Overlay and P2P Networks

Introduction

Prof. Sasu Tarkoma

12.1.2015
Contents

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Course Overview

• Overlay networks and peer-to-peer technologies have become key components for building large scale distributed systems.

• This course will introduce overlay networks and peer-to-peer systems, discuss their general properties, and applications. The course will cover the following topics:
  – Currently deployed peer-to-peer systems and how they work
  – Distributed Hash Tables as a base for structured peer-to-peer systems
  – Peer-to-peer storage systems
  – Performance issues, legal aspects, and privacy issues
  – Overlay content distribution algorithms
General Info

Advanced course, 5 credits

The course replaces the P2P Networks course
You cannot take this course if you took the old course

Requirements: basics of networking

Assignments/exercises done as group work (1-2 persons),
idea is to keep the same group structure (but do tell about freeriders!)
Lectures

- Lectures
  - Monday 14-16 in D122 12.1.-26.2.
  - Thursday 12-14 in D122 11.1-26.2.
- Assignments/exercises
  - Assignment topic given two weeks before deadline
- Course based on book
Overlay Networks Book

Introduction
Overview
Overlay Technology
Applications
Properties of Data
Structure of the Book

Network Technologies
Networking
Firewalls and NATs
Naming
Addressing
Routing
Multicast
Network Coordinates
Network Metrics

Properties of Networks and Data
Data on the Internet
Zipf’s Law
Scale-free Networks
Robustness
Small Worlds

Unstructured Overlays
Overview
Early Systems
Locating Data
Napster
Gnutella
Skype
BitTorrent
Cross-ISP BitTorrent
Freenet
Comparison

Foundations of Structured Overlays
Overview
Geometries
Consistent Hashing
Distributed Data Structures for Clusters

Distributed Hash Tables
Overview
APIs
Plaxton’s Algorithm

Chord
Pastry
Koode
Tapestry
Kademlia
Content Addressable Network
Viceroy
Skip Graph
Comparison

Probabilistic Algorithms
Overview of Bloom Filters
Bloom Filters
Bloom Filters in Distributed Computing
Gossip Algorithms

Content-based Networking and Publish/Subscribe
Overview
DHT-based Data-centric Communications
Content-based Routing
Router Configurations
Siena and Routing Structures
Hermes
Formal Specification of Content-based Routing Systems
Pub/sub Mobility

Security
Overview
Attacks and Threats
Securing Data
Security Issues in P2P Networks
Anonymous Routing
Security Issues in Pub/Sub Networks

Applications
Amazon Dynamo
Overlay Video Delivery
SIP and P2PSIP
CDN Solutions

Conclusions
References
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Lectures

12.1. Introduction. Exercises.
15.1. Unstructured networks I
19.1. Unstructured networks II
22.1. Bittorrent, modelling and evaluation (Given by Petri Savolainen)
2.2. Consistent hashing. Distributed Hash Tables (DHTs) I
5.2. DHTs II (Given by Dr. Samu Varjonen)
9.2. Applications I
12.2. Applications II
16.2. Advanced topics (Guest speaker planned)
19.2. Conclusions and summary
Grading

Course grading will be based on the final exam and the assignments/exercises.

Course exam 4.3.2015 16:00 B123

Separate exam on 24.4.2015 16:00 in B123
You can use the exercise score with the first separate exam
Assignments/Exercises

- Assignments are given two weeks before the session, due date is the day before the assignment session 4pm.
- Assignments are done in two-person groups (or alone), groups can change between assignments.
- Assignments give bonus points for the exam.
  - Max exam points 18, max bonus points 4.
- Tuesdays 14-16 B119 last session 24.2.
  - 20.1. Reception on questions I
  - 27.1. Answers to questions I
  - 3.2.1. Reception on questions II
  - 10.2. Answers to questions II
  - 17.2. Reception on questions III
  - 24.2. Answers to questions III
Consistent hashing alleviates network problems and eventual consistency can be achieved through replication and synchronization.

Examples: Dynamo, Cassandra

Replication, Gossip, etc.

