Exercise
for Lecture "P2P Systems"

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Exercise No. 1
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Submission only via the Moodle platform in PDF, plain text, or JPG/PNG.
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– Example Solution –

Problem 1.1 - RB-HORST User Study

RB-HORST is a research prototype resulting from a research project sponsored by the European Union. We will utilize a software prototype as a part of the P2P lecture's exercise to allow students to have a hands-on experience with a live deployment of a cutting-edge distributed Peer-to-Peer system and the respective hardware in their home premises.

- **Please take part in the following survey:** http://bit.ly/rbhsurvey

Problem 1.2 - P2P Architectures and Classifications

A) Argue why it is harder for an authority to shut down a decentralized P2P system than to shut down a Client-Server system. How about centralized P2P networks?

Solution: *Decentralized*: no single addressee of a lawsuit
Centralized: easy to shut down with a single lawsuit

B) Choose the right answer:

		TRUE	FALSE
i)	In a DHT-based P2P network the connections in the overlay are "fixed".	☐	☐
ii)	A P2P system is more fault-tolerant than a Client/Server system.	☐	☐
iii)	A Client/Server system scales better with the number of users than a P2P system.	☐	☐
iv)	In a hybrid P2P network any terminal entity can be removed without loss of functionality.	☐	☐
v)	A hybrid P2P network suffers from a single point of failure.	☐	☐

Solution:

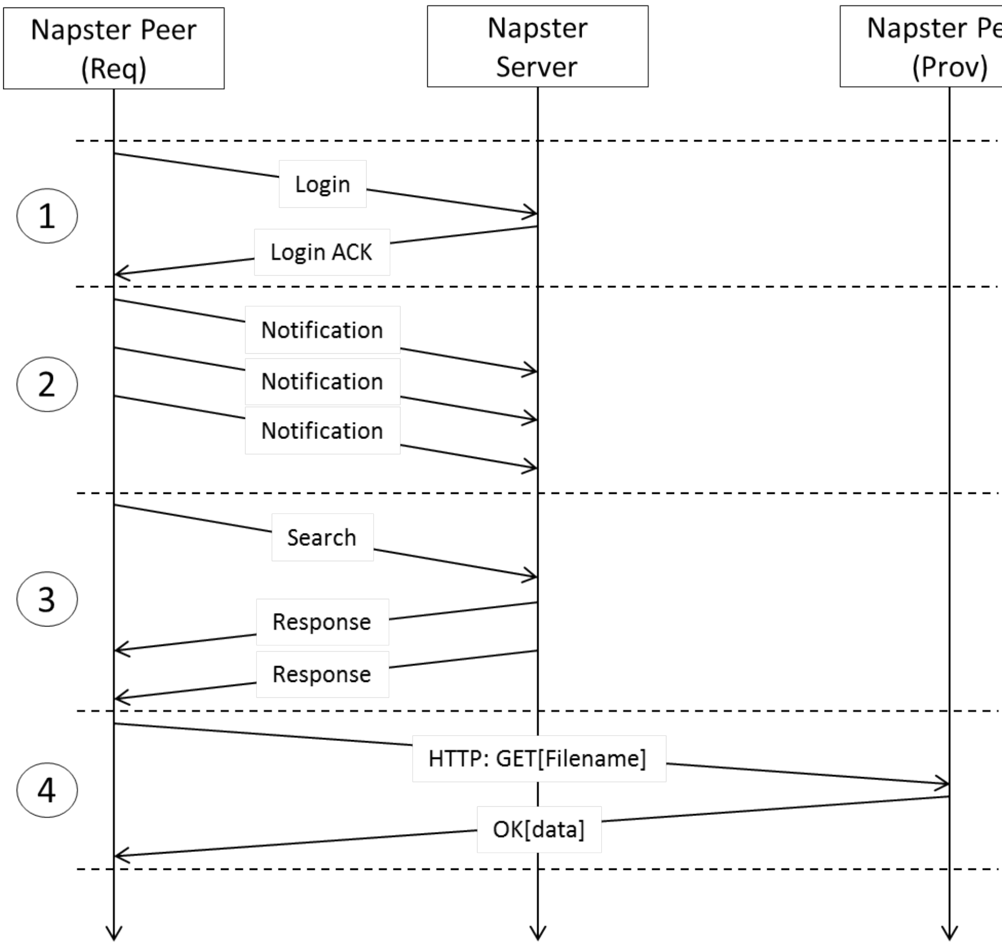
		TRUE	FALSE
i)	In a DHT-based P2P network the connections in the overlay are "fixed".	☒	☐
ii)	A P2P system is more fault-tolerant than a Client/Server system.	☒	☐
iii)	A Client/Server system scales better with the number of users than a P2P system.	☐	☒
iv)	In a hybrid P2P network any terminal entity can be removed without loss of functionality.	☒	☐
v)	A hybrid P2P network suffers from a single point of failure.	☐	☒

Problem 1.3 - Napster

A) Does Napster match the derived key characteristics of P2P systems as defined in the lecture? Explain your answer.

