נושאים מתקדמים במערכות אחסון (18103701)
סמסטר א', תשפ"ד
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Homework #3: Consistent Hashing, Bloom Filters, Data Deduplication

1. Consistent Hashing

The goal is to study the load balancing characteristic of the Consistent Hashing algorithm. We will do that by implementing a simulation of Consistent Hashing on n=100 servers and 10,000 objects.

a. Create 10,000 random keys (numbers) in the range$[0, \dots, 2^{32} - 1]$.
b. Create 100 random server id's in the range$[0, \dots, 2^{32} - 1]$.
c. Assign the keys to the servers according to the algorithm: a key is assigned to smallest server that is larger than the key, wrapping around from $[\, 2^{32} - 1]$ to 0.
d. Compute the median, average, minimum and maximum loads as well as the 25% and 75% percentiles of the load distributions (i.e., the load value that is larger than x% of the other load values) for all 100 servers.
e. Now map each server to 4 virtual copies. Namely, create 400 server virtual id's where every 4 id's correspond to one server.
f. Compute the median, average, minimum and maximum load as well as the 25% and 75% percentiles of the load distributions (i.e., the load value that is larger than x% of the other load values) for all 100 servers.
g. Compare the numbers obtained in (d) to the numbers obtained in (f)

To create random numbers in the range$[0, \dots, 2^{32} - 1]$ you can use the "rand" function that generates random values in $[0, \dots, 1)$ and multiply them by 2^{32} .

Your answer should include a link to git with the simulation code, and the graphs containing the distributions for both cases.

2. Bloom Filters

Consider the following scenario in a web caching setting.

Suppose that a single server is likely to store 40 million objects; furthermore, suppose that we are willing to tolerate as many as 0.1% false positives (an object not in the cache will be misclassified as being the cache).

- What should be the size of the Bloom Filter (in bits) that represents the cache? Is this a reasonable size that can realistically fit in memory?
- How many hash functions should be used?

3. Data deduplication

a. A user of a storage system who owns a large repository wants to free some space. The most straightforward strategy is to delete the biggest files from the repository. Is that always a good strategy?
- Describe what can happen if data deduplication is applied to the repository. Consider two cases (i) file-based deduplication (ii) chunk-based deduplication

b. In order to compute the variable-size chunking a rolling hash is used, which requires a fixed window size. What are the guidelines for choosing the window size?
- What's the benefit of a small window size?
- What are the benefits of a large window size?