Scalable Persistent Storage for Erlang: Theory and Practice

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Outline

- What does this research aim to do as a part of the RELEASE Project?
- General principles of scalable DBMSs
- NoSQL DBMSs for Erlang
- Measuring the Reliability of Riak
- Scalability of Riak in Practice
- Investigating the scalability of distributed Erlang
- Conclusion & Future work

RELEASE project

- RELEASE is an European project aiming to scale Erlang onto commodity architectures with 100000 cores.

Scaling Erlang

Scaling Erlang in three levels:

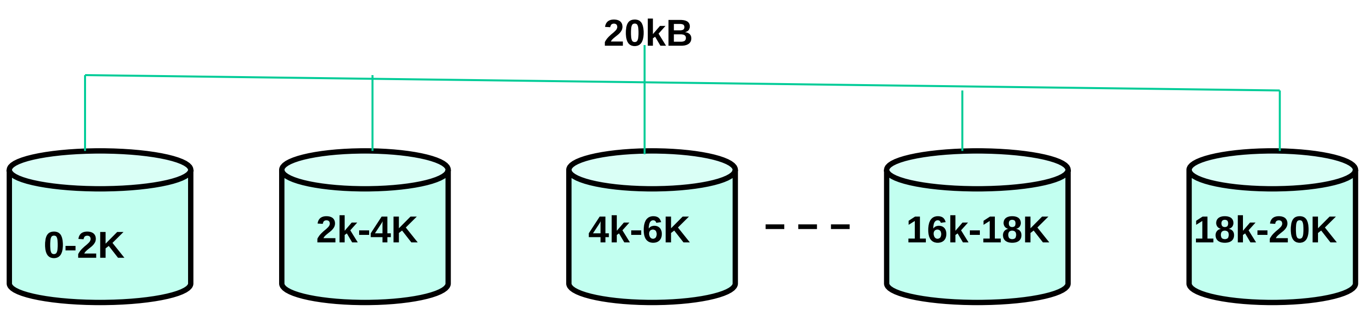
- Distributed Erlang (SD Erlang)
- In-memory Data Structure (ETS table)
- Scalable Persistent Storage for Erlang

General principles of scalable DBMSs

Data Fragmentation

1. Decentralized model (e.g. P2P model)
2. Systematic load balancing (make life easier for developer)
3. Location transparency

e.g. 20k data is fragmented among 10 nodes



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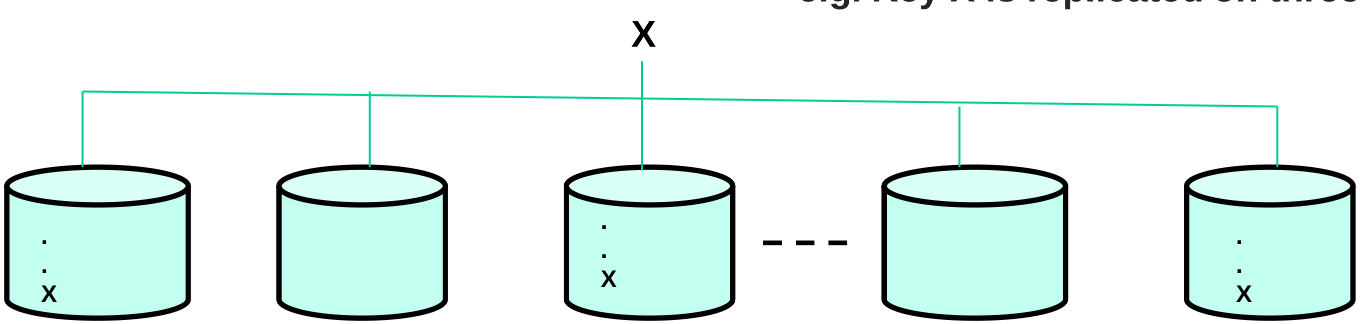
General principles of scalable DBMSs

Replication

1. Decentralized model (e.g. P2P model)
2. Location transparency
3. Asynchronous replication (write is considered complete as soon as on node acknowledges it)

e.g. Key X is replicated on three nodes



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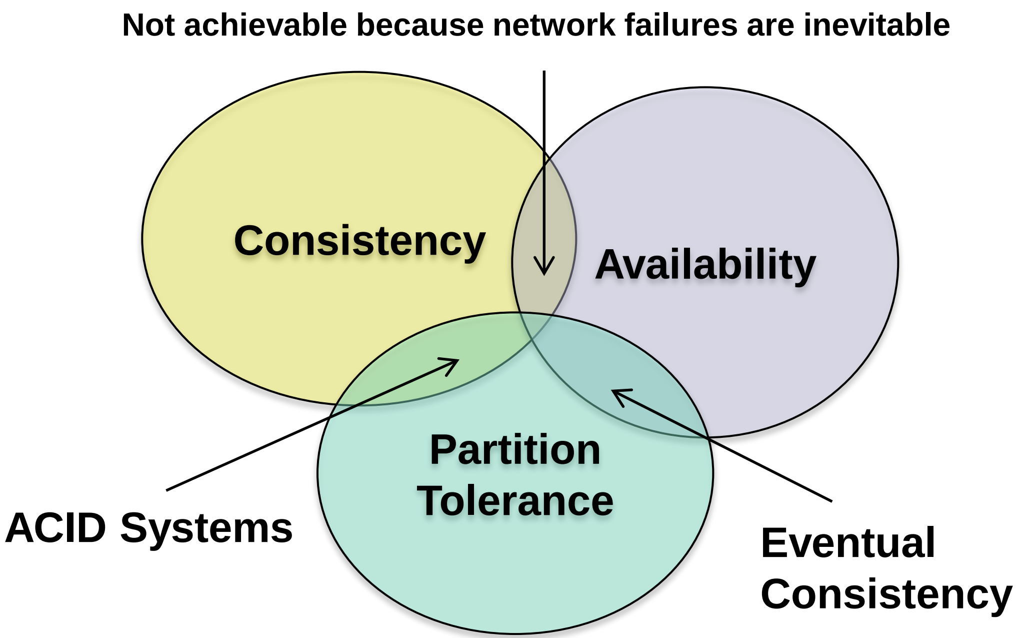
General principles of scalable DBMSs



CAP theorem: cannot simultaneously guarantee:

•**Partition tolerance**: system continues to operate despite nodes can't talk to each other

•**Availability**: guarantee that every request receives a response

•**Consistency**: all nodes see the same data at the same time

Solution: Eventual consistency and reconciling conflicts via data versioning

ACID=Atomicity, Consistency, Isolation, Durability

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NoSQL DBMSs for Erlang

	Mnesia	CouchDB	Riak	Cassandra
Fragmentation	•Explicit placement •Client-server •Automatic by using a hash function	•Explicit placement •Multi-server •Lounge is not part of each CouchDB node	•Implicit placement •Peer to peer •Automatic by using consistent hash technique	•Implicit placement •Peer to peer •Automatic by using consistent hash technique
Replication	•Explicit placement •Client-server ? •Asynchronous (Dirty operation)	•Explicit placement •Multi-server •Asynchronous	•Implicit placement •Peer to peer •Asynchronous	•Implicit placement •Peer to peer •Asynchronous
Partition tolerance	•Strong consistency	•Eventual consistency •Multi-Version Concurrency Control for reconciliation	•Eventual consistency •Vector clocks for reconciliation	•Eventual consistency •Use timestamp to reconcile
Storage limitation	•The largest possible Mnesia table is 4Gb	•No limitation	•Bitcask has memory limitation •LevelDB has no limitation	•No limitation

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Initial Evaluation Results

General Principles

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Initial Evaluation

- Mnesia
- CouchDB
- Riak
- Cassendra

Scalable persistent storage for SD Erlang can be provided by Riak (or Cassandra)

Availability and Scalability of Riak in Practice

- Basho Bench, a benchmarking tool for Riak
- We use Basho Bench on 348-node Kalkyl cluster
- How does Riak cope with node failure? (Availability)
- How adding more Riak nodes affect the throughput? (Scalability)
- There are two kinds of nodes in a cluster:
  - *Traffic generators*
  - *Riak nodes*

