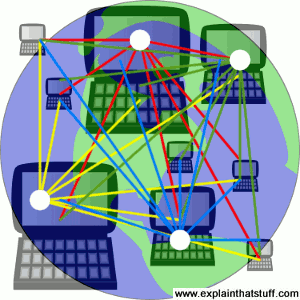
# How does BitTorrent work? https://www.explainthatstuff.com/howbittorrentworks.html



by [Chris Woodford](https://www.explainthatstuff.com/chris-woodford.html). Last updated: October 19, 2018.

You've heard of a transportation nightmare called gridlock—where a city's streets become so packed with cars and trucks that no-one can go anywhere and the entire place grinds to a halt. But have you heard how the [Internet](https://www.explainthatstuff.com/internet.html) can lock up the same way? The Net is based on a distributed architecture with no single, central point of control, but lots of similar systems working in parallel; that's why it works incredibly efficiently most of the time. Even so, [failures of important cables](https://www.theguardian.com/technology/2008/jan/30/asia.internet.outage) (like the ones that link countries and continents under the sea), systematic attacks by criminal hackers, or sudden surges in demand all have the power to bring the Net to its knees. As more and more people go online, the chances of Internet gridlock grow steadily greater. What's the solution? One answer is for people to make better use of the Net's distributed architecture using a superbly clever way of sharing files known as BitTorrent (or, to give it its full name, the BitTorrent protocol). Let's take a closer look at how it works!

Artwork: BitTorrent is an efficient, decentralized way of distributing large online files to many people at the same time. Instead of downloading from a central server, all the people who want a file download a small part and then share the bits between themselves to reassemble the whole thing.

## How client-server downloading works

If you've read our article about [how the Internet works](https://www.explainthatstuff.com/internet.html), you'll know that it uses two kinds of computers linked together:

* Servers are the big powerful machines that hold [web](https://www.explainthatstuff.com/howthewebworks.html) pages, downloadable [MP3](https://www.explainthatstuff.com/how-mp3players-work.html) music files, videos, and all the rest.
* Clients are the small machines we have in our homes and offices that download data from servers.

Browsing a website involves a lengthy conversation between a client and a server: a program called a web browser, running on your [computer](https://www.explainthatstuff.com/howcomputerswork.html), sends repeated requests for bits of the websites (individual web pages and the text, photo, and multimedia content they contain) to a server, which does its best to oblige.

This system works well most of the time, but if you think about it a little, you can immediately see there's a problem. Suppose you have a server that's hosting some really popular file: the latest MP3 music track from world-beating band The Uber Popular Sharks. Let's say the Sharks release their track one Monday morning after a lengthy marketing campaign telling the world that's exactly what they'll be doing.

The server hosting the Sharks' track is going to be besieged with traffic from all over the world at exactly the same time. Even if it doesn't grind to a halt, it's going to run incredibly slowly so it could take each person ages to download the track. Worse, all that music is going to congest parts of the Internet linked to the Sharks' server. Suppose the server is based on a small island like Fiji. Chances are, the whole of Fiji's Internet service will be severely degraded just because lots of people are downloading the Sharks track from a server nearby! The whole exercise is also going to cost the Sharks an absolute fortune in website hosting fees: the more data people download from their server, the more bandwidth the Sharks will use and the more they'll have to pay to their ISP (Internet Service Provider)—which is pretty crazy if they're a small band without much money.

You can see how ridiculous the whole thing gets if you consider what happens if a large number of Sharks fans all live near one another on the opposite side of the world in, say, Seattle. Vast amounts of Internet data is going to be steaming over the Internet between Fiji and Seattle, but because everyone is downloading the same track, it's going to be pretty much the same data making that same stupidly long journey over and over again. Sounds crazy? Wouldn't it be much more sensible if one person in Seattle downloaded the Sharks track and then shared it with all the other Sharks fans who live nearby? Roughly speaking, that's the idea behind BitTorrent.

## How BitTorrent works using peer-to-peer

Since there's no single, central computer controlling the Internet and (in theory) every computer that's online is connected indirectly to every other one, it should be possible for any two computers to share information by communicating directly—and it is! This is called peer-to-peer (P2P) communication and it's used by some of the more popular instant messaging (IM) chat programs (as well as controversial file-sharing programs, which earned themselves a bad name when people started using them to share copyright music tracks illegally).



Photo: BitTorrent is constantly reinventing itself. Here's Resilio Sync (formerly called BitTorrent Sync), an app for mobiles (and desktop computers), that uses peer-to-peer to synchronize files between all your different devices. It's positioned as an alternative to using third-party [cloud](https://www.explainthatstuff.com/cloud-computing-introduction.html) storage that avoids the need to upload and download large files. It works even on internal networks and across firewalls.

