Chapter 31
Congestion Distance Based BitTorrent-Like P2P Traffic Optimization

Qian He, Yanlei Shang, Yong Wang and Guimin Huang

Abstract A large number of P2P traffic brings great impact on the bearer network, so how to utilize network bandwidth efficiently has become a common trade problem of Internet Service Providers (ISP) and terminal users. A P2P traffic optimization model is derived from the aims of ISPs and users. Minimizing the congestion distance is chosen as the main objective which not only can represent the requirements of two sides, but also can be distributed implemented easily. According the optimization model, Bittorrent-like P2P system is improved. The distance aware peer selection and secondary sorting choking/unchoking algorithms are proposed. The experiments results show that this optimization can reduce inter autonomous system (AS) traffic effectively and respond to network congestion automatically.

Keywords P2P · Traffic optimization · Congestion distance · Bittorrent

31.1 Introduction

Peer-to-Peer (P2P) technology develops very fast recently, and it is widely used in content sharing, instant messaging and so on. The Internet traffic distribution results, given by Ipoque in 2008/2009, showed P2P systems contribute 42.5–70 %

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to the overall network traffic [1]. While utilizing P2P to accelerate the content transmitting, it also impacts network bandwidth very much and has put Internet Service Providers (ISP) in a dilemma [2, 3]. Among them, BitTorrent(BT) is arguably the biggest constituent of P2P traffic, which contributes 30–80 % to the whole P2P traffic [1]. How to use network bandwidth reasonable while giving full play to the P2P performance has become a big problem concerned by the ISPs and ordinary users together.

BT is one of the typical and most popular P2P content sharing systems, and it can also support video on demand and live multimedia streaming after modified. All these P2P systems mainly based on BT protocol are BT-like systems in this paper. In the normal BT, the peers fetch neighbors from the tracker randomly and choose communication objective peers with "tit for tat". It doesn't consider the network layer topology. The random selection algorithm of P2P application is one of the main reasons causing large P2P traffic on backbone, so the network topology optimization are becoming a hot research field [3, 4]. After analyzing the actual BT traffic logs, Karagiannis et al. [2] think the probability of requesting the same file in the same ISP is 30–70 %. The Verizon network field testing also found that the average P2P connections after 5.5 metro jumping, which does not affect the performance of reduced to 0.89 jump [3].

There have been several proposals on locality-aware P2P solutions. Reference [5] takes advantage of the cosine similarity of CDN redirection to guide partner selection, while Ref. [6] leverage a distance dataset extracted from publicly available information. Meanwhile, Aggarwal et al. incorporate Oracle [7] and last-hop bandwidth of each peer to judge the link quality. Furthermore, Refs. [8, 9] both designed and implemented real locality-aware BT clients. These researches may give us the foundation to optimize BT-liked P2P traffic deeply. However, there is little work on the P2P traffic optimization description and simplifying, especially for BT-like P2P applications as a whole.

In order to optimize the BT-like P2P traffic, a general optimization model and improving BT algorithms are proposed in this paper. The optimization model starts from the requirements of ISPs and normal P2P users, in which the fast download speed, inter-AS traffic and backbone congestion are discussed in the objectives. And then, the special congestion distance is concluded for distributed implementation. Based on minimizing congestion distance, BT is as the example to be simulated and analyzed for optimizing BT-like P2P traffic optimization.

31.2 P2P Traffic Optimization Model

For the P2P users, they normally concentrate on fast download speed. On the other hand, ISPs hope to be reward from P2P, but not to get such bad affection as high traffic impression, low transfer performance, congestion and so on. The fast download speed and the more P2P users mean there may be more P2P traffic flow on the backbone, so the requirements of users and ISPs are often conflicted. The backbone network links are used to connect each ISP which topology can be described by a graph $G(V,L)$, where V is the backbone nodes set and L is the key Links connecting ASes set. Because the network topology, the bandwidth between ASes, and the upload/download speed of each peer are relatively fixed, the P2P traffic optimization model is a multi objectives optimization with constraints, which can be defined as follows:

$$\begin{array}{l} \min P_m, P_c, I_c \\ s.t. \forall i, f_i + \tau_i \le b_i \\ \qquad u_i \le pu_i \\ \qquad v_i \le pd_i \end{array} \tag{31.1}$$

Where, f_i, τ_i and b_i are the P2P traffic, background traffic and bandwidth of link i; u_i and v_i are the upload and download rate of peer i; pu_i and pd_i are the max upload and download rate of peer i; P_m is the mean download rate of all the peers, $P_m = (\sum_i d_i)/n$; P_c is the variance of download rate of all peers which can represents the fair of peers, $P_c = \left(\sum_i (d_i - P_m)^2\right)/n$. The P_m and P_c represents the users' requirements, and the bigger P_m and the litter P_c are better. The congestion reflection index (I_c) is used to represent a function of traffic and congestion.

