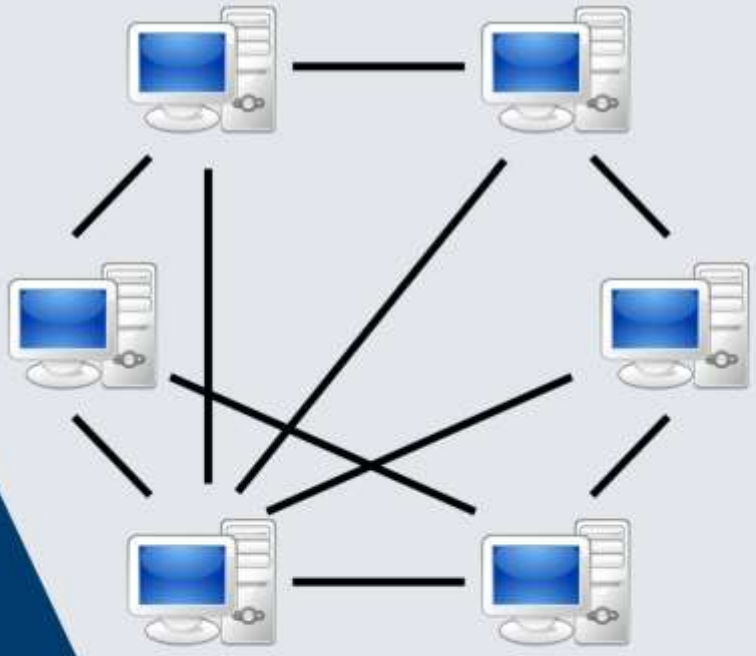
AN OVERVIEW OF DENIAL OF SERVICES IN PEER-TO-PEER NETWORKS



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PREFACE

Peer to peer networks and video-on-demand services are some of the fastest-growing technologies in the world today. One of the ramifications of their growth is the tremendous growth in research and development for the development of these technologies. The newcomers in this field of research, sometimes face Challenges regarding understanding new emergent Technologies.

Features of the Book:

Several book features are designed to make it particularly easy for a student to understand the basics of peer-to-peer network and video-on-demand services.

Structure:

We have you read the book into a number of chapters. These chapters are logically arranged so that reader doesn't find it difficult to understand the concepts.

Visual Approach:

The highly technical subject matter is presented in this book. Complex numerical expressions and formulas are being avoided to make the book e more user-friendly for a new reader in the area. The book contains a balanced mix of text and figures. Videos help a lot in explaining the networking concepts which are obviously based on connections and transmissions.

Recommended Reading:

The book provides a detailed reference to the areas described in it. These references may help the reader to understand the matter more clearly.

Each topic in the book is provided with a reference number. The reader may refer to the reference paper for more elaborative study.

Chapters:

The book is broadly divided into three chapters namely introduction, Peer to peer network and references. In the introduction chapter, we have given the initial introduction to the peer network system, Bit Torrent and video on demand system. In the second chapter, we have elaborated study of peer to peer network, overlay network and their applications, Bit Torrent and algorithms related to Bit Torrent protocol, all Video-on-demand services, different types of Video-on-demand services and various peer-to-peer network topologies.

This book is dedicated to

Maa, baba, Wife

And beloved daughter Sakshi

ACKNOWLEDGMENTS

This book is based on research conducted on peer-to-peer based Video on demand service. I am grateful for a number of friends and colleagues encouraging me to start the work, persevere with it, and finally to publish it.

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Finally, I would like to acknowledge with gratitude, the support and love of my family- my parents, my brother, my wife and my daughter.

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Chapter 1

Introduction

This chapter starts with the brief introduction to peer to peer based video on demand system. In the section 1.1, 1.2 and 1.3 discusses brief introduction to peer to peer sys-tem, Bit Torrent network and Video on Demand system and their motivation. Section 1.4 discusses the scope and objective of the ongoing thesis. Lastly section 1.5 gives the organization of the thesis.

1.1 Peer to Peer System:

Peer to peer system is a type of system whose architecture is distributed. It normally divides the network workloads among the coordinating peers. In this type of systems, all the participating peers or computers are equal. This means, no peers are superior to any other peer. That is why this type of network is known as peer-to-peer network.

In this type of network, all the participating nodes or computer provides some portion of their resources to the network. These resources can be storage spaces, processing power etc. The peers share their resources among their peer groups without the help of any centralized servers [2]. In the traditional client-server model, the consumer requests for resources and the resource provider are distinct. Their server is mostly the resource provider whereas their clients are mostly the consumers. But in contrast, in a peer-to-peer network, this is not the case. Here, a participating peer is both the consumer and the resource provider.

Over time, the peer-to-peer network has emerged from simple resource sharing systems to more complex and robust systems, where it is not necessary that all the participating share a common goal. Nowadays, the peer-to-peer system, which is also referred to as P2P systems, can coordinate among themselves even if their goal is totally different. Yet it can be beneficial to all participating the peers [3].

1.2 Bit Torrent:

Bit Torrent is one of the most prominent peer-to-peer network protocol or Technology. The main purpose of Bit Torrent is to make transfer or distribution of large les easier without using a large bandwidth of the network. This is done by utilizing the upload link capacity of the downloaders. The main advantage of the Bit Torrent network is that it can handle a large number of users. A tremendous increase in users only results in a small increase of load in the network. Bit Torrent has found itself applicable in a wide range of areas.

Bit Torrent has huge potential in business. Someone can use it for distribution of large les to the users. Downloading large les in a traditional network can be very much time-consuming. For downloading operating system, ISO les or security patch update etc. can be done through the Bit Torrent network. It will drastically reduce download time and will increase user's convenience. Organizations, smaller or bigger, can use Bit Torrent network to transfer large les. The main problem with Bit Torrent nowadays is that it has become the platform for sharing illegal music, videos, movies etc.

Most of the contents available in Bit Torrent are not legal, because of copyright infringement like issues. But the positive aspect is that a number of legitimate contents are increasing day by day. Usage of Bit Torrent is increasing especially for downloading Linux distributions. The downloading Linux distributions from Bit Torrent is preferable because it does not put much pressure on the network like that of FTP or http protocols.

The main components of the Bit Torrent architecture are as follows:

a. A tracker.
b. The seeders who are the original downloaders.
c. The lechers who are the end user downloader.
d. A Torrent le for storing static Meta information.

When a user wants to share a le, it creates a Torrent le for that. This Torrent le contains the name of the le, the size of the le, address of itself and some hashing information. Then the user release that Torrent le to the internet.

This torrent file can be shared with others with the help of email, HTTP etc. There are many free and open source software available for creating that .torrent le. This facility is also available in most of the versions of the Bit Torrent application.

1.3 Video on Demand System:

Video on demand system (VoD) is a type of system where a user or consumer can demand a video to download and watch. Here, the consumer selects and watch a video or audio such as Cinemas, movies, TV serials songs etc. as per their will or demand. The user does not depend upon the scheduled broadcast time or the general broadcast method of over-the-air programming. IPTV systems are generally used for bringing Video on demand services to the television as well as to the personal computers [4].

Today's Video on demand services, available in the television, can have the content streamed to television either using set-top boxes or any such similar devices. This system allows viewing the video's content in real time or download the content to the devices such as a digital video recorder or portable media player for viewing at any desired time. There are many advantages of Video on demand services.

The main advantage of Video on demand services is that it provides all the features that are available in portable media player and DVD player. Many of the videos of the VoD services systems such as a television set sometimes have a hard disk in it, so that the downloaded content can be stored game. Also, some systems have memory buffer which helps in fast forwarding and fast rewinding the videos being played. These features add the fast forwarding and fast rewinding of traditional media players into the modern Video demand service systems and it has evolved into many forms. The cable provider companies have tailored the VoD services into their systems.

Many of the cable service providers has launched its own apps for offering Video on demand services. Now, the consumer can assess the add an order of a particular video on the local cable network.

1.4 Scope and Objective:

The main objective of our research work can be summarized as follows:

a. Creation of Denial of Service Attacks on the P2P System:

Unlike some other attack, P2P based applications are built on the top of overlay networks, which can introduce additional layer of attack. At the overlay network layer, the current P2P overlays in the literature provide limited security for message dissemination. Hence, a malicious peer has many opportunities to corrupt P2P based communication at the overlay level. Assuming the underlying network is secure and reliable, attacks on the overlay, such as denial of service (DoS) attack can potentially hinder the functionality of P2P based video on demand. Denial of service attacks are those attacks which hinders or denies the normal services provided by a system.

Besides the above, routing table attacks and message forwarding attacks can cause denial of services. Naomov and Ross describe two approaches to create DDOS engine out of a P2P system: poisoning of distributed index in peers and poisoning the routing table in the peer. Both the approaches here are able to significantly deny services to any of the nodes or peers.

b. Creation of Intrusions Detection System for the Attacks:

The most popular counter measure for DoS attack include service/host backup, reactive detection, rate limiting, and filtering. Having an emergency block of ip address or node IDs, for example, can be invaluable in surviving DoS attacks. Pat-tern detection are often helpful by storing the signature of known attacks in the database. Rate limiting mechanism can impose a rate limit on a stream that has been characterized by malicious by the detection mechanism. These are often used as response technique when a detection mechanism cannot characterize the attack stream.

1.5 Organization of the Thesis:

The rest of the thesis is organized in five chapters as described below:

- Chapter 2 discusses the review of literature. In this chapter, the concept and recent develop in the area of peer to peer network, bit torrent network, video on demand system are discussed.
- Chapter 3 discusses the attack methodologies. This chapter includes and discuss various types of attack that are possible in peer to peer based network.
- Chapter 4 discusses the two new attacks that we have created for the peer to peer based video on demand system. We have given the detailed speciation of the test bed that we created for the simulation of peer to peer based video on demand system. Beside, this chapter also discusses the intrusion detection system that prevents the attacks on the video on demand service system.
- Finally in Chapter 5 conclusion is drawn based on the endings of chapter 4

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Chapter 2

Peer to Peer Network

2.1 Peer to Peer (P2P) System:

Peer to peer system is a type of system whose architecture is distributed. It normally divides the network workloads among the coordinating peers. In this type of systems, all the participating peers or computers are equal. This means, no peers are superior to any other peer. That is why this type of network is known as peer-to-peer network.

In this type of network, all the participating nodes or computer provides some portion of their resources to the network. These resources can be storage spaces, processing power etc.. The peers share their resources among their peer groups without the help of any centralized servers [2].

In the traditional client-server model, the consumer requests for resources and the resource provider are distinct. Their server is mostly the resource provider whereas their clients are mostly the consumers. But in contrast, in a peer-to-peer network, this is not the case. Here, a participating peer is both the consumer and the resource provider. Over time, the peer-to-peer network has emerged from simple resource sharing systems to more complex and robust systems, where it is not necessary that all the participating share a common goal.

Nowadays, the peer-to-peer system, which is also referred to as P2P systems, can coordinate among themselves even if their goal is totally different. Yet it can be beneficial to all participating the peers [3]. In the early 90s, there were many applications which were based on P2P network [5], but it was popularized only after the advent of Napster. Napster was originally released in 1999. This concept has inspired a new area of communication among human beings.

