

# Network System Peer-To-Peer Network

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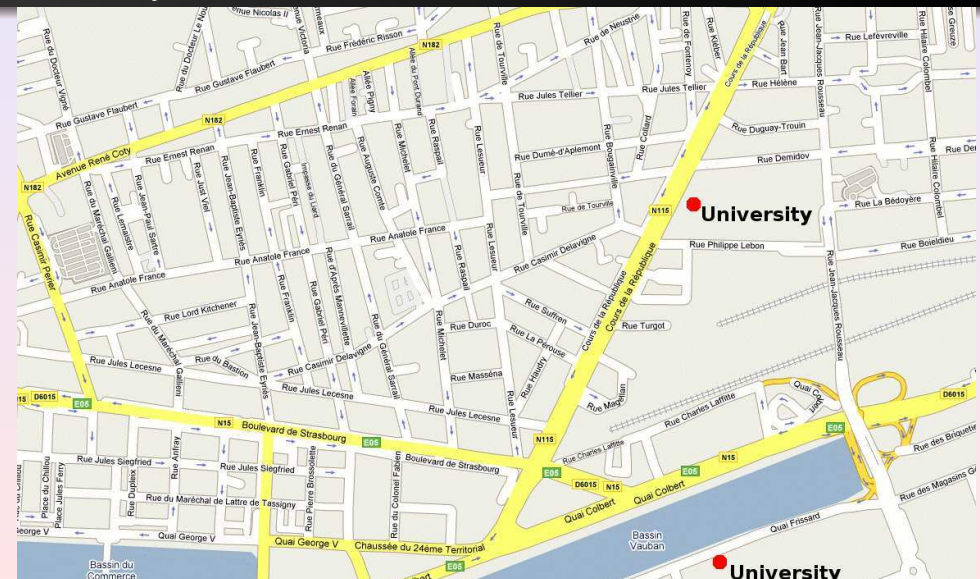
## Who am I?

- Wǒ tiào Duvallet Claude, Wǒ shì fǎ guó rén
  - Associate Professor in computer science since September 2003.
  - PhD obtained in October 2001 at Le Havre University, France
- Where do I come from? Le Havre University (France)  
dà xué lè ā fuó ěr.
- My topics of interest:
  - Teachings: Programming (Java, C/C++), Operating Systems (Linux, Unix), Distributed System (CORBA, RMI, RPC, EJB, LDAP), Network Protocols and Architectures, Network and System Administration.
  - Research: Real-Time Databases, Multimedia Systems, Quality of Service Management, Distributed Systems, etc.
- Current PhD supervising: Nizar Idoudi, Emna Bouazizi and Bechir Alaya.
- My homepage in English:  
<http://litis.univ-lehavre.fr/~duvallet/index-en.php>

## Le Havre in France



## University of Le Havre



## Presentation of the University of Le Havre



- University of Le Havre is a small university: 7000 students.
- Four topics of studies:
  - Sciences, Technologies, Health.
  - Law, Economics, Management.
  - Letter Language.
  - Social and Human Sciences.
- 3 Faculties and 2 Institutes:
  - Faculty of Sciences and Technologies.
  - Faculty of International Affairs.
  - Faculty of Letters and Humanities.
  - Institute of Technology.
  - Institute of Logistic.

## Computer Science, Information Processing, and Systems Laboratory

## Peer-To-Peer Network

## Outline

- 4 Introduction
- 5 Why do we need Peer-To-Peer networks?
- 6 How do the Peer-To-Peer systems work?
- 7 Peer-To-Peer Applications

## Introduction (1/3)

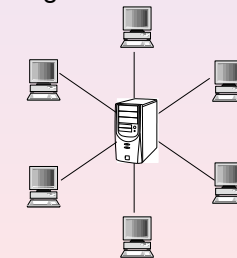
- For many people, Peer-To-Peer systems are only the software like Napster, Kazaa, BitTorrent, eMule and other eDonkey.
- These are often used to exchange illegal files like music, films, software and so on.
- Many words could be used to designate these systems like equals to equals or other words.
- It must not mistake with the notion of Point-to-Point or the protocol PPP.
- Peer-To-Peer network are made of:
  - users (most of the time with an undefined number and not a fix number),
  - the protocol which allow them to communicate (Gnutella, BitTorrent, CAN, etc.),
  - and the working of this protocol between the different hosts.

