Distributed Hash Tables

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KTH

HT15

Distributed Hash Tables

- Large scale data bases
  - hundreds of servers
- High churn rate
  - servers will come and go
- Benefits
  - fault tolerant
  - high performance
  - self administrating

A key-value store

- Identify : how to uniquely identify an object
- Store: how to distribute objects among servers
- Route: how to find an object

Unique identifiers

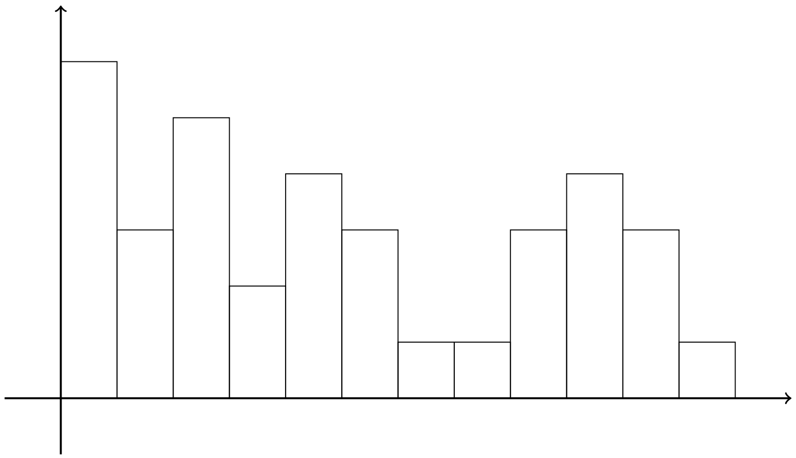
We need *unique identifiers* to identify objects.

How to select identifiers:

- select a name
- a cryptographic hash of the name
- a cryptographic hash of the object

why hash?

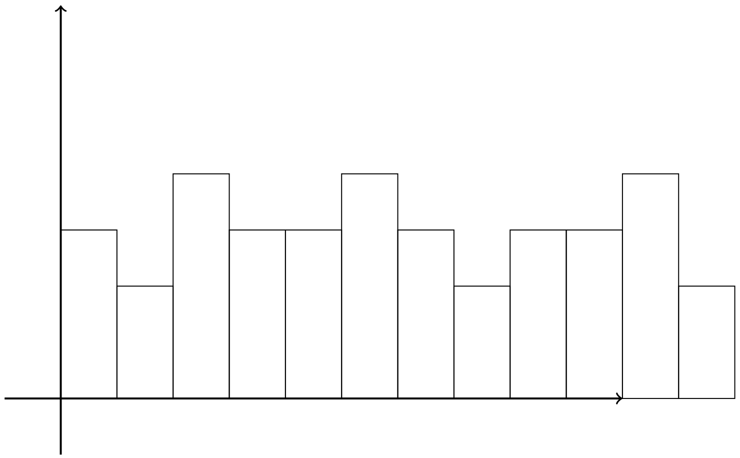
name distribution



cryptographic hash functions

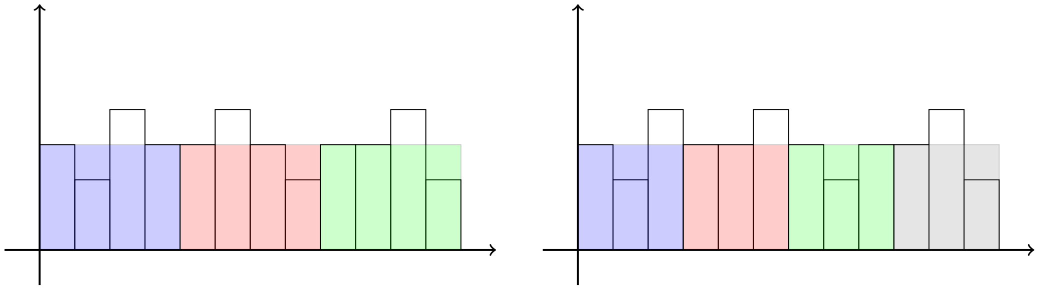
A cryptographic hash function will give us an even distribution of the keys.

