Peer-to-Peer Networks

Organization and Introduction
1st Week

Albert-Ludwigs-Universität Freiburg
Department of Computer Science
Computer Networks and Telematics
Christian Schindelhauer
Summer 2008

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Organization

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Web & Dates

‣ **Web page**

- http://cone.informatik.uni-freiburg.de/lehre/vorlesung/peer-to-peer-s08/index.html

‣ **Lecture**

- Tuesday, 11am-1pm, building 101, room 00-010/14
- Wednesday, 11am-12am, building 101, room 00-010/14

‣ **Exercise**

- Arne Vater
- Wednesday, 12am-1pm, building 101, room 00-010/14

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Exercises

‣ **Exercise class**

- Wednesday, 12am-1pm, building 101, room 00-010/14

- start: 30.04.2008

‣ **Exercises**

- appear every Wednesday on the web-pages

- should be solved by students

- are the bases for the oral exam

- solutions of the exercises are discussed in the following week

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Exam

‣ **Dates by appointment**

- possible dates are presented in the last four lectures

    - probably first week after the lecture and in the middle of the lecture free summer

- Contact me during the lecture or send an E-Mail to schindel@informatik.uni-freiburg.de

‣ **Oral exam**

- based on the lecture and the exercises

‣ **Mandatory registration**

- Students of computer science register at the secretary of exams *(Prüfungssekretariat)*

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Materials

‣ **Slides**

- appear before the lecture on the web-page

‣ **Book**

- at least 70% of the lecture can be found in *Mahlmann, Schindelhauer, Peer-to-Peer-Netzwerke — Methoden und Algorithmen, Springer 2007*
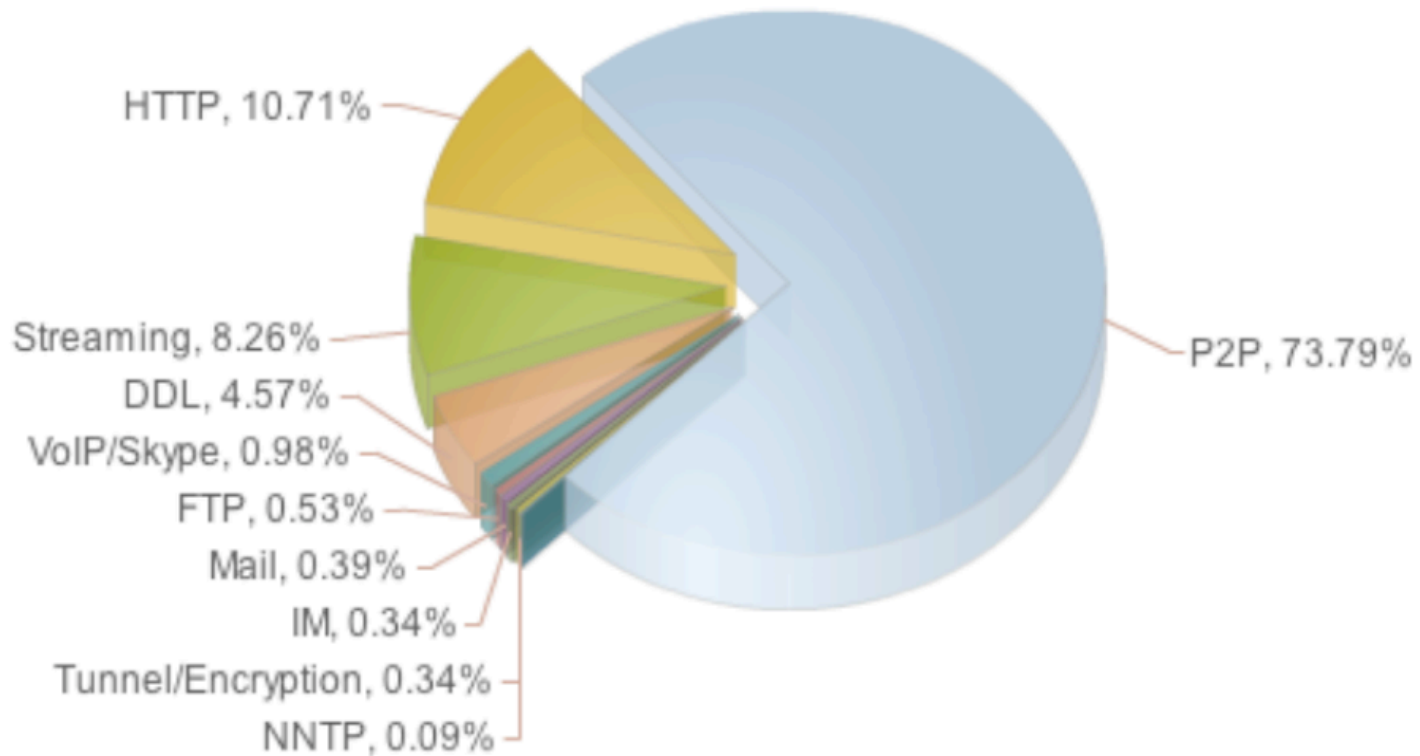
‣ **Further Literature**

