Gagnasafnsfræði

Björn Patrick Swift

November 18, 2011

Hver er maðurinn

- 2011: MSc Parallel and Distributed Computer Systems, Vrije Universiteit
- 2008: BSc Hugbúnaðarverkfræði, Háskóli Íslands

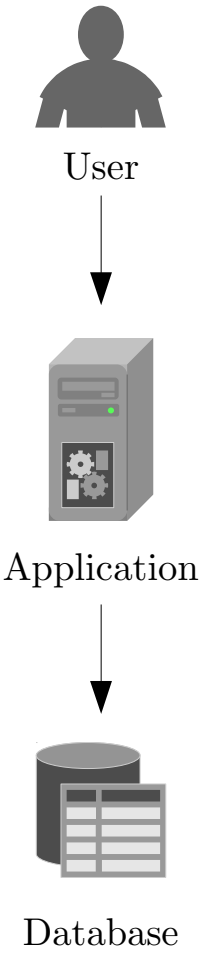
- 2011 – : Amazon AWS
- 2006 – 2009: CCP
- 2006: FRISK

Transactional

ACID properties

- Atomicity
- Consistency
- Isolation
- Durability

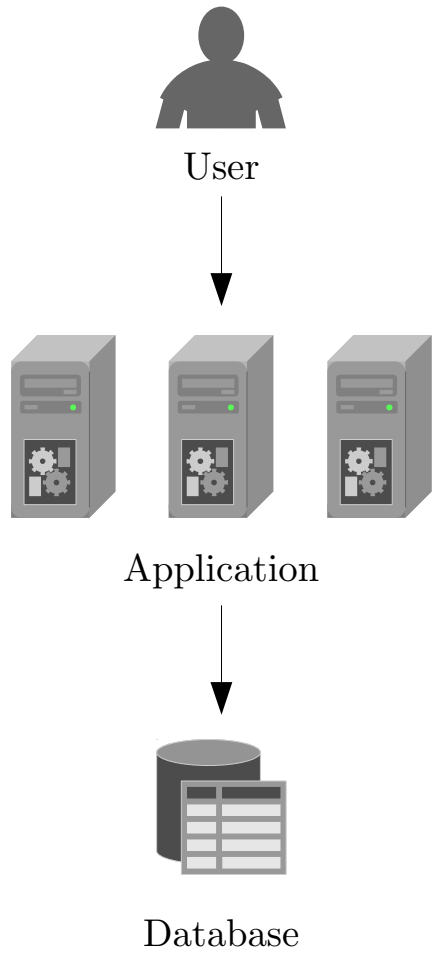
Transactions: All or nothing.



User, application, database

Application layer scales well.

Same does not hold for the database layer



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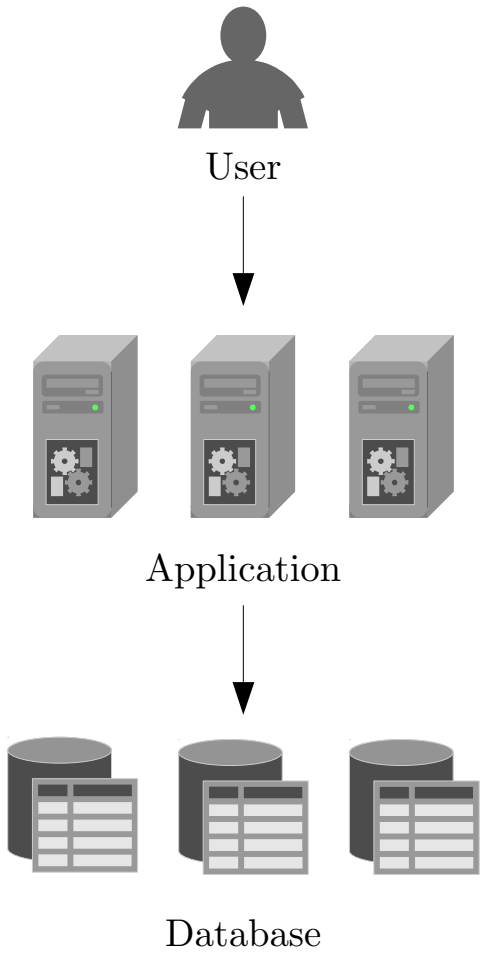
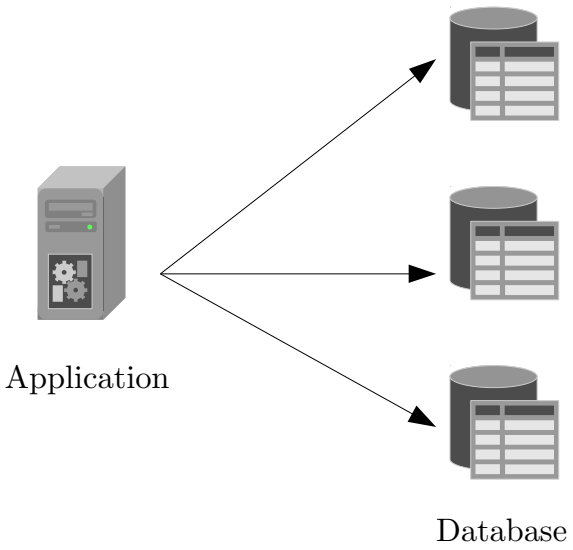


Full replication

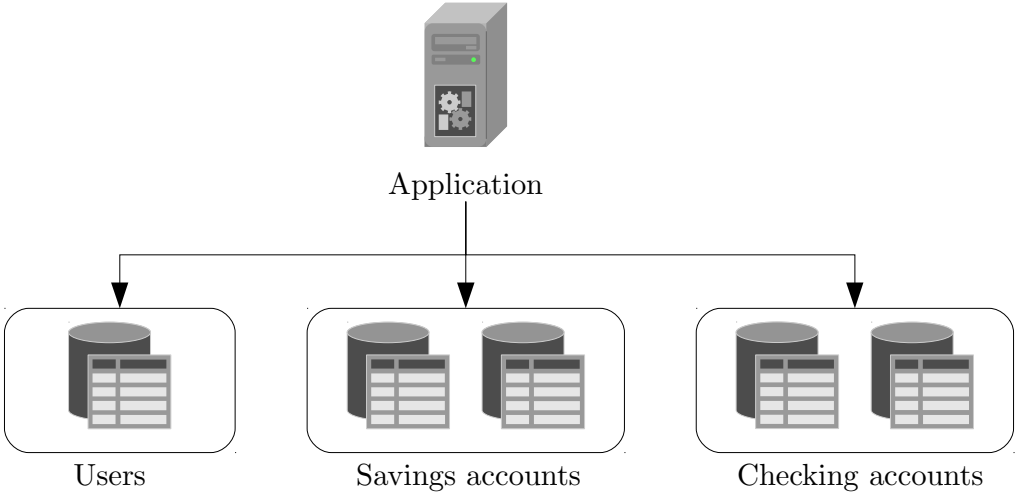
- State is fully replication across all servers
  - Writes need to be performed on all servers



Sharding

- Withdraw 100$ from checking account, deposit to savings account.
  - Operation 1: Withdraw 100$ from checking account.
  - Operation 2: Deposit 100$ to savings account.
  - Could something have changed between operations one and two?

Trade-off between transactional consistency and scalability.



