P2P Traffic Optimization based on Congestion Distance and DHT

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Abstract

P2P traffic has brought serious impact on the bearer network, and how to utilize network bandwidth has become a common concern problem for the Internet Service Provider (ISP) and the P2P user. A congestion distance and DHT based P2P traffic optimization method is proposed in this paper. The P2P traffic optimization model imports both aims of the ISP and the P2P user, and the cost of congestion and communication for links is converted into congestion distance uniformly. A distributed scheme with flow controllers and information collectors is realized where information collectors are constructed to a Distributed Hash Table (DHT) overlay. The traffic optimization application case using Bittorrent is discussed, where node selection and choking algorithms are changed. The experiment results show our optimization method can reduce the network traffic of inter autonomous system (AS) substantially, and react to the network congestion automatically, and then the win-win result for the ISP and the P2P user is achieved.

Keywords: P2P Traffic Optimization, Congestion Distance, Bittorent, Win-win

1 Introduction

P2P technology is widely used in such fields as content sharing, instant messaging. In the P2P system, each peer is both client and server, and the resource can be shared and exchanged directly. The Internet traffic distribution results showed P2P systems contribute more than 50% to the whole network traffic [18]. While utilizing P2P to accelerate the content transmitting, it also impacts network bandwidth seriously and has put Internet service providers (ISPs) in a dilemma [18, 10]. Using P2P technology, the terminal bandwidth can be utilized as much as possible, but the bottleneck takes place on the backbone alternately. How to use network bandwidth reasonable while giving full play to the P2P performance has become a common problem concerned by the ISP and the P2P user.

A lot of ISPs start to throttle and restrict the bandwidth of P2P, but these control methods cause that the quality of service (QoS) of P2P applications is decreased. It is a major reason of upgrading her accessing bandwidth for the internet customer to use such interesting P2P applications as Bittorrent, Xunlei, and Skype. So, the throttling and restricting methods are too rude. Employing caching of P2P content can alleviate the bad effect of P2P traffic, just like PeerCache for FastTrack, but it needs to deploy many cache servers. The caching schemes normally are expensive and easily bring copyright entanglement.

After analyzing the actual Bittorrent (BT) traffic logs, Karagiannis et al [10] think the probability of requesting the same file in the same ISP is 30% -70%. If the requesting peers in the same ISP are selected

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firstly, the traffic between ISPs can be reduced. 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 [23]. So, the inconsistency between the logical topology of P2P communication and the actual network topology brings a lot of unnecessary inter-AS traffic. The ISP and P2P users including the content provider and the terminal user are two key roles for the P2P traffic optimization. The P2P traffic optimization scheme should consider their aims together, and try to give a better P2P network topology with better consistency for the bearer network. In a good P2P traffic optimization, all sides can get be awarded.

In order to let P2P application utilize the network bandwidth rationally, a P2P traffic optimization model with congestion distance is induced and then a optimization scheme based on congestion distance and Distributed Hash Table (DHT) overlay is implemented in this paper. The P2P traffic optimization model starts from aims of the ISP and the normal P2P user. BT is chosen as a typical case to analyze and simulate how to apply our P2P optimization method. Bittorrent (BT) is a typical and popular P2P system, which is normally used to as the discussed object in the P2P traffic optimization researches [22, 12, 3]. The main contributions of this paper are as follows:

Firstly, the P2P traffic optimization model integrating aims of the ISP and the P2P user is induced. The congestion status of backbone link is converted into a communication distance value to optimize uniformly, which can be easily realized in a distributed environment and used by the P2P system. Secondly, A P2P traffic optimization realization scheme with multiple flow controllers and the information collectors is implemented. Information collectors are constructed a DHT overlay. The optimization scheme can provide different Quality of Services (QoS) for different P2P applications and support business application.

Thirdly, the P2P traffic optimization case using BT is realized. The peer selection and choking/unchoking algorithms are adapted based on our P2P optimization scheme. Through the simulation, we obtained some valuable results such as that the inter AS traffic is reduced very much and the network congestion control can be work automatically.

The rest of this paper is organized as follows. Section 2 gives the related works. The P2P optimization model is given in Section 3 and Section 4 gives the distribute realization scheme. The BT based optimization case is given in Section 5 and the evaluation performances are analyzed in Section 6. Finally, we conclude the paper in Section 7.

2 Related Works

In recent years, the problem of the performance of the bearer network affected by P2P is becoming more and more overhang. The random selection algorithm of P2P application is one of the main reasons, so the network topology optimization becomes a hot point of research [5, 9, 1, 2, 11, 17, 8, 15, 3, 13, 14].

