Hash Tables: Distributed Hash Tables

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Data Structures
http://bit.ly/algospecialization

Outline

1. Online Storage Systems

2. Distributed Hash Tables

- Have you ever wondered, how large files are sometimes uploaded instantly to Dropbox?

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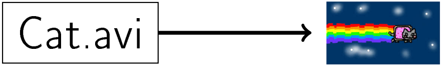
- Want to know how Dropbox, Google Drive and Yandex Disk save petabytes of storage using the ideas from this module?
- Interested in distributed storage?
- This lesson

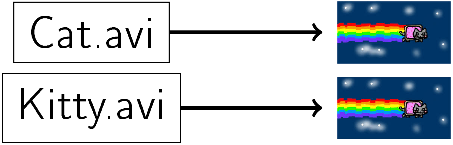
Storage optimization

Storage optimization



Cat.avi

Storage optimization



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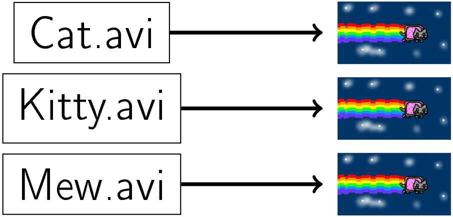

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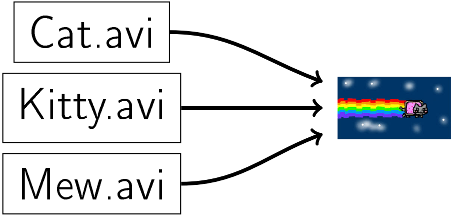

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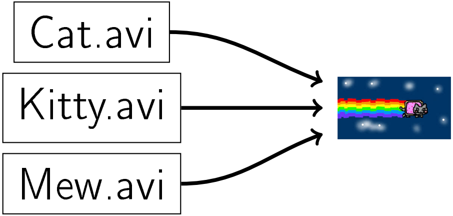
Mew.avi

Storage optimization



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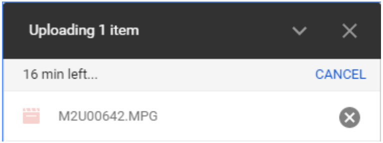
66% of storage space saved!

New File Upload



Uploading 1 item

16 min left...

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- Need to determine whether there is already the same file in the system

Naive Comparison

- Upload new file

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- If there's the same file, store a link to it instead of the new file

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- N grows, so total running time of uploads grows as $O(N^2)$

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- If there's a file with the same hash, upload and compare directly

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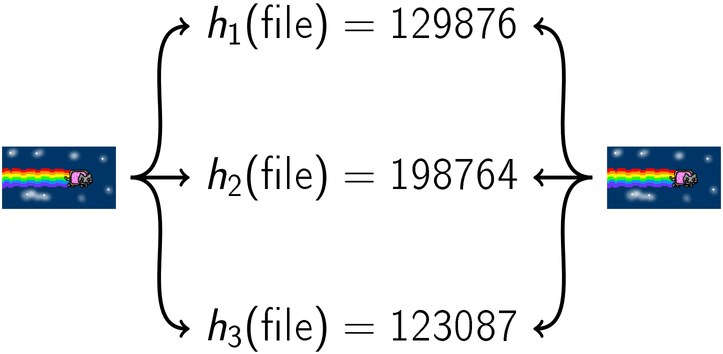
- Still have to compare with all N stored files

Idea: Several Hashes



$h_1(\text{file}) = 129876$

$h_2(\text{file}) = 198764$

$h_3(\text{file}) = 123087$

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- There are algorithms to find collisions for known hash functions
- However, even for one hash function collisions are extremely rare
- Using 3 or 5 hashes, you probably won't see a collision in a lifetime

Problem: $O(N)$ Comparisons

- Still have to compare with N already stored files

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- Only need the hashes to search in the table

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- Solution: distributed hash tables

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- Send request to that computer, search/modify in the local hash table

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- $h(O)$ mod 1000 no longer works

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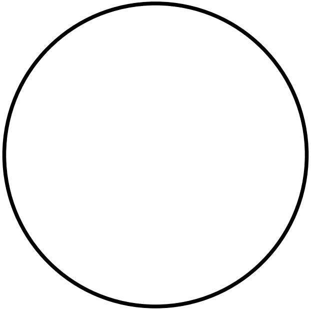
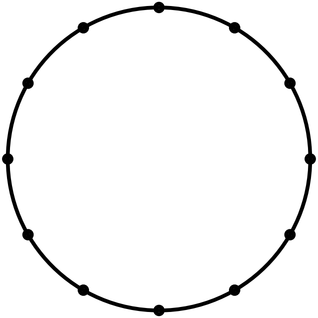
- Map computer IDs to the same circle: $compID \to$ point number $h(compID)$



