A PEER-TO-PEER FILESHARING NETWORKS INTERCONNECTION SYSTEM

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ABSTRACT
Since the recent appearance of P2P file-sharing networks, a few years ago, many Internet users have chosen this technology to search for programs, films, songs, etc. This number of users is growing every day. The main reason has been the content (in occasions illegal) that can be found and downloaded over these networks. This article deals with the description of an Interconnection System over Peer-To-Peer Filesharing Networks. It would allow finding a file placed on any P2P network interconnected to this global system.

KEY WORDS
Peer-To-Peer, Filesharing Networks, Overlay Networks, Interconnection.

1. Introduction and motivation

The number of users connected to public P2P Networks is increasing daily. Today, there are a great variety of P2P networks and some of them with a lot of P2P clients. The first distinction that has to be done is the difference between P2P networks and P2P clients. P2P networks are a set of rules and interactions that allow P2P clients to communicate. A P2P client is a computer application that allows a user to interact with others in the same network.

P2P filesharing is one of the Peer-To-Peer variants that is accumulating more and more participants. Although there are users that try to download files from the network without intention of providing any to anyone, there are is a large number of users who are willing to share what they have to the whole community without caring about who is downloading their files.

Currently there are a lot of public P2P filesharing networks in existence, and many of them have millions of on-line users. The main public Internet P2P filesharing networks are Gnutella [1], FastTrack [2], Freenet [3], BitTorrent [4], Opennap [5], Edonkey [6], Soulseek [7] and MP2P [8]. although there are other networks that are not so popular [9]. All of these networks have advantages and disadvantages and each of them is better than the others according to the environment where it is implemented or according to a desirable fixed parameter.

What a user really wants is to find the file that he is looking for. But this file is not always in the network where the user is searching. On the other hand, there is a big probability to find, for example, an audio file if it is being searched in a network where only audio files are shared. Most of the networks implemented nowadays support any filetype.

There are some actual P2P software clients that are able to use more than one P2P protocol and they can join several networks. Some of them are Shareaza [10], MLDonkey [11], Morpheus [12] and cP2Pc [13][14]. However the use of this solution, in order to search a file, means that the user has to be permanently connected to all networks. On the other hand, if a client is developed to be able to join all networks, the computer running this client will need a lot of processing capacity. In addition, if a new P2P filesharing network is developed, a new client is required to support the new architecture and all users will have to update their client to join the new network.

What is needed is a system which will allow to search in every P2P network. To do so, the architectures mentioned above have been analyzed and classified in order to find the best way to interconnect them. Finally, a P2P overlay network interconnection system is presented.

2. Architecture analysis

P2P software applications communicate with peers in order to exchange data. These applications allow a peer to become servers and clients at the same time, these peers are called servents. The data transfer is made directly between the edge clients, without any central server mediating in this transfer.

P2P networks can be classified based on:

- Kind of architecture: P2P Decentralized architectures, P2P Centralized architectures and P2P Partially centralized architectures.
- Discovery and search algorithm: Centralized indexes and repositories Model, Distributed Indexes and Repositories Model, Flooded Queries Model, Selective Queries Model and Documents Routing Model.

- File downloading system: Single-source download, multi-source download and Segmented multi-source download.

3. Proposal of network interconnection

This section discusses the system that will allow interconnecting all P2P overlay networks. But first of all, there are some premises that should be discussed:

- If we consider each analyzed network as if it were an independent network, every P2P client connected to the proposed system could access each network, allowing doing searches over each of them.
- The interconnection system has to be scalable. The number of P2P emergent networks is increasing continuously, so every new P2P network could be joined to the system.
- The process of searching from other P2P networks doesn't have to be P2P client dependent. In other words, all the P2P client applications will not need to be upgraded or will not need a new plugin in order to find files from other networks.
- It is needed to take care of the interconnection system overload. If there is no connection between end peers directly the data have to be transmitted over the interconnection system.

This premises will help the successful setup of the interconnection system in actual public Internet P2P Filesharing networks.

3.1. Network interconnection system

First, for each P2P overlay network there is one fixed node that is joined to a P2P network and it will belong to the network distribution layer. This type of node is called *gateway node*. There are two kind of gateway nodes, the fixed (FG) and the aggregated ones (AG).The distribution layer is composed of a fixed gateway node network that will interconnect every network to the distribution layer. All fixed gateway nodes form the backbone of the distribution layer. There must be authentication between gateways in order to know which on is acting as a gateway. This authentication process allows the creation of a *distribution table* composed by a list of fixed gateway nodes and the P2P overlay network where they are joined. Every gateway node must have an identifier of its own P2P network and a maximum number of supported connections from other network gateways. Every new joined node, called *aggregated gateway node*, to this architecture will act as support to the distribution layer.

