Peer-to-Peer Internet Applications: A Review

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Outline

• Introduction
• Key points
• Lookup task
  – Centralized (Napster)
  – Query flooding (Gnutella)
  – Distributed Hash Table (Chord)
• Simulation Tools
• Streaming P2P
• Potential research interests
Introduction

• All nodes in a network join together dynamically to participate in both traffic routing and processing tasks.
• Flat architecture
  – No central server
  – All nodes are equal: each node acts both as client and server
• Applications:
  – distributed DB
  – distributed services
  – network games

Some names

• Real-world applications:
  – Napster,
  – Freenet,
  – WinMX,
  – Gnutella,
  – KaZaA,
  – BitTorrent,
  – Skype
Some names (2)

- Research:
  - Pastry,
  - CAN,
  - Chord,
  - Oceanstore,
  - Yallcast,
  - Kademlia,
  - Tapestry,
  - Koorde,
  - JXTA

Overlay network

- A new application-level network build over the hosts of the traditional IP network (hosts+routers)
- Nodes have IDs (application-level addresses)
  - IDs are then mapped on IP addresses
- A neighborhood function is defined
  - 2 nodes that are neighbors in the ID space may be very far in the IP space!
Overlay network (2)

- Transport-level links between hosts
- Advantages
  - No need for public IP addresses (IDs are used)
  - It works with firewalls and NAT
  - No changes in the IP network (no need for agreements with administrators)
- Disadvantages
  - Waste of bandwidth due to suboptimal data transfers

Overlay network (3)
Network dynamics

- Number of nodes
- Mean degree
- Turnover
- Half-life
- Persistence
- Size-change

Milestones

- 1997: paper by Plaxton et al.
- 1999: Napster
- 2000: Gnutella
- 2001: Chord, CAN (Content Addressable Network), Pastry, Tapestry
- 2002: Kademia, Viceroy
- 2003: Skype
- SuperNode (KaZaA) ? Joltid ?
Main functions

• Boot/Topology
  – how to choose the node ID and to create connections in order to keep the graph balanced and to minimize communication costs?
    • Unstructured vs Structured P2P networks
• Lookup (and routing)
  – given a search topic, the nodes responsible for the topic must be identified.
• Application-level multicast

Main functions (2)

• Security
• Anonimity
• Reliability
• Robustness to
  – Attacks (e.g., Denial of Service, Poisoning)
  – Freeriders
• Reputation management (virt. Currency)
• Node heterogeneity and networks changes
Lookup

- Centralized index: Napster
- Query flooding: Gnutella
- Super-peer: KaZaA (FastTrack)
- Distributed Hash Table (DHT): Chord
- Efficiency metrics:
  - Size of the routing tables $k$
  - Number of hops $h$

Lookup: centralized index

Napster central index

1) query
2) answer
3) download

Napster client

$k = O(N)$  $h = O(1)$
Lookup: query flooding

- Query flooding among super-peers
- Centralized index with respect to client peers
- \( k = O(1) \)    \( h = O(N) \) but with smaller constants
Lookup: super-peer

• The most used approach in widespread peer-to-peer applications
• Various names for the super-peer:
  – Hub (Direct Connect)
  – SuperPeer, UltraPeer (Gnutella2)
  – SuperNode (KaZaA)
  – RendezVousNode (JXTA)
  – MainPeer (EDonkey)
  – Server (WinMX)

Lookup: distributed hash table

• Each resource is associated to a key by a hashing function.
• Keys belong to the same space of node IDs.
• A node contains resources whose keys are close to its ID.
• \( h = O(\log N) \)  \( k = O(\log N) \)
• Problem: uneven distribution of resources.
Application-level multicast

- Multicast is reproduced at application level
- No need to enable multicast in layer 3 routers
  - No need to reach agreement with providers
- Waste of bandwidth due to data replication

Simulation tools

- Microsoft Research Pastry Simulator 3.0
- GnutellaSim (tool for NS)
  - www.cc.gatech.edu/computing/compass/gnutella/
P2P streaming

• P2P-radio, Peercast: basati su Icecast
• Skype: voice over UDP (no RTP), session open/close with TCP packets, ~20kb/s per talker.
• BitTorrent: file sharing (not streaming), the tracker is responsible for tracking nodes which have a piece of the resource, MIT license.
• GnuStream, PALS, PROMISE: multi-sender aggregation

Potential research interests

• Multimedia-specific issues
  – Reliability through retransmission and correcting codes
• Multicast over P2P
• Multisender aggregation
  – Multiple description coding
• Common ideas as with sensor and ad-hoc networks
• Simulation tools