ADDRESSING NETWORK CONGESTION IN RIAK CLUSTERS

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COOL TALK, BRO

Riak

Riak

- A distributed

Riak

- A distributed highly available

Riak

- A distributed highly available eventually consistent

Riak

- A distributed highly available eventually consistent highly scalable

Riak

- A distributed highly available eventually consistent highly scalable open source

Riak

- A distributed highly available eventually consistent highly scalable open source key-value database

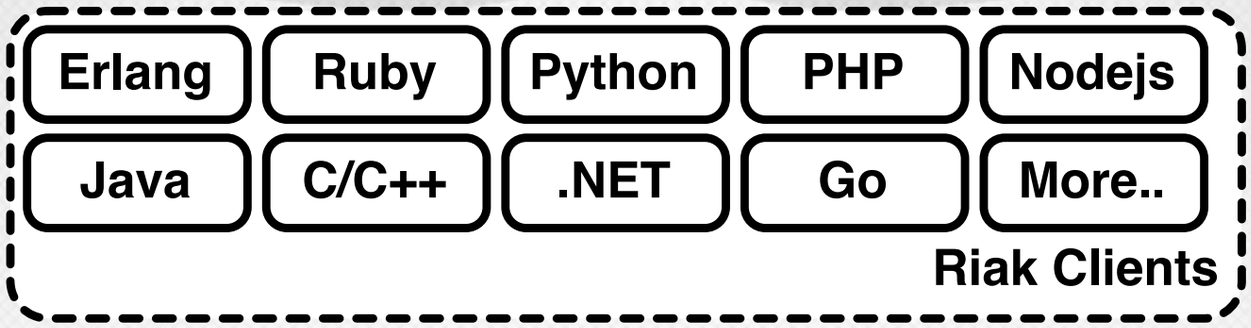
Riak

- A distributed highly available eventually consistent highly scalable open source key-value database written primarily in Erlang.

Riak

- Modeled after Amazon Dynamo
  - see Andy Gross's "Dynamo, Five Years Later" for details https://speakerdeck.com/argv0/dynamo-five-years-later
  - see annotated version of Dynamo paper with comparisons to Riak: http://docs.basho.com/riak/latest/references/dynamo/
- Also provides MapReduce, secondary indexes, and full-text search
- Built for operational ease

Riak Architecture



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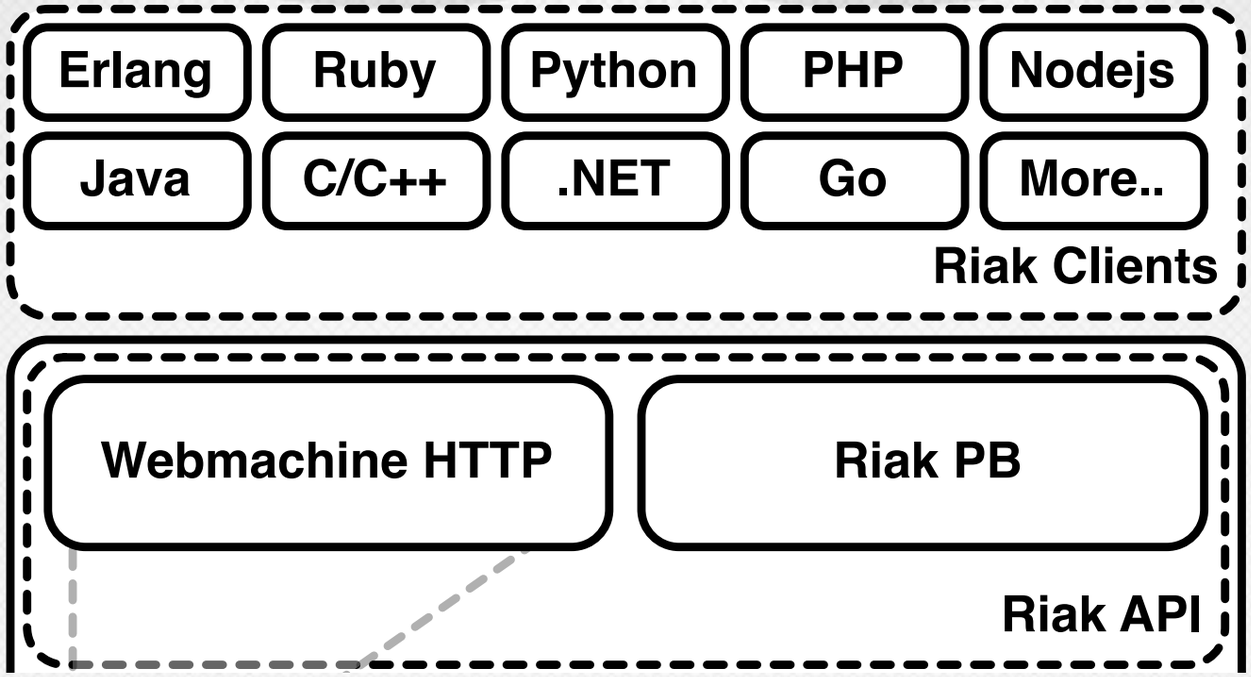

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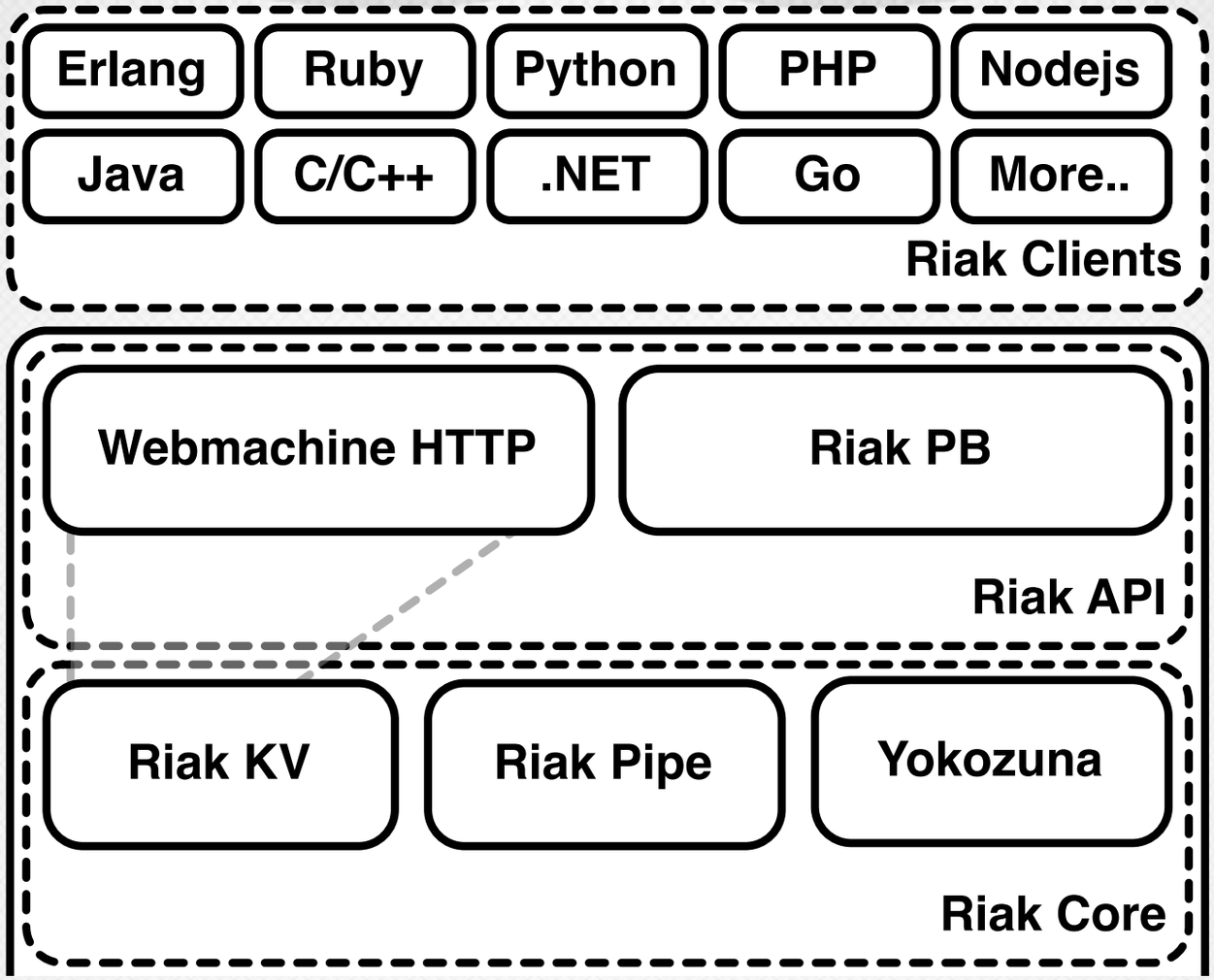