Traffic locality seems to be a side effect to reduce the ISP sizes in the P2P distribution. The advantage of the cosine similarity of the content distribution network redirection is taken to guide partner selection in [5] , while a distance data set extracted from public available information is leveraged in [9]. A Oracle role and last-hop bandwidth are imported to judge the link quality for each peer in [1] and Ref [8] talks about the optimal peer choice algorithms based BGP information. Picconi and Massoulie [15] propose an ISP-friendly scheduling strategy where each peer requests most data from the topologically close neighbors and communicates with remote peers only when data is not available locally. Furthermore, Lin et al. [11] and Ren et al. [17] both designed and implemented real locality-aware BitTorrent clients. However, these optimization methods are strongly depended on underlay information, so their practicality can be improved further.

It is another important method to reduce inter-AS traffic through the cooperation of the ISP and the P2P user which is discussed in [23, 22, 1, 2, 14, 20]. If the ISP and the P2P user acts independently to realize their own objectives, the sub-optimal performance for both the ISP and the P2P user can be achieved [14]. Aggarwal et al. [1, 2] think that non-cooperative situation is disadvantageous for both ISP and the P2P users, where the immense P2P traffic impacts a significant traffic challenge to the ISP's backbone links without controllable capability, while the P2P application has to measure the path performance itself. So, an "oracle" is provided by the ISP can help the P2P users to optimize their traffic. Since ISPs can use the network management equipments freely, it is relatively easier for them to obtain the topology information. Xie et al. [22] introduce Peer Coordination Protocol (P4P) to realize a cooperation framework to allow more effective cooperative traffic control for the ISP and the P2P application. Peng Yang et al. propose a self-adapting, QoS-protected peer selection algorithm and model the tradeoffs between inter-AS P2P traffic and the P2P streaming performance as a multi objective optimization problem, and solve it using the Goal Attainment method based Genetic Algorithm [23]. An fully decentralized intriguing flow control algorithm is presented by Tomozei and Massoulie [20]. The above corporative P2P traffic optimization scheme achieve obvious effects, but they normally adapted slowly to the link load dynamically.

The network evaluation is a key foundation for the P2P traffic optimization. Ref. [12] designed a AS mapping tool between the IP address to an AS number based on Cymru Team [6], which can help to identify the ISP easily for a peer. However, the gotten AS number range is not exact correct enough. For example, such Chinese universities in different cities as Tsinghua, Fudan and Hunan University have the same AS ID using the tool of [12]. How to model the objects of ISPs and P2P users and measures the distances or other optimized required information fine are very important. We will try to provide an independent method to obtain AS information.

In addition, all above studies cannot support a business application to encourage P2P users to participate in the optimization work. Without the business support, ISPs and P2P users may not take part in the P2P optimization scheme actively. Our method inherits P4P to take the advantages of a win-win terms between the ISP and the P2P user, and tries to import the business support.

3 Optimization Model

In this section, we will induce a general P2P traffic optimization model to integrate both aims of the ISP and the P2P user which can be easily used in real implementation. The main notations used in this paper are list in Table 1.

3.1 Optimization Aims Analysis

For P2P users, they normally concentrate on fast download speed, whereas ISPs hope to be reward from P2P applications and not get such bad affections as network congestion. The faster download speed and more P2P users bring more P2P traffic flow on the backbone, so the aims between ISPs and P2P users become conflicted. How to satisfy them simultaneously becomes a trade-off optimization problem.

The P2P network 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. In the network topology, the bandwidth between ASes and the upload/download speed of each peer are relatively fixed. The P2P traffic optimization model are defined as a multi-objective optimization problem with constraints:

Notation	Definition
V	*Backbone nodes set*
L	*Backbone link set*
P_m	*Mean download rate*
P_c	*Variance download rate*
t_i	*Current traffic speed of link i*
τ_i	*Background traffic of link i*
b_i	*The bandwidth of link i*
u_i	*Upload rate of peer i*
υ_i	*Download rate of peer i*
pd_i	*Max download rate of peer i*
pu_i	*Max upload rate of peer i*
I_c	*Congestion reflection index*
f_c^i	*Congestion conversion traffic*
C_i	*Congestion rank*
δ	*Congestion adaption gene*
l_i	*The ith key link*
d	*Communication distance*
R	*Decreased ratio of inter-AS traffic*

Table 1: Summary of the main notations

$$\begin{aligned} \text{min: } & I_{ISP}, I_{user} \\ \text{st. } & \forall i, t_i + \tau_i \leq b_i \\ & u_i \leq pu_i \\ & \nu_i \leq pd_i \end{aligned} \tag{1}$$

Where, I_{ISP} represents the index of the ISP's aim to reduce the P2P communication cost. The communication cost normally consists of inter-AS traffic and congestion. I_{user} represents the index of the users' aim like the faster download speed. The download speed can be described by the mean download P_m and the variance P_c for each peer.