31.2.1 Congestion Distance Based Optimization

Because this rate information is changing constantly, the Eq. 31.1 may be weak for practice in a big P2P network. It should be decoupled and simplified deeply to satisfy the requirements of distributed implementation.

Proposition 1 *When the fixed-size data is distributed, the more key links are passed through, the inter-AS traffic is bigger.*

Proof Assuming peer A wants to distribute x M bytes data to peer B, the inter-AS traffic f_i equals to the value that is gotten from $d * h$, where $h = |G| + 1$, $|G|$ is the number of AS passed through. Therefore, we can get: $f_i = x \cdot (|G| + 1) = x \cdot |V|$. Therefore, the inter-AS traffic f_i is proportional to the number of key links $|V|$; the more key links passed through, the inter-domain traffic is greater.

Based on Proposition 1, we know that the aim of inter-AS traffic can be convert into the function of the number of key links, $|V|$ is relatively stable after the route is determined and it can be tested by trace-route tools or sensors set on the key links [9]. Integrating the affection of congestion, the congestion distance (d_c) is the summary of d and the accumulation of all the key links' congestion mapping value:

$$d_c = |V| + \delta \sum_{i \in L} c_d^i. \tag{31.2}$$

Where c_d^i is the congestion level of link i. If no congestion, $c_d^i = 0$; with the more serious congestion c_d^i become 1,2,3, and so on. δ is a congestion adaption gene to adapt the congestion affection.

Proposition 2 *The congestion distance d_c can be compute by this equation*:

$$d_c = d + \delta \cdot \sum_i c_d^i \cdot n_i \tag{31.3}$$

Proof $\sum_{i \in L} c_d^i$ equals the summary c_d^i of all the backbone, it can be the summary c_d^i of multi congestion levels. That is to say, we can compute the congestion separately, and sum them together finally. From the Eq. 31.2, we can get this: $\sum_{i \in L} c_d^i = \sum_i c_d^i \cdot n_i$, and then $d_c = d + \delta \cdot \sum_i c_d^i \cdot n_i$.

31.3 BT Traffic Optimization Scheme

BT is a P2P file-sharing application designed to distribute large files to a large of users efficiently. BT consists of seed, peer and tracker. During the neighbor selection process, the peer learns from the tracker the knowledge of other peers in the same group of peers interested in the same file and a peer list is returned by the tracker. Upon receiving the peer list, a peer connects with the majority of them. It then sends to its neighbors the bitfield messages. If a neighbor has needed pieces, it informs the neighbor with an interested message. The peer choking/unchoking is the decision process made by a peer about which of its "interested" neighbor it should send data to. In the next, assuming the congestion distance is already obtained from other traffic optimization architecture, how to use the congestion distance to improve the performance of BT is discussed.

31.3.1 Minimizing Congestion Distance Peer Selection

During the neighbor selection process, the peer learns from the tracker the knowledge of other peers in the same swarm, which is the group of peers interested in the same file. The tracker returns a peer list to the inquiring peer, and if the population of the swarm exceeds this number, the selection is entirely random. In this paper, we replace the random peer selection with the selection that minimizes d_c. The optimization of peer selection consists of tracker and peer, and they are similar in our procedure. The tracker selection procedure is given in Fig. 31.1. After peer queries the tracker, the tracker not only returns the peer list in the aforementioned fashion, but also attaches d_c in an add-on field.

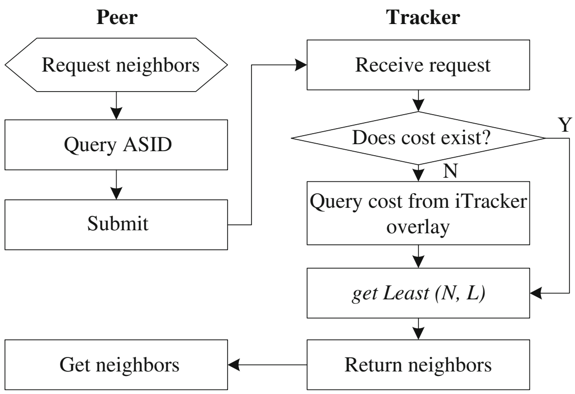

Fig. 31.1 The flow of peer requesting neighbors

31.3.2 Secondary Sorting Choking/Unchoking Algorithm

The secondary sorting choking/unchoking algorithm is modified from "*Tit-for-Tat*". The new method not only considers the peers' contribution data (*CD*), but also considers d_c. Firstly, the neighbors are sorted by *CD*, a rank of each peer (r_u) can be gotten. Then, the final rank (r) can be obtained:

$$r = r_u + \beta \times d_c \tag{31.4}$$

Where, β is a gene to adapt the affection of congestion distance. The bigger β, the more important is d_c. We set β equals to the number of unchoking peers (default 4) in order to proof the communication costs are preferred. Only the d_c of peers is equaled, the Tit-for-Tat mechanism works. Finally, we keep the original BitTorent optimistic unchoking and boycott to neglect policy intact, for the purpose to help bootstrap brand new peers and avoid the peers with higher costs will choke forever. The improved choking/unchoking algorithm is as follows:

Input: the local candidate peers *PL*

Output: the unchoking peers *unchokeL*

(1) *if* $|PL| < ucNum$, *ucNum*: the number of unchoking Peers
(2) *return PL*;
(3) *else {*
(4) *Sort PL by* d_u, and refresh *PL.urank*.
(5) Integrate d_c and refresh the secondary rank *PL.rank* using the Eq. 31.4.
(6) Select the *ucNum* Peers from PL with least *PL.rank*.
(7) *return unchokeL*;
(8) *}*

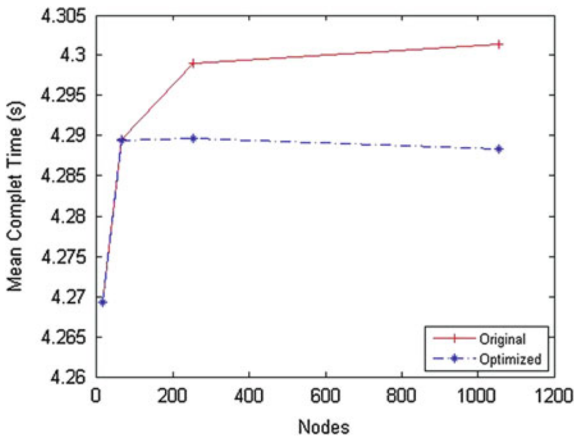

Fig. 31.2 The mean complete time t_m

31.4 Experiments Analysis

The performances of Optimized BT are evaluated in the General Peer-to-Peer Simulator (GPS) [10]. All the experiments are run on a computer with Inter Core 2 Q9400 2.66 GHz CPU and 4 GB Memory where the windows 7 operation and 1.5 JDK are installed.

31.4.1 Inter-AS Traffic

Assuming there are no congestions in all the links, we monitor the indexes including the mean t_{m} and variance t_{c} of each peers' complete time and I_{f} according the Eq. 31.1. Referring to the Ref. [10], two-level Transit-Stub topologies are generated using GT-ITM. There are four different topologies with 16, 64, 252 and 1054 peers, A transit domain means a AS, and its number is 4, 8, 18 and 34. The bandwidth between AS is 1000 Mbps, bandwidth between transit and stub is 100 Mbps and there are no connections within stubs. BT Peers are randomly attached to non-transit nodes. All the documents are 500 MB in size. In the simulation, t_{c} of the optimized is similar to the original. Figure 31.2 gives the mean complete time which shows that the optimized BT has better download speed for peers. Figure 31.3a gives the total inter-AS traffic and Fig. 31.3b shows the decreased ratio (R) of inter-AS traffic about optimized BT. The optimized BT has litter inter-AS traffic than the original and R become larger with the more peers.

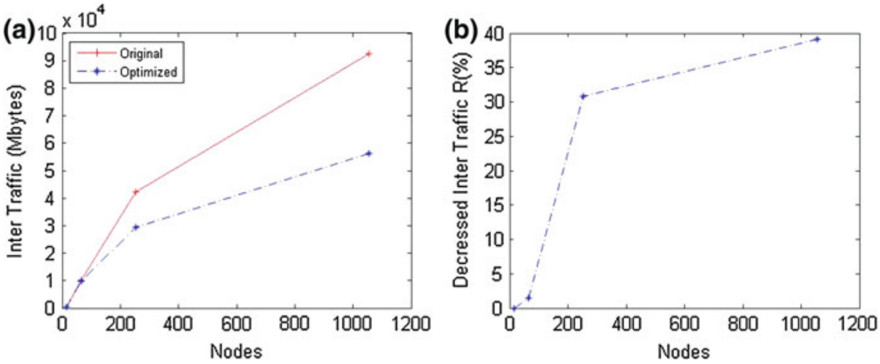

Fig. 31.3 Inter-AS traffic analysis. **a** The inter AS traffic: I_f. **b** The decreased ratio of inter-AS traffic: R