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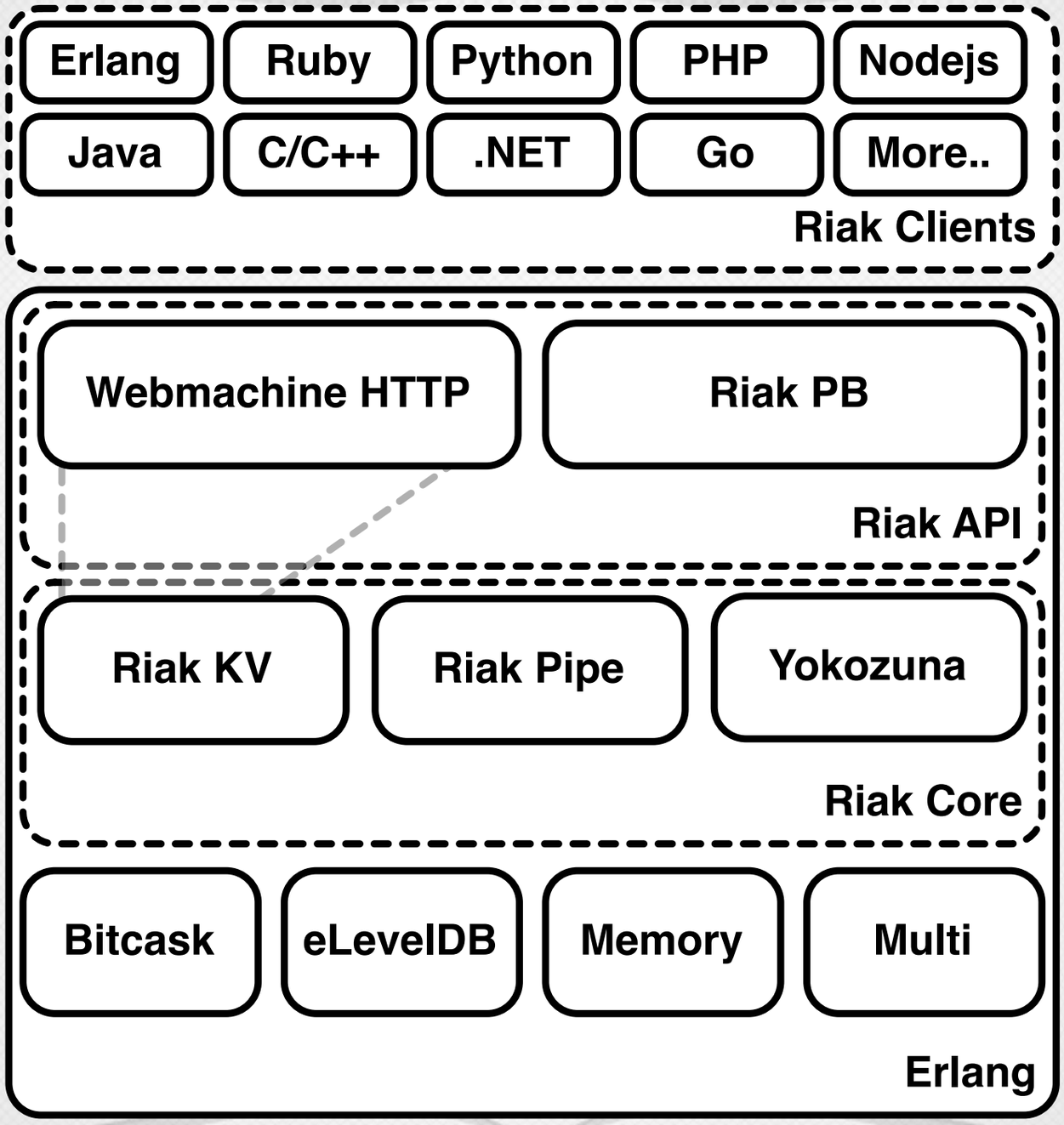

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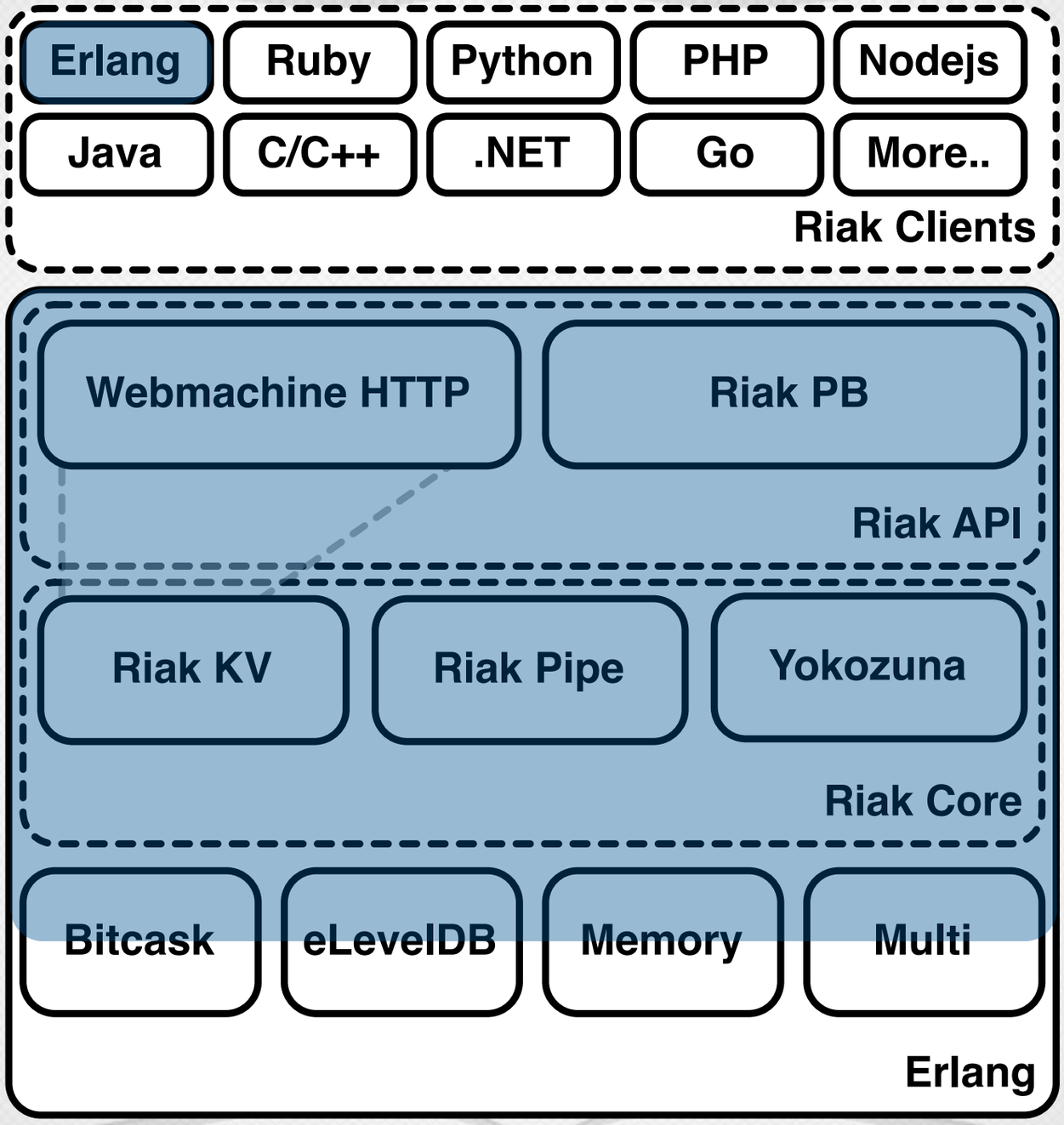

- Erlang parts

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Riak Cluster

node 0

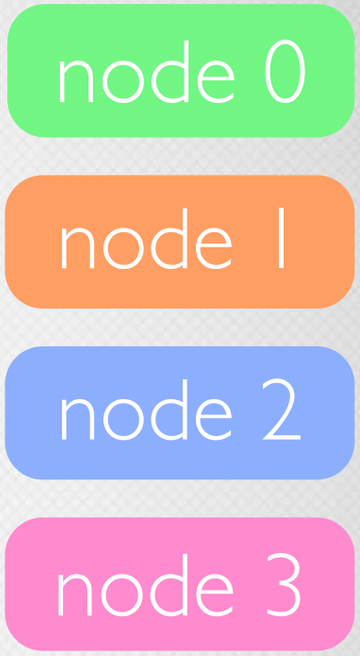
node 3

node 1

node 2

Distributing Data

- Riak uses **consistent hashing** to spread data across the cluster
- Minimizes remapping of keys when number of nodes changes
- Spreads data evenly and minimizes hotspots



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Consistent Hashing

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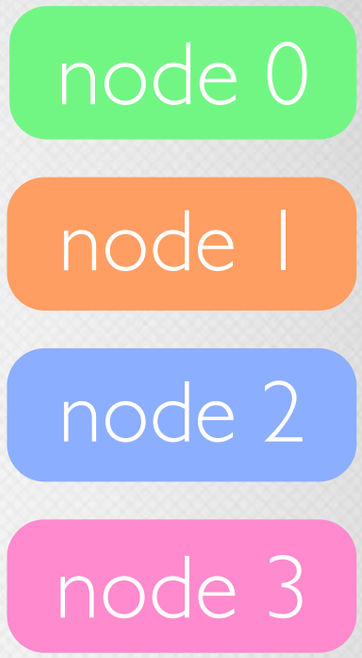

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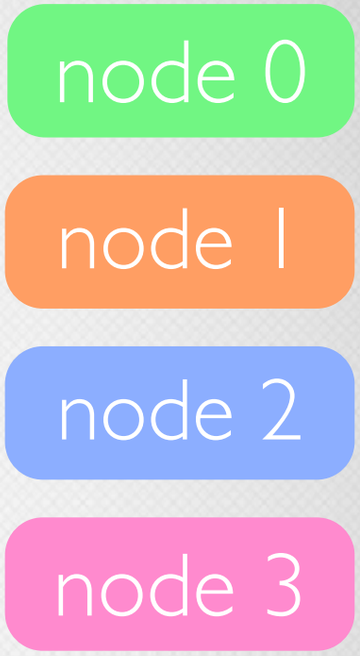

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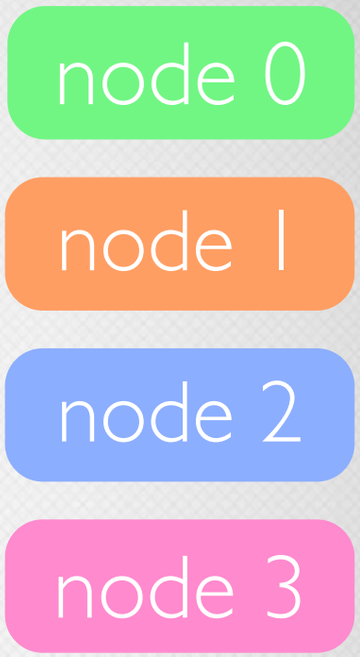

