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Problem 1.2

a) To shutdown a Client-Server system, an authority could simply shutdown the central servers which serve the clients. In contrast, Decentralized P2P have no central entities and are designed to have high tolerance for adding or removing nodes from the network so, shutting them down is harder.

   Centralized P2P, on the other hand depend on Central entities for some actions in the network, like bootstrapping or searching. Depending on the type of services offered by central entities, their shutdown difficulty lies somewhere between Client-server and Decentralized P2P

b) Answers
   i. False
   ii. True
   iii. False
   iv. True
   v. False

Problem 1.3

a. Napster is a centralized P2P network. All peers are connected to the central entity. Central entity is required to provide the service. Napster does not match Equality, Autonomy, Decentralization and Self-Organization for P2P systems.

b.

1	Req. Peer sends Login message to Napster Server. Server responds with a Login Ack
2	Req. Peer announces 3 shared objects to the Napster server
3	Req. Peer sends a **Search** query to Napster server. Server responds with two possible peers, in separate responses.
4	Req. Peer peer makes a HTTP-GET Request to one of the Prov Peer. for the file

Possible issues at (4):
→ The Prov. Peer, either one or both, could be offline
→ The Prov. Peer could go offline before the Req. Peer could fetch the whole file

Problem 1.4

A. Function ID is required to configure the TTL field in Gnutella like protocols. The tradeoff here is the high signalling traffic due to decentralization. If no physical structure, network load increases.

B. PINGS and QUERY mechanisms are used to avoid loops while forwarding messages. PINGS and QUERY with the same Function ID and Gnode ID are discarded to avoid loops.

C. Number of reachable users:
   i. For t=8 and n=5:
      f(n,x,y) = f(5,1,8) = 5[1+4+16+64+256+1024+4096+16384] = 109,225 users
   ii. For t=7 and n=8:
      f(n,x,y) = f(8,1,7) = 8[1+7+49+343+2401+16807+117649] = 1,098,056 users

D. For n=6, t= 6 to 8:
   f(n,x,y) = f(6,1,8) = 6[3125+78125] = 487,500 users

Problem 1.5

A) Node and data IDs need to be random and equally distributed so that the overall load is balanced among all nodes of the network rather than concentrated at few nodes while other have little to no load at all.

B) Advantages of unstructured P2P over structured ones:
   1. Fuzzy queries possible
   2. Content is stored only at the providing node
   3. No additional information about the actual location of content needed

C) Maintenance operations are performed by all nodes in the network independently. Given that number of nodes is O(log(n)) and the operation from each node is of O(log(n)), the overall operation complexity in the network would come out to $O(\log^2(n))$.

D) DHT uses Hash mapping to map a key to a hash value. Since a slight change in key value would change the hash in an unpredictable way. Operations other than equality are not possible when hashes are used. This makes fuzzy queries hard to implemented on DHTs.