



INCENTIVE MECHANISM AND FREE RIDER PROBLEM IN BITTORRENT

G.N Purohit; Upma Yadav, Urmil Malik
Computer Science Deptt, Banasthali Vidyapith

Abstract: In the present study incentive mechanism in BitTorrent based on TFT is discussed, further the behavior of peers in the presence of incentive mechanism is analysed. Analytical results show that in a large pool of peers, around one-fifth of them are free-riders. Among these free riders around one-tenth of them do not contribute any uploading. This category of peers may be due to the optimistic unchoke policy. When the peers are classified as low bandwidth capacity peers and high bandwidth capacity peers, it is observed that they cooperate irrespective of their category. A peer in one category does not hesitate in punishing (by choking) a peer in other category on observing unbalanced uploading. It is concluded that, to a large extent, BitTorrent system continues to work well under TFT based incentive mechanism.

Keywords: BitTorrent, Incentive Mechanism, Free Rider, Tit-for-Tat.

1. Introduction:

In this section we describe the free-rider problem in general P2P networks and their impact on P2P networks and BitTorrent.

1.1 Free Rider:

It is assumed that users, in a distributed system like P2P in general and BitTorrent in particular are obedient, that is, they observe rules and regulations of the system religiously, ignoring their own utility. However, this assumption of adherence to the protocols of the system by users appears unrealistic, as these users interact with each other as competitors for enhancing their own gains. Owing to this, it is now assumed that users are rational and act in such a manner that their individual utility is maximized, even at the cost of acting against the protocols of the system. In a P2P system including BitTorrent, cooperation of the participant peers can significantly contribute towards the system's cost, and this is inherent obligation in BitTorrent to cooperate. However, these rational users may not contribute their share or contribute partially their share. Users deriving benefits by using other's

resources and not contributing their own resources in return are called free-riders.

The problem of free-riders is not confined to BitTorrent or P2P networks only, it is a general problem of society. Free rider problem has been investigated by economists as well Sweeny [1973], Marwell & Ames [1979]. In, "the tragedy of commons", Hardin [1968] described it as, "A situation where some selfish individuals refrain from contributing to common good. Some of the familiar examples in the society are:

Overuse of public resources such as over fishing in the deep ocean, pollution of the environment, excessive use of pesticides etc".

1.2 P2P Networks and Free Riders: The problem of free riders is of renewed interest among researchers and has invited attention of many researchers. Moor [2006], Karakaya et al. [2009], Azzedin [2010], Das and Bhattacharjee [2015]. According to Karakaya et al. [2009], "As a P2P concept, free riding means exploiting in P2P Network resources (through searching, downloading objects or using services) without contributing to the P2P at desirable level." Free riding may be an important threat against the existence and efficient working of P2P networks, if the degree of free riding is high Adar and Huberman [2000] argue that, "free riding leads to degradation of the system performance and adds vulnerability to the system. If this trend is not stopped then issues related to copyright may become redundant and it may lead to collapse of the system.

The problem of free riders in a P2P system prompts the issue of unfairness to the peers who behave altruistically in uploading the files. In general, cooperation of all peers in BitTorrent is desired for enhancing the utility of the system to maximum. The architecture of BitTorrent is so designed that all the peers will behave altruistically, however, there is always a sizeable number of peers (leechers) who will receive the file for themselves but will not upload for others. It is also true that some of the free-riders do not behave in this manner intentionally. The most common reason among many, for doing so, is to avoid criminal proceedings

against them. They have the apprehension of uploading /distributing /contributing of copy right content (say films/songs) illegally .The consequences of such an act is much severe compared to simply downloading a similar file .Thus the uploaders in the network take an essential risk and thus they avoid uploading.

1.2 Free Riders in BitTorrent:

Among the many threats faced in BitTorrent , the threat of free riders is most significant .Though it is not much sever in BitTorrent compared to its severness in other content distribution systems. Adar and Huberman[2003],” In a comprehensive study of file sharing system in Gnutella through measurement study,observed that seventy percent of the peers do not upload any file and around thirty seven percent share of the total files are uploaded by one percent of all peers

Participating in the network .Further,”Similar results have been obtained in similar studies of Napster and Gnutella networks” Saroiu et.al[2002] .Hughes et al.[2005]found that percentage of free riders in the users of Gnutella has increased to 85%.In a measurement study for BitTorrent ; Zghaibeh & Harmantzis [2008],reported that 20% of peers in a BitTorrent are free riders .