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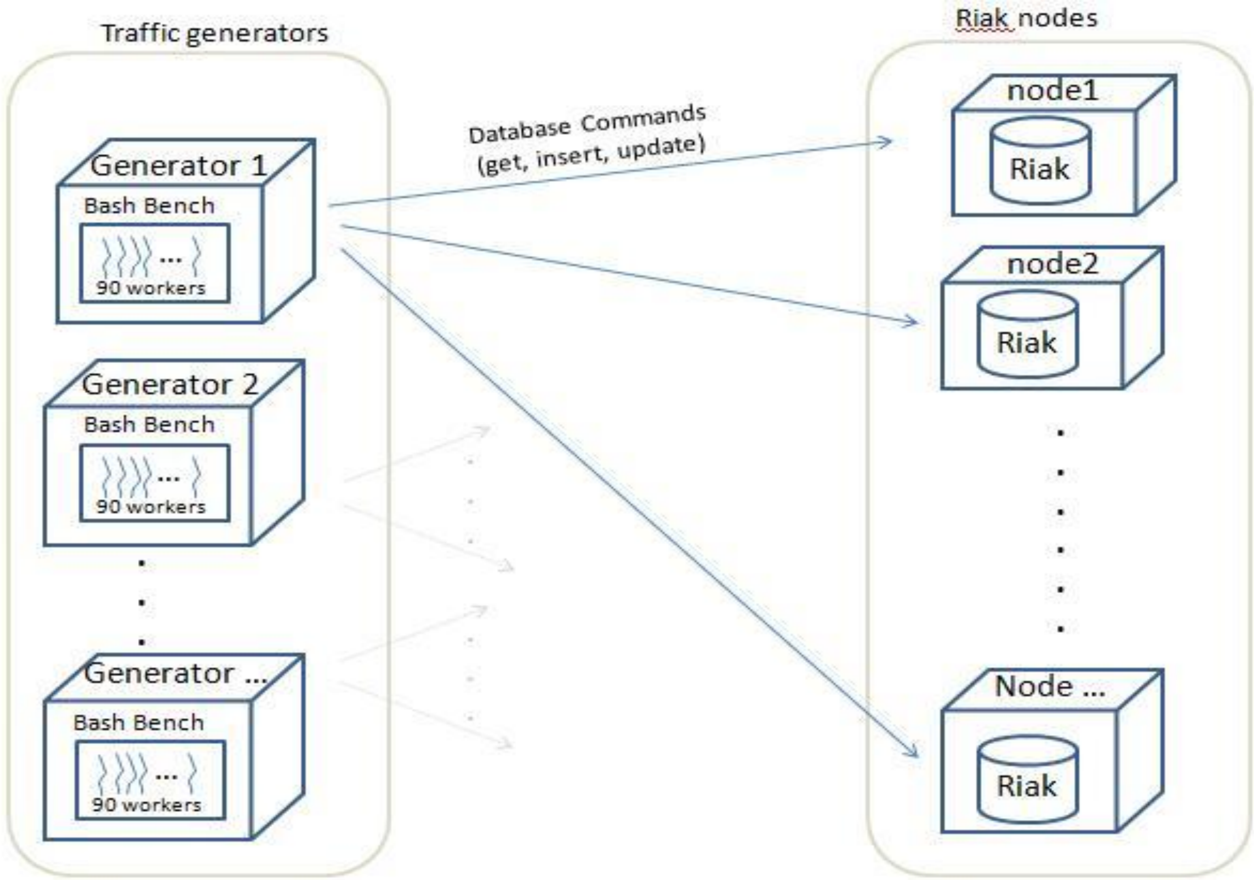
Node Organisation



We use one traffic generator per 3 Riak nodes

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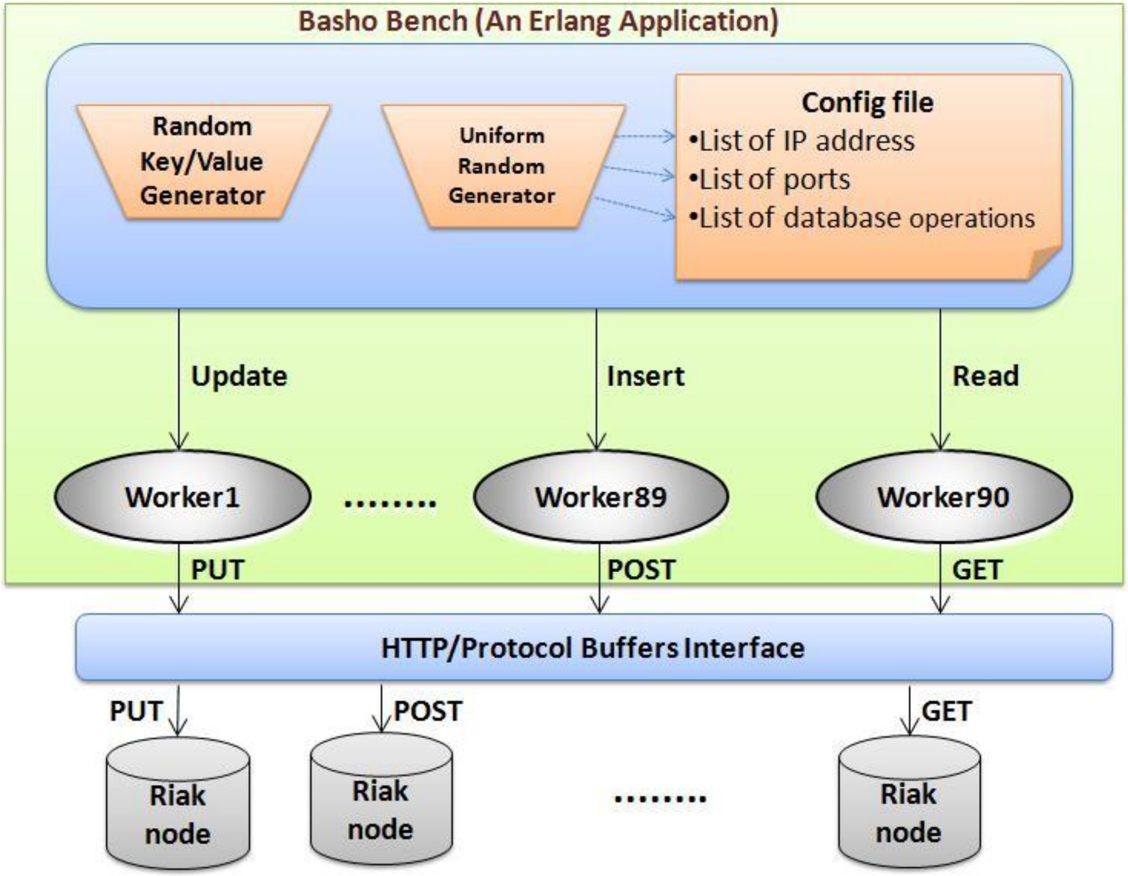
Traffic Generator



