The OceanStore Write Path

Sean C. Rhea John Kubiatowicz
University of California, Berkeley

June 11, 2002

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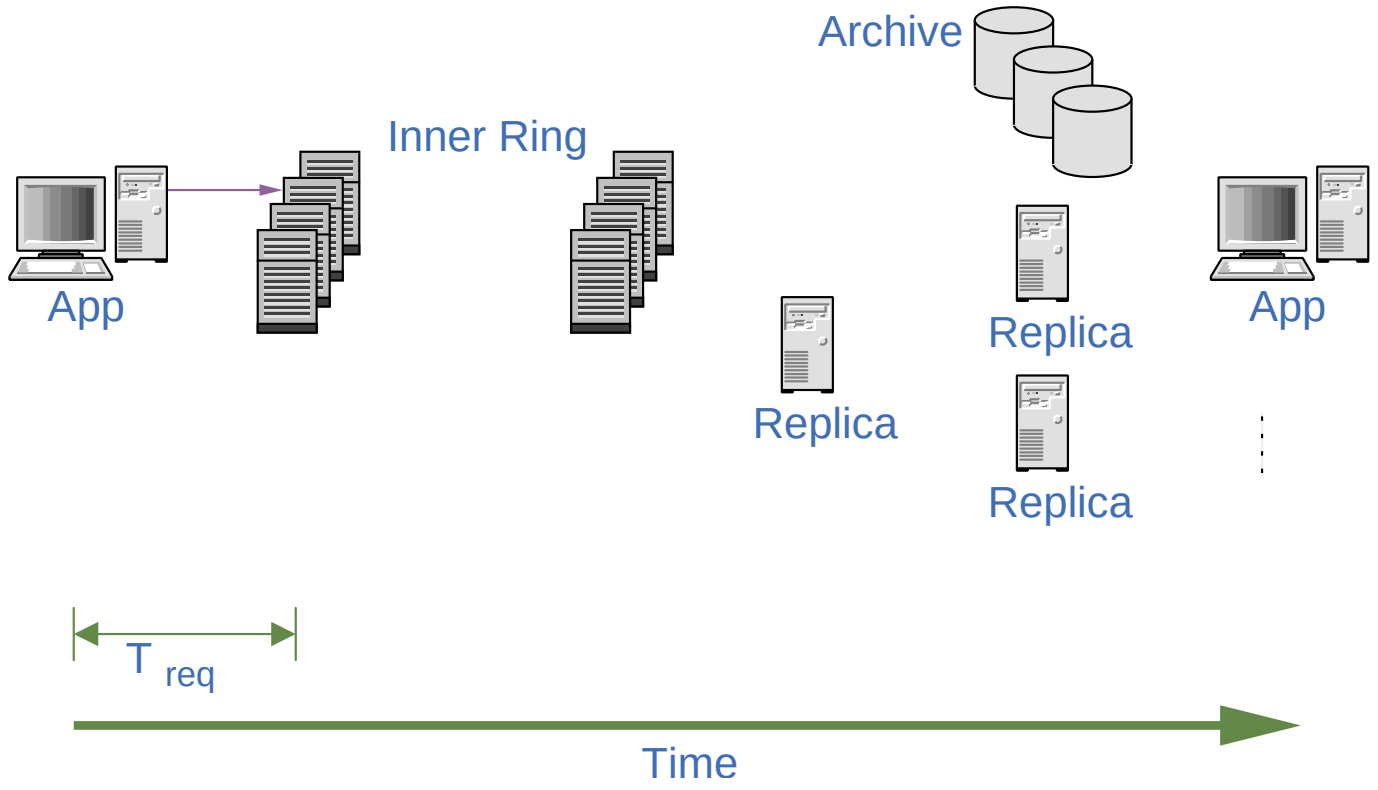
- The Client Machines
  - Create updates and send them to the inner ring
  - Wait for responses to come down the dissemination tree

Introduction: the OceanStore Write Path (con't)



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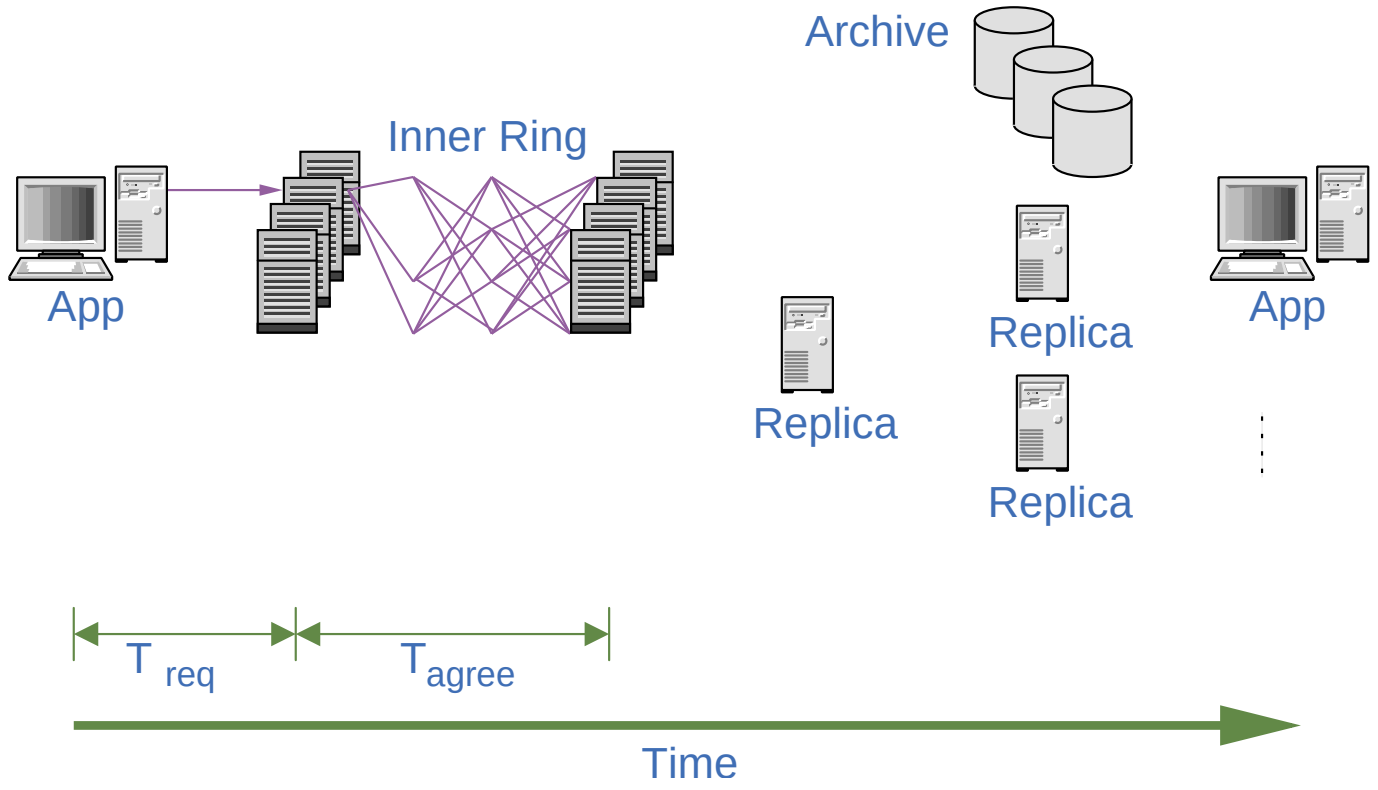

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2. *The inner ring performs a Byzantine agreement, applying the update*

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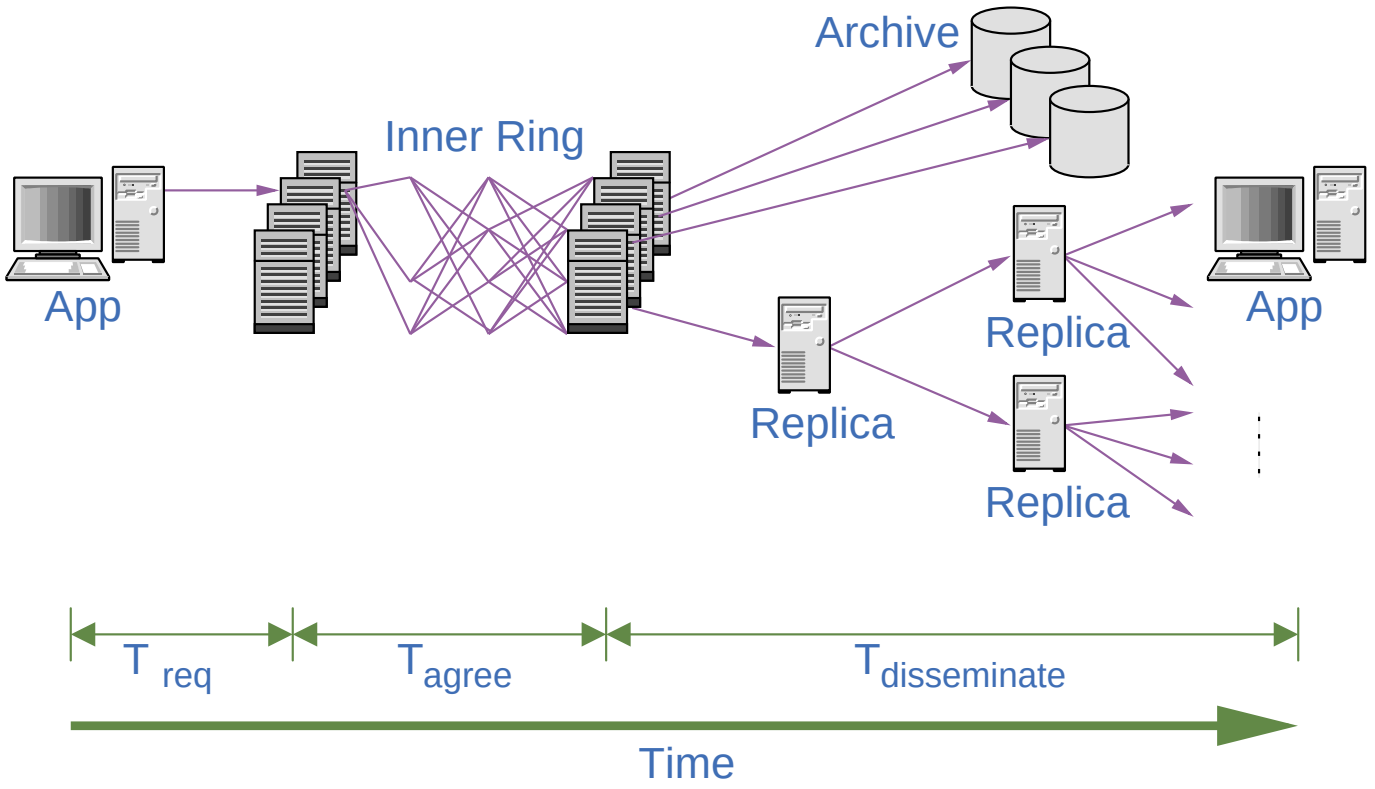

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3. *The results are sent down the dissemination tree and into the archive*

Write Path Details

- Inner Ring uses Byzantine agreement for fault tolerance
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- Inner Ring certifies decisions with proactive threshold signatures
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  - Each member has a *key share* which lets it generate *signature shares*
  - Need $f + 1$ signature shares to generate full signature
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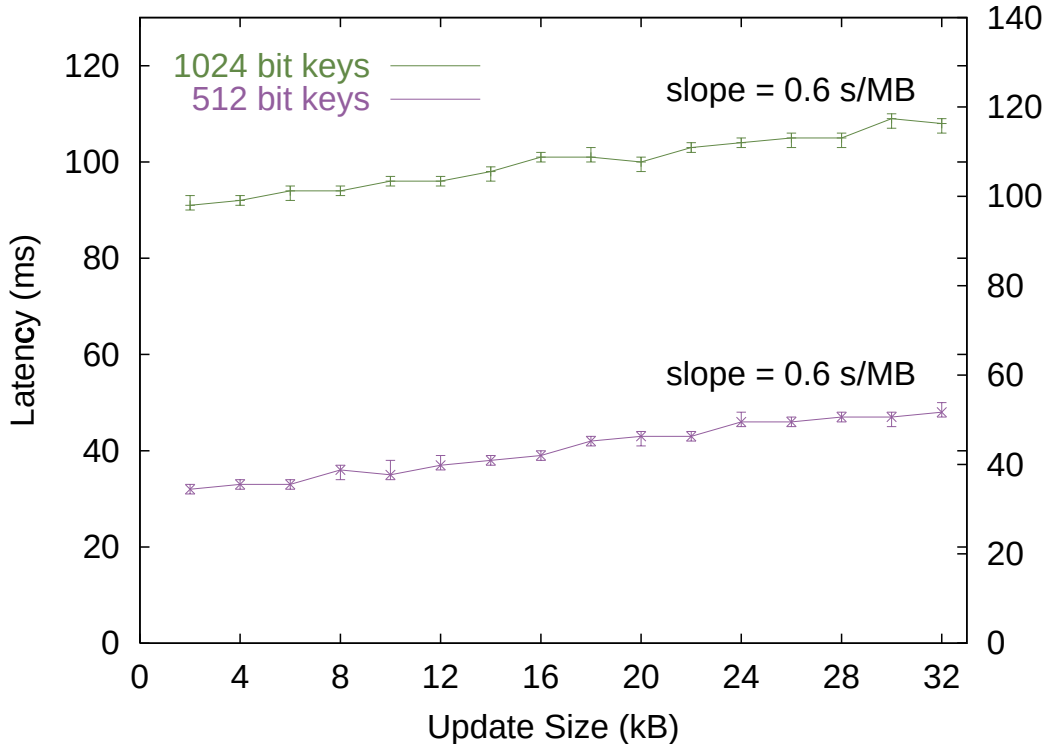
  - Independent sets of key shares can be used to control membership
- Second Tier and Archive are ignorant of composition of Inner Ring
  - Know only the single public key
  - Allows simple replacement of faulty Inner Ring servers

Micro Benchmarks: Update Latency vs. Update Size



- Use two key sizes to show effects of Moore's Law on latency
  - 512 bit keys are not secure, but are $4\times$ faster
  - Gives an upper bound on latency three years from now

Micro Benchmarks: Update Latency Remarks

- Threshold signatures are expensive
  - Takes 6.3 ms to generate regular 1024 bit signature
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  - (Combining shares takes less than 1 ms)

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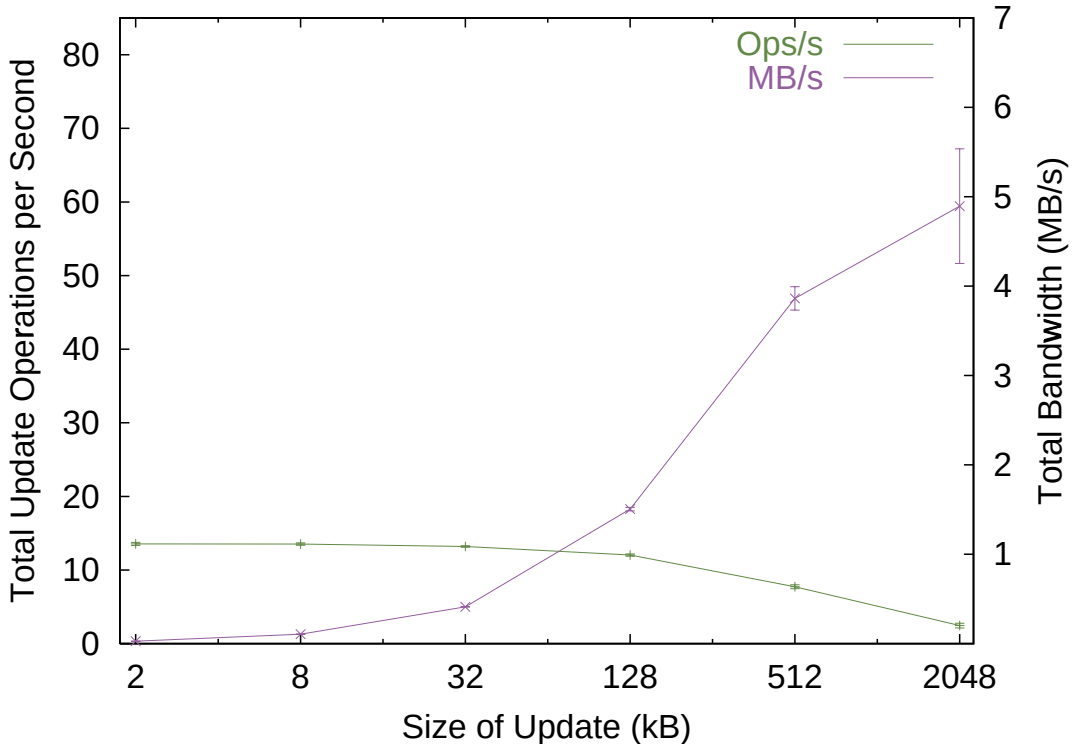
- Almost no research into performance of threshold cryptography

Micro Benchmarks: Throughput vs. Update Size



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- Max throughput is a respectable 5 MB/s
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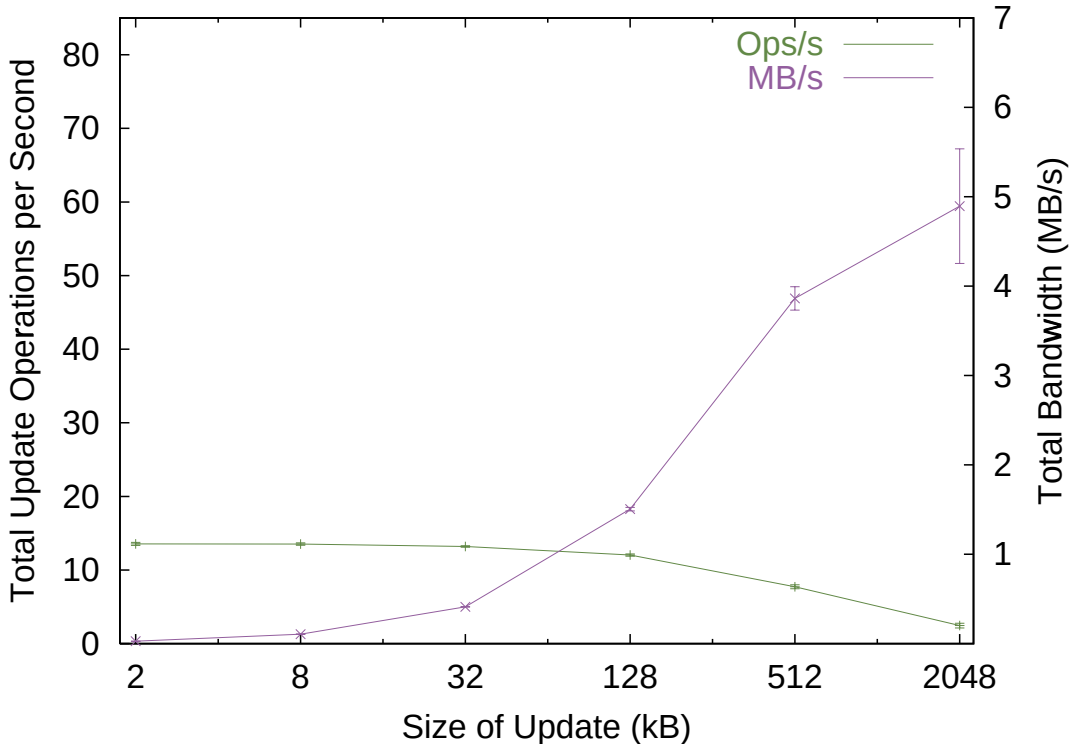

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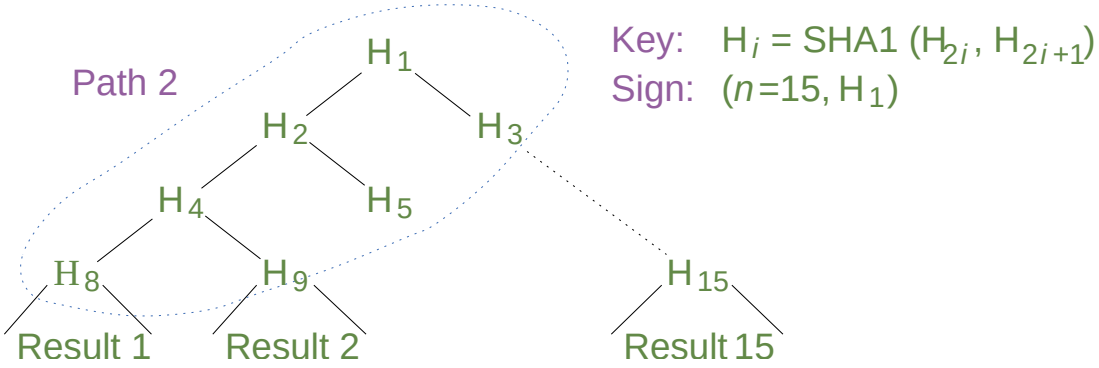
- But makes signatures unwieldy
  - Each signature is now $O(\text{batchsize})$ long
  - For high throughput, we want batch sizes in the hundreds or thousands

Merkle Trees: Making Batching Efficient



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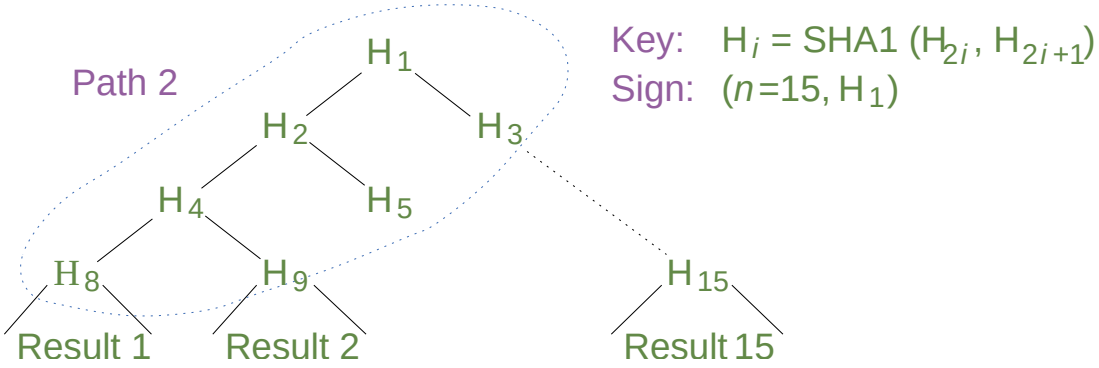

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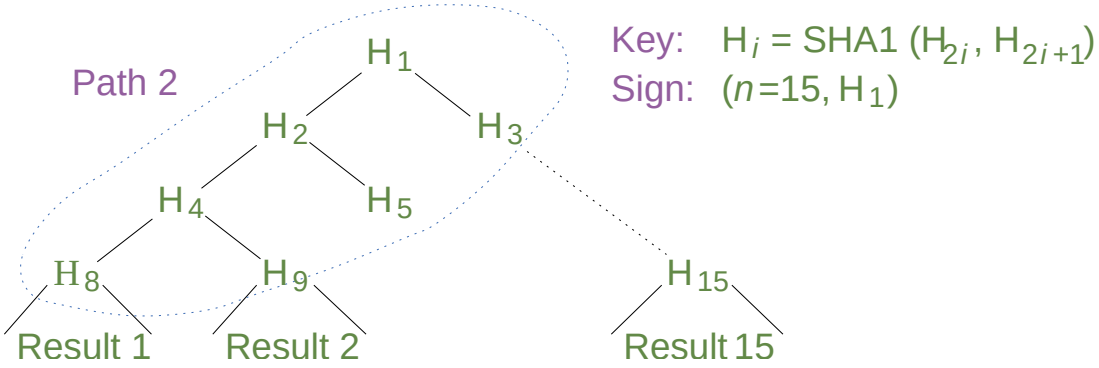

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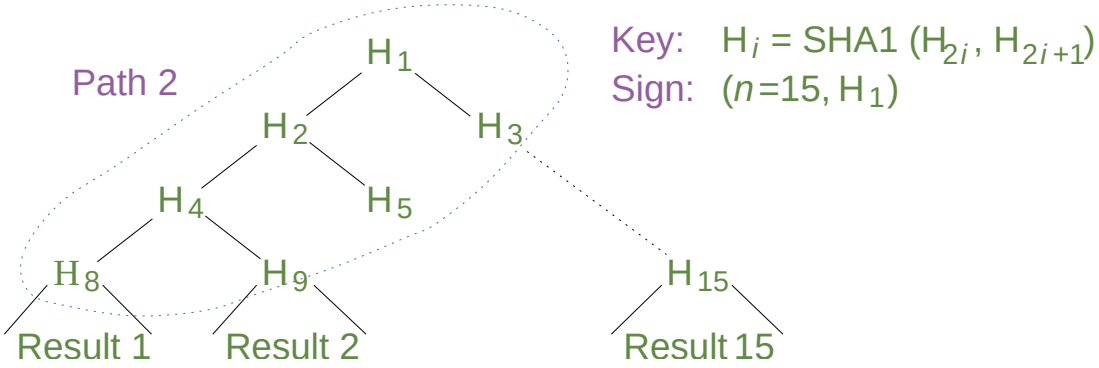

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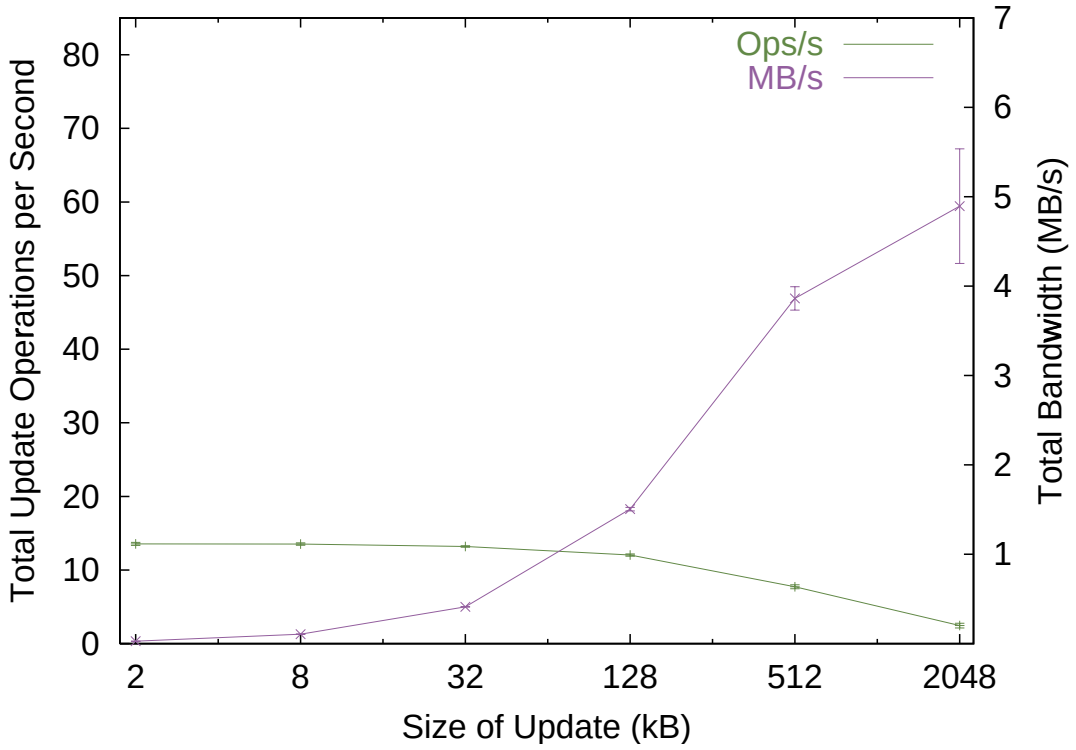

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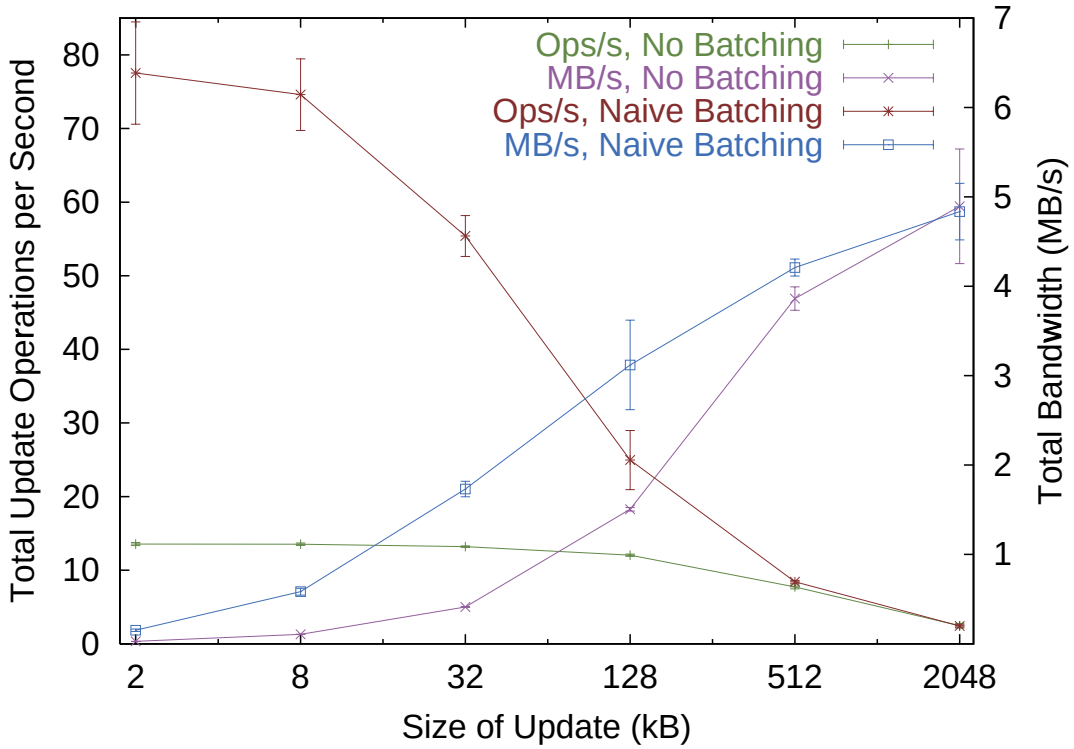

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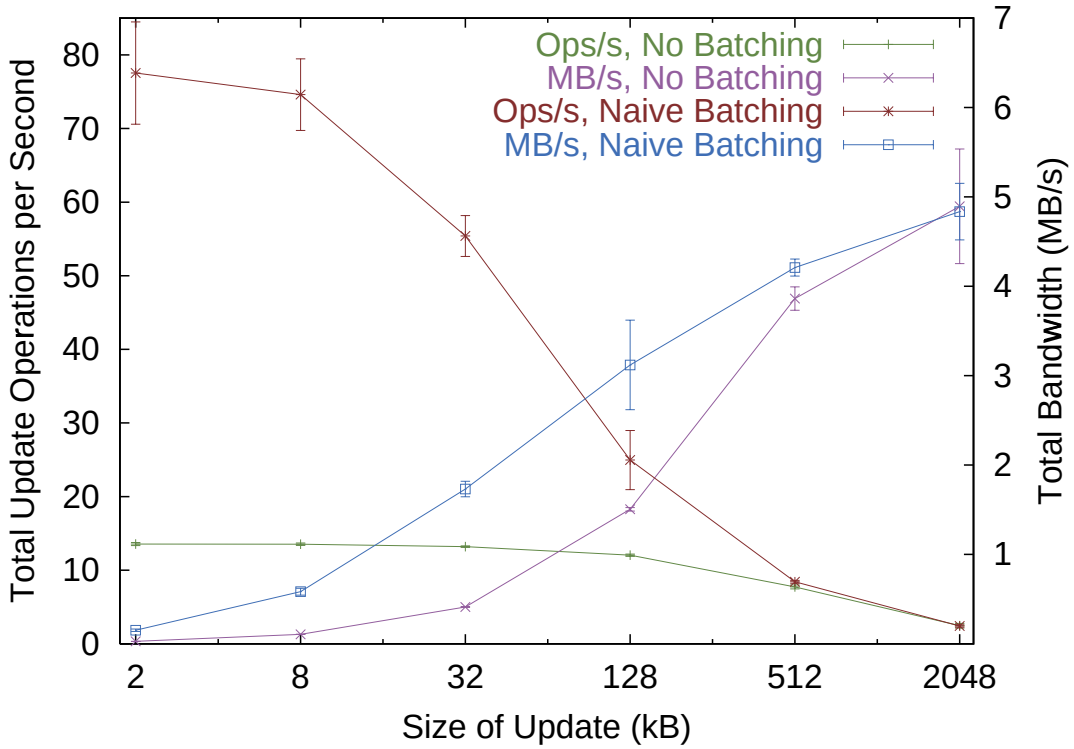

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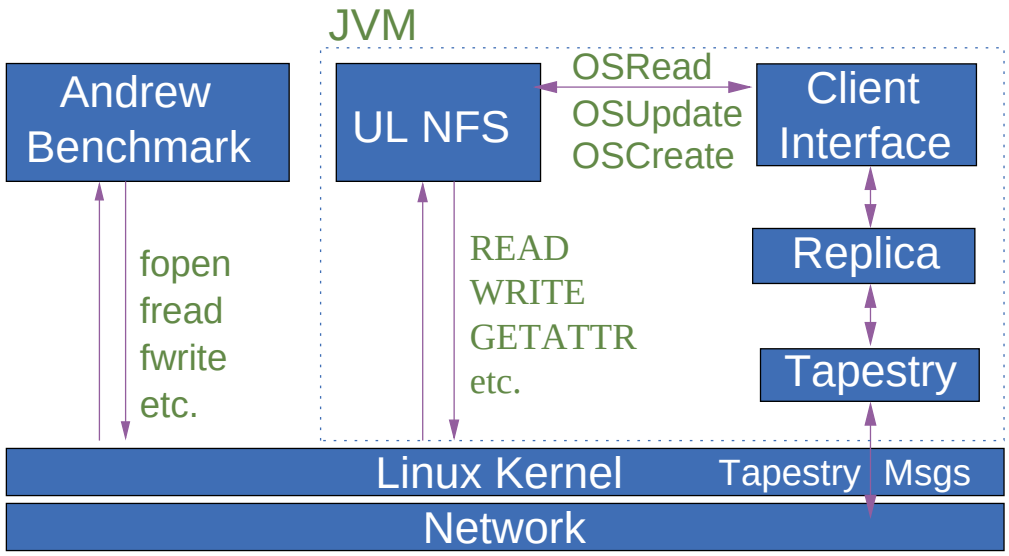
  - Introspecting on batch size should further improve small update tput

Macro Benchmarks: The Andrew Benchmark



- Built a UNIX file system on top of OceanStore
  - Runs as a user-level NFS daemon on Linux
  - Application's use familiar `fopen`, `fwrite`, etc. *No recompilation.*
  - Kernel translates to NFS requests and sends to local daemon
  - Daemon translates to OceanStore requests and sends out on network

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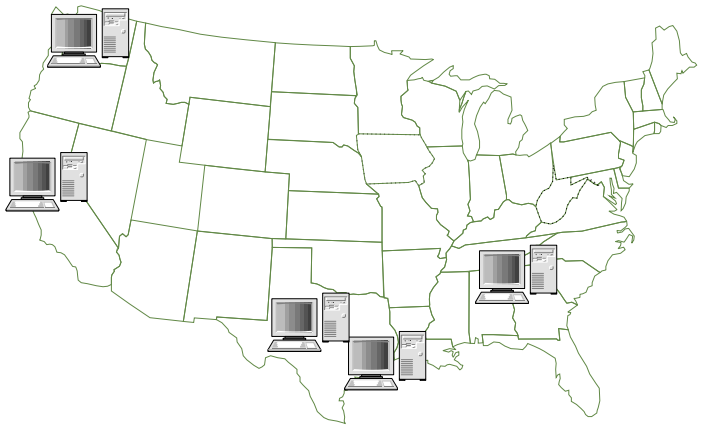

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Source	U. TX	GA Tech	Rice	UW
UCB	45.3 (0.75)	56.5 (0.14)	49.6 (3.1)	20.0 (0.11)
UTA	–	24.1 (0.49)	8.45 (1.5)	61.7 (0.22)
GA Tech	–	–	27.7 (2.2)	59.0 (0.20)
Rice	–	–	–	61.5 (0.69)

Inter-host ping times in milliseconds

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  - Find out whether Byzantine agreement is practical in wide area
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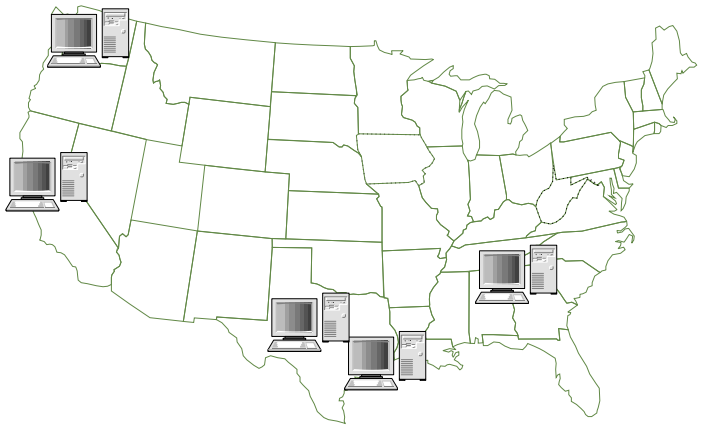

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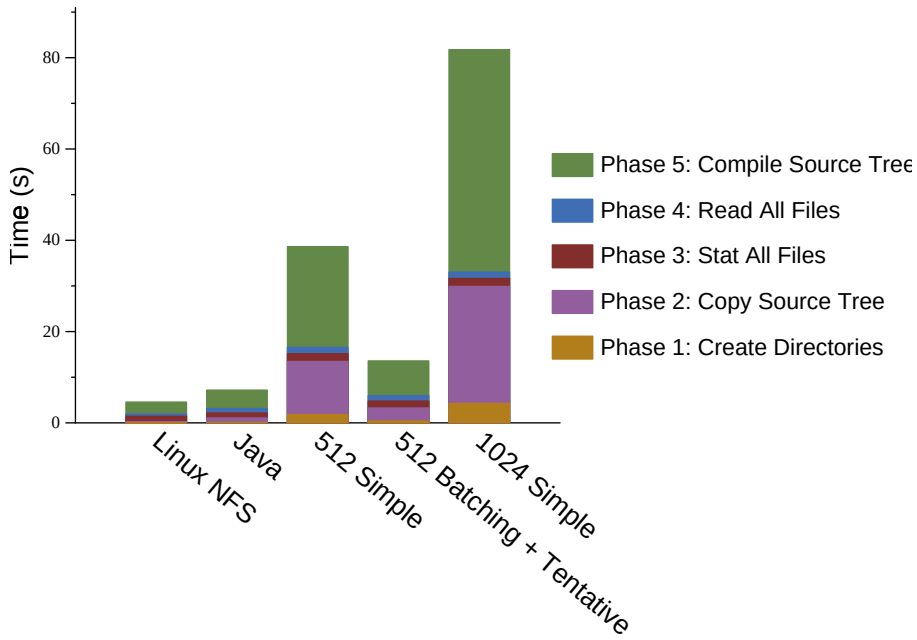
- Ran the Andrew Benchmark
  - Simulates software development workload
- For control, used several competitors
  - Linux user-level NFS daemon: real NFS, ships with Debian GNU/Linux
  - Java-based user-level NFS daemon: uses disk (not OceanStore)

Macro Benchmarks: Local Andrew



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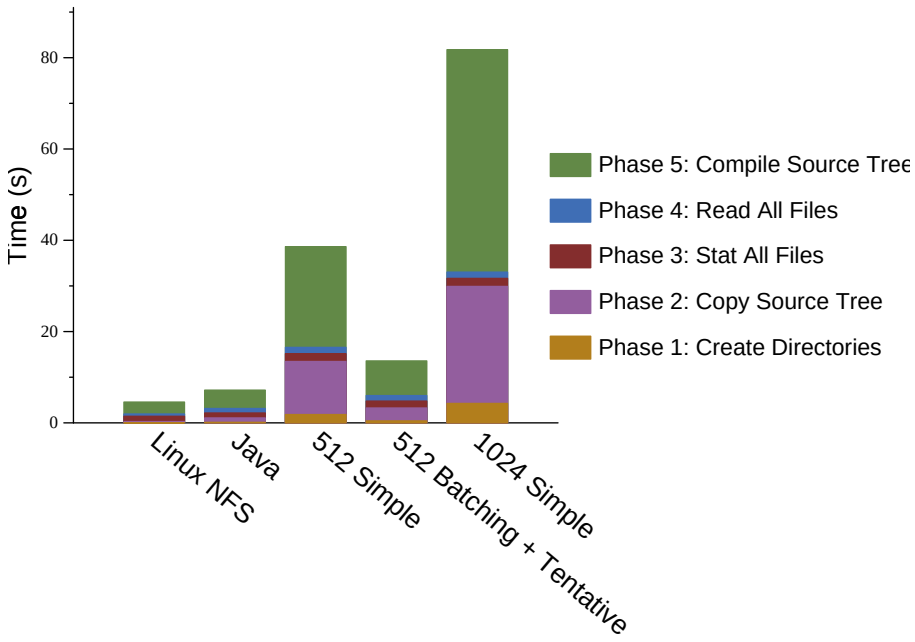
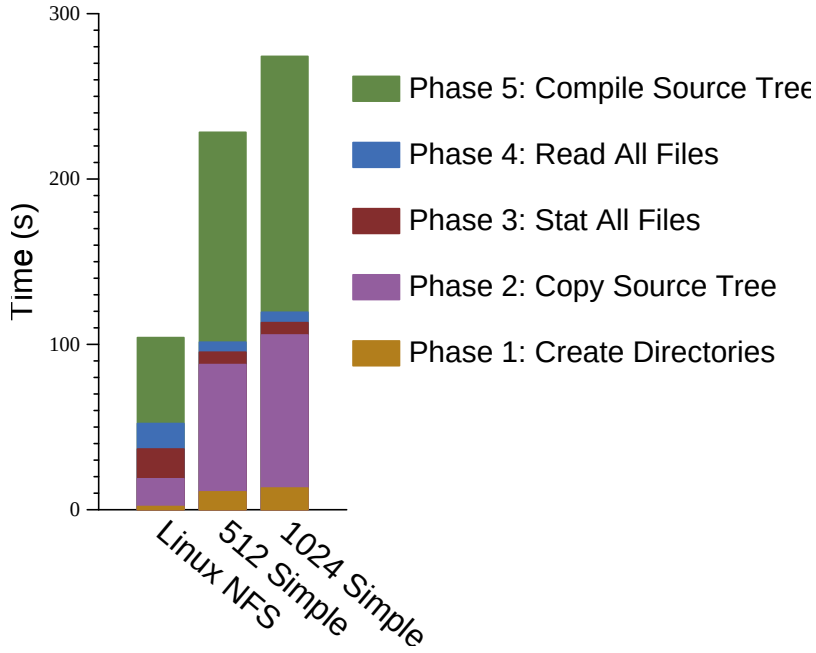


- Simple OceanStore performance not so hