Advanced Distributed Systems
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Lecture – 16
Bitcoin and Blockchain Technology

Welcome to the ultra-short lecture on Bit Torrent. So, Bit Torrent is one of the most popular file sharing programs peer to peer, network based file sharing programs as of 2021. And this is based on the familiar technology of DHTs; so, this is an ultra-short lecture.

But, before you go forward, I would request all of you to take a look at the videos for Pastry and Chord that are a part of this lecture series; because without understanding Pastry and Chord, this lecture series will this lecture will not be comprehensible. So first, take a look at that and we will only outline few of the basic points, salient features of Bit Torrent. The rest will be fairly clear to somebody who understands distributed hash tables; so overview.

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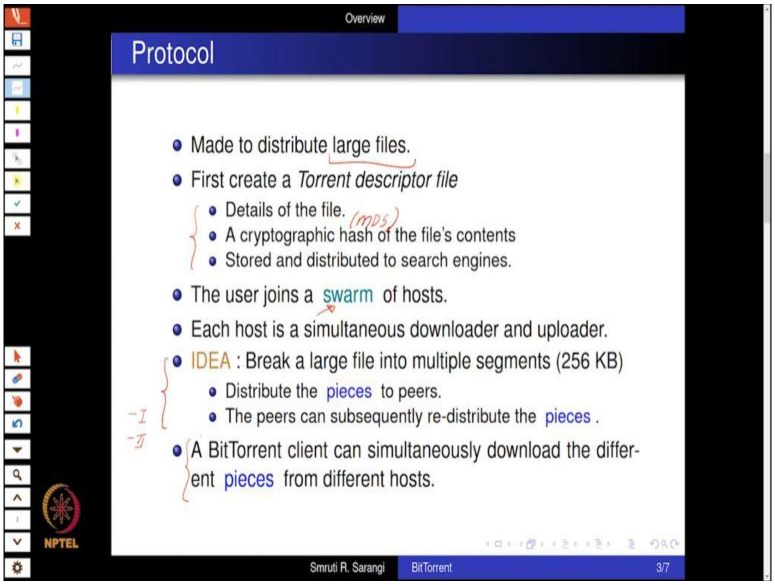

Overview

Protocol

- Made to distribute large files.
- First create a *Torrent descriptor file*
  - Details of the file.
  - A cryptographic hash of the file's contents (MD5)
  - Stored and distributed to search engines.
- The user joins a swarm of hosts.
- Each host is a simultaneous downloader and uploader.
- IDEA : Break a large file into multiple segments (256 KB)
  - Distribute the pieces to peers.
  - The peers can subsequently re-distribute the pieces .
- A BitTorrent client can simultaneously download the different pieces from different hosts.

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So, as compared to Napster and Nutella, that were typically for smaller files like mp3 files and music files. BitTorrent was made to serve large files, or large video files. So, it was the main aim was to distribute large video files. So because of that, it is necessary to kind of re-architect our system. So, the user first the user who is sharing the first creates what is called a torrent descriptor file. The torrent descriptor file has the details of the file, a cryptographic hash of the file's contents.

So, the cryptographic hash is required for integrity; because since we are talking of a large file, and we will discuss how it is actually served. It is possible that some bytes may develop a fault. So, because of that a cryptographic hash is required; so typically, the MD5 hash is used for this purpose.

And then it is stored and distributed via search engines or via peer to peer system. So, the user joins a swarm of hosts; it can simultaneously be a downloader and uploader. So, we have been seeing the same format in other p2p systems as well. We have seen the same in Napster same in Nutella; that the user actually shares a shared directory, where you have songs and videos and so on.

So, since we are talking about large files, such as videos, we break a large file into multiple small segments. So, each segment is 256 KB and these are distributed to peers; so, these pieces of files are distributed to peers. So, this allows the client, the BitTorrent client to actually download all of these segments in parallel. So, this increases the bandwidth and also reduces the time needed to get a file; and furthermore, it increases the robustness of the system.

So, the peers can themselves re-distribute the pieces. So this will further add to the robustness; and pretty much for every file, we will number the segments 1, 2, 3, 4 and so on; and we know how many segments there are.

So, these segments will then come from different parts of the network. So, the BitTorrent client, which is a piece of software that every user needs to install, can simultaneously download the different pieces from different hosts.