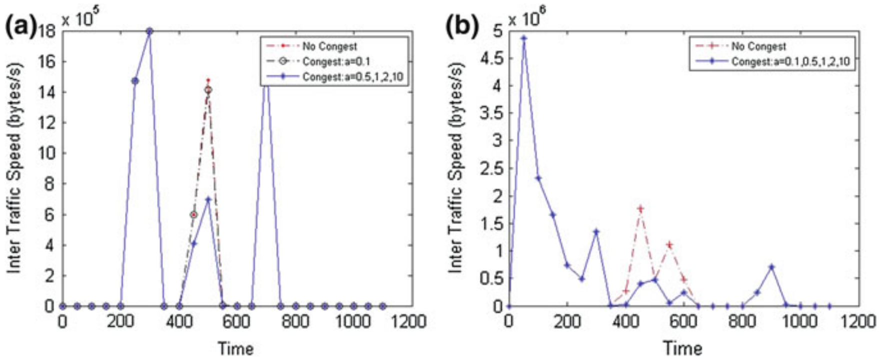

Fig. 31.4 The P2P traffic flow rate on congestion links. **a** Link1_7. **b** Link1_18

31.4.2 Congestion Response

The moderate congestion events are added to Link1_7 and Link 1_18 from the simulation time 300.0–600.0. In the simulation, the peer download rate can be reduced very much during the congestion time in the optimized BT system. From Fig. 31.4a and b, the mean rate γ of Link 1_7 can be reduced by 46.6 %, and γ of Link 1_7 can be reduced by 71.2 %. On the other hand, we can find that $\delta = 0.5$ or 1.0 decreased more than $\delta = 0.1$. The bigger δ means it is more sensitive to the congestion so the bigger δ can bring more flow is avoided. However, if δ reach to the big value, it will not be changed any more. When $\delta = 0.5$, 1, 2 in the Fig. 31.4a, they have the same results on link1_7. From Fig. 31.4b, we can find that the traffic on link1_18 always is same under various δ. This is because how δ works is based on whether the congestion distance will affect the selection algorithms and choking/unchoking algorithm or not. Since the decreased traffic will alleviate congestion and BT chooses other links may fast peers' download speed, it is useful for backbone to respond to congestion automatically.

31.5 Conclusions

In this paper, a congestion distance based BT-like P2P traffic optimization scheme is proposed to make full of P2P application and reduce the bad impacts of P2P traffic. Importing the aims of ISP and P2P users, a general P2P traffic optimization model is obtained and the congestion distance becomes the main optimization object which is suitable to use for distributed peers. The distance aware peer selection and secondary sorting choking/unchoking algorithms are proposed for improving BT. In the large scaled network, the optimized BT has remarkable advantages comparing to the original and the inter AS traffic can be reduced remarkably. In the congestion simulation, the optimized BT can respond network congestion automatically. In the future, we will try to modify real BT and deploy it to the planetLab, and then analyze its performance under the real network environment.

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References

1. Schulze H, Mochalski K (2009) Internet study 2008/2009. https://portal.ipoque.com/downloads/index/get/id/265/
2. Karagiannis T, Rodriguez P, Papagiannaki K (2005) Should internet service providers fear peer-assisted content distribution? In: Internet measurement conference, Berkeley, CA, pp 1–14
3. Yang P, Xu L (2011) On tradeoffs between cross-ISP P2P traffic and P2P streaming performance. Comput Netw 55(18):4033–4042
4. Xie H, Yang YR, Krishnamurthy A et al (2008) P4p: provider portal for applications. In: Proceedings of the ACM SIGCOMM 2008. Seattle, pp 351–362
5. Choffnes DR, Bustamante FE (2008) Taming the torrent: a practical approach to reducing cross-ISP traffic in peer-to-peer systems. In: Proceedings of ACM SIGCOMM, vol 38(4), pp 363–374
6. Hsu CH, Hefeeda M (2008) ISP-friendly peer matching without ISP collaboration. In: Proceedings of the ACM CoNEXT conference
7. Aggarwal V, Feldmann A, Scheideler C (2007) Can ISPs and P2P users cooperate for improved performance? ACM SIGCOMM Comput Commun Rev 37:29–40
8. Lin M, Lui J, Chiu D (2010) An ISP-friendly file distribution protocol: analysis, design and implementation. IEEE Trans Parallel Distrib Syst 21(9):1317–1329
9. Liu B, Cui Y, Lu Y et al (2009) Locality-awareness in BitTorrent-like P2P applications. IEEE Trans Multimedia 11:361–371
10. Yang W, Abu-Ghazaleh N (2005) GPS: a general peer-to-peer simulator and its use for modeling BitTorrent. In: Proceedings of IEEE computer society's annual international symposium on modeling, analysis, and simulation of computer and telecommunications systems. Atlanta, pp 425–432