Which type of Overlay Network performs better for Multimedia Distribution and Information Sharing?

Shahin Talaei
Department of Computer Science
Ryerson University
stalaei@scs.ryerson.ca

Abdolreza Abhari
Department of Computer Science
Ryerson University
aabhari@scs.ryeson.ca

ABSTRACT

Facebook is widely used in multimedia distribution. Users are continuously posting multimedia files on their profile and sharing it with their friends. Furthermore, users are exchanging information with each other by sending messages and providing feedback. In this paper, Facebook, peer-to-peer and ring networks are taken into account. The media and information sharing of users in Facebook network, peer-to-peer network and ring overlay network are analyzed. Average throughput and the speed of information transfer in each network topology are measured to assess the performance.

General Terms

Measurement, Performance, Design, Experimentation

Keywords

Facebook, Peer-to-Peer, Ring,

1. INTRODUCTION

People are connecting more and more online with one another. According to [1] "Web 2.0 is the use of lightweight, intuitive, Web-based services that rely on user participation and user-contributed data, and generally involve some level of social interaction and networking". Based on Fraser et al. [2] one of the most noticeable features of web 2.0 is the introduction of online social networking (OSN). 42% of all European Internet users participate in OSN [1]. Emarketer.com shows that 37% of US teenage internet users used OSN every month in 2007. Social networking websites offer a highly dynamic and proactive setting for multimedia distribution.

1.1 Facebook

Facebook is a social networking site where users interact through the networks such as university, friendships, interest groups, favorite movies and etc. Facebook contains more than 800 million users [3]. Users need to register to use the web site, where they can add each other to be able to share messages, photos and videos with each other. In order to join Facebook network users needed to be to be part of an institution but currently anyone can join Facebook. Facebook Web-Based applications are significantly growing. One of the most interesting features of Facebook is integrating Skype to its instant chat messaging service. Facebook emphasized the fact that users will not have to create new account to call each other and this is made by the minimal amount of setup in using Skype through Facebook.

Based on [4] applications on Facebook can be classified into the following categories:

- Friend comparison: applications that allow users to create list of top friends or best friends.
- Casual communication: users can write on each other's wall, send messages and in general communicate with each other.
- Rating, Taste Matching and Recommendation: It allows users to recommend items to each other, ranging from restaurants to music.
- Gesture: Contains application that allow user perform visual gestures.
- Self-Expression: allows users to express their moods and their opinions about different topics, etc.
- Gifting: users exchange virtual gift with each other.
- Meeting people: An application for the people who are interested in online dating.

Other online social networks:

Google plus [5] is a social networking web site created by Google. It has more than 90 million users.

LinkedIn [6] is a business-related social networking site founded in 2002.

Orkut [7] a social networking web site operated by Google which is very popular in Brazil and India.

Twitter [8] allows a user to send and read text-based posts of up to 140 characters, known as tweets.

1.2 Peer-to-peer networks

It has been more than a decade that P2P architecture became very popular compared to the traditional Client-Server. Peer-to-peer networks are distributed systems consisting of interconnected nodes, able to self-organize into network topologies with the determination of sharing resources such as content, CPU cycles, storage, and bandwidth. Content distribution, a noticeable application area of peer-to-peer systems, is built on systems and infrastructures designed for sharing digital media and other data between users. According to Shirky, [9]"peer-to-peer is the class of applications that takes advantages of resources-storage, cycle's content, human presence-available at the edges of the internet". Efficient content localization and replication are the main reasons for its success .The most famous P2P file sharing applications are gnutella network [10], eDonkey and LimeWire however, the only application that relies on content replication is BitTorrent.

In P2P structure, responsibilities such as administration and maintenance are handled with users instead of a single unit. The key aspect is a suitable algorithm for the placement of information, receiving, sending information and giving permission to the download resources located on computers throughout a network [10, 11].

