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# A Survey of Fairness Mechanism in BitTorrent's Peer Selection Protocol

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***Abstract*—Achieving fairness in peer to peer (P2P) file sharing require user's contribution of bandwidth resource that is peer's download bandwidth is equal to the upload bandwidth it contributes to the system. BitTorrent,a popular file sharing employs a "tit-for tat" (TFT) peer selection strategy to guarantee fairness, whereby a peer chooses to upload to a small set of neighboring peers that providing it with the best download rates. However, despite of BitTorrent achieves excellent utilization of upload capacity, many measurement and simulating studies found its fairness are less impressive where it lack of incentive for a peer to contribute and not effective enough to penalize free riders.This paper presents a literature survey of recent works of fairness improvement including free riders prevention in BitTorrent swarm through its TFT peer selection towards better downloading times and improve system stability.**

***Keywords*—BitTorrent, fairness, free riders, peer to peer file sharing ,swarm**

## I. Introduction

The core idea of peer to peer (P2P) file sharing is to increase peers participating in the downloading process and contribute uploading service back to the system. For example a work in [1] keep the P2P network fairness by calculate each peer's global contribution to make decision whether transaction can be made between to peers or not. Achieving fairness in P2P file sharing require peer's download bandwidth is equal to the upload bandwidth it contributes to the system[2]. Specifically, the system is consider as fairness when a peer say peer *p* sends to another peer say peer *q* a block of file but peer *p* does not send more until peer *q* sends a block in return. If peer *q* wants more blocks from peer *p*, it has the incentive to act fairly and return peer *p's* favor.

Our survey focus on BitTorrent file sharing protocol [25], which contributed to large internet traffic portion [3],[4] and has proven in distributing large files effectively [5]. This has attracted the interest of the research community that has thoroughly evaluated the performance and the demographic aspects of BitTorrent. An understanding of BitTorrent can be reviewed in [6],[7],[29].

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BitTorrent strives to ensure fairness by considering the clients who do not contribute data to the system should not achieve high download throughput. Regarding fairness among peers, previous measurement studies as survey in [8] found that the BitTorrent Tit-for-Tat (TFT) peer selection still not effective to guarantee fairness [9],[10] and vulnerable to free riders [11][12] although the protocol is designed to prevent free-riding. The authors in [9] found the unfairness of BitTorrent exists when low bandwidth peers have download more than they upload to the network. In contrast, authors in [10] addressing unfairness based on the peer contribution ratio and found high downloading peers frequently download much more data and uploading less.

Free riding is the most significant threat in the BitTorrent environment and most P2P systems. Most peers in a P2P system behave selfishly and try to maximize their performance only. This behavior create unfairness problem to the remaining users who contribute when free riders choose to download a file and consume resources without uploading in return. In addition, other cases happen when newly arriving peers have to produce some blocks initially to start the transaction. A free-rider who is not willing to share his blocks will cheat the newly arriving peers by collecting the initial blocks they share. Free riders in BitTorrent aim to increase their peer set size, to increase the probability of being optimistically unchoked by a leecher or picked by a seed's unchoke mechanism [20].

Tit-for-tat (TFT) peer selection also called BitTorrent's incentive policy is designed to prevent free riding in BitTorrent which takes a peer with a low ratio of the upload rate versus the download rate is choked (refuse to upload). A freeriding client named BitThief has been demonstrated to show BitTorrent is not efficient enough to rule out free riding[11].BitThief has faster open connections when interacting with newly arriving peers ,cheat the tracker easily and will not leave the system when complete downloading the file. Furthermore, a measurement study [27] found that over 10% of all peers are free riders while in [12], the free riders in BitTorrent can achieve the same file download completion time as a contributor leechers. In this paper, two recent works of reducing free riders in BitTorrent by applying Trust-based management [13] and Credit based reputation propagation [14]. Trust management based Bittorrent used tracker to act as authoritative agent to calculate and disseminate global trust values for all peers. The system assign a local trust value to each of its neighbors based on their past contributions. The local trust values of selfish peers will be decrease and thus will not be unchoked by their neighbors when it becomes negative value. Credit-based Reputation Propagation propagate the existence of possible free riders using a list of free riding

scores of other peers in the swarm[14].The score is incremented everytime someone attempts to free ride on itself or others and thus,it will never be unchoked by other neighbours.As lots of studies have discover about peers behavior in BitTorrent environment,our purpose of study is to highlight the importance of fairness which has been considered as performance metric for BitTorrent efficiency. We focus on five recent papers working for strictly fairness using (1) buddies protocol [15], (2) deficit-based[16], (3) incentives effort-based [17],(4) Reinforce Learning algorithm [18] and (5) planned optimistic unchoke[19].

