Exercise
for Lecture "P2P Systems"

Prof. Dr. David Hausheer
Dipl.-Wirtsch.-Inform. Matthias Wichtlhuber, Leonhard Nobach, M. Sc., Dipl.-Ing. Fabian Kaup, Christian Koch, M. Sc., Dipl.-Wirtsch.-Inform. Jeremias Blendin

TECHNISCHE UNIVERSITÄT DARMSTADT

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Exercise No. 6
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Submission only via the Moodle platform in PDF, plain text, or JPG/PNG.
Contact: `[mwichtlh|lnobach|fkaup|ckoch|jblendin]@ps.tu-darmstadt.de`
Web: `http://www.ps.tu-darmstadt.de/teaching/p2p/`

Surname (Nachname):	
First name (Vorname):	
ID# (Matrikelnummer):	

Problem 6.1 - Hypercube Networks

A) Show graphically the recursive construction of a d-dimensional binary hypercube network, as d varies from 0 to 3. Label each node accordingly.

B) Consider a 3-dimensional binary hypercube network. A message should be routed from node `001` to node `110`. Show the routing process by evaluating the distance to the final destination, the available next hop options and the routing path. Whenever more than one option is available select any option randomly.

Problem 6.2 - Gnutella 0.6

A) Compare the join process of Gnutella 0.4 and Gnutella 0.6 respectively.

B) Compare the dissemination of search queries of Gnutella 0.4 and Gnutella 0.6 respectively.

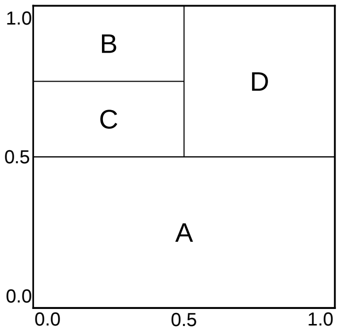
C) Given an origin node in a Gnutella system, the result of formula $f(n,t)$ is the maximum number of reachable users from this node, given n, the number of neighbors per node, and t, the used TTL counter.

$$f(n,t) = n * \sum_{i=0}^{t-1} (n-1)^i \tag{1}$$

In a Gnutella 0.6 network only a fraction of all peers (super peers) forwards search queries, thus a smaller TTL can be configured. Derive a formula to calculate the percentage of saved routing decisions (not considering leaf nodes) in a Gnutella 0.6 network in comparison to a Gnutella 0.4 network. Use the formula to calculate the percentage of saved routing decisions for $t_{0.4} = 8$ and $t_{0.6} = 5$ and $n = 5$.

Problem 6.3 - CAN – A Scalable Content Addressable Network

Consider the following topology of a CAN-based P2P system:



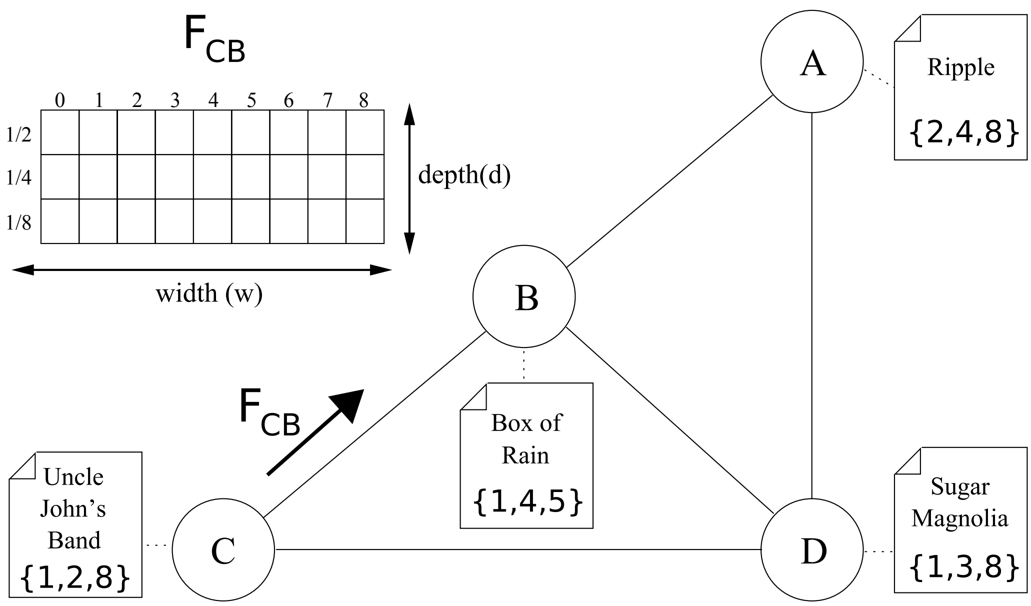
In this implementation a zone split is preferentially done horizontally.

A) Now two nodes join the network: node **E** at (0.9, 0.1) and node **F** at (0.2, 0.8). What will be the resulting network topology after the integration of these new nodes?

B) Now node **E** is sending a lookup for the key (0.2, 0.9). What would be the virtual path (also explain why this path will be chosen)? Is this the optimal path from the overlay's perspective?

C) Now two more nodes join the network: at first node **G** at (0.6, 0.2) and then (after node **G** aquired its own zone), node **H** at (0.55, 0.1). What will be the resulting network topology after the integration of these new nodes?

Problem 6.4 - Bloom Filters



A) Consider a Bloom Filter consisting of an array of size m and k hash functions. Initially all the bits of the array are set to zero. Assume that each position of the array can be selected by each hash function with equal probability. Calculate the probability that a certain bit will be set to 1 after inserting n elements.

B) Consider a Bloom Filter where $m = 5$ and $k = 2$. Furthermore, $H_1(x) = x \mod 5$ and $H_2(x) = (2 * x + 3) \mod 5$. Initially the bit vector is unset (each element is equal to

0). Insert 9 and 11 in the Bloom Filter. Show the state of each bit before and after each insertion.

C) Assuming the populated Bloom Filter of the previous part, show how the membership operation for the values 15 and 16 is handled by the aforementioned Bloom Filter. Verify the outcome of each operation with respect to false positives and false negatives.

D) Consider the picture of a P2P network above. Denoted are 4 peers, each of them holding a content item with a respective hash. Fill in the attenuated Bloom Filter for node C considering the link F_{CB}.