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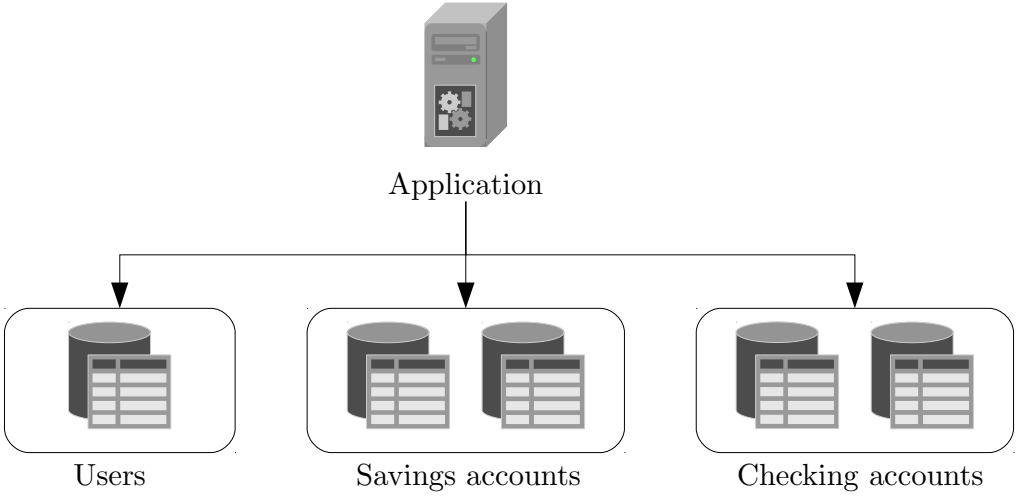

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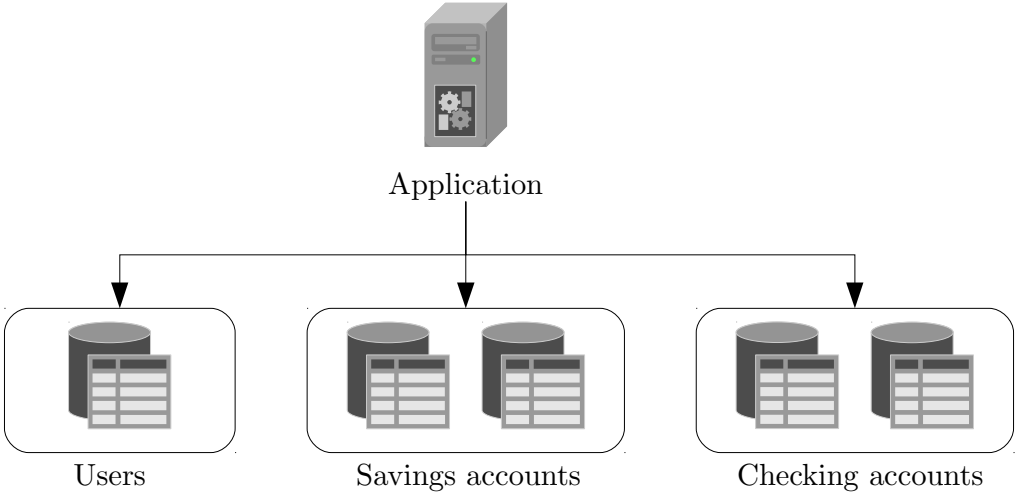

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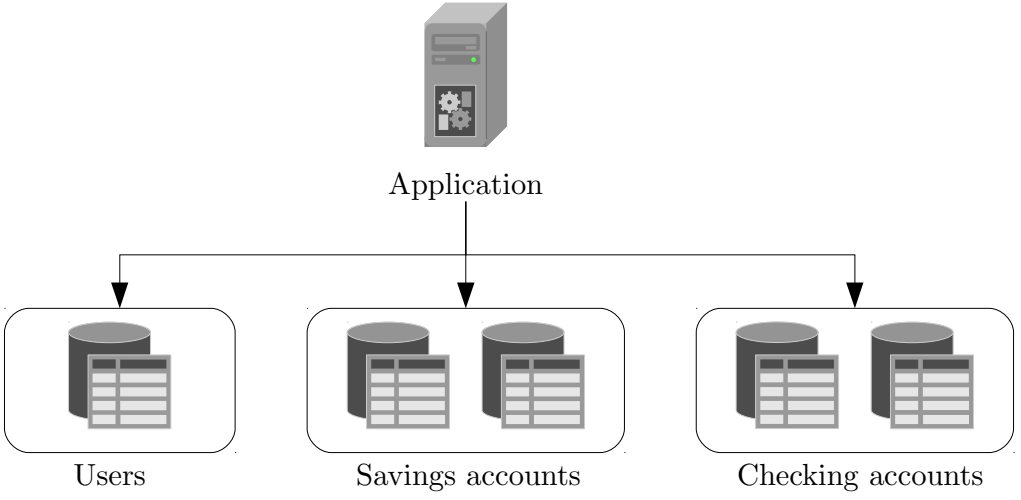

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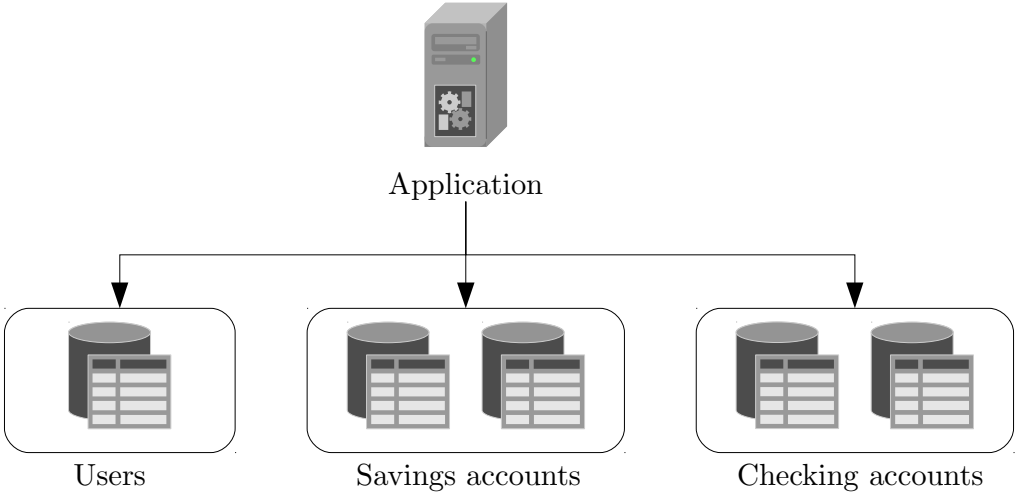

How far can we scale without ACID?

- Emphasis on scalability
- Several distributed data stores, both proprietary and open source.
  - BigTable, HBase
  - Dynamo, Cassandra, Riak
  - SimpleDB
  - CouchDB, MongoDB, ...
- Transactional consistency not supported.

“Practice is just around the corner”

- Consistent hashing
- Chord
- Object versioning with Vector Clocks
- Quorums
- Replica synchronization
- Gossiping

- Incremental scalability
- Symmetry
- Decentralization
- Heterogeneity
- High Availability

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CAP Theorem

Of three properties of shared-data systems

- data consistency
- system availability
- tolerance to network partition

only two can be achieved at any given time.[a]

[a] Brewer, E. A. 2000. Towards robust distributed systems (abstract). In Proceedings of the 19th Annual ACM Symposium on Principles of Distributed Computing (July 16-19, Portland, Oregon): 7.

We need to relax some constraints.

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- get(key)
  - A single object
  - List of objects with conflicting versions and a *context*
- put(key, context, object)

- Objects are binary blobs, Dynamo had no schema.
- Keys are hashed using MD5.

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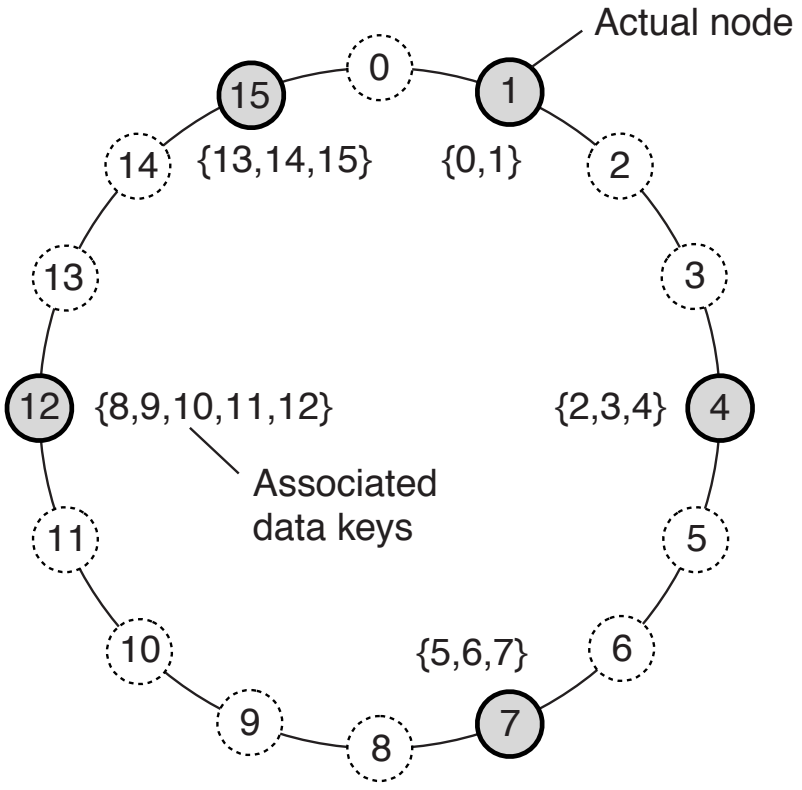
Chord system

... with a twist

- Each node gets multiple tokens in the ring

Virtual nodes address:

- Heterogeneity
- Incremental scaling



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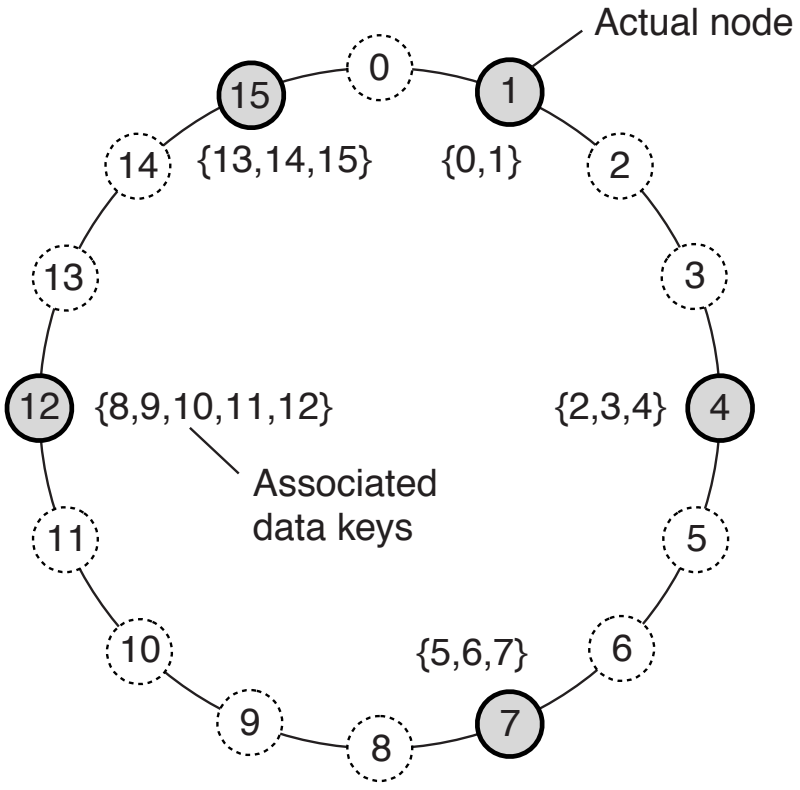

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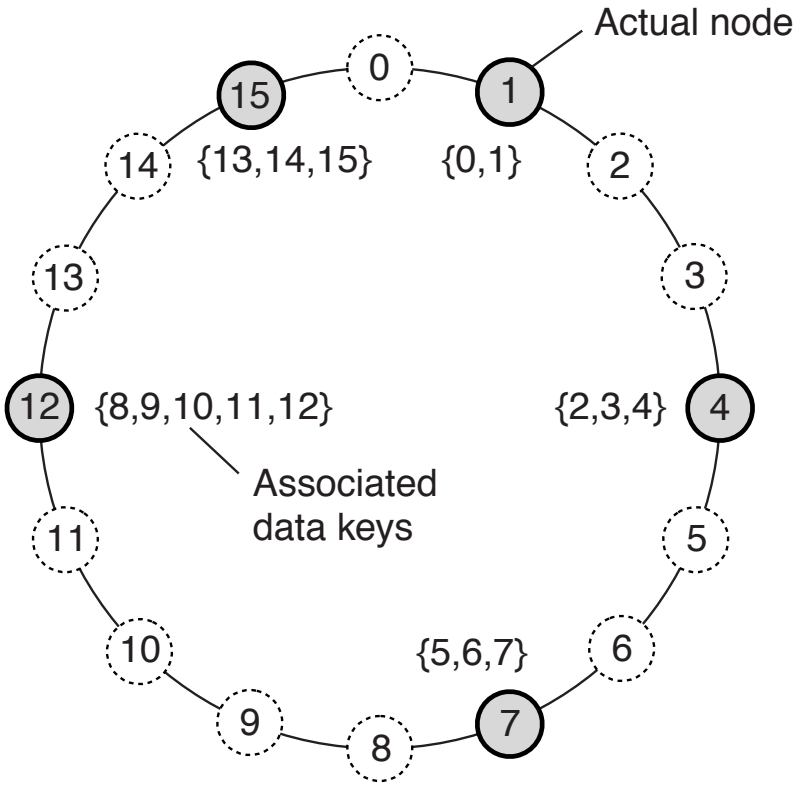

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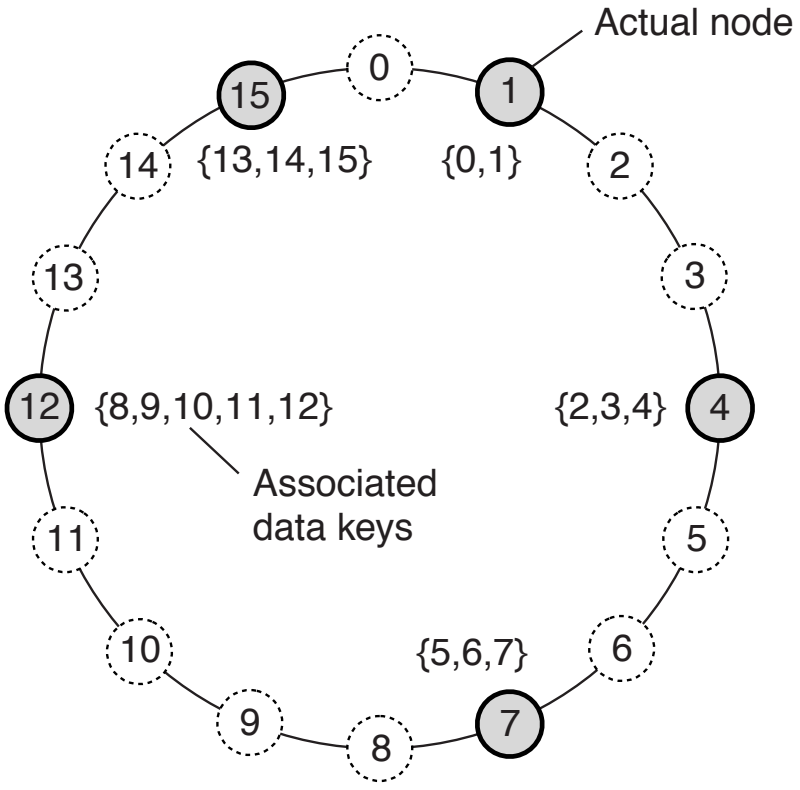
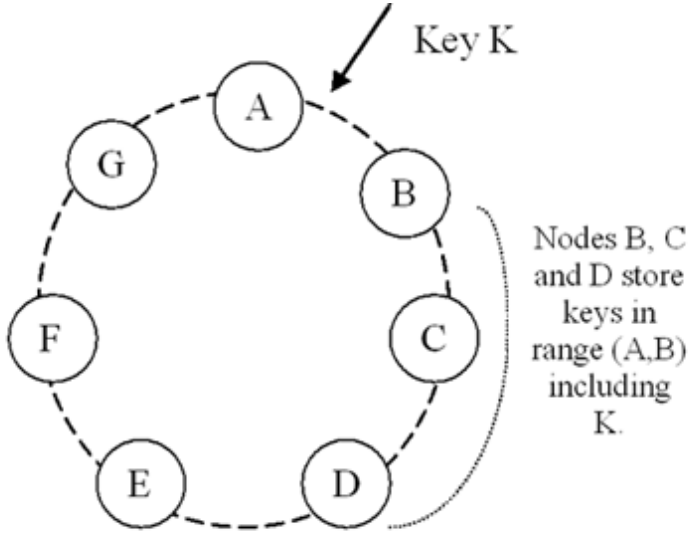