Giving the congestion reflection index (I_c) to represent a function of traffic and congestion, we can only consider about I_c of a backbones while talking about communication costs. I_c is the sum congestion conversion traffic f_c^i of all the backbone links defined as follows.

$$I_c = \sum_{i \in L} f_c^i = \sum_{i \in L} c_i f_i \tag{2}$$

Where, c_i is a numerical mapping value of the congestion degree, and the different degree has different c_i . In our paper, the value of c_i is defined as follows:

$$y = \begin{cases} 1 & : \quad no \\ 2\delta & : \quad mild \\ 3\delta & : \quad moderate \\ 4\delta & : \quad servere \\ \infty & : \quad forbidden \quad link \end{cases} \tag{3}$$

Where, δ is a congestion adaption gene. If c_i =1, I_c equals to the sum traffics of all the edge links between each AS. The background flow is not considered in the P2P traffic model for the internet bandwidth t_i can be adapted dynamically in the equation 1. Summarizing above analysis, a P2P traffic optimization can be defined as:

$$
\begin{aligned}
\text{min: } & P_m, P_c, I_c \\
& P_m = (\sum_i d_i)/n \\
& P_c = (\sum_i (d_i - P_m)^2/n \\
& I_c = \sum_{i \in L} c_i f_i \\
\text{st. } & \forall i, f_i + \tau_i \leq b_i \\
& u_i \leq pu_i \\
& v_i \leq pd_i
\end{aligned} \tag{4}
$$

3.2 Congestion Distance Optimization Model

In Equation 4, the upload and download rate information of each peer and link should be obtained and then the global optimization is needed. Because this rate information is constantly changing, the Equation 4 may be weak for practice in a big P2P network. It should be decoupled and simplified deeply to meet the requirements of real application.

Proposition 1: while distributing fixed-size data in a P2P system, the more key links passed through means the inter-AS traffic becomes greater.

Proof: Assuming that the peer A wants to distribute x M bytes data to peer B, the inter-AS traffic f_i equals to the value that is $d \cdot h$, where h equals that the number of AS passed through pluses one. On the other hand, the number of AS passed through between A and B is the number of key links ($|l_i|$) . Therefore, the summary inter-AS traffic is:

$$f_i = x \cdot (|AS| - 1) = x \cdot |l_i| \tag{5}$$

So, the inter-AS traffic f_i is proportional to the number of key links $|l_i|$; 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 passed key links, ($|l_i|$) is relatively stable after the route is determined and it can be tested by trace-route tools. Because the inconsistence between P2P overlay and physic network is the important reason that cause the big P2P traffic on backbones, it is in line with the requirements of P2P optimization to make a better P2P overlay topology.

Definition 1 (Communication Distance): In P2P application system, the number of key links passed through in a peer communicate with another peer is called the communication distance (d), $d = |l_i|$.

Definition 2 (Congestion Distance): Integrating the affection of congestion into the communication cost, the congestion distance (d_c) is the summary of d and the accumulation of all the key links' congestion mapping value:

$$d_c = d + \delta \sum_{i \in L} c_d^i \tag{6}$$

Where c_d^i is compute from c_i. If no congestion exists, $c_d^i = 0$, else $c_d^i = (c_i/\delta) - 1$. If there isn't congestion on all the key links passed through by P2P application, d_c equals to d. δ is used to adapt the affection degree about congestion, the bigger δ means the more sensitive for congestion. The mathematic optimization is decoupled to this formula for each peer:

$$\text{min: } d_c \tag{7}$$

The Equation 6 has three good features comparing to Equation 4. Firstly, the smaller d_c, the inter-AS traffic is less and the communication cost for ISPs is less. They have similar optimization objects. Secondly, these peers with short path and less congestion are chosen which normally bring the fast download speed. ISPs and P2P users both can be benefit from the optimization. Thirdly, Equation 6 is very simpler, which has no constraints and can be computed distributed by each peer. In the next, we will use d_c as the objective to design the optimization scheme, and use the Equation 4 to validate the optimization performance.
The performance indexes consist of the mean (t_m) and variance (t_y) of the complete time for each peer, the inter-AS traffic (I_f), and the decreased ratio (R) of inter-AS traffic using our P2P traffic optimization method.$R = (I_f^{old} - I_f^{opt}/I_f^{old})$. R implies the optimization effect. R is greater, and the optimization result is better.
The congestion distance d_c can be achieved based on the Equation 5, but it needs store the congestion level for each link which brings too many information items for management.
Proposition 2: The congestion distance d_c can be computed by the equation:

