Peer-to-Peer and Overlay Networks
Unstructured Networks I

Ricardo Lopes Pereira
ricardo.pereira@inesc-id.pt

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1images from Peer-to-Peer Systems and Applications, Springer LNCS 3485 by Rüdiger Schollmeier and Jörg Eberspächer (Technische Universität München)
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   - Characteristics
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Limitations of the centralized P2P model

- Central entity represents single point of failure
- Central entity may constitute a significant cost, which must be supported by someone
- Central entity may be a performance bottleneck (CPU, bandwidth, storage)
- Central entity controls the entire network
Unstructured P2P systems

- Decentralized systems
- Self-organizing systems
- Content and description remain in the nodes that supply it
  - Randomly distributed over the network
- Nodes may connect (attach) to any other node, generating a random structure
- Network provides signaling and search
- Content exchange is performed out-of-band
Unstructured P2P systems

- Nodes act as servers and clients (server + client -> servent)
- Nodes actively participate in the overlay network management
- Nodes identified by GUID (General Unique ID) created using hash of random or unique value
- Overlay network comprised of TCP connections among peers
- Nodes are consumers and suppliers of resources but also message routers for the overlay network
- Nodes may be removed without loss of functionally (content may be lost)
Example of unstructured network
Characteristics of overlay network

- Independent from and unrelated to the physical network
- May include hierarchy
- Network may be completely random, being modeled by random graph
- Follows an address and routing scheme distinct from IP’s
Disadvantages of the centralized P2P model
First generation unstructured P2P systems
Second generation unstructured P2P systems

Characteristics
Gnutella 0.4
Limitations

Joining the network (bootstrapping)

- Protocols don’t usually define bootstrapping
- To join the network, the client must know at least one already connected peer
- There are several ways to find already connected peers
  - To know address of always on peer
  - Dynamic DNS (multiple replies)
  - Anycast
  - Cache: connect to peers from the previous session
  - Broadcast: multicast channel or LAN broadcast
- There is no registration/login, only join
Gnutella 0.4 characteristics

- File sharing without any centralized server
- Peers leaving the network does not affect functionality
- Peer join the network by establishing TCP connection to peer from predefined list or using cache from previous session (out of the protocol scope)
- No login, just join
- Reactive routing, using flooding
- Connections among peers are stable (ignoring exits)
- Two types of messages, source search and content search
- File transfers among peers performed using HTTP
- Network has random topology ignoring underlying network
- Offers some anonymity
Disadvantages of the centralized P2P model

First generation unstructured P2P systems
Second generation unstructured P2P systems

Gnutella history

March 2000, version 0.4
Created by Justin Frankel and Tom Pepper, as open source software. They worked at Nullsoft, a division fo AOL. It was promptly withdrawn!!

Spring 2001
Version 0.6 released. It addressed the scalability issue.
Disadvantages of the centralized P2P model

First generation unstructured P2P systems

Second generation unstructured P2P systems

Characteristics

Gnutella 0.4

Limitations

Example of Gnutella 0.4 network
Search message routing

- Flooding algorithm
- TTL used to limit flooding and prevent cycles
- GUID assigned to each message
- Memory stops cycles
- Hop counter and TTL
How to efficiently route back the replies?
Routing the replies

- Replies use the same GUID as queries
- Also include TTL and hop counter
- Peers remember where query came from
- Replies are sent to the peer which sent the question
Measurement of a real network
Disadvantages of the centralized P2P model

First generation unstructured P2P systems

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Messages

Ping/Pong

Used to find peers. Peer joining the network floods a ping. All peers which receive ping reply with pong, stating their IP address, port, number and KB of shared files and GUID.

Query/Query Hit

In order to find a file, a peer floods a query message, stating the minimum upload speed and a set of keywords. Peers with matching files and capacity send a query hit message, indicating: their IP address, port, GUID, upload speed and for each matching file, their MD5 hash, size and name.
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Ping example
Query examples
Limitations

- Lots of signalling traffic, which limits scalability
- Nodes with little bandwidth become bottlenecks
- Topology is far from optimal from a performance point of view
- It’s impossible to have a global view of the network/available files (TTL)
- High path stretch results in large delays
- High path stretch may cause the same message to cross the same physical link several times
The main goal was to increase scalability
- Reduce the signaling traffic
- Increase network reach/visibility

Hierarchical levels introduced

The goal is to decrease the weight of signaling traffic while maintaining reliability
Main characteristics

- An additional network level was introduced (2 level hierarchy)
  - Supernodes/superpeers: connect 50 to 100 leafnodes to each other and to other supernodes
  - Leafnodes: are only connected to superpeers
- Peers (leafnodes) perform registration with their supernode
- Routing is no longer just reactive but also becomes proactive
- Flooding restricted to the supernode level
Superpeer election

- Peer joins the network by connecting to a superpeer
- A new superpeer must be chosen when:
  - A superpeer leaves the network
  - A superpeer was too many leadnodes
  - A superpeers was too few leafnodes
- Election is based on peers’ capacity (cpu, storage), bandwidth and peer availability (uptime)
Disadvantages of the centralized P2P model
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Network topology
Disadvantages of the centralized P2P model

First generation unstructured P2P systems

Second generation unstructured P2P systems

Characteristics

Gnutella 0.6

Disadvantages

Fewer connections
When it joins the network, peer issues ping request in order to get to know other superpeers.

Ping message is sent to superpeer.

Superpeer replies with the pong messages from other superpeers it has on its cache.

Superpeer will flood ping messages at regular intervals in order to update its cache.

Ping messages will only circulate in the superpeers level network.
Registration procedure

- When connecting to a superpeer, the peer will inform it of the list of files it shares.
- Route-table-update messages are used for this purpose.
- Content may be appended or replaced in superpeer’s memory throughout the session.
- Peer sends 32b hash of each of the keywords that describe the content being shared.
- Message may be compressed.
Query

- Peer sends query to superpeer
- Superpeer floods message to other superpeers
- Superpeer only forwards query to those leafnodes which it finds likely to have matching content (using the keyword hashes)
Disadvantages of the centralized P2P model
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Characteristics
Gnutella 0.6
Disadvantages

Ping example
Disadvantages

- Signaling traffic is still significant
- Failure to obtain an answer does not guarantee that wanted content does not exist
- Asymmetrical load distribution (superpeers)
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**Disadvantages of the centralized P2P model**

First generation unstructured P2P systems

Second generation unstructured P2P systems

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The end

Any questions?