Load-balancing and Scaling in Kubernetes

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Introduction

What is Kubernetes?

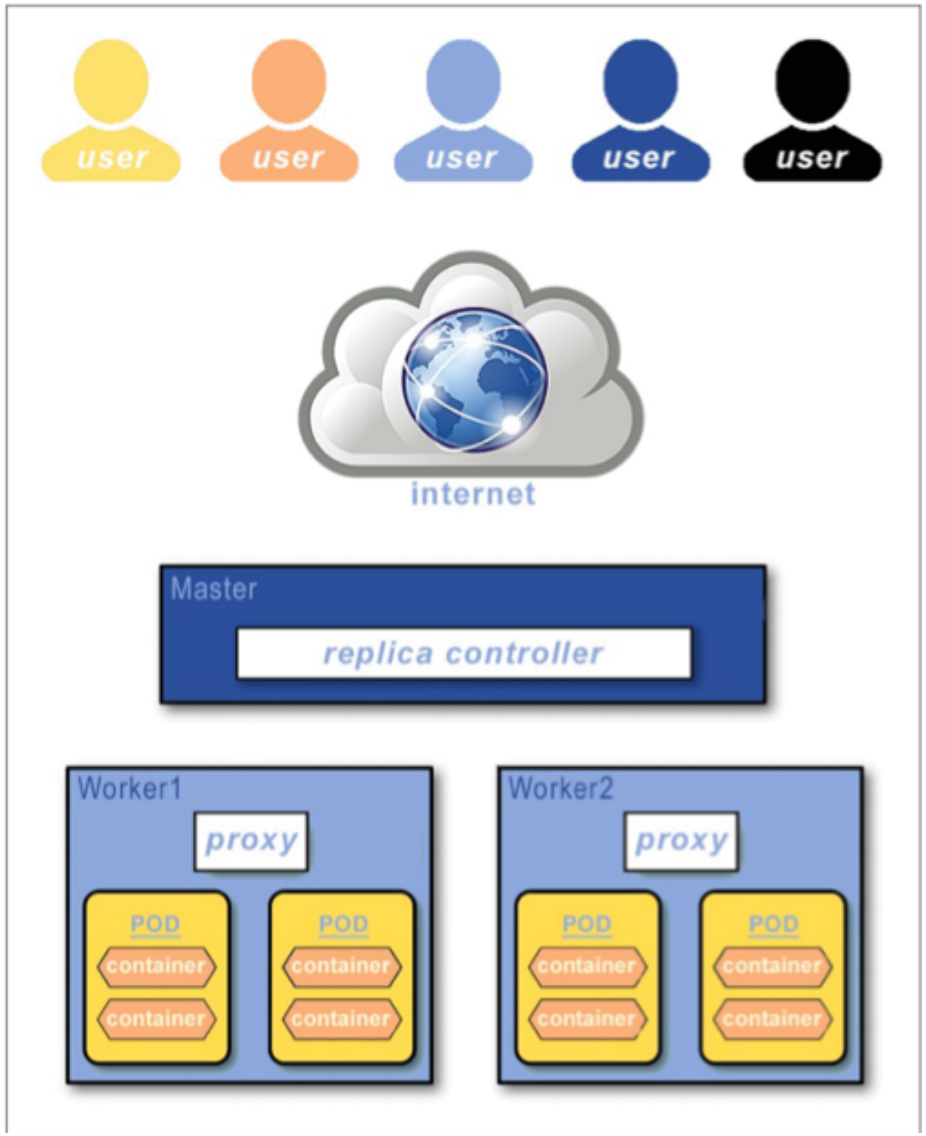
- Automation of deployment and management
- Created by Google in 2015
- Software companies use own version now
- Scaling and load balancing increase performance of application

Outline

- Background Concepts
  - Kubernetes Hierarchy
  - Load-balance vs Scaling
  - Central Processing Unit (CPU)
- Methods
  - Load-balancing
  - Scaling
- Conclusion