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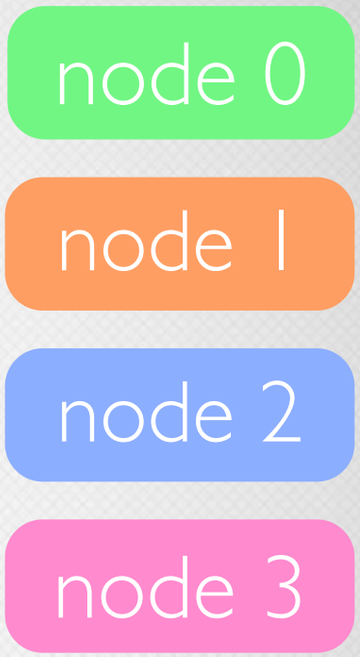

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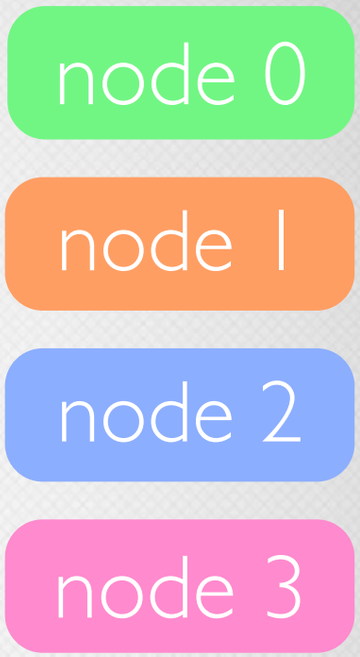
- Each physical node in the cluster hosts multiple vnodes



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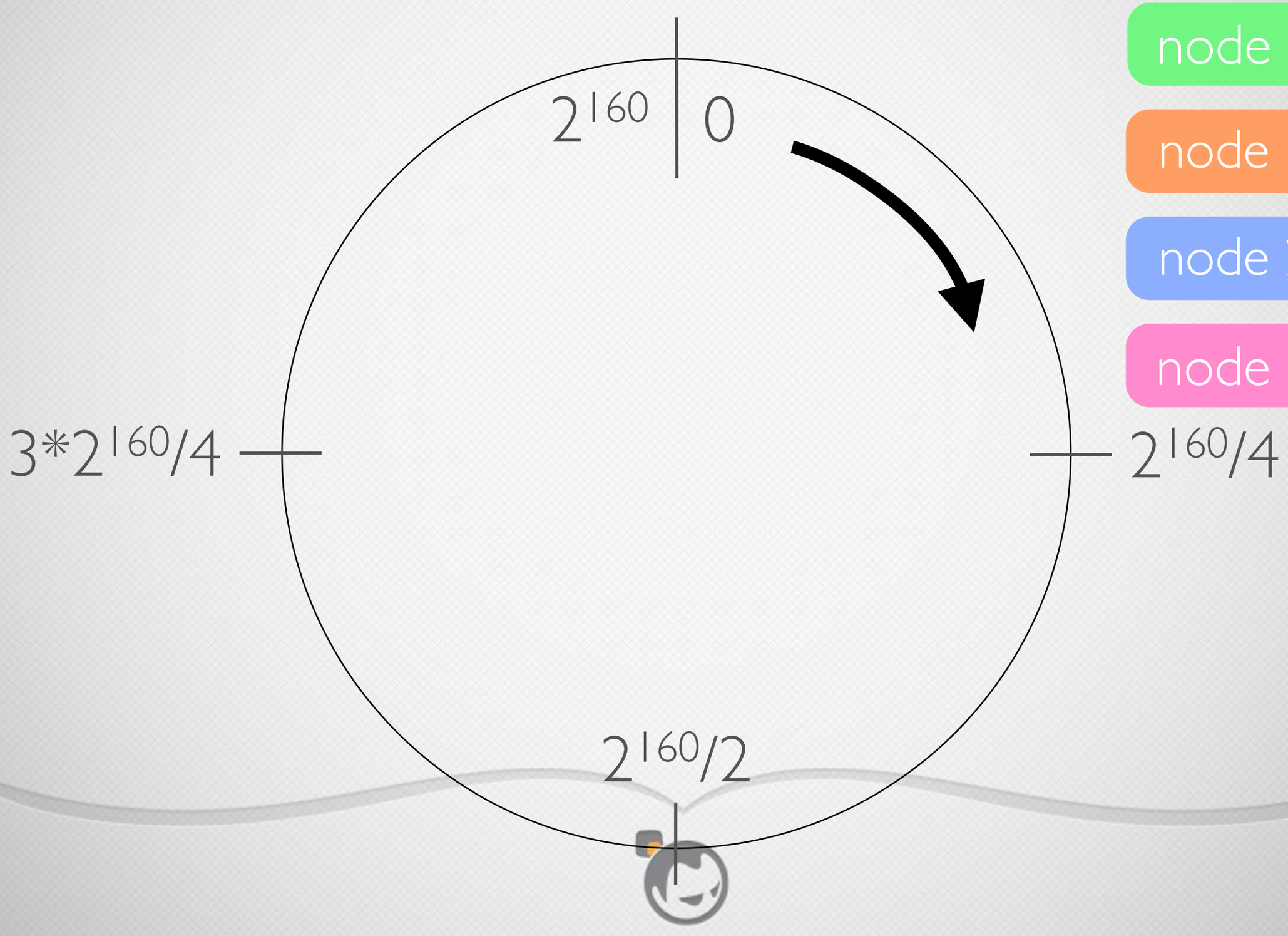

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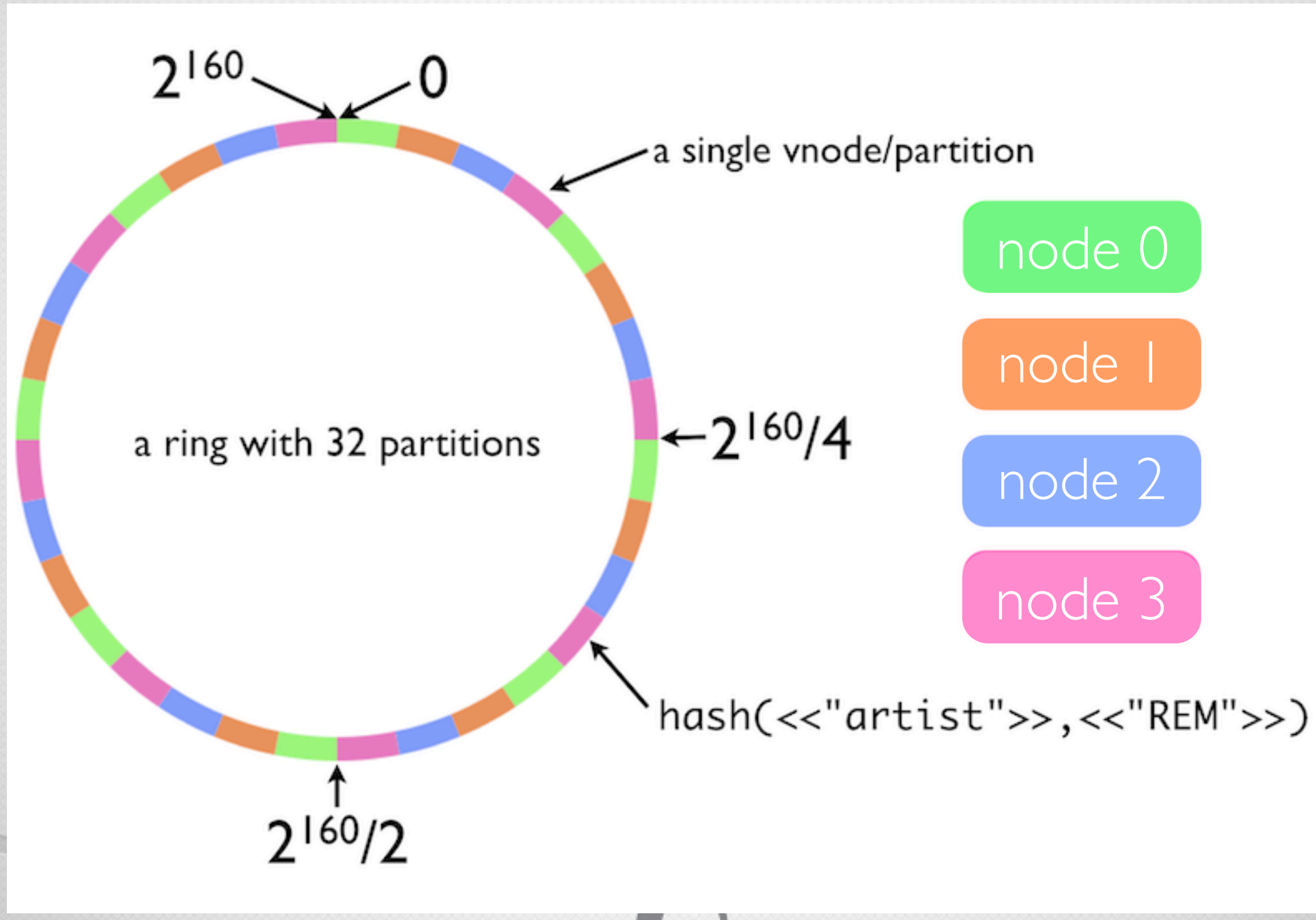
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a single vnode/partition
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node 1
node 2
node 3
a ring with 32 partitions
←2^160/4
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2^160/2