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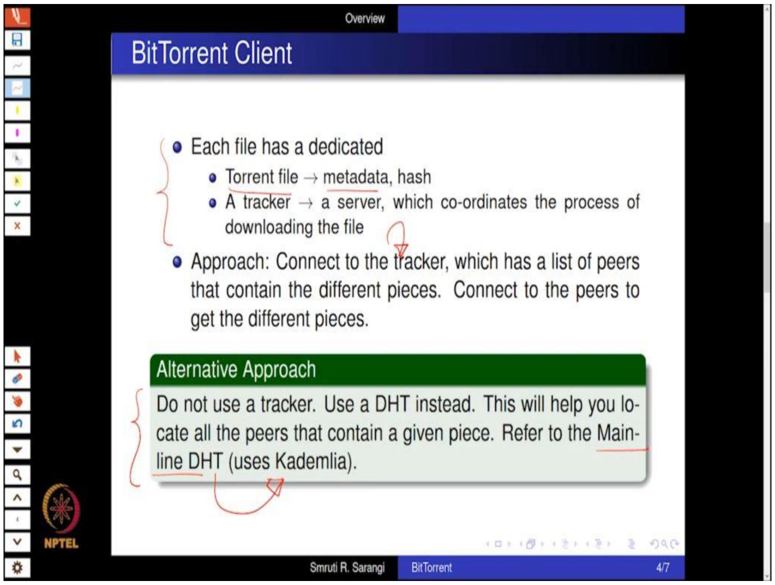

Overview

BitTorrent Client

- Each file has a dedicated
  - Torrent file → metadata, hash
  - A tracker → a server, which co-ordinates the process of downloading the file
- Approach: Connect to the tracker, which has a list of peers that contain the different pieces. Connect to the peers to get the different pieces.

Alternative Approach

Do not use a tracker. Use a DHT instead. This will help you locate all the peers that contain a given piece. Refer to the Main-line DHT (uses Kademlia).

So, the key elements in BitTorrent are like this. One is a torrent file, which contains the metadata. Metadata means a description of the file that will be used for searching and the hash. And then we have a specialized entity called a tracker, which is a server; so this used to be pretty popular in the early days of Bitcoin. So, the tracker was coordinating the entire process of downloading a file. This means that the approach would be to connect to the tracker, so the client would connect to the tracker server. This would have a list of peers that contain the different segments; and then the client would connect to the peers to get the different pieces.

But, now the tracker has gone away mainly because of legal issues. You do not want to have one server which has a list of the entire network. So, instead of the tracker, this has been replaced by a DHT. And the DHT will help you locate all the peers that contain a given piece, using our same DHT mechanism that we have studied in Pastry and Chord. And the DHT that is used is called the main-line DHT, which basically uses the Kademlia protocol. So, recall that in the last few slides, so the Chord lecture we did discuss the Kademlia protocol to a certain extent.

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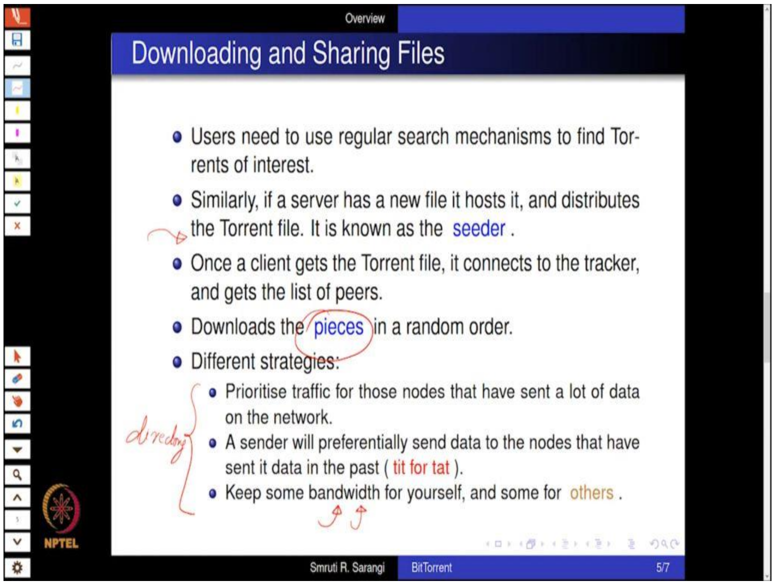

Overview

Downloading and Sharing Files

- Users need to use regular search mechanisms to find Torrents of interest.
- Similarly, if a server has a new file it hosts it, and distributes the Torrent file. It is known as the seeder .
- Once a client gets the Torrent file, it connects to the tracker, and gets the list of peers.
- Downloads the pieces in a random order.
- Different strategies:
  - Prioritise traffic for those nodes that have sent a lot of data on the network.
  - A sender will preferentially send data to the nodes that have sent it data in the past (tit for tat).
  - Keep some bandwidth for yourself, and some for others .

directory

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So, downloading and sharing files will users need to use regular search mechanisms to find torrents of interest. Similarly, if a server has a new file; it will host it and distribute the torrent file so it is known as the seeder. So, once the client finds a torrent file, it will connect to the tracker; or it will use the main-line DHT and will download the pieces in a random order; so, there is no fixed order. So, you can download piece three piece one, piece two, piece four in any order; so, there can be different strategies. So, we can prioritize traffic for those nodes that have sent a lot of data on the network.