Client Server Architecture

- User
- Internet
- Nodes

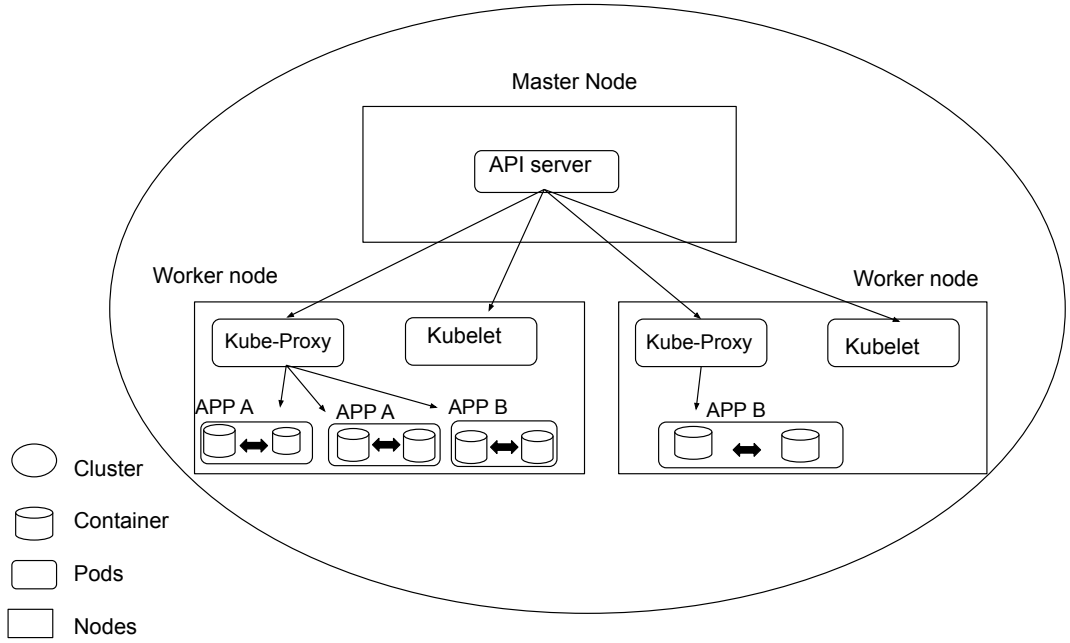


The Kubernetes Hierarchy: Containers

Containers:

- Run faster and more consistent between environments

Application runs inside of the containers

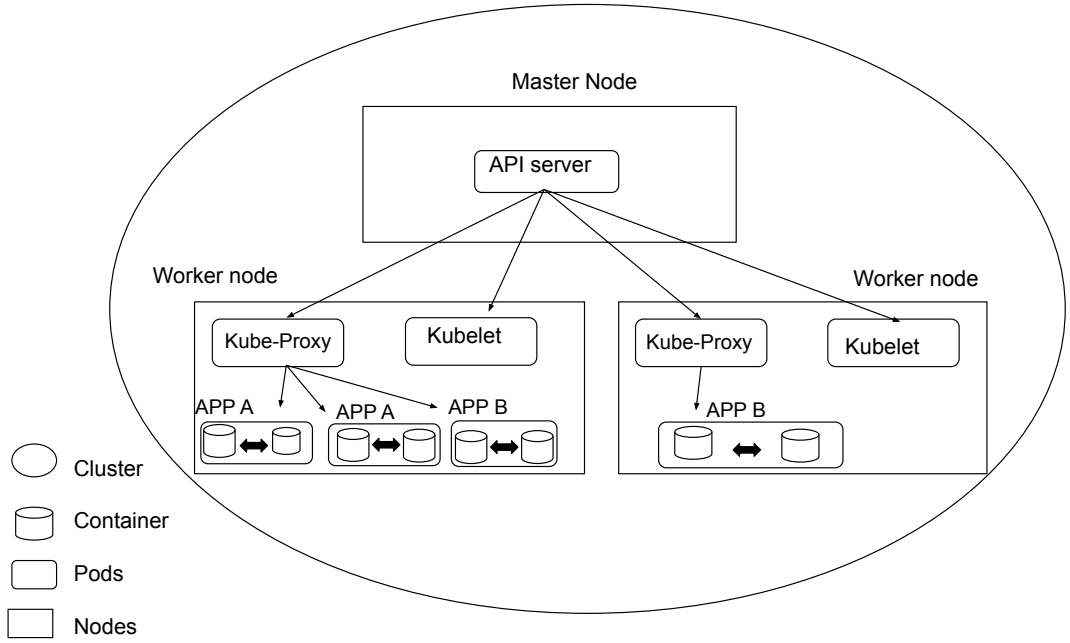


The Kubernetes Hierarchy: Pods

Containers run inside of pods

1 or more container per pod

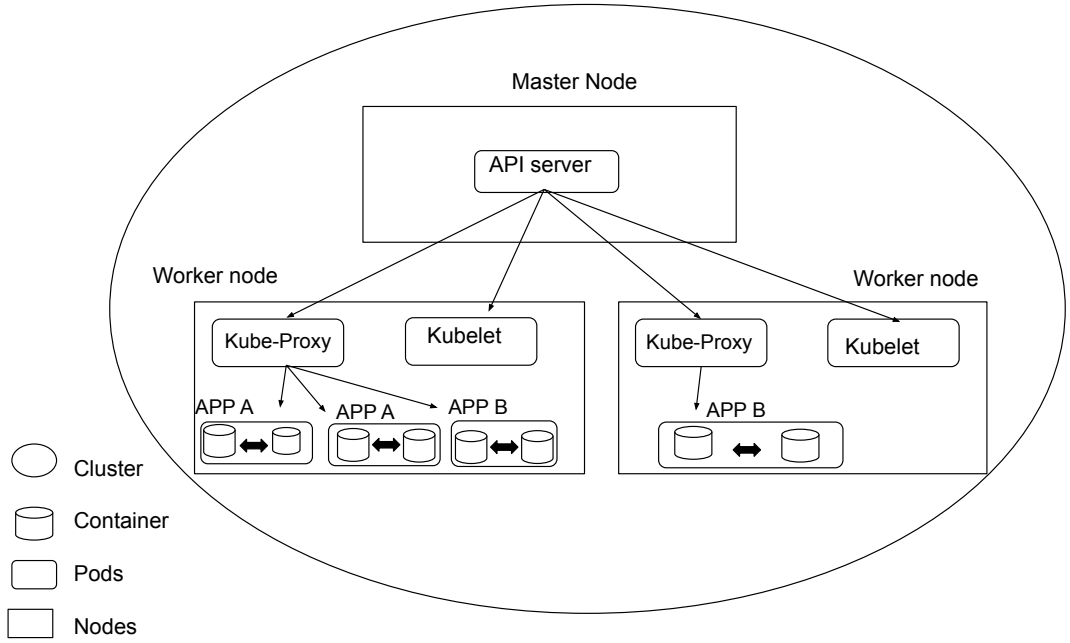
Pods: smallest unit of execution



The Kubernetes Hierarchy: Nodes

Two types of nodes in Kubernetes:

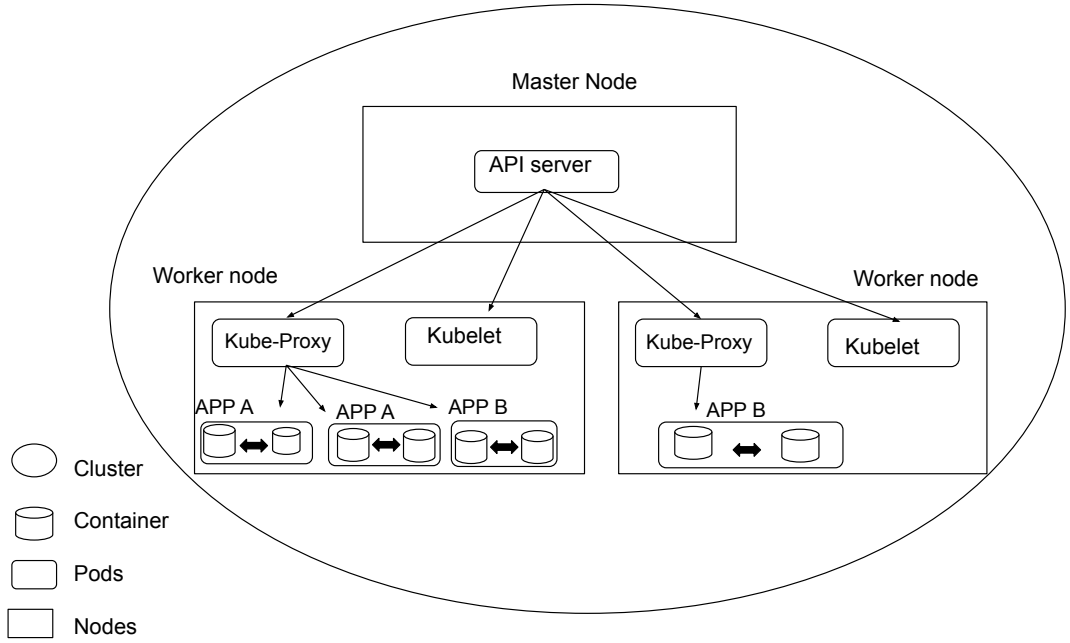
- Worker Node
- Master node



The Kubernetes Hierarchy: Cluster

A cluster is made up of:

- containers, pods, and nodes
- Unique cluster IP

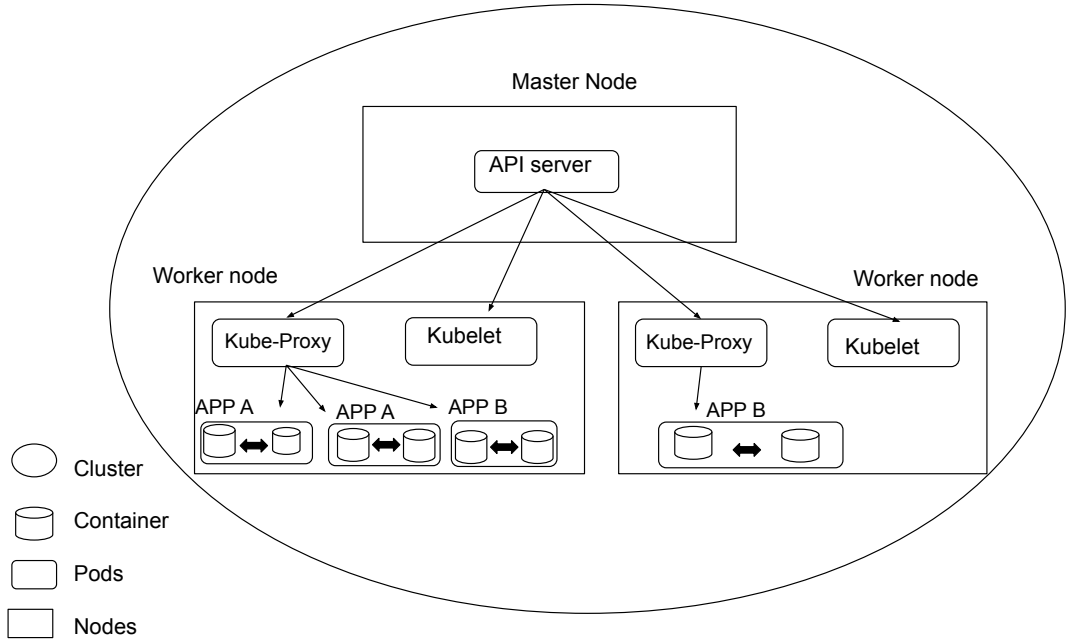


API server

Application Programming Interface (API)