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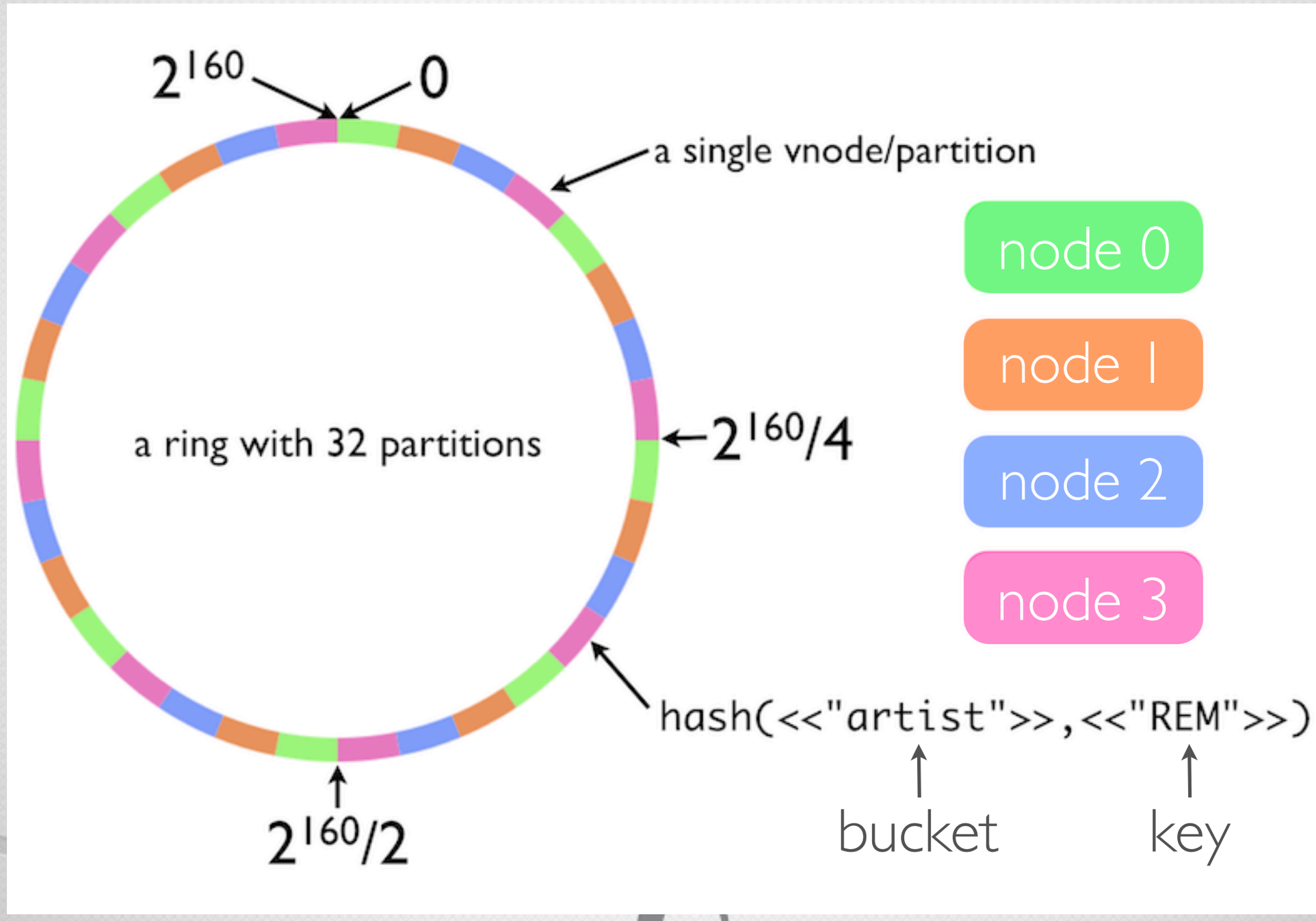
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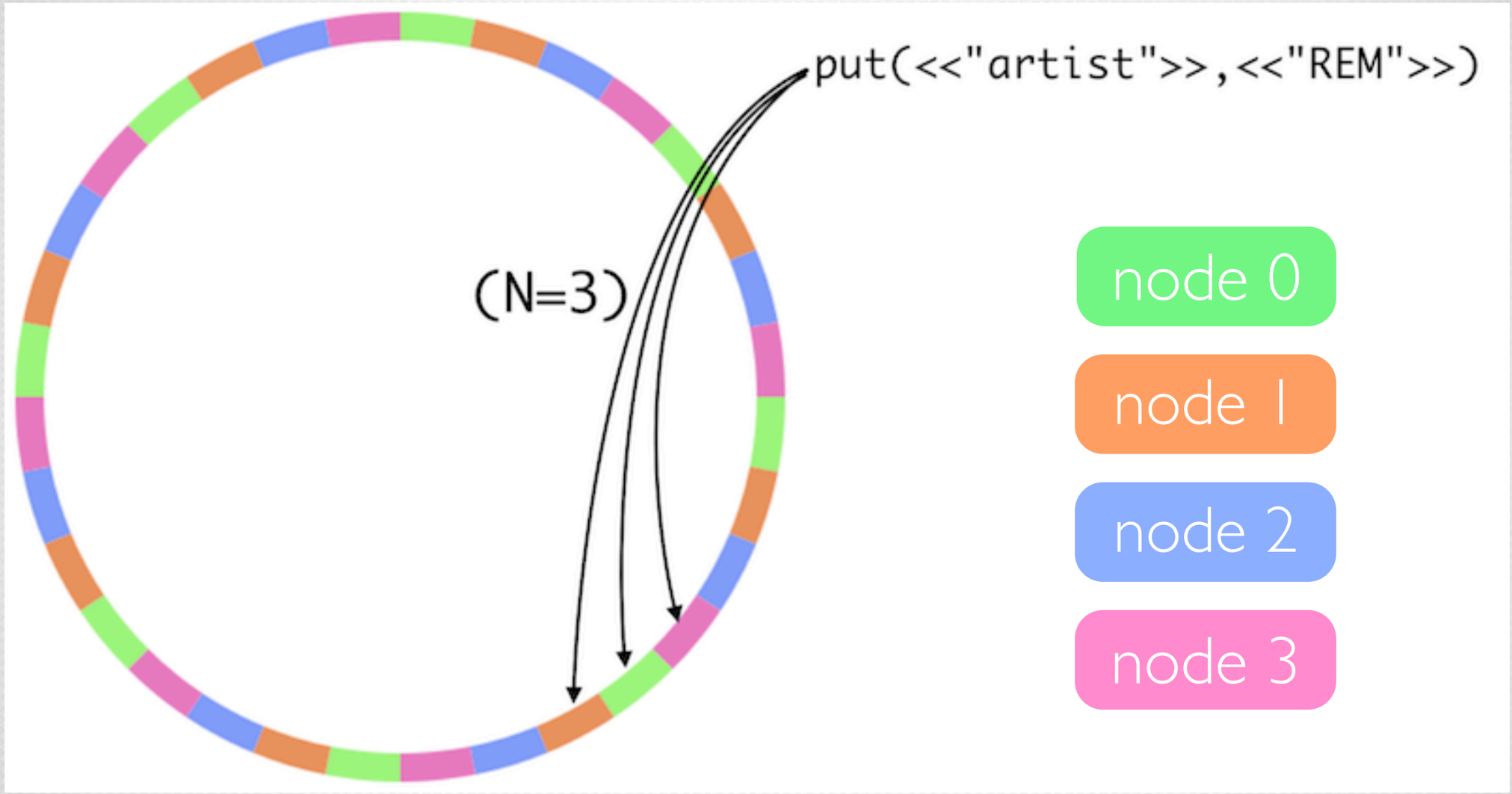

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- When the primary returns, the fallback performs a handoff to transfer data to it