$m = 12$



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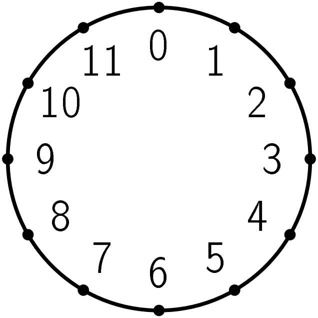

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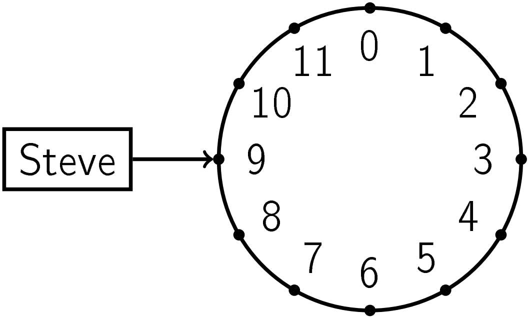

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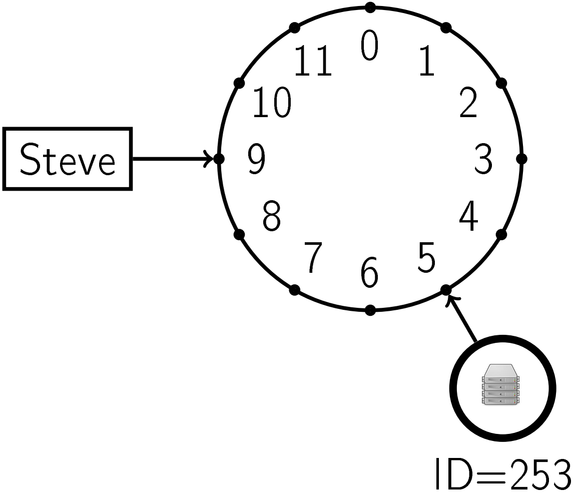

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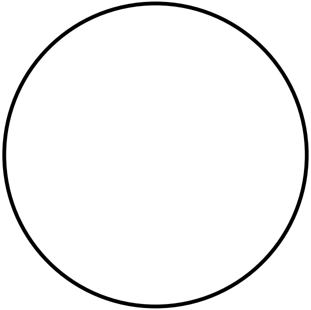
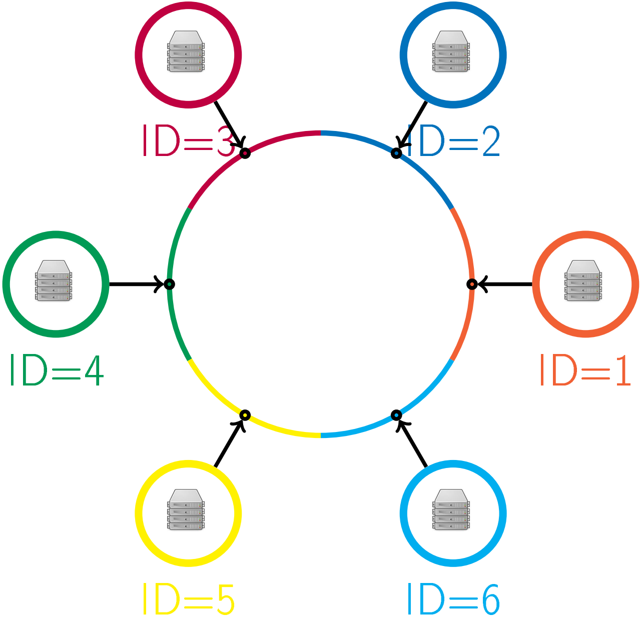
- Each object is stored on the “closest” computer
- Each computer stores all objects falling on some arc of the circle




ID=3
ID=2
ID=4
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Computers In and Out