- Research papers will be presented during the lecture on the slides and on the web-page
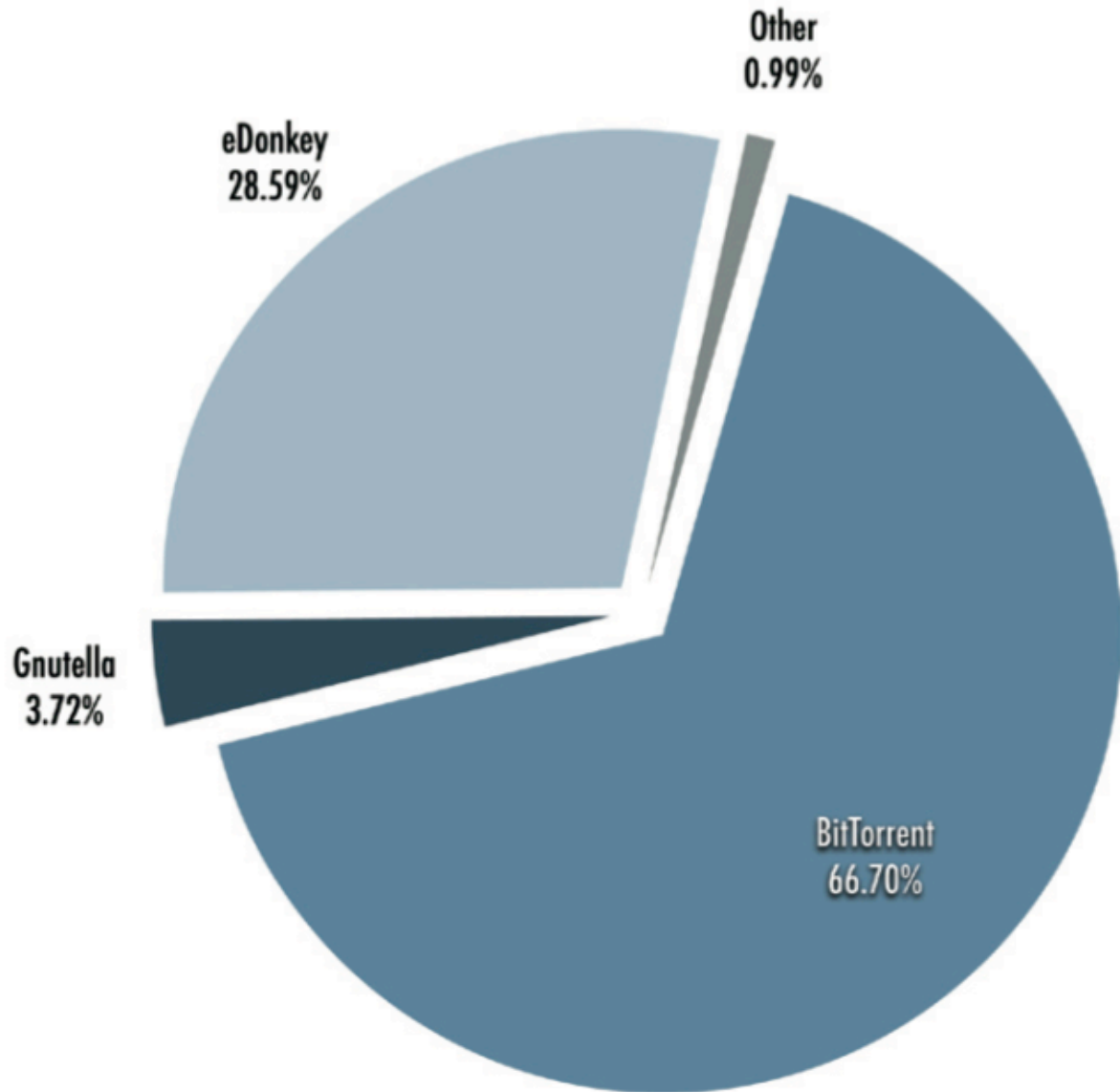
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Motivation

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P2P Share Germany 2007

HTTP, 10.71%

Streaming, 8.26%

DDL, 4.57%

VoIP/Skype, 0.98%

FTP, 0.53%

Mail, 0.39%

IM, 0.34%

Tunnel/Encryption, 0.34%

NNTP, 0.09%

P2P, 73.79%

Source: Ipoque 2007

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P2P Systems Germany 2007 by Volume

Other 0.99%

eDonkey 28.59%

Gnutella 3.72%

BitTorrent 66.70%

Source: Ipoque 2007

What Germans Download 2007 by Volume

Traffic Volume per Content Type
Germany, BitTorrent

- TV 21.15%
- aBook 1.41%
- Music 7.78%
- eBook 0.81%
- Game 5.77%
- Porn 13.05%
- Application 4.97%
- Picture 0.09%
- Movie 37.24%
- Anime 7.09%
- Music 0.65%

Legend:
- Video 79.17%
- eBook 0.81%
- Picture 0.09%
- Audio 9.19%
- Software 10.74%