The rest of the paper is organized as follows.In Section II we provide a brief overview about BitTorrent and how BitTorrent peer selection protocol works to ensure fairness of peer's bandwidth. In Section III we discuss five recent works of fairness mechanism improvement for BitTorrent fairness. Finally, the paper is concluded in Section IV.

# II. BitTorrent's Background

We give a brief overview of BitTorrent and its peer selection protocol.

Each BitTorrent network is called a swarm and millions of peers may join multiple swarms and stay until they finish downloading the file completely [24] As described in [26] files which transferred using BitTorrent are split in pieces, and each piece is split in blocks. A user who wish to download a file,first downloads a torrent file from a Web site, and starts the BitTorrent client to join as a new peer. .torrent file contain information such as the name of the content, its size, the hashes of the pieces, and the address of the tracker.

The tracker is a central node that keeps a list contains the addresses of all peers who participate in distributing the content and their positions in the download and upload process. A new arriving peer then registers on the tracker, which responds to it with a list of randomly chosen 40 active peers possessing blocks, and then attempts to establish connections with these peers as its neighbor peers. Finally, new arriving peer begins to exchange blocks with its neighbor peers and when completing all the blocks, a leecher become seeds and they are no longer downloading and expected to remain online to continue uploading to other peers.BitTorrent peers are called leechers if they are still in downloading process.

The peer selection protocol in BitTorrent known as Tit-for-tat (TFT) implements two principle: unchoke and choke policy. Its effectiveness on fairness specifically ensures that each peer contributes by uploading pieces to other peers) proportionally to how much it receives by downloading pieces from other peers [24].The strategy split the available upload bandwidth of a peer into equal slots which are used to upload pieces on the connection called unchoke. Through strategy called regular unchoke, a peer choosing to unchoke (upload) four number of peers who have the highest upload rate and chokes the others. Choking is a temporary refusal to upload to a peer [24]. For example, if a peer has 1000 kbps of upload bandwidth and it is serving 4 peers, 3 peers with 1000 kbps download bandwidth and 1 peer with 100 kbps download bandwidth, then the "slow" peer will get its 100 kbps and the remaining 900 kbps is evenly divided between the three "fast" peers.For every rechoke period which takes 10 seconds,a leecher checks the current download rates of all leechers in its swarm. If the lowest download rate provided by an unchoke peer is less than the rate amount provided by a choked peer, then the peer chokes the former and unchokes the latter. The TFT policy also enabling leechers to reserve one slot of their available bandwidth for sending pieces to random peers using mechanism called optimistic unchoke.Every 30 seconds that is every third rechoke period,optimistic unchoke is performed to give opportunity to new arriving peers to obtain their first blocks of files.

# III. BitTorrent's Fairness Literature

The most significant paper that reviewed by most researchers regarding unfairness in BitTorrent protocol is the work in [9] which focusing on how to ensure nodes will not download much more data than they upload. The proposed scheme namely quick bandwidth estimation to avoid the needs of optimistic unchoke and pair wise block level tit-for-tat that shows the maximum number of extra block served by node is bounded. In this study,we choose five recent research papers with attention to solve unfairness in BitTorrent TFT peer selection.

## A. *Collaborations in BitTorrent system*

Buddies-enhanced protocol [15] takes the pairs of peers that have similar upload capacity to solve unfairness problem for high capacity leechers from observation in [21]. The buddy protocol enhance fairness for high capacity leechers by controlling optimistic unchoke which only performed when necessary .Furthermore, buddies protocol consists an added function named buddy unchoke to force a leecher to always unchokes all its buddies. Interested readers can also review another fairness protocol designed which similar to buddies protocol called team incentives [22] to prevent free riders.

Specifically,buddies-enhanced protocol takes a leecher say leecher *i* to find its potential buddy with similar upload as its own,by estimates the upload bandwidth of peers it interact with using its own history of past download interactions with these peers. Once it founds its buddy,say buddy *j*, the buddy *j* will tag the leecher *i* if it has not reached it maximum number of buddies and leecher *i* tags the buddy *j*. For every rechoke period, a peer in buddy mode checks the upload rate of its buddies that remains similar to its own. As the number of buddy connections increases, it leads to a reduction in optimistic unchokes upload.The experimental result shown the leechers in regular BitTorrentt show the percentage value always equal to 1 while perform optimistic unchoke whereas

in buddy protocol, the optimistic unchokes reduced by 60% for most of the downloading process.the low capacity leechers slow down their downloading process in 9% to 32%.Furthermore,the download completion times for free-riders slowed down by 29% until 56% using buddies protocol.

