CS 744: BIG DATA SYSTEMS

Shivaram Venkataraman

Fall 2018

ADMINISTRIVIA

- Course Project round 3 meetings signup!
- Final class on Dec 6^{th}
- No class on Dec 11^{th}
- Poster session Dec 13^{th} – More details very soon!

RDMA: REMOTE DIRECT MEMORY ACCESS

MOTIVATION

Need to access remote data fast

- Increasing NIC speeds (up to 100Gbps)
- OS/CPU bottlenecks

RDMA

- Perform direct memory access (DMA) from NIC!
- Bypass remote CPU, OS etc.

RDMA cost / availability

FARM

Approach

- Model distributed memory as shared address space
- Communication primitives over RDMA

Features

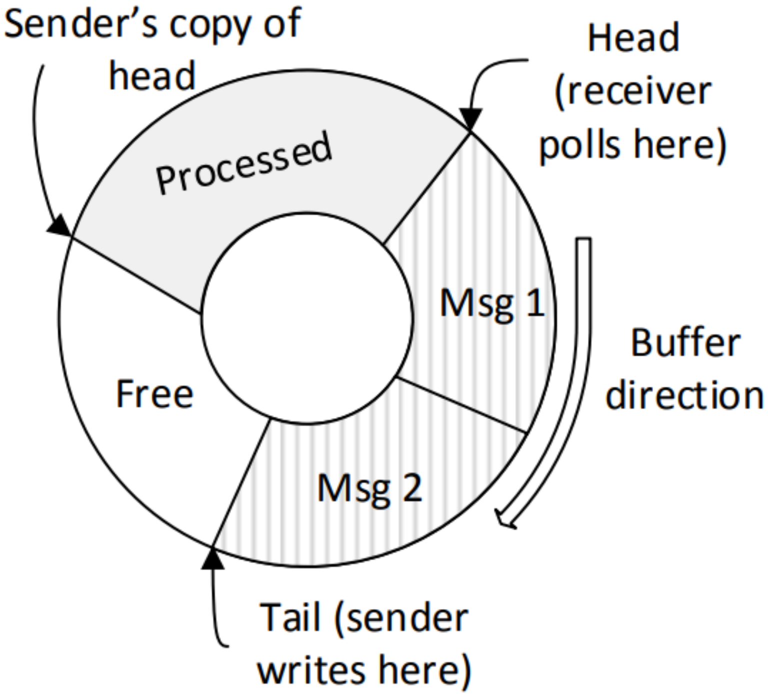
- Memory Management
- Transactions
- Datastructures