Source: Ipoque 2007

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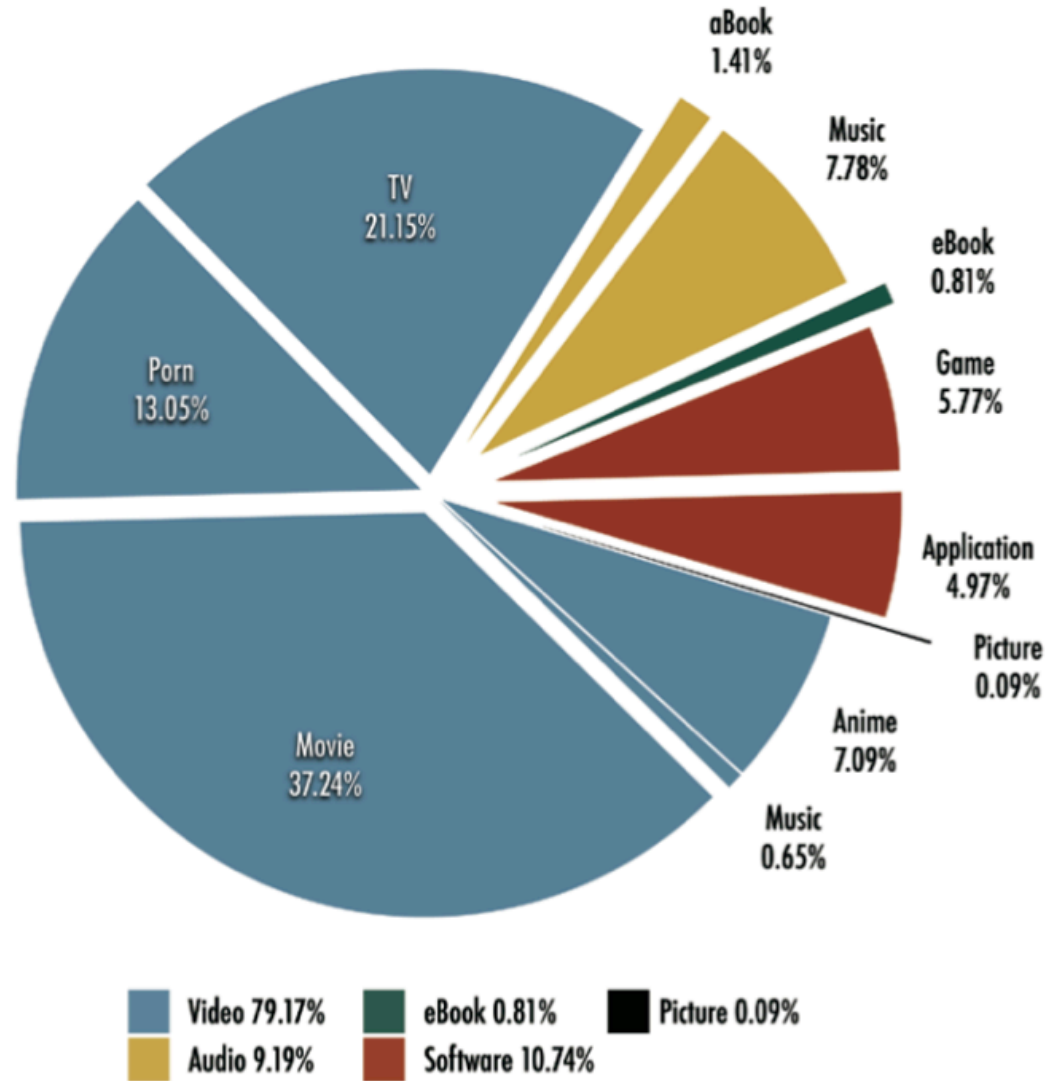
Global Internet Traffic Shares 1993-2004