Communicates with Kubelet and Kube-Proxy

Changing the number of nodes

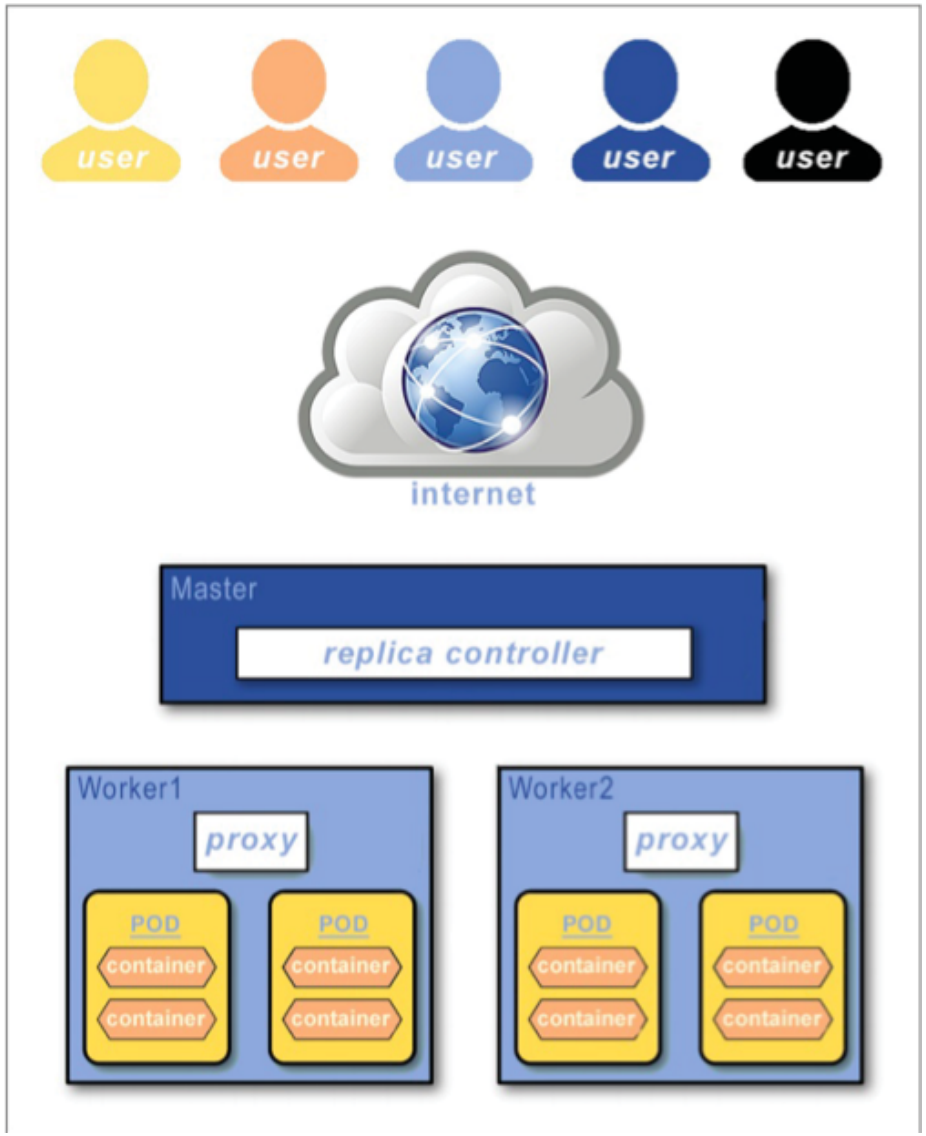


Scaling Background

Kubernetes provides Horizontal scaling

- Changing number of pods or nodes
- Distribute workload

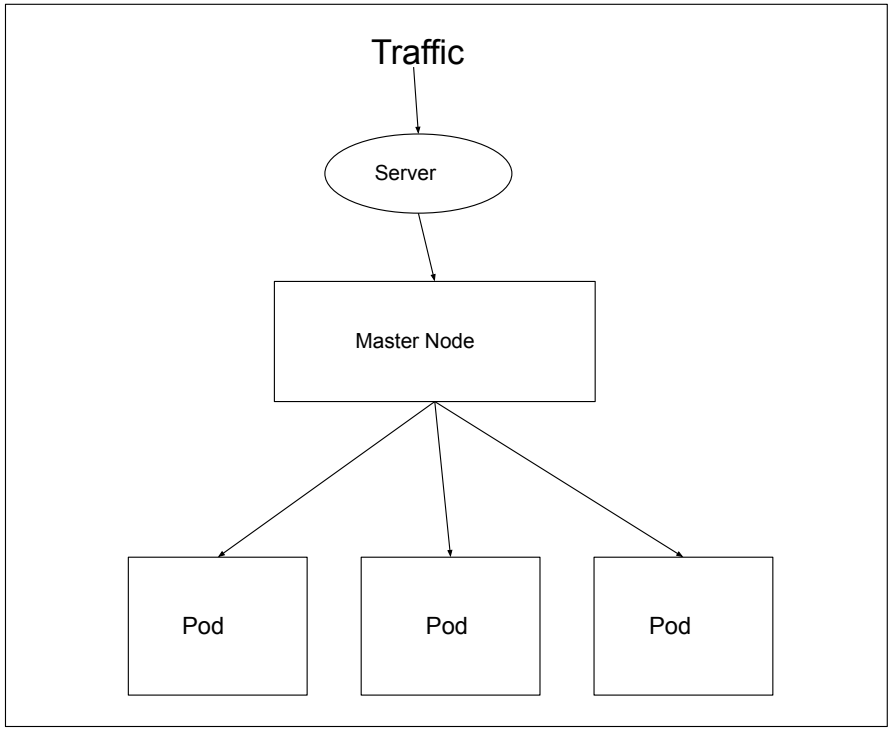
Ex. CPU usage of a pod hits 80 percent of capacity



Load-Balancing Background

Distributes traffic to replicated applications

Bottleneck?



Central Processing Unit (CPU)

CPUs are measured in cores

- Measures the compute processing in a machine
- Most cases CPU usage in Kubernetes is measured in millicores
- Millicore is one thousandth of a core
- Ex. 2000 millicores (or 2000m) is equal to 2 cores
- This is standard for every unit in Kubernetes

Server Scalability Using Kubernetes

L. P. Dewi, A. Noertjahyana, H. N. Palit and K. Yedutun, "Server Scalability Using Kubernetes,"

Study uses 3 services

- Get- get data
- Post- send data
- Delete- delete data

Evaluates CPU usage single vs. multiple server (Using scalability)

3 Kubernetes nodes with multiple servers

- 1 master node
- 2 worker nodes

Kubernetes Horizontal Pod Autoscaling

What is KHPA?

- Increase or decrease based on the number of concurrent users.
- KHPA takes the target input as a percentage of CPU usage
- The output is the pods target number

CPU Usage

Simulated behavior using a combination of services

1,650 requests in each task

Task	CPU Usage Pod (in millicores) on Single Server	CPU Usage Pod (in millicores) on Multiple Server
1	576.00	209.00
2	526.00	369.00
3	498.00	333.00
Average	**533.33**	**303.66**

CPU Usage

Users send 8000 requests of each service

Evaluates CPU usage (millicores) of single vs. multiple servers

Average	GET-1	625.33	236.66
	GET-2	595.33	233.66
	POST	567.66	264.00

Averages of previous scenario:

Average	533.33	303.66

Scaling Results

Single Server

- In both scenarios the CPU usage was much higher
- When the number of requests went up the CPU usage increased

Multiple Servers (Scaling)