Solution:
No equality - nodes are not equal, central server is crucial for working network.
No autonomy - central server is a form of central control, nodes cannot act on their own.
Partial decentralization - server is central entity, but does not handle traffic.
No self-organization - nodes cannot organize themselves without the central server.
Fully shared resources - peers are able to share resources.

B) Describe what is happening during phases (1) - (4) in the following sequence diagram of a Napster session. What problem can occur in step (4)?



Solution:
(1) Login procedure, is ACKed by server.
(2) The client notifies the server about files it possesses.
(3) The client sends a search request. The server returns two hits.
(4) The client starts downloading the file (potential problem: the provider's firewall does not allow the incoming connection.

Problem 1.4 - Gnutella

A) Which information (about the system) is required to configure the **TTL** field in Gnutella-like protocols? Consider the tradeoff of the probability to find all the potential matches in the network and the incurred overhead.

Solution:
The network *diameter D*, i.e. the maximum path length between any two peers. If **TTL**$\geq D$, all peers can be found (unless some peers fail in between). However, too high **TTL** values can also increase the probability that the same message is received multiple times (especially, if peers have to delete the information about forwarded messages from time to time).

B) Which mechanism is used (besides TTL and Hop counter fields) by Gnutella to avoid loops while forwarding messages?

Solution:
Each Gnutella peer stores the `Descriptor IDs` and `Payload Descriptors` of received messages. Thus, duplicates of a message can be recognized and dropped.
A simple example is a triangle topology with three peers A, B, and C connected to each other. Let A send a message that will be received by both B and C. Then both B and C would forward the message to each other. By recognizing these messages as duplicates the (unnecessary) forwarding to A can be avoided.

C) Given an origin node A in a Gnutella system, derive a formula $f(n,t)$ for the maximum number of reachable users from this node, given n, the number of neighbors per node, and t, the used TTL counter. Assume that no duplicate nodes are traversed on the path.

Use the formula to calculate the number of reachable users for t = 8 and n = 5 as well as for t = 7 and n = 8.

Solution:
For each of the n links of node A, the number of reachable nodes can be calculated similar to the number of nodes of a complete tree with height $t-1$ and a degree of $n-1$:

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

Using this formula, the number of reachable users for the two examples result in:

$$f(5,8) = 5 * \sum_{i=0}^{7} (4)^i = 109,225 \tag{2}$$

$$f(8,7) = 8 * \sum_{i=0}^{6} (7)^i = 1,098,056 \tag{3}$$

D) Derive a formula $g(n,x,y)$ for the maximum number of reachable users that are at least x but no more than y, with $x \leq y \leq t$, hops away from node A, using the assumptions of the previous task.

Calculate the number of reachable users that are between 6 and 8 hops away from A, assuming $n = 6$.

Solution:

The formula is:

$$g(n,x,y) = n * \sum_{i=x-1}^{y-1} (n-1)^i \tag{4}$$

Using this formula, the number of reachable users for the two examples result in:

$$g(6,6,8) = 6 * \sum_{i=5}^{7} (5)^i = 581,250 \tag{5}$$

Problem 1.5 - Distributed Hash Tables

A) In a DHT, why is it important that node and data IDs are (nearly) random and equally distributed?

Solution: Avoid collisions, achieve better load distribution among nodes (this might still not be enough, e.g. due to a content popularity).

B) Name two advantages of unstructured (flooding-based) P2P architectures over structured ones (such as DHTs)?

Solution:
Advantages (unstructured P2P): More flexible selection of connections between nodes, more simple implementation.
Disadvantages (unstructured P2P): Less scalable, generate high traffic load on the network.

C) Why do maintenance operations in DHTs (like Chord or Pastry) have a complexity of $O(log^2(n))$ but lookup operations only $O(log(n))$?

Solution: Because maintenance operations typically require a node lookup for each entry in the routing table and the size of routing tables is typically $O(log(n))$

D) Explain why fuzzy queries are not simple to be implemented using Distributed Hash Tables?

Solution: Just as non-distributed hash tables, DHTs primarily aim at providing efficient store and look-up functionality of key-value pairs. Therefore, an equal distribution of stored entries among either memory buckets (in the non-distributed case) or peers (in the case of DHTs) is a key requirement. To achieve this, cryptographic hash functions, such as *SHA1* or *MD5*, are used as they, besides other cryptographic requirements, equally distributed map inputs to a key space. In addition, an important property of these hash functions is that a small change to a given input results in a large change to the generated hash value. This implies that similar keys (mostly interesting for fuzzy queries, such as for wildcards searches) are being stored with a high probability at different peers in the network. This makes it impossible to map fuzzy queries to peers in an deterministic way (making it inefficient).