In the mechanism of BitTorrent ,developed by Cohen[2003],the sharing cost is reduced by distributing load from a single node to all the participating nodes in the system further the setup is such that the participating peers are essentially required to cooperate for enhancing their own utility. The basic incentive scheme in BitTorrent ,for motivating the peers to cooperate, is that download bandwidth is linked to the upload activity .Actually this incentive model uses,Tit- for-Tat(TFF) mechansim and in game theory parlance it leads to Iterated Prisoners Dilemma(IMD), Hardin [1968].Moreover it is claimed in the design of BitTorrent that this incentive model is strong enough to discourage selfish and malicious behavior of the participating nodes. Thus BitTorrent is claimed to be fair and robust ,however some recent studies have revealed that its incentive schemes are not so effective to discourage the peers from adopting malpractices ,Bharamble et.al[2005],Guo et al.[2005].

2.BitTorrent:

In this section the BitTorrent is described and description is limited to the needs of this chapter.

2.1 BitTorrent Paradigm:

All P2P networks in general and BitTorrent in particular ,are distributed systems in which every node is of equal status and can act independently either as a client or as a server. BitTorrent developed by Cohen [2003],is basically an application P2P for file sharing or sharing a collection of files.In this system there are three types of nodes(i)tracker,(ii)seeder and (iii)leecher. A tracker is a central powered entity ,which keeps record of all the peers who are downloading /uploading contents in a specific swarm.Peers participating in a particular swarm are subcatagorised as seeders and leechers .Seeders are the peers ,who possess already downloaded complete file and obediently providing any piece of file to other peers in the swarm on request.Leechers

are the peers,which are in the process for downloading the content. Whenever an user wishes to obtain the content then he initially downloads the Torrent from internet .After noting downloading the meta-data file he contacts the tracker and sends the information about the content .The tracker provides the information and addresses of the peers (seeders)about possessing the parts of content file and after receiving the information they(leechers)contact the relevant seeder .The seeders upload the requested pieces of file to the respective leechers ,while the leechers upload in return to only those peers who provided them some content . At regular intervals say about ten seconds, a fixed set of peers is selected per interval for uploading by unchoking these peers. If any peer does not upload during the interval then it is choked and in its place another peer is unchoked .This mechanism is employed for motivating all the peers to contribute.

2.2 BitTorrent Incentive Mechanism:

Since in BitTorrent file sharing process peers seeders as well as leechers are dependent and rely on each other therefore implementation of incentive mechanism is more convenient .The basic mechanism of incentive in BitTorrent is choking and unchoking .This process of choking and unchoking has been described in detail by Zghaibeh & Anagnostakis[2007],” In BitTorrent the cost of redistribution of the load is reduced since a peer shares the file with many peers for downloading pieces of the file .However in practice it is observed many peers are connected to a peer(seeder),but the seeder uploads to a few of them.It is the discretion of the peer(seeder),whom to serve, however, the discretion is based on some predefined three rules .(1) Unchoking a remote peer is done on considering its current upload rate ,using TFT mechanism it will be given service in return of its reciprocal service.(2)Some times for provoking a peer to cooperate in the system,it is unchoked even in the absence of reciprocal services provided by the peer .(3) If an unchoked peer does not contribute

any content to the system in the session allotted to it, then it is presumed that the peer is not cooperative and it is choked. To summarise the above it can be stated that for implementing incentive mechanism BitTorrent uses the choke and unchoke mechanism and forcing the peers to cooperate. Thus BitTorrent uses the unchoke mechanism to reciprocate services to nodes that cooperate and periodically choke nodes that choose not to cooperate. Thus the incentive mechanism uses “the Tit-for-Tat (TFT) strategy or the game theoretic Iterated Prisoners Dilemma (IPD) model”.