### B. FairTorrent: A Deficit-Based Distributed Algorithm to Ensure Fairness in Peer-to-Peer Systems

Fairtorrent [16] bring the fairness solve the problem of fair bandwidth allocation that need to be estimate the amount of bandwidth resources in advance. The algorithm guarantees high utilization where it deterministically tells the peer to send a block as long as it has a peer to send the block to. The protocol takes leecher *i* to unchoke each neighbor which interested in its data by selecting the destination of the next block with the smallest deficit value. A deficit value named $DF_{ij}$ maintains by leecher say leecher *i* for each leecher, say leecher *j*, where $DF_{ij} = Sent_{ij} - Recv_{ij}$. The value $Sent_{ij}$ equal to total number of bytes that a leecher *i* has sent to a leecher *j*. $Recv_{ij}$ variable is a total number of bytes that leecher *i* has received from leecher *j*.Leecher *i* begins by moving along its randomly ordered list of peers and sends a block to each leecher *j* that requests data, and increments $DF_{ij}$ . If leecher *j* reciprocates, $DF_{ij}$ value is reset and leecher *i* will send the next block to $L_j$ before moving further down its list.Fairness measurement is defined as maximum difference between the numbers of bytes that a peer has contributed and number of bytes they received from other leechers[23].FairTorrent shown the result of 436KB of maximum positive service error that is 18 to 73 times smaller compared to other BitTorrent-like protocol.

### C. Improving Efficiency and Fairness in P2P systems with Effort-based Incentive

Effort based incentives [17] bring the fairness in BitTorrent system by rewarding according to effort instead of contribution based on the reward principal Participatory Economics (*Parecon*) [28].This design takes two classes of peers, fast peers and slow peers with upload capacity 1024 kbps and 512kbps.A peer,say peer *i* to periodically decide to whom it will allocate its upload slots by ranking the other peers according to value $r_j$. This value means a peer say peer *j*, holds value $r_j = b_{ji}$ for contribution based policy and $r_j = b_{ji}/U_j$ for effort-based policy. A variable $b_{ji}$ is the amount of bytes uploaded by peer *j* to peer *i* in some sliding window of time and variable $U_j$ is the upload capacity of peer *j*. The experimental result shown that the fast peers achieved as much as a 60% higher speed than slow peers with contribution based policy whereas with the effort policy, the speeds of the two groups almost identical values with fast peers reaching speeds only 2% more than slow peers. Consequently, the effort policy treats slow and fast peers much more evenly and beneficial to BitTorrent regarding both system efficiency and fairness.

### D. Reinforce Learning in BitTorrent system

Reinforce Learning (RL) approach [18] solve the weakness of TFT protocol where the upload decisions are made based on the most recent observations of the resource reciprocation.RL based approach proposed to replace the TFT mechanism by modeling peers interaction across the various rechoke period as a repeated stochastic game as a means repeated interactions (i.e., reciprocating resources) among several players (i.e., peers) in which a player takes actions (i.e.,unchoke peers) to maximize long-term reward (i.e.,cumulative download rates).The protocol is divided into three process. The first process determines the updated information about statistical behaviors of the associated peers' resource reciprocation. This process involves reward calculation method and state transition calculation method which allow each peer capturing the time-varying resource reciprocation behaviors of its associated peers. The second process computes the policy of peer say peer *j* by RL algorithm designed to maximize the cumulative discounted expected reward.The last process is determining the associated peers to be unchoked or choked for every rechoke period based on RL policy.T he result shown a longer time taken for free riders to complete their downloads. Another result shown using RL policy could reduce fluctuations by 57% on average compared to regular BitTorrent.

### E. EnhancedBit: Unleashing the Potential of the Unchoking Policy in the BitTorrent Protocol

EnhanceBit protocol [19] consider unfairness problem to peers that have no high demand data or no data at all to get its optimistic unchoking slots. The design takes the message used in original BitTorrent protocol but HAVE message is enhanced. The ratio of interest (RI) indicates the amount of data requests that a peer will receive from others defined as $RI_i = int_i/v$, where the value of $int_i$ is the number of interested connections that peer *i* maintains, and variable *v* is the number of clients remotely connected to peer. EnhancedBit aim to maximize the ratio of interest of peers to increase the number of interested connections.Every time an optimistic unchoke starts,a peer with minimum RI will be selected as planned optimistic unchoked.It is kept unchoked for 30 seconds, regardless of its contribution to local peer .If planned optimistic unchoked is part of the set of three peers in regular unchoked, a new peer is chosen and unchoked repeatedly until an interested peer is identified. Based on the result,approximately 90% of leechers received their first optimistic unchoke interval within 30 seconds under EnhancedBit whereas approximately 55% of leechers received an optimistic unchoke interval within 30 seconds under regular BitTorrent.