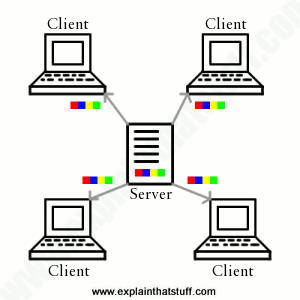
BitTorrent is a protocol (a set of rules that different computer systems agree to use) based on P2P that can be used to share large files very efficiently. Suppose the Sharks decide they want to use BitTorrent. They take their music track and make it available on their computer as a file called a torrent. The computer that hosts the original file, in its entirety, is called a seed and it splits the file up into lots of pieces.

Anyone who wants the file uses a program called a BitTorrent client to request it from a seed. The client is sent one of the pieces and gets all the remaining pieces, over a period of time, from other people's computers through P2P communication. At any given moment, each computer is downloading some parts of the file from some of these peers and uploading other parts of the file to other peers. All the computers cooperating in this way at any time are called a swarm. The more popular a file is, the more computers there are in the swarm and the quicker the process is all round.

Share and share alike is the ethos behind BitTorrent so, when people have finished downloading a file, they are encouraged to stay online for a while so they can continue uploading the file to others in the swarm—an activity known as seeding. Quitting from a swarm the minute your download is complete, without seeding, is a selfish activity that's earned itself the nickname leeching! If everyone leeched, BitTorrent wouldn't work at all.

Although BitTorrent is a decentralized P2P process very different from old, client-server-type downloading, there has to be some sort of order and control. Someone has to keep track of which computers have which bits of the file. This works in different ways with different BitTorrent clients. Some rely on centralized computers called trackers which, as their name suggests, keep track of where all the pieces of the file can be located at any moment. There is also a more decentralized version of BitTorrent where the clients manage the tracking process among themselves (sometimes called trackerless torrents or distributed torrents).

## Downloading versus torrenting

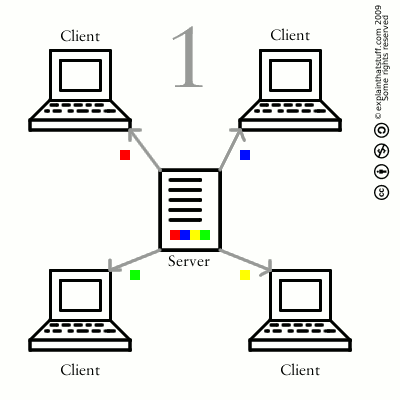


Here's a quick summary of the difference between downloading a file through a traditional client-server approach and using a P2P BitTorrent:

### Downloading with client-server

In a client-server setup (for example, when people download the same file from the same website), each computer (client) downloads a complete copy of the file (shown by the four colored blocks) from the server. Since the server has to provide one copy of the file to each client, this can work out hugely expensive for the person making the file available. If everyone downloads at the same time, the server has to divide its effort between the different clients so the speed of downloading goes down in direct proportion to the number of clients. That's why, even with a fast Internet connection, you will still sometimes experience very slow downloads.

### Peer-to-peer BitTorrent



With a P2P BitTorrent:

1. The originating server (the seed) makes available one copy of the file, which is then split up into chunks. Different chunks are sent out to the various computers (BitTorrent clients) trying to get hold of a copy of the file.
2. Each client uploads their part of the file to other clients while simultaneously downloading bits of the file they don't have from other clients. All the clients work together as a swarm to share the file. The file-sharing process doesn't happen in the systematic, sequential way we show here (purely for simplicity): clients upload and download simultaneously and the file actually builds up in a more random way. There are often hundreds of clients involved in each swarm.
3. Eventually, every client receives a complete copy of the file. However, in this example, as in real life, one client (lower left) finishes downloading before the others. If the owner of that machine switches off as soon as they're done, the other clients will never receive complete copies of the file!

Note two crucially important differences from client-server downloading. First, the originating server potentially has to make available only one copy of the file—so the whole process is much cheaper for them. Second, the more clients there are, the more effective the whole process will be for everyone involved (unlike in client-server, where more clients slow the process down for everyone involved).

## The pros and cons of BitTorrent

If you have a fast Internet connection, why should you care about BitTorrent? You have to understand that a fast connection doesn't guarantee you a fast download: if the server you're trying to download from is congested, you're going to download just as slowly as everyone else. You can only really "get" the idea of BitTorrent if you think about the Internet as a collaborative experience with lots of people trying to do lots of similar things all at the same time. If we all want to be able to download movies, we can't all do it at the same time from the same server—just as we can't all drive down the same highway at exactly the same moment. We have to learn to cooperate and share the limited resources we've got instead of selfishly trying to push everyone else out of the way.

BitTorrent is of most immediate benefit to people who want to make large files available, rather than those who want to download them, because it greatly reduces the cost of publishing big files online. That means the content providers can afford to make a bigger range of files available—and that's where the community as a whole benefits.