Game theory appears to be most appropriate tool for studying this type of reciprocative incentive scheme in BitTorrent, and TFT mechanism is an appropriate strategy for IMD. Axelrod [1984] has described IMD as :

“The two player multiround game starts when the first player cooperates at the beginning of the game then its response in second round is based on his opponents previous action. If the second player keeps cooperating the first player will always cooperate. If the second player defects the first player will retaliate.”

BitTorrent employs this strategy (IMD) in totality by implementing periodically *choke*, *unchoke* and *optimistic unchoke* mechanism.

In spite of this sound incentive mechanism for cooperation, free riding in BitTorrent is possible and exists for various reasons. A newcomer can also receive pieces of a file without uploading any content. If an user adopts the strategy of becoming a newcomer repeatedly and not contributing any content, it becomes a free rider. Optimistic unchoking allows a peer to connect to peers, who can provide potentially high download speed. Thus taking advantage of optimistic unchoking an user can achieve much higher download speeds compared to many other peers and thus can be exploited by a free rider.

3. Fairness in BitTorrent :

In context of BitTorrent fairness means “Receive as much as you give.” and in context of participating peers it means that “content distribution encourages peers to actively collaborate in disseminating content”. For the overall improvement of the BitTorrent system fairness is a vital entity, however, some researchers Guo et al. [2005], Bharambe et al. [2006], Piatek et al. [2007] have reported that resource reciprocation in BitTorrent is not fair enough and this is particularly true in peers with

heterogeneous upload bandwidth,” some high capacity leechers may upload in full capacity but not be able to download as much, due to upload constraints of the downloading leechers and limited number of unchoked slots. In the article “Achieving fairness in BitTorrent” the authors Salky & Macdougall [2009] observed. “It has generally been found that agents have very little incentive to upload data to other users, with the result that overall social welfare drops. This problem strikes especially hard at those who do share, since all peers will download from them.” Liu et al. [2014] considered performance and fairness for NAT (Network Address Translation) peers in BitTorrent and observed, “The fundamental problem of BitTorrent unchoke is that it is unaware of and unfair to NAT peers.”

Many of researchers, mentioned in previous paragraph, have proposed improved mechanism to increase fairness in BitTorrent. One suggestion extended by Bharambe et al. [2006] suggested, “A block based TFT policy to improve fairness in place of rate based TFT”. The concept of BitTorrent client was proposed by Piatek et al. “A BitTorrent client adopts a new peer selection mechanism that reallocates upload bandwidth to maximize peers download rates”. Further in a later work these authors suggested. Piatek et al. [2007], “A one-hop reputation system, in which peers that are not interested in the current available content perform data exchanges for the assurance of failure paybacks”. Selby and Mac Dougall [2009] considered free rider problem and Sybil problem in BitTorrent and proposed the following for combating these problems, “Reputation based systems which track aggregate contribution over time, strict tit-for-tat strategies that accept slower overall downloads in exchange for fairness and the ability to punish free riders and improve the fairness of the system without significantly decreasing the overall social welfare of the system”. Liu et al. [2014] proposed, “A tunable optimistic unchoke strategy in order to improve the overall system performance and fairness metrics considerably”.

3.1 Incentive Mechanism & Peer Behavior.

Many studies have reported the behavior of peers is influenced by the incentive mechanism in BitTorrent. Feldman & Chuang [2005] observed a positive effect of Tit-for-Tat incentive mechanism used in BitTorrent. Further they opined that it provokes the peers for cooperation among them. Andrade et al. [2005] expressed the similar view and emphasized that the reciprocating mechanism of downloading/uploading designed in BitTorrent motivates the

peers for increased corporation. However, in some cases due to large number of seeders, BitTorrent fails in reducing free riding, since there is no specific inbuilt mechanism for limiting their gains. In the same year Jun and Ahmad[2005] argued otherwise, and stated that there is lack of fairness in BitTorrent. They argued that there is no mechanism in BitTorrent which punishes effectively the free riders or rewards the altruistic peers. Evaluation of the unchoke mechanism and its working was questioned by Legout et al.[2006], "The unchoked mechanism in BitTorrent is not efficient as it is not effectively balancing the upload and download rates. Further this unchoke mechanism is favourable only to leechers" Halesand and Polaris[2005] argued. "Robustness of BitTorrent is not related to the tit-for-tat mechanism and the presence of altruistic peers in swarms is the major factor behind the robustness of BitTorrent. Further if the swarms are highly infected with selfish peers, BitTorrent does not reach to expectations and such swarms tend to die fast.."