Instantaneous deployment and minimal cost are the actual advantages of Peer-to-Peer. Peer-to-Peer decreases the cost and bandwidth limitation of Client Server Architecture. Enormous number of users are entering and leaving the network. Any of these users could simply fail in terms of providing performance. Consequently the major difficulties for P2P architecture are scalability and self-organization without a server based technology.

P2P networks are divided into two categories: structured and unstructured [11]. This division is based on the connection of the nodes in overlay network.

- In structured P2P, nodes at overlay network communicate in a deterministic procedure. Distributed hash table (DHT), which is a class of decentralized distributed system is responsible for indexing and creating a random key for data items. What is challenging here is creating a good multi paradigm programming language that uniquely maps the key of the data to the identifier of a node. DHT have also been used in unstructured P2P file sharing applications such as Napster and Gnuttella (Gnuttella is an unstructured P2P network). Tracker is one of the components of BitTorrent which optionally use DHT. Chord is an example of structure P2P network [12].

- In unstructured P2P, the overlay network is shaped randomly. There is no algorithm defined for organizing the network connections. It uses a flooding mechanism for searching a desired content. This way, peer submits the query which travels through the network to find as many peers as possible that have the content to share. If the data is popular, the query is most likely to become successful in finding a high number of provider peers. Examples of popular unstructured P2P networks can be Napster, KaZaA, Gnutella [13], and BitTorrent. Research shows , for today's mass market data sharing applications, unstructured overlays perform better with more support than structured overlays since peers are extremely transient [14].

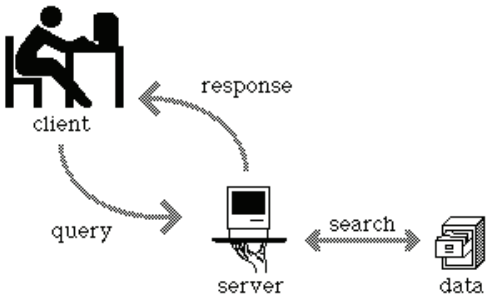

Figure 1.Client Server [15]

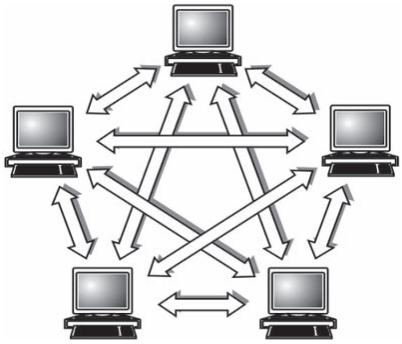

Figure 2. Peer-to-Peer network

1.2.1 Classification of peer-to-peer applications

Communication and collaboration: This class includes the applications that often provide real-time, communication and collaboration between user's computers. Chat and instant messaging applications such as, Yahoo and Msn are examples of this category.

Distributed Computation: This category belongs to systems that use other users' processing powers. A complex task of a peer is separated into different parts and distributed to several peers therefore peers will execute the task and return their results.

Internet Service Support: Based on peer-to-peer architecture several applications have merged that are supporting internet services. For example, peer-to-peer multicast systems [16] and applications providing protection against virus attacks [17].

Database Systems: significant research has been done on creating distributed database systems based on peer-to-peer architectures. Edutella [18] is an open source project, which provides a metadata structure and querying capability for peer-to-peer applications. PIER [19] is a scalable distributed query engine made on top of a peer-to-peer overlay network in which allows relational queries across multiple users.

Content Distribution: Most of the peer-to-peer file sharing applications fall into this category, where users are sharing large and small files in different format with each other. Media files, Text files and applications could be among these files.

1.2.2 BitTorrent

Bram Cohen created one of the most successful P2P applications called BitTorrent [20]. The idea was to create an application which could easily update and download large size files. It is apparent from recent literature that BT has become one of the most successful P2P applications. Reason being there are high efficiency and an outstanding scalability [21, 22]. In previous applications of P2P, the shared files were small, typically MP3 files, but BT can transfer huge files such as movies and TV series.