$$d_c = d + \delta \cdot \sum_i c_d^i \cdot n_i \tag{8}$$

Proof: According to the definition 2, d_c equals to $d_c = d + \delta \sum_{i \in L} c_d^i$. Where, $\sum_{i \in L} c_d^i$ equals the summary c_d^i of all the backbone, so it is the summary c_d^i of multi congestion levels. That is to say, we can compute the congestion separately, and sum them together finally. So, $\sum_{i \in L} c_d^i = \sum_i c_d^i \cdot n_i$, and then $d_c = d + \delta \cdot \sum_i c_d^i \cdot n_i$.

4 Optimization Scheme

A general P2P traffic optimization scheme is designed for realizing the given P2P traffic optimization model in this section.

4.1 System Architecture

The P2P traffic optimization scheme provides the congestion distance query service, which is capable of sensing communication and congestion status information. We propose a congestion distance based P2P traffic optimization scheme with information collectors and flow controllers. Through cooperation between information controllers and flow collectors, the key network information including the correspondent congestion distance can be collected and evaluated. All the interfaces provided for P2P applications are encapsulated in web services. The whole scheme is shown in Figure 1.
The information collectors are linked with each other to construct an overlay to realize communication status collection and information sharing. The flow controller is network equipment deployed on the key links. A general P2P traffic optimization management platform is realized which can be managed by a third organization, and then the business service can be supported.

4.2 Information collector overlay

The layers of information collector are figured as Figure 2. In a information collector, there are four layers: physical layer, DHT, functions background and interface encapsulation. The information collector overlay is constructed by the collector on each AS using DHT, which is responsible for registering

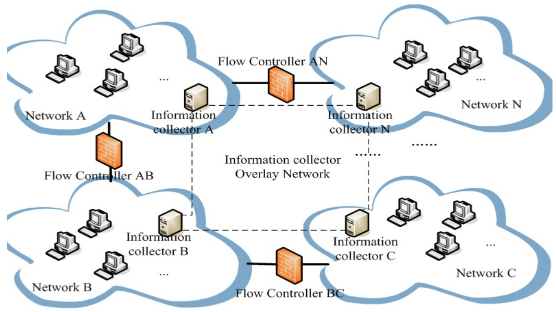


Figure 1: P2P traffic optimization scheme

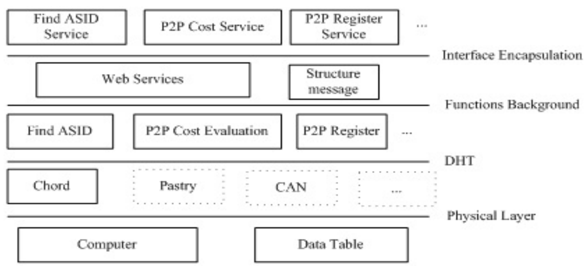


Figure 2: The layers of an information collector

P2P application, collecting network status information, evaluating distances, and so on. The upper layer of information collector overlay may be implemented based on Services Oriented Architecture which provides web services interfaces for P2P application programs. Using DHT, all the controllers can work corporately easier, and the DHT algorithms may be chosen freely, e.g Chord[19], CAN[4], Pastry[16] and so on.

On the information collector overlay, every AS has an information collector where ID and ASID are one-to-one mapping. Information collectors have several backup successors in the DHT ring to realize fault tolerance.

4.3 Flow Controlle

Flow controllers are deployed in the key links to control P2P flow. Such network flow controller as router, firewall and DPI equipments can be used to be extended as a flow controller. More and more network equipments are made by hardware directly using FPGA and advanced data analysis technology, the process speed of DPI become faster and faster, and some equipments can support 75 G bit/s throughput [18]. The flow controller can be extended by adding P2P flow identification and control mechanisms.

A lot of flow controllers running in the backbone can not only be used to optimize P2P traffic, but also help to improve security of the whole internet by providing network status monitor capability. It may be a gradual process to deploy controllers on the key links in the internet. We can only deploy controllers on some most important key physical links in order to optimize their performance in the first, and then deployed in other internal main links. With the incensement of controllers the traffic performance of more key links will be optimized.