CacheLogic Research   **Trends of Internet Protocols 1993-2004**

Source: CacheLogic 2005

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P2P Share
June 2004

Source: CacheLogic

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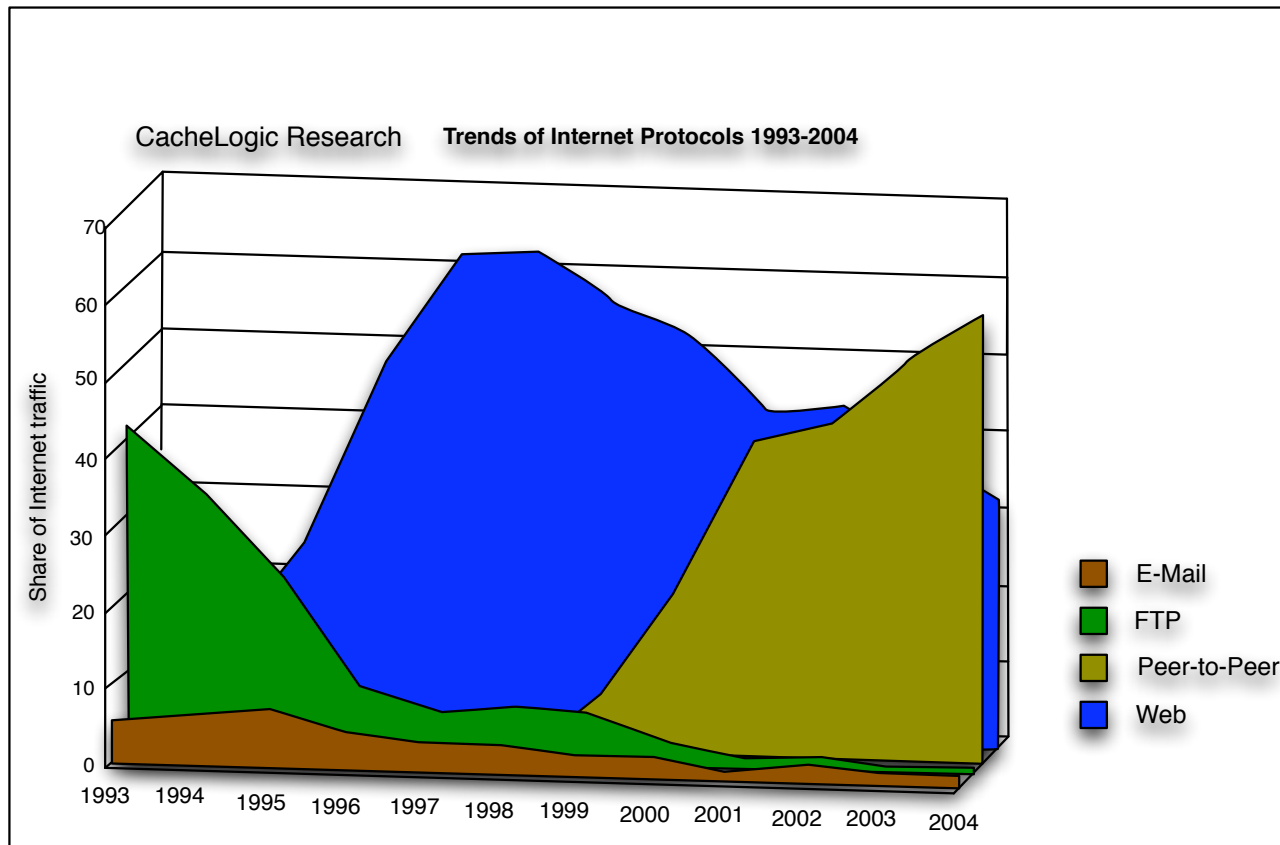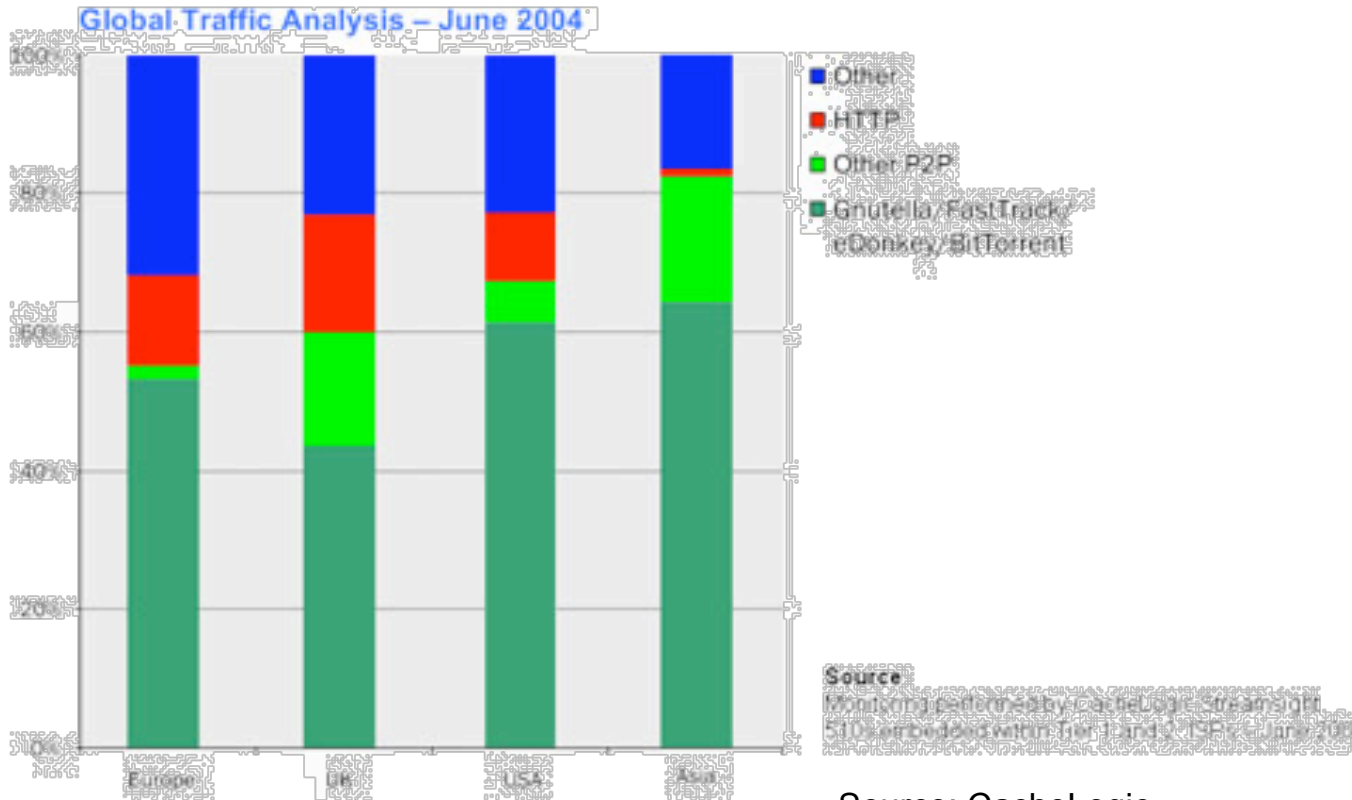
Global Internet Traffic 2007