Tit for tat schema: Preventing freeriders (client who acts selfishly and only downloads without uploading) is a key concern here. In previous P2P applications a user was able to download at a very high rate depending on the bandwidth. However, the upload could be slower. BT Tit-for-Tat policy makes the download rate proportional to the upload rate [23]. In this way fairness is achieved and clients who are downloading the same file at the same time are profiting from each other (Tit for tat has a significant impact on popularity of BT) [24].

2. RING

Ring network or ring topology is a network structure where network nodes are connected to each other forming a large circular shape. The ring topology is considered cost-effective sustainable network architecture due to bandwidth sharing and increased survivability. Each packet is transmitted around the ring until it reaches its final destination. Our ring network consists of bidirectional connections. Here is an example of ring topology:

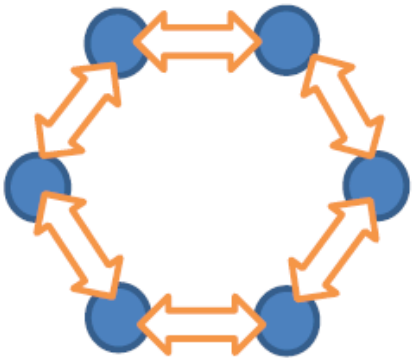

Figure 3. Ring Topology

The ring topology does not require a central node to organize the connection of its users. This is one of the advantages of a network with a ring topology. Conversely, if one node fails, it creates a problem for the entire network.

3. NETWORK SIMULATOR 2(NS2)

We simulated the above topologies and performed several experiments by Network Simulator 2(Ns-2), which is a discrete-event simulator. Ns-2 is an open-source simulator that supports wide variety of network protocols. Ns-2 is based on two languages: C++ and Object-oriented Text Command Language (OTCL). Data collection in Ns-2 is supported by traces. Traces keep track of the events related to the generation, enqueueing, forwarding, and dropping of packets. Trace files consist of lines of ASCII characters that have information related to the packets. Packet size, source/destination addresses and the type of the protocols are contained in the trace files [25, 26]. The Following figure precisely describes the information contained in the trace files:

Event	Time	From node	To node	Pkt type	Pkt size	Flags	Fid	Src addr	Dst addr	Seq num	Pkt id

Figure 4. Fields appearing in a trace [26]

3.1 Simulation and experiments

In this paper, the overlay networks of the three topologies are implemented and examined. Connection of users in Facebook user network, download phase of peer-to- peer network and ring network.

In general, there are four phase for peer-to-peer network: join, query, download and depart [27]. In the first phase a node joins a P2P network. In this phase it can get some basic information. Second phase a node creates query for objects it wants. Here the peer-to-peer simulation is emphasized on the download phase. Timing for sending packets is random, uniform distribution is used for all three topologies. Furthermore, Nodes are sending packets in different times and this is applied for Facebook and Ring as well. Facebook, peer-to-peer and ring all three have bidirectional connections.

The Facebook network was generated based on Pakzad's simulator [28]. In this work [28], all data and node connections were gathered over seven months in the Distributed System and Multimedia Processing (DSMP) lab at Ryerson University. We found that the node degree distribution of Facebook fits the lognormal distribution. In the first trace file, the Facebook simulation contains 1031 connections of user network. The 1031 connections are integrated in Ns2 simulation. The second and third trace file consists of 975 connections each. In our work, we measure the average throughput of each network along with the information transfer to assess the performance of each of the three topologies tested.

3.1.1 Simulation of Simple Information Transfer

Experiments begin with simple information transfer where nodes are exchanging packet size of 512 bytes. The packet size of 512 bytes is chosen since the users are exchanging feedback, such as comments and other posts for sharing their opinions. Here the simulation time is 170 seconds for all three traces. Speed of distribution is the performance metric used in this specific experiment. The results of this experiment are shown in the Figure 5, Figure 6 and Figure 7.

