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Peer-to-Peer Systems – Exercise
Winter Term 2014/2015

General Remarks

Welcome to the exercise for the lecture Peer-to-Peer Systems.

Please follow the general remarks regarding the organization of the exercise.

- The lecture's website is to be found here: `http://tsn.hhu.de/teaching/lectures/2014ws/p2p.html`
- For further inquiries, please contact the lecturer under the following email address: `graffi@cs.uni-duesseldorf.de`

Problem 3.1 - Strange DHT Topologies

Let us assume a DHT, which is built the following way: Currently, n peers are in the network. The n peers are enumerated from 0 to $n-1$, each peer knows its ID. The object IDs are also natural numbers, as hash function we use:

$$h : \mathbb{N} \to \{0, \dots, n-1\}, k \mapsto k \bmod n$$

The responsibility function M is given as: $M(i) = h(i)$. I.e. the peer with id i is responsible for the object IDs k with $h(k) = i$.

a) Quality Rating

Explain, why this is *not* a good basis for a DHT. Name at least two fundamental issue.

b) Routing in Strange DHTs

Let us assume, that despite of your good arguments, the overlay exist. There are two variants for constructing the network topology:

Variant 1:

All peers are sorted according their IDs and connected to their predecessors and successors (mod n). Thus peer i is connected to peer $i-1$ and $i+1$ (mod n). Routing is done through forwarding lookup requests to the neighbor closer to the queried ID.

Variant 2:

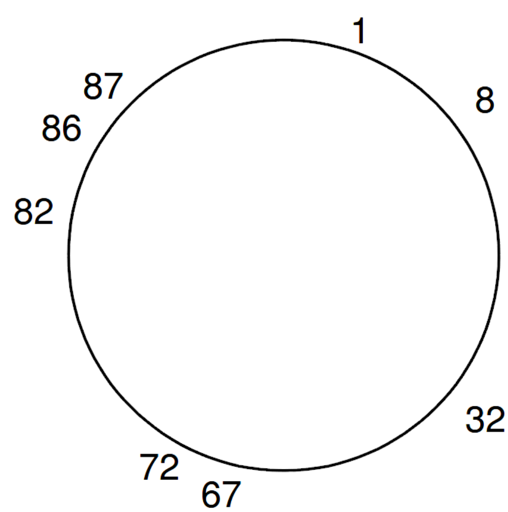
In this variant, each peer is connected to the peer with ID 0. No further connections exist. Routing is done by forwarding lookup requests to peer 0, which forwards the lookup request further to the target peer.

A) What is the routing complexity of both variants, i.e. the (asymptotic) average number of hops until the lookup request reaches the responsible peer?

B) What is the worst-case state complexity of both variants, i.e. the the (asymptotic) maximum number of contacts, a node has to maintain.

Problem 3.2 - Chord Network

Consider the Chord network shown in the figure. In this network, 8 nodes participate having the following Globally Unique Identifiers (GUIDs): 1, 8, 32, 67, 72, 82, 86, 87.



a) Chord Topology

How many fingers are needed if the GUID range is between 0 and 99? Which formula provides the ith finger of node n? Provide the fingers table for node 82 according to the format finger, target id and node id. Give the responsibility areas of all nodes in this Chord network according to the format (Peer ID, From, To).

b) Routing in Chord

Node 82 is performing a lookup request with input value 7. How many steps are needed assuming that the network is stabilized? Show the followed path until the destination.

Problem 3.3 - Content Addressable Network - CAN

In this exercise, with have a look at CAN.

a) Graph Properties

Let us consider a CAN - network with an generalized ID space $[0, 1)^2$. The 2-dimensional space is considered a square, you can ignore the wraparound, i.e. the space being a torus. Further assume, that the network is populated with $n = 4^i$ nodes, with $i \in \mathbb{N}$. With this in mind, the placement of the nodes is assumed to be "perfect", with all nodes having the same size of space being responsible for.

A) How large is the graph diameter, i.e. the maximum distance between two peers in hops, with respect to the number of peers n?

B) In the previous example, CAN hat a dimension of $d = 2$. Generalize d in the formula for the graph diameter and assume that the number of nodes grows correspondingly. A network with dimension d has 2^d nodes. How large is the network diameter with respect to the number of nodes n and the dimension d?

b) Defragmentation in CAN

Let us consider the cases, in which a peer leaves the CAN network and its responsibility area needs to be assigned to another node. Sketch a situation, in which the reassignment creates a complex case in which one single defragmentation step is not sufficient: A single node with several zones, out of which the neighboring zone of its smallest zone is itself split.

A) Draw a CAN network with such a situation, before and after the leaving of the node.

B) Draw a corresponding tree diagram of this CAN network, after the node left.

C) Give a protocol (messages and communications), that describes how step by step a consistent valid CAN state can be reached in which every peer is only responsible for one zone.