‣ **Ellacoya report (June 2007)**

  • worldwide HTTP traffic volume overtakes P2P after four years continues record

‣ **Main reason: Youtube.com**

P2P
37%

gaming
2%

non-HTTP video streaming
3%

Newsgroups
9%

VoIP
1%

rest
2%

HTTP
46%

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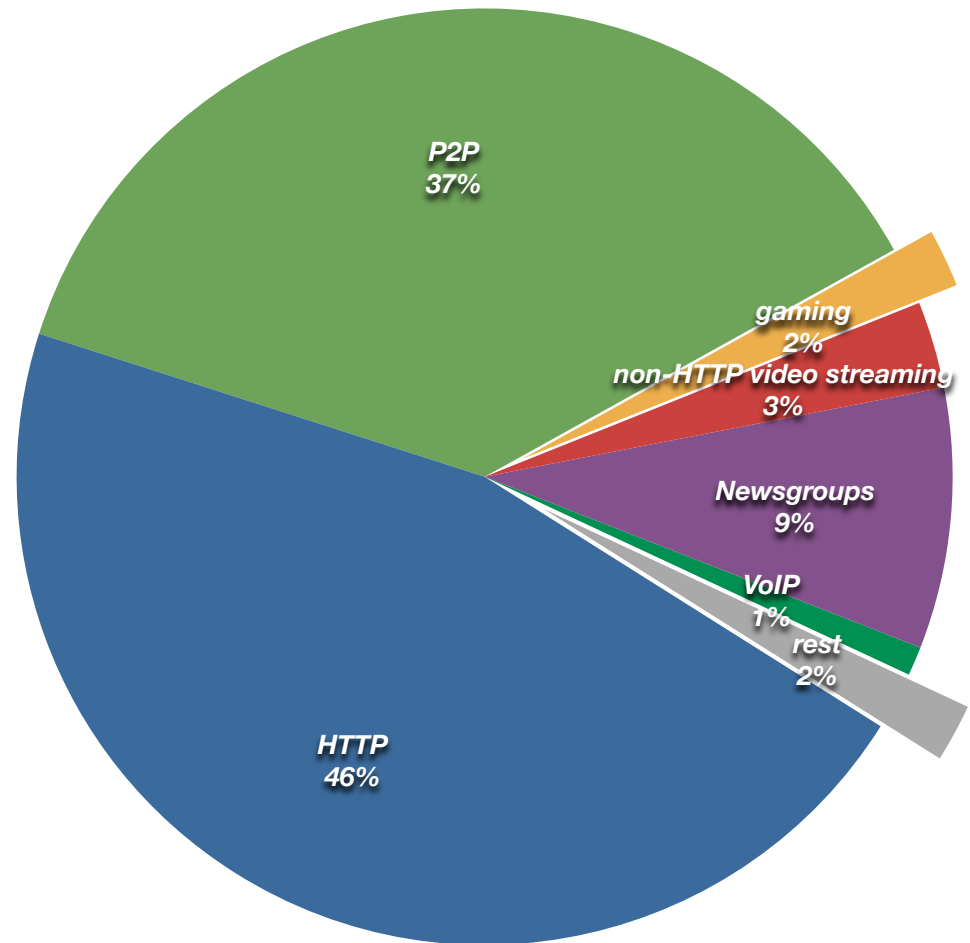
Milestones P2P Systems

- **Napster (1st version: 1999-2000)**
- **Gnutella (2000), Gnutella-2 (2002)**
- **Edonkey (2000)**
  - later: Overnet usese Kademlia
- **FreeNet (2000)**
  - Anonymized download
- **JXTA (2001)**
  - Open source P2P network platform

- **FastTrack (2001)**
  - known from KaZaa, Morpheus, Grokster
- **Bittorrent (2001)**
  - only download, no search
- **Skype (2003)**
  - VoIP (voice over IP), Chat, Video

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Milestones Theory

‣ **Distributed Hash-Tables (DHT) (1997)**
- introduced for load balancing between web-servers

‣ **CAN (2001)**
- efficient distributed DHT data structure for P2P networks

‣ **Chord (2001)**
- efficient distributed P2P network with logarithmic search time

‣ **Pastry/Tapestry (2001)**
- efficient distributed P2P network using Plaxton routing

‣ **Kademlia (2002)**
- P2P-Lookup based on XOr-Metrik

‣ **Many more exciting approaches**
- Viceroy, Distance-Halving, Koorde, Skip-Net, P-Grid, ...

‣ **Recent developments**
- Network Coding for P2P
- Game theory in P2P
- Anonymity, Security

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What is a P2P Network?

‣ **What is P2P NOT?**

- a peer-to-peer network is *not a client-server network*

‣ **Etymology: peer**

- from latin par = equal

- one that is of equal standing with another

- P2P, Peer-to-Peer: a relationship between equal partners

‣ **Definition**

- a Peer-to-Peer Network is a communication network between computers in the Internet

  - without central control

  - and without reliable partners

‣ **Observation**

- the Internet can be seen as a large P2P network

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Contents

‣ **Short history**
‣ **First Peer-to-Peer Networks**
- Napster
- Gnutella

‣ **CAN**
‣ **Chord**
‣ **Pastry und Tapestry**
‣ **Hop optimal networks**
‣ **Internet and hole-punching**
‣ **Game theory**
‣ **P2P traffic**
‣ **Codes**
‣ **P2P in the real world**

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The First P2P-Network — Napster

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Napster

‣ **Shawn (Napster) Fanning**

- published 1999 his beta version of the now legendary Napster P2P network
- File-sharing-System
- Used as mp3 distribution system
- In autumn 1999 Napster has been called download of the year

‣ **Copyright infringement lawsuit of the music industry in June 2000**

‣ **End of 2000: cooperation deal**

- between Fanning and Bertelsmann Ecommerce

‣ **Since then Napster is a commercial file-sharing platform**

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How Did Napster Work?

‣ **Client-Server**
‣ **Server stores**
  - Index with meta-data
    - file name, date, etc
  - table of connections of participating clients
  - table of all files of participants
‣ **Query**
  - client queries file name
  - server looks up corresponding clients
  - server replies the owner of the file
  - querying client downloads the file from the file owning client

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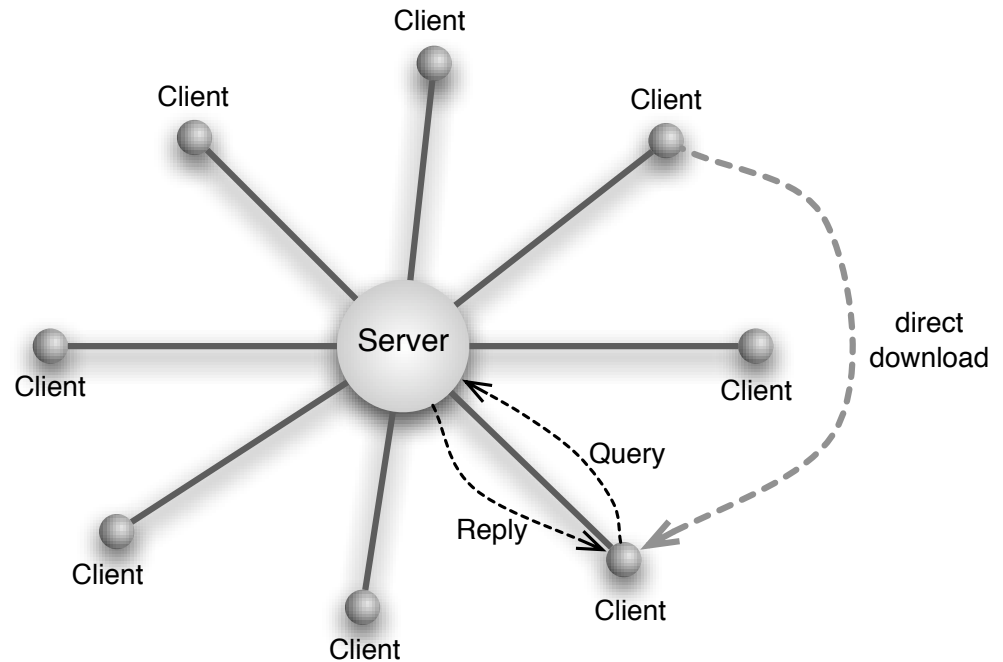
Discussion of Napster