3.1.2 Simulation of Short Video Streaming with Fixed Size of 10 MB

In the second group of experiments we used a synthetic workload generator for simulating YouTube video parameters [29] in order to simulate short video sharing in these three networks. During five months research, statistical behaviors of 250,000 popular and regular videos were analyzed in [29]. Soraya found out the

average size of the popular videos on YouTube are 10 MB and the distribution of file sizes is weibull distribution. In the second experiment nodes are exchanging a fix size, short video of 10 MB. Simulation time is 2700 seconds.

3.1.3 Simulation of Short Video Streaming with Variable Size

In third experiment, the distribution of file sizes is based on the weibull distribution as described in [29]. It's still short video streaming, however the size of the packets is generated by weibull distribution. The simulation time is 2700 seconds.

The weibull distribution is a continuous probability distribution. The probability density function (PDF) of the weibull distribution is calculated with the following formula:

$$f(x; a; b) = \begin{cases} ab^{-a} x^{a-1} e^{-(x/b)a} & x \geq 0 \\ 0 & x < 0 \end{cases} \quad (1.5)$$

Where *a* is shape and *b* is scale parameter of the distribution.

4. RESULTS

The following tables and graphs illustrate the different types of experiments that we performed in our work and illustrate which networks perform the best in each experiment.

Table 1.Number of connections and number of nodes

	Number of connections between nodes	Number of nodes in each topology
Trace 1	1031	1000
Trace 2	975	1000
Trace 3	975	1000

In the simulation we are considering download bandwidth of 2MB for each node and queuing delay of 2ms for all three traces.

The first three experiments indicate that the ring topology is the fastest in terms of distributing information between users.

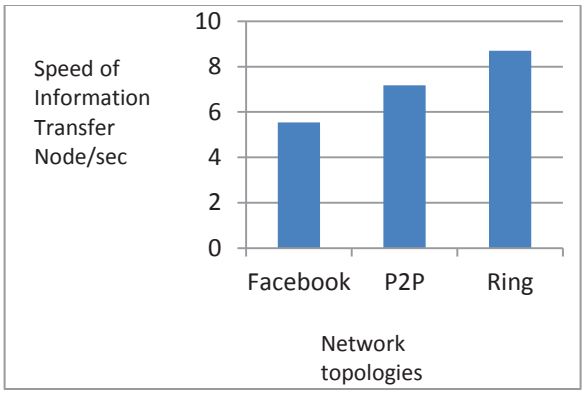

Figure 5. Experimenting on Trace1 with packet size of 512 bytes

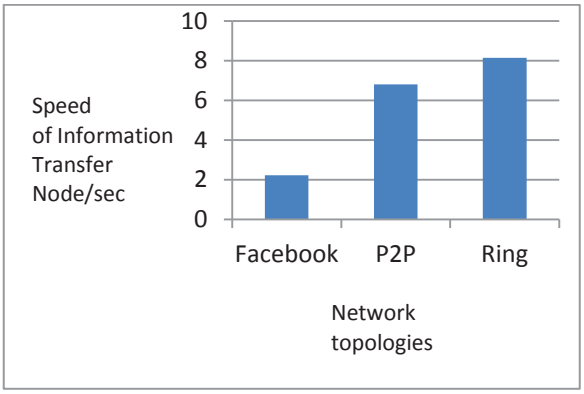

Figure 6. Experimenting on Trace 2 with packet size of 512 bytes

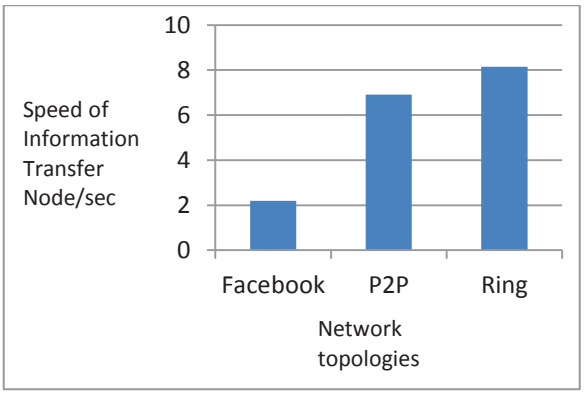

Figure 7. Experimenting on Trace 3 with packet size of 512 bytes

The next three graphs shows the video sharing based on file size with weibull distribution where Facebook has the highest average throughput. By setting the file size to 10 MB as the average of the file sizes for each trace file, a similar trend is observed and Facebook continues to have the highest average throughput.

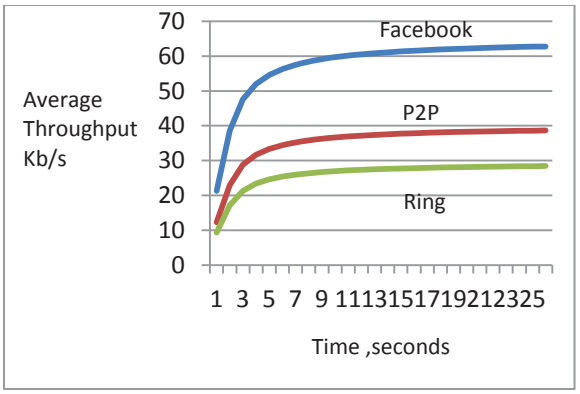

Figure 8. Trace1-Short video streaming with weibull distribution of file sizes

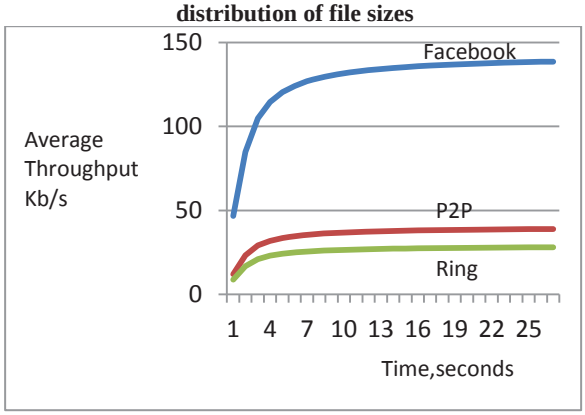

Figure 9. Trace2-Short video streaming with weibull distribution of file sizes

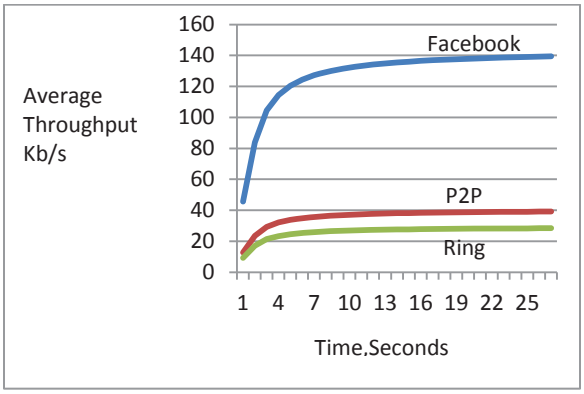

Figure 10. Trace3-Short video streaming with weibull distribution of file sizes

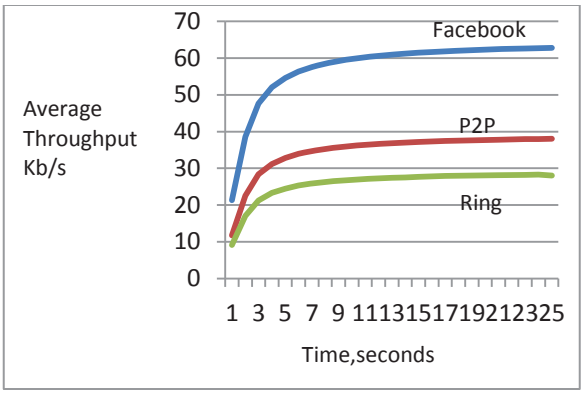

Figure 11. Trace1-Short video streaming with constant size of 10MB

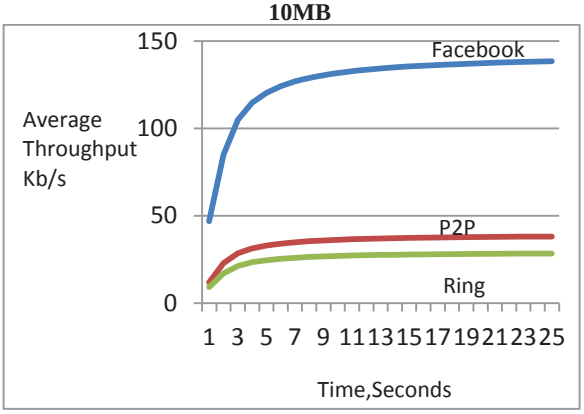

Figure 12. Trace2-Short video streaming with constant size of 10MB

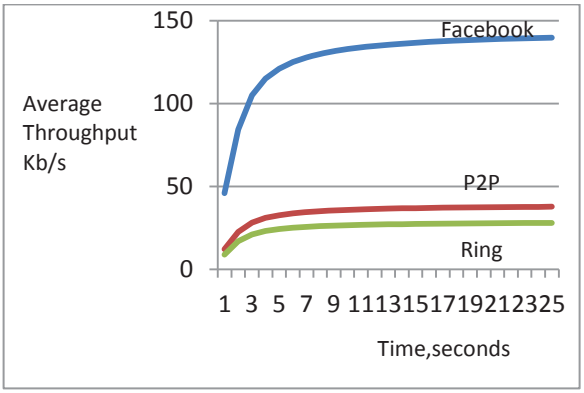

Figure 13. Trace1-Short video streaming with constant size of 10MB

5. CONCLUSION

Users in Facebook must add each other and become friends before exchanging any information. In P2P networks, while users are downloading and uploading files, they can constantly exchange messages with each other without knowing one and another. Therefore, the diversity of the network is higher in P2P networks as compared to Facebook. In the first experiment, this is the reason behind the higher speed of information transfer among the nodes measured by number of nodes receiving a packet in the unit of time. Overall ring network has 16% average improvement in speed of information transfer over peer-to-peer network and 60% average improvement in speed of information transfer over Facebook. Thus we conclude in the ring network, information can be transferred faster. While considering