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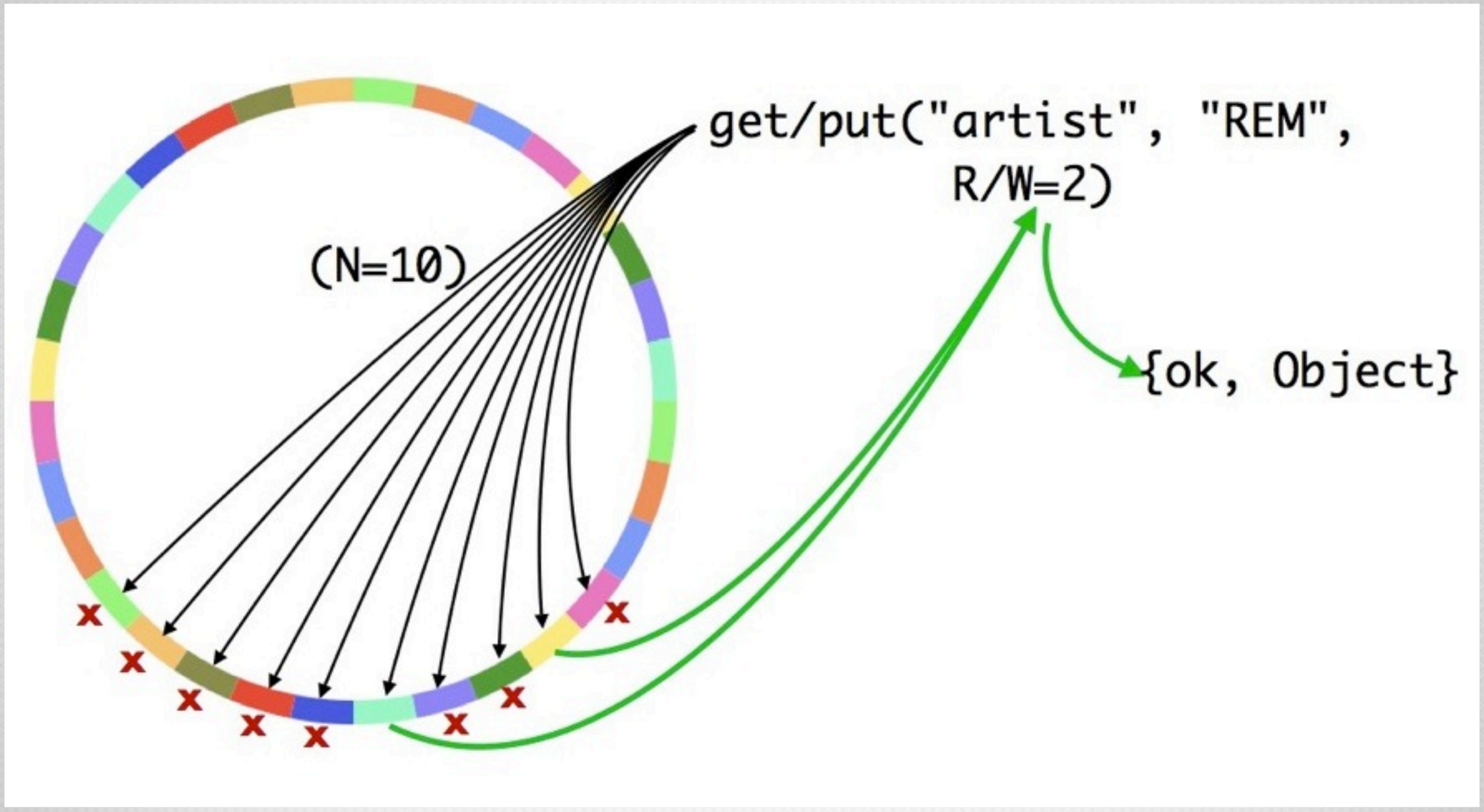
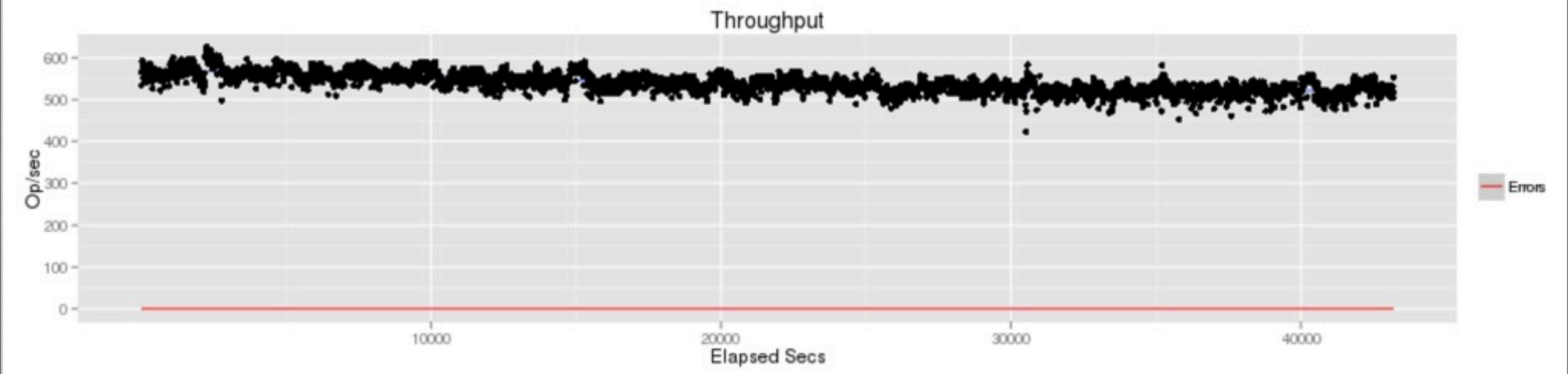
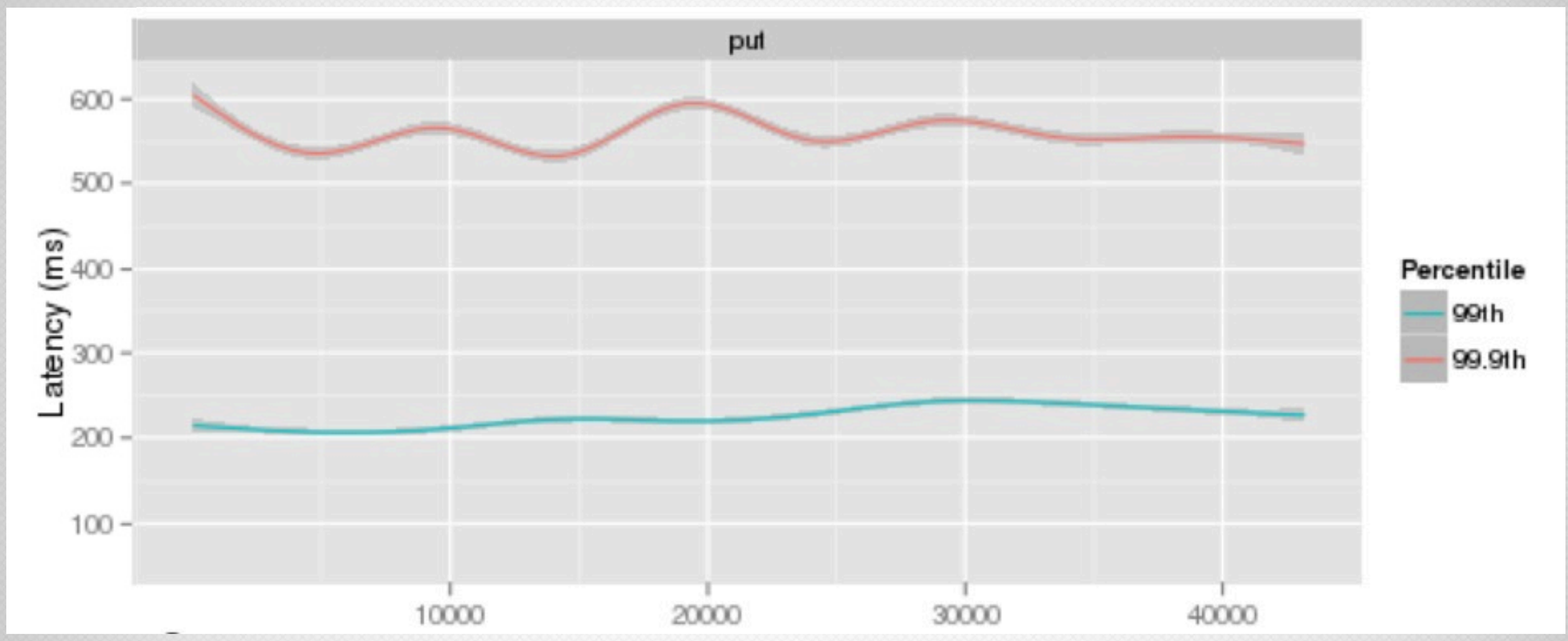


Cluster Throughput Under Extreme Load



Latency Of Puts Under Extreme Load



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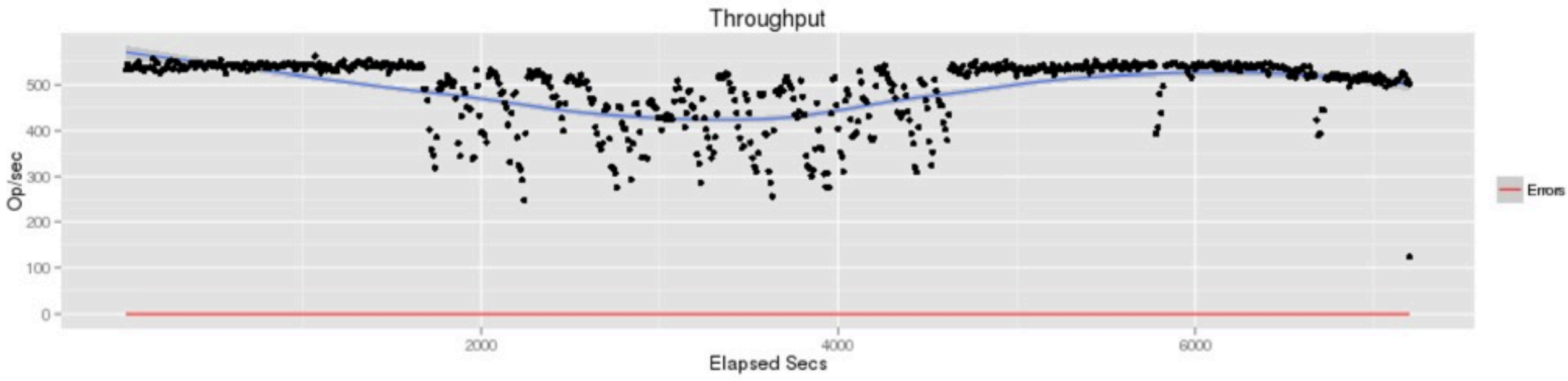
- Handoff occurs to move data between nodes