4.4 P2P Flow Identification and Control Mechanism

In order to identify a P2P application clearly, a P2P application registration mechanism is provided in the management platform. While registering a P2P application, the signatures about that P2P application should be submit to the flow controller. The P2P application registration process works as follows:
Step 1, the P2P application operator submits a registration appliance to the management platform of the P2P traffic optimization.
Step 2, after the appliance is authenticated, the registration service of the information collector overlay is called, and then broadcasts the P2P information all over the overlay.
Step 3, each information collector posts the registration information to its neighbor flow controller, and the controller will save signatures of the new P2P application. Based on the registration process, it may help to realize various commercial modes, e.g. provide different QoS for different registration types based on the paid fee.
In addition, a mechanism to perceive the status of the key link and adding congestion rank actively. According to the current network flow, bandwidth and the lost packet rate of the perceived link, the impact of the congestion is achieved. And then, the congestion degree is set to 4 ranks: no congestion, mild congestion, moderate congestion and sever congestion.

4.5 Distance Evaluation

According Equation 6, d_c is the objective of traffic optimization model. In our scheme, it is evaluated by information collectors and flow controllers. Assuming there are two Peers are in AS A and B, the congestion distance between A and B are evaluated as followed:
Step 1, the collector in AS A sends a special distance evaluation packet ($TPing$), which contains triple: source AS, destination AS and current hops.
Step 2, the distance evaluation packet is detected and analyzed by the passed flow controller. If $hop < MAX$, hop is added by one and forward it to the two neighbor collectors for setting initial congestion level and notifying P2P application users when their link's congestion status is changed.
Step 3, when the collector of the destination AS B receives a distance evaluation packet, the distance evaluation process is finished, and it will extract the hop value from the $TPing$ packet as the congestion distance d_c.
Step 4, the collector on AS B responses d_c to the collector on AS A directly, and then any peers of AS A and B can query d_c from the information collector overlay.
The evaluation process takes place in two conditions. First, when a peer in an AS where no peers have used the P2P traffic optimization joins; Second, when the refreshing period is fired. If a collector can't receive the response in the expected time, it will send $TPing$ again. If the response is not received second times, d_c will be set MAX. All the information collectors have two data tables in the memory database: "$refresh$" and "$congestion$" shown in Figure 3.

The refresh table saves the relations between the controller and the P2P connection. A row is added into refresh table in Step 2 of the distance evaluation process. If the flow controller finds the congestion status is changed, it will notify the neighbored collectors to adapt their congestion level. Based on the information control overlay, the congestion information between $ASID_A$ and $ASID_B$ is modified. And then, the number of old congestion level is reduced by 1, while the number of new congestion level is added by 1. The congestion table stores all congestion distances including d_c and the number of various rank congestions. Based on Equation 6 and the congestion table, it is easy to obtain the congestion conversion distance d_c.

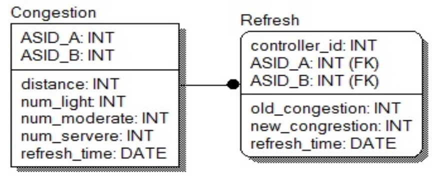


Figure 3: The congestion tables of an information collector

5 Application Example

BT is used as a P2P traffic optimization case to be discussed in this section.

5.1 BT Features

BT is a typical and popular P2P content sharing system, which can support VOD and live multimedia streaming [7, 21]. BT consists of seed, peer and tracker. The neighbor selection and peer choking/unchoking are two important algorithms.

In the neighbor selection, the peer queries the knowledge of the neighbor peers in the same group of peers interested in the same file from the tracker and a peer list is returned. If the population of the swarm exceeds the requesting number (default value is 50), the selection is entirely random. A peer connects with the majority of the neighbors at the maximum number 35, and then sends the “bitfield” messages which gives the availability pieces information. Upon the “have” message collected from neighbors, each peer maintains an array of interest entries, which are the numbers of neighbors owning the corresponding piece. If a neighbor wants to down interested pieces, it informs the neighbors with an “interested” message.

In the peer choking/unchoking, a peer decides which of its “interested” neighbor it should send data to. It sends “choke” message to most of its neighbors, and then sends “unchoke” message to a small number (default value 4) of neighbors with the highest uploading rate to itself. The unchoking criteria is best known as tit-for-tat. After a peer becomes seed, it unchokes the four neighbors with the highest downloading rates from itself to speed up the entire swarm distribution. Finally, it sends unchoke message to a random peer to bootstrap brand new peers without uploading rate.

In order to utilize CDPTO, the algorithms of neighbor selection and choking/unchoking are modified.

5.2 Minimizing Congestion Distance Peer Selection

The default peer selection of BT is changed into the peer selection algorithm that minimizes d_c to promote locality awareness in our P2P traffic optimization scheme. The working roles consist of the tracker and the peer. The tracker selection procedure is shown in Figure 4.