The peers of every P2P overlay network will form the access layer. In figure 1, the described topology can be seen (only fixed gateway nodes are shown).

In order to create and maintain the distribution layer, there are two kind of tables: the distribution table and the access table. Every gateway will have those two tables. The distribution table is used to other network gateways in order to forward the data. The access table is used to communicate all gateways of the same network.

3.2. Distribution table

The distribution table is formed by fixed or aggregated gateway nodes of other networks. This information is obtained through the fixed gateway nodes and it is maintained by incremental updates. The distribution table has the following columns with registers:

- First column: N registers with the IP of the N gateways (fixed gateways or aggregated gateways) of the N other networks.
- Second column: N registers with the network identifier of the other network gateways.
- Third column: N registers with the metric associated to the other N networks. This metric is set manually in the local gateway, or learned by other gateways, in order to control the weight of every partial metric (this will be discussed later).
- Fourth column: N registers with the type of files it can be searched in these networks.
- Fifth column: N registers with the maximum number of allowed connections to other network gateways.

3.3. Access table

The fixed gateway node together with all the aggregated gateways in the same network form the access table. Every fixed network gateway has a different access table. The fixed gateway, and all the aggregated gateways have the same access table and it is maintained by incremental updates. The access table has the following columns with registers:

- First column, N registers with the IP of the N gateways of its own network.
- Second column, N registers with the load of the N gateways of its own network.
- Third column, N registers with the N maximum number of allowed connections to other N network gateways.

3.4. Metric

A metric is needed in order to known which is the best network where the file could be downloaded.

The results will be a function of a metric that depends on the following parameters (all values between 0 and 1):

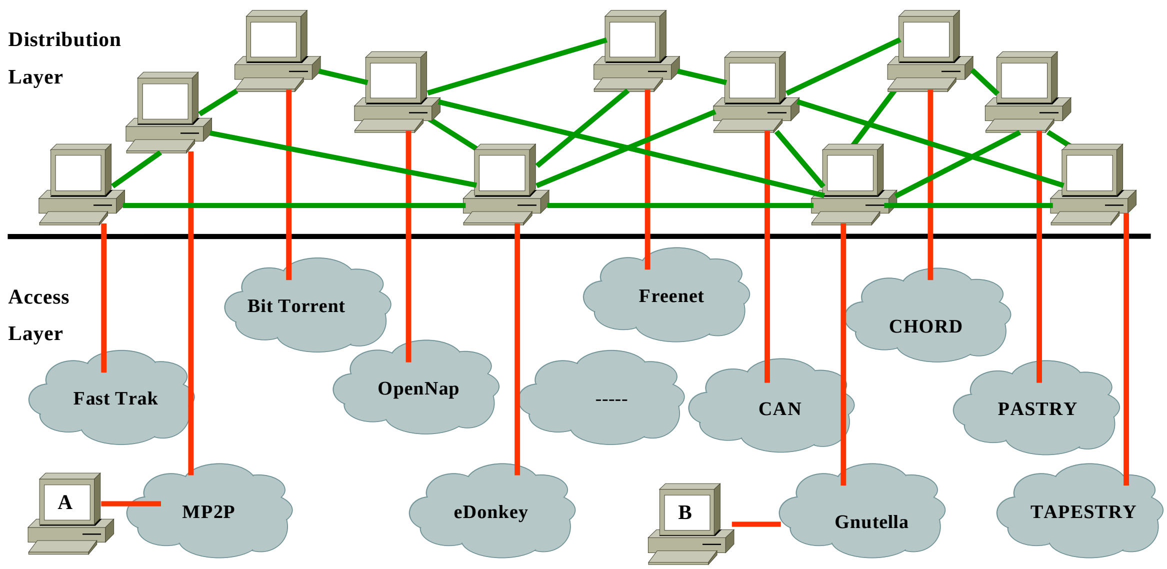

Figure 1. Network interconnection using a distribution layer

- Optimum maximum (OM): Initially, all the networks and models have to be analyzed in order to find which is the maximum number of users that the network can have without affecting performance. In this situation, this parameter will be set to 1. The gateways of a network will inform the number of users of its own network to other gateways of the distribution layer in order to calculate the OM.
- File Size (FS): It is needed to establish a relationship between the size of the file and the used download system. It will create a table for each download system related with the size of the file. Therefore, a multisource download system with a small file will have a value of 1. Also, a segmented multisource download system with a big file will have a value of 1 too.
- Queue (Q): When a download is done from another peer, there is a download queue system. Every queue system needs to be measured for each network and its performance analyzed This parameter will be a value of 1 in the network with the best queue performance.
- Download Source Peers Bandwidth (DB): It will be 1 to that peer, with the file searched, that has the highest available upload bandwidth.