Selective flooding

Consistent hash (O(1) DHT)

Good for arbitrary data and search functions, can aggregate routing info, structure improves scalability

Examples: Gnutella and Freenet

Example: BitTorrent

Limited flooding / depth first / Bloom filters

Tracker

Examples: Lookup: Chord, CAN, Kademlia

Storage: PAST

Rendezvous: Scribe (for multicast), i3

DHT

Search

Storage

Rendezvous

Search

Storage

Rendezvous

Search

Storage

Rendezvous

Cluster

Wide-area (unstructured)

Wide-area (structured)

Internet (TCP/IP)

Good for name/value data, note flat address space, one node is responsible, churn is a concern

Examples: Lookup: Chord, CAN, Kademlia

Storage: PAST

Rendezvous: Scribe (for multicast), i3

Consistent hashing alleviates network problems and eventual consistency can be achieved through replication and synchronization.

Limited flooding / depth first / Bloom filters

Consistent hashing alleviates network problems and eventual consistency can be achieved through replication and synchronization.

Limited flooding / depth first / Bloom filters

Consistent hashing alleviates network problems and eventual consistency can be achieved through replication and synchronization.
<table>
<thead>
<tr>
<th>Main theme</th>
<th>Prerequisites</th>
<th>Approaches learning goals</th>
<th>Meets learning goals</th>
<th>Deepens learning goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlay and peer-to-peer networks: definitions and systems</td>
<td>Basics of data communications and distributed systems (Introduction to Data Communications, Distributed Systems)</td>
<td>Knowledge of how to define the concepts of overlay and peer-to-peer networks, and state their central features Ability to describe at least one system in detail</td>
<td>Ability of being able to compare different overlay and p2p networks in a qualitative manner Ability to assess the suitability of different systems to different use cases</td>
<td>Ability to give one’s own definition of the central concepts and discuss the key design and deployment issues</td>
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<tr>
<td>Distributed hash tables</td>
<td>Basics of data communications and distributed systems (Introduction to Data Communications, Distributed Systems) Big-O-notation and basics of algorithmic complexity</td>
<td>Knowledge of the concepts of structured and unstructured networks and the ability to classify solutions into these two categories Knowledge of the basics of distributed hash tables Ability to describe at least one distributed hash table algorithm in detail</td>
<td>Ability of being able to compare different distributed hash table algorithms Ability of designing distributed hash table-based applications Knowledge of key performance issues of distributed hash table systems and the ability to analyze these systems</td>
<td>The knowledge of choosing a suitable distributed hash table design for a problem Familiarity with the state of the art</td>
</tr>
<tr>
<td>Reliability and performance modelling</td>
<td>Basics of probability theory Basics of reliability in distributed systems</td>
<td>Ability to model and assess the reliability of overlay and peer-to-peer networks by using probability theory Knowledge of the most important factors pertaining to reliability</td>
<td>Ability of analytically analyzing the reliability and performance of overlay and peer-to-peer networks Understanding of the design issues that are pertinent for reliable systems</td>
<td>Familiarity with the state of the art</td>
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<tr>
<td>Content distribution</td>
<td>Introduction to Data Communications</td>
<td>Knowledge of the basic content distribution solutions Ability to describe at least one overlay and p2p network based content distribution solution</td>
<td>Knowledge of different content distribution systems and the ability to compare them in detail Knowledge of several content distribution techniques</td>
<td>Familiarity with the state of the art</td>
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<tr>
<td>Security</td>
<td>Basics of computer security</td>
<td>Knowledge of the basic security issues with overlay and p2p networks Knowledge of the sybil attack concept</td>
<td>Ability to discuss how security problems and limitations can be solved Knowledge of how to prevent sybil attacks</td>
<td>Knowledge of how to prevent sybil attacks Familiarity with the state of the art</td>
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Contact information

Lecturer prof. Sasu Tarkoma (contact info on homepage)

Assignments: Juhani Toivonen (@cs.helsinki.fi)

Course homepage can be found: www.cs.helsinki.fi/courses
Questions?