2.2 History of Peer to Peer (P2P) System:

Historically, there were many applications which were dependent on P2P systems [5]. The concept of the peer-to-peer system was popularized by the music sharing application, Napster. With the help of peer-to-peer systems, millions of users are able to connect to one another without directly forming groups [6]. The basic concept of peer-to-peer networking was rst introduced in the principles stated in the rst Request for Comments, RFC 1. [7]

At the beginning of networking, the networks were more open where a computer can easily send any packet to anyone. But later, rewalls were introduced for security reasons [6] which is against the concept of broadcast like architecture of the internet [8] [9].

The ARPANET project marked the beginning of the internet era. The project was based on the successful client-server model. Here every node, which is participating in the network, can send a request to packets as well as it can also serve the contents.

But the ARPANET project was not a self-organized. It did not have ability beyond simple address-based routing for proving the contents or context [9].

The USENET is a distributed messaging system, and it is often referred to as the early to the peer-to-peer architecture based system. It was developed in 1979. It followed a decentralized model of control. The fundamental model in the perspective of the user is the client-server model, and it offers newsgroup a self-organizing approach. But the news servers act as peers in order to communicate and propagate UseNet news article over the entire group of network servers.

The same logic can be applied to the SMTP email in a way that the basic email relaying agents shows the characteristic of a peer-to-peer network. But on the top, the email between the nodes strictly show the client-server model relationship.

In early 1999, hundreds of million people have joined the internet. By this time Napster was introduced. It was introduced by Shawn Fanning. It was the start of the peer-to-peer network where each participating peers used to establish a virtual network on the top of the physical network. These networks were not compiled to follow any administrative authorities [9].

2.3 Architecture:

A peer-to-peer network is a type of network designed with an assumption that all the participating nodes have equal rights and they act as both client and server.

This architecture of network differs from the traditional architecture where the communication is from or to a central server. The le transfer protocol uses the traditional architecture whereas Skype uses the peer-to-peer network.

Routing and route discovery:

Peer to peer network works as an overlay network which works on the top of existing infrastructure architecture. Here, the participating nodes of the peer-to-peer network form a subset of nodes from the physical network.

The actual communication takes place through the underlying network which follows the TCP protocol. But, the application at the application layer is able to directly communicate with one other.

The overlay architecture 8 Provides the means of indexing and peers discovery and it makes the application at the top-most layer of the architecture appear independent [10] [11] [12].

2.4 Overlay network:

An overlay network is a type of network that is built on the top of another network. The connections among nodes in an overlay network are virtual or logical links.

Here, each connection can be thought of paths in the underlying network.

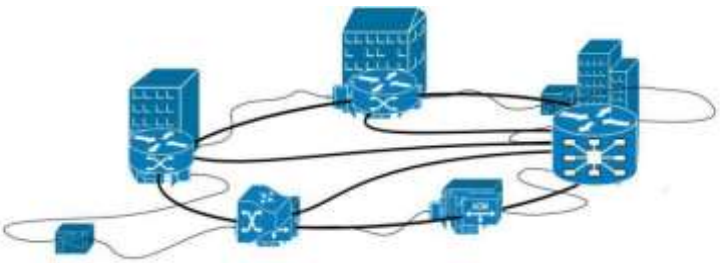

Figure 2.1: A simple overlay network [1]

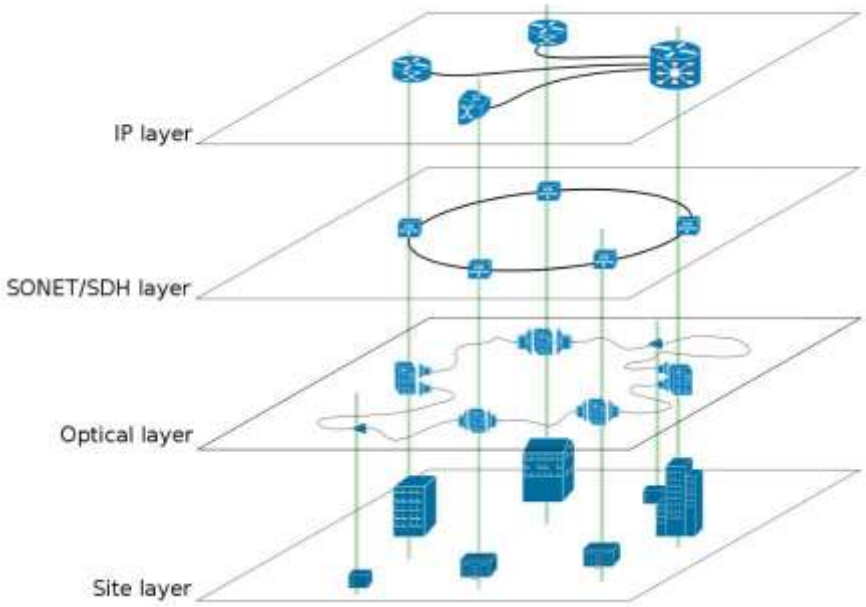

Figure 2.2: Overlay network broken up into logical layers [1]

Overlay networks are popular in telecommunications. The reason behind the popularity is the availability of the digital switching equipment and optical fiber [13]. The telecommunication and ip networks have at least an optical fiber layer, a transport layer and an IP switching layer. Enterprise networks were initially built on the top of telecommunication networks, such as frame relay and ATM (asynchronous transfer mode) packet switching infrastructure. From the perspective of physical infrastructure, building overlay network is very complex (refer Figure 1) as they operate between various logical layers and these logical layers are built and operated by the various business, universities, governments etc.

The positive about this is that any single organization could not be able to provide those services. [14]. initially, when the internet was introduced, it was built on the top of the telecommunication network. But nowadays the telephone networks are increasingly turning into an overly network on the top of the internet. Overlay network can be broadly divided into two categories based on how the connections are made and how resources are kept track of. Those two broad categories are unstructured network and structured network.

2.4.1 Unstructured Network:

The Figure 2.3 shows an unstructured P2P network, illustrating the ad hoc nature of the connections between nodes. The main characteristic of the unstructured network is that it does not impose any particular structure on the network. Here, the network structure is formed by the random connections made by the participating nodes [15].

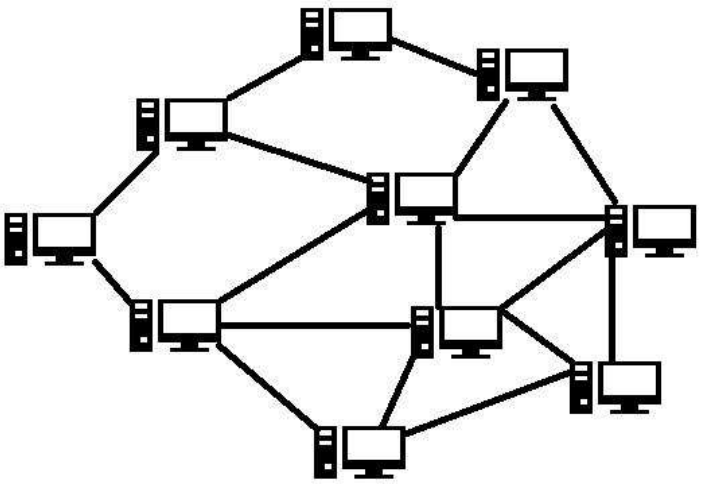

Figure 2.3: Unstructured Peer to Peer network

Gossip, Kazaa and Gnutella are prominent examples of unstructured peer-to-peer network [16]. The unstructured peer-to-peer networks are easy to build since there is no structure globally imposed upon them and hence they can be locally optimized for different requirements of different regions. The unstructured networks have a high rate of churn as all the peers in the network have an equal privilege. The \churn" is the frequency of peers joining and leaving the peer-to-peer network [17] [18]. But, there is some disadvantage of unstructured peer-to-peer network and it arises from its lack of structure.

The main disadvantage is that when a peer needs a file/data, it needs to flood the network with a query. Flooding the network with queries causes huge congestion, also uses more computational power as well as a large amount of memory.

All this trouble to the network without any guarantee that the query will be fulfilled. Only the query for popular contents will be fulfilled as more number of peers will be having le/data and the less popular le or data will have fewer chances to be found in the network [19].

2.4.2 Structured Network:

As soon in the Figure 2.4, in structured peer to peer network, the architecture is structured into some specific topology, so that the protocol implemented to ensure that any node can efficiently work [20] and search the entire network for a desired le or resource. In this type of network, rare resource can be easily found.

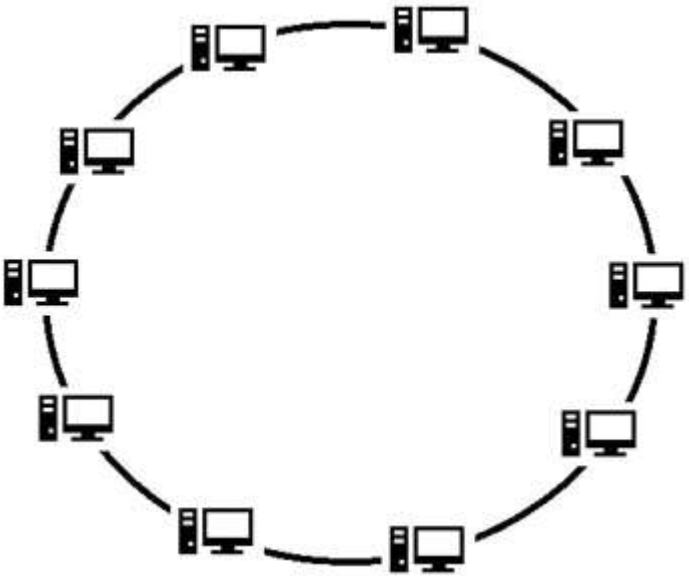

Figure 2.4: Structured Peer to Peer network

Distributed Hash table (DHT) is commonly implemented as the most common type of structured peer-to-peer network [3][21].A variant of distributed Hash table consist of hashing which is capable of assigning ownership of a le to a particular peer[22] [23]. The searching for a particular le in a network using Hash table (key, value) is possible. The key and the value pairs are stored in the distributed Hash table and any node which requires a particular le can easily and efficiently find out the le with the help of the key in the DHT [24] [25].

Distributed Hash Table:

As in the case of the unstructured overlay network, structured overlay networks also have any number of nodes. But, it must maintain a list of its neighbors and those neighbors must satisfy some specific criteria to be in the list. This is done in order to make the routing more efficient and less congested traffic. This makes the rate of churn lesser in the network [18] [26]. Recently, numerous issues have been found in real-life scenarios with the DHT based solutions of the peer-to-peer network. The issues with the DHT best solution is that it has a high cost of advertising and also has a high cost of discovering resources. Also, it suffers from static and dynamic load balancing [27].

Some noteworthy peer-to-peer networks that use distributed Hash table are Bit Torrent distributed tracker, the Kad network, YaCy, the storm botnet, and the Coral content distribution network. Some of the notable areas of research where work is going on are PAST storage utility, kademlia, cord project, P-grid. These are the self-organizing and emerging over the network and cooperative content distribution system [28].