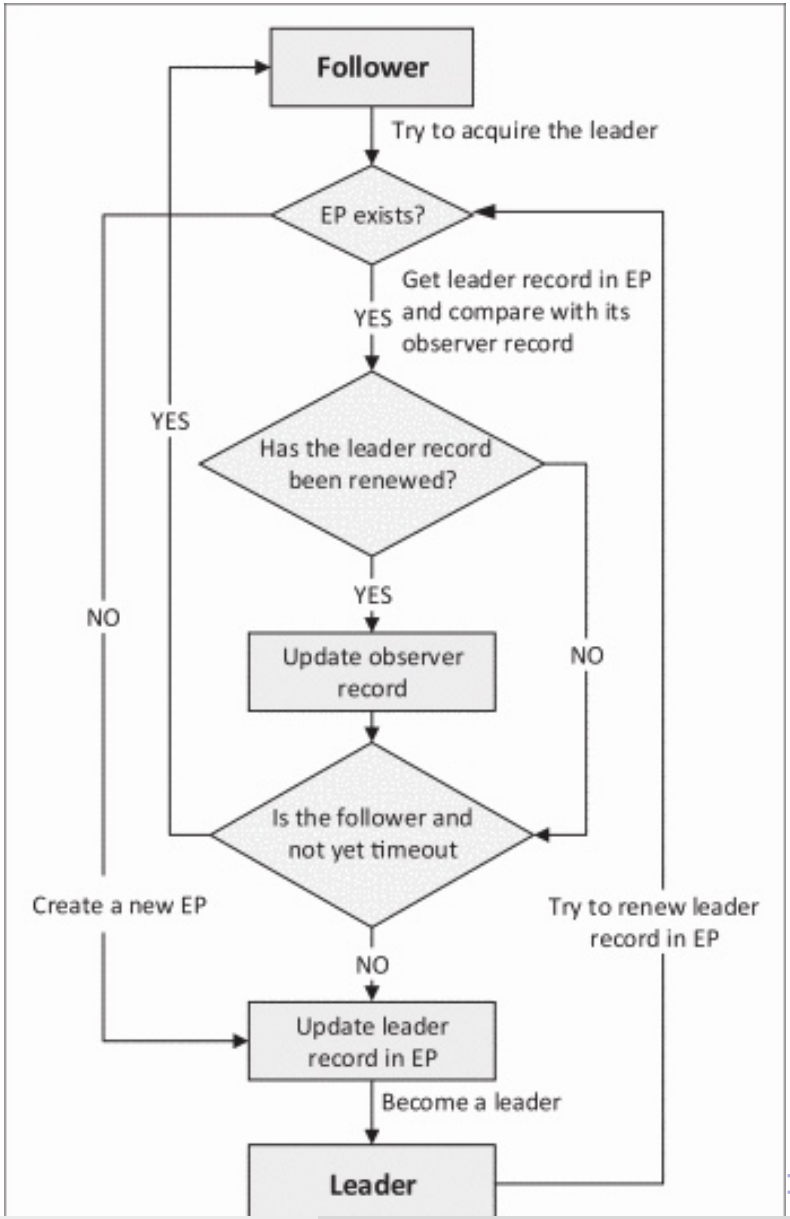
- Servers distribute workload
- CPU usage is smaller when there are more requests

Raft Algorithm

Leader selection algorithm for Kubernetes

Used to select pod leaders in a node

- Majority of traffic goes to leaders
- Candidates try to become the leader
- Followers are replica applications that don't get the majority of traffic



Toward Highly Scalable Load-Balancing in Kubernetes Cluster

N. Nguyen and T. Kim, "Toward Highly Scalable Load Balancing in Kubernetes Clusters," in IEEE Communications Magazine, vol. 58, no. 7, pp. 78-83, July 2020, doi: 10.1109/MCOM.001.1900660.