Throughput With Node Join/Leave



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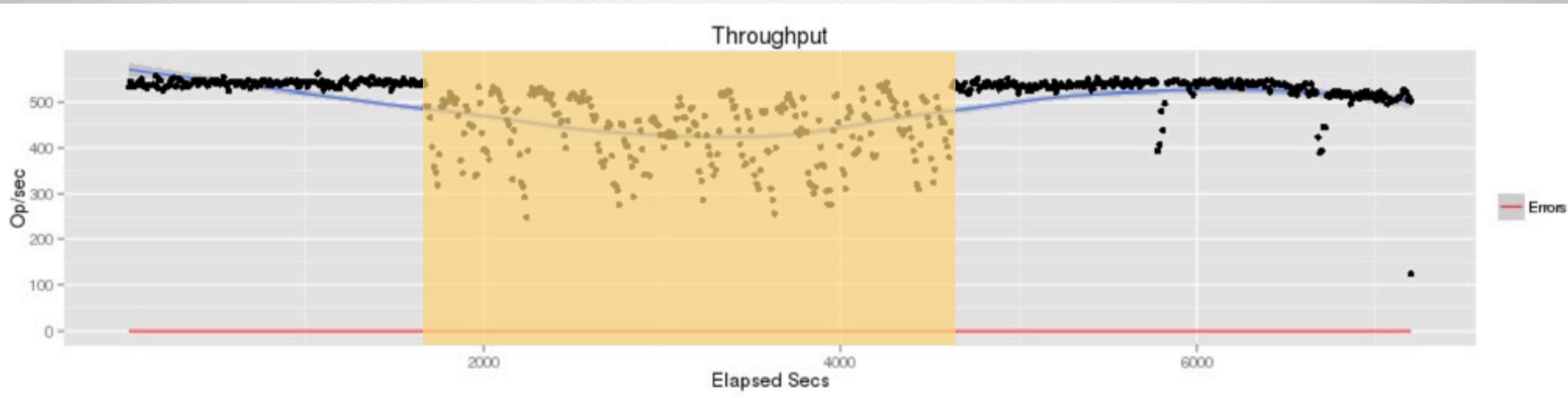

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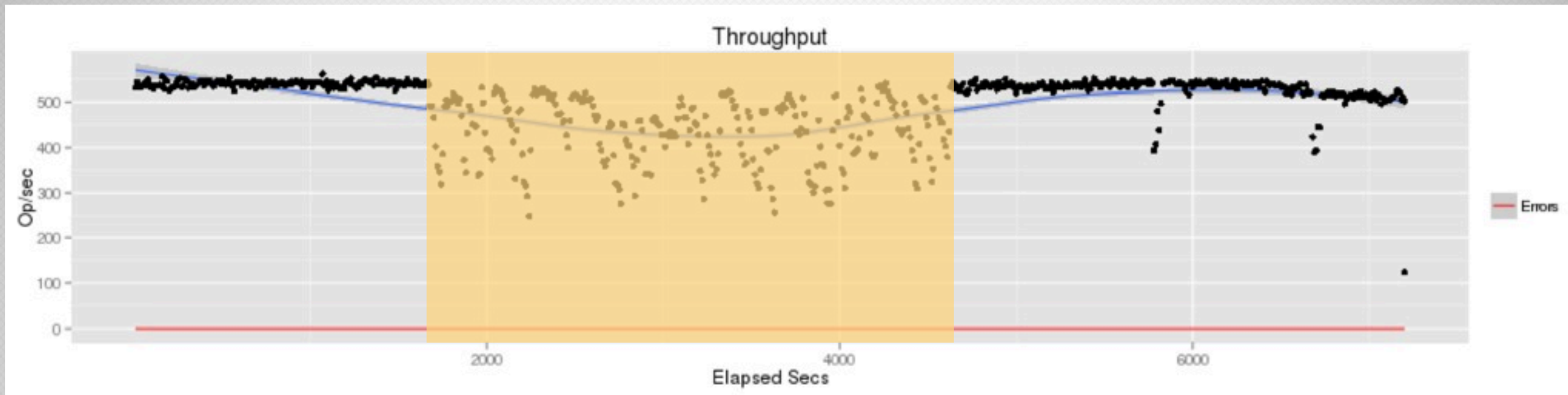

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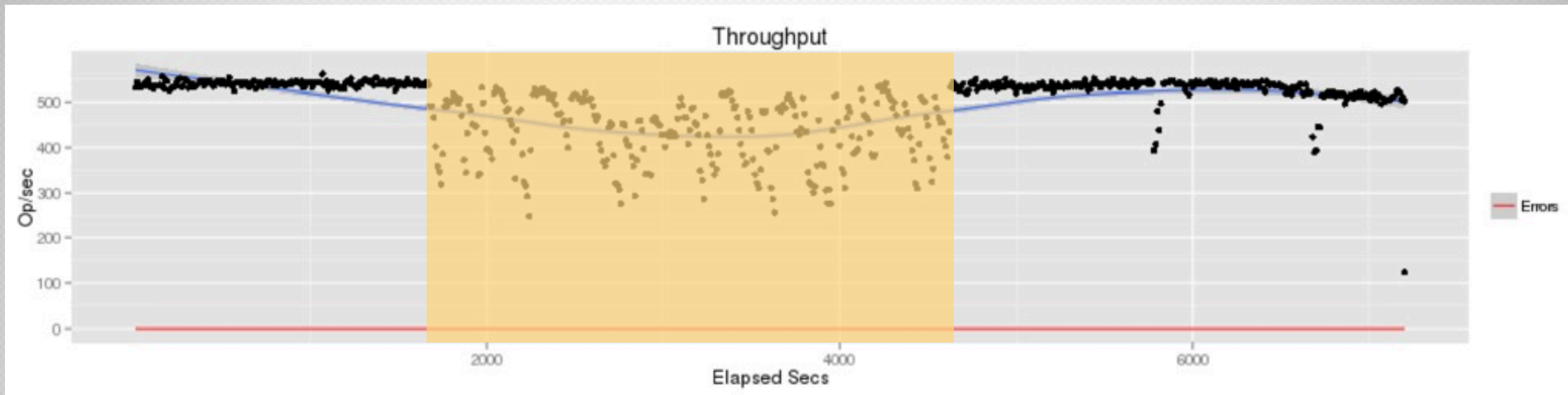

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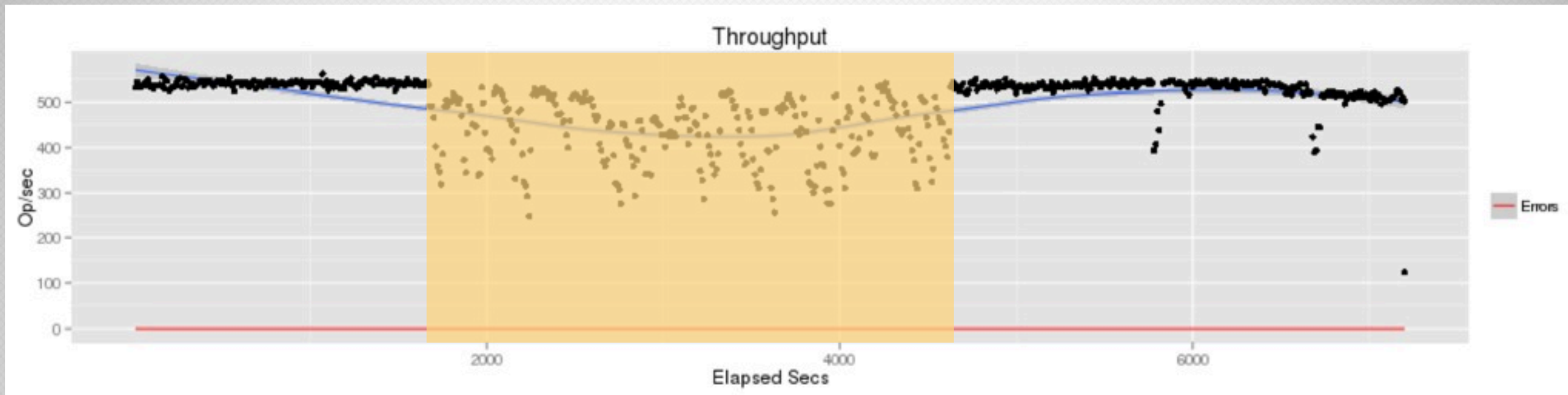

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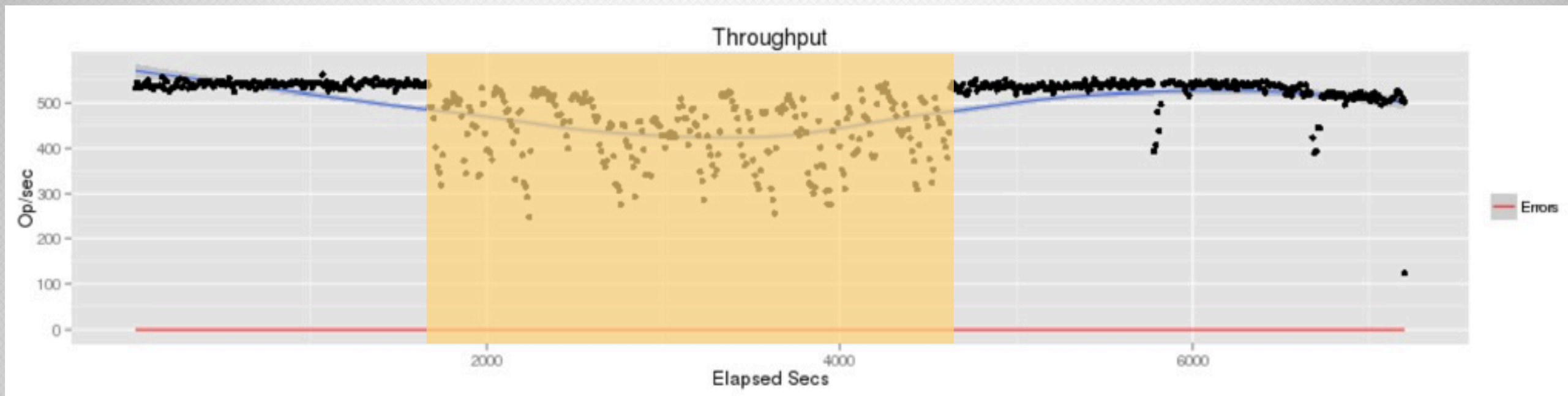

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- Result is significant throughput collapse
- Affects systems like Riak because multiple vnodes (the many) often send messages nearly simultaneously to a coordinator (the one)

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- Suitable for "background" tasks like bulk data transfer

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- Their C++ library implementation is on github: https://github.com/bittorrent/libutp