A distributed Hash table based network has many uses. It is used for the efficient resource discovery in cloud-based systems as well as grid computing system. It is also helpful in keeping track of the resources and its management. In some areas, it also helps in the scheduling of applications.

2.4.3 Hybrid Model:

As the name suggests, a hybrid model is a combination of peer-to-peer networking models and traditional client-server models [29]. One of the well-known examples of hybrid models is spotify. It was very popular until 2014. There are various types of hybrid models available. This model makes a tradeoff between the services offered by the client-server model and peer-to-peer unstructured network models. But, recently the hybrid model has gained popularity because it has a better performance as compared to that of unstructured peer-to-peer network and structured peer-to-peer network. It is because some functions such as searching resources require a centralized function and the benefit of distributed aggregation of nodes is only provided by unstructured peer-to-peer networks[30]. Both of them are available only in hybrid networks, so this network is able to take out the better of these two types of networks.

2.5 Security and Trust:

As any computer application or software, peer-to-peer networks or systems also face many security challenges. Peer-to-peer networks also have certain vulnerabilities. The main reason for vulnerabilities is that any node in the peer-to-peer network works as a server as well as a client. This means that the entire network can be more vulnerable to any remote or exterior exploits [31]. Routing attacks are also possible because all the node contributes to routing particular traffic to the distant network. Denial of service attacks is also a prominent type of attack which is faced by peer to peer networks. Examples of common routing attack include incorrect lookup routing where the routing table is fed with incorrect data by sending wrong information about the route [31].

2.5.1 Corrupted data and Malware:

One of the major problem faced by the peer-to-peer network is Malware. Each protocol of the network faces various degrees of Malware. A study has been conducted for analyzing the malware spread on the peer-to-peer network. It is found in the study that more than 60 percent of the download request which are made in the Bit Torrent network contains some malware and less than 3 percent of the content which are downloaded from openfFT contain Malware. Another study which has been conducted on traffic in Kazaa network. It is found that more than 15 percent of 500 thousand le samples are infected by various types of computer virus. There were more than 365 different types of computer viruses [32].

Another problem faced by the peer-to-peer network is that the corrupted data can be distributed on the network. This is done by modifying the content of the le which is already available in the network. For example, RIAA managed to introduce fake music and movies in the p2p network. It was done intentionally to discourage illegal sharing of the les in the network [33]. As a result, the peer-to-peer network had to increase its security and introduce a verification mechanism. In modern history, Chunk verification and various types of encryption have made the peer-to-peer network more robust and secured [34].

2.5.2 Resilient and Scalable Computer Networks:

The p2p networks are decentralized in nature. Thus, it reduces the single point of failure, unlike the traditional client-server-based networks [35].

Since the network is distributed in nature if the number of computers connected in the network increases or a number of searches of queries increases, the network become more robust and strong. So, the capacity of the network also increases. But in a traditional client-server architecture if the number of nodes of computer increases in the network, then the system becomes loaded. Hence it gets slowed down. In a client-server-based network, if the server fails, the entire network fails. But this is not the case with the peer-to-peer network. It is because there are no centralized server [35].

2.5.3 Distributed Storage and Search:

YaCy is an example of a distributed search engine. It is different from Google or Yahoo search. Yahoo and Google search make a request to a centralized index server in order to find the result of a particular server query. YaCy does not use any centralized server. For data backups' availability and recovery, there are some advantages and disadvantages in a peer-to-peer network. The main problem with the p2p network is that no one has got any authority on the data. Say, for example, in a centralized network, if some le or data is not desired in the network, then the administrator of the network can delete the le from the server and the le will not be available in the network anymore. But this is not the case with the distributed peer-to-peer network. In a p2p network, a peer can delete a content which is available with it, but it cannot delete the content which is available with another node for the computer. Since the structure of peer-to-peer network allows multiple copies to be present in the network, it is not an easy task to delete a le or a data from the community of the network. This makes the system vulnerable because orders from the government to delete a certain le or information from the network is not possible to implement. For example, the famous video content sharing platform YouTube has been pressurized by many governments throughout the world to delete certain contents from it. Since YouTube is a centralized server architecture network, it can delete a certain le. But a system without any centralized server cannot do so.

In a client-server network, the system administrator is able to monitor or manage the contents available because of which there is the stability of ability of refusal to the content being hosted. A p2p network is not as much reliable as client server-based network because sharing unpopular les or media will become very unpopular in which type of networks. The peer-to-peer network requires that at least one node in the network has a certain data, and that node requires to hold that data in the network so that other peer will be able to connect to the node requesting that data. Sometimes, this requirement becomes very di cult to maintain because a user may leave the network or stop sharing data [36].

In a peer-to-peer network, the community of users, which are using the network for searching are solely responsible for the content to be available in the network. The draw-back of this type of network is that the unpopular media resources slowly disappears from the network and become unavailable for user access. But, the popular les will remain in the network for a longer period of time and there will be multiple copies of the same le in the network.

All the popular les which are in more demand have more stability and availability in the network as compared to that of client-server-based networks. The main problem with the centralized network is that if a node gets disconnected from the network, he won't be able to get the le from other sources. In client-server-based networks, the administrator is responsible for backing up all the data and its recovery in case of system failure.

But this doesn't apply to peer-to-peer network because, here, each node requires its own backup system. Due to the lack of the central authority in a structured and unstructured peer-to-peer network, many of the music industry players and governments have stopped sharing contents in the p2p network.

2.6 Applications:

There are many applications of peer-to-peer networks which are listed below:

2.6.1 Content Delivery:

Unlike client-server-based network, in a peer-to-peer network, the nodes act as both client and server. That is, it provides the resources and also it uses the resources. This means that the capacity of content sharing will increase drastically as more number of users access the contents. This is true especially with the case of Bit Torrent which requires a user to share its own content and also participate in performance measurement studying [37].

This property has a major disadvantage. It is because it will take more time to start up the network and also, the cost for hosting a very small original content will be more[38][39].

2.6.2 File Sharing Network:

There are many le-sharing networks such as Gnutella and eDonkey. They have made the peer-to-peer technologies more popular. The purpose of le sharing network can be summarized into three categories which are listed below:

a. Delivery networks that provide peer-to-peer content.
b. Service networks that provide services to peer-to-peer content delivery network.
c. Software Publication and distribution [40].

2.6.3 Copyright Infringement:

One of the burning issues related to networking is copyright infringement. Since there is no Central server for monitoring the data transfer between one users to another user, there is no way to check the content being transferred. Because of which, the companies involved in the development of p2p applications have numerous legal cases especially in the United States over the copyright infringement issues [41] [42].

2.6.4 Multimedia:

Peer-to-peer assisted streaming solution refers to p2p based software's which are used to distribute or broadcast video streams online. The main contents provider for p2p assist streaming solution are TV channels from around the world. This service and the application has a huge potential because it will make any TV channel globally accessible as any numbers of viewers can watch the video in real time. This allows scalable distribution of the content to a large number of audiences with an insignificant amount of cost. In any p2p TV system, each user has to upload a certain content to the network while it is downloading a le. Thus it is utilizing the overall bandwidth available.

The quality of the video being watched over these p2p based systems depends upon the numbers of users watching it. If the number of users watching the video is more than the quality of the video will be better. It is because the content will be available with many numbers of peers, so it can be easily downloaded. But if the number of users watching the video is less, then the quality of the content will be poor, since very few numbers of peers will be having that video to share.

The architecture of p2p based TV Network can be thought of as a real-time version of the Bit Torrent network. It is because, if a user wants to view or download a program, then it has to contain a tracker server to update its address of the TV set-top box as well as the detail of the desired video.

The trackers store the address of the p2p TV because the users' address can be given to some other users. That is why it is required by them for searching a particular le. Some application based on the peer-to-peer network allows the consumers, that is, the users to broadcast their own videos through the TV tuner card or video capture card. The p2p TV applications, nowadays, has gained huge popularity in China. Many applications such as TVU player, PP life, QQ live, PP streams are developed in China. Most of the Chinese p2p TV application broadcast mostly Asian TV channel with exception of TVU player which also provide content from North American and European channels. Many of the applications provide the content of popular TV channel without a proper license or permissions [43]. The US government has blocked many websites because they have shared for the proprietary content of other channels without proper permission [44].

Peer distributed transfer protocol is an internet le transfer protocol. It distributes les from Central service to peer-to-peer networks. The limitation of peer distributed transfer protocol is similar to that of Bit Torrent, but it allows live streaming media as well. The internet assigned number authority has assigned port 6086 to the protocol, and the primary implementation of this protocol is distribustream.

Another popular streaming approach is a peer-casting which is the method of multi-casting streams. It usually streams audio and video to the internet with the help of the peer-to-peer network. Peer-casting can be used by all even if he is an amateur or he is independent expert. Peer-casting can also be used commercially.

One of the advantage with peer-casting is that it also supports video on demand content delivery. Peer-casting normally works with the help of peers which automatically transfer a stream of video to another peer. But, many a times this method suffers from poor quality of service especially when a number of peers connection increases or decreases. This event is called \Churn" [45].The solution to this type of problem is \minute swarming". In minute swarming, a live stream is broken down into small pieces of length of minutes. Then, they are shared with the help of available p2p software's such as Bit Torrent or Coral.

This approach solves the problem but still introduces another problem. The problem introduced here is that the system suffers from excessive overhead due to the formation of new swarms every time. Another mechanism, used to stop the problem in Peer casting, is like that of RAID striping. In this technique, the live stream is striped into multiple sub-streams. Then, error correction and data integrity techniques are applied to the sub-streams, so that original video can be obtained on combining them up.

Some other p2p applications [46] [47]:

a. Tradepal and m-commerce applications are based on peer-to-peer networks. They provide a powerful real-time Marketplace.
b. Cryptocurrencies such as Bit coin, peer coin are peer to peer based digital Cryptocurrencies. The i2p is also a p2p based application which is used to browse internet anonymously
c. There are many le-sharing applications which are based on the peer-to-peer network for example in nit. Many wireless community works are built based on the p2p network such as Netsukiku.
d. Many data connection sharing applications have been built based on p2p network. For example open-Garden. Many of the research content distribution systems are based on peer to peer network. For example code past storage, utility acceptor are p2p based.
e. JSTA is a peer-to-peer protocol which has been designed for Java Platform.
f. Web search engine such as FAROO are p2p based application another application for peer to peer network is Bit Torrent which has been described in the next section.

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Chapter 3

Bit Torrent

3.1 Bit Torrent:

Bit Torrent is one of the most prominent peer-to-peer network protocol or technology. The main purpose of Bit Torrent is to make transfer or distribution of large les easier without using a large bandwidth of the network.

This is done by utilizing the upload link capacity of the downloaders. The main advantage of the Bit Torrent network is that it can handle a large number of users. A tremendous increase in users only results in a small increase of load in the network.