## Introduction (2/3)

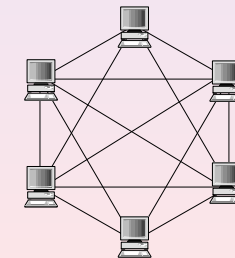
- The name of Peer-To-Peer allow to designate the host and their interconnection at a moment, with a fix number of hosts/users.
- The term of node is used to designate the software which is present on a host so most of the time it is a user (but it could be many users).
- The term of link designate a connection (often TCP) between two nodes.
- The term of object designate what could be shared in a Peer-To-Peer system:
  - a computation power,
  - some files,
  - some services (DNS).

## Introduction (3/3)

- In a Peer-To-Peer system, the nodes do not only play the roles of client or server but both the two in the same time.
- In fact, they are both client and server for the other nodes of the network contrary to the classical system client-server.
- The nodes are also functioning like a router by forwarding the messages of data research or the data itself.



Client-Server System



Peer-To-Peer System

## Internet, a successful network

- Internet has been design to work as a client-server system.
  - Many servers are dedicated to the storage of WEB site and have an increase of the request from the users more and more numerous.
- ⇒ increase of the use of the bandwidth and the congestion of the network.
- ⇒ creation of low bandwidth part in the internet network.

## The Peer-To-Peer could help the Internet network

- By increasing the communication between the users without using main servers.
- ICQ: the first Peer-To-Peer network
  - Yossi Vardi is one of the creators of the firm that which publish the software of his son.
  - This software has been created in 1996.
  - It allows the software to communicate between them thank to the Mirabilis servers.
  - In 1996, the Mirabilis servers were able to have more than 500 000 connection simultaneously.
- Now, the Razorback association could have more 1 million of users on only one server and these users could share more than many hundred of mega bytes.

## Peer-To-Peer: an economical asset but also a technical one

- It allows to decrease the utilization of the bandwidth.
- On Internet and on the web site, the data are located thanks to Uniform Resource Locator (URL) which designates servers and names of files.
- In Peer-To-Peer Network, we talk about Uniform Resource Identifier (URI) and not about URL.
  - They are built thanks to hash algorithms.
  - The URI of a file contains a unique numeric signature.
  - If only one byte of the file changes then the signature will be different.
  - The could be located on the Peer-To-Peer Network thanks to this Uniform Resource Identifier.

## Definition for Peer-To-Peer

- Each node could be both a client and a server.
- Each node pay its participation by giving access to a part of its resources.
- Property:
  - No centralized coordination.
  - No centralized databases.
  - No node has a global view of all the system.
  - The global behavior comes from all the local interactions.
  - All the services and the data are available from all the nodes.
  - The nodes are autonomous (off-line).
  - Nodes and connections are not reliable.

## Different class of Peer-To-Peer network

- Hybrid Peer-To-Peer (e.g. Napster):
  - A centralized index (not fault tolerant).
  - Direct exchanges of data between the nodes.
- “Pure” Peer-To-Peer (e.g. Freenet, Gnutella)
- Hierarchical Peer-To-Peer or “Super-Peers” (e.g. Kazaa):
  - A mix Client/Server system with a Peer-To-Peer system.
- Semantic Peer-To-Peer (e.g. Routing Indices)
  - “Pure” Peer-To-Peer with routing based on semantic information.

## Characteristics of a Peer-To-Peer system

- Discovering resources.
- Update management.
- Scaling.
- Fault tolerance.
- Security.

## «Pure» Peer-To-Peer systems (1/3)

- Request spreading:
  - Each node which receive a request, must send it to a limited number of nodes neighbors.
  - The number of successive spreads is limited.
  - There is a detection of the cycles.
- The underlying principles:
  - Equality between the nodes: same capacities (power, bandwidth, ...), same behavior (all could be both client and server).
  - The most popular request: the resources the more asked must be the more replicated.
  - Network topology: graphs minimizing the number of path between two nodes of the network and minimizing the distance.

## «Pure» Peer-To-Peer systems (2/3)

- Reality about the equality between the nodes:
  - A difference between 1 to 3 times in the available bandwidth.
  - 70% of the users do not share any files, 50% of the results are provided by 1% of the nodes.
  - Only one user could disturb the network because of the overloaded of the bandwidth.
  - No interest for the people who share files (It is not reciprocal) and the network can fail or be attacked.
  - Some nodes underestimate their bandwidth in order to not be chosen.

## «Pure» Peer-To-Peer systems (3/3)

- What's about the most popular request:
  - The one hundred most frequent requests are informally distributed.
  - The techniques which use buffer can be applied and they are increasing the performances.
- What's about the network topology:
  - Many studies show that the graph of Gnutella is « small-world » graph.
  - The degree of the node is following a « power law » for the distribution.

## Resume about «Pure» Peer-To-Peer systems

- Completely decentralized.
- Very fault tolerant.
- Well adapted to the network topology.
- Simple, robust and scaling.
- Using a large bandwidth.
- No guarantee to be successful, no estimation of the requests duration.
- No security, No repudiation.

## Super-Peers

- Mix of Client/Server system and Peer-To-Peer network.
- To avoid the problems due to the heterogeneity of the bandwidth of the node.
- All the nodes are not equals:
  - The nodes which have a good bandwidth are organized in a Peer-To-Peer network: the Super-Peers.
  - The nodes with a low bandwidth are attached to a Super-Peer like in client/server system (cluster).
  - The Super-Peers have an index of all the resources available in their cluster.
- It was used in the KaZaa Peer-To-Peer network.

## The redundancy of the Super-Peers

- Super-Peers introduces possible fault.
- Possible improvement: to choice k super-peers in a same cluster.
- Each Super-Peer of the cluster is connected to a client and have an index of all their resources.
- The client are sending their request to the super-peers according to the « Round Robin » principle.
- The load for a node in the cluster is decreasing from a k factor.
- The cost of the entry of a new client is increased from a k factor.
- The number of open connections is increased from  $k^2$ .

## Private Peer-To-Peer

- The private Peer-To-Peer network are networks that only allow few confidence hosts to share files.
- It can be done thanks to a central server to authenticate the client. In this case, it looks like a private FTP server, but with some files that are directly transmitted between the clients.
- Alternatively, the users could exchange a password or a public cryptographic key with their friends in order to create a decentralized network.
- Unlike Friend-To-Friend networks, the private Peer-To-Peer networks allow any members to connect to all the other members of the network.
- So, a private Peer-To-Peer network cannot grow up without compromising the anonymity of its users.

## Friend-To-Friend networks

- The Friend-To-Friend networks (F2F) are a kind of anonymous Peer-To-Peer network in which the users have direct connections only with their friends.
- A Friend-To-Friend software allow only your confidence people to exchange file with your computer thank to their IP address or their numeric signature.
- Then, the friends of your friends could indirectly exchanges files with your computer and without using your IP address.
- Unlike the private Peer-To-Peer, the Friend-To-Friend network can grow up without compromising the anonymity of its users.

## Class of applications

- Share files: Napster, Gnutella, Freenet, Kazaa, eDonkey, etc.
- Persistence storage in a large scale: OceanStore.
- Grid Computing: Seti@home, Folding@home.
- Streaming: Peercast, Streamer, Skype.
- Network games.

## Secure multisourcing (1/2)

- Some of the platform are more oriented toward the data exchange security.
- **Kameleon**: <http://kameleon.sourceforge.net>
  - A French project that allows to do anonymous and secure Peer-To-Peer.
  - The anonymity of the data exchanges is done by a proxy mechanism and by broadcasting the requests ⇒ No possibility to physically find the author of an information and the addressee for this information.
  - Security in case of direct exchanges between confidence peers. This security do not use proxying of the anonymity.
  - We are either on an anonymous link or on a secure link but not both the two. It is technically impossible.
  - A mechanism of GridStorage / GridCache allow to propose a better availability of the most asked blocks (it is similar to Hispread).

## Secure multisourcing (2/2)

- **Kameleon** (following)
  - Multisourcing is the possibility to unload from many sources (peers) in the same time (like BitTorrent).
  - It is possible to encapsulate exchanges in HTTP or HTTPS.
- **I2p**: <http://www.i2p.net>
  - A secure and efficient platform.
  - It exist an adaptation of the BitTorrent crypted by I2p.
  - This Peer-To-Peer network is already used to anonymously distribute Web site.
  - In theory, it could be done with any protocol (IRC, SNMP, FTP,...) by using the network as tunneling.

## Distributed computing

- In the scientific world, the Grid Computing allow to exploit the resource of an infinity number of computers by distributing the load on each computer and organizing the automatically retrieval of the results.
- The first project of this type was the **Seti@home** project which search for extraterrestrial intelligence.
- **Folding@home:**
  - Realized by some researchers of the Stanford university.
  - It is the study the folding of protein, the abnormal folding, the aggregation of protein and the linked diseases.
- Peer-To-Peer architecture are used to replace the "supercomputers" because they allow a saving of time and of money which are considerable.

## More efficient than the classical streaming

- Very efficient in distributing contents, the Peer-To-Peer is more and more used in the multimedia.
- **1-Click:** <http://www.1-click.com/>
  - They use Peer-To-Peer techniques to replace streaming broadcasting and to improve the quality of the broadcast and in a same time by using a low bandwidth.
  - 1-Click is a firm that already proposes solutions to broadcast video contents for TV partners or movie partners.
  - It allow users to see, on Internet, teasers or movie with a higher quality like full screen TV.
  - For the moment, it only uses Windows Media Player and Internet Explorer, the new version should be compatible with a greater number of operating systems and internet browser.
  - For the future, a possible evolution is to allow to use other contents like music or video games.
  - In the future, it is also the possibility for the users to provide their own contents to all the community.

## Audio streaming

- Radio becomes more and more numerous thanks to Peer-To-Peer architectures and open source projects:
  - **Peercast:** <http://www.peercast.org/>
  - **Streamer Peer-To-Peer Radio:**  
<http://www.streamerp2p.com/>
- Broadcasting an audio stream with a good quality for many hundred of users of the internet.
- The stream, received by the people who are listening it, is sending to the other users.
- **Mercura:** <http://www.mercura.com/>
  - American society which using this concept.
  - Each user of Mercura may be a broadcaster.
  - Instead of downloading and sharing music, the users could receive and transmit the stream to the other users.
  - Community creation that could broadcast many hours of music without any problems of legacy.

## Voice on IP (VoIP)

- Voice on IP with Skype:
  - **WEB site:** <http://www.skype.com/>
  - More than two million of users who are using it to communicate.
  - The vocal communications are totally crypted.
  - SkypeOut allow to call fix phone with a cheaper cost.
  - Skype has been bought by eBay.
- **Wengo of 9Telecom:** <http://www.wengo.fr/>
- **Qnext:** <http://www.qnext.com/>
  - Canadian software extremely complete.
  - Immediate messenger to do all: VoIP, videoconference, to transfer file, on line games, IRC, etc.
  - Inspired from Grouper (<http://www.grouper.com/>) which allow to create small private and secure networks.



## PeerCast (1/2)

- PeerCast.org has been launched in April 2002 in order to provide non-commercial software of radio broadcasting in Peer-To-Peer.
- The project is a simple client to use but it is robust. It allows to all people to broadcast its own media on Internet.
- In a first time, it only allows to broadcast audio.
- PeerCast allows a considerable saving of bandwidth for the broadcaster, who do not need to plan the bandwidth needed for each client.
- PeerCast is a robust network because there is not any central server. Each user may be both a client, a server and a broadcaster of stream.
- It provide anonymity because it is difficult to find the original stream. It is also possible to broadcast toward a client located in a foreign country.

## PeerCast (2/2)

- PeerCast allow to directly broadcast stream from a multimedia player.
- It works, like most of Peer-To-Peer software, by sharing file but instead of downloaded the file, it downloads the streams. These streams are exchanged with the other users in real-time.
- No data are stored on a local computer connected to the network.
- A WEB server included in the client allow the users located in the same WEB to view the received streams. In an office, a PeerCast client may provide streams for all the LAN.
- It is also possible to create a private network with your friends in order to listen music. You have the choice to connect or not to the PeerCast network.