‣ **Advantages**
- Napster is simple
- Files can be found fast and effective

‣ **Disadvantages**
- Central structure eases censorship, hostile attacks and vulnerability against technical problems
  - e.g. denial of service (DOS) attack
- Napster does not scale
  - i.e. increasing number of participants implies a decline in performance
  - bandwith and memory of the server is limited

‣ **Conclusion**
- Napster is not an acceptable P2P network solution
- Except the download part Napster is not a real P2P network

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The First Real P2P-Network — Gnutella

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History of Gnutella

‣ **Gnutella**

- was released in March 2000 by Justin Frankel and Tom Pepper from Nullsoft

- Since 1999 Nullsoft is owned by AOL

‣ **File-Sharing system**

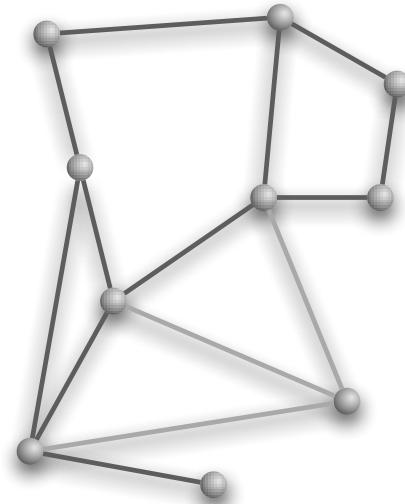- Same goal as Napster

- But without any central structures

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Gnutella — Connecting

‣ **Neighbor lists**

- Gnutella connects directly with other clients
- the client software includes a list of usually online clients
- the clients checks these clients until an active node has been found
- an active client publishes its neighbor list
- the query (ping) is forwarded to other nodes
- the answer (pong) is sent back
- neighbor lists are extended and stored
- the number of the forwarding is limited (typically: five)