The figure 3.1 and 3.2 shows the comparison of data flow between computers using a traditional network and Bit Torrent network respectively. [17]

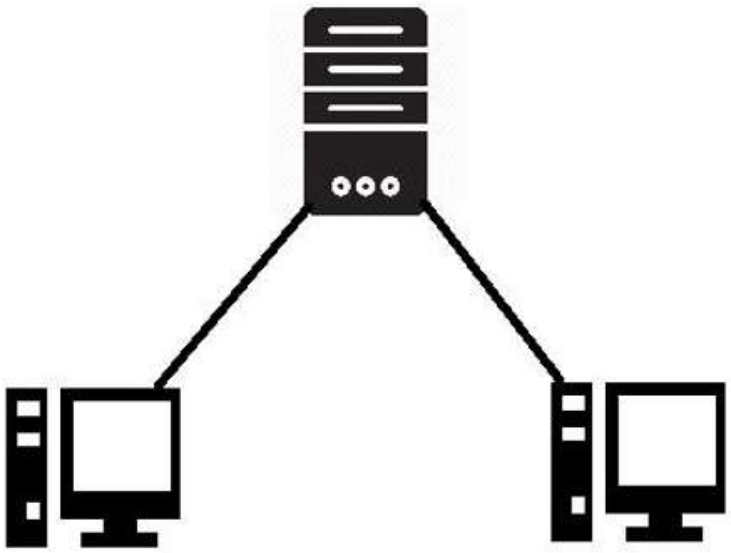

Figure 3.1: Data Transfer in Client Server Model

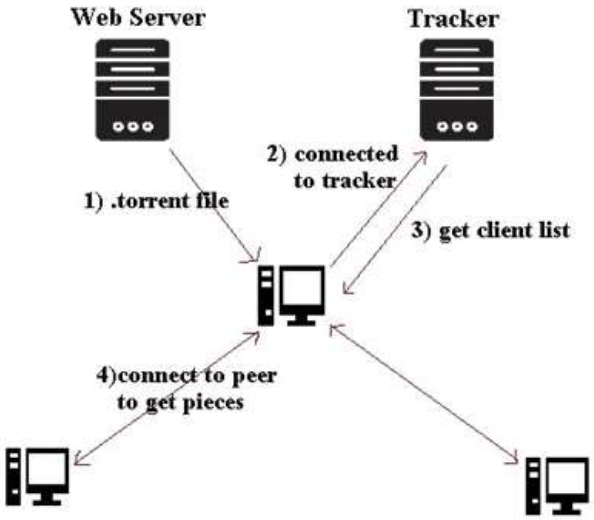

Figure 3.2: Data Transfer in Bit Torrent Model

The figure 3.1 shows a traditional computer network. This network follows the client-server model and the figure 3.2, shows computer network using the Bit Torrent protocol. As we can see from the figures that in a traditional approach of downloading a le, every user has to request to the server for providing the le. As the number of users increases in the system, the number of the request for downloading a le also increases. It may be noted that the les being downloaded can be of large sizes. Hence the performance of network degrades as the number of hosts or computers increase. But the situation is different for the network with Bit Torrent protocol. Here, requesting computers or users, also known as peers, do not request to the central server for providing the media content. It only asks for the addresses of the computers, having the desired le, to a specially designated node. Once the requesting computer or host knows the IP address of the computer having the required le, makes direct connection with that computer. Then, the computer downloads the desired le involving no central server.

3.2 The History of Bit Torrent:

Bit Torrent was introduced by Bram Cohen in the year 2001. The main motivation behind the introduction of Bit Torrent was Cohen's earlier job. The objective of his earlier job was to divide a le into several parts and store them in various locations, keeping the le safe and secure. But unfortunately, the company went bankrupt and never released any product. Then Cohen realized that this concept can be used for transferring large les from one host to another host in the network.

After building the Bit Torrent application, Cohen released its rst beta version in the summer of 2001. Then he showed and presented the concept of Bit Torrent in a conference next year. The main objective of this software was to distribute Linux software online. But in the year 2004, Bit Torrent got the attention of pirates. Pirated copies of movies, games and TV shows quickly become popular in the Bit Torrent platform. Thus making Bit Torrent one of the most popular peer-to-peer application. Today's internet contains more than 35 percent its traffic as Bit Torrent traffic [48].

Bram Cohen leads a simple life. He has made the Bit Torrent completely free and open source. Because of this, Cohan makes very less earning. Cohen is dependent on the goodwill donation made by Bit Torrent users. Of course, the open source nature of Bit Torrent has made it so much popular. Bit Torrent protocol is considerably different from other peer-to-peer networks.

According to Cohan, the main problem faced by the traditional peer-to-peer network is the speed difference of internet connectivity at most users' end. Let us assume that a user A is downloading a le from a user B. Both are having different internet speed. User A is having an internet speed of, say, 2 Mbps and user B is having an internet speed of 1 Mbps.

The rate of download of the le, from user B to user A, will not be as per the satisfaction of user A. Though user A is having a good internet connectivity, but not able to download satisfactorily because the upload data rate is lower at user B's end due to its slower internet connectivity. From this, we can conclude that direct transfer of a le between two computers, do not necessarily mean faster le transfer. The rate of le transfer between two computers is affected by the quality of the network at both of the ends [49].

Traditional peer-to-peer networks follow the above mentioned method of le transfer, because of which these peer-to-peer networks like Kazaa, Chord etc. suffer. Cohen sensed the problem and solved it by splitting the le into a large number of pieces. These pieces of the le can belong to a various number of users in the network. When a user requires a file, it simply sniffs the network. Once it knows who are having those pieces of the le, it simultaneously downloads them, optimally utilizing the down-link capacity [49].

3.1.1 Applications of Bit Torrent:

Since its introduction in 2001, Bit Torrent has found itself applicable in a wide range of areas. Bit Torrent has huge potential in businesses. Someone can use it for distribution of large les to the users. Downloading large les in a traditional network can be very much time-consuming. Downloading of operating systems, ISO les or security patch update can be done through the Bit Torrent network. It will drastically reduce download time and will increase user's convenience. Organizations, smaller or bigger, can use Bit Torrent network to transfer large les.

The main problem with Bit Torrent nowadays is that it has become a platform for sharing illegal music, videos, movies etc. Most of the contents available in Bit Torrent are not legal, because of copyright infringement like issues. But the positive aspect is that the number of legitimate contents are increasing day by day. Usage of Bit Torrent is increasing especially for downloading Linux distributions. The downloading of Linux distributions from Bit Torrent is preferable because it does not put much pressure on the network like that of FTP or http protocols.

When the version 8 of Opera browser was released, the server crashed because of high network load [50] [51] for downloading the browser. Such situation can easily be avoided with the use of the Bit Torrent network. Nowadays, many of the producers of popular TV shows, deliberately put them in the Bit Torrent.

Also, the trailers of new movies or TV shows are put in the Bit Torrent network [52].

3.1.2 The Architecture of Bit Torrent:

The main components of the Bit Torrent architecture are as follows

a. A tracker.
b. The seeders who are the original downloaders.
c. The leechers who are the end user downloader.
d. A Torrent file for storing static Meta information.

When a user wants to share a le, it creates a Torrent le for that. This Torrent le contains the name of the le, the size of the le, address of itself and some hashing information. Then the user release that Torrent le to the internet. This torrent le can be shared with others with the help of email, HTTP etc.

There are many free and open source software available for creating that .torrent le. This facility is also available in most of the versions of the Bit Torrent application.

If a user wants to download a le with the help of Bit Torrent, then it requires a Bit-Torrent client. There are various versions of Bit Torrent client available in the internet [53]. The versions of Bit Torrent client may di er from one another in some aspects, but the core implementation of Bit Torrent protocol is the same. The Bit Torrent versions may not necessarily be compatible with each other [54]. Once the user has downloaded the Bit Torrent client application, he or she has to search for the torrent le on the internet. Once the user opens the torrent le in the Bit Torrent application, the downloading process starts automatically. The original downloader, who is downloading the content from the Bit Torrent, is known as \seeders".

Another important component in the Bit Torrent network is a tracker. Trackers, in the Bit Torrent network, help the users and other hosts who have the required les. The tracker keeps track of all the users who are downloading a particular le. In the beginning, the users who are willing to download some les, give some information, like which le it will be downloading, the port number it is listening on to, is given to the tracker.

In return, the tracker gives the IP addresses of all the hosts who have pieces of that le. It may be noted here that the tracker does not involve in the actual le transfer between the peers. It simply assists the peers to share the les among themselves. A peer can contact the tractor with the help of a simple protocol which is built on the top of HTTP. The group of peers who are downloading the same le or who are sharing the same Torrent le is said to form a \Swam".

Now suppose, the user has successfully built the. Torrent le and shared it on the internet. But still, there is no guarantee that the le will be shared in the Bit Torrent community. The reason behind it is the original downloader, also known as the seeder. The seeder has to make sure that at least one copy of the entire le has been downloaded by other users.

Until or unless one copy of the entire le is downloaded, the seeder has to keep the uplink open. Once the downloading is complete, the seeder can stop uploading and the downloading process at the other end will continue as long as someone is downloading the le. Here it seems to be a drawback with the Bit Torrent model.

If a popular file is shared in the network, even if only one seeder has downloaded the le, the entire copy of the le will be available in the network. It is because some peer will have downloaded some portion of the le from that seeder. But if the le is not a popular one, then the seeder has to keep the connection open for longer period of time. Since the le is not a popular le, a few number of peers will be downloading that le. Now if some of the peers become offline, then some portion of that le will be missing from the network. The downloaders who used to download les from the seeders are called \leechers"[53].

Bit Torrent provides data authenticity with the help of SHA-1 algorithm. As per Bit-Torrent protocol, if a user wants to distribute a le over a network, the le is broken into smaller-sized pieces. The size of the le can be 512 KB or 256 KB. Then, for each pieces, SHA-1 hash codes are calculated. This hash code is included in the Torrent le. Once the pieces of a le are downloaded, SHA-1 hash code is calculated and compared to the codes mentioned in the Torrent le. So, with the help of SHA-1 hashing algorithm, the pieces of les are checked for errors and authenticity. After successful completion of the download of a piece of the le, the host tells about it to all the members of the swarm. So that the piece of the le can be downloaded, if required by someone else.

3.2 The Bit Torrent Algorithm:

In most of the peer-to-peer networks, a peer can download a le from only one peer. Here, the downloading peer chooses another peer by itself. The advantage with Bit Torrent protocol is that a computer can download the desired content from more than one computer. The selection of these computers or peers are not done by the user itself. It is done by the BitTorrent application. As we have already mentioned, a le is broken down into a number of pieces. These pieces are of sizes of 512 KB or 256 KB. These pieces are again broken down into smaller pieces of 16 KB sizes. Here, the smaller pieces are referred as sub-pieces. If numbers of computers, participating in the BitTorrent network, are having the sub-pieces then requesting computer can connect to multiple numbers of computers and start downloading them simultaneously. But, the breaking of the content into smaller pieces has introduced the problem of selection of pieces which are to be downloaded rst.

Care must be taken while downloading the pieces and its sub-pieces because wrong selection may result in degradation of the quality of service of the BitTorrent network.

