CLOUDCOM 2010
A Novel Approach for Cooperative Overlay-Maintenance in Multi-Overlay Environments

Wu-Chun Chung, National Tsing Hua University  2010/11/30
A Novel Approach for Cooperative Overlay-Maintenance in Multi-Overlay Environments

Chin-Jung Hsu, CS, National Tsing Hua University, Taiwan
Wu-Chun Chung, CS, National Tsing Hua University, Taiwan
Kuan-Chou Lai, CIS, National Taichung University, Taiwan
Kuan-Ching Li, CSIE, Providence University, Taiwan
Yeh-Ching Chung, CS, National Tsing Hua University, Taiwan
Outline

- Introduction
- Related Work
- Cooperative Strategy
  - CFD – failure detection
  - CNPE – network-proximity estimation
- Experimental Results
- Conclusions
Introduction

- Overlay Network
  A virtual network overlay another layer
  - Chord, Gnutella, Super-Peer model, etc.

- Focus: over the Internet

<table>
<thead>
<tr>
<th>Name</th>
<th>IP</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>User A</td>
<td>66.238.93.162</td>
<td>80</td>
</tr>
<tr>
<td>User B</td>
<td>220.74.26.128</td>
<td>823</td>
</tr>
<tr>
<td>User C</td>
<td>118.169.74.72</td>
<td>8080</td>
</tr>
<tr>
<td>User D</td>
<td>66.238.93.162</td>
<td>168</td>
</tr>
</tbody>
</table>
Internet Visualization

Wikipedia: Opte Project
Example: Ring-based overlay

Wikipedia: Opte Project
More and more applications

- Overlay-based applications are growing
  - P2P file sharing – gnutella, eDonkey, BitTorrent, etc.
  - P2P Streaming – PPStream, PPLive, Joost, etc.
  - Resource Discovery – Mercury, MAAN, etc.
  - Cloud computing – Cassandra, Hadoop, etc.

- Multiple overlays co-habit the Internet
A multi-overlay environment (MOE)
Each overlay network may serve an application.
Motivation

- Overlay network introduces maintenance cost
  - failure detection
  - latency/bandwidth measurement
  - routing table adjustment
  - adaptive approach
  - ... etc.

- $n * \text{Cost} = \text{large} \implies \text{how to reduce?}$
  - Some of these overlay-maintenance costs are redundant
Related Work

- [2007][ICDCS] Build One, Get One Free: Leveraging the Coexistence of Multiple P2P Overlay Networks
  - Sharing information to reduce maintenance cost
  - Focus on two specific overlays

- [2009][DAIS] Exploiting Synergies between Coexisting Overlays
  - A comprehensive consideration on the reduction of maintenance costs
  - Lack of the consideration of intersection ratio
Intersection Ratio

- the percentage of nodes which locates in both overlays

Intersection Ratio

Overlay A

Overlay B

25%
Objective

- Multi-overlay environments
- Reduce the total maintenance cost
- Propose a general approach
- Consider a realistic MOE environment
Cooperative Strategy

- To reduce the maintenance costs
- The total cost could be smaller

\[ n < n_1 + n_2 + n_3 \]
Master-Slave Model

- One overlay is selected to be the master
- The master overlay could help reduce the common maintenance operations

\[ n < n_1 + n_2 + n_3 \]
Master-Slave Model

- Two kinds of inter-overlay protocols to support two types of overlay maintenance

Diagram:

1. subscribe
   - slave A
   - master
   - slave B

2. notify
3. query
4. response

Periodical Maintenance
State Sharing

Wu-Chun Chung, National Tsing Hua University  2010/11/30
Inter-Overlay Protocols

- Subscribe/Notify protocol
  - periodical maintenance
  - E.g. failure detection
    - periodically checks the status of neighbor nodes to ensure the routing mechanism

- Query/Response protocol
  - state sharing
  - E.g. network-proximity estimation
    - share the information of network state to make the decision of routing path
Cooperative Failure Detection (CFD)

Elimination

master

A

B

probe

slave

A

B

probe
Cooperative Failure Detection (CFD)

Cooperation
CFD – Subscription Process

1. subscribe

master

slave

2. notify
CFD – Notification Process

1. subscribe
2. notify

master

slave
Cooperative Network-Proximity Estimation (CNPE)

master

slave

Elimination
Cooperative Network-Proximity Estimation (CNPE)

master

 Exploration

slave

Wu-Chun Chung, National Tsing Hua University  2010/11/30
CNPE – Query/Response Process I

1. query

latency: <50ms (2)

E (30ms), C (45ms)

2. response

master

slave
CNPE – Query/Response Process II

1. query

Neighbor’s Neighbor

Explore

A

B

C

D

E

20ms

30ms

45ms

E (30ms), C (45ms), B (50ms)

latency: <50ms (3)

2. response

master

slave
Experimental Environment

- PeerSim simulator
- Cycle-based simulation engine
- Unstructured, Ring, Tree Overlays
- Parameter K: neighbor numbers
- Comparison metric: reduction rate
The higher the reduction ratio is, the more efficient our approach will be.

**CFD**

\[
RR = \frac{M - M_{CFD}}{M} \times 100\% = \left(1 - \frac{M_{CFD}}{M}\right) \times 100\%.
\]

**CNPE**

\[
RR = \left(1 - \frac{M_{CNPE}}{M}\right) \times 100\%.
\]
Experimental Results – Session Time

**CFD**

- Master: Unstructured (K=4), Slave: Ring (K=2)
- Master: Unstructured (K=4), Slave: Tree (K=3)
- Master: Ring (K=2), Slave: Unstructured (K=4)
- Master: Ring (K=2), Slave: Tree (K=3)
- Master: Tree (K=3), Slave: Unstructured (K=4)
- Master: Tree (K=3), Slave: Ring (K=2)

**CNPE**

- Master: Proximity (K=4, N=2), Slave: Proximity (K=6, N=2)
- Master: Proximity (K=6, N=2), Slave: Proximity (K=4, N=2)
Experimental Results – Intersection Ratio

**CFD**

Master: Unstructured (K=4), Slave: Unstructured (K=6)

Master: Unstructured (K=6), Slave: Unstructured (K=4)

**CNPE**

Master: Proximity (K=4, N=2), Slave: Proximity (K=6, N=2)

Master: Proximity (K=6, N=2), Slave: Proximity (K=4, N=2)
Overlay A
Unstructured (K=4)

Overlay B
Unstructured (K=6)

Overlay C
Ring (K=2)

Overlay D
Tree (K=3)

50% 25% 75%

Master CNPE

Master CFD
- The total reduction rate approximates 40%
Conclusions

- Multi-overlay environments have emerged
- Total maintenance cost is high
- Some operations are redundant
- Cooperative maintenance approach
- A general Master-Slave model
  1) CFD – Subscribe/Notify protocol
  2) CNPE – Query/Response protocol
- Reduce more than 60%
Conclusions

Maintain one, Get many free
Future Work

- Other operations of overlay maintenance
- Master overlay selection criteria
- Automatic selection mechanism
THE END

A Novel Approach for Cooperative Overlay-Maintenance in Multi-Overlay Environments

Wu-Chun Chung, National Tsing Hua University  2010/11/30