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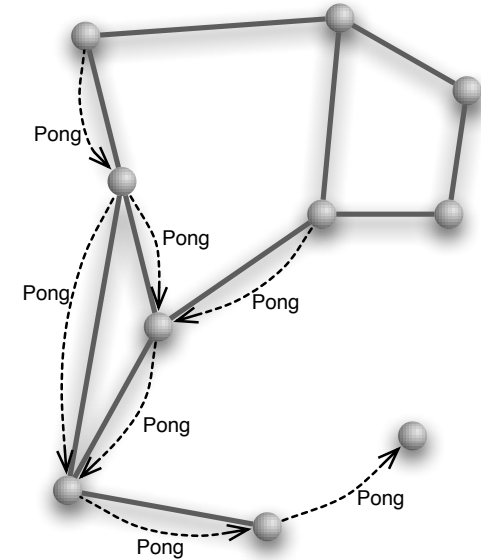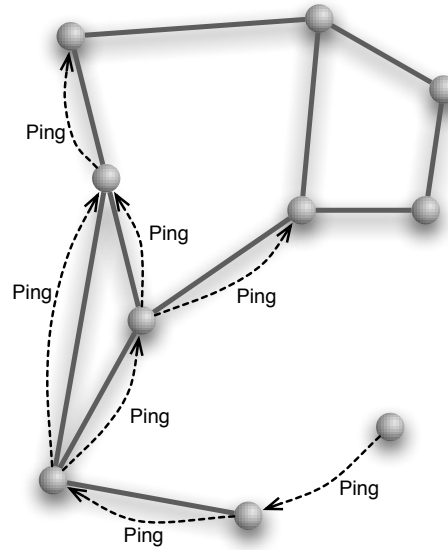
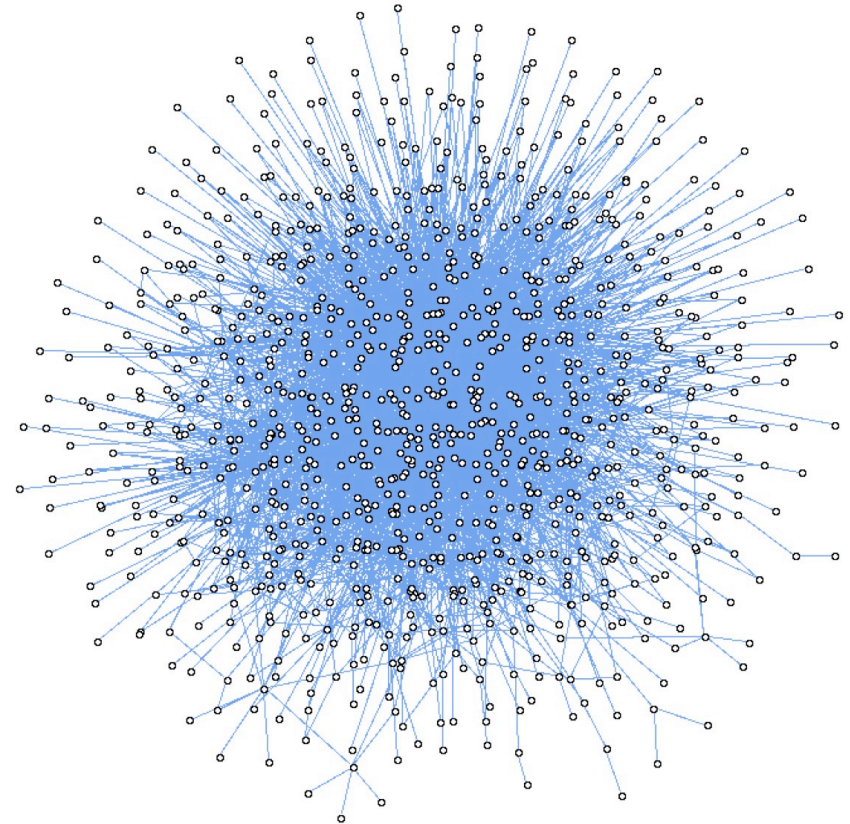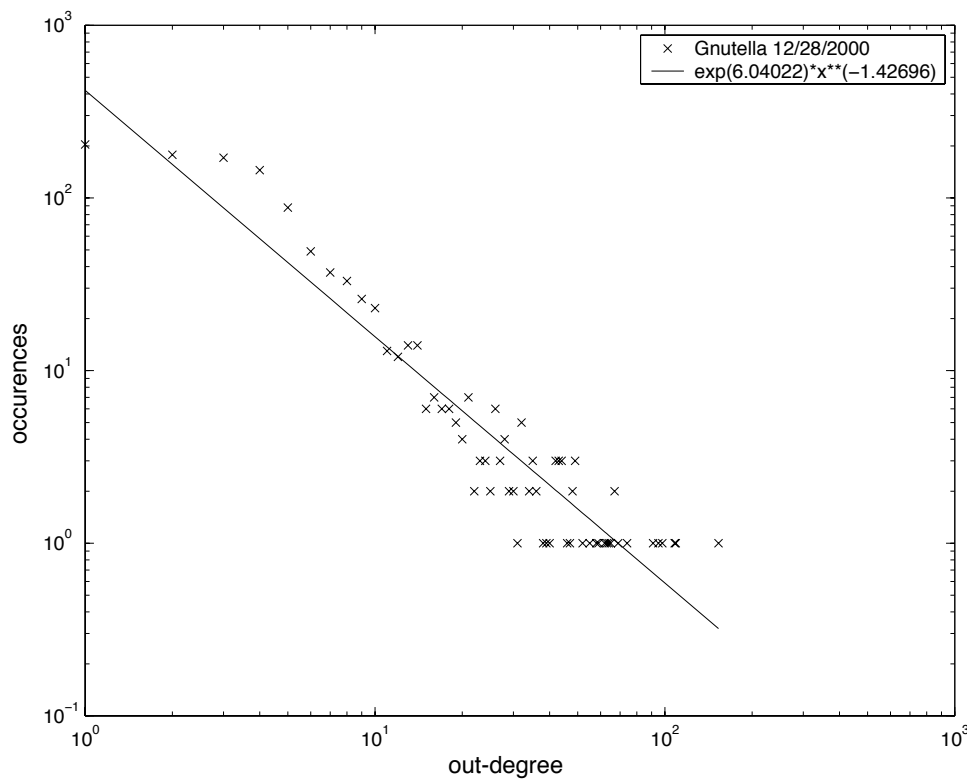# Gnutella – Connecting

‣ **Protokoll**

- Ping
    - participants query for neighbors
    - are forwarded according for TTL steps (time to live)
- Pong
    - answers Ping
    - is forwarded backward on the query path
    - reports IP and port adress (socket pair)
    - number and size of available files

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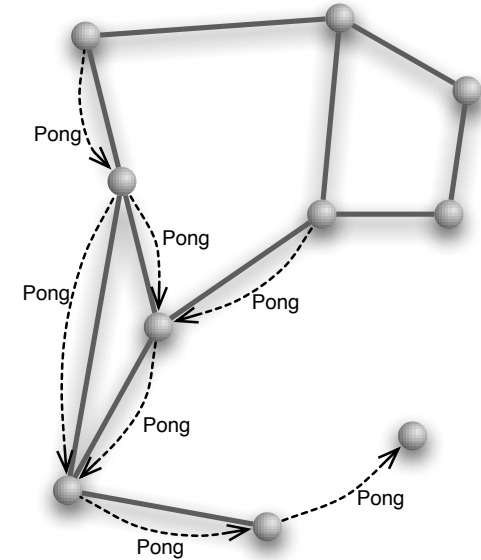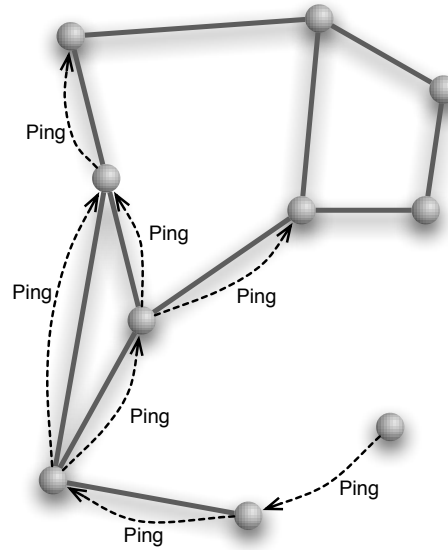
Gnutella — Graph Structure

‣ **Graph structure**
  - constructed by random process
  - underlies power law

Gnutella snapshot in 2000
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Gnutella — Query