But, fortunately, BitTorrent has solved the problem by introducing the piece selection algorithm. Choking is the problem faced by the BitTorrent where a peer or a computer does not let others download a piece of the desired le. Such type of problem causes troubles in resource allocation.

3.2.1 The Algorithm for Piece Selection:

Smart and efficient piece selection algorithm is very much required in the BitTorrent algorithm. If improper selections of pieces are done, then the BitTorrent network will be having the pieces which are readily available in the network. The rare pieces of the le will disappear slowly from the network. Thus, it will affect the performance of the network. The primary objective of piece selection algorithm is to make an exact copy of available different pieces of the le on the different computer as quickly as possible.

Replication of the pieces of le or contents will increase the download speed at peers. Also, this makes sure that the whole le, that is, all the pieces of the le are available somewhere in the network.

BitTorrent works on the top of traditional computer network architecture. Hence, it uses transmission control protocol, also popularly known as TCP protocol, beneath it. Therefore, it is always required to constantly transfer data in the network otherwise it will result in a drop in data transfer rate. To keep the data transfer always up, the protocol keeps at least 5 requests for sub-pieces in the pipeline. Whenever download of one sub-piece is done, the next request is immediately sent. All the sub-pieces are generally downloaded from different participating peers which greatly reduces the download time [55].

Different piece selection strategies are mentioned below:

Strategy Number 1:

The rst strategy is also known as a strict strategy. Assume a peer has to download pieces numbered from \i" to \n", where \i" and \n" are serial numbers of the pieces. Here all the pieces have sub-pieces. If one sub-pieces of the piece \i" is downloaded, then preference to download all the sub-pieces of the piece of \i", will be given. The downloading of sub-pieces of rest of the pieces will start only after when downloading of sub-pieces of a piece \i" is over. [55].

Strategy Number 2:

The most important strategy which is incorporated in the BitTorrent protocol is \Rarest rst". According to this strategy if a peer has to decide which sub-piece is to be downloaded from the available list, then the peer will download the rarest sub-piece rst [55] [51]. There are many reasons why the nearest rst strategy is employed. Some of them are mentioned below:

In the beginning, when a new le is uploaded in the BitTorrent network, the seeder will be the only peer who is having the complete piece. Because of which there will be a bottleneck like situation in the network. A computer or a downloader who is participating in the swarm can easily see which peer is having what sub-pieces. The rarest rst policy will make sure that only the pieces which are fewer in instances, will be downloaded rst.

One of the other advantages of rarest rst strategy is that it encourages uploading. A rare piece of a le is the most sought after. Therefore, many of the interested peers will be uploading to the host who is having the rarest piece of the le. Rarest rst strategy also increases the download speed of a le in the BitTorrent network. Because of the strategy, all subparts of pieces of a le, are available to different peer on the network.

This gives the downloader many options to download from. As a result, a downloader connects to multiple peers to download sub-pieces of a le resulting in increased download speed.

Another merit of rarest rst strategy is that the most common pieces of a le are downloaded last. It is because since the piece of the le is available readily in the network, so the probability of being able to download that piece of the le is higher. One of the major advantages of using rarest rst strategy is that this algorithm prevents missing of any of the rarest pieces.

Strategy Number 3:

This strategy is also known as \Random rst piece". At the beginning, when a new le is uploaded in a BitTorrent network, it is not possible to download a piece of that le very quickly. It is because most of the peers do not have that le and they try to download that le from the seeder as soon as possible. As a result, a bottleneck is created at the seeder's end. Therefore \rarest rst strategy" is not suitable for a peer who has just joined the network, started downloading and don't have anything to upload. Now, if the downloader, implementing only \rarest rst strategy", waits for the rarest le, the efficiency of the network will decrease drastically. To avoid such problems, \random rst piece" strategy is adopted. Therefore, the downloader selects the rst piece of le randomly to download.

Strategy Number 4:

This strategy is also known as \Endgame mode". A downloader can download a piece of a le from many numbers of peers. This reduces the download time. A piece of a le can have many sub-pieces. Now, because of some reason, if the downloading time for a sub-piece has increased dramatically, this will result in a delay in downloading of the pieces of the le. Therefore, in this type of situation \Endgame mode" is employed, where the connection, which is causing too much of delay, is terminated forcefully. In such a situation, the request for that sub-pieces is broadcasted in the network. This helps downloading the piece of le as fast as possible [55].

3.2.2 Resource Allocation between Networks:

As we have already discussed, there is no central server in a BitTorrent network. So it is not possible to allocate resources by any central entity. Therefore, it is the responsibility of the downloading peers to allocate resources for themselves. Obviously, a peer will try to download the desired le as quickly as possible, and resource allocation, for downloading a le, is better handled by themselves. In order to decide which peer to be allowed to upload to, a \tit for tat" strategy is employed. This strategy originates from repeated game theory. This strategy works on the principle of cooperation and reciprocation [56].

3.3 The Choking Algorithm:

The choking is one of the popular terms that we hear when talking about BitTorrent algorithm. In relation to the BitTorrent algorithm, choking means the refusal to allow uploading of data to another peer temporarily. The peer which has been choked, still allows data to download from. In the BitTorrent network, the peer which do not co-operate in uploading les are choked.

The fundamental principle behind choking is to allow uploading to hosts (peers) who have recently uploaded a file to you. The basic fundamental question in the implementation of choking algorithm is how to decide which peer is to be choked and which peer is not to be choked. The number of peers which are to be un-choked is determined by the algorithm. By default, it is set to four. The algorithm takes the help of current download data rates to determine which peer is to be unchoked. 20 seconds is the average time chosen to decide this? But due to the limitation of TCP protocol, frequent choking and un-choking is not possible [55]. Therefore, it is calculated after every 10 seconds.

The choking algorithm makes sure that any peer will upload les to peers which are offering one of the best download data rates. In another word, we can say that if a host is having higher upload data rate, then other peer or host will allow it to download les from them. From this, we can conclude that a host or a peer will have maximum download data rate if it has higher upload data rate. The algorithm is one of the most important algorithms in BitTorrent protocol as it discourages \Free riders". The free Riders are those peers which only download les from the BitTorrent network but does not upload les to it.

The BitTorrent protocol is the peer-to-peer protocol where a corporation from all the peers are required. Therefore all the peers should contribute to make the network more versatile and efficient. Other peer-to-peer networks don't o er choking algorithm because of which other networks suffer from inefficiency. Since the BitTorrent protocol is having the choking algorithm, the protocol has become so popular.

3.3.1 The Optimistic Unchoking:

The BitTorrent protocol allows unchoking of one choked peer. The un-choked peer can be anyone from the choked Peer. One of the choked peer is unchoked optimistically. They are unchoked only for 30 seconds. After 30 seconds, some other choked peer is unchoked. 30 seconds is enough to attain maximum speed for downloading. The main reason for optimistic unchoking is to find any unused connection which might o er better download data rates than the used ones. If a better connection is found by unchoking, then it replaces the existing connections.

3.3.2 Anti Snubbing:

Suppose, a peer is downloading a le from a number of peers. But suddenly all the peers snubbed it and the downloading process stops. Now, what can the downloading peer do? It cannot rely on optimistic unchoking mechanism since the unchoking mechanism unchokes a choked peer only after 30 seconds and that too if it is an unused connection. So for overcoming such type of situation, the concept of \Snubbing" is introduced. If a client A is snubbed by another client B i.e. client B stops uploading data for client A, then in retaliation client A also stops uploading data for client B. The \snubbing" works on the principle of \tit for tat". Then the client A will increase the number of optimistic un-chokes in order to find new and faster connections [55] [52].

3.3.3 Traffic Management:

The popularity of BitTorrent has increased significantly since its introduction. When BitTorrent was introduced, there was no significant mechanism to handle a large amount of traffic it generated. Because of which BitTorrent data traffic was treated equally as that of other real-time services such as VoIP. Thus BitTorrent data traffic c used to have adverse effects on overall network data traffic. But now this problem has been solved the problem with the introduction of \bulk traffic markers". This marker helps distinguish between BitTorrent data traffic and data traffic from other network or services.

Now any standard data traffic shaping tool can manage the traffic generated from the BitTorrent network and it can pass through any slow network more easily [48].

Decentralized Tracker:

One of the major problem, that the BitTorrent network faced, was that it was not fault tolerant. There was a single point of failure. In a bit torrent network, thousands of peers communicate with each other in order to transfer les. Each and every peer know one another with the help of the tracker. If somehow the tracker is compromised, the participating clients or peers will not be able to find one another. Also, because of the same reason, the central tracker is subjected to a various type of attacks such as Denial of service attacks. Decentralized trackers were introduced in the BitTorrent network to solve above-mentioned problems. Decentralized tracker was rst introduced in the year 2005.

The user has the option to use centralized tracker or decentralized tracker.

The decentralized tracker system in BitTorrent, every client or peer works as a tracker. Distributed hash tables (DHT) are used to handle different decentralized trackers. Distributed hash tables make possible to share a le in the BitTorrent network with a minimum number of resources. The downside of such a system is that there is no guarantee in terms of reliability [57]. One of the merits of such type of system is that any new user who has very little experience or no experience with the BitTorrent network can easily share the torrent of the le which it wants to share with the help of any website or blogs. But the website owner may have to pay a high amount of money to the internet service provider since it will be generating a huge amount of network traffic.

Cohen, the founder of BitTorrent, thought it as injustice. Because TV broadcasters need not pay huge amounts depending upon the number of active viewers. A TV broad-caster has to pay the same amount if there are only one hundred viewers or if there are millions of viewers. Therefore, Cohen decided to remove trackers from the websites. Now the website owner need not worry about the huge traffic it generates. Since the website will be having only the Torrent le, whose size is in kilobytes, there will be less traffic. So, the owner of the website will have to pay a little amount of money. The web server will not be used for keeping track of all the users.

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Chapter 4

Video-on-Demand System

4.1 Video-on-Demand System (VoD):

Video-on-demand system (VoD) is a type of system where a user or consumer can demand a video to download and watch. Here, the consumer can select and watch or listen a video or audio such as Cinemas, movies, TV serials songs etc as per their will or demand. The user does not depend upon the scheduled broadcast time or the general broadcast method of over-the-air programming.

IPTV systems are generally used for bringing Video-on-demand services to the television as well as to the personal computers [4]. Today's Video-on-demand services, available in the television, can have the content streamed to television either using set-top boxes or any such similar devices. This system allows viewing the video content in real time or download the content to the devices such as a digital video recorder or portable media player for viewing at any desired time.

The major services provided by on-demand content provider are as follows:

a. Video-on-demand streaming where a user can choose a video as per his/her interest and play it instantly with little delay.
b. Another service provided by the content provider is that it allows downloading of the content to the DVR (Digital Video Recorder) for future viewing.
c. Nowadays, internet television has got a lot of popularity because of its own Video-on-demand services. The Video-on-demand services can be accessed via any portable tablet, laptops or even mobile.
d. The Video-on-demand services are even provided inside the airplane. The onboard entertainment systems for the passengers in aero plane also provide such type of Video-on-demand services.