The final metric of every interconnected network is:

$$\text{Metric} = OM \cdot FS \cdot Q \cdot DB \qquad (1)$$

The desirable metric value is 1.

3.5. Joining or leaving the architecture and node failures

If a new node joins the distribution layer as a fixed gateway node of a new P2P network, there has to be an authentication process with all other fixed gateways of the other networks. The new fixed gateway node has to send its own IP, the identifier of its attached network, the type of files it can be searched in its network and its maximum supported connections. This new entry will be added to the fixed gateway distribution table. The associated metric to this network could be inserted manually or learned by other gateways.

When a new node joins the distribution layer as an aggregated gateway node, it sends a query to the fixed node of its own network. The fixed gateway will request its own access table and distribution table. The access table will be saved. The distribution table will be used to send queries to other networks fixed gateways in order to know to which other networks aggregated gateways could be connected. The fixed gateways will consult its own access table and they will send which is the designated aggregated gateway and the feasible successors of their network in order to establish the connection. This decision is taken as a function of available connections and the load of the gateways.

As a function of the received data, the new gateway sends the connection establishment to the selected gateways. This connection is only refused by the remote gateway if this gateway has reached the maximum number of allowed connections. In this case, the connection establishment is sent to the successor gateway.

Two tables have to be maintained due to the joining or leaving the interconnection system by the gateways. The proposed maintenance is as follows:

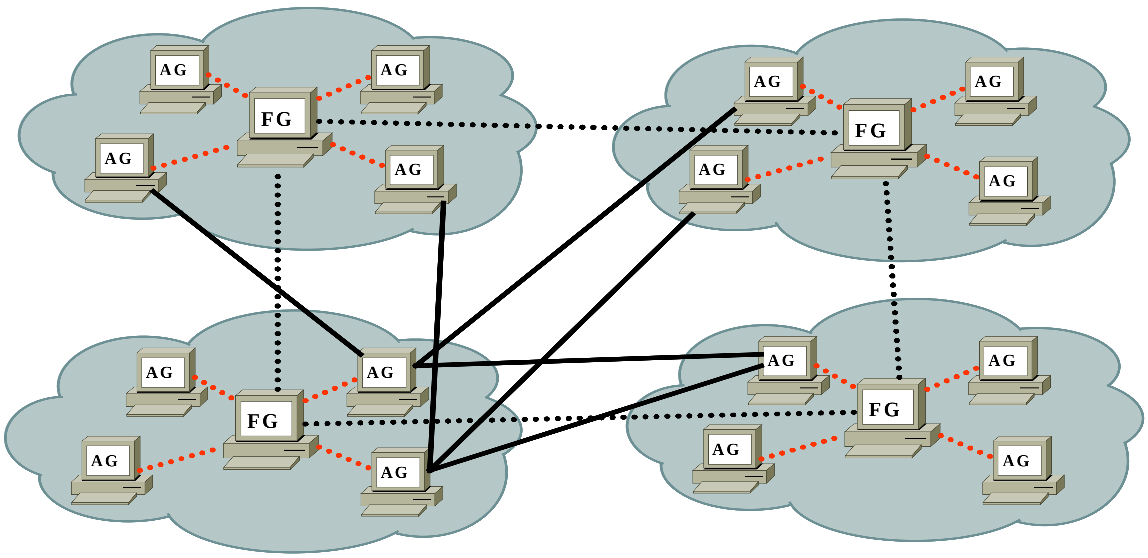

Figure 2. Network interconnection between Fixed Gateways and Aggregated Gateways

First, the distribution table needs to be updated in order to have the optimum performance. The system proposed, in order to maintain the distribution tables, is as follows:

- Every time a gateway sends a search query to another gateway and this replies to the search query, the counter for both gateways for this entry is reset to 0.
- If no search query is sent to a gateway in its distribution table during 180 seconds, it sends a keepalive message to the gateways of the other networks.
- If there is no reply from the other gateway due to a failure, it sends a query to the fixed gateway of this network in order to have a substitute to the one that has failed. This decision is taken by the fixed gateway as a function of available connections and the load of the gateways.