COMMUNICATION PRIMITIVES

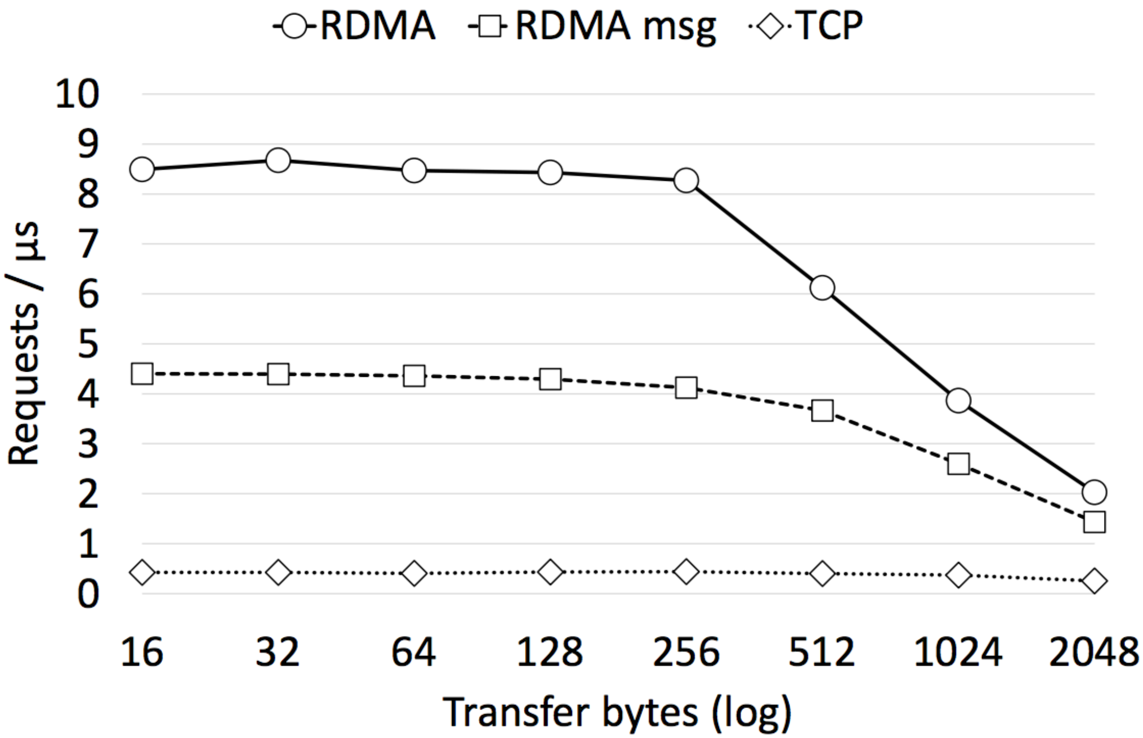
Key idea: One sided RDMA read/writes

How to implement writes ?

- Circular buffer on receiver
- Recv polls at "Head"
- Sender writes at "Tail"
- Ensure sender doesn't overwrite



COMMUNICATION PRIMITIVES



RDMA CHALLENGES

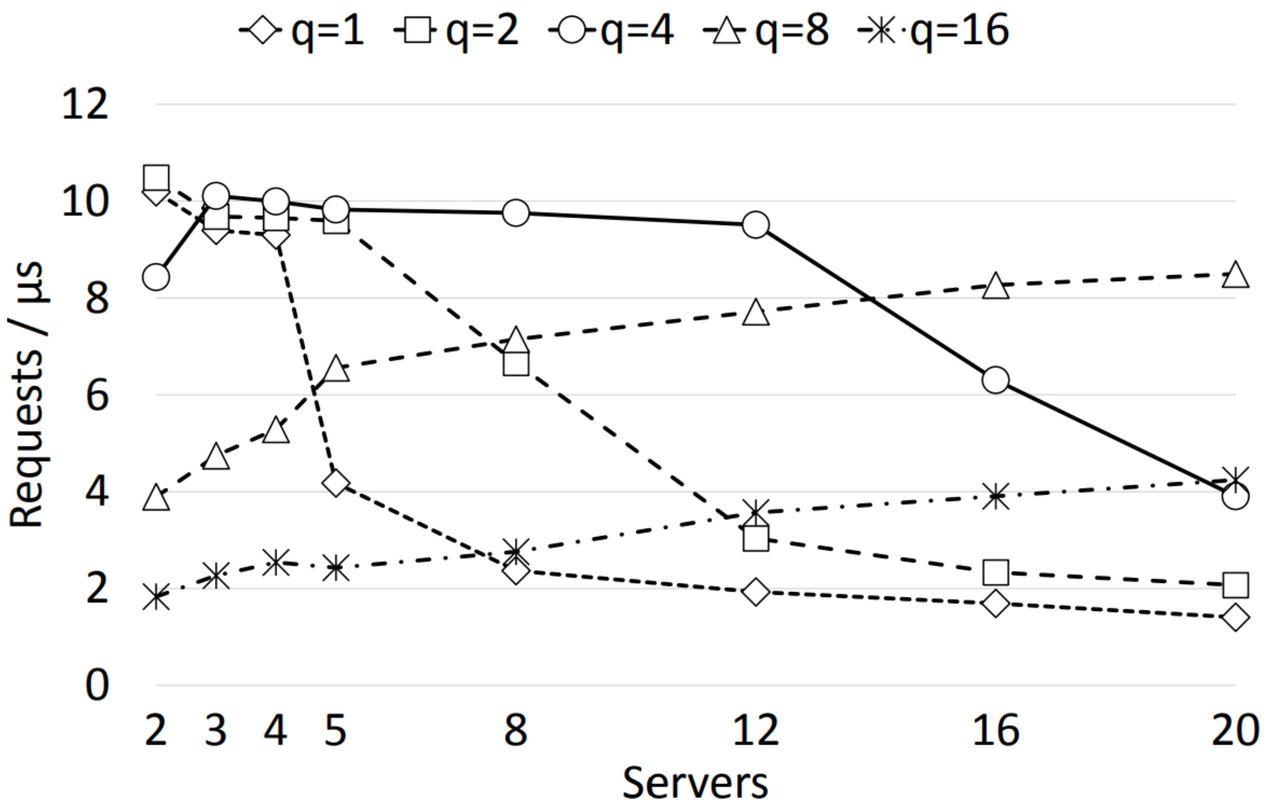
Page Table Size

- Doing DMA requires NIC to cache page tables
- Need for larger pages to make page table smaller
- PhyCo – kernel driver that allocates 2GB pages!

