分散式系統與雲端應用開發實務

Spring 2022, Final Exam, 2022.06.02

考試規則：考試時可查閱(含上網)任何資料，但禁止與同學或外界討論，違者以作弊論，並送校方處置。禁止將試卷分享與他人(考試結束後亦然)。

請在試卷上寫下“我誓言考試過程中，沒有與同學或外界討論。”

1. (25%) Suppose you are to build a peer-to-peer large distributed storage system on top of hundreds of thousands of autonomous hosts across the world. In addition, a DHT layer is used for storage and lookup, and three candidates are considered: CAN, Chord, and Kademlia. Compare the three candidates with respect to (i) hot-spot prevention, (ii) fault tolerance/availability for read/write, (iii) efficiency in data retrieval, (iv) cost of maintaining the DHT layer. For each of the aspect, you need to discuss, in detail, whether one DHT has a clear advantage over another, or, explain why there is no significant difference among them (because one can easily modify the original DHT design such that an advantage claimed by one DHT can also be obtained by another).

2. (10%) Continue from question 1. For the application, for each of the three candidate DHTs, discuss whether there is some type of applications that will particularly benefit from choosing the DHT over the others.

3. (25%) Continue from question 1. One problem to use DHT is that routing in the DHT layer is generally expensive, as overlay neighbors could be far apart in the physical layer. There are two possible approaches to overcome the problem: (i) to build an overlay that reflect network proximity, (ii) use a two-tiered search mechanism as in OceanStore (2000). Discuss, for each of the three candidate DHTs, how the above two approaches can be implemented.
   Then, overall, for each of the two possible approaches, do you find a candidate DHT that has a clear advantage over the others? Why?

4. (20%) Suppose a big company which owns many data centers across the world is also to develop a large distributed storage system on their data centers. Again, the proposal is to use a DHT layer for efficient data insert and lookup, and the three DHT candidates CAN, Chord, and Kademlia are considered. If you are the CTO, which of the three candidates will you choose? Why?
   And what modification you will adopt to take the advantages that the storage system is built in your data centers?

5. (20%) Recall the algorithm BG(m) proposed by Lamport, Shostak, & Pease (1982) that solves the Byzantine Generals problem for $3m+1$or more generals with at most m faulty processes. According to the impossibility result, the algorithm cannot let non-faulty processes to reach consensus if there are 6 processes but 2 of them can be faulty.
   Trace the algorithm, and show how the 2 faulty processes should behave to prevent the 4 non-faulty processes to reach consensus when executing the BG(m) algorithm.