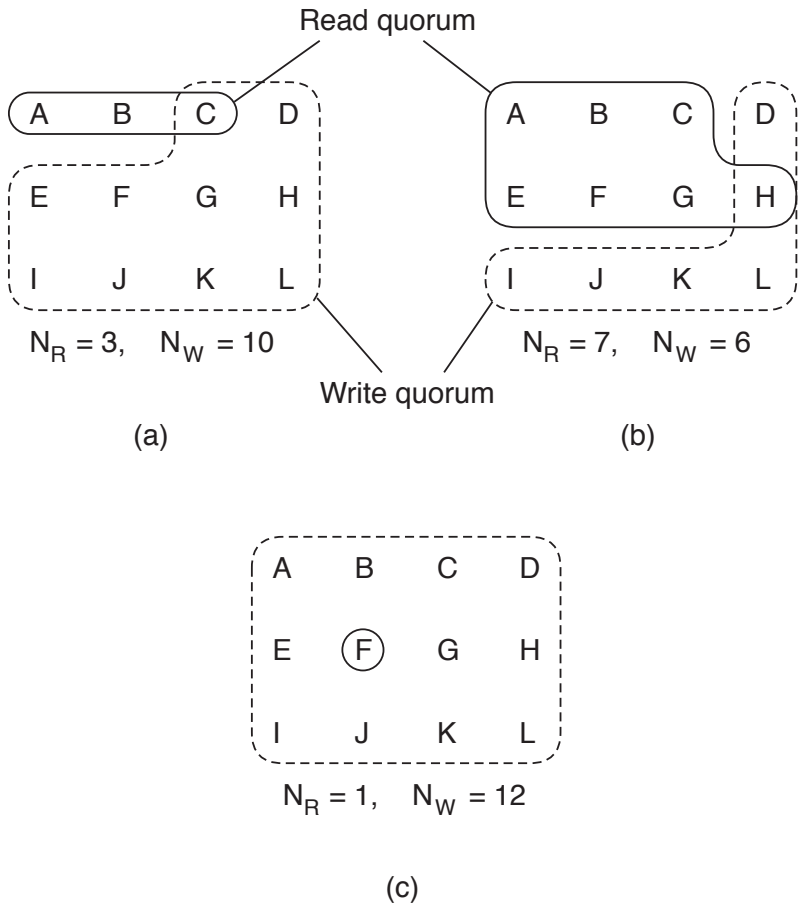
Each object is replicated to N nodes

- N-1 successors to the coordinator



Traditional quorum

- R + W > N
- W > N/2
- Dynamo allows clients to tune N, R and W

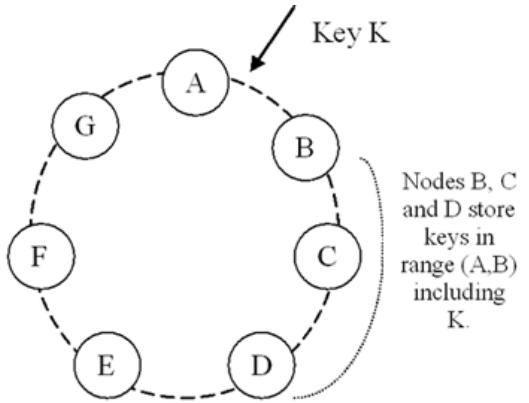


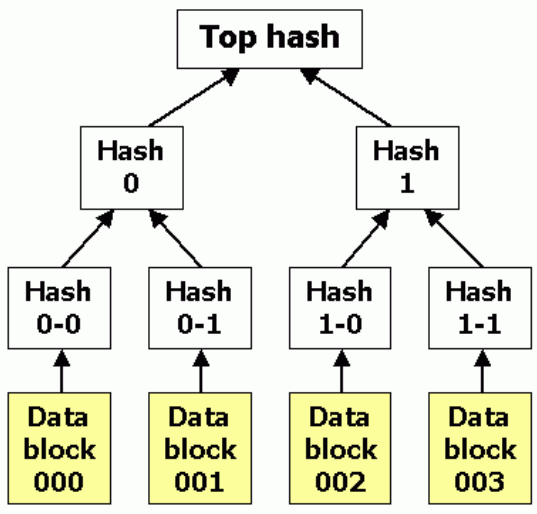
Sloppy-Quorum

- The set of nodes in N may change

Anti-entropy

- Merkel hash trees used to find “out of sync” keys





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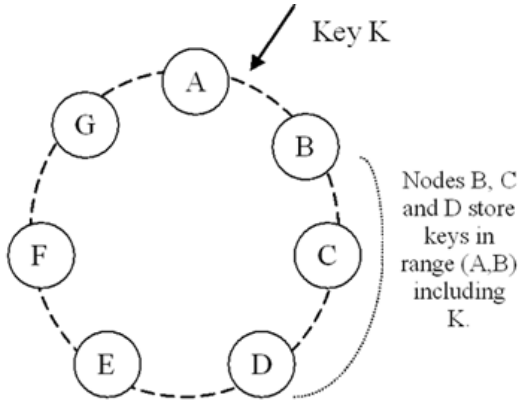
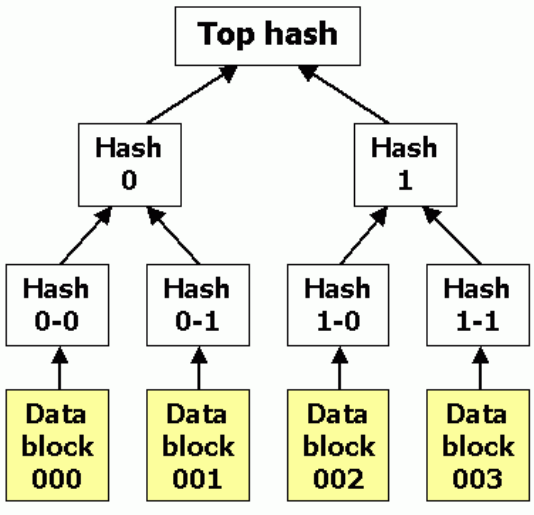
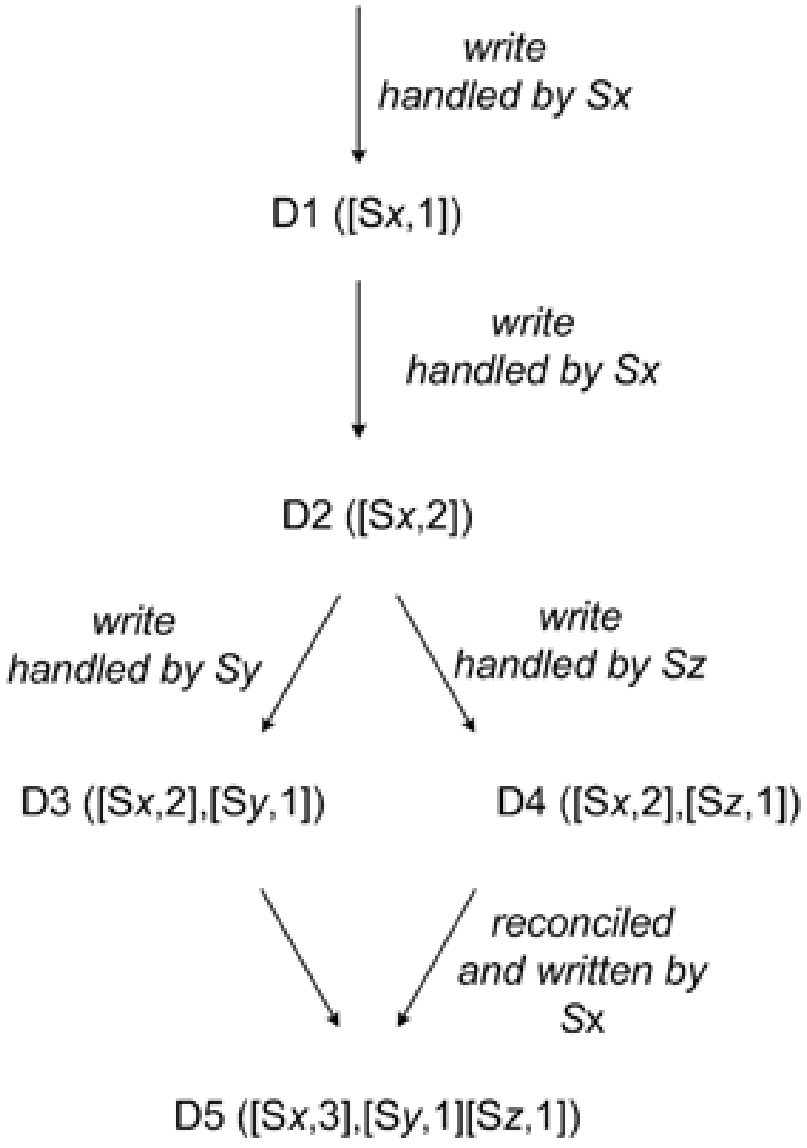




Each object has a Vector clock

- Captures causal ordering



Conflict resolution

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  - During writes?
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When do divergent version arise?

- Failure scenarios
  - Node, data center, network partitions
- Large number of concurrent writes

How frequently are divergent versions created?[1]

Versions	Requests
1	99.94%
2	0.00057%
3	0.00047%
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[1] 24 hour profile of the Shopping Cart Serivce

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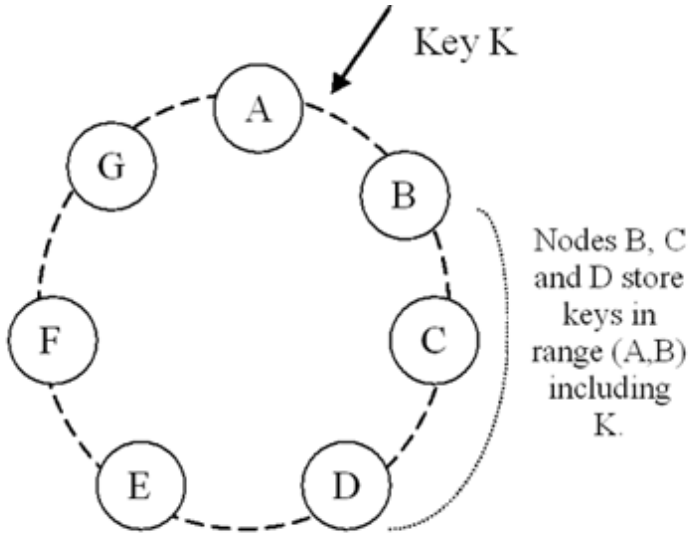
Client-driven vs Server-driven coordination



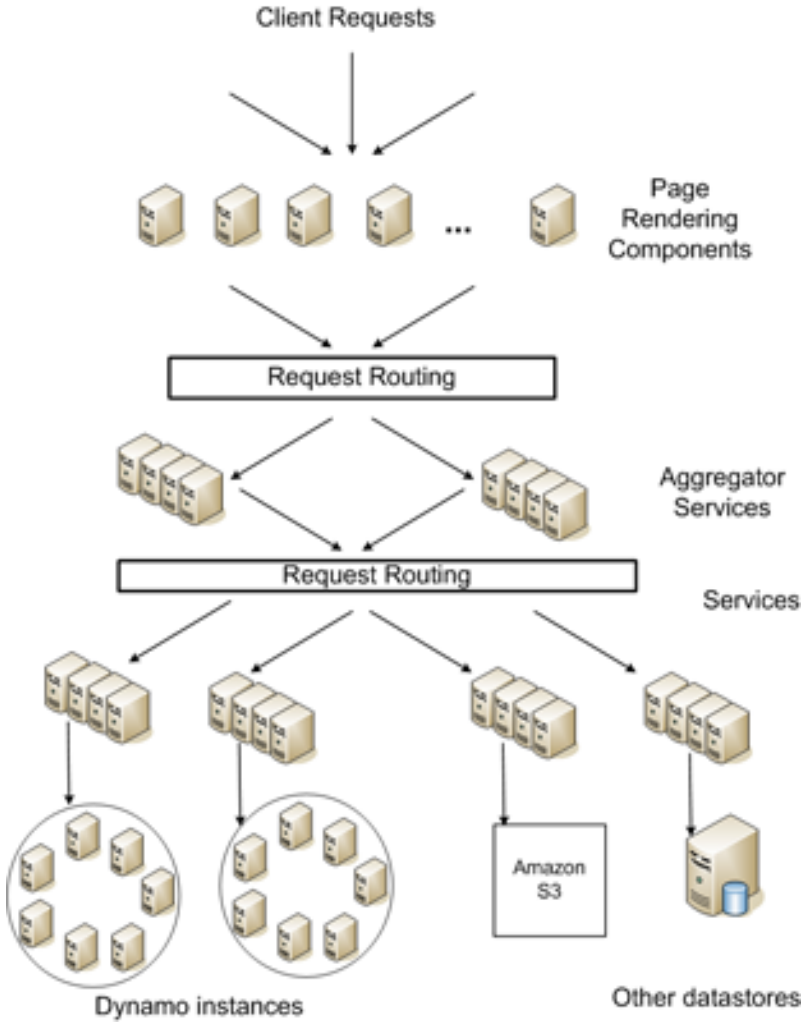
	99.9th percentile read latency	99.9th percentile write latency	Average read latency	Average write latency
Server-driven	68.9	68.5	3.9	4.02
Client-driven	30.4	30.4	1.55	1.9