Caching queue pair data

- Need a queue pair (connection) between every sender-receiver
- 2*m*t^2 for m machines, t threads per machine
- Solution: Share queue pair among threads – 2*m*t/q

CONNECTION MULTIPLEXING



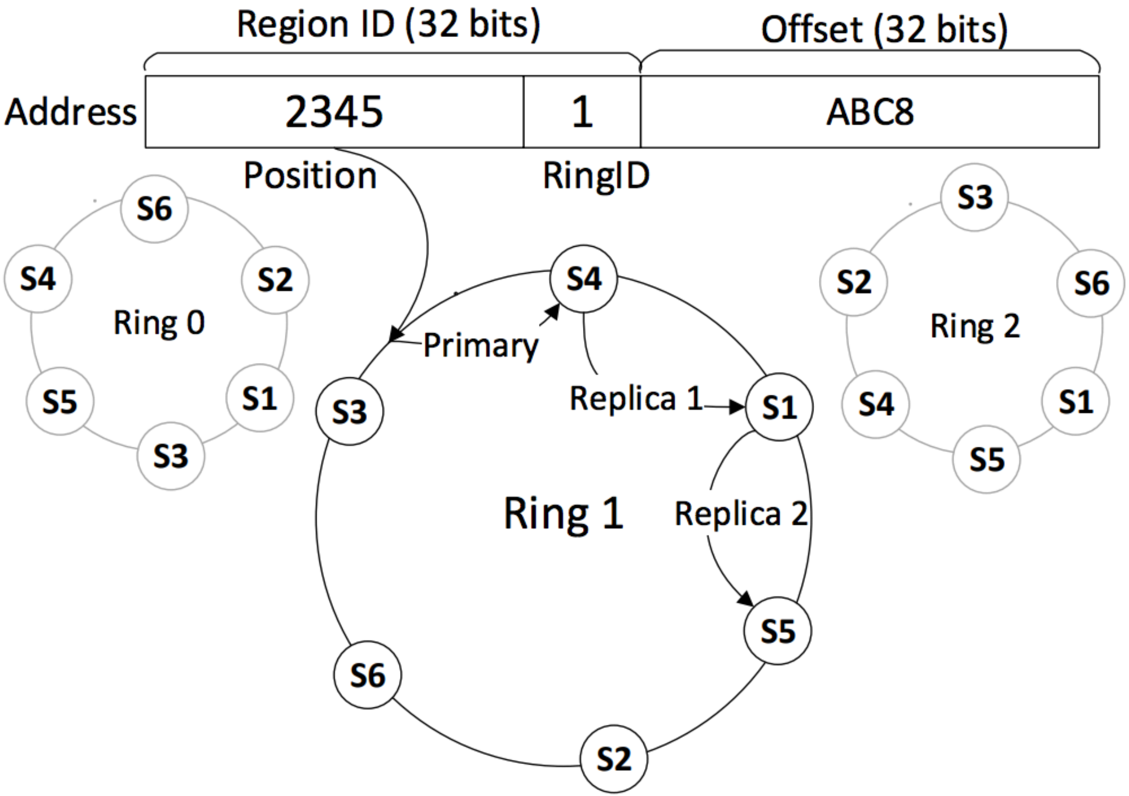
FARM API

```
Tx*  txCreate();
void txAlloc(Tx *t, int size, Addr a, Cont *c);
void txFree(Tx *t, Addr a, Cont *c);
void txRead(Tx *t, Addr a, int size, Cont *c);
void txWrite(Tx *t, ObjBuf *old, ObjBuf *new);
void txCommit(Tx *t, Cont *c);

Lf* lockFreeStart();
void lockFreeRead(Lf* op,Addr a,int size,Cont *c);
void lockFreeEnd(Lf *op);
Incarnation objGetIncarnation(ObjBuf *o);
void objIncrementIncarnation(ObjBuf *o);

void msgRegisterHandler(MsgId i, Cont *c);
void msgSend(Addr a, MsgId i, Msg *m, Cont *c);
```

MEMORY MANAGEMENT



Every 2GB alloc is *region*

32-bit id, 32-bit offset

Map regions in hash ring

Why multiple rings ?