One of the popular Video-on-demand services provider is Net ix. The Net ix uses the subscription model. In this model, the user has to pay a monthly rent for the subscription and the user can watch any of the video available on Net ix at any time and there are other Video-on-demand services which are freely available but it is based on advertising based models.

Functionality:

There are many advantages of Video-on-demand services. The main advantage of Video-on-demand services is that it provides all the features that are available in portable media player and DVD player.

Many of the videos of the Video-on-demand services systems such as a television set sometimes have a hard disk in it, so that the downloaded content can be stored there.

Also, some systems have memory buffer which helps in fast forwarding and fast rewinding the videos being played. These features add the fast forwarding and fast rewinding of traditional media players into the modern Video demand service systems and it has evolved into many forms. The cable provider companies have tailored the Video-on-demand services into their systems. Many of the cable service providers has launched its own apps for offering Video-on-demand services. Now, the consumers can assess the service and order a particular video on the local cable network.

The consumer can watch the video from any device which is internet compatible. Also, the cable providers have bundled the app with radio streaming services. Some apps provided by the cable operators are voice enabled. Here, the consumer has to use the phrases like \go" or \watch" for watching videos like news reports etc in real time [58]. Another approach for providing Video-on-demand services is via a wide area network. With the help of wide area network, the Video-on-demand services is provided to the community. But there is a catch. The responsiveness of the Video-on-demand system is reduced.

4.2 History of Video-on-Demand System (VoD):

The earlier Video-on-demand systems used to use tapes for providing the contents in real time. But soon these tapes have been replaced by discs and DRAMs [59]. In the early 1980s, ATT; T was a leading player in Video-on-demand services, but it has to break up into a number of smaller telephone companies because of an antitrust lawsuit led in the US. These smaller companies are used to be called as \Baby bells".

Then, the US government's cable communication policy act 1984 forced these baby bell companies not to provide Video-on-demand services in their respective regions.

Letter on, the national communication and information infrastructure was proposed by the government and it was passed in US house and senate which allowed this baby Bells companies to provide Video-on-demand services in the United States of America. These baby bell companies include Bell Atlantic, Bells Ameritech, Bell south, Pacific Telesis, Southwestern Bell, and US West. Now, these companies with proper permission started trials of advanced systems for supplying Video-on-demand services over the telephone as well as cable networks.

One of the bell companies originated from ATT announced a successful trial of Video-on-demand services in the early 1990s. By the same time, IBM also had started developing a system for Video-on-demand services and named it as \Tiger Shark". Digital-Equipment was also another company which was involved in the development of scalable video service required for Video-on-demand service. In 1993, there was a collaboration between Bell Atlantic and IBM which resulted in the rst Video-on-demand services over ADSL. This was the rst commercial rollout of Video-on-demand services outside the laboratory of any research institute. This service provided 50 video streams. In the middle of 1993, one of the \Baby bells" companies called US West led for a system which consisted of a digital interactive information server, network and the setup box. The scientific Atlanta was supposed to provide networks for the led system and 3DO Vastu to provide set-top boxes. These set-top boxes were supposed to be deployed to more than 2500 families in USA. Then, in 1995, a company namely US west led for providing Video-on-demand services in many of the cities of the United States of America.

They claimed they had more than 3 lakh subscriber, that too, only in one of the smallest states of USA namely Denver. They also claimed they have near 3 lakhs and 1.5 Lakh subscriber in Minneapolis and Portland respectively.

Before rolling the Video-on-demand services in the USA, companies had to try a various combination of service, network capacity infrastructure and set-top boxes. Domain companies were also trying their hand in Video-on-demand services. Telecommunication companies didn't remain far behind. They were using Servers from Microsoft, USA video, Hewlett Packard, nCube [60] [61] [62] [63] for Video-on-demand services. The DEC server systems were more frequently used than any of the servers mentioned here. DEC was more frequently used and popular because the DC servers used interactive gateways for streaming videos. The DEC Video-on-demand service servers were capable of delivering a large amount of content from VAX server to more than 100000 users that too with complete VCR like functionality. That is, fast forwarding and the fast rewinding facility was provided by the DEC Video-on-demand servers. More importantly, this VCR like functionalities were provided in early 1990s [64]. By the year 1994, US West upgraded its DEC Video-on-demand server. The up-gradation was made to DEC Alpha computer which act as Video-on-demand server. This up-gradation allowed the company to add more numbers of consumers to the Video-on-demand service.

But, by the same time, Oracle also introduced Video-on-demand services. The consumer base also increased from near 500 to 30000. Also, the consumer base for SGI systems also increased to 4000. This means by the end of 1995 Video-on-demand services got used to popularity in United States of America [65].

The popularity of Video-on-demand services was not only limited to the United States of America. The service also got popularity in the United Kingdom. It is evident from the fact that Video-on-demand services contributed a major part in Cambridge digital interactive television trials [66]. The United States of America has the highest contribution in making a Video-on-demand services popular.

The Video-on-demand services is now available in all the states of United States of America and in the majority of Europe. The Video-on-demand services applications are also becoming popular in the developed countries of Asia such as Japan and South Korea. Lately, the Video-on-demand services are also getting popular in China. Net ix and Amazon Prime are the examples of Video-on-demand services. These are the two companies trying to infiltrate the Indian market. The Net ix contents in India has increased much more as compared to other country [67] The Video-on-demand services is normally a video delivery mechanism. But, this delivery mechanism has to comply with the local as well as International laws applicable. The idea of Video-on-demand services can be traced back to peer-to-peer networking. Peer-to-peer networking is a networking for sharing les.

The model of p2p networking has shown that the burden of sharing of newly created content to the world can be divided among the peers. This means, the content creator can be relieved from the task of sharing the video to the consumers. The job of sharing the created content or videos can be done by the Video-on-demand services very easily and efficiently.

The job of sharing of created content or video is not an easy task especially because of the cost associated with centralized streaming services.

Many of the popular Video-on-demand services can even streams popular movies with-out any cost. Torrent is another alternate option for sharing the media les and it consist of more than 6% of the global network traffic. One of another emerging reason for the popularity of peer-to-peer network based Video-on-demand services is net neutrality. Recently, Net ix has switched to peer-to-peer based model in order to solve the problem associated with net neutrality.

4.3 Video Distribution Models in Video-on-Demand Services:

There are many models which are popular for video distribution in Video-on-demand services. Some of them are listed as below:

4.3.1 Push Video-on-Demand:

As the name suggests, push Video-on-demand services pushes the video content to every consumer's set-top boxes without the knowledge of the consumer. The consumer has no idea what contents are supplied to its set-top boxes. The main reason it is done because of the network problems prevailing in the area of the consumer. If the bandwidth of the network for the consumer is not at par quality, then the full VCR functionality cannot be provided. That is, if the network quality is poor, then fast forwarding or fast rewinding will not work properly and sometime the quality of video provided by the service provider will also degrade. To solve this problem, what the video-on-demand service provider does is that it simply broadcasts all of its content to the set-top box while the consumer is watching some other video. Now, when the consumer requests for the video, the video can be immediately played.it happens because the video is already available in its set-top box. The downloading of the video to the set-top box is generally done while some other video is being played or overnight time. Therefore, the consumer can watch the downloaded video as per his or her will. But, length of the downloaded content is limited, so the options available are also [68].

The set-top box used in such type of Video-on-demand services is almost similar to that of PVR. The set-top box has his own hard drive. But still there is a limitation. The limitation is that the hard drive present in the set-top box has limited space.

So, the contents stored in set-top box will be deleted after some time automatically so as to accommodate newly downloaded content. Recently, new push Video-on-demand services set-top box has been introduced in the market. This set-top box has the latest error correction codes which can drastically reduce the size of downloaded content. Another advantage of the newly introduced set-top boxes is that it can free a significant amount of the network bandwidth. Also, it can deliver e-journals or iterative application such as games alongside videos and movies.

4.3.2 Subscription Models:

Like traditional cable services, Video-on-demand services also works on monthly or yearly subscription models. The consumers are charged on a daily basis. There are many versions of subscription models available. In some substitution models, few months of free access are given. Some of the service providers which follow subscription models are Amazon prime videos, Net ix, now TV, Hulu Plus etc.

Subscription based Video-on-demand services business model has attracted the attention of many lm industry and TV industries. Many of the content providers such as movie creator and TV industries have launched original contents only for peer-to-peer based Video-on-demand services such as Net ix, Amazon prime videos.

By July 2018, Net ix is supposed to have more than 50 original movies in it [69]. Many of the Video-on-demand service providers are also investing heavily in content Creations. For example, Hulu has invested millions in creating contents only for Video-on-demand services. Similarly, Amazon also invested heavily for content creation for kids, Amazon prime videos. Because of the popularity of the contents available in Amazon prime videos, Amazon has appeared in 2017 Cannes Film Festival in France. Till now subscription based Video-on-demand services are highly successful and it will continue to go more [70].

4.3.3 Transactional Video-on-Demand Services:

Transactional Video-on-demand services is another type of video subscription method where the user has to pay for each video it has watched or viewed. This type of services are available with traditional TV where a set-top box is attached. Now, if a new movie was released, the consumer can directly buy the movie in the TV itself and watch as per its convenience. The transactional Video-on-demand services has two categories. The rst one is \Electronic sell through" which is also known as EST. The second one is \download to rent" which is also known as DTR.

In the rst approach the customer of the content can permanently keep the downloaded video which is downloaded via Internet or through set-top box. But, in the second category the user cannot store the downloaded video permanently in its hard drive. The user has to watch the video in the given time frame. When the given time frame expires, the video automatically gets deleted. The user cannot transfer the downloaded video from the set-top box to any other hard drives [71] [72].Some example of transactional Video-on-demand services Apple's iTunes online store and Google Play service.

4.3.4 Catch-up Televisions:

Catch up televisions are the televisions which o er repeat telecast of already aired contents. This type of televisions are very useful when the consumers or the users have not viewed or watched the live television program. Numbers of users watching catch up television programs are increasing day by day. So, the number of television channels offering catch up TV also increasing day by day. The important things to note here is that gives catch-up TV are based on peer-to-peer based Video-on-demand services. This type of televisions empowers the users to watch the video when they have free time even if days have been lapsed when the programme was originally broadcasted on the television [73].

4.3.5 Near Video-on-Demand:

Near Video-on-demand service system is a special case of subscription-based Video-on-demand services. In this type of Video-on-demand services, the user has to pay on per view basis. The main disadvantage of near Video-on-demand system is that it needs very high bandwidth for transmission of the video.

Such type of Video-on-demand services are generally used by multichannel broadcasters having a content distribution mechanism through satellite and cable television. Here, multiple copies of the same video is broad-casted repeatedly within a short interval of time. That is, if a video is broadcasted at 1 a.m., then the same video will be broadcasted again at 1:15 a.m. and again at 1:30 a.m. and so on.