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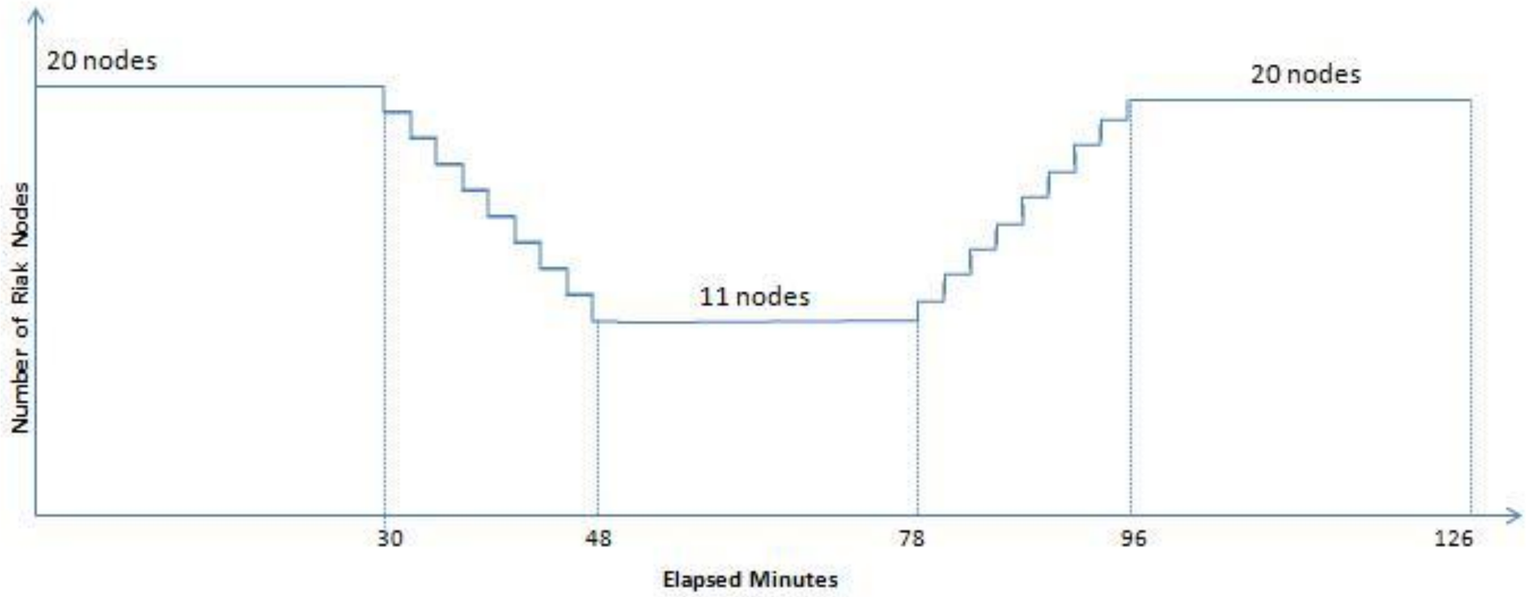
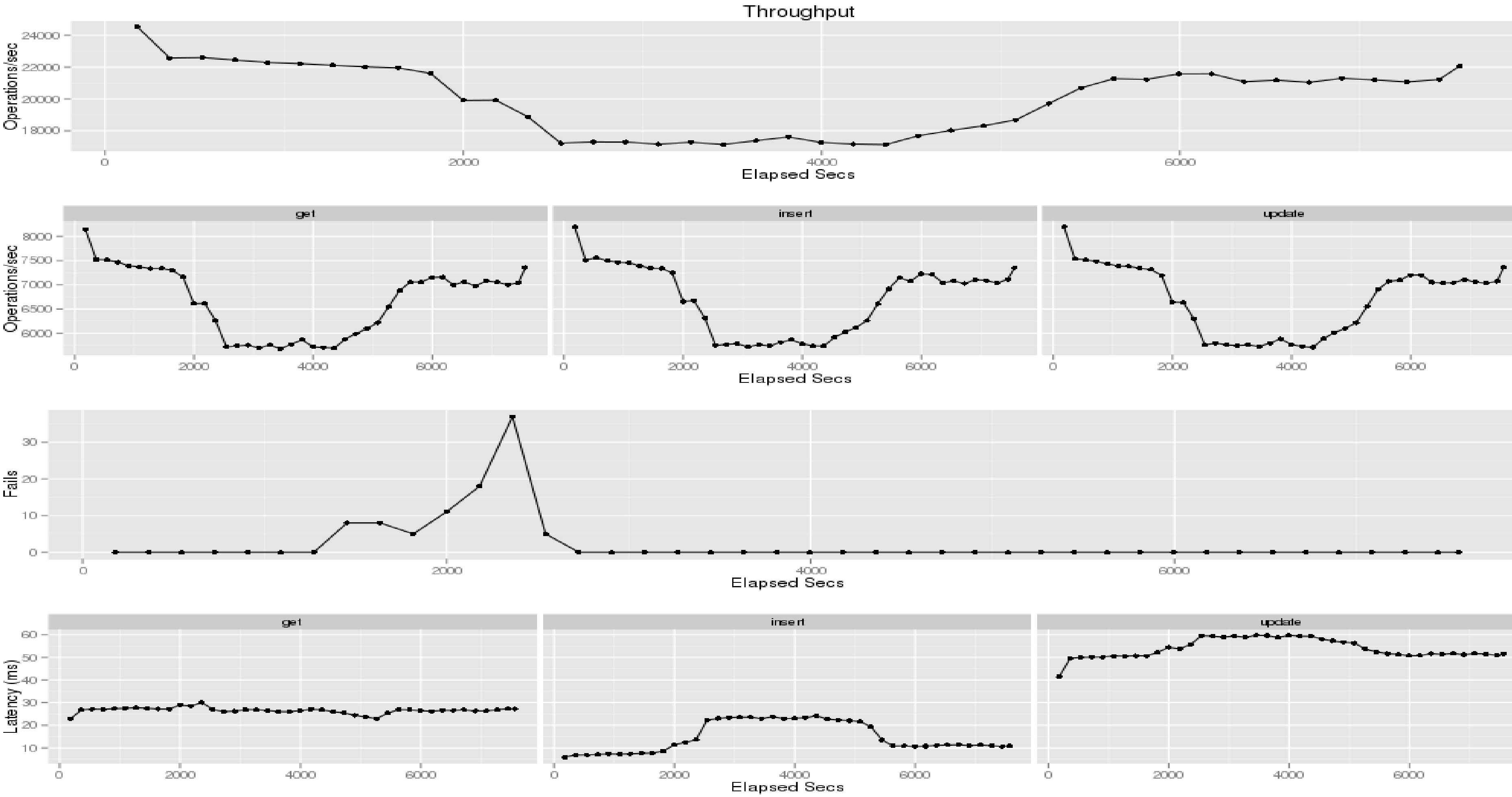
Riak Availability



Time-line shows Riak cluster losing nodes

Riak Availability



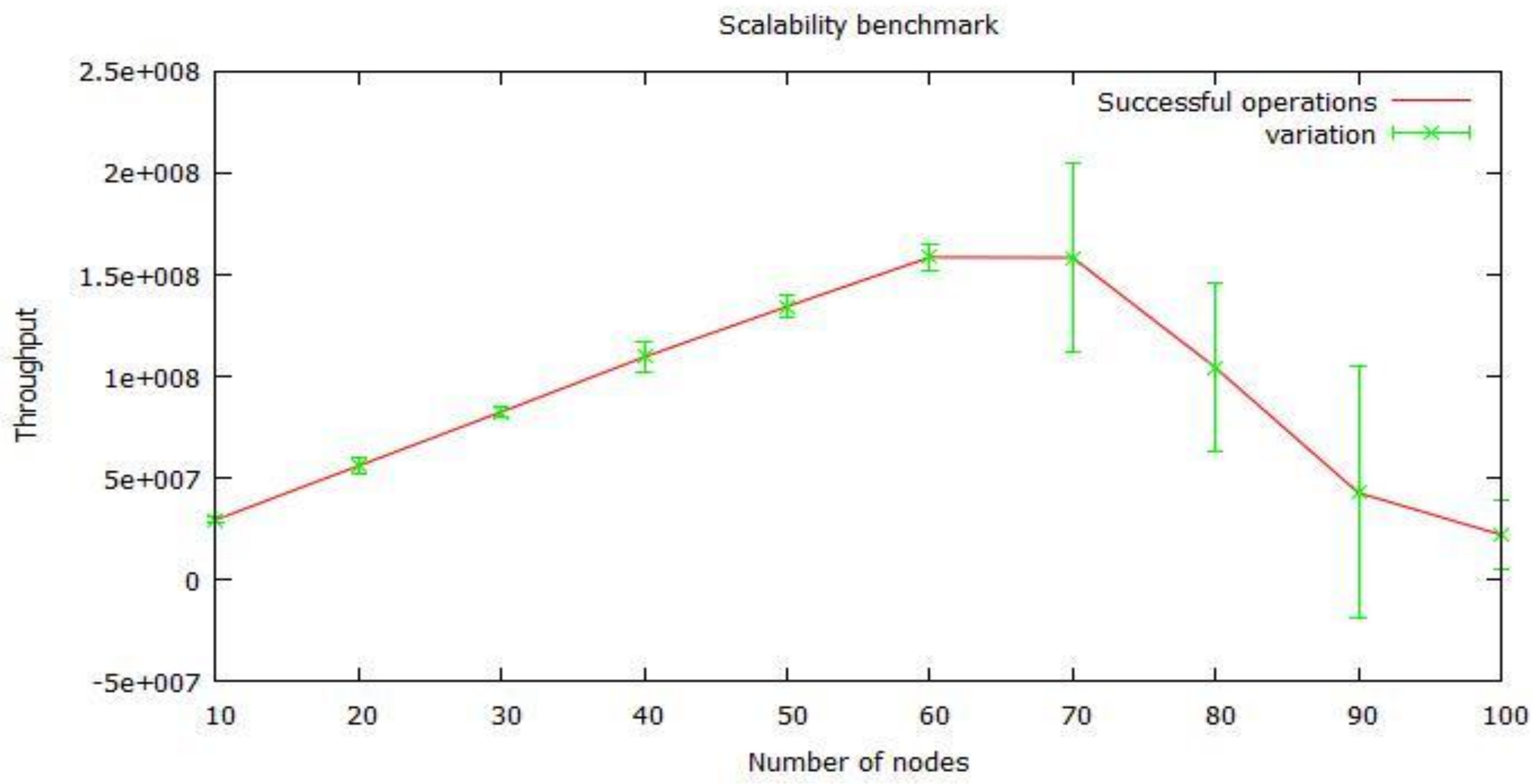
How Riak deals with failures

Observation

- Number of failures (37)
- Number of successful operations (approximately 3.41 million)

- When failed nodes come back up, the throughput has grown which means Riak has a good **elasticity**.

