CS 345
Topics in Peer-to-Peer Systems

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Notes 01: Introduction to Peer-to-Peer Systems

What is Peer-to-Peer?

P2P is a computer network with nodes that serve as both clients and servers to others

- Large network size
- Large data size
- High dynamism

...
Why is Peer-to-Peer exciting?

Human society [evolving ecology]
- 10^9 individuals
- 6 degrees of separation [Mil67]
- Greedy routing of messages works [Kle00]

What is of interest to us in CS345?

Design and study of data-centric P2P systems
- Network structures for efficient queries and updates
- Semantics of query results and updates
- Authenticity of query results
- Privacy of queries and data
- Collection of statistics

Data of the form: (key, value)
E.g., [“Sgt. Pepper’s lonely”, fluke.stanford.edu]

Queries of the form: Q(key) = value
E.g., Q(“Sgt. Pepper’s lonely”) = fluke.stanford.edu

Which data structure would you use?
Teaser: Network structures for lookups

1. Put("Sgt. Pepper's lonely", fluke.stanford.edu)
2. Get("Sgt. Pepper's lonely")

1. H("Sgt. Pepper's lonely") = 3
2. Send message to node 3 to store/retrieve data

Scale: Can node 1 maintain entries for all N nodes?
Dynamism: Can data/entries survive node failures?
Stay tuned…

Teaser: Collection of network statistics

Query algorithm for aggregates [Count, Sum, Average, Min, Max]
Scales to network size
Handles dynamism
Query result [R = count(nodes)]
Completeness and timeliness guarantees of R
[within 1% of “true” R over interval [now, now+T]]
Stay tuned…

Course Logistics – Spring 2004
Lectures: MW 10:00 – 11:15 am
Location: Herrin T185
Teaching Fellows: Me & Prasanna Ganesan
Office: Gates 432
Email: {bawa,pganesan}@cs.stanford.edu

Course Logistics - Readings
No textbook required.
Papers will be posted on the website
http://www.stanford.edu/class/cs345
Student presentations of two papers per day
Make slides for a 45 min presentation (~20 slides)
Highlight 3 most important points and flaws
Ask questions (How would…? What if …?)
Get a discussion going for 30 min
Course Logistics - Research Project

Topics will be suggested next week [04/07/04]
Substantial research contribution expected
Start early
Respect the timeline [posted on website]
Pick our brains as often as needed
Groups of 1 or 2 persons

Best project prize (thanks, Hector!)
(a)RA for summer/fall quarter, or
(b)Paid trip to conference

Course Logistics - Grading

Research project : 50%
Final exam [06/04/04] : 30%
Class participation : 20%

Measurements of P2P File-Sharing Systems
[BB+03, GD+03, SG+01, SG+02]

Measurement methodology
University of Washington & rest of the Internet
Passive monitoring of all traffic
Monitoring hosts at border routers
Inbound and outbound traffic traces
Some traces are upto 6 months long
Traces analyzed for KaZaa, Gnutella, WWW traffic

How do peers behave? [SG+01]

Session durations
50% of sessions were 60 mins or less
80% of sessions were 180 mins or less
Shared files
25% share 0 files
75% share 100 files or less
7% share 1000 files or more

How do peers behave? [BB+03]

Session durations depend on application domain
How many items & nodes? [SG+02]

<table>
<thead>
<tr>
<th></th>
<th>WWW</th>
<th>Kazaa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique objects</td>
<td>72M</td>
<td>111K</td>
</tr>
<tr>
<td></td>
<td>3M</td>
<td>166K</td>
</tr>
<tr>
<td>Clients</td>
<td>40K</td>
<td>4.6K</td>
</tr>
<tr>
<td></td>
<td>1M</td>
<td>0.6M</td>
</tr>
<tr>
<td>Servers</td>
<td>403K</td>
<td>281K</td>
</tr>
<tr>
<td></td>
<td>1.4K</td>
<td>4K</td>
</tr>
</tbody>
</table>

How much traffic? [SG+02]

Web = 14% of TCP ; P2P = 43% of TCP
P2P clearly dominates Internet traffic

What is the load profile? [SG+02]

1K of 111K Kazaa objects cause 50% traffic

Who consumes this load? [SG+02]

200 of 4.6K Kazaa clients cause 50% traffic

Who serves this load? [SG+02]

334 of 4K servers supply 80% of Kazaa traffic

Summary of network usage

A small number of objects consume an enormous fraction of traffic

“popularity” distributions of objects is skewed?
A small number of peers generate the most load
A small number of peers serve the most load
load is not uniformly spread across peers?
How do objects behave? [GD+03]

Peers rarely re-download the same object
94% of the time, an object is fetched at-most-once
99% of the time, an object is fetched at-most-twice

Popularity is short lived
only 5% of the top-100 audio objects stayed in the top-100 over the entire trace [video: 44%]

Newly popular objects tend to be recently born
Of audio objects that “broke into” the top-100,
79% were born a month before becoming popular [video: 84%]

Several implications on placing and managing caches!

Next time

Network structures for efficient lookup queries
Distributed hash tables (DHTs)
Be sure to check website for readings

References
[BB+03]: M. Bawa, R. J. Bayardo Jr., et al. Make it fresh, make it quick – searching a network of personal webservers
[GD+03]: K. P. Gummadi, R. J. Dunn, et. al. Measurement, modeling, and analysis of a peer-to-peer file-sharing workload.
[Kle00]: J. Kleinberg. The small-world phenomenon – An algorithmic perspective.
[SG+01]: S. Saroiu, K. P. Gummadi, et. al. A measurement study of peer-to-peer file-sharing systems.