This way the user can start watching the video or the movie after waiting very less amount of time. The problem with such type of Video-on-demand services is that it is very bandwidth intensive. The distributor of the video has to use a numerous number of channels for providing the video. So, only very large Corporation or operators who are having a very redundant capacity can employ such type of content distribution mechanism. Because of which, such a type of distribution mechanism has become very unpopular, especially with the introduction of a newer version of Video-on-demand services.

Nowadays, only a few companies are providing near Video-on-demand service experience. Only the satellite Dish network and direct TV are continuing to provide such service because most of the consumer base of this network provider do not have a broadband or high-speed internet access. At the peak of the popularity of such service, some content provider provided 40 channels in early 2000[74]. Near Video-on-demand services are now only limited to covering some events such as live Sporting events like wrestling, boxing, and music concerts. In many parts of the world near Video-on-demand, services are used to o er newly launched movies only.

4.3.6 Advertising on Video-on-Demand Services:

One of the main methods for revenue earning for Video-on-demand service provider is advertising. For this, the content provider uses the advertising-based revenue model. In such type of models, companies can broadcast their advertisement to the target audience. Here, if the user watches the advertisement, then he or she can assess the video content without paying any Subscription depending upon what point is earned after watching the advertisement. Hulu is one of the pioneer advertising Video-on-demand service provider. But, the company has discontinued providing free access to the contents by the end of 2016 [75] [68]. The problem with such type of advertising on Video-on-demand services is that the consumer will continue to get the same advertisement over again and again while watching the video. To solve this problem, a company named crackle has introduced the concept of a variable advertisement for the same video.

In this concept, a series of different advertisements are collected together, and they are broadcasted to the consumer watching the same video by calculating some properties. A consumer watching a video will get different advertisements from the set of collected advertisements depending upon the time of the day and duration of the video been watched.

4.4 Peer to Peer Network Topologies:

Peer to peer network can be classified into two categories

a. Pure peer-to-peer networks
b. Hybrid peer-to-peer networks

Gnutella and Free net are examples of the pure peer-to-peer network. This network doesn't have any Central server. Next-year group and Maggie are the examples of a hybrid peer-to-peer network. Unlike pure p2p network, it uses a central server to obtain Meta information for identifying authenticated peers. This Central server is used to store the security credential of participating peers. In Hybrid p2p network, each and every peer has to communicate with the central server to make communication with other taking part peers.

The population peer in the peer-to-peer network may be different but all the transfer of les must be done through the data connection which is made between the serving beer and the requesting peer [76]. The control structure for sharing the le may be different for different types of network. As per [77], the peer-to-peer network can be categorized into four categories based on the structure of le sharing

a. Centralized Peer to peer networks
b. Decentralized Peer to peer networks
c. Hierarchical Peer to peer networks
d. Ring based Peer to peer networks

The mentioned type of peer-to-peer networks can exist on their own. But today's network architectures have become more complex as two or more types of basic network topologies are combined together to form a network known as a hybrid network. In the next section, we have described the basic peer-to-peer network topologies.

4.4.1 Centralized Topology:

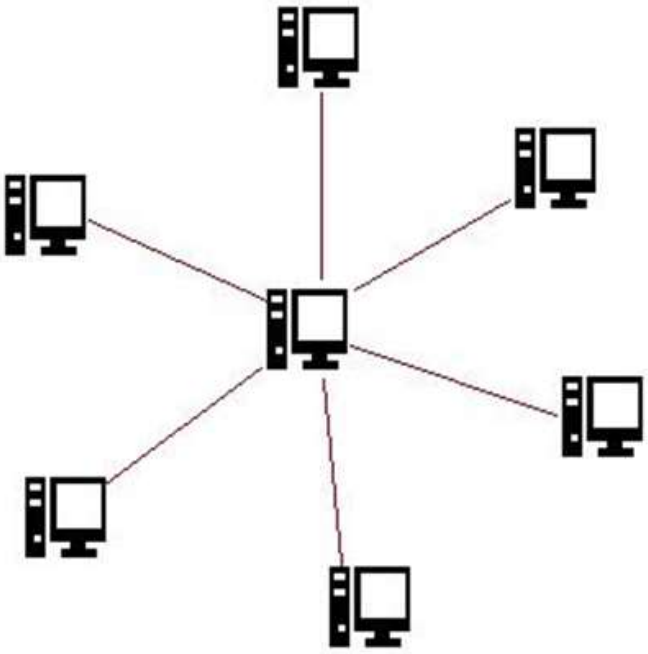

Figure 4.1: Centralized Topology

The figure given below shows the structure of satellite Technology. This type of topology is influenced by the traditional client-server model. Here, each and every peer participating in a network is directly connected to a central server. The function of the central server is to manage the list of connected peers and the available resources with the peers. The satellite server also maintains logs for different activities. In this type of network, each and every peer rst communicate with the central server to declare its IP address and a list of les it is willing to share with the network. This process is repeated every time whenever the application associated with the p2p network is launched. The information gathered by the central server from the connected peers will be used by it to create a database of available contents and a list of IP address who are willing to share that. Whenever a peer requires a content, it requests to the central server. Then the central server makes a search for the content in its database. Once the content is found, then the IP address of the peer having it is shared with the requesting peer. Then the connection is established between the requesting peer and the peer having the contents. Here, a direct connection is established for transferring the le [78]. It may be noted that in no circumstances, the central server stores the actual data.

4.4.2 Ring Topology:

As the name suggests, the structure of the ring topology is like that of a ring. This means that a computer is connected to the next computer and the next computer is connected to the next computer and so on. The last computer will be connected to the rst computer. The main advantage of the ring topology is that it overcome the primary requirement of centralized server model. The central server, in a centralized p2p model, becomes a bottleneck and susceptible to link failure resulting in the complete network failure. The advantage of the ring topology is that, since in this topology, a cluster of machines is arranged in the form of the ring, it acts as a distributed server [77].

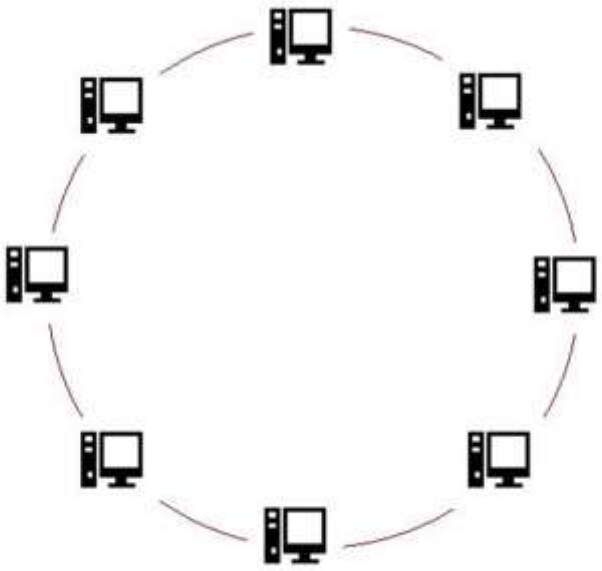

Figure 4.2: Ring Topology

As a result, the ring topology better in load balancing and load management. Also, this type of network makes the higher availability of contents. But, this topology has also got some disadvantages. The main disadvantage here is that the ring topology can be made only when the participating peers are relatively close in proximity. This means such type of topology is only possible in a single organization only. The figure above shows a simple ring topology.

4.4.3 Hierarchical Topology:

This type of topology is another popular topology and has been around for a quite a long time. This type of topology is an inheritance in the begin of human civilization. The government, corporations, military etc. all work in a hierarchical fashion.

In fact, the service provider of the internet also works in this fashion. This type of topology is used where some form of control, authority, or governance is required.

Another example of such kind of topology is that of certification authorities (CAs). The main job of the certification authority is to verify and validate any entity on the internet. The figure below shows heretical topology.

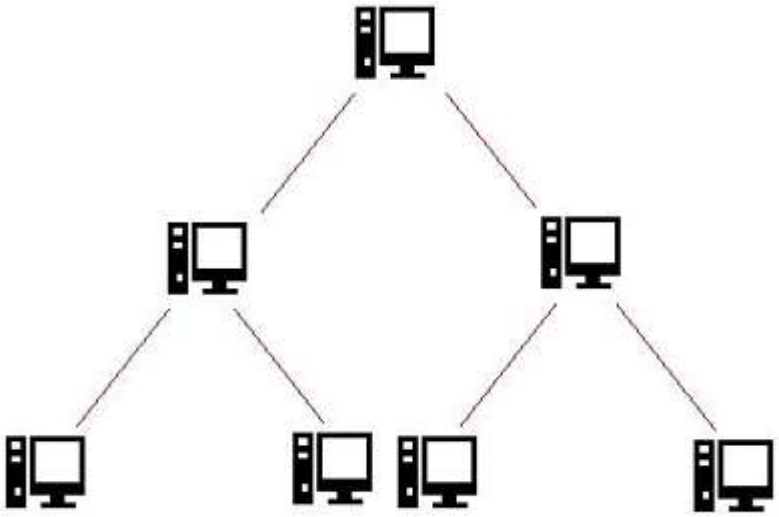

Figure 4.3: Hierarchical Topology

The node at the top of the hierarchy is called the root node and all the nodes connected to the root node are called children of that node. So, in order to do something, a child node has to take permission from its parent node, which is the node to which the child node is directly connected.

4.4.4 Decentralized Topology:

Decentralized topology is an example of pure peer-to-peer network architecture. In this type of topology, there is no Central server. All the participating node in decentralized topology are equal.

If a node wants to connect to such type of topology, then it must contact a specially designated node which is always online.

This specially designated node is known as bootstrapping node. Bootstrapping node gives IP address of a few already connected peers to the connection requesting peer. Now, by connecting to the given IP address, the requesting Peer can become part of the network.

Since the topology of this type of network is decentralized, there is no particular shape or size of the network.

A decentralized topology can vary from other decentralized topology in terms of number peer, size of the network or even in the structure of the topology. The figure below shows the structure of decentralized topology.