Times are in milliseconds.

Amazon

- Service architecture
- Decentralized
- Loosely coupled

- SLA expressed and measured at the 99.9^{th} percentile
  - Optimizations not focused on averages



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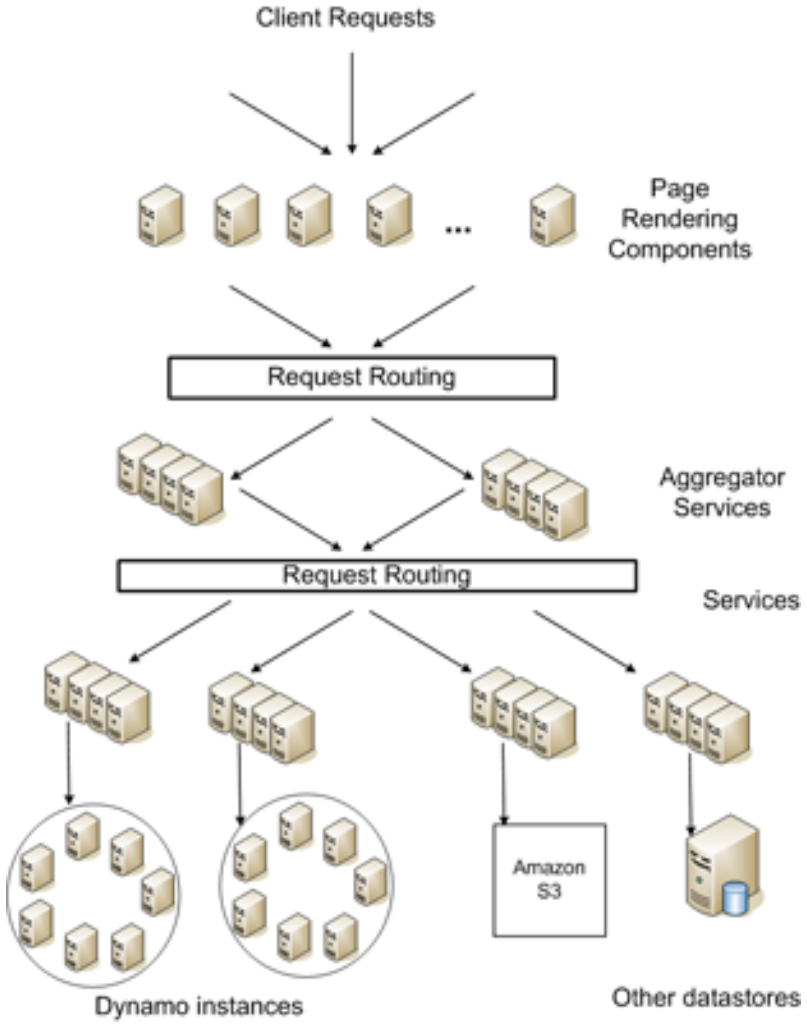
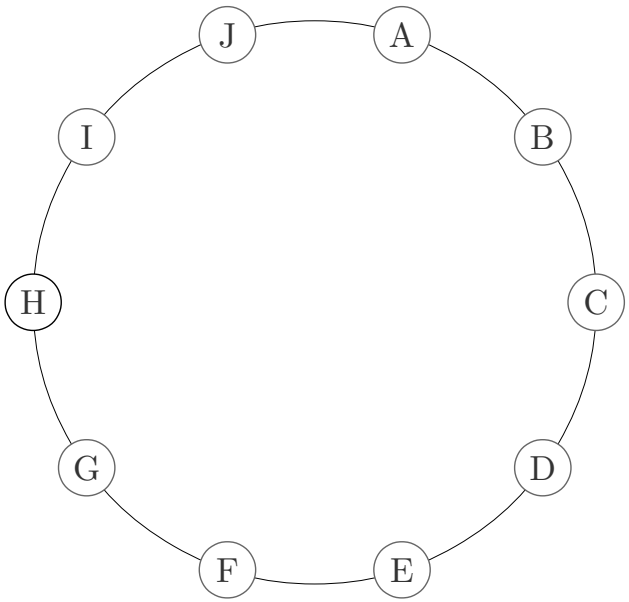


Distributed buckets



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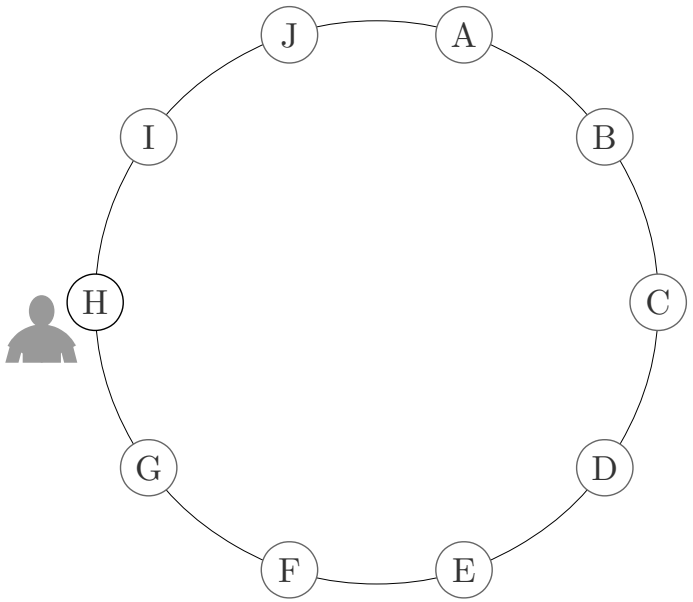