Firstly, a peer sends a query message including its *ASID* and the destination *ASID* to a well known default information collector, and then submits a request messages with *ASID* to the tracker. Secondly, the tracker checks d_c in the caches. If the responding d_c exits, it returns a sorted list to the requesting peer. Otherwise, the tracker will start a query process on the information collector overlay. Finally, the tracker returns the peer list with d_c attached, and the fixed number peers with minimal d_c are selected.

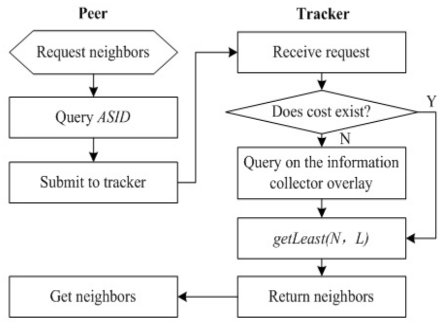


Figure 4: The flow chat of peer selection

5.3 Congestion Distance based Choking Algrithm

In BT, how to choose peers in the interested list to upload is based on the choking/unchoking algorithm. Our P2P traffic optimization choking method not only considers the upload data of a peer (d_u), but also considers d_c. After neighbors are sorted by d_u in a peer, the rank of each peer (r_u) can be gotten. The final rank (r) used for choking is induced by:

$$r = r_u + \beta \times d_c \tag{9}$$

β is a gene to adapt the affection of a link's congestion distance. Where, the bigger β means the more important for the congestion distance. We set β equals to the number of unchoking peers (default is 4). If d_c of all peers are equaled to each other, the unchoking selection works as the default "Tit-for-Tat" mode. The original BT optimistic unchoking and boycott is kept in our method to help bootstrap brand new peers and avoid the peers with higher d_c will be choked forever. The improved choking algorithm is as follows:

Choking/unchoking algorithm
Input: local candidate peers *PL*
Output: unchoking peer list *unchokeL*
1) if $|PL| < ucNum$ //ucNum is the number of unchoking Peers
2) return *PL*;
3) else {
4) Sort *PL* by d_u and refresh *PL.urank* (r_u).
5) Integrate d_c and refresh the secondary rank *PL.rank* (r) using the Equation 8.
6) Select *ucNum* Peers into the list of *unchokeL* from *PL* with minimal r.
7) return *unchokeL*;
8) }

6 Experiment Results

The performances of the P2P traffic optimization are evaluated using the General Peer-to-Peer Simulator (GPS) [24]. All the experiments are run on a computer with Inter Core 2 Q9400 2.66GHz CPU and 4GB Memory where the windows 7 operation and 1.6 JDK are installed.
GPS provides a extensible framework for simulating P2P networks efficiently and accurately. Three main

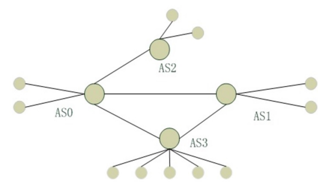


Figure 5: Simulation network topology with 4 ASes

config files (simulation.ini, documents and events) are used to adapt simulation parameters. Firstly, the simulation.ini is the main configure file which sets such delay, bandwidth and the other config files about documents, events and topology. Secondly, the documents file is used to set key, size, initiate seeder and tracker of download files. Thirdly, the events file is used for users to set their events take place. In the experiments, we test the functions, discusses the performances about inter-AS traffic and relative features, and analyze the congestion respondence performance for our P2P optimization scheme using BT.

6.1 P2P Traffic Optimization Simulation

The flow controller and information collector are realized as two models in GPS, and "SimEventHandler" interface is implemented. Through the "confEvents" method of the P2P protocol class, the controller and collector are initiated. The default congestion rank for distance on each key link is set to zero, that is, $\forall i, c_d^i = 0$. All the functions of the P2P traffic optimization scheme are tested in the simulation.

At first, we simulated resisting a new P2P application. The applications were registered in different types, and the network links have different bandwidth. The flow controller can identify the difference and the P2P applications with high priority in the registration have faster distribution speed. Therefore, QoS can be provided for various registered P2P applications, and the traffic of unregistered P2P application can be limited by the controller.

Secondly, publishing and downloading documents are simulated on the optimized BT. We construct a network with 4 ASes and 16 nodes, shown in Figure 5, to be simulated in the next performance evaluation.

The publishing and downloading events are simulated through add event items in the "events" config file. When a peer requests firstly, we find that it will bring the distance evaluation event. In the information collector overlay, we can check refresh and congestion tables to validate their value. Through the flow controller, the network flow state on each link is achieved, and then the inter-AS traffic can be monitored easily. In addition, the events of congestion taking place can be known actively.