So, if let us say that I have been a very active uploader in a sense, I have been very actively supplying my files; I should get some priority while downloading. And also tit for tat relationships, in the sense if I gave you something; then you will also give me something back with a high priority. And furthermore, I can reserve some bandwidth for myself and have some bandwidth for others. So, the main problem actually that happened with Bitcoin is that again, we go back to college students. So, what they were doing is that they were sharing a directory; and the directory used to have these files and their associated torrent files.

So, all day others were downloading unbeknownst to the sharer; so that was eating up a large part of their bandwidth. And when they wanted to download, they did not have enough bandwidth. So, some of that just modern clients are configurable; so some bandwidth can be reserved for oneself and some for others.

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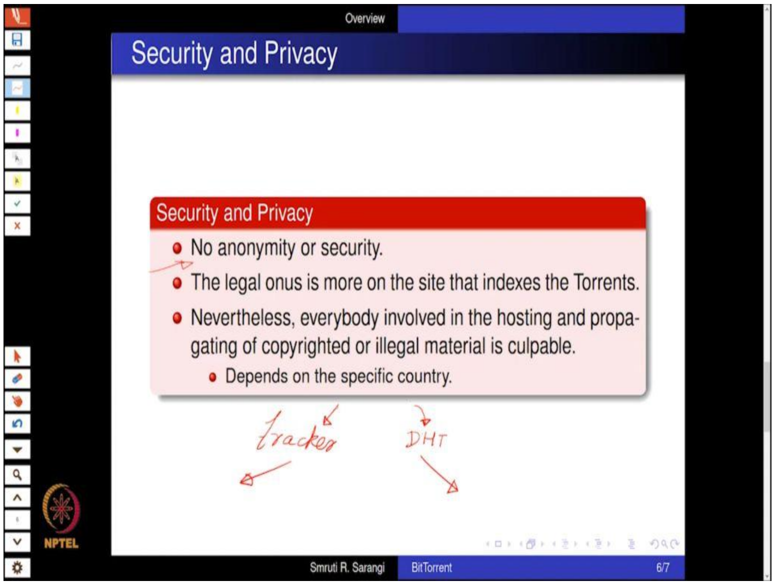

Security and Privacy

Security and Privacy

- No anonymity or security.
- The legal onus is more on the site that indexes the Torrents.
- Nevertheless, everybody involved in the hosting and propagating of copyrighted or illegal material is culpable.
  - Depends on the specific country.

Security and privacy, so as such bit a BitTorrent does not provide anonymity or security. And furthermore, the onus is on the site that indexes the torrents like the tracker sites. Even without that everybody involved in the hosting and propagation of copyrighted or illegal material, in a sense is legally culpable. So of course, to what extent it is enforced depends on the laws of the specific country. But there are two broad approaches; either we use a tracker server that provides a directory or we use a DHT. And then the problem with a DHT is, it will require multiple hops; but again the legal liability is much lower.

And furthermore, there is more robustness as well as it is easy to locate; and given the fact that it will take proportionally much longer time to download the entire segment. Locating a node that has the torrent file will not take that much of time. Plus, these are not strictly real time tasks; so we do not really need to worry about the latency to that extent. So, big torrent as of today is banned in a lot of places, particularly university campuses, regardless of whatever you are using tracker or DHT; so that needs to be understood.

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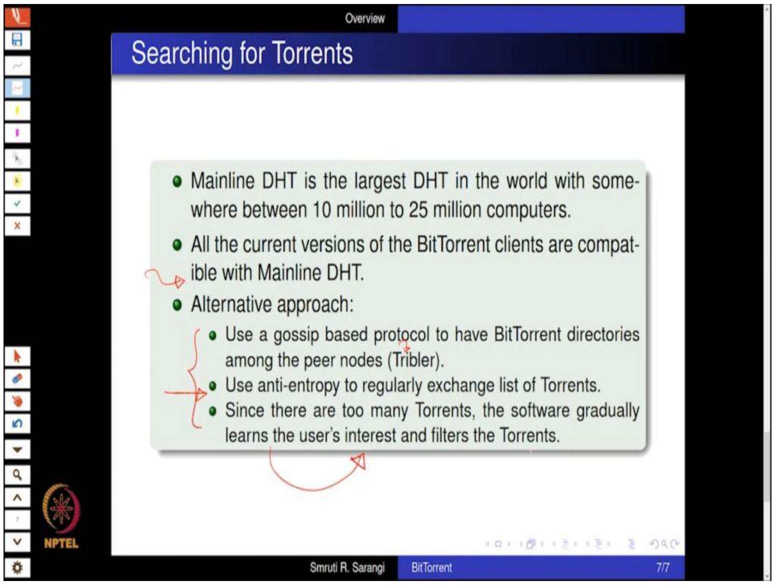

Overview

Searching for Torrents

- Mainline DHT is the largest DHT in the world with somewhere between 10 million to 25 million computers.
- All the current versions of the BitTorrent clients are compatible with Mainline DHT.
- Alternative approach:
  - Use a gossip based protocol to have BitTorrent directories among the peer nodes (Tribler).
  - Use anti-entropy to regularly exchange list of Torrents.
  - Since there are too many Torrents, the software gradually learns the user's interest and filters the Torrents.