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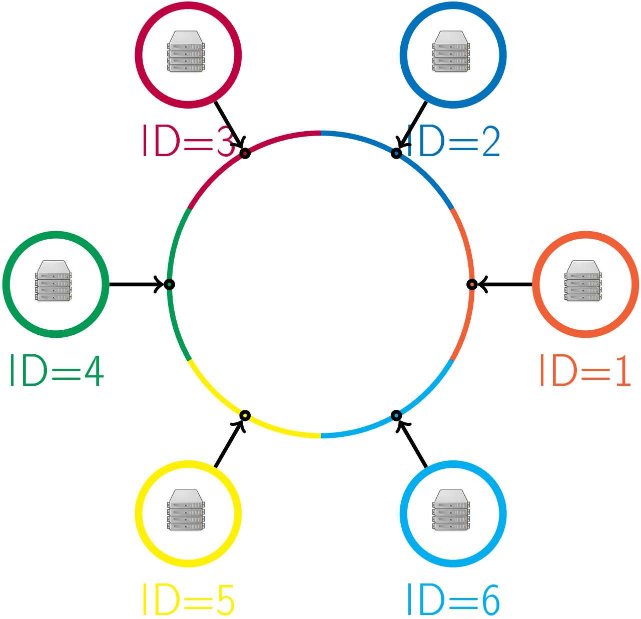
- When a new computer is added, it takes data from the “neighbors”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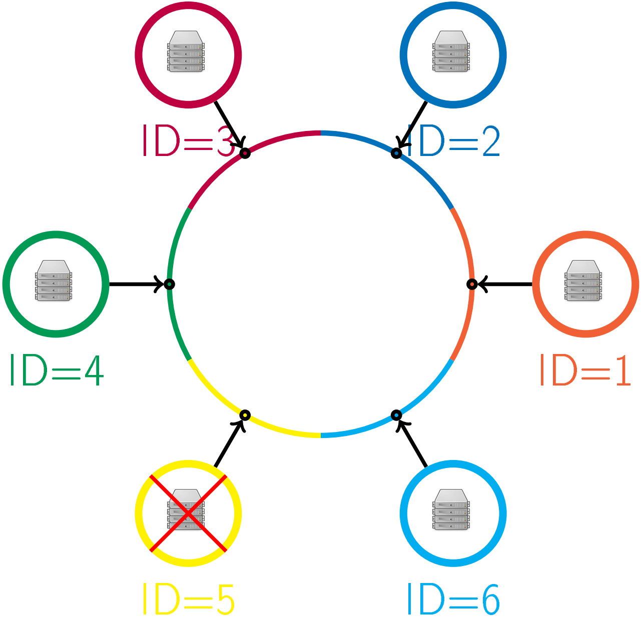
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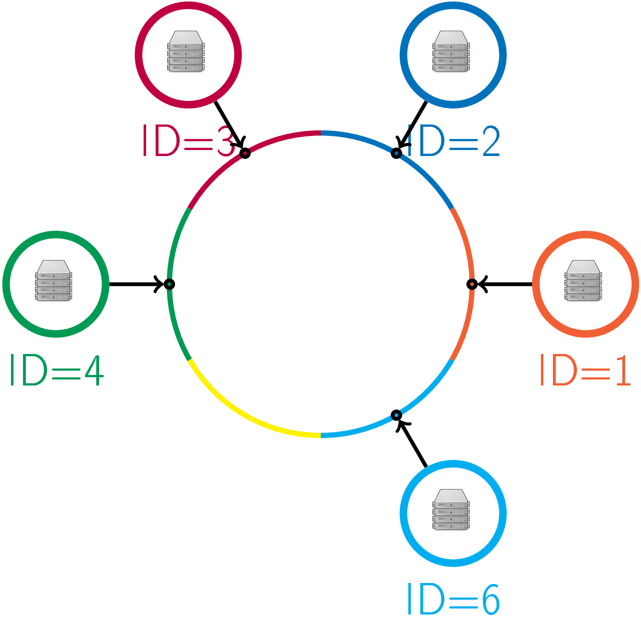
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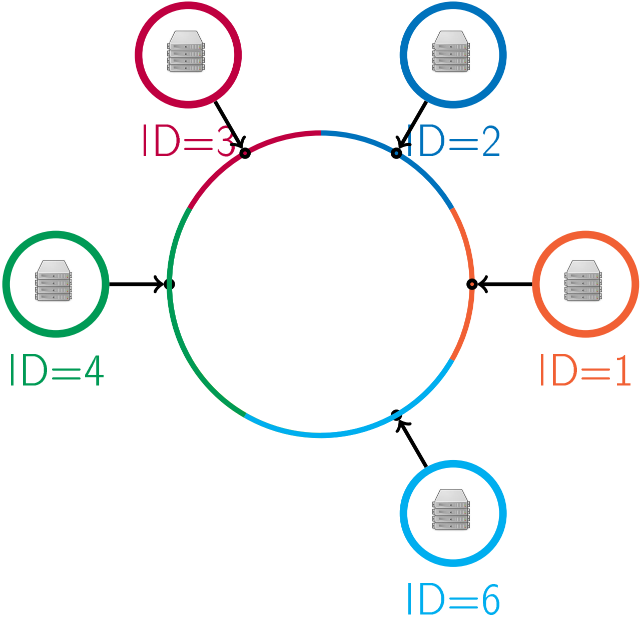
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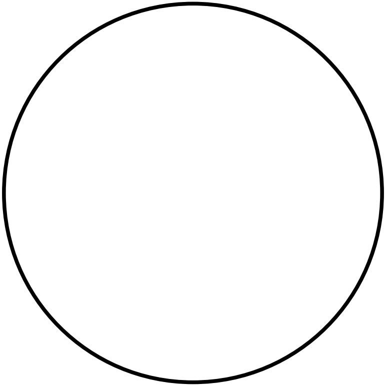
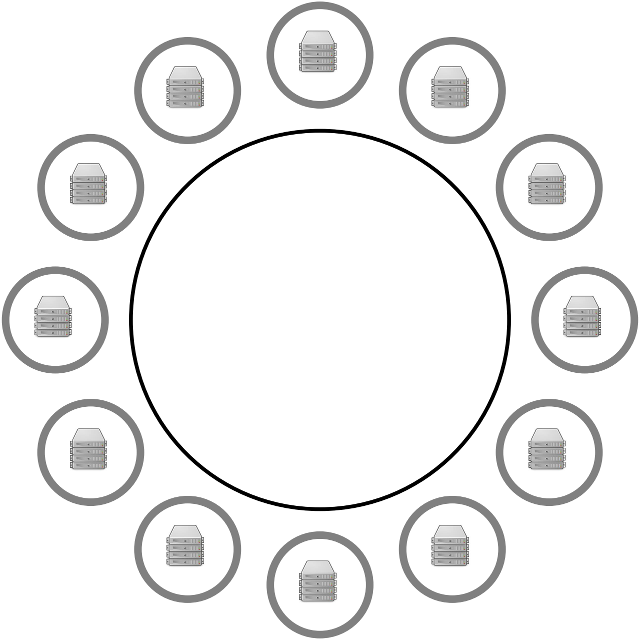