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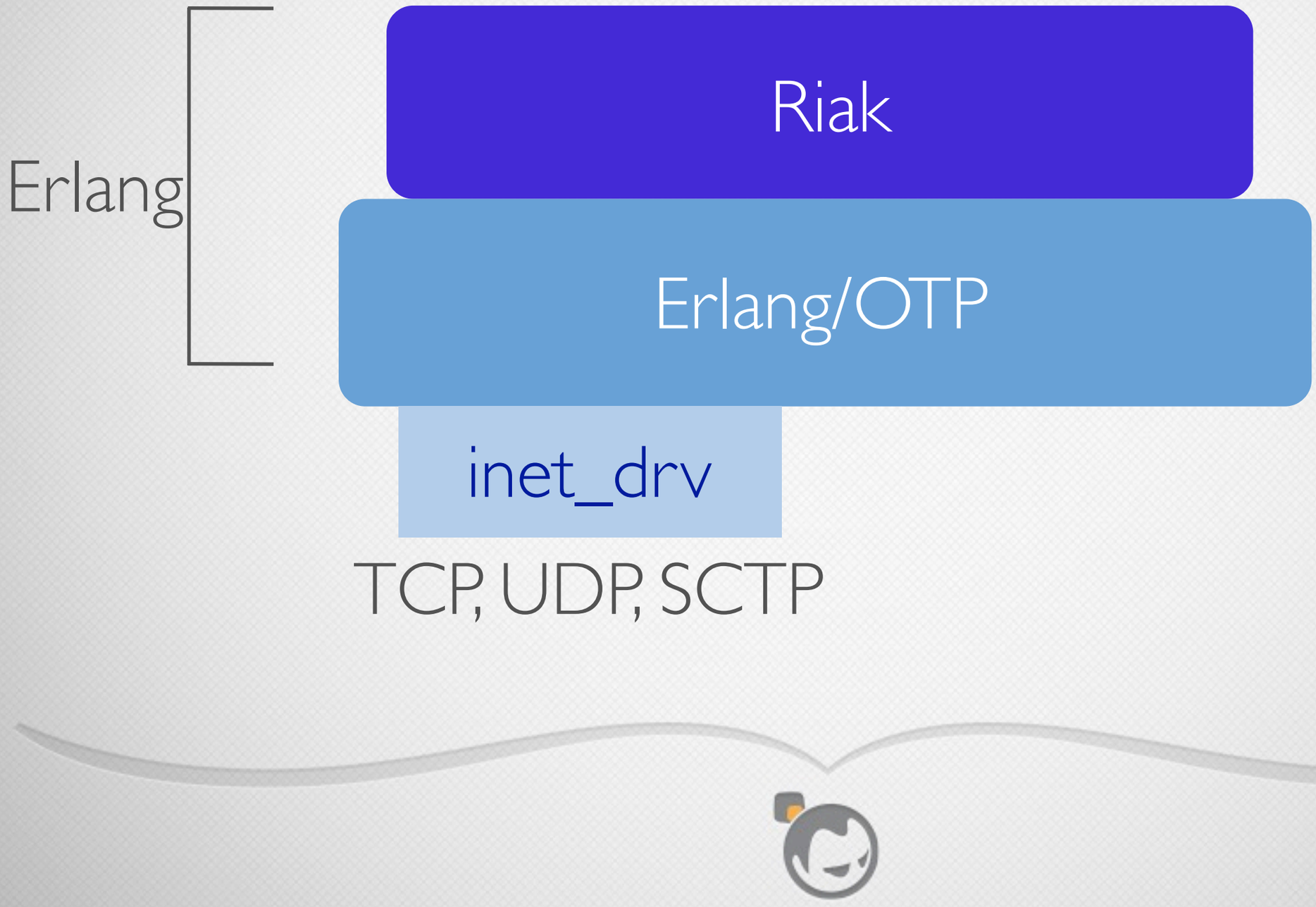

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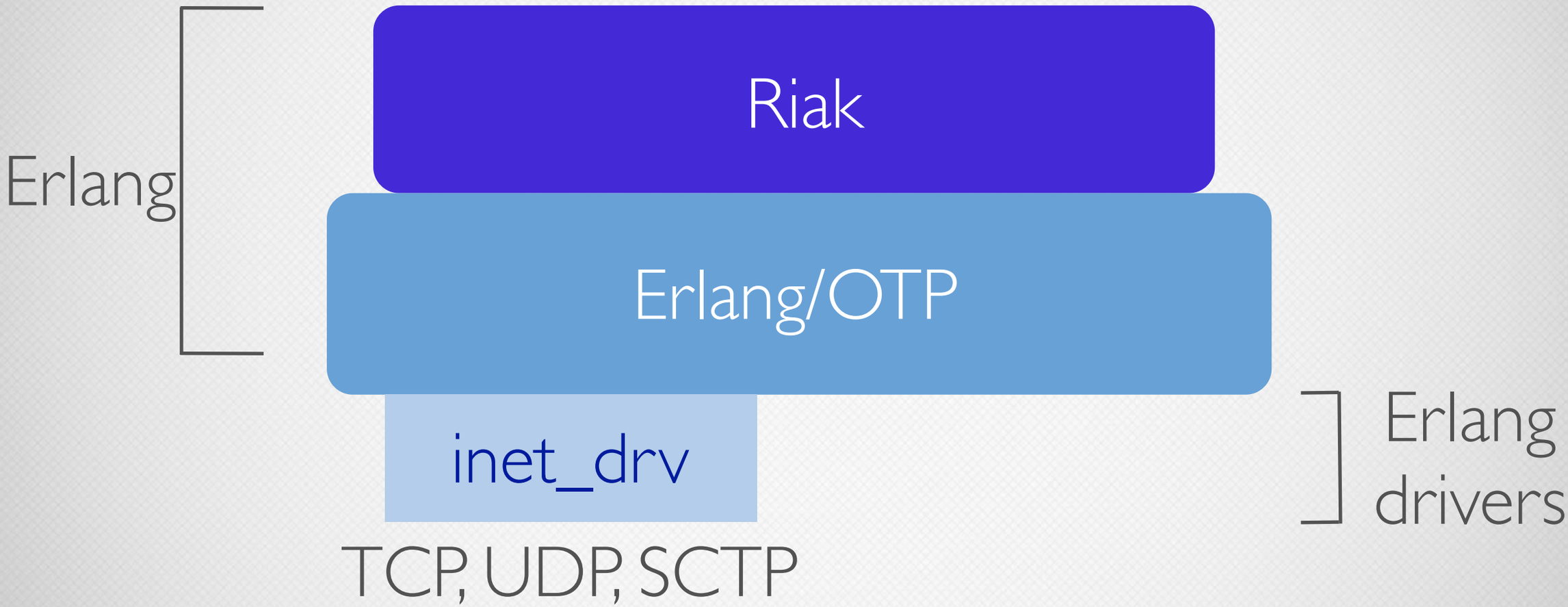

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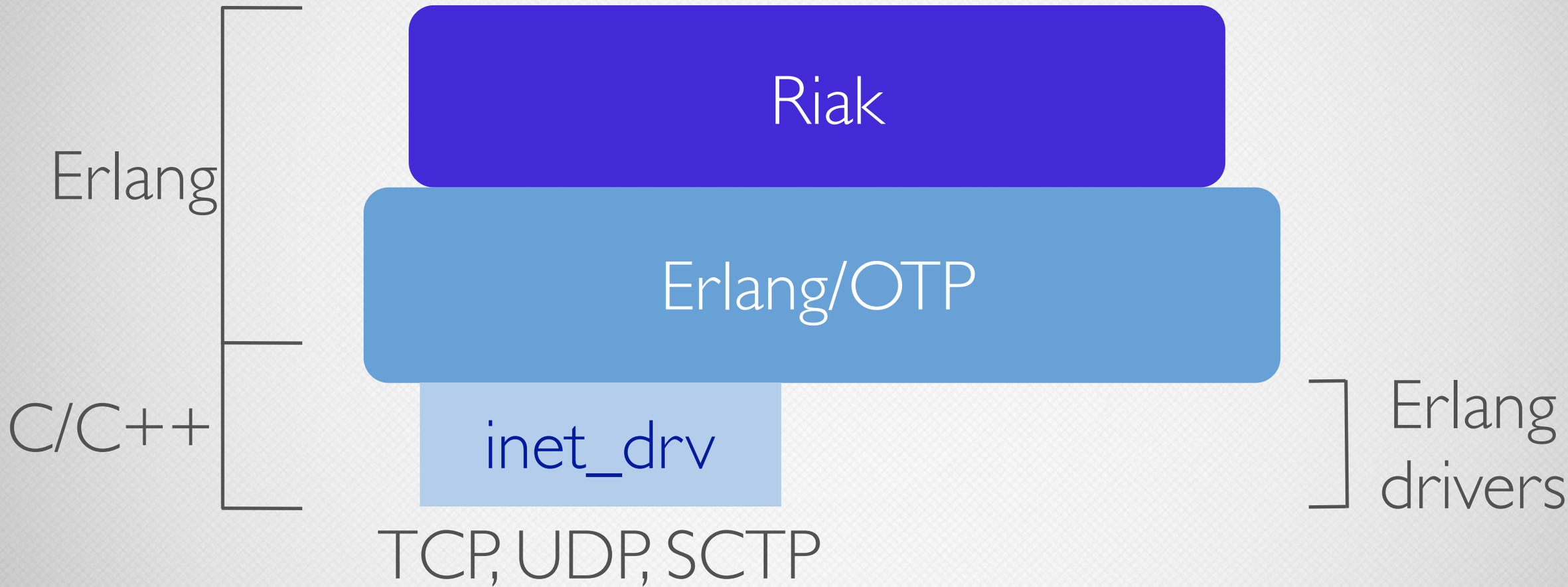