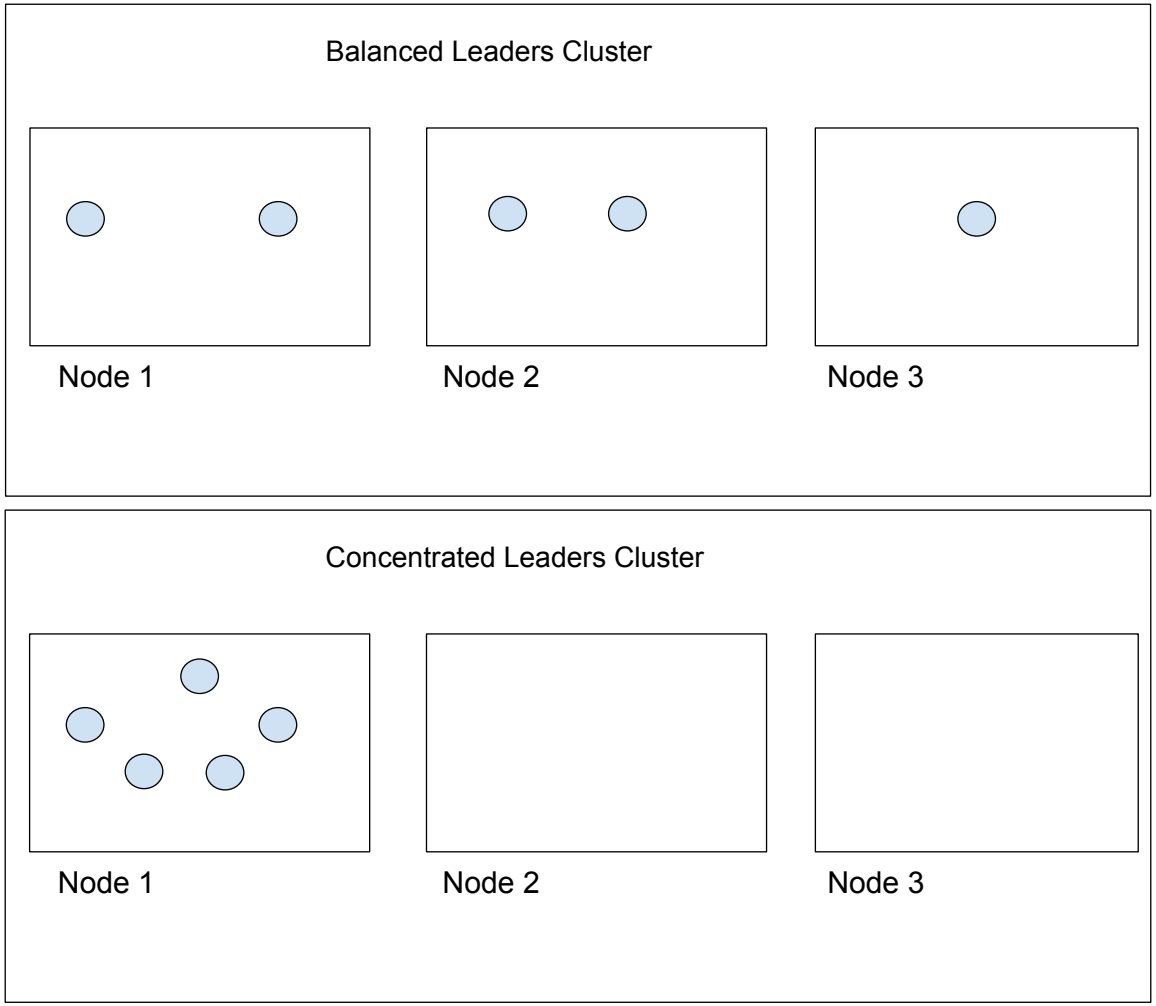
Concentrated vs. Balanced Leaders

- 5 leaders distributed to 3 nodes
- Balanced leaders uses the leader election
- Majority of traffic is sent to the leaders

Leaders

Concentrated vs. Balanced Leaders

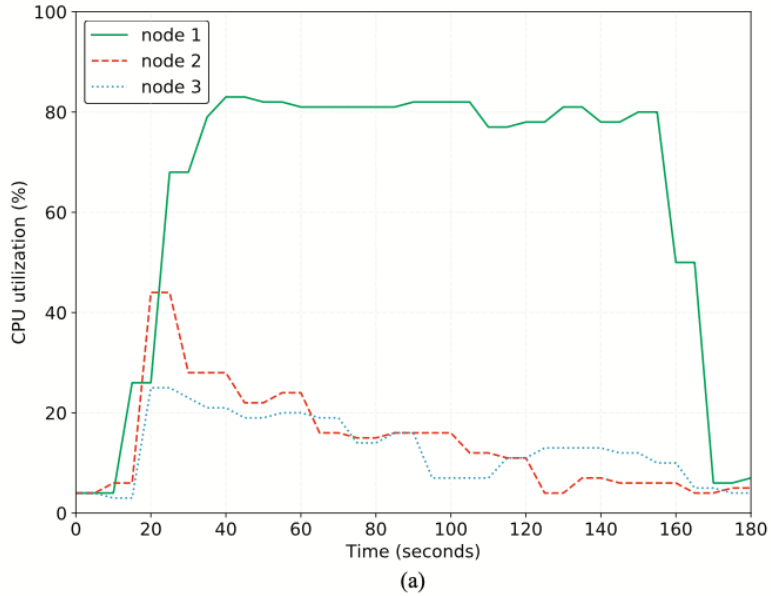
- Concentrated: 5 leaders in node 1
- Balanced: 5 leaders distributed throughout 3 nodes