6.2 Inter-AS Traffic

Assuming there are no congestions in all links, we monitor the factors including the mean t_m and the variance t_c of each peers' complete time and I_f according the Equation 4.

Referring to the ref.[24], the tested two-level Transit-Stub topologies with 16, 64, 252 and 1054 peers are generated using GT-ITM. A transit domain is an AS, and its number is 4,8,18 and 34. The bandwidth between AS is 1000Mbps, and the bandwidth between transit and stub is 100Mbps. The delay between AS is 5ms, and the delay between transit and stub nodes is 10ms. Table 2 gives the simulation scenario

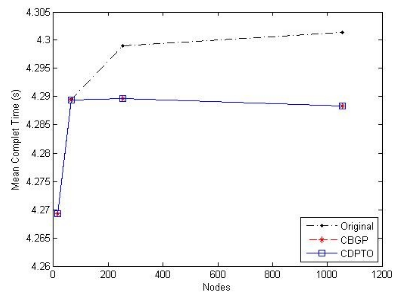


Figure 6: The mean complete time t_m

parameters of the experiment, and the download events are the same as [14].
BT Peers are randomly attached to non-transit nodes, and documents with different popularity rankings

	Nodes	ASes	Peers	Files	Downloads
1	16	4	8	1	4
2	64	8	32	1	16
3	252	18	128	1	64
4	1054	34	512	1	128

Table 2: Simulation scenarios

are randomly stored at Peers. The downloading peer selects a document to download using the popularity rank Zipf distribution, and all the document sizes are 500MB.

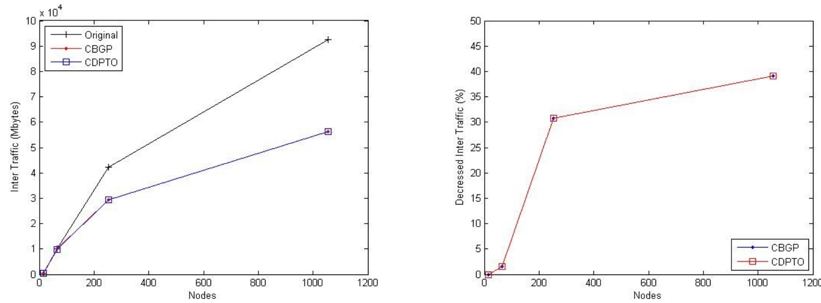
In the simulation, the performances of original, CBGP [8] and our Congestion Distance P2P Traffic Optimization method (CDPTO) are compared. Figure 6 gives the mean complete time (t_m) of the original BT and the optimized with CBGP and CDPTO. The CDGP and CDPTO are substantially faster than the original. t_m is stable with the increase of the number of peers while the peer number is bigger than 64 and the variants of complete time are small.

Figure 7.a gives the total inter-AS traffic (I_f) about the optimized BT under CBGP and CDPTO. When there is no congestion, the congestion distances in CDPTO is similar to BGP hops, and then the optimized BT programs under CBGP and CDPTO have the same inter-AS traffic performance. The total inter-AS traffics of the optimized become smaller, and the optimized BT have litter inter-AS traffic.

Figure 7.b shows the decreased ratio (R) of inter-AS traffic. R becomes larger with the number peers. In the third scenario, R has been 30.8%, and the decreased flow has been 13.05G; in the fourth scenario, R has been 39.1%, and the total decreased inter-AS P2P flow reaches 36G. Overall, the inter-AS traffic can be optimized observably and also can optimize users download time. Since the larger scale is more meaningful in practice, the next experiments will be based on the fourth scenario in Table 2.

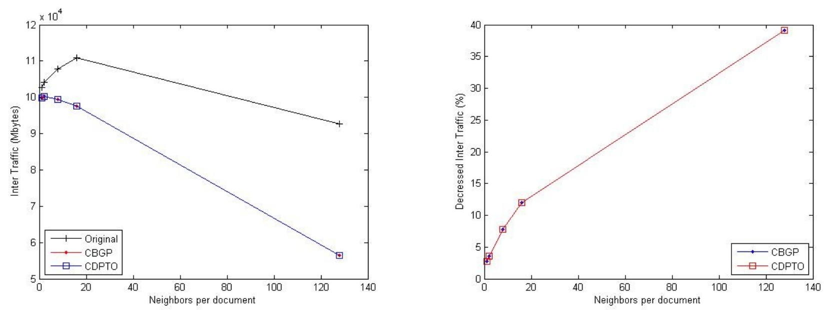
6.3 Inter-AS traffic and neighbor peer

It is obvious that the inter-AS traffic can be avoid completely if there are adequate peers including a seeder downloading the same document in the same AS. The inter-AS traffic is not only related to the network topology, but also is related to the distribution of objective documents. The relationship between inter-AS traffic and the mean neighbors number of documents (N_f) is discussed in this experiment.