There appears two contradictory observations regarding behavior of peers in BitTorrent. For example observations by Andrade et.al [2005] and observations by Halesand and Patarin[2005]. Similarly those of Gue et al.[2005] and Bharamba et al.[2005] expressing contrary opinions related to bandwidth capacity of peers and reciprocating download uploading volumes.

The opinions expressed in various studies regarding peer behavior in BitTorrent having TFT incentive mechanism have motivated to analyse the peer behavior particularly free riders in a different manner. For identifying free riders in a BitTorrent with TFT policy for incentive mechanism, two characteristics features of peers are considered (i) reciprocating behavior for cooperation and (ii) download and upload bandwidth capacity.

4. Experimental Set up

4.1 Reciprocation Behavior:

The aim of present study is to consider behavioral performance of peers in BitTorrent in real scenarios and to ascertain and quantify the presence of free riders in the system. For collecting the data trackers were hosted on independent platforms. The trackers were robust enough to provide download volume, upload volume, connection time etc for each peer in the swarm. Contents comprising of four to six parts and unique torrent associated with each part were

provided to the trackers. These unique torrents were created using the BitTornado. The purpose of offering these contents was to identify the free rider peers according to their behavior. In the present study, as usual, a free rider is considered that peer who exploits the network design knowingly or unknowingly and downloading without uploading in reciprocation. The free riders are further classified in three categories as: (i) Fair, a peer appearing free rider in one torrent and having altruistic behavior in other torrents, (ii) Rational, a peer free rider rarely uploading to fellow peers in the swarm, (iii) Unfair, a free rider who never uploads. This classification is according to the volume uploaded by them in a content having multiple torrents.

In the present set up there were 47 four part contents, 53 five part contents and 40 six part contents and thus $4 \times 47 + 5 \times 53 + 6 \times 40 = 693$ torrents. The average part size was 850 MBs with part size varying from 750 MB to 1100 MBs.

On an average 520 peers per torrent, among 360746 peers, participated. The percentage of free riders is around 20% of the participating peers. Further the percentage of different kind of peers among themselves is shown in Figure 1(a) and their numbers in Figure 1(b)

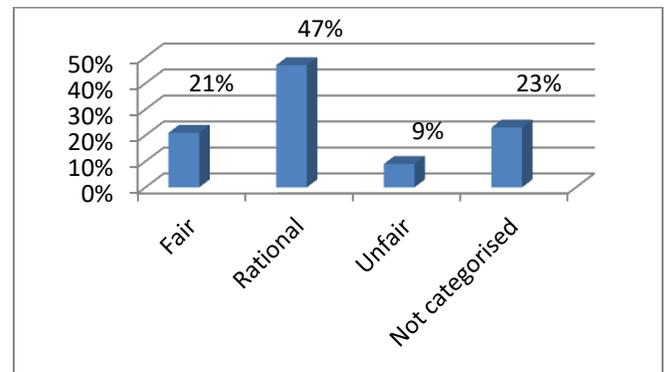


Fig.1(a). Percentage of free rider peers.

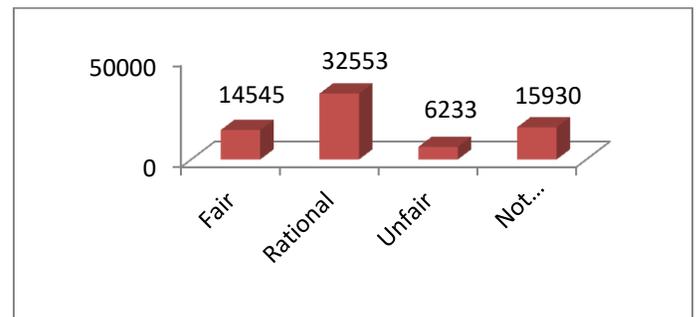


Fig.1(b). Different number of free riders.



