EXHIBIT A-2

organizes services (data files and programs) that it makes available to each of the clients. A P2P computer network differs from the client/server model in that each computer on the network is viewed as a co-equal, or a "peer."

28.   Peer computers can simultaneously function as both clients and servers to the other computers on the network. P2P networks are typically characterized by a large number of computers that connect and disconnect at random times. To participate in a P2P network, each computer must have special software that uses the appropriate protocol.

29.   Well-known examples of P2P networks are Napster, Gnutella, FastTrack, and BitTorrent. Each of these defines a different way of communicating, and computers must have installed the software for these protocols to participate in the P2P network they define. The most common use of such P2P networks is for sharing files that typically contain audio or video data. It is widely known that these networks are commonly used for the exchange of unauthorized media files.[1]

30.   The Napster system was one of the earliest P2P systems. Developed by nineteen-year-old Shawn Fanning in June 1999, its purpose was to facilitate the exchange of audio files. Users downloaded the Napster software, called MusicShare, and placed files they wished to share in a specific folder on their computers. The names of all shared files were sent to the Napster server. A user would enter a query into the MusicShare software, which communicated with the Napster server, returning a list of currently connected computers with

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[1] One of many scholarly works that deals with unauthorized content on P2P networks, including Gnutella, can be found at http://p2pecon.berkeley.edu/pub/CWC-EC05.pdf. One of many popular articles that discuss the presence of unauthorized content on P2P networks, including Gnutella, can be found at http://www.seethru.co.uk/music/napster_alternatives.htm.

files whose names matched the query. The user could then initiate a download of the file, directly from one of the selected computers.[2]

31.   Another well-known P2P application, Kazaa, and its underlying protocol (FastTrack) were conceived by Niklas Zennström, Janus Friis, and others. It was introduced by their Dutch company Consumer Empowerment around late 2000. Kazaa/FastTrack introduced many new features into P2P including: (i) a two level hierarchy of computers called peers and supernodes, (ii) use of a unique number to identify a file (UUHash), and (iii) swarming to speed up the downloading of a file.

C.   *Gnutella*

32.   The original Gnutella protocol was developed in early 2000 by Justin Frankel and Tom Pepper. When the original Gnutella protocol was first released to the public, it was referred to as a "Napster clone."[3] The protocol is an open standard that has been through several revisions.[4] Each Gnutella P2P application (e.g. LimeWire, Morpheus) contains an implementation of some version of the Gnutella protocol. Nevertheless, each application provides its own user interface and its own feature set that builds upon the protocol. Gnutella applications "interoperate," in the sense that users of one Gnutella application can typically download from and upload to users of other Gnutella applications.

33.   Lime Wire LLC engineers have been heavily involved in or

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[2] *A&M Records Inc. v. Napster, Inc.*, 239 F.3d 1004 (2001).

[3] See Plaintiffs' Exhibits 516 and 517.

[4] The specification for version 0.4 can be found at http://www9.limewire.com/developer/gnutella_protocol_0.4.pdf, version 0.6 can be found at http://rfc-gnutella.sourceforge.net/src/rfc-0_6-draft.html. Also of interest is the Gnutella Developer Forum (GDF) hosted by Yahoo Groups at http://groups.yahoo.com/group/the_gdf.

responsible for major changes to Gnutella, such as: (i) an ultrapeer-to-leaf architecture,[5] (ii) query routing through and among ultrapeers (QRP protocol),[6] and (iii) dynamic querying.[7] These are discussed ahead.

34.   Ultrapeers are peer computers that are not behind a firewall[8] and that satisfy a set of minimum requirements, e.g. bandwidth and uptime.[9] In this modified architecture, each peer joining the network is connected to one or more ultrapeers. Peers are leaf nodes of ultrapeers. Ultrapeers take on a lot of the processing formerly done by leaf nodes.

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[5] See "Ultrapeers: Another Step Towards Gnutella Scalability", by Anurag Singla and Christopher Rohrs of LimeWire LLC, dated December 18, 2001.

[6] See http://www.limewire.com/developer/query_routing/keyword%20routing.htm by Christopher Rohrs.

[7] See "Gnutella Dynamic Query Protocol v0.1" by Adam Fisk, dated May 2003.

[8] LimeWire also supports the transfer of files when both the requester and the provider are located behind firewalls. To accomplish this, both peers must satisfy certain conditions, chiefly the ability to send and accept UDP messages. After identifying each other and determining that both peers are firewalled, an exchange of information is effected through so-called push-proxys, computers that are capable of communicating with each of the peers and with each other.