Riak Scalability



Benchmark on 348-node Kalkyl cluster at Uppsala University

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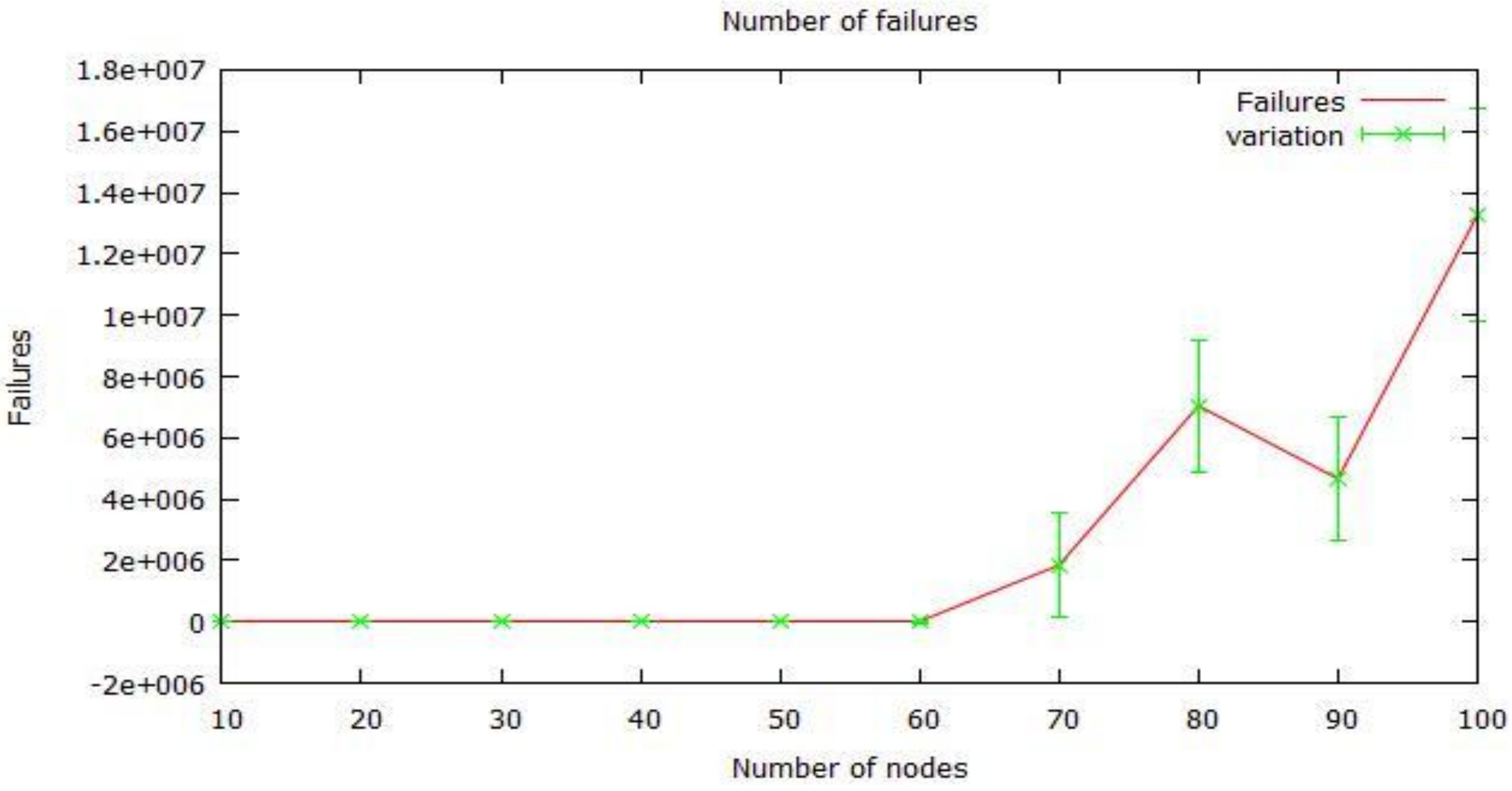
Failure



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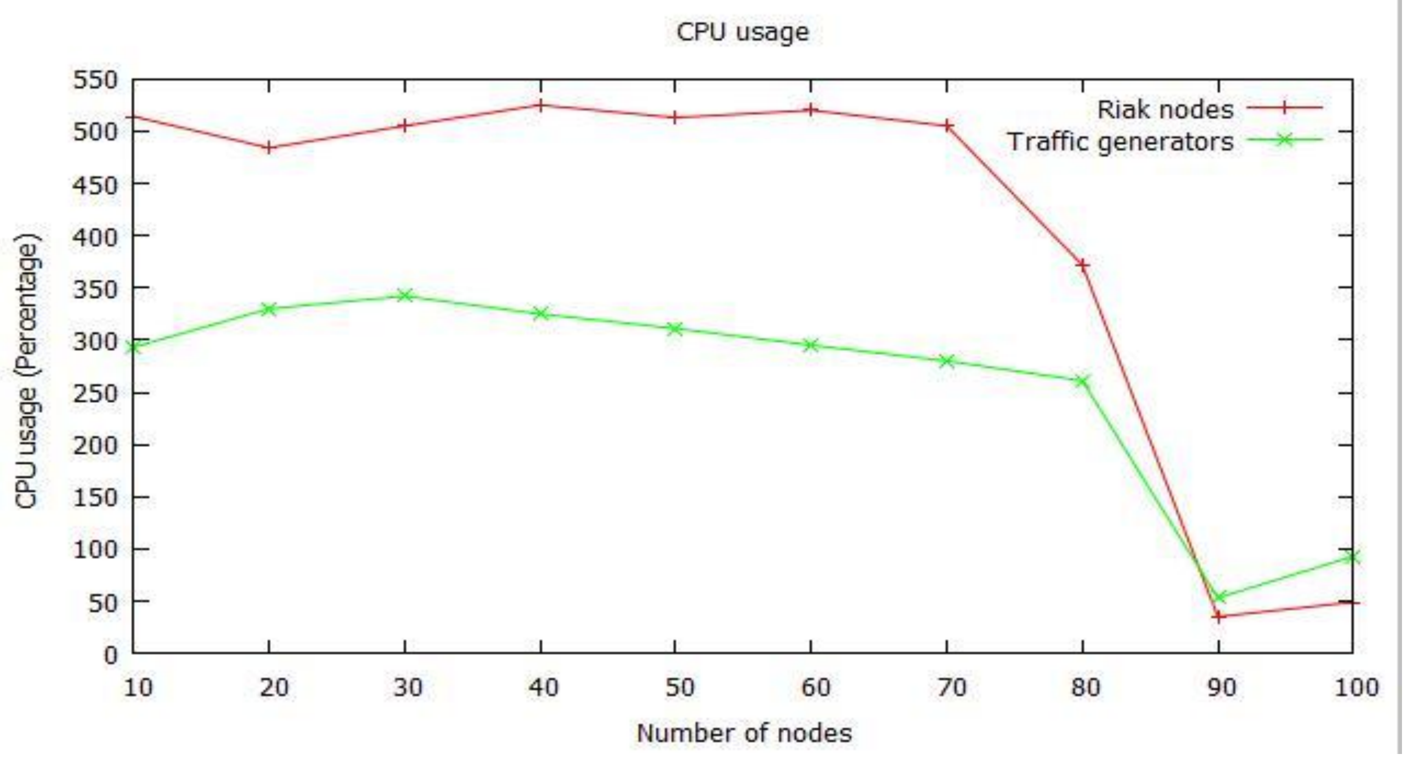
What is the Bottleneck?



CPU Usage

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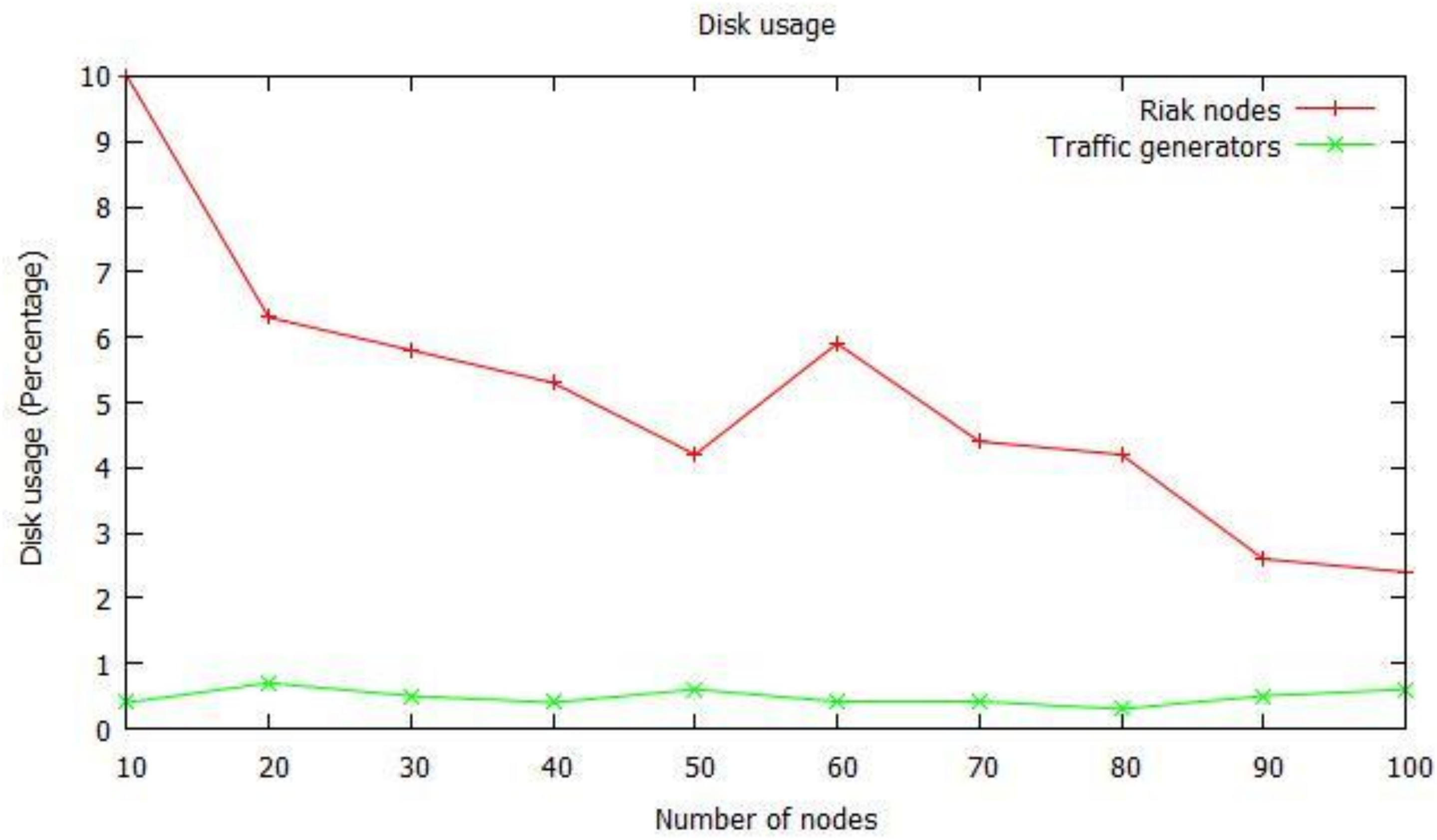
Profiling DISK



DISK Usage

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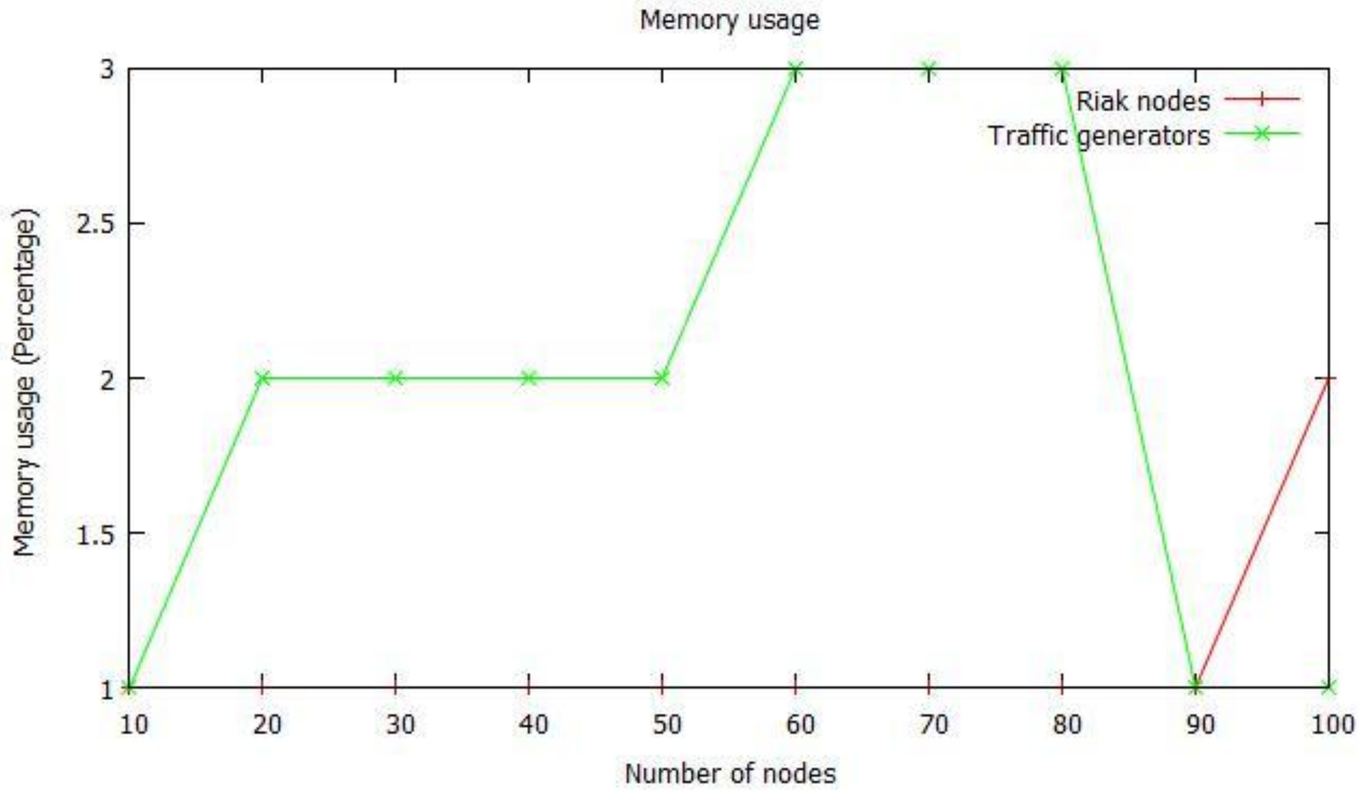
Profiling RAM



Memory Usage

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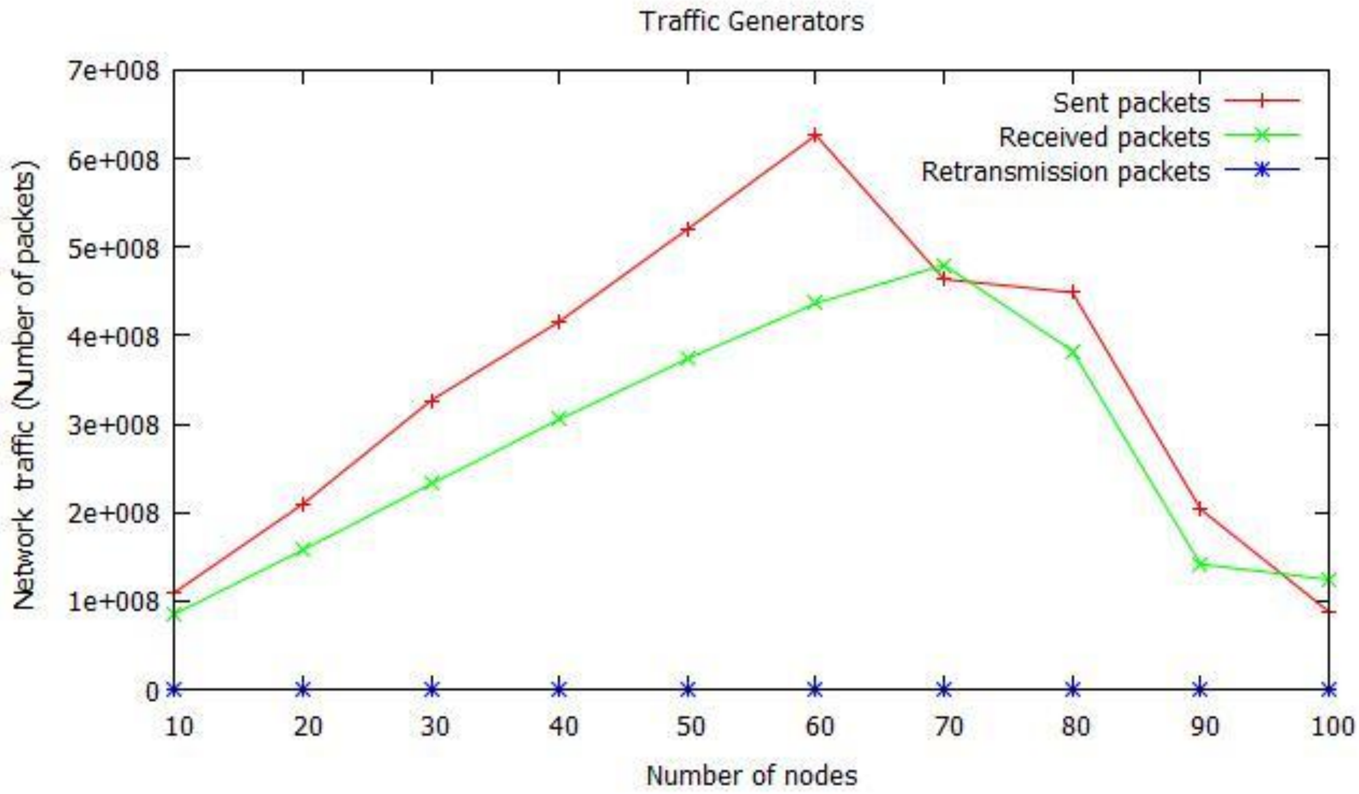
Profiling-Network (Generator)



Network Traffic of Generator Nodes

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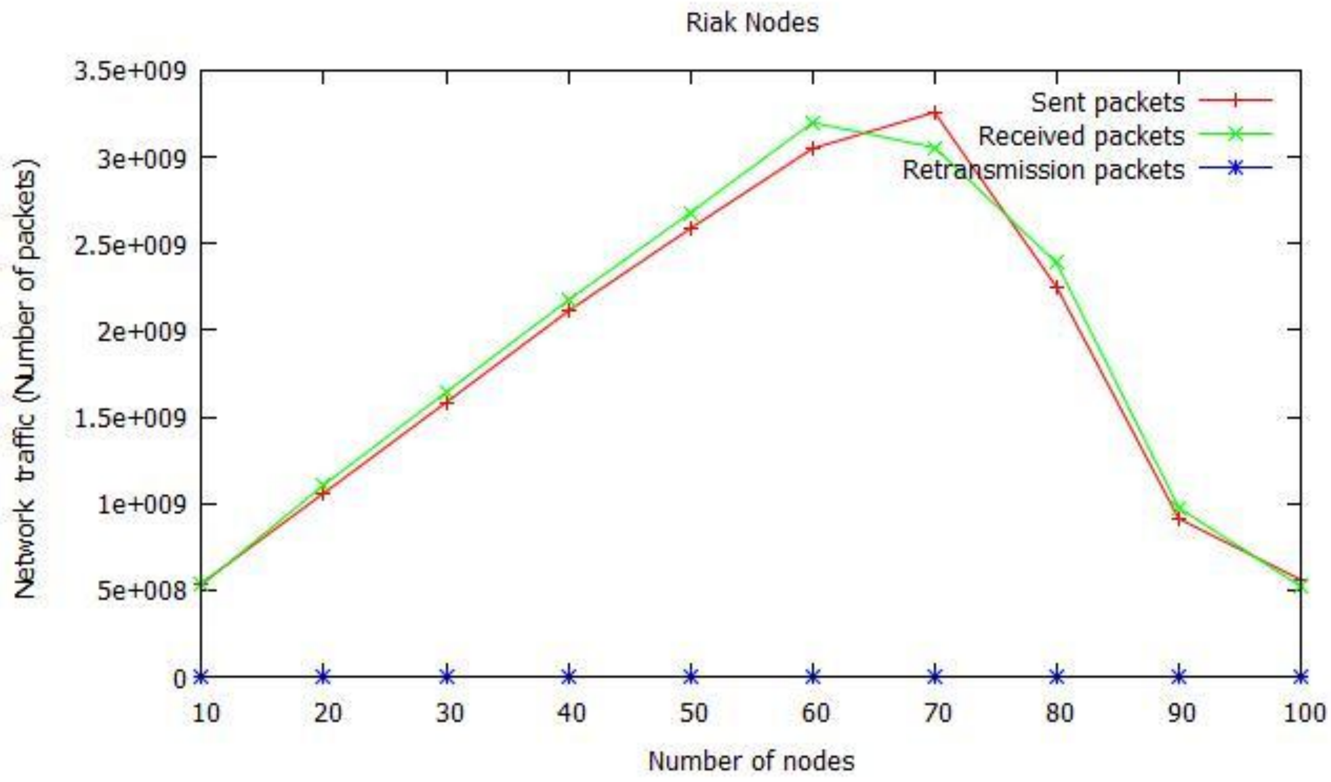
Profiling-Network (Riak)



Network Traffic of Riak Nodes

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Bottleneck for Riak Scalability

The results of profiling *CPU*, *RAM*, *Disk*, and *Network* reveal that they can't be bottleneck for Riak scalability.

Is Riak scalability limits due to limits in distributed Erlang? To find it, we need to measure the scalability of distributed Erlang.

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DEbench

- We design Debench for measuring the scalability of distributed Erlang
- Based on Basho Bench
- Measures the Throughput and Latency of Distributed Erlang commands

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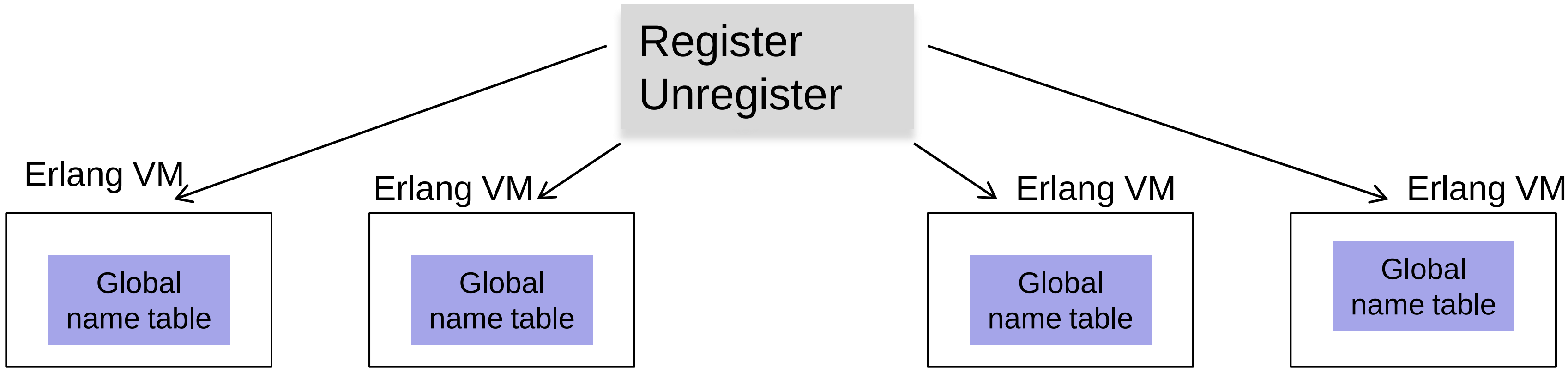
Distributed Erlang Commands

- ***Spawn:*** a peer to peer command
- ***register_name*** : global name tables located on every node
- ***unregister_name*** : global name tables located on every node
- ***whereis_name*** : a lookup in the local table



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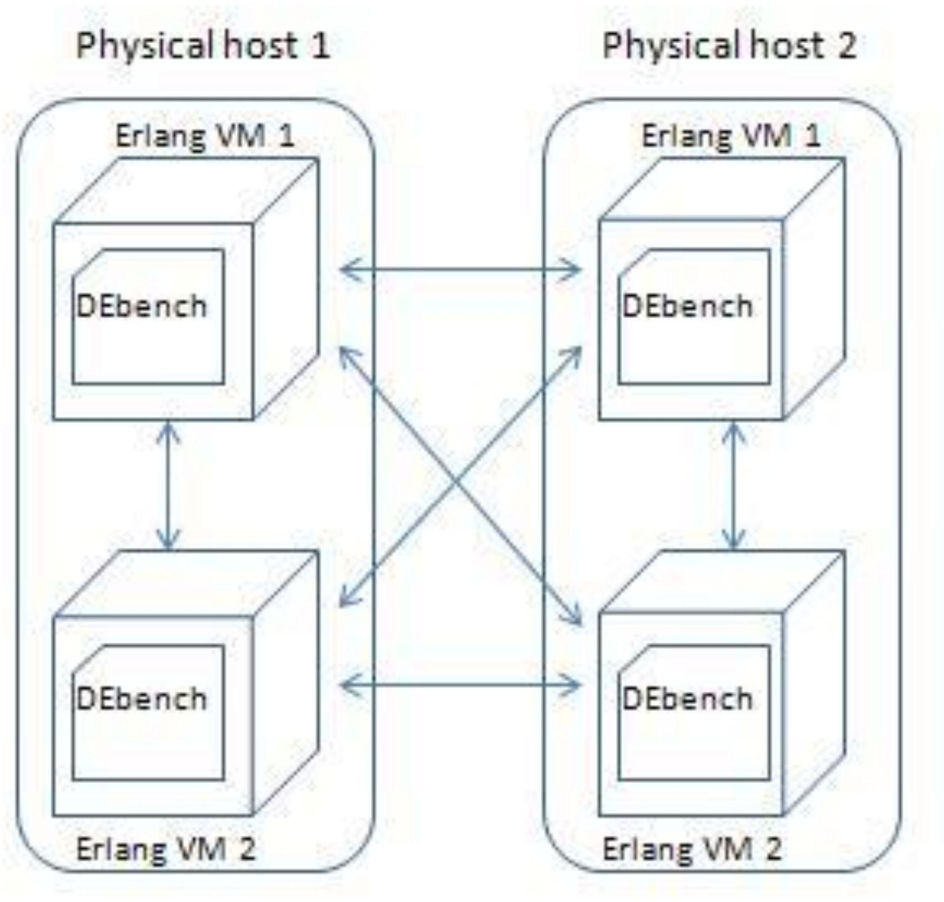
DEbench P2P Nodes