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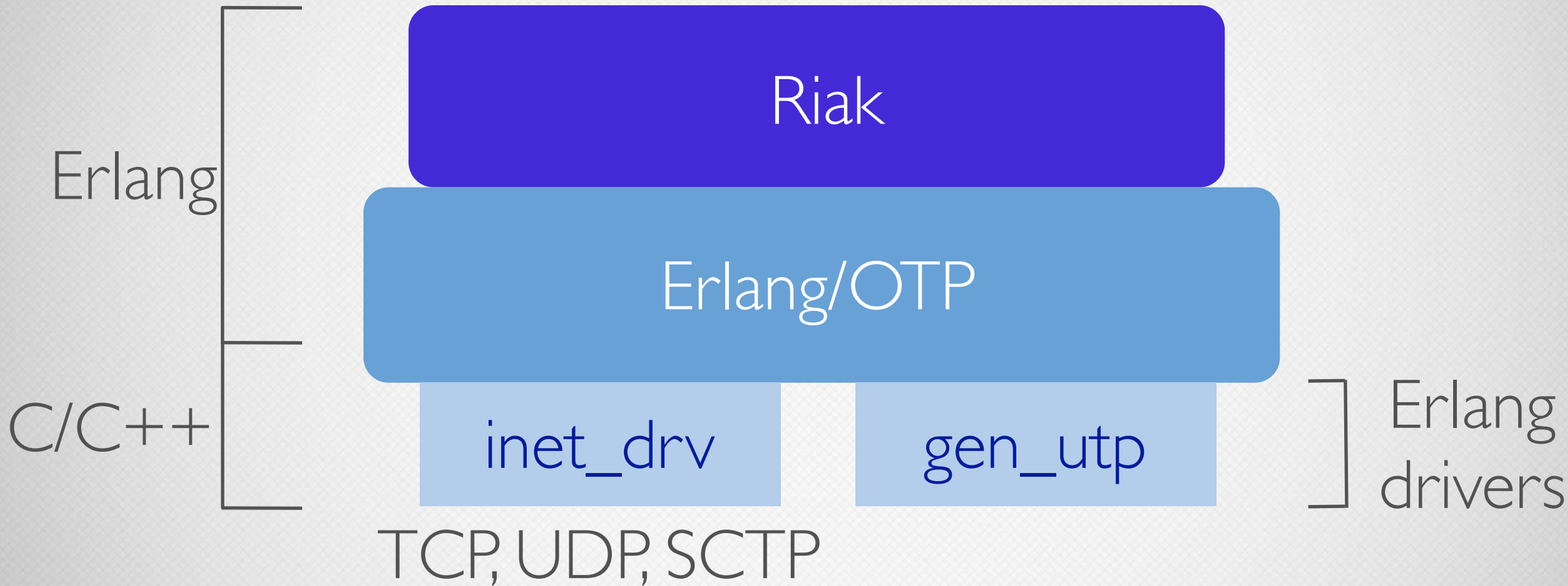
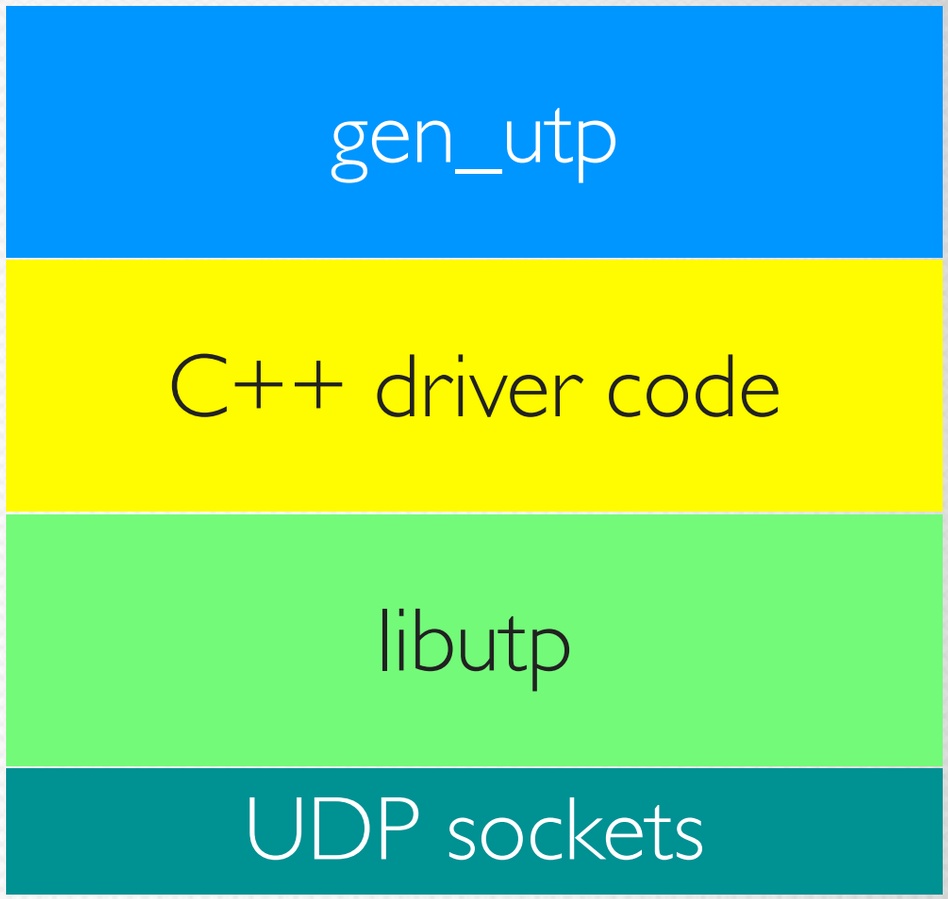


Gen_utp

- Erlang interface matches standard library gen_tcp
- gen_utp module wraps access to the driver
- C++ driver code wraps libutp
- C++ driver also manages underlying UDP sockets



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- Attach to already-open UDP socket file descriptor

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22> {ok,ClientSock} = gen_utp:connect("localhost", ServerPort, [{active,true}]).
{ok,#Port<0.617>}
23> receive {utp_async,ListenSock,Ref,{ok,ServerSock}} -> ServerSock end.
#Port<0.618>
```

Gen_utp Example

```
19> {ok,ListenSock} = gen_utp:listen(0, [{active,false},binary]).
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20> {ok,Ref} = gen_utp:async_accept(ListenSock).
{ok,#Ref<0.0.0.177>}
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25> {ok,Msg} = gen_utp:recv(ServerSock, 0).
{ok,<<"this is a test">>}
26> gen_utp:send(ServerSock, <<"this is also a test">>).
ok
27> flush().
Shell got {utp,#Port<0.617>,"this is also a test"}
ok
```

Gen_utp Internals

- libutp is a C++ library, so the Erlang driver is also C++
- libutp works via callbacks
- libutp implements the uTP protocol, you have to supply all socket handling
- Sockets are UDP, libutp adds the protocol reliability

Gen_utp Internals

- Master branch has a C++ class hierarchy of Handlers
- Handlers implement socket handling, uTP handling, and Erlang port handling
- Development branch (not yet working) breaks these into parallel hierarchies of Handlers and Ports

Handler Classes

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- UtpHandler: handles libutp callbacks
  - derived from SocketHandler

Handling Events

- UDP sockets are registered in the Erlang runtime's polling set
- Erlang runtime calls SocketHandlers when sockets have input
- libutp also has a timeout check that the uTP driver calls every 10ms

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- UtpPort: base class for ports dealing with UtpHandlers
  - AcceptPort: port returned from accept calls
  - ConnectPort: port returned from connect calls

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- TCP accept means "give me a new socket connected to that client", and we want the same semantics

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  - any subsequent traffic from that client is seen only by the accept socket
  - all sends on the accept socket go only to that client (i.e., using send vs. sendto)

Implementing Accept

- Unlike inet_drv, the uTP driver uses the driver queue for reads, not writes
- Implementing {active,false} or {active,once} for TCP just means deselecting the socket
- uTP driver always has to read all incoming messages to check if they're uTP messages, so it never deselects
  - driver queue stores read messages not yet delivered up through gen_utp

Shortcomings

- No good way to implement a listen queue
  - uTP client will just timeout if nobody's accepting
- uTP is slow when closing a socket, seems to want to exchange a bunch of messages
- libutp is not thread-safe, all access must be serialized
- Getting lifetimes of sockets, Erlang ports, and C++ handler instances right is hard
  - hoping the Handler/Port split will help

Gen_utp Testing

- Definitely a work in progress!
- Integrated with Riak some months ago on a branch
- successfully performed small-scale handoff
- but no large-scale Riak testing yet

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  - same throughput as gen_tcp at 10baseT
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  - 2x slower than gen_tcp at 1000baseT
  - gen_utp shows higher CPU in all cases, most likely due to copying forced by libutp callback interface

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Gen_utp Testing

- Lower throughput on fast networks could be a showstopper, since datacenter LANs are usually fast
- Always deferring to TCP flows might not always be desirable, for example:
  - when adding nodes to scale a cluster that's struggling to keep up with load
  - you want data transfer to happen as quickly as possible so the new nodes help manage load

Current Status

- gen_utp available at https://github.com/basho-labs/gen_utp
- It mostly works but:
  - recent updates for Erlang R16B introduced bugs on master related to binary vs. list delivery
  - current development branch (Handler/Port split) still needs work

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- Next step: testing on a Riak cluster under load
- Redesign the driver to work with Erlang's prim_inet layer
  - this should allow SSL to work over uTP
- If it doesn't help with congestion, consider using it for Riak Enterprise multi-datacenter syncing over WANs

Related Work

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- He basically reverse engineered libutp
- I didn't use it because I thought libutp would make things easier, and because I can layer SSL over a driver
- He's stopped work on it but is willing to entertain pull requests :)

THANKS

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