‣ **File Query**
  - are sent to all neighbors
  - Neighbors forward to all neighbors
  - until the maximum hop distance has been reached
    - TTL-entry (time to live)
‣ **Protocol**
  - Query
    - for file for at most TTL hops
  - Query-hits
    - answers on the path backwards
‣ **If file has been found, then initiate direct download**

Query

Query

Query

Query

Query

Query

querying peer

QueryHit

QueryHit

QueryHit

QueryHit

querying peer

direct download

querying peer

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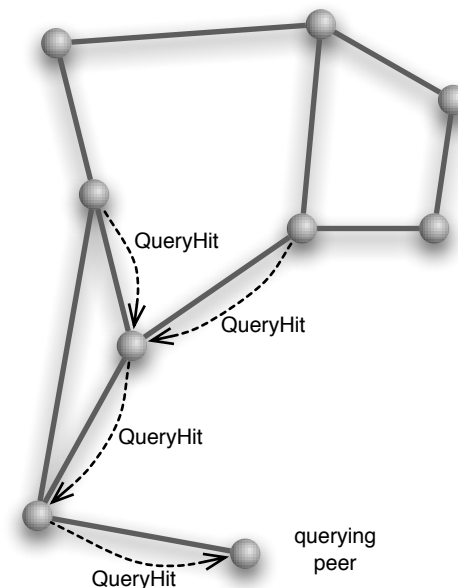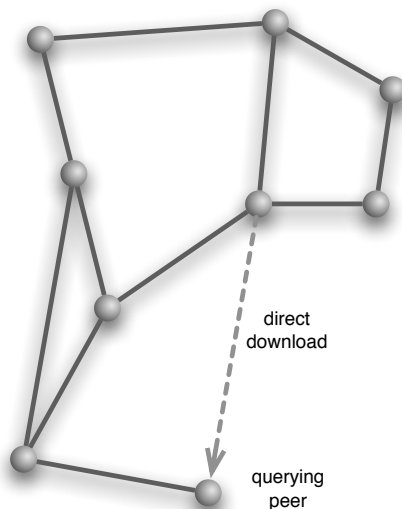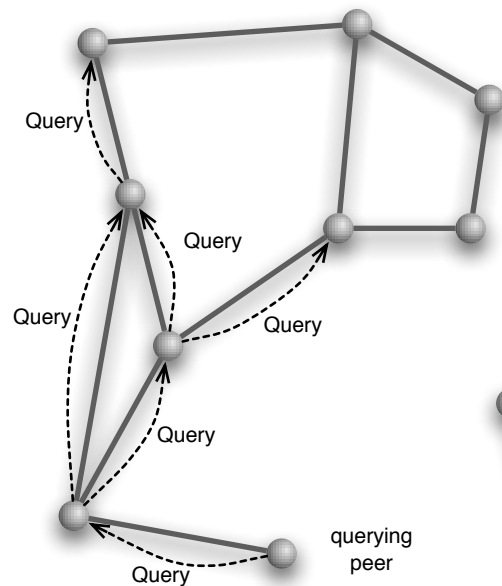
Gnutella - Discussion

‣ **Advantages**

- distributed network structure
- scalable network

‣ **Disadvantages**

- bounded breadth depth search leads to implizit network partition
- this reduces success probability
- long paths, slow latency

‣ **Suggested improvements**

- random walks instead broadcasting
- passive replikation of index information

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FastTrack & Gnutella2

‣ **Hybrid Structure**
  - high bandwidth node are elected as P2P-servers, aka. super-nodes
  - super-nodes are connected using the original Gnutella protocol
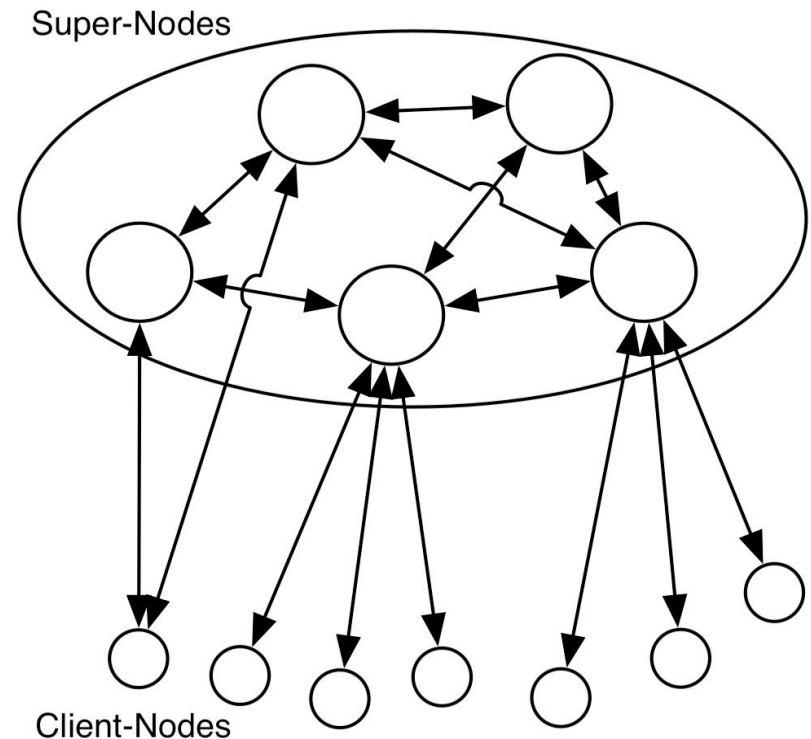 - client nodes are connected only to super-nodes

‣ **Used in**
  - FastTrack
  - Gnutella 2

‣ **Advantages**
  - improved scalabilty
  - smaller latency

‣ **Disadvantages**
  - still unreliable and slow
  - peers decline to serve as super-nodes

Super-Nodes

Client-Nodes

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End of 1st Week

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