hashing keys

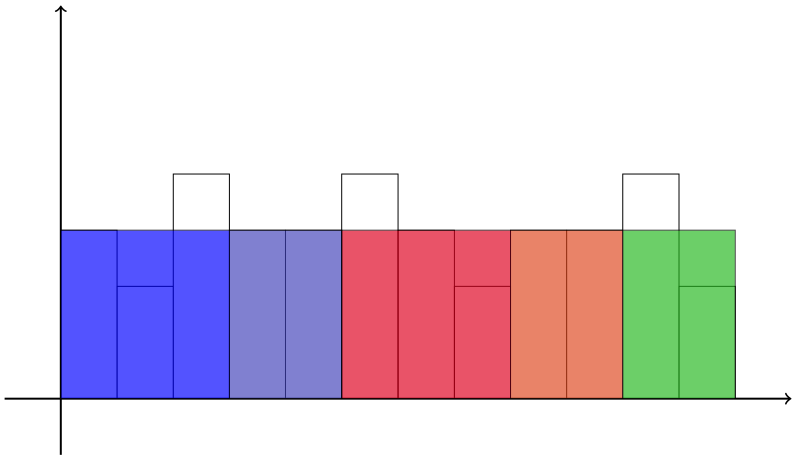


add a server

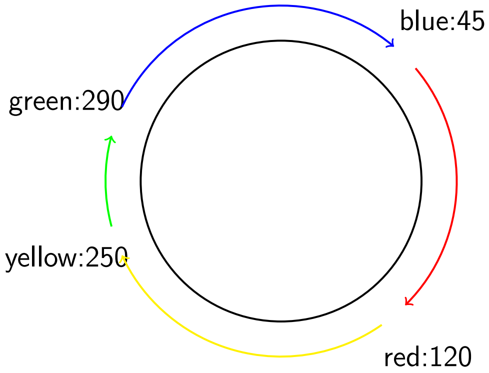
at three-o'clock-in-the-morning do:



random distribution

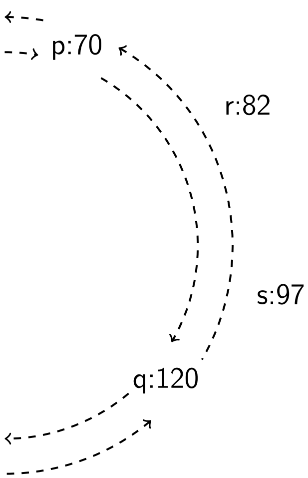


circular domain



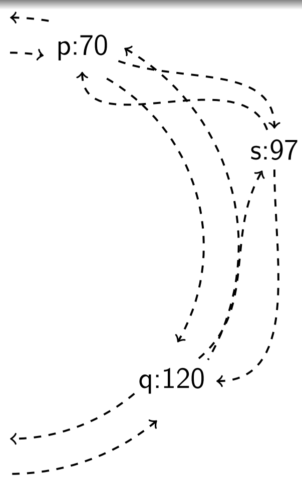
- responsibility: from your predecessor to your number
- when inserted: take over responsibility
- talk to the node in front of you

double linked circle



- predecessor
- successor
- how do we insert a new node
- concurrently

stabilization



- s: - Who is your predecessor?
- q: - It's p at 70.
- s: - Why don't you point to me!
- p: - Who is your predecessor?
- q: - It's s at 97.
- p: - Hmmm, that's a better successor.
- p: - Who is your predecessor?
- s: - I don't have one.
- p: - Why don't you point to me!

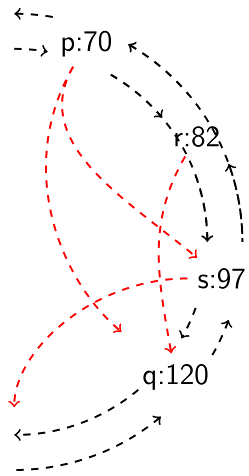
Let's play a game!

Stabilization

Stabilization is run periodically: allow nodes to be inserted concurrently.

Inserted node will take over responsibility for part of a segment.

Crashing nodes



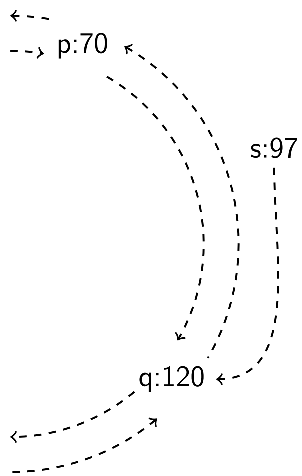
- monitor neighbors
- safety pointer
- detect crash
- update forward pointer
- update safety
- stabilize

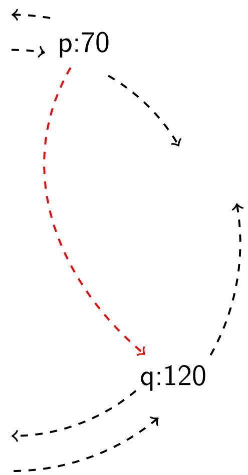
Russian roulette

How many safety pointers do we need?

replication

Where should we store a replica of our data?