- Parallel recovery
- Load balancing

MEMORY ALLOCATION

Hierarchy

- Slabs, regions, blocks
  - Thread-level, private slab allocators
  - Blocks multiples of size1MB
  - Regions on size 2GB

Hints

- Applications request allocation “close”
- Same block as hint or same region or nearby position

TRANSACTIONS

Transaction components

- Reuse standard protocols from DB (2-phase commit, OCC)
- Components: Read set, write set
- Coordinator that runs transaction

Process

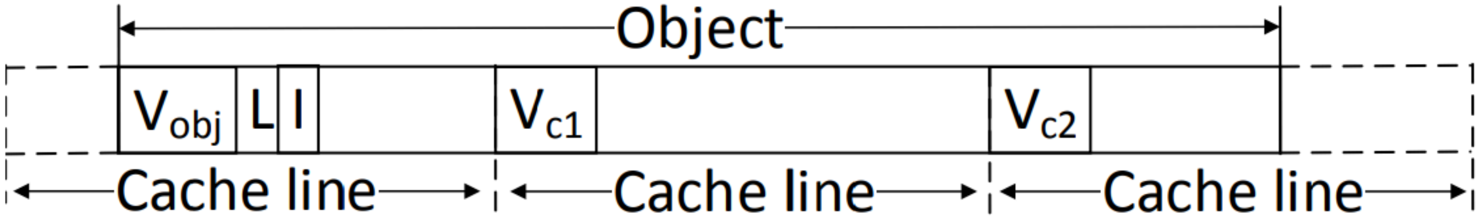
- Prepare message to lock write set
- Validate messages to check read set
- Commit messages: first to replicas then to primaries

LOCK-FREE OPERATIONS

Locks are still expensive! → Design lock-free read operations

Version numbers stored per-cache line – Why do we need this ?

Use memory barriers to update one line at a time



HASHTABLE CHALLENGES

Goals

- Perform most operations using single RDMA read
- Achieve good utilization (avoid resizing hash table)

Challenges

- Chaining / Cuckoo hashing: Key could be in many disjoint locations
- Hopscotch hashing: Each bucket has a neighborhood of H-1 buckets
- But large H → more reads and small H → poor utilization

HASHTABLE SOLUTIONS

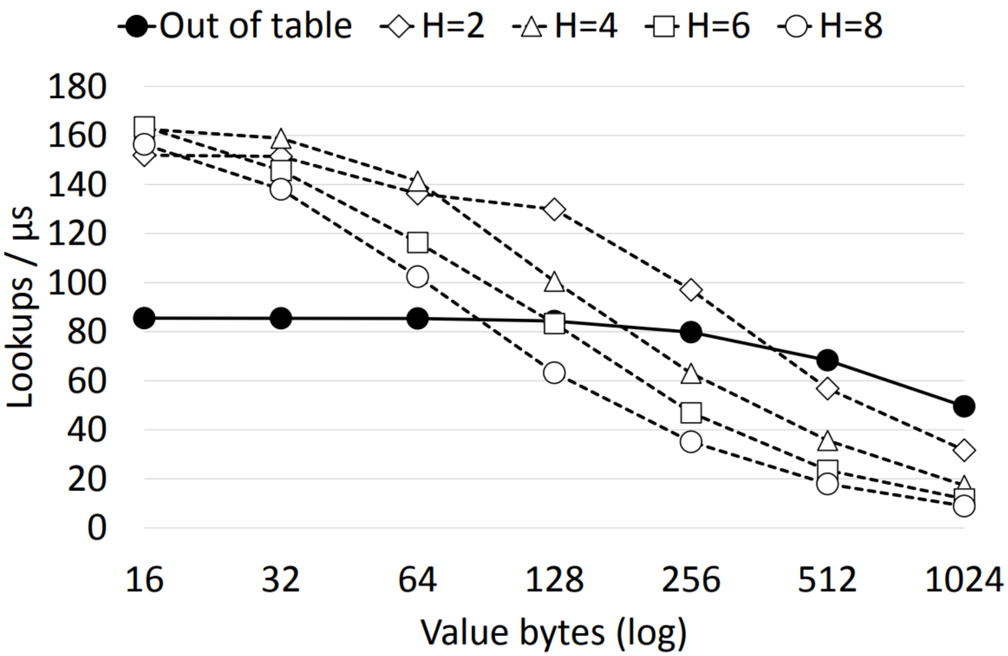
Soln: Chained associative hopscotch

Maintain overflow chain per-bucket

- Add key to overflow if reqd
- Small chains limit overhead
- Inline values next to key

Other optimizations

- Lookups use lock-free read
- Combine updates in 1 transaction



SUMMARY

New networking hardware enables fast systems

Insights

- Avoid CPU overheads using RDMA read
- Design higher-level primitives based on that

Drawbacks

- Need to do multiple round trips ?
- Hardware dependent wins ?