## BitTorrent: introduction

- Appeared on the WEB in summer 2002.
- A real speed of download (more than 100 kbps).
- BitTorrent is a Peer-To-Peer transfer protocol of data which has been designed by the American Bram Cohen.
- This protocol has been quickly become essential to download the Linux distribution or other big program.
- It is also the best way to provide some personal big files like some album of photography, etc.

## BitTorrent: functioning (1/2)

- The principle of BitTorrent is that each user, who want to download the same file, always participate to its broadcasting.
- So, each computer share its files by receiving and sending little individual blocks of the distributed file.
- This exchange of little packets contributes to improve the transfer speed.
- For any user, the first step consist on downloading a little in the torrent format (only few kilo bytes).
- After its execution, its launch the dedicated software and so the data transfer is beginning.
- Then, the packets are individually transferred from the Peer-To-Peer network.

## BitTorrent: functioning (2/2)

- The fragmentation of the file in many little blocs means that we could download in a muddle.
- In fact, more there are users in the same time more the speed of exchanges will increases.
- Compared to other Peer-To-Peer platforms, this system create emulation between all the users.
- As soon as you have downloaded some blocks of files, they are immediately available and redistributed toward the other users.
- Drawbacks: sending your IP address to all the other users.

## The JXTA platform (1/4)

- Some of the Peer-To-Peer software uses closed protocols like the protocol FastTrack (Kazaa) and other use open protocols like BitTorrent or Gnutella.
  - The application for Peer-To-Peer network are not limited to the share or the transfer of file. It exist many other possible applications.
  - Many network applications may profit from the mechanisms and the techniques which are used in the Peer-To-Peer networks.
- ⇒ Increasing use of platform of development oriented Peer-To-Peer.
- Development of many projects of Voice On IP (VoIP), of network games, of storage of data, of immediate messaging, of auction sales, or of scientific computation.

## The JXTA platform (2/4)

- The WEB site: <http://www.jxta.org/>
- Beginning of the development: summer 2001.
- Project of Sun Microsystem.
- Under license Apache Open Source 1.0
- Some projects based on JXTA platform:
  - Peer Rendezvous: a system of communication in a firm.
  - Peer-To-Peer Go Client: a games of Go for many players.
  - JXCube a distributed platform of collaboration.
  - Venezia-Gondola: a system to make sell between private individual.

## The JXTA platform (3/4)

- The four main objectives of JXTA:
  - 1 **Interoperability** between the applications (XML) and the different Peer-To-Peer systems.
  - 2 **Independence** of the applications, the languages, the operating systems and the network.
  - 3 **Ubiquity** (Tini, sensors, PDA, routers, PC, Servers, organizers, GPS,...).
  - 4 **Security at different levels**, taking into account in the kernel of JXTA.
- Specifications of 6 different protocols from the implementation to the development of the API (Framework, Middleware).

## The JXTA platform (4/4)

- The notion of virtual network JXTA (JVN(Jxta Virtual Network)  $\approx$  JVM) allow to have a homogeneous and transparency vision of the network:
  - independence of the network,
  - independence of the platform,
  - creation of semantic network software: creation of network topologies by the developers and not the network administrator.
- Why JXTA:
  - To design distributed Peer-To-Peer application.
  - To design semantics networks.
  - To design network that are weakness linked and permits intermittent connections.

## Conclusions

- Peer-To-Peer is not only for hackers and exchanges of illegal files.
- It is a new architecture of network which could be very useful.
- Some links:
  - <http://www.p2pnet.net/>: every day, a detail actuality about what happens in the world of the Peer-To-Peer systems.
  - <http://www.zeropaid.com/>: Useful to know the evolution the Peer-To-Peer software.
  - <http://www.DistributedComputing.info/>: for all people who are interested by the distributed computing project.
  - <http://www.openp2p.com/>: paper and directory of the entire different Peer-To-Peer project.