Routing overlay

- The problem of finding an object in our distributed table:
  - nodes can join and crash
  - trade-off between routing overhead and update overhead

In the worst case we can always forward a request to our successor.

leaf set

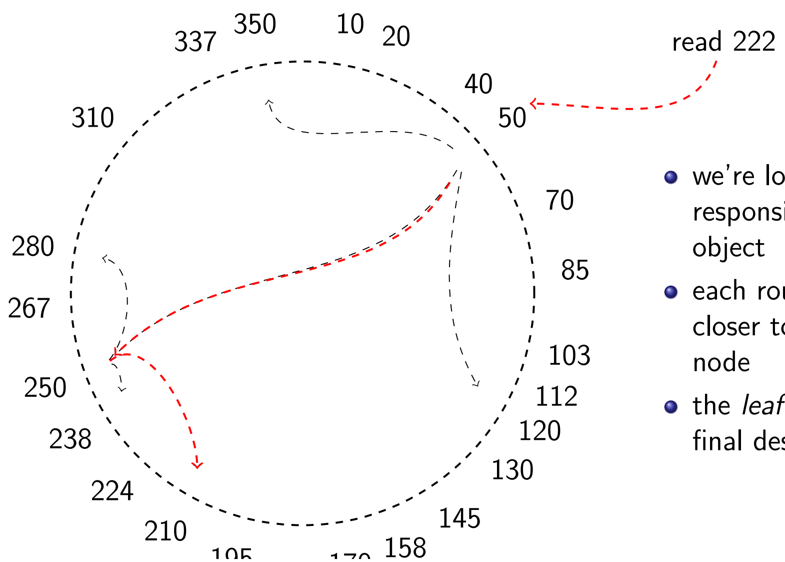
Assume that each node holds a *leaf set* of its closest ($\pm l$) neighbors.

We can jump l nodes in each routing step but we still have complexity of $O(n)$.

Leaf set is updated in $O(l)$.

The leaf set could be as small as only the immediate neighbors but is often chosen to be a handful.

Improvement



- we're looking for the responsible node of an object
- each router hop brings us closer to the responsible node
- the *leaf set* gives us the final destination

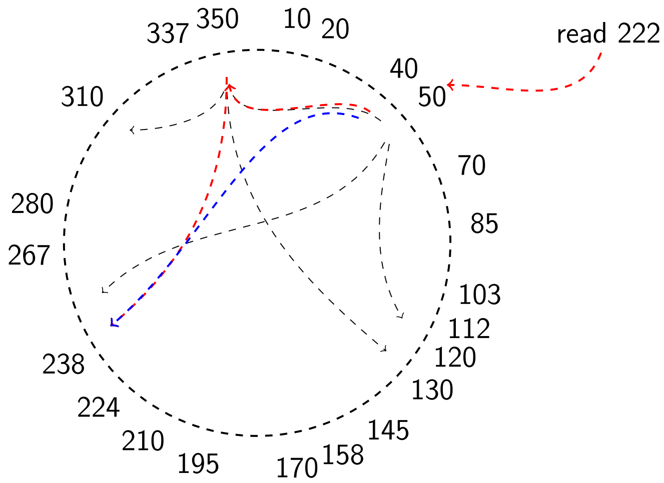
Pastry

A routing table that with rows, each row represents one level of routing.

- 32 rows
- 16 entries per row
- any node found in 32 hops
- maximal number of nodes 16^{32} or 2^{128} (more than enough)
- search is $O(lg(n))$ where n is number of nodes

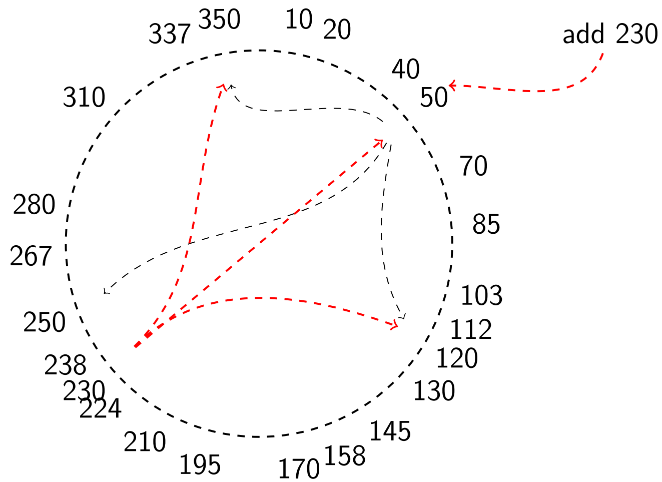
the price of fast routing

How do we keep the routing tables updated?



- be lazy
- detect failed nodes when used
- route in alternative direction
- ask neighbors of alternative node

network aware routing



- when inserting new node
- attach to the network-wise closest node
- adopt the routing entries on the way down

overlay networks

Structured

- takes time to add or delete nodes
- takes time to add objects
- easy to find objects

Unstructured

- easy to add or delete nodes
- easy to add objects
- takes time to find objects

DHT usage

Large scale key-value store.

- fault tolerant system in high churn rate environment
- high availability low maintenance

The Pirate Bay

- replaces the tracker by a DHT
- clients connects as part in the DHT
- DHT keeps track of peers that share content

Riak

- large scale key-value store
- inspired by Amazon Dynamo
- implemented in Erlang

Summary DHT

- why hashing?
- distribute storage in ring
- replication
- routing