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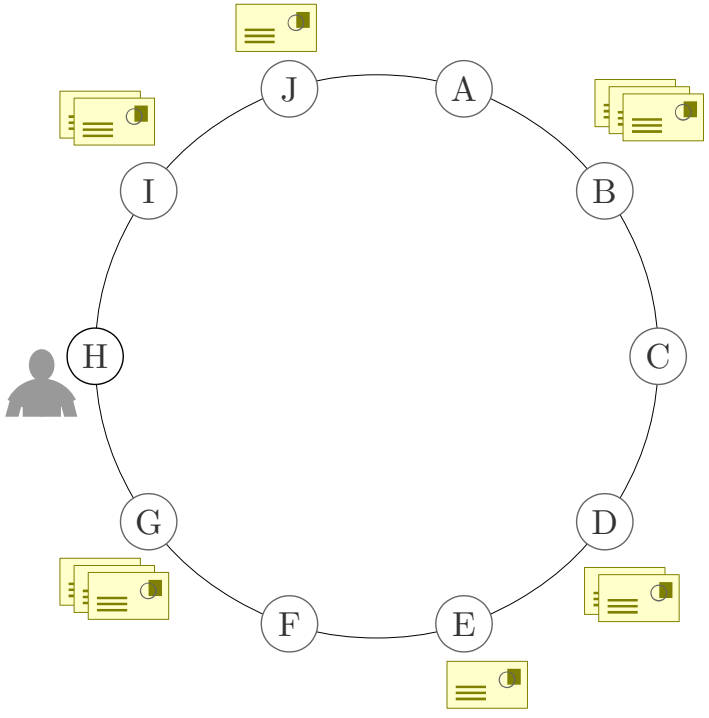

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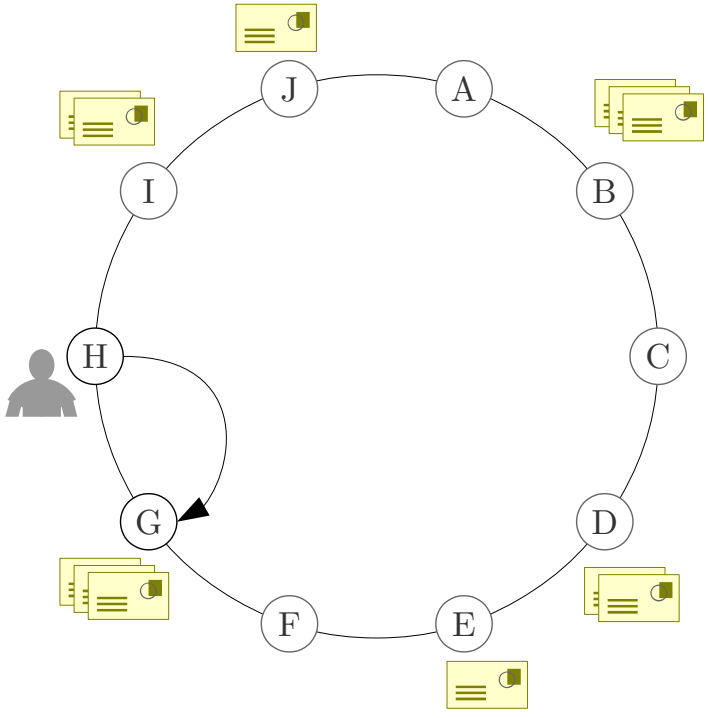

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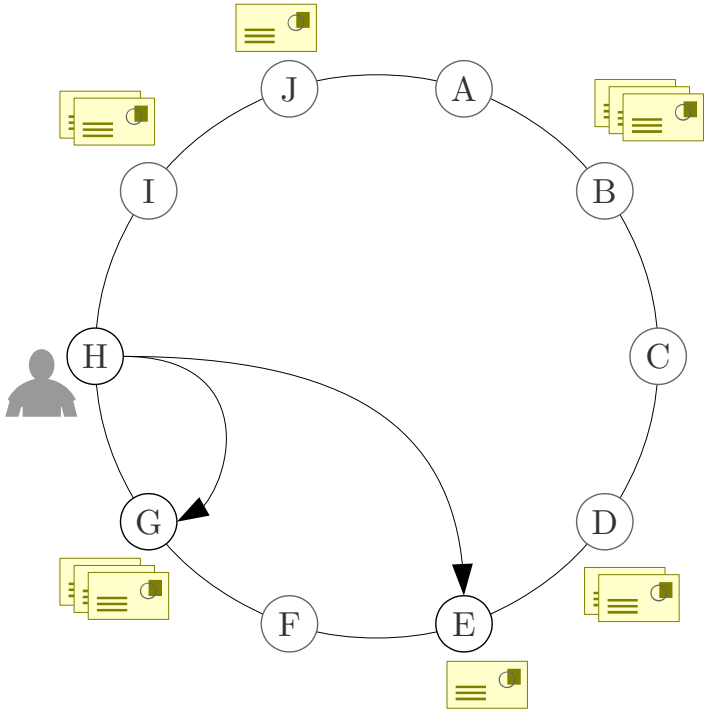

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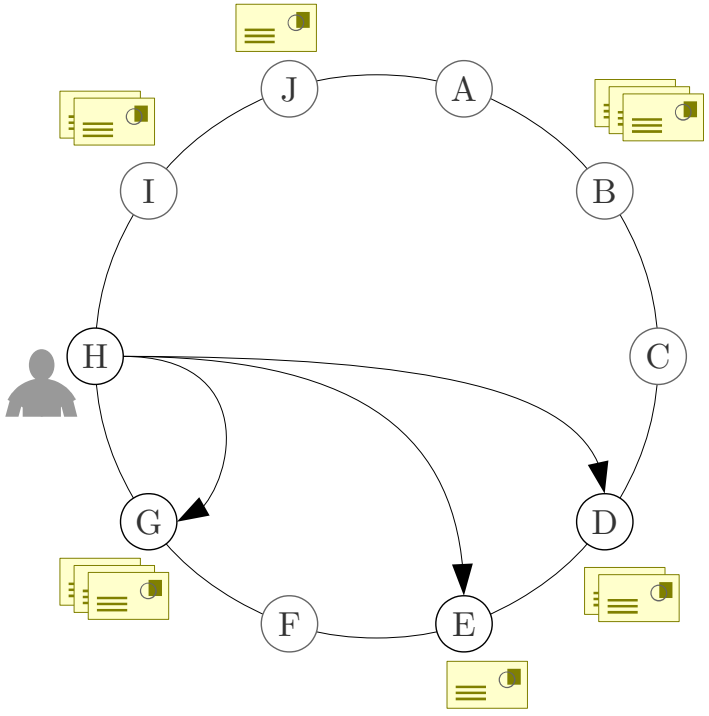

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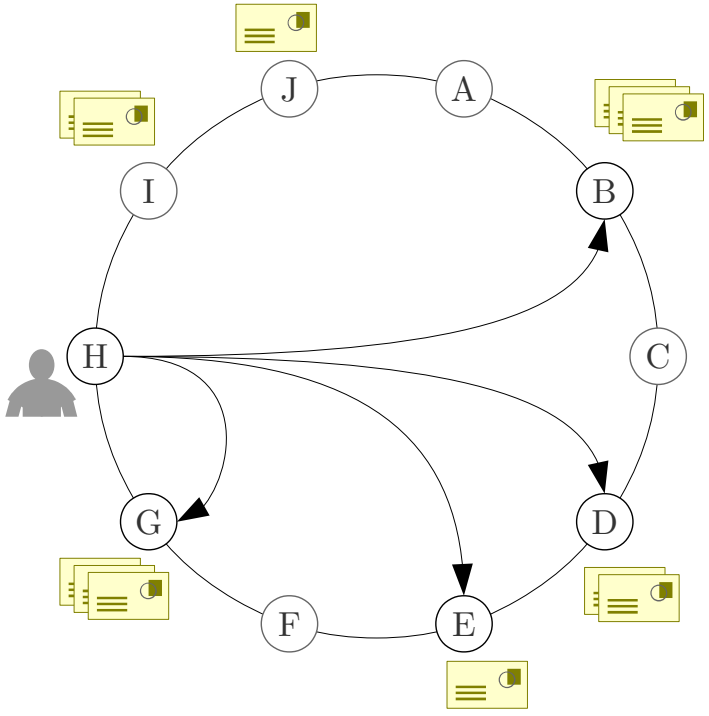