4.2 High,Low Bandwidth Capacity Peers .

In previous studies it has been argued that,” The system is exploited by the peers possessing Low bandwidth capacity” Bharambe et al. [2005].On the contrary Guo et al. [2005]argued that”,The system is exploited the peers having high bandwidth capacity”.In this experimental set up both types of bandwidth capacity peers are considered .These peers are classified as LBR (low bandwidth capacity rational peers)LBNR (Low bandwidth capacity non-rational peers)HBR(High bandwidth rational peers) HBNR(High bandwidth non-rational peers)..Among the peers around one-fourth of peers are low bandwidth capacity peers in the range 0to 40 kbps and the remaining are high bandwidth capacity peers in the range 100-700 kbps .The performance data of peers was as usual,recorded by the trackers and the details are given in Table-1

Table -1

Activity	LBR	LBNR	HBR	HBNR
Download Capacity	20 kbps	20kbps	100-600kbps	100-600kbps
Maximum Upload rate	1kbps	8kbps	60kbps	300kbps
Contribution Percentage By LBC Peers	65	44	32	38
Contribution Percentage By HBC Peers	35	56	68	62
Percentage of choked peers By LBC Peers	21	40	73	52
Percentage of choked peers By HBC Peers	79	60	27	47

5. Analysis of Results

Rational peers constitute the highest number of free-riders as evident from Fig:1.Data analysis show that their uploading volume content was only five percent only of the volume they downloaded.

On the other hand the unfair peers whose upload volume is 0 kbytes constitute only nine percent of free riders.The non-categorised free riders participated in one torrent only and did not upload any volume.The most surprising result is of fair free-riders which constitute 21% of free riders .

In the second experiment it is observed that peers,who gained at the cost of others and exploited the system did not belong to any particular class of low bandwidth capacity[LBC]peers or HighBandwidth Capacity[HBC]peers.The LBC peers were equally capable to exploit the system as HBC peers.The analysis of choked peers reveal that the TFT mechanism is successful as the uncooperative peers are punished and cooperative peers are prized irrespective of their capacity status .Further LBR peers chocked the HBR users and vice-versa,when even there was unbalanced reciprocation data.This indicates that TFT is a successful incentive mechanism in BitTorrent.Further, it is inferred that clients in BitTorrent are well acquainted with its protocols and to a large extent observe the regulations and protocols of the system.

References:

- [1] Adarne E,Huberman,B.A[2000]”Free Riding on Gnutella”.First Monday,pp.1- 22
- [2] Andrade N,Mowbray M,Lima A,Wagner G, Ripeanu M[2005]”Influences on cooperation in bittorrent communities”Proceedings of the 3rd workshop on economics of P2P systems (P2P Econ),Philadelphia.
- [3] Axelrod R [1984] “The evolution of cooperation” .Basic books Newyork.
- [4] Azzedin F and Omar,S.[2010]”Impact of Dishonesty and collusion on free riding in Distributed Multimedia Systems”.Int.Conf.on High Perf Compu&Simulation pp.355-361.
- [5] Bharambe AR,Herley C,Padmanabhan VN[2005]”An analyzing and improving bittorrent performance”.Technical Report MSR-TR-2005-03,Microsoft Research ,Microsoft Corporation One Microsoft Way Redmond, WA 98052,USA.
- [6] Bharambe AR,Herley C,Padmanabhan VN[2006]”An analyzing and improving bittorrent performance”.Technical Report MSR-TR-2005-03,Microsoft Research ,Microsoft Corporation One Microsoft Way Redmond,WA 98052,USA.
- [7] Das,A ,Bhattacharjee,A.[2015]”On analyzing Free Riding in BitTorrent Communities“17th UKSIM-AMSS Int.Conf.on Modelling and Simulation.



