Scalable Web Architectures(SWA)

COMP 599 - Graduate Seminar, Fall 2018

Rihan Pereira, MSCS

Department of Computer Science
California State University, Channel Islands

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Roadmap

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- Availability
- Partial Tolerance
- Consistency
- scalability
- Maintenance

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Vertical & Horizontal scaling

Horizontal img/hv.png

- ability to redirect request to another nodes (in short, resilency) *
- load balancing
- network calls RPC/REST
- data consistency issues
- system scales proportional to variable data sets *

Vertical img/vertical.png

- has a single point of failure
- N/A
- inter-process communication (IPC) *
- consistent *
- hardware limit

Beyond single node deployment

Imagine a simple image upload service using a central server

img/data_acces

Very soon, your appln is a hit!
You start getting lot of traffic

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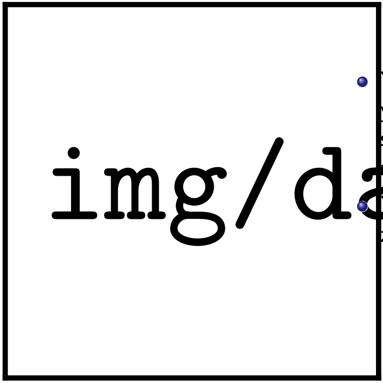

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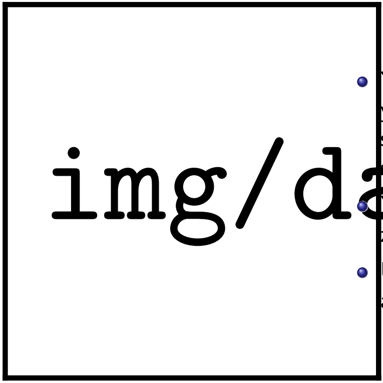

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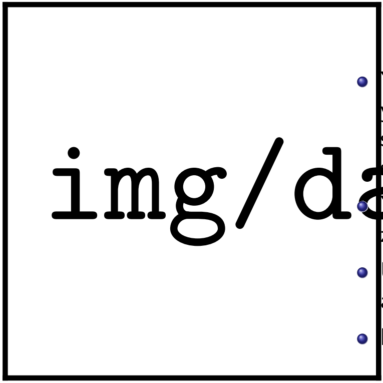

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- low-latency request-response

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keeps a copy of the same data on multiple machines connected via a network.

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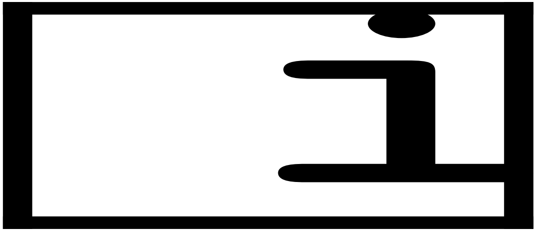
1. Single-leader based replication
2. Multi-leader replication
3. Leaderless replication

Single-Leader based replication



- Also called master-slave replication
- Considering sy[illegible]ous/[illegible]ron[illegible] co[illegible]g in data[illegible]ses.
- U[illegible] synchr[illegible]us [illegible]ti[illegible]
- Async configuration is widely used in production deployments.

leader follower copying strategy

in

Follower setup without downtime

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- Leader failure
    - one of its followers takes the leader
    - clients need to be reconfigured to send writes to new leader
    - other followers need to start consuming data changes from new leader.
    - old leader joins back as normal follower

Multi-leader based replication

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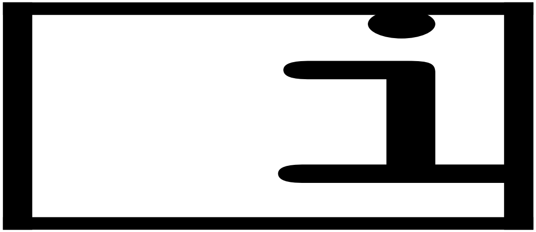

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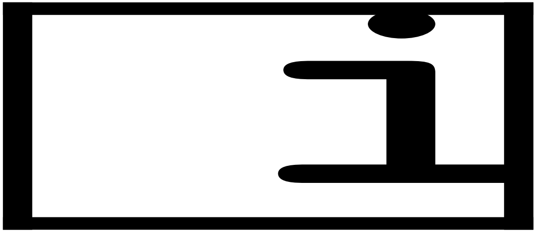

- natural extension of leader-based replica, allows more than 1 node to accept writes
- each leader simultaneously acts as follower to each leader
- mostly used in multi-data center operations

Conflict resolution problem

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- There is some research on conflict resolving
  - Conflict-free replicated data types
  - Mergeable persistent data structures
  - Operation transformation