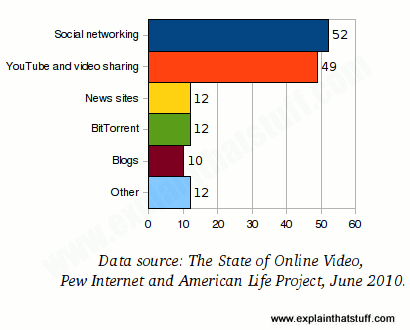
BitTorrent also helps the Internet as a whole by spreading traffic more evenly and helping to reduce congestion. P2P is generally a far more efficient system than client-server: it's like people driving down all the streets and roads they can think of instead of all trying to use just one central highway. It's also important to note that uploading by BitTorrent helps to make files available for downloading by other methods. From time to time, media research organizations publish surveys of online video use that compare BitTorrent traffic with things like YouTube and Facetime. In 2010, for example, the Pew Internet and American Life Project published the data shown here, revealing that BitTorrent traffic represented only about 12 percent of total online video sharing. In fact, as a [2013 survey by Sandvine](https://www.theguardian.com/technology/2013/nov/11/netflix-youtube-dominate-us-internet-traffic) revealed, this is misleading. More video *uploading* (almost 40 percent) is done by BitTorrent than using any other method, though torrenting is a much less popular way for ordinary users to *download* (just a 4 percent share, compared to 19 percent for YouTube, and 32 percent for Netflix).

Chart: While roughly half of all video uploaders use social media and video sites such as YouTube, only a fraction use BitTorrent. At first glance, that suggests BitTorrent is a fairly insignificant way of sharing video online. But even if video torrenting is only a quarter the size of (say) YouTube sharing, that's still an enormous amount of traffic! Chart drawn by Explainthatstuff.com using original data from Kristen Purcell "The State of Online Video." Pew Internet and American Life Project, Washington, D.C. (June 6, 2010), <http://www.pewinternet.org/2010/06/03/the-state-of-online-video/>, accessed on August 25, 2014.

It's commonly believed that BitTorrent encourages piracy by providing a simple and effective way for people to share copyright movies, music tracks, and other content without paying—but exactly the same charge could be leveled at sites like YouTube and Facebook. And it's important to be clear: there's nothing illegal about using BitTorrent clients unless you download copyright-protected works without paying the owners for the privilege. It's not necessarily the tool that's at fault if people use it in antisocial ways. The same argument applies to cars and guns: both are perfectly legal, valuable tools unless you happen to put them together and use them in an armed robbery. If you stick to legal downloads, you'll be doing nothing wrong; in fact, you'll be doing something right by helping to use the Internet as a whole to operate more efficiently. Some surveys have shown that torrenters, far from the pirates they're popularly portrayed as, tend to be much more informed Internet users who have a better understanding of copyright issues and are more likely to pay for things they download. For example, a [2014 study by BitTorrent](http://blog.bittorrent.com/2014/11/20/where-creativity-thrives-bittorrent-2014-user-study/) revealed that its users were 170% more likely to buy music versus average Internet users, which ought be music to the ears of the content producers.

## The future of BitTorrent

Meanwhile, BitTorrent continues to evolve and improve, despite the [fluctuating fortunes of its parent company](https://www.wired.com/2017/01/the-inside-story-of-bittorrents-bizarre-collapse/), BitTorrent, Inc., and its search for a profitable business model. After a financially challenging 2017, the company was taken over by TRON, a blockchain company, the following year. Later in 2018, it introduced a version of its most popular client, μtorrent, that runs in a web browser and looks, to users, quite similar to ordinary [streaming](https://www.explainthatstuff.com/streamingmedia.html). Following TRON's acquisition, it also announced [Project Atlas](https://www.bittorrent.com/project-atlas/), extensions to the BitTorrent protocol that would connect its estimated 100-million regular users with TRON's blockchain-based operating system. Two of the promised benefits are faster downloads and incentives (in the form of tokens) to encourage users to seed for longer with more of their bandwidth, both of which should make BitTorrent a more attractive platform for people who want to distribute their content online. Other recent developments include the release of [BitTorrent Live](http://blog.bittorrent.com/2016/05/17/bittorrent-live-multichannel-app-for-live-and-linear-programming-unveiled-at-intx/), a peer-to-peer streaming system that allows anyone to broadcast live video like a TV station.

## Check with your ISP first!

One thing to note about BitTorrent: it can involve you uploading and downloading huge amounts of data through your ISP—and that can have an adverse effect both on their system performance and on other people who use the same ISP. For this reason, many ISPs have "fair-use" policies that limit the use of BitTorrent to off-peak times (during the middle of the night, for example), or ban them altogether. Before using BitTorrent, check your ISP's policy and make sure you're not breaking their rules.