Algorithms and Programming IV
DHT-based P2P-Systems (20-3)

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Peer-to-Peer

- Ressources are shared between the peers.
- Resources can be accessed directly from other peers.
- Peer is provider and requester (servent concept).

Unstructured Overlay

Centralized P2P

Pure P2P

Structured Overlay

DHT-based

- All features of P2P included
- Any terminal entity can be removed without loss of functionality
- No central entities
- Connections in the overlay are fixed
- Example: Paestry, Chord, CAN
Peer-to-peer systems

PASTRY
Introducing Pastry

• P2P overlay that is using Dynamic Hash Tables (DHT) with prefix-based routing with both peer ID and object ID.

• Prefix routing narrows the search for the next node along the route by applying a binary mask that selects an increasing number of hexadecimal digits from the destination GUID after each hop.

• It is originally developed Microsoft and Rice Uni but a free version (FreePastry) exists that is a prototypical implementation of Pastry. The latter is mostly used by scientific community.

• Similar algorithms are Chord and CAN.
Introducing Pastry (cont.)

- Any computer connected to the Internet and running PASTRY node software can be a PASTRY node.
- Application specific security polices may be applied.
- Each node is identified by a unique 128 bit node identifier (NodeId).
  - The node identifier is assumed to be generated randomly
  - Each NodeId in is assumed to have the same probability of being chosen
  - Node with similar NodeId may be geographically far
Mode of Operation of a Distributed Hash Table

Every node stores and maintains part of the hash table. Every object/resource has a (hash) key which is stored at the node responsible for its key.

```
lookups(key) -> node or data directly

Lookup where it is stored,
```

```
applications

publish/insert (key, data)  get/lookup (key)  data

DHT
distributed hash table
```

Node
Distributed Hash Table: Steps of Operation

1. Mapping of nodes and data to the same address space
   - Peers and content are addressed using flat identifiers (IDs)
   - Common address space for data and nodes
   - Nodes are responsible for data in certain parts of the address space
   - Association of data to nodes may change since nodes may disappear

2. Storing / Looking up data in the DHT
   - “Look-up” for data = routing to the responsible node
   - Responsible node not necessarily known in advance
   - Deterministic statement about availability of data
Sketch of the Routing Algorithm

• Assume we want to find the node in the PASTRY network with the NodeId closest to a given key.

Routing Idea

In each routing step, a node normally forwards the message to a node whose NodeId shares with the key a prefix that is at least one digit longer than than the key shares with the present node. If such a node is not known, the message is forwarded to a node that shares the same prefix of the actual node but its NodeId is numerically closer to the key.
First Four Rows of a Pastry Routing Table

<table>
<thead>
<tr>
<th>$p =$</th>
<th>GUID prefixes and corresponding nodehandles $n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 1 2 3 4 5 6 7 8 9 A B C D E F</td>
</tr>
<tr>
<td></td>
<td>n n n n n n n n n n n n n n n n n n n</td>
</tr>
<tr>
<td>1</td>
<td>60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6F 6E 6F</td>
</tr>
<tr>
<td></td>
<td>n n n n n n n n n n n n n n n n n n n</td>
</tr>
<tr>
<td>2</td>
<td>650 651 652 653 654 655 656 657 658 659 65A 65B 65C 65D 65E 65F</td>
</tr>
<tr>
<td></td>
<td>n n n n n n n n n n n n n n n n n n n</td>
</tr>
<tr>
<td>3</td>
<td>65A0 65A1 65A2 65A3 65A4 65A5 65A6 65A7 65A8 65A9 65AA 65AB 65AC 65AD 65AE 65AF</td>
</tr>
<tr>
<td></td>
<td>n n n n n n n n n n n n n n n n n n n</td>
</tr>
</tbody>
</table>
Pastry Routing Example

Source NodeID 65A1FC
Destination NodeID D46A1C
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Unstructured P2P

Centralized P2P

Pure P2P

Hybrid P2P

Structured P2P

DHT-based

Example: Pastry, Chord, CAN

1st Generation

Example: Napster
Example: Gnutella 0.4, Freenet

2nd Generation

Example: Gnutella 0.6
References


• Smruti R. Sarangi: Distributed Hash Tables Pastry (http://www.cse.iitd.ernet.in/~srsarangi/csl860/docs/pastry-lec.pdf)

Routing in Unstructured Overlay Networks: Flooding vs. Random Walk