media sharing by simulating short video sharing, Facebook network shows 61% average improvement in throughput compared to peer-to-peer and 71% average improvement over ring network. In the third experiment while testing with the files size of 10 MB, Facebook has 62% average improvement in throughput for media sharing over peer-to-peer and 72% average improvement over ring network. Facebook is the most suitable network for sharing multimedia files between users since it has the highest average throughput.

6. REFERENCES

[1] Probst F. 2010. "Valuation of online social networks taking into account users interconnectedness". Appears in: ISeBM Special Issue.

[2] M. Fraser, S. Dutta, 2009. "Yes, CEOs Should Facebook and Twitter", http://www.forbes.com/.

[3] "Facebook files for mega-IPO" Retrieved on 2/13/2012. http://www.thestar.com/business/article/1124945--facebook-files-for-mega-ipo.

[4] M.Gjoka, M. Sirivianos, A. Markopoulou, X. Yang, August 2008, "Poking Facebook: Characterization of OSN Application", In Proceedings of Workshop on Online Social networks, Seattle, WA, USA,.

[5] Official Web site of Google Plus-https://plus.google.com/.

[6] Official Web site of LinkedIn- http://www.linkedin.com.

[7] Official Web site of Orkut- Online Social Network Web site, http://www.orkut.com.

[8] Official Web site of Twitter- http://twitter.com/.

[9] "What Is P2P ... And What Isn't" Retrieved on 1/09/12. http://openp2p.com/pub/a/p2p/2000/11/24/shirky1-whatisp2p.html?page=2.