# IV. Conclusion

Several significant papers of BitTorrent system have been published including mathematical models, measurements, and simulation as surveyed by [8] to understand the behavior of peers in real world torrents. Generally,BitTorrent's fairness can be classified as fairness in peer selection, fairness in piece selection and fairness in workload distribution. This paper presented a survey study on BitTorrent with different kind of strategies to enforce fairness in peer selection specifically in uploading process decision that is peers are equally contributed. Throughout the literature, the unfairness in BitTorrent TFT protocol is cause by the presence of free riders. Based on survey ,the first part that need to consider in reducing unfairness in TFT protocol is enhancing the process of optimistic unchoke which a peer should not perform individually. Another attention should be put on peer's bandwidth seed which is a valuable asset in BitTorrent system. A detection mechanism is needed for seeds to identify strictly between non-free riders and free riders before performing uploading.

Despite of focusing solutions on technical issues in earlier studies,BitTorrent now starts to shift its torrent sharing in social way towards long term cooperation and communication by changing the old way peers-based to friend-based .Developing private cooperative group such as Private BitTorrent [30] have been widely suggested to be enhanced accelerate the downloading time for peers.The tit-for-tat-like protocols are thus no longer necessary across these peers and could be replace with more trendy solution like peer's interest based and the same time still a resource-intensive. Thus, the existence of socially file sharing system such as [31] should be enhanced to give more impact to performance of P2P file sharing by giving more incentives to establish a fast cooperative downloading.

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## *References*

[1] H.Nishida and T.Nguyen,"A Global Contribution Approach to Maintain Fairness in P2P Networks",IEEE Trans on Parallel And Distributed Systems, vol. 21, no. 6, pp.812-826, 2010.

[2] X. Yang and G. de Veciana "Performance of peer-to-peer networks: Service capacity and role of resource sharing policies," Performance Evaluation – Special Issue on Performance Modeling and Evaluation of P2P Computing Systems, vol.63,no.3,pp.175–194, 2006.

[3] Internet Studies 2008/2009.[Online]. Available : http://www.ipoque.com/sites/default/files/mediafiles/documents/internet-study-2008-2009.pdf

[4] BitTorrent: The "one third of all internet traffic" myth, Sept. 2006. Available:http://torrentfreak.com/bittorrent-the-one-third-of-all-internet-traffic-myth/

[5] S.Kaune, J.Stolzenburg, A. Kovacevic, and R. Steinmetz. "Understanding BitTorrent's Suitability in Various Applications and Environments," 1st International Workshop on Computational P2P Networks: Theory and Practice (COMP2P), 2008.

[6] A.Legout, "Understanding BitTorrent:An experimental Perspective," Technical Report, INRIA-00000156, Inria, November 2005.

[7] K.Xu, "Performance Modeling of Bittorrent peer to peer file sharing Networks,":http://arxiv.org/ftp/arxiv/papers/1311/1311.1195.pdf.

[8] R.L.Xia and J.K Muppala, "A Survey of Bittorrent Performance",IEEE Communication Surveys & Tutorial,vol 12,no.2,pp 140-158,2010.

[9] R. Bharambe, C. Herley, and V. N. Padmanabhan, "Analyzing and improving a BitTorrent network's performance mechanism," Proc. IEEE INFOCOM, Barcelona,Spain, 2006, pp.1-12.

[10] L.Guo, S.Chen, Z.Xiao, E.Tan,Z.Ding and X.Zhang, "Measurement,analysis and Modeling of BitTorrent-like system",IEEE J.Selected.Areas Commun.,vol.25,no.1,pp-155-169,Jan 2007.

[11] T. Locher, P. Moor, S. Schmid, and R.Wattenhofer. Free Riding in BitTorrent is Cheap," Proc. of HotNets-V, Irvine, Canada,November 2006, Available:http://www.disco.ethz.ch/publications/hotnets06.pdf

[12] .S. Jun and M. Ahamad, "Incentives in BitTorrent Induce Free Riding," in Proc. of the Workshop on Economics of Peer-to-Peer Systems,Philadelphia, August 2005,pp.116-121.