In spite of that, BitTorrent is extremely popular. So, the main-line DHT which BitTorrent uses is the largest DHT in the world. So, it does have somewhere between 10 million to 25 million connected computers. So, BitTorrent is clearly the largest file sharing system in the world at the moment. And all the current versions of the BitTorrent clients are compatible with main-line DHT; but they can connect to trackers as well.

Furthermore, BitTorrent is expanding, or rather I would say has expanded and it uses other kinds of protocols. For example, it uses a gossip based protocol. So, basically to synchronize BitTorrent directories to implement BitTorrent directories among the peer nodes; so, this protocol is called Tribler.

So, this is again a gossip based thing where I just maintain a directory of file names and servers, and we periodically exchange and update; so, go back to the lecture on epidemic and gossip based algorithms. So, we use anti-entropy to regularly exchange the list of torrents. And furthermore, since there are lots and lots of torrents, the BitTorrent software also gradually learns about the user's preferences, and filters the torrents; and essentially stores those torrents that are more aligned to the user's viewing preferences. So this in a nutshell was BitTorrent. We did not discuss much about the Kademlia protocol or the main-line DHT.

But, I my feeling was that whatever we discussed towards the end of code is enough to give an introduction to Kademlia. And the protocol of course, can be read up on the web. But, the main idea with BitTorrent should be clear that it is clearly the largest DHT in the sense that runs in the world; and it uses other methods also. It uses other methods also that include gossip based algorithms and trackers.

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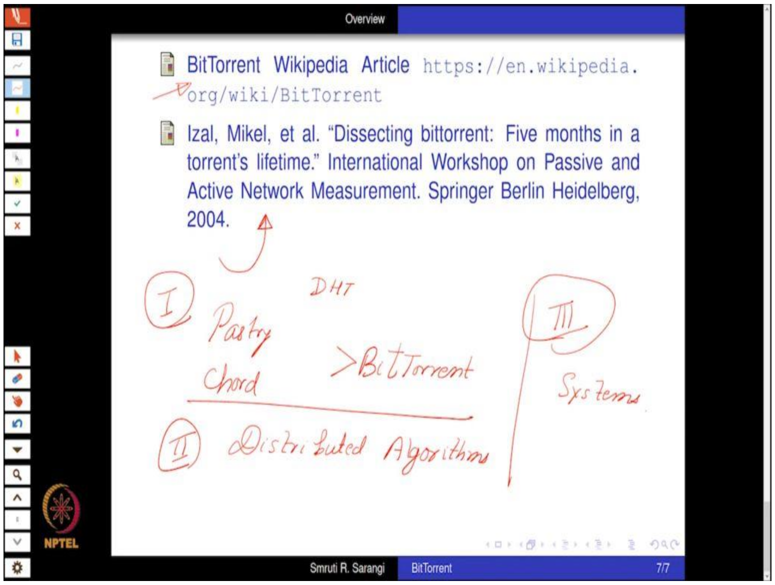

Overview

- BitTorrent Wikipedia Article https://en.wikipedia.org/wiki/BitTorrent
- Izal, Mikel, et al. "Dissecting bittorrent: Five months in a torrent's lifetime." International Workshop on Passive and Active Network Measurement. Springer Berlin Heidelberg, 2004.

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So, the BitTorrent Wikipedia article can give a quick introduction. If you want to know more about BitTorrent, you can always read this paper by Izal, Mikel, et al. And it talks about five months in the torrent's lifetime; so it will tell you everything about it. So, this lecture pretty much finishes our discussion on DHTs; we have discussed quite a few; we have discussed the Pastry. We have discussed Chord, we have discussed T Pastry, Kademlia one slide each; and now we have discussed a system made on a DHT, the main-line DHT the BitTorrent system.

So, subsequently we will move to the second half of the course. So, the first part was essentially DHTs and epidemic gossip based algorithms and so on. So, the second half of the course will basically look at distributed algorithms. And that is important because, once we have DHTs are only one kind of a distributed algorithm; but there are many more types and all of them are required. And finally, we will use the results of parts one and two to create actual systems. So, we did see one actual system, BitTorrent is an actual system; but, we will create bigger systems that use the results taught in parts one and two of this course.