[10] G, Coulouris, J, Dollimore and T.Kindberg. 2005. Distributed Systems Concepts and Design, 4rd ed. Edinburgh: Addison-Wesley, pp. 397-399.

[11] A, S. Tanenbaum and M. V. Steen, Distributed Systems Concepts and Paradigms. 2007. 2nd ed. Upper Saddle River: Pearson Prentice Hall, pp. 43-53.

[12] A, R. Bharambe, C. Herley, and V. N. Padmanabhan. (2006). "Analyzing and improving a BitTorrent network's performance mechanisms". Proceedings of the 25th IEEE International Conference on Computer Communications. In infocom.

[13] Gnutella-http://rfc-gnutella.sourceforge.net/.

[14] S. Saroiu, K. P. Gummadi, and S. D. Gribble, "Measuring and analyzing the characteristics of napster and gnutella hosts," Multimedia Syst., vol. 9, no. 2, pp. 170–184

[15] Client/Server Model of Computing-http://infomotions.com/musings/waves/clientservercomputing.html.

[16] Indranil Gupta, Ken Birman, Prakash Linga, in. Lecture Notes in Computer Science, 2003, Volume 2735, Peer-to-Peer Systems II, Pages 160-169.

[17] Ioannidis, j., Ioannidis, s., Keromytis, a., and Prevelakis, v. 2002. fileteller: paying and getting paid for file storage. In proceedings of the sixth international conference on financial cryptography.

[18] Loeser, A., Wolpers, M., Siberski, W., and Nejdl, W. 2003. Semantic overlay clusters within super-peer networks. In Proceedings of the International Workshop on Databases, Information Systems and Peer-to-Peer Computing (P2PDBIS). Berlin, Germany.

[19] Matthew Harren , Joseph M. Hellerstein , Ryan Huebsch , Boon Thau Loo , Scott Shenker , Ion Stoica, March 07-08, 2002, Complex Queries in DHT-based Peer-to-Peer Networks, Revised Papers from the First International Workshop on Peer-to-Peer Systems, p.242-259.

[20] B. Cohen. BitTorrent protocol specification. http://www.bitconjurer.org/BitTorrent/protocol.html, February 2005.

[21] Cohen, B. (2003). "Incentive Build Robustness in BitTorrent". In Proceedings of the First Workshop on the Economics of Peer-to-Peer Systems, Berkeley.

[22] A. Legout, G. Urvoy-Keller, and P. Michiardi. Oct. 2006, "Rarest First and Choke Algorithms Are enough," ACM IMC, Rio de Janeiro, Brazil.

[23] J. Li, Y. Cui, and B. Chang, 2007, "Peer Streaming: Design and Implementation of an On-Demand Distributed Streaming System with DRM Capabilities," Multimedia Systems Journal.

[24] Liogkas N, Nelson R, Kohler E and Zhang L. (2006). "Exploiting BitTorrent for fun (but not profit)". Proc. International Workshop on Peer-To-Peer Systems.

[25] Altman, E and Jimenez, T. (2003-2004), "NS Simulator for beginners". University de Los Andes, Merida, Venezuela and Essi, Sophia-Antipolis, France.

[26] Fall, K. (2011). "The ns Manual (formerly ns Notes and Documentation)".

[27] C. Wang, B. Li, Feb, 2003 "Peer-to-peer overlay networks: A survey", Technical Report, Department of Computer Science, HKUST.

[28] F. Pakzad and A. Abhari, "Characterization of User Networks in Facebook", April 2010. In the Proceedings of 13th Communications and Networking Simulation Symposium (CSN10) of SCS/SpringSim '10 in Collaboration with ACM/SIGSIM,Orlando, FL., US.

[29] A. Abhari, M. Soraya, June 2009, "Workload Generation for YouTube", Multimedia Tools and Applications journal, Vol 46, pp. 91-118, 2010.