- [8] Feldman M,Chuang J[2005] “Overcoming free-riding behavior in peer-to-peer systems” Proceedings of the ACM Sigecom exchanges,July,vol 6.ACM,newyork,p1.
- [9] Guo L,Chen S,Xiao Z, Tan E,Ding X,Zhang X[2005] *Measurements,analysis,and modeling of BitTorrent – like systems* “Proceedings of the IMC,Berkeley,19-21.
- [10] Halesand D,Patarin S[2005]”*How to cheat BitTorrent and why nobody does*”.Technical Report PUBLICS-2005012.
- [11] Hardin.G[1968]”*The tragedy of the commons,Science*”1243-1248.
- [12] Hughes,D.,Coulson,G, and Walkerdine,J[2005] “*Free Riding in Gnutella Revisited :The bell tolls*”IEEE Distributed Systems Online.
- [13] Jun S,Ahamad M[2005] “*Incentives in BitTorrent induce free riding*”Proceedings of the ACM SIGCOMM workshop on economics of peer-to-peer systems(P2PECON),Philadelphia,22-22
- [14] Karakaya,M.,Korpeoglu I and Adar,E[2009] “*free riding in Peer-to-Peer networks*”.IEEE Internet Comput.
- [15] Legout A,Urvoy-K G,Michiardi P[2006]”*Rarest first and choke algorithms are enough*”. Technical report inria-00001111,INRIA,Sophia Antipolis,September
- [16] Liu, Y and Chang, L and Pan,J[2014]”*On the performance and fairness of BitTorrent-like data swarming systems with NAT devices*”Computer Networks,vol 59 .
- [17] Marwell,G and Ames,R[1979]”*Experiments in the provision of public goods:resources interest group size and the free rider problem* “Am.J.Social.Vol.84.
- [18] Moor.P[2006]”*free riding in BitTorrent and countermeasures*”Master Thesis,fed.Inst Technol.Zurich.
- [19] Piatek M,Isdal T ,Anderson T,Krishnamurthy A[2007]”*Do incentives build robustness in BitTorrent*”Proceedings of the 4th USENIX symposium on networked systems design and implementation ,Cambridge
- [20] Roussopoulos,M.,Baker,M.,Rosenthal D.S.H.[2004]”*2 P2P or Not 2 P2P?*”Third International Conference on Peer-to-Peer Systems pp 1-6.
- [21] Saroiu,S,Gummadi and Gribbed S.[2002],”*A measurement study of peer-to-peer file sharing systems* “Proceedings of Multimedia Computing and Networking MCN’02.
- [22] Selby. P and MacDougall. J[2009]”*Achievement Fairness in BitTorrent*“ www.cs.uibe.ca/~kevinib/teaching 1-9.
- [23] Sweeny ,J[1973]”*An experimental investigation of the free rider problem*”.Soc.Sci.Res.vol.2.
- [24] Zghaibeh M,Harmantzis F[2006]” *Lottery-based pricing scheme for peer to peer networks*”Proceedings of IEEE international conference on communications ICC06,Istanbul,11-15
- [25] Zghaibeh.M and F.C.Harmantzis[2008]”*Revisiting free riding and the Tit-for-Tat in BitTorrent:A measurement study*”Peer-to-Peer Netw Appl 162-173.

Biographies

FIRST A. G.N Purohit received the M.Sc. and Ph.D. degree from University of Rajasthan,Jaipur(India) in Mathematics in the years 1960 and 1967 ,respectively.Formerly he was professor and head deptt of Mathematics,University of Rajasthan Jaipur.Currently, He is Dean of the faculty of Mathematical Sciences and Computing,Banasthali University,Banasthali(India).His present area of research in computer networking and communication. Dr. G.N Purohit may be reached at gn_purohitjaipur@yahoo.co.in.

SECOND B. Upma Yadav received the B.C.A from University of Agra, Mathura ,UP(India)in the year 2013 and received the M.C.A from Banasthali University, Rajasthan, Jaipur(India)in the year 2016.Currently,she is a junior technical assistant, Banasthali University, Banasthali(India).Her present area of research in Medical Image Processing. Her paper are “An Authentication Algorithm for a Node in Peer-To-Peer Network. Ms Upma Yadav may be reached at yadavupma02@gmail.com.

THIRD C.Urmil Malik received the M.C.A from M.D.University Rohatak(Haryana)India. Presetly she is doing research in Banasthali University in P-2-P Network . Mrs Urmil Malik may be reached at urmil.malik1984@gmail.com.