangs if the resource size is too large and there are not many initial copies in the network, while as the BT approaches can handle resources 4 to 5 times larger without any problems.

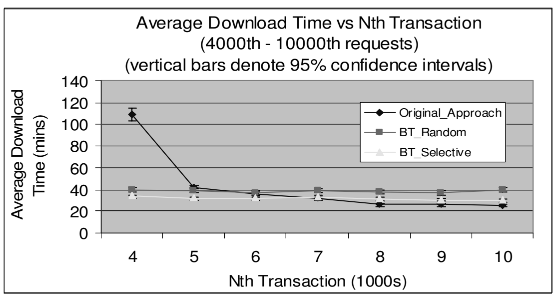

Figure 2 average download time comparisons (4000^{th}-10000^{th} requests)

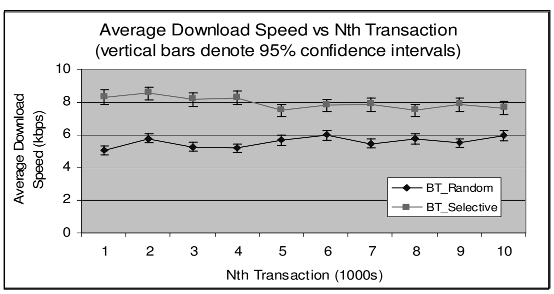

Figure 3 average download speed comparison of different approaches

Figure 2 zooms in on the 4000^{th} to 10000^{th} requests, and it shows that the access time of *Original_Approach* eventually dropped below the BT approaches. This is because that *Original_Approach* did not require peers to download and upload at the same time. In a real world situation, however, it is unlikely that peer senders are dedicated machines which only upload to other peers. In comparison, *BT_Selective* not only has a much lower average access time than *BT_Random*, but approaches *Original_Approach*. In addition, the decrease in download time contributes to an increase in download speed which is particularly evident for low-end peers. This is shown in Fig. 3 which compares *BT_Random* and *BT_Selective*.

6. Conclusion

This paper has investigated the combination of Dynamic Resource Adaptation and a BitTorrent-like file segment distribution strategy in a P2P environment. A peer selection strategy was proposed based on an existing P2P adaptation architecture to select peer senders according to their capabilities and shared resource segments. Simulation results have shown that the BT based approaches overcome the initial download congestion faced by the one-to-one download method used in our original architecture. Furthermore, the peer selection strategy shows it reduces the average download time by 30-35% while increasing the average download speed by up to 30% in comparison to the random approach.

7. References

[1] L. Zou, E. Zegura and M. H. Ammar, “The Effect of Peer Selection and Buffering Strategies on the Performance of Peer-to-Peer File Sharing Systems,” *MASCOTS*, Fort Worth, Texas, 2002.

[2] M. Adler, R. Kumar, K. Ross, D. Rubenstein, D. Turner, and D. D. Yao, “Optimal Peer Selection in a Free-Market Peer-Resource Economy,” *the Second Workshop on Economics of Peer-to-Peer Systems*, Cambridge, MA, 2004.

[3] S. G. M. Koo, C. S. G. Lee and K. Kannan, “A Genetic-Algorithm-Based Neighbor-Selection Strategy for Hybrid Peer-to-Peer Networks,” *ICCCN’04*, Chicago, IL, 2004.

[4] R. Schollmeier, “A Definition of Peer-to-Peer Networking for the Classification of Peer-to-Peer Architectures and Applications,” *P2P’01*, Lingkoping, Sweden, 2001.

[5] B. Cohen, “Incentives to Build Robustness in BitTorrent,” *the First Workshop on Economics of Peer-to-Peer Systems*, Berkeley, CA, 2003.

[6] L. Rong and I. Burnett, “Dynamic resource adaptation in a heterogeneous peer-to-peer environment,” *CCNC 2005*, January, 2005.

[7] R. Lienhart, M. Holliman, Y. Chen, I. Kozintsev, M. Yeung, A. Zaccarin, and R. Puri, “Challenges in Distributed Video Management and Delivery,” *Handbook of Video Databases*, CRC Press, Boca Raton, Florida, 2003.

[8] L. Rong and I. Burnett, “Improved Dynamic Adaptation-based Peer-to-Peer System with Locality-based Clustering,” *submitted to AXMEDIS 2005*, November, 2005.

[9] S. Saroiu, P. K. Gummadi, and S. D. Gribble, ”A Measurement Study of Peer-to-Peer File Sharing Systems,” *the Multimedia Computing and Networking Conference*, January, 2002.

0-7695-2348-X/05 $20.00 © 2005 **IEEE**