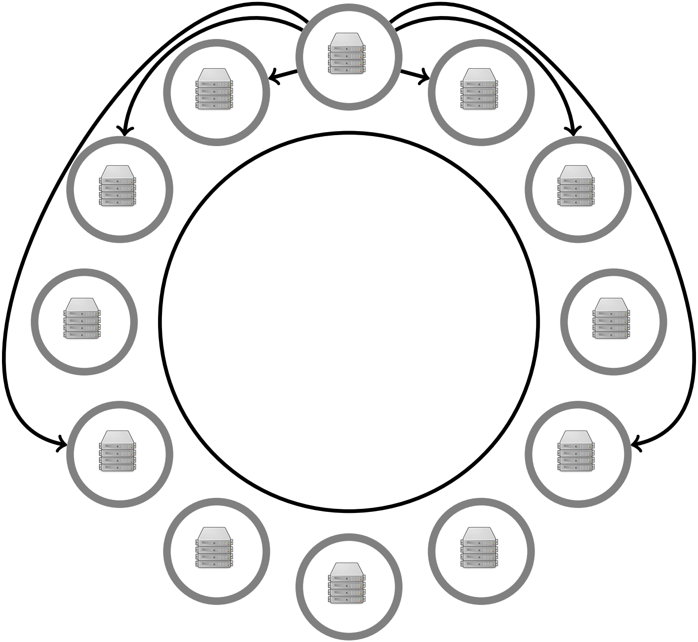
- For each key, each node will either store it or know some node "closer" to this key
- E.g., each node knows neighbors, $\pm 1, \pm 2, \pm 4, \pm 8, \ldots$ — $O(\log n)$ nodes, and can get/send any key in $O(\log n)$







Conclusion

- Distributed Hash Tables (DHT) store Big Data on many computers
- Consistent Hashing (CH) is one way to determine which computer stores which data
- CH uses mapping of keys and computer IDs on a circle
- Each computer stores a range of keys
- Overlay Network is used to route the data to/from the right computer