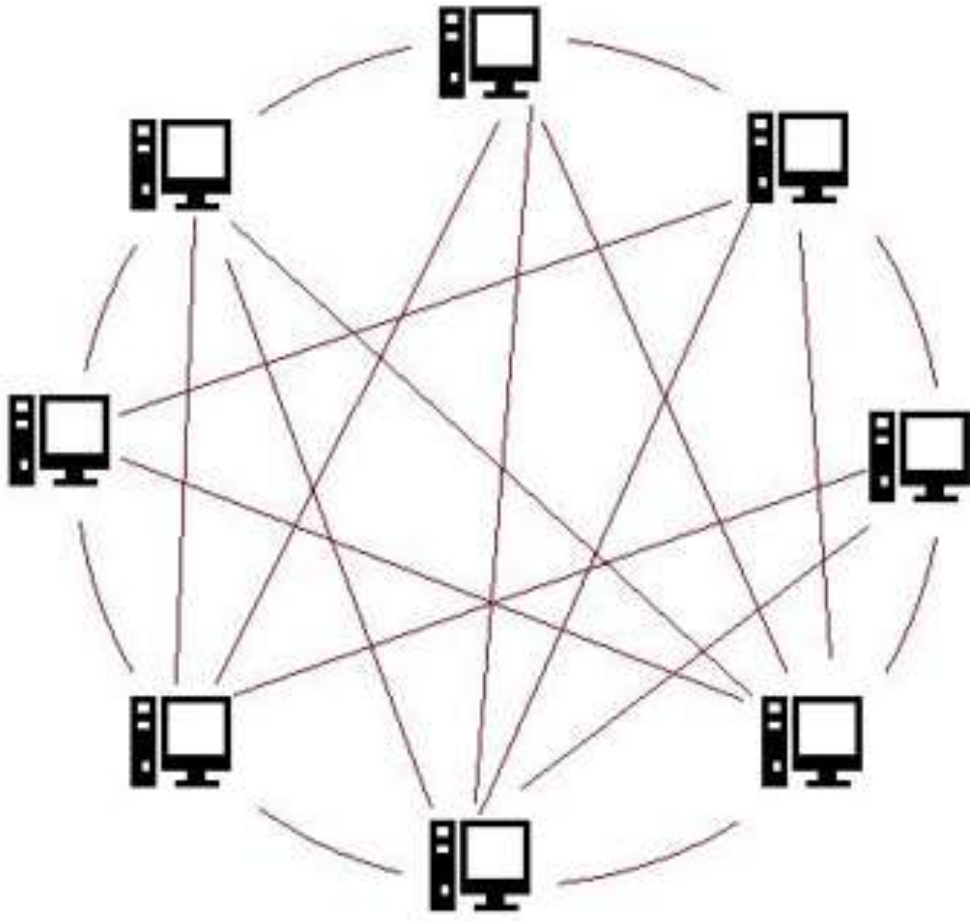

Figure 4.4: Decentralized Topology

Since there is no particular structure of this type of topology, the whole network is often flooded with queries. Sometime, it even causes congestion in the network [78]. One of the prominent examples of decentralized topology is Gnutella.

4.4.5 Hybrid Topologies:

The hybrid topology is an example of real-world topology which uses a combination of two or more topology. In this type of topology, a particular machine or node is required to play more than one role. Some of the prominent example of hybrid topology are listed below.

A. Ring Topology And Centralized Topology:

This combination of topology is very popular in the world of web hosting. The core of this type of topology is a ring topology which is surrounded by connecting nodes. The figure below shows the hybrid topology of the ring and centralized topology.

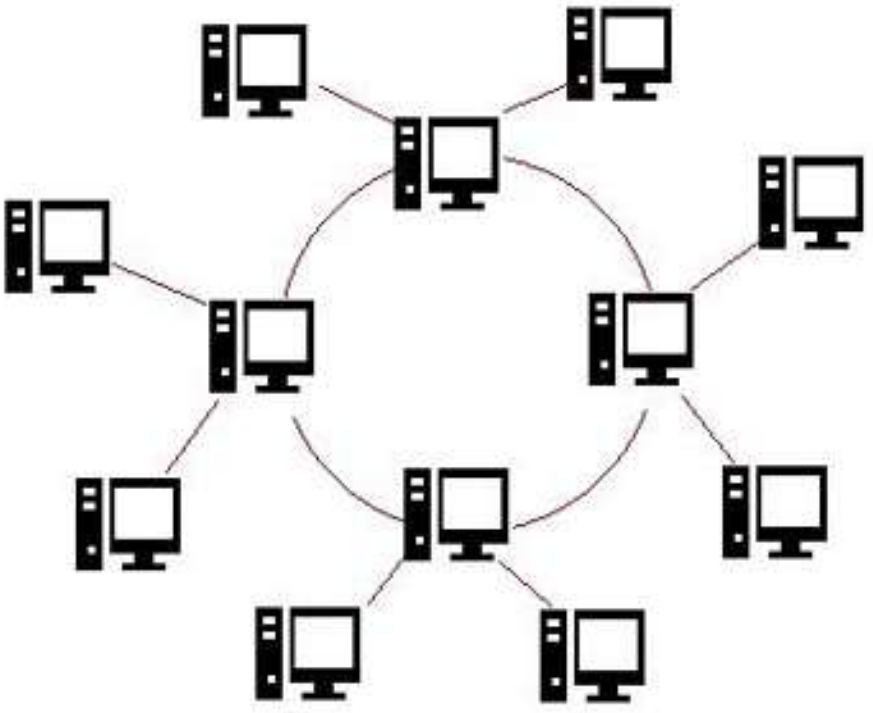

Figure 4.5: Hybrid Topology (Ring & Centralized Topology)

As mentioned in the previous section, a ring topology is better suited for load balancing and have a very low rate of failure.

This property of ring topology has been exploited in the hybrid topology.

Here, all the connecting peers are connected to the network in the form of the ring.

Hence, we can say the entire system is of hybrid structure, that is, it is a mixture between ring topology and centralized topology. This type of hybrid topology has the advantages of both sturdiness of the ring topology along with the centralized topologies' simplicity.

B. Centralized and Centralized Topology:

This type of networks are the networks which have a structure of centralized topology and are connected to other networks in centralized topology fashion.

The figure below shows the structure of hybrid topology which is made up of the centralized and centralized topology.

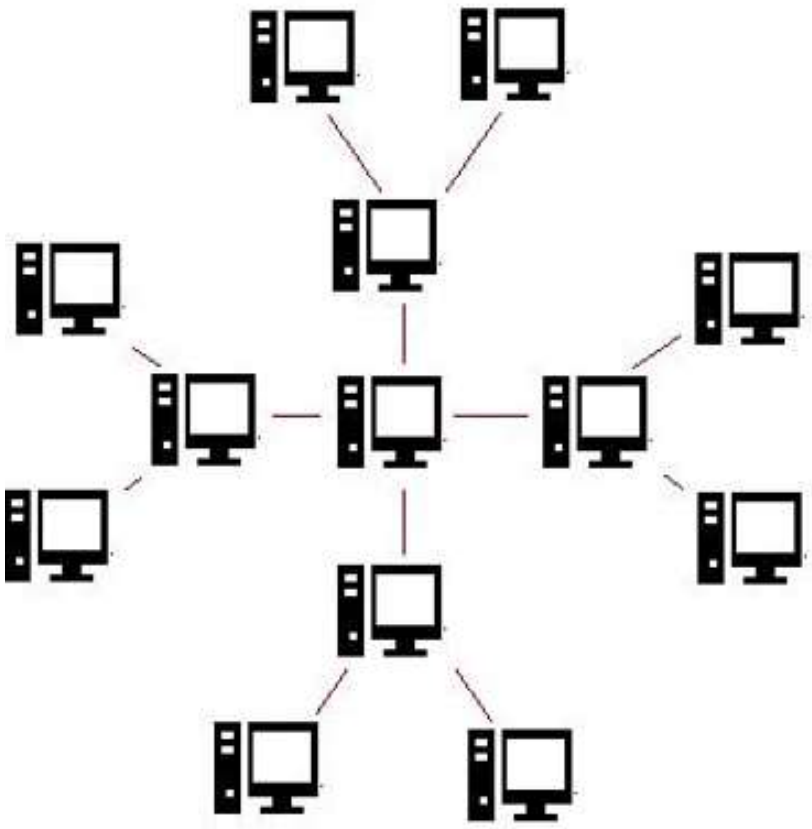

Figure 4.6: Hybrid Topology (Centralized & Centralized Topology)

One example of this type of topology can be any web browser which is connected to the centralized web server. In this case, the web browser contacts web server to get the request in a proper format, say, in HTML format. But while doing so, the server itself may contain different other databases in a different server. This may be required to get necessary requested information.

C. Centralized and Decentralized Topology:

In this type of topology, a centralized topology is combined with a decentralized topology, hence, forming a hybrid topology. In this type of topology, a peer is chosen as the group leader of some section of peers.

This chosen group leader acts as a representation for the section of the Peers. This chosen group leaders are commonly known as Ultra nodes. These Ultra nodes are sometimes also known as super-nodes.

In this type of hybrid topology, the Ultra nodes act as the centralized server and perform all of its duties as the central server. It may be noted here that the Ultra node act as a server only for small portion of peers and these Ultra nodes may be connected with each other in a distributed fashion.

Therefore, this type of topology uses two different levels of control. The rst is when some subset of peers connect to Ultra node and form centralized topology and the second is when all the Ultra nodes connect with other ultra-nodes other in a distributed fashion. The figure below shows a hybrid topology which is made up of centralized and decentralized topology.

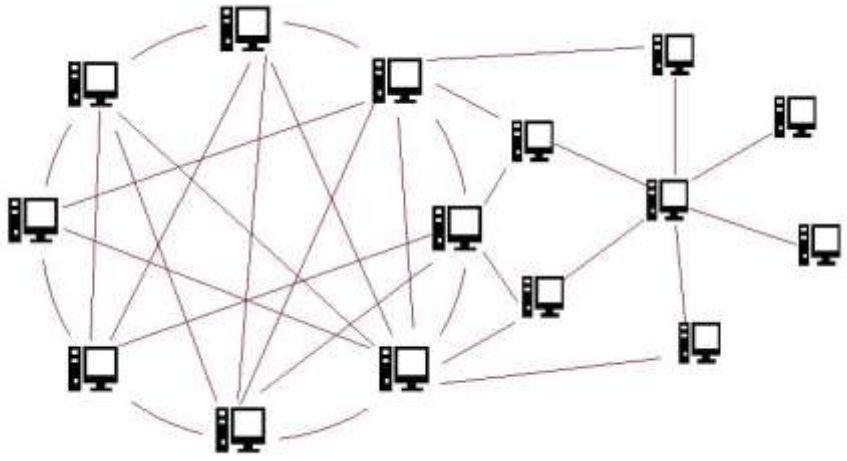

Figure 4.7: Hybrid Topology (Centralized & Decentralized Topology)

In this type of hybrid topology, the Ultra nodes keep track of all the content available in the network along with the IP addresses of the peer who are having the contents. The Ultra nodes keep tracks for IP address and media content only for a subset of peers from which it was chosen as group leader. In the real-world scenario, the node, who is having highest speed of internet connectivity, is chosen as the group leader. The Fastrack and Kazaa are some of the best examples of this type of hybrid topology. Common internet mail systems can also be the example of systems which incorporate this type of topology. The mail server, like the Ultra nodes, also share the mails with other servers in a decentralized Manner.

D. Other Hybrid Topology:

The hybrid topologies that have been described in the above sections are the commonly used ones. There can be more combination of basic peer-to-peer network topologies to form more useful and complex hybrid topologies. As the number of topologies involved in hybrid topology increases, the manageability and security of the network becomes more di cult and hence it is not encouraged.

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About the Book

Advancements and rapid development have led to many ramifications in the ever-changing world of computer networking. This book is structured to trace the advancements made and landmarks achieved in the field. This book not only incorporates latest and enhanced computer networking techniques and practices in the area of peer-to-peer networking but also shows how these techniques are applied into the practical computer networking assignments. The chapters are incorporated with illustrative examples to add analytical insight on the subject. The book is logically organised to cover the expanded and elaborated treatment of all peer-to-peer based video-on-demand services.

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