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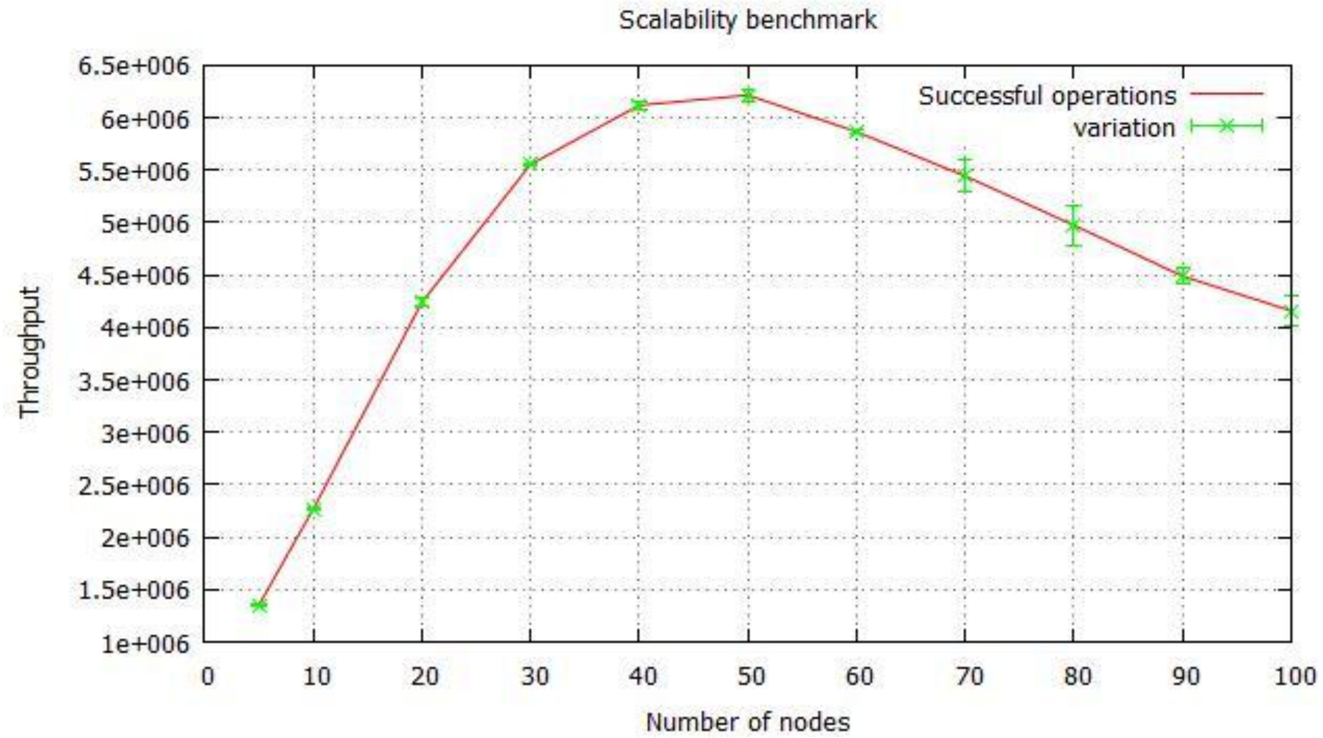
Scalability of Distributed Erlang

0.5% Global operation



- **Throughput peaks at 50 nodes**
- **Little improvement beyond 40 nodes**

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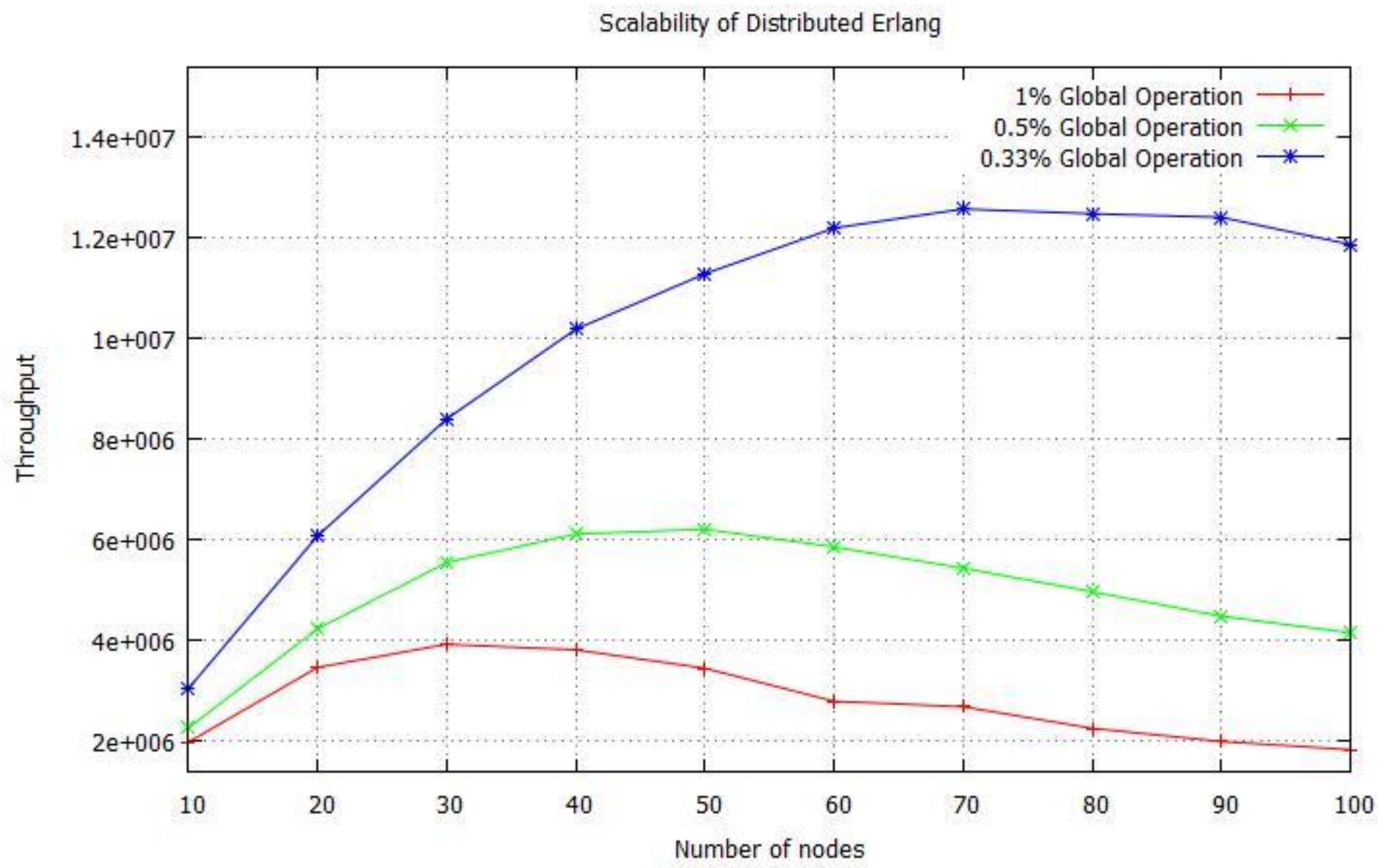
Frequency of Global Operation



Frequently	Max Throughput
1%	30 nodes
0.5%	50 nodes
0.33%	70 nodes

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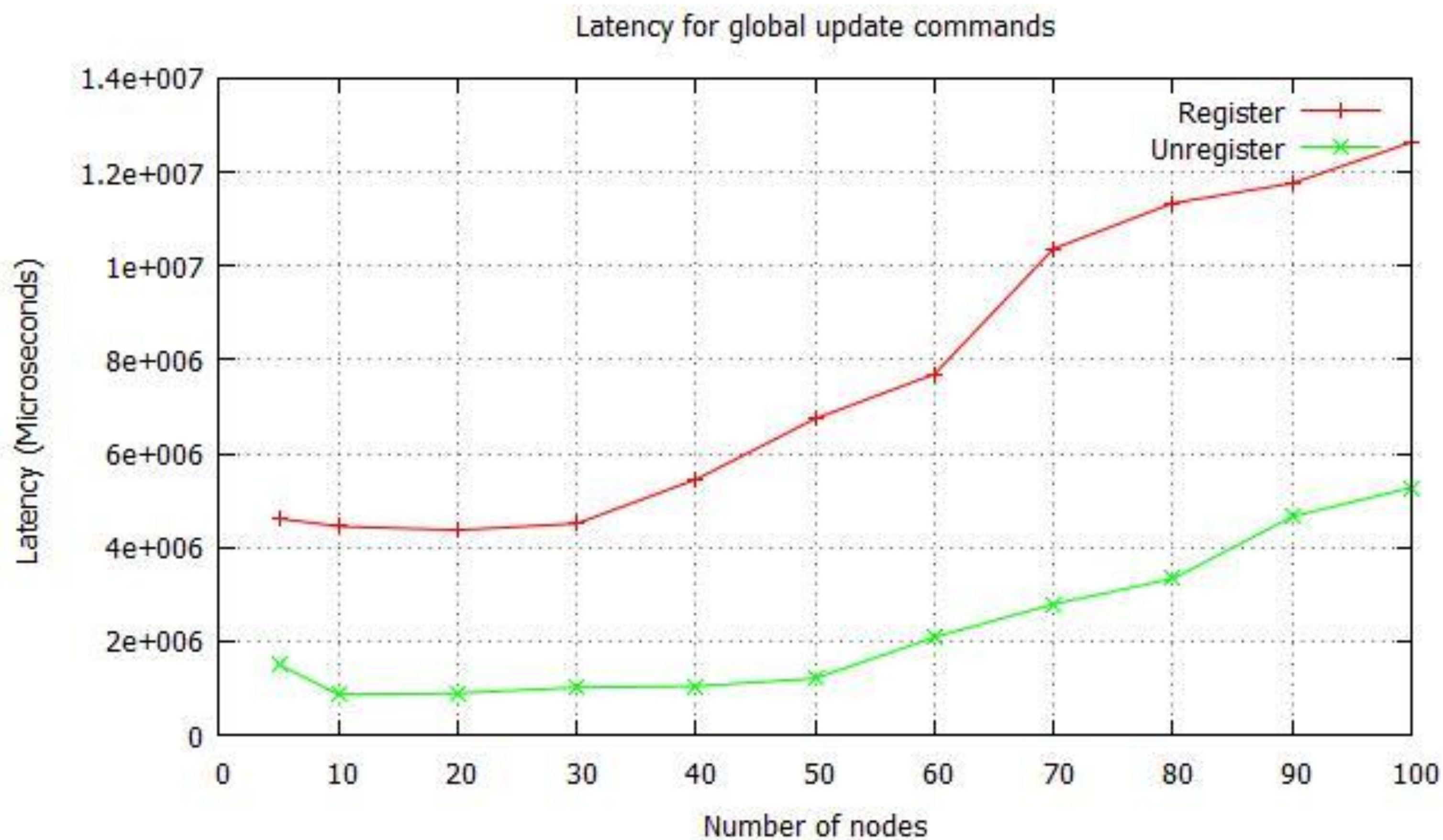
What is the Bottleneck?