(a) I_f (b) R

Figure 7: Inter-AS traffic comparison



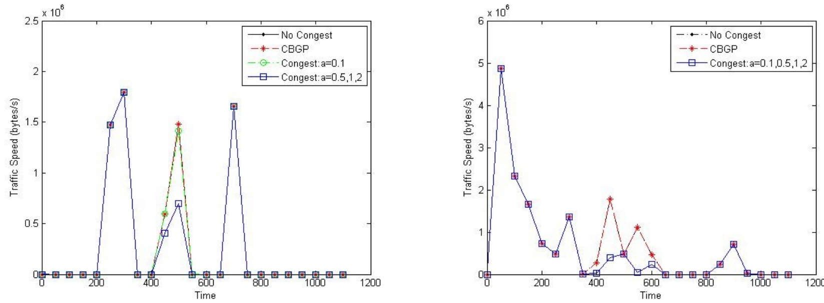
(a) I_f (b) R

Figure 8: Inter-AS traffic *vs* neighbor peers

In the simulation, one download event (E) means one peer joining the P2P network. If we add the objective documents, N_f will decreased where $N_f = |E| / |D|$. So, N_f is adapted by adding the objective documents while fixing the topology and downloading events. In the scenario of sub section 6.2, the download events number is 128. We change the number of objective documents with 1, 8, 16, 64 and 128, and then the correspondence N_f is changed into 128, 16, 8, 2 and 1. Fig.8 shows R of CDPTO and CBGP is similar with each other under different N_f.
The inter-AS traffic of original and optimized are all decreased with N_f. However, the optimized decreased faster, and then R increased with N_f. When N_f equals 1, R equals 2.7%. While N_f equals 128, R equals 39.1%, more than one third traffic saved. The bigger N_f means more peers downloading a same documents, so a hot content distribution task can be benefit more from the BGP or CDPTO optimization.

6.4 Congestion Response

The congestion response experiment is used to validate whether the CDPTO can help to reduce P2P traffic on the congestion links automatically after congestion takes place. Multiplue congestion events as a special action are added in the event file. The mean rate of P2P traffic per 50 seconds (v) is discussed for the congestion experiment.
We can obtain all the link traffic information without congestion from the above experiments. There are relatively bigger flow on Link1_7 connecting AS 1 and AS 2 and Link 1_18 connecting AS 1 and AS 18,



(a) Link1_7 (b) Link1_8

Figure 9: The P2P Traffic flow changing on congestion links

so they are chosen to be the objective links in the congestion response experiments. We design a new event file that is added a moderate congestion on Link1_7 and Link 1_18 from the simulation time 300.0 to 600.0. The congestion events script is as follows:

...
300.0,C,1,7,1.0,600.0
300.0,C,1,18,1.0,600.0

In the simulation, CBGP did not reduce the traffic on the congestion link, but the P2P traffic v is reduced obviously during the congestion time (300.0 - 600.0) in CDPTO. From Fig 9.a and Fig 9.b, v of Link 1_7 are reduced by 46.6%, and v 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 more sensitive to the congestion, so the bigger δ can reduce more P2P traffic. However, if δ reaches a threshold value, the adaption affection will not work. When $\delta = 0.5,1,2$, there are the same results on link1_7 and the v on link1_18 always is same under various δ. How δ works is based on whether the congestion distance value affects the selection algorithms or choking algorithm for BT.
Since decreased traffic on congested link will alleviate congestion, P2P applications avoid to choose these peers that pass through the congestion links. So the distribution speed for P2P users and bad affection for ISPs are all optimized.

7 Conclusion

In order to make full of the excellent distribution capacity of the P2P application and reduce the bad impacts for the backbone links of ISP, a P2P traffic optimization scheme based on congestion distance and DHT is proposed. The P2P traffic optimization model is induced on the aims of the ISP and the P2P users which is easily used in a distribute environment. The implemented P2P traffic optimization scheme consists of a lot of flow controllers and information collectors deployed in the network, and the information collectors are constructed into a DHT overlay. Improving the selection algorithms and choking/unchoking, BT can optimize the traffic well. The experiment results show that our P2P optimization is a win-win P2P traffic optimization scheme for the ISP and the P2P user and our P2P traffic optimization method also can be used by other the distribution systems to optimize their traffic.

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