[9] LimeWire source code is maintained as open source. Lime Wire LLC maintains the LimeWire code and uses the software products Fisheye and Crucible to provide (among other things) browsing of the code via a web interface. All present and past versions are maintained using a version control system. All references to source code in this report are taken from that site, https://www.limewire.org/fisheye/browse/limecvs. For example, the precise set of conditions for ultrapeers can be found in the routine UltrapeerSettings.java located at https://www.limewire.org/fisheye/browse/limecvs/core/com/limegroup/gnutella/settings/UltrapeerSettings.java. The most recent version is 1.17. The "raw" version includes only the source code, while the "annotated" version adds programmer names and denotes version changes.
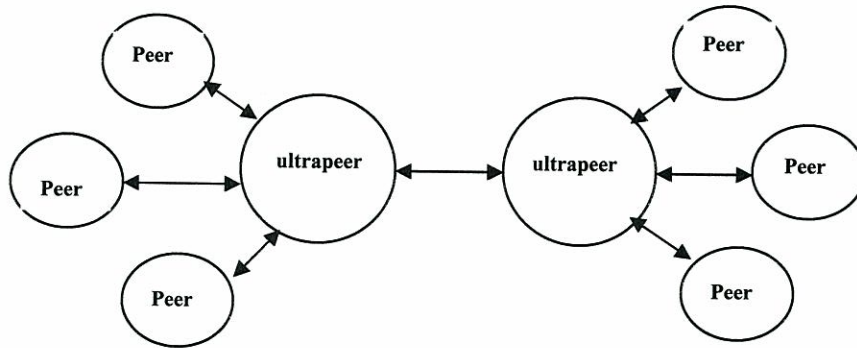
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Figure 1: Gnutella Peer-Ultrapeer Hierarchy

35. Ultrapeers are responsible for routing search requests and results. Each peer acting as a leaf will periodically send a list of all of its files' keywords (file name, metadata), hashed[10] in a Query Routing Protocol (QRP) table, to its ultrapeer. This data is maintained by the ultrapeer in a combined QRP table. When an ultrapeer receives a query, it checks it against the data in its QRP table and only forwards the query to leaves (peers) that have a possible match.

36. Another modification is *dynamic querying*.[11] In this scheme, a peer node attempting a search first makes a "probe" query to a subset of its ultrapeers. Using the data that comes back, it makes an estimate of the success of a full query. If the estimate concludes that there are many files satisfying the query, then the peer will send the query to a small subset of its ultrapeers with a small time-to-live (TTL) value.[12] On the other hand, if the probe indicates that there are very few such files, then the peer will send the query to a

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[10] Note that the hash in the QRP protocol is computed using the file name and metadata, which is entirely different from the SHA-1 hash, which is computed using the contents of the file.

[11] For *dynamic querying*, see http://www.ic.unicamp.br/~celio/peer2peer/gnutella-related/gnutella-dynamic-protocol.htm.

[12] A Gnutella message is assigned an initial TTL, typically three or four. The value is decremented by one each time the message is received by a peer. The message is discarded when the TTL becomes zero.

larger number of ultrapeers with a higher TTL hoping to locate more matches. When searches are made for "popular," i.e., widely available files, dynamic querying reduces the load on the network and makes searching more efficient.[13]

IV. Download and Basic Functioning of Limewire

37.   LimeWire is the dominant Gnutella file sharing application, and one of the most popular file sharing applications of any type. Although the official download source for most users is the Lime Wire LLC download website at http://www.limewire.com, LimeWire can also be downloaded indirectly through a number of other websites, including the website Download.com (a division of CNet), which lists many programs for users to download. Download.com publishes weekly statistics of the most downloaded programs that it tracks. For the week ending April 13, 2008, LimeWire is listed as the third most popular downloaded program (and the most popular P2P program).[14] Download.com shows the total number of downloads for LimeWire to be 142,014,448. LimeWire is also listed as the most popular download for the category "MP3 & Audio Software."[15] A search of the Internet Archive at http://www.archive.org reveals the Download.com statistics going back several years and shown in Table 1. LimeWire has had more downloads than any other file sharing application as listed on Download.com.

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[13] Lime Wire LLC has also implemented a Distributed Hash Table (DHT) to function in parallel with LimeWire's use of the Gnutella network. It is a modification of an earlier implementation of DHT called Kademlia. The LimeWire implementation is referred to as Mojito.

[14] See http://www.download.com/3101-20-0-1.html, though the page is changed every week.

[15] See http://www.download.com/MP3-Audio-Software/?tag=dir.

Date	Overall Popularity Rank	Total Copies Downloaded
July 31, 2005	6th	63,189,564
December 18, 2005	4th	72,086,848
July 2, 2006	4th	87,578,183
December 3rd, 2006	5th	103,061,800
July 3, 2007	6th	120,580,784

Table 1. Download.com Statistics for Downloads of LimeWire

38.   During the course of this litigation, Lime Wire LLC has released many new versions of their software. A release refers to the version of the software that a user downloads from the Lime Wire LLC website. For LimeWire Basic, version 4.12.15 was available on July 9, 2007, version 4.14.9 was available on September 18, 2007, version 4.14.12 was available on October 15, 2007, and version 4.16.2 was available on January 18, 2008. The LimeWire features history webpage (http://www.limewire.com/features/history.php) contains a list of versions and changes. In my report, I will generally be discussing version 4.14.10, and for any other version, I will explicitly mention the version number.

A.   *Download Process*

39.   An individual wishing to use the LimeWire program would begin by connecting to the Lime Wire LLC home page at http://www.limewire.com, as shown in Figure 2.[16]

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[16] Lime Wire LLC is the owner of the limewire.com and limewire.org domains and is responsible for placing content on the pages contained within that domain. Netcraft.com provides data on domain ownership, e.g. http://searchdns.netcraft.com/?host=limewire.com&position=limited.