Multi-leader topologies

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Leaderless replication

Leaderless replication

- takes different approach instead of developing leader-follower concept

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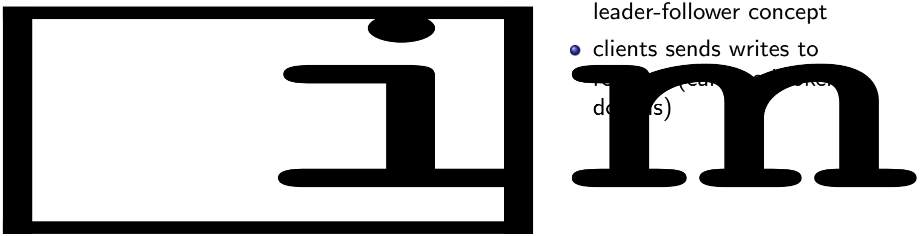

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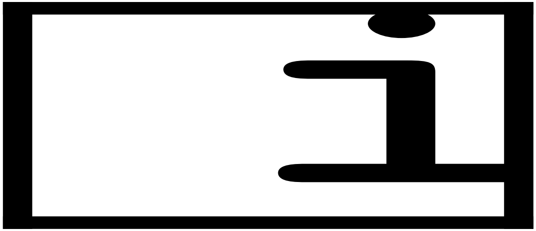

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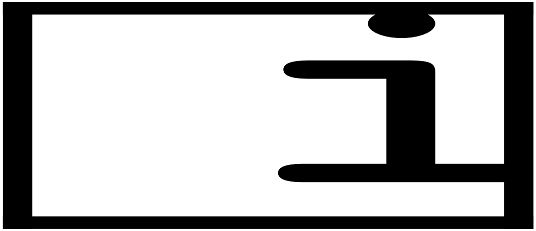

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- Amazon's DynamoDB is built using this concept
- examples include Cassandra, Riak

Leaderless write mechanisms

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- **Anti-entropy process**
  - does reconcilation in background process
  - writes are copied in unordered way

Quorums for reading and writing

Write processed on 2 out of 3 replicas. What if only 1 of 3 replicas accepted write ? How far can we push ?

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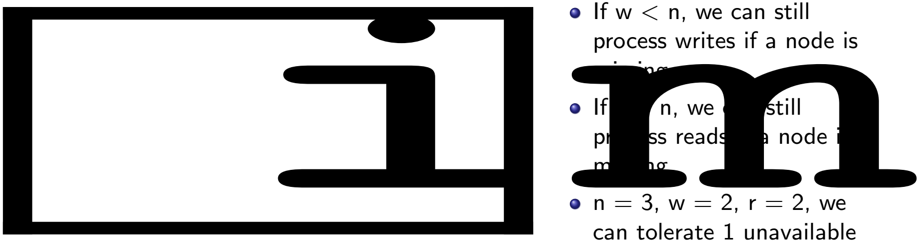

- If w $<$ n, we can still process writes if a node is [illegible]
- If [illegible] n, we [illegible] still pr[illegible]ss reads [illegible]a node i[illegible] m[illegible]ng
- n = 3, w = 2, r = 2, we can tolerate 1 unavailable node
- n = 5, w = 3, r = 3, we can tolerate 2 unavailable nodes

Sharding/Partitioning

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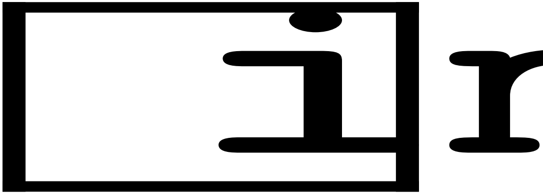
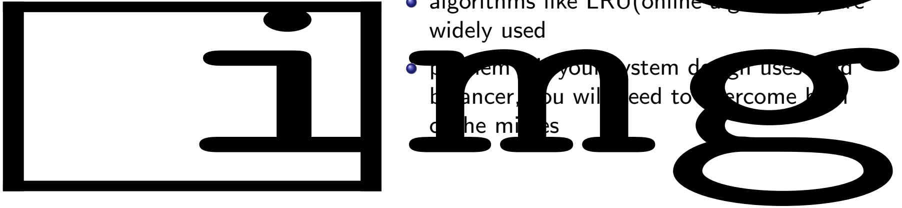


Using Caches



- a [illegible] serio[illegible] app [illegible] deplo[illegible] cache se[illegible]r
- u[illegible]ally p[illegible]ed in[illegible]ont of [illegible] data source
- algorithms like LRU(online [illegible]) [illegible] widely used
- p[illegible]em [illegible] you[illegible]ystem d[illegible] uses [illegible] b[illegible]ancer, [illegible]ou wil[illegible]eed to [illegible]ercome [illegible] c[illegible]he mi[illegible]es

Overcoming cache misses

figure 1

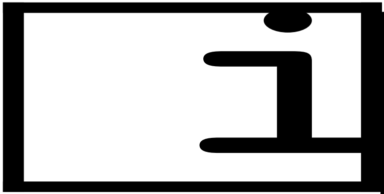


figure 2

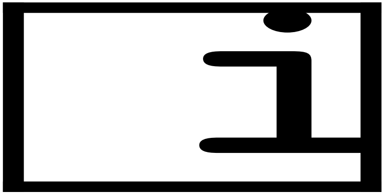


figure 3

1st figure	handles eviction and data retrieval on its own
2nd figure	application handles eviction
3rd figure	each of the hold portion of cached data
3rd figure	uses consistent hashing to lookup data across nodes

Proxies

basic role is to receive requests from client and relay them to next node in line.

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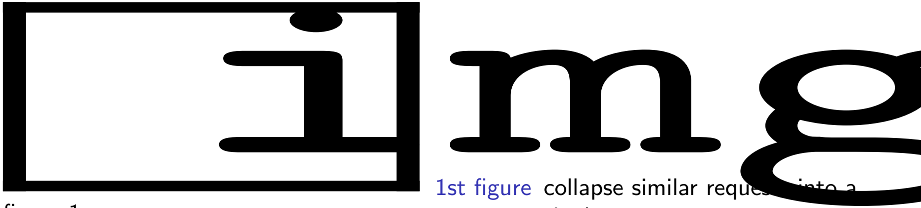

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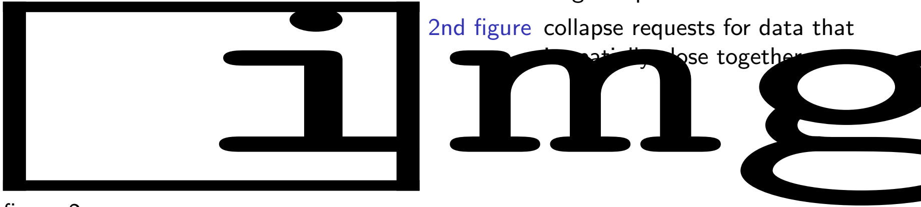

figure 2

1st figure	collapse similar requests into a single request
2nd figure	collapse requests for data that is spatially close together

Indexes

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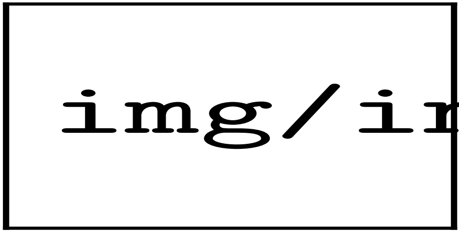

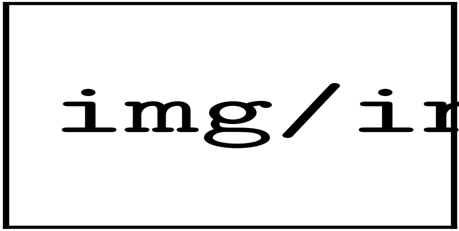

- the trick is to index your database based on users data access patterns
- In return for faster data access they do add write overhead and requiring updating indexes on each write

Load Balancers

Their role is to distribute incoming requests evenly, fairly among available servers. They serve as a brokers between client and logical nodes, handling lot of simultaneous connections.

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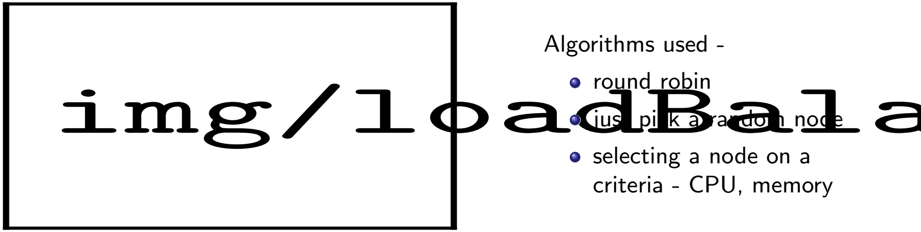

Algorithms used -

- round robin
- just pick a random node
- selecting a node on a criteria - CPU, memory

Queues

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img/queue_syn

img/queue_asy

- work in async manner
- client is given acknowledgement that request is served
- tasks range from as simple as write to a data store to as complex as extracting pdf from text

Naive Hashing

hashing.png

`img/naive hashing.png`

some assumptions -

- no. of nodes serving request never change
- repeated request can be served using cache
- requires rehashing every single key, caches get obselete.

Consistent Hashing

Incoming requests and serving nodes are placed onto a virtual ring structure called *hashring*

img/consistent_has

- placement of server nodes is not fixed on the ring, instead are placed at random locations
- each server owns a range of hashring
- No worries on adding new servers or server disruptions
- only rehashing of affected portion of requests is required

Martin Kleppmann,
Designing Data Intensive applications, **2017**

James Hamilton,
On Designing and Deploying Internet-Scale Services, **2007**.

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Automatic Management of Partitioned, Replicated Search Services, **2011**.

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Thank you! Questions ?