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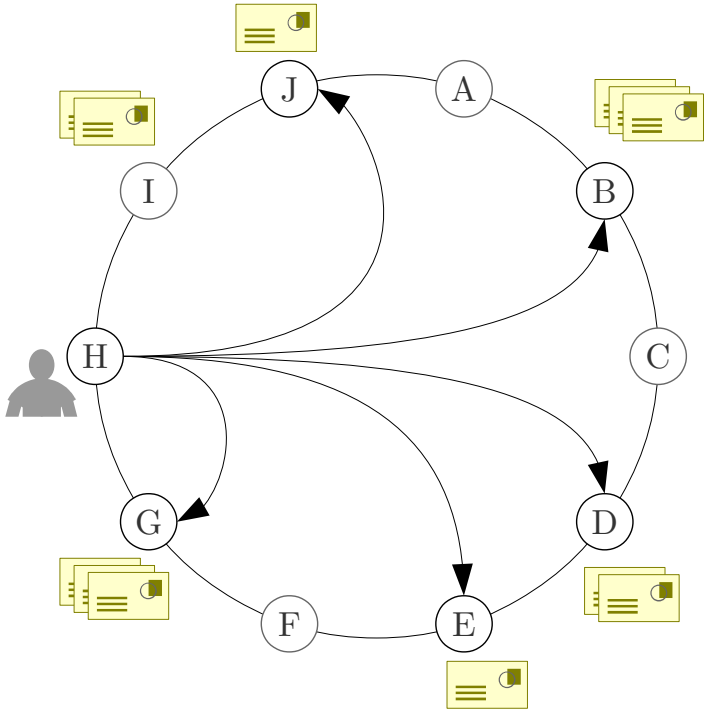

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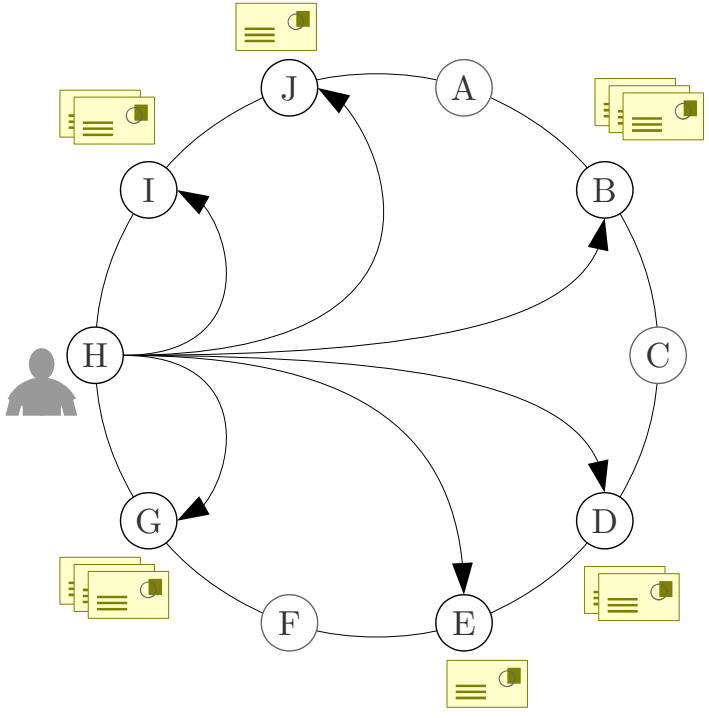
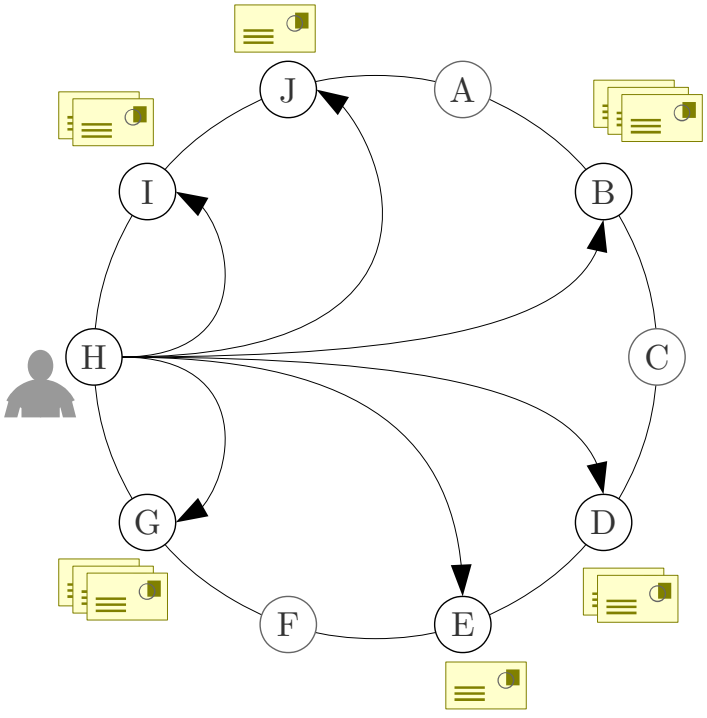
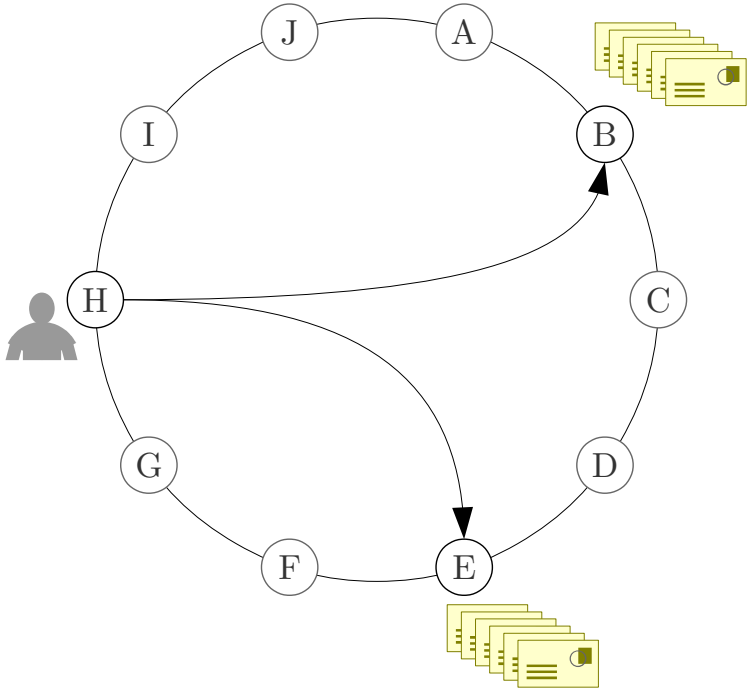


Data placement



Random



Clustered