Second, the fixed gateway is the responsible to maintain the access table. All aggregated gateways will send keepalive messages every 180 seconds to the fixed gateway of its own network. Those entries with no keepalive messages will be deleted in its access table. New entries or deleted entries will be sent as incremental updates to all aggregated gateways in its network.

3.6. Architecture Design

The distribution layer nodes can be normal nodes within their joined network, but with an additional service that will allow them to connect to the distribution layer network. These nodes must have great processing capacity and high bandwidth. They must have a maximum number of simultaneous connections to their network peers. Every established connection by a peer of its own P2P network will be released when the search query of this peer is finished.

Several gateways of the same network can exist in the distribution layer (the fixed and the aggregated ones). All fixed gateway nodes must know of the existence of all the aggregated gateways in their network by the access table.

There could be aggregated nodes in the same P2P network that would have connections with the same aggregated node of the other network.

In figure 2 it is shown the Network design. As can be seen, the fixed gateways (FGs) would have connections with other fixed gateways of the other networks (lines formed by black points). The aggregated gateways would have connections with the fixed gateway of its own P2P network (lines formed by red points) and with the selected aggregated gateways of the other networks (solid black lines).

When a gateway sends a query, it will not be sent to its own network gateways. In order to do a search, first its distribution table is looked up, and it is sent only to that networks gateways (it will prevent searching loops). It is also looked up the associated metric and the type of file it can be searched (some networks allow audio searches only). It will minimize the waste of resources and bandwidth.

When a client sends a query, it is initially sent to its own P2P network. If no result can be found, the search is sent to its network gateway. The gateway node will be ordered to send the search to the other networks gateways in its distribution table. Every distribution layer gateway, that receives that query, will send the search to network and will receive the results.