Latency for *register* and *unregister for 2% global update*

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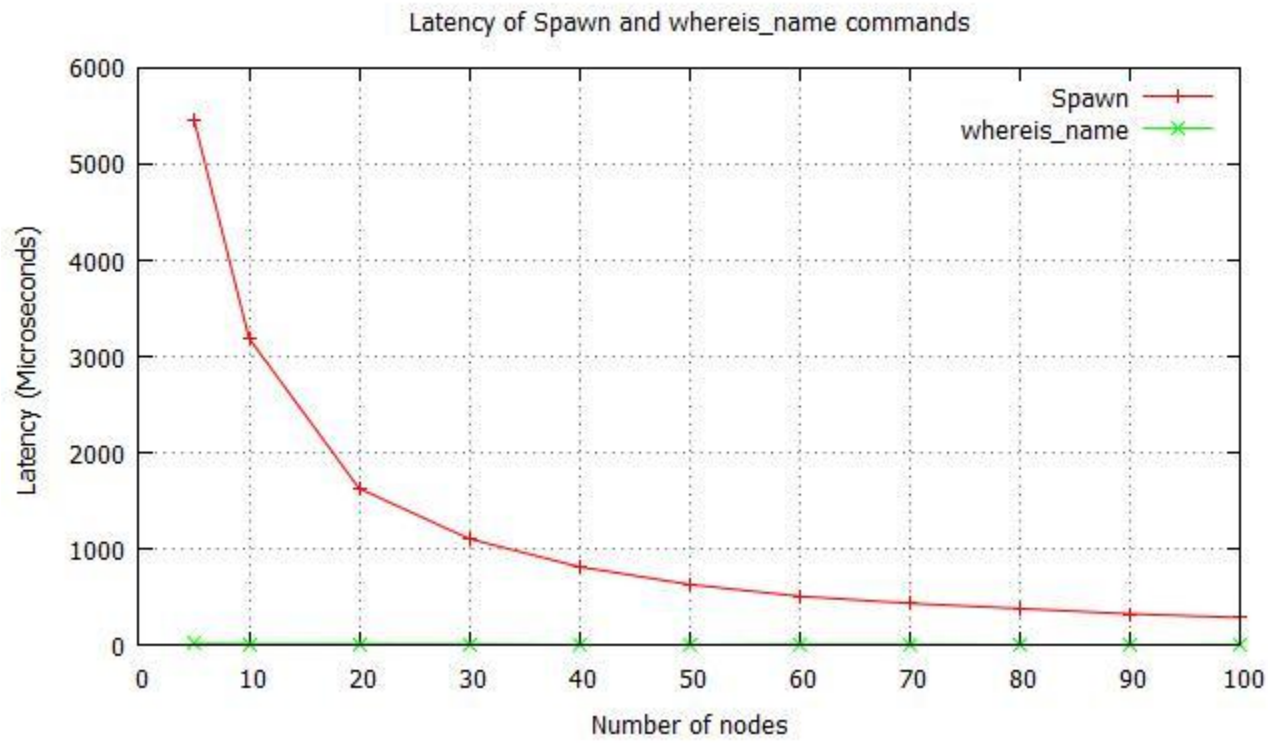
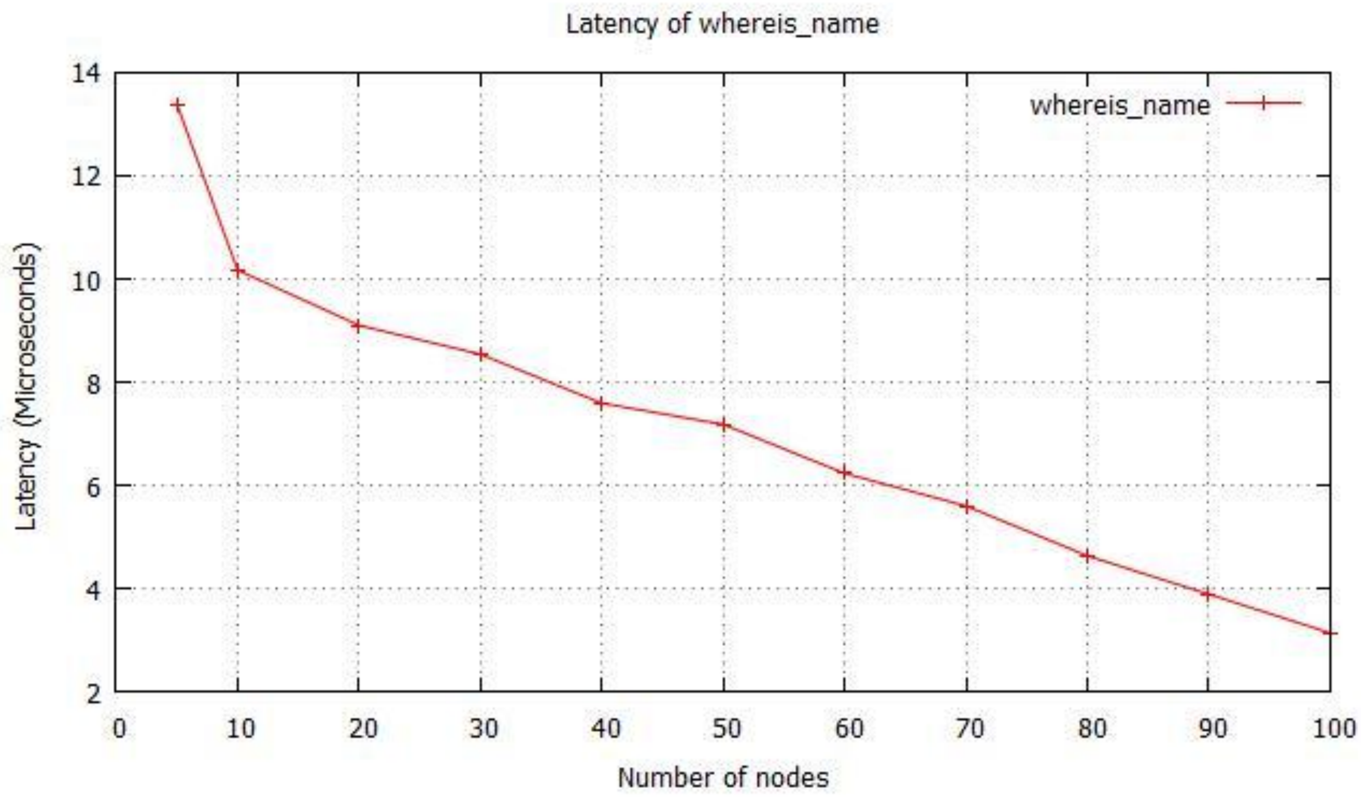
What is the Bottleneck?



Latency of *spawn*

What is the Bottleneck?



Latency of *whereis_name*

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Conclusion and Future works

- Our benchmark confirms that Riak is highly available and fault-tolerant.
- We have discovered the scalability limits of Riak is ~60 nodes
- Global operation limits the scalability of distributed Erlang.
- In the RELEASE, we are working to scale up Distributed Erlang by designing and implementing Scalable Distributed Erlang (SD Erlang)

Thank you!

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