[13] F.Qin,J.Liu and L.Zheng, "Improving robustness and fairness in BitTorrent-like P2P system," Proc of Fourth International Conf. on Communication & Networking,China,August 2009,pp.1-5.

[14] S.Paul,S.Nandi and A.Pal, "Credit Reputation Propagation : A strategy to Curb Free riding in a Large BitTorrent Swarm",in Lecture Notes computer Science,Berlin,Springer-Verlag,vol.5935,pp.207-218,2010.

[15] R.I.Ratzin, "Collaboration in BitTorrent system", in Lecture Notes Computer Science, vol 5550,Berlin,Springer-Verlag, pp.338-351,2009.

[16] A.Sherman, J. Nieh and C.Stein, "FairTorrent: A Deficit-Based Distributed Algorithm to Ensure Fairness in Peer-to-Peer Systems**,** IEEE Trans. on Networking, vol.20, no. 5,pp. 1361–1374 ,October, 2012.

[17] R. Rahman, M. Meulpolder, D. Hales, , J.A. Pouwelse, , D.H.J. Epema, and H.J.Sips. Improving efficiency and fairness in P2P systems with effort-based incentives," Proc. of IEEE International Conference.Communication, South Africa, May 2010,pp.1-5.

[18] R.I.Ratzin, H. Park, and M. van der Schaar, "Reinforcement Learning in BitTorrent Systems," in Proc. of IEEE INFOCOM, Apr. 2011,pp. 406-410.

[19] V.Adlidakis,M.Roussopoulos,A.Delis,"EnhancedBit: Unleashing the potential of the unchoking policy in the BitTorrent protocol," Available:http://dx.doi.org/10.1016/j.jpdc.2013.08.008

[20] A.L.H.Chow,L.Goubchik and V.Misra, "Improving BitTorrent: A Simple Approach," in Proc of 7th International Conference on Peer-to-peer systems, February 2008, Available: http://www.cs.toronto.edu/iptps2008/final/62.pdf

[21] M. Piatek, T. Isdal, T. Anderson, A. Krishnamurthy, and A. Venkataramani. "Do Incentives Build Robustness in BitTorrent,". Proc of the 4th Symposium on Networked Systems Design and Implementation,April. 2007. Available http://usenix.org/event/nsdi07/tech/piatek/piatek.pdf

[22] R.I.Razin, N. Liogkas, and R. Majumdar, "Team incentives in Bittorrent systems," in Proc of IEEE International Conference on computer Communication and Network,San Francisco,August 2009, pp.1-8.

[23] M. Shreedhar and G. Varghese. "Efficient Fair Queueing Using Deficit Round-Robin". IEEE Transactions on Networking ,vol.4,no.3,1995.

[24] B. Cohen, "Incentives build robustness in BitTorrent," Proc. of Workshop on Economics of Peer to Peer Systems, May 2003.,pp.116-121.Available: http://www.bittorrent.org/bittorrentecon.pdf

[25] The BitTorrent Protocol. http://www.bittorrent.com

[26] BitTorrent http://en.wikipedia.org/wiki/BitTorrent

[27] M.Zghaibeh,K.G Anaqtostakis and F.C.Harmantzis,"The Behavior of Free riders in BitTorrent Network",Handbook of Peer to Peer Networking,Springer Science,pp.1207-1230.2010.

[28] Parecon. *www.parecon.org*

[29] C. Zhang, P. Dhungel, D. Wu, and K.W. Ross. Unraveling the bittorrent ecosystem. *IEEE Transactions on Parallel and Distributed Systems*,vol.22,no.7,pp.1164-1177,2011

[30] M. Meulpolder, L. D'Acunto, M. Capot˜a, M.Wojciechowski, J.A. Pouwelse, D.H.J. Epema and H.J. Sips. "Public and private BitTorrent communities: A measurement study,".Proc. of 9th international conference on Peer-to-peer systems (IPTPS), 2010. Available:https://www.usenix.org/legacy/event/iptps10/tech/full_papers/Meulpolder.pdf.

[31] J.A.Poulwese,,P. Garbacki, J. Wang, A. Bakker, J. Yang, A. Iosup, D. Epema,M. Reinders, M. van Steen, and H. Sips, TRIBLER: a social-

based peer-to peer system: Research Articles," Concurrency and Computation: Practice &Experience, vol. 20, no. 2, pp. 127-138, 2008.

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