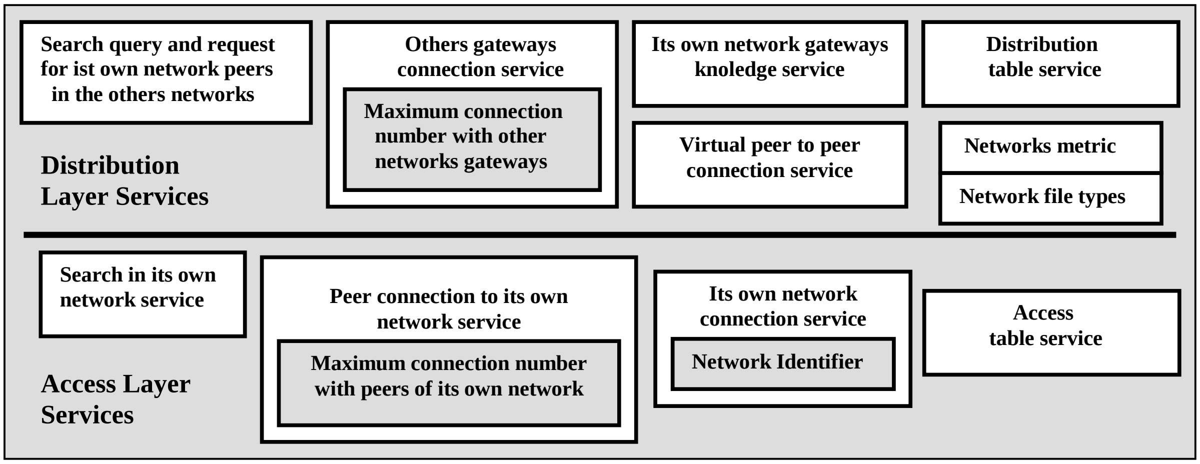

Figure 3. Gateway node services

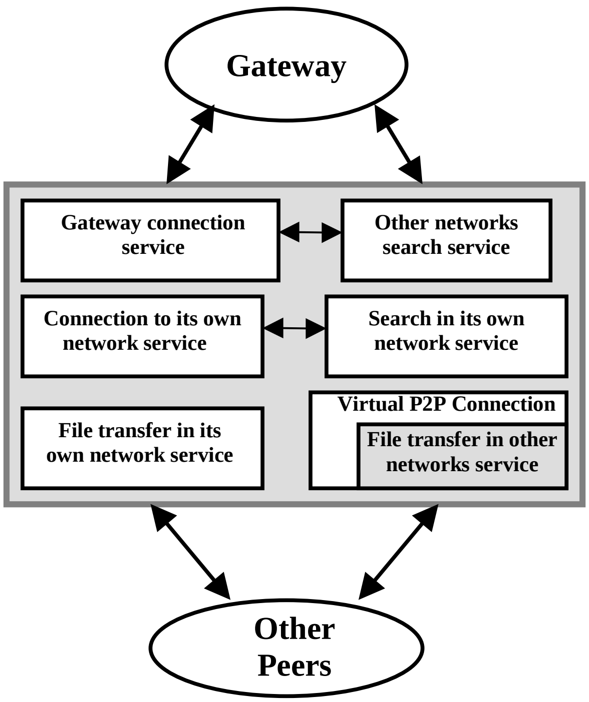

Figure 4. Services of an access layer node

These results will be sent to the source gateway with an identifier of its network. This identifier will be used to know the associated metric from the local gateway. Finally, the result of the query is sent to the peer which requested it. This result will have the name or names of the found files, the network where it was found and the associated metric.

Figure 3 shows the services needed to implement a gateway node.

3.7. Download system discussion.

The greatest problem is to exchange data between peers of different networks. In order to download data from other peers, three possibilities are proposed:

- Due to the existence of a communication through the distribution layer, the network gateways can take over the responsible of transferring the data and make the translation between clients. This option will suppose low changes over the architectures and the actual clients, but it will increase the load over the distribution layer.
- It could be done changing the original code or creating plugins for it. This plugin can be responsible of opening a specific socket and making the translation between peers. In this case, when a search is done to other network, it is necessary to receive the peer identifier in the other network with the data requested. The plugin will open a temporally connection to that network and will allow to download the file requested.
- There could be cases where the peer needs to be registered with the network (like in DHT-type). This can be done using a Virtual P2P Network (VP2PN) connection. In this case, the peer will be registered to the network using a gateway node of the other network. This Virtual Connection will be temporary (the time needed to download the file requested). The gateway node will be the one that found the requested file in the other network. This kind of connection will permit an unstructured P2P peer to join to a DHT-type network.

The services needed to be implemented in an access layer node are shown in Figure 4.

4. Conclusions

P2P filesharing networks have been analyzed based on their architecture, search algorithm and downloading system. All of these characteristics have their advantages and disadvantages and each of them performs better than the other ones according to the working environment or a desirable parameter.

An interconnection system between all the analyzed networks has been proposed. It allows doing data searches in any architecture connected to the one we have described in this article. Finally, three ways have been proposed in order to exchange files between users from different networks.

Assuming that each P2P network attached to this interconnection system has a probability of finding a file, the system proposed will be a sum of all interconnected network probabilities. Thus increasing the probability of finding the desired file.

The proposed method doesn't depend on specific network; it is open to any existing network and new ones.

As a future works, the authors will try to find the best way to download files from peers of other networks.

5. References

[1] Eytan Adar and Bernardo Huberman. Free riding on gnutella. *First Monda*y, 5(10), October 2000.

[2] Nathaniel Leibowitz, Matei Ripeanu, and Adam Wierzbicki. Deconstructing the Kazaa Network, 3rd IEEE Workshop on Internet Applications (WIAPP'03), June 2003, San Jose, CA

[3] I. Clarke et al. Freenet: A distributed anonymous information storage and retrieval system, ICSI Workshop on Design Issues in Anonymity and Unobservability, Int'l Computer Science Inst., 2000.

[4] Bram Cohen. Incentives Build Robustness in BitTorrent, Workshop on Economics of Peer-To-Peer Systems Berkeley CA June 2003

[5] OpenNap http://opennap.sourceforge.net/

[6] Oliver Heckmann and Axel Bock. The eDonkey 2000 Protocol. Technical Report KOM-TR-08-2002, Multimedia Communications Lab, Darmstadt University of Technology, December 2002.

[7] Soulseek http://www.slsk.org

[8] MP2P http://www.blubster.com/protocol1.html

[9] Wikipedia http://www.wikipedia.org/wiki/Peer-to-peer

[10] Shareaza http://www.shareaza.com

[11] MLDonkey http://mldonkey.berlios.de/

[12] Morpheus http://www.morpheus.com

[13] Benno J. Overeinder, Etienne Posthumus, Frances M.T. Brazier. Integrating Peer-to-Peer Networking and Computing in the AgentScape Framework. Second International Conference on Peer-to-Peer Computing (P2P'02). September, 2002

[14] cP2Pc: Integrating P2P networks. Ihor Kuz, Maarten van Steen, www.nlnet.nl/project/cp2pc/20030620-cp2pc.pdf