Zone-based Peer-to-Peer

Wolfgang Kellerer
DoCoMo Euro-Labs, Munich

Rüdiger Schollmeier
Technische Universität München
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Motivation

- Peer-to-Peer (P2P): self-organizing overlay networks to offer distributed resources (e.g., files) of its nodes to user applications
- P2P overlays can accommodate changes of the node availability → support ubiquitous environments
- P2P supports user-provided services

- Design goal: **High success probability** with **efficient search**

- But (in pure P2P)
  - Search means flooding ↔ scarce wireless resources
  - P2P overlay networks not aware of underlying physical infrastructure or TCP/IP connections between nodes
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**P2P Signaling Efficiency**

**background noise in kbit/sec**

<table>
<thead>
<tr>
<th>System</th>
<th>Noise (kbit/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gnutella 0.4 Leafnode</td>
<td>2.87</td>
</tr>
<tr>
<td>Gnutella 0.6 Ultrapeer</td>
<td>2.27</td>
</tr>
<tr>
<td>Gnutella 0.6 Ultrapeer</td>
<td>43.25</td>
</tr>
<tr>
<td>Napster</td>
<td>0.02</td>
</tr>
<tr>
<td>JXTA Simple Peer</td>
<td>0.1</td>
</tr>
<tr>
<td>JXTA Simple Peer with keep alive</td>
<td>1.75</td>
</tr>
<tr>
<td>MPP</td>
<td>0.04</td>
</tr>
</tbody>
</table>

**file transfer overhead in byte**

<table>
<thead>
<tr>
<th>System</th>
<th>Overhead (byte)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gnutella 0.4 Leafnode</td>
<td>4850</td>
</tr>
<tr>
<td>Gnutella 0.6 Ultrapeer</td>
<td>4850</td>
</tr>
<tr>
<td>Gnutella 0.6 Ultrapeer</td>
<td>4850</td>
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<tr>
<td>Napster</td>
<td>4580</td>
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<tr>
<td>JXTA Simple Peer</td>
<td>12750</td>
</tr>
<tr>
<td>JXTA Simple Peer with keep alive</td>
<td>1966</td>
</tr>
<tr>
<td>MPP</td>
<td></td>
</tr>
</tbody>
</table>

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Random Establishment of connections in the virtual overlay, resulting in zigzag routes.

Example of measured zigzag route
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Problems & Objective

- High signaling overhead for search in P2P networks due to simple flooding-based mechanisms
- No knowledge about topology
- Reactive search schemes rather than proactive search schemes cause long search

- Target: mobile environment
  - Low data rates → low overhead required
  - Frequent join and leaves of nodes
  - Number of hops (e.g., ad hoc networks) should be minimized

Objective: Optimize peer-to-peer search for resource constrained systems using proactive search
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Proactive Request Routing

- Unstructured P2P
  - Gnutella 0.4 → simple flooding
  - Gnutella 0.6, JXTA → hierarchies, still flooding
  - Reactive request routing, no a priori knowledge of resources

- Structured P2P
  - Dynamic Hash Table (DHT) based approaches
  - Chord, CAN → request routing path is determined before a request is issued
  - Towards proactive request routing
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DHT-based Overlay Approaches – Chord

- Nodes form a Chord ring based on address hashing
- Content is hashed and shifted to the node with respective hash key

- Problems for unstable, mobile environments:
  - Unstability causes frequent shift of content (overhead)
  - No exploration of local proximity
  - Load on nodes is not balanced
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Zone-based Peer-to-Peer

- Employing proactive routing schemes in overlay (from ad hoc networks: DSDV, AODV, ZRP)
- Establishment of zones as special peer groups
- Zone setup could be based on local proximity
- In zones, knowledge about available content is shared among the peers
- Requested content could be found with less effort

DSDV Destination sequenced distance vector protocol
AODV Ad-hoc on-demand distance vector routing
ZRP Zone Routing Protocol
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Zone-based Peer-to-Peer (ZBP)

- Examples of Zones established (zone radius 2)
- Each node is center of a zone
ZPB: Protocol Stack

**ZBP – layered model**

**ZBP Application:**
- application, controls other protocols

**ZSP: Zone Setup Protocol**
- Zone establishment and advertisement handling

**ZQP: Zone Query Protocol**
- Search within zone and through border nodes

**BRP: Bordercast Resolution Protocol**

**Connection Handler (CH)**
- Interface to transport layer
- Creates connections according to physical topology or other relationship

**HTTP**
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Sample Signaling Flow

Establish connections to closest nodes

Set-up zone and distribute knowledge

Content is not available locally

Low query effort
mechanism of queries through border nodes

ZP2P node (1)
Connect 200 Ok

ZP2P node (2)
Connect 200 Ok

ZP2P node (3)

Connect 200 Ok

Connect 200 Ok

Connect 200 Ok
Query-Routing by bordercasting: Routing not flooding

ZBP

Gnutella

Border nodes of this zone
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Evaluation

• Analysis
  – Connectivity model based on random graph theory
  – Assumptions (from previous measurement):
    • 3 connections per node
    • Uptime 900 sec
    • 100 files shared by each peer
    • 2 downloads per session
    • Replication rate: 0.55%

• Simulation
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Analytical Evaluation

- Availability of specific content against zone radius
  - Availability increases fast with zone radius
  - Radius of 2 → 100% success rate incl. neighbor zones

![graph showing content availability against zone radius](image)

- Probability to find content in the local zone
- Probability to find content in neighbor zones

availability of the content within the zone
availability of the content in the inner and all neighbor-zones
• Signaling traffic compared to Gnutella 0.4 and compressed Gnutella 0.4
  – Overhead can be reduced significantly
• Analysis

• Simulation
  – Assumptions (from previous measurement):
    • Topologies with 100, 200, 300, 700 nodes
    • 3 connections per node
    • Uptime 900 sec
    • 100 files shared by each peer
    • Replication rate: 0,55%
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Simulation results

- Average total traffic simulated for one ZBP- and one Gnutella-node
  - ZBP traffic does not grow with network size
  - ZBP node only sends packets within zone
Simulation results

- Success probabilities for different network sizes in a ZBP network and a Gnutella network
  - In ZBP less query hit messages are in vain
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Summary

• **Problem**: High signaling overhead for content search in P2P networks due to flooding-based mechanisms

• **Zone-based Peer-to-Peer**
  - Establishment of zones as special peer groups
  - In zones, knowledge about available content is shared among peers
  - Requested content could be found with less effort

• **Advantages**
  - reduced signalling load
    • Important for resource-limited mobile networks
    • Faster search → better acceptance of P2P applications by users
    • Decrease of cost
  - Mapping of zones to physical or logical topologies
    • Mapping to physical network avoids 'long' links
    • Support of semantic 'peer groups'

• **P2P as a building block for next generation mobile service platforms**