CPU Utilization

4 clients send requests for 150s

The requests are handled by the leader pods



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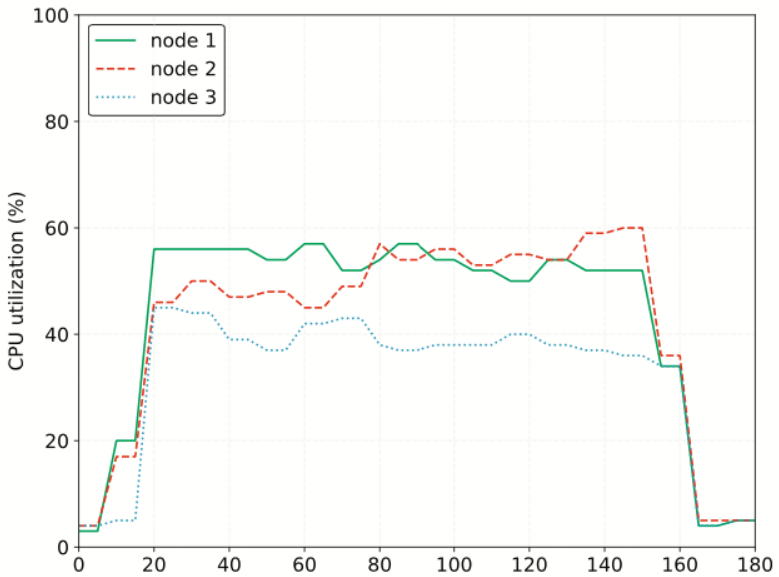
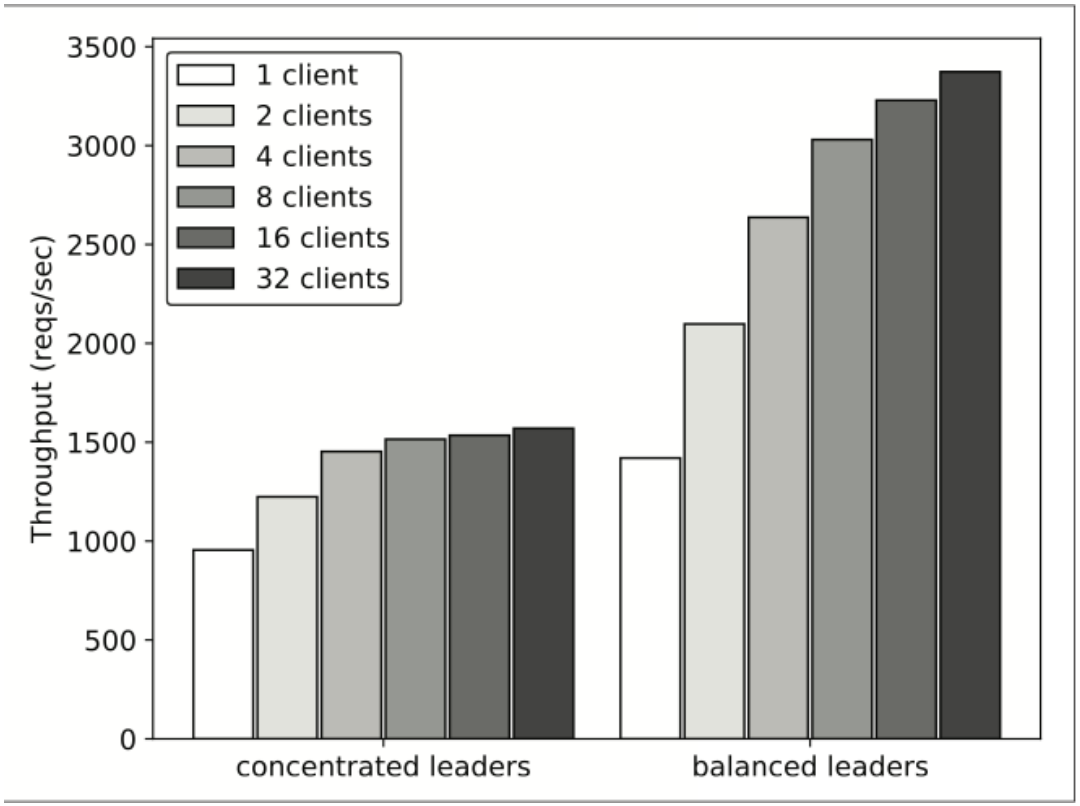


Throughput

Clients increasing from 1 to 32

Clients send 2000 requests each

Throughput- Number of request per second the cluster can recieve



Load-Balancing Results

Concentrated leaders

- CPU utilization 60 percent higher in node 1 versus the other two nodes
- Once 4 clients send requests throughput is constant

Balanced leaders

- More balanced CPU utilization
- More requests per second

Conclusion

- Scaling and load-balancing increase performance
- Scaling focused on distributing to different nodes
- Load-balancing focused on distributing network traffic

Acknowledgements

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Questions

Questions?

L. P. Dewi, A. Noertjahyana, H. N. Palit and K. Yedutun, "Server Scalability Using Kubernetes," 2019 4th Technology Innovation Management and Engineering Science International Conference (TIMES-iCON), 2019, pp. 1-4, doi: 10.1109/TIMES-iCON47539.2019.9024501.

N. Nguyen and T. Kim, "Toward Highly Scalable Load Balancing in Kubernetes Clusters," in IEEE Communications Magazine, vol. 58, no. 7, pp. 78-83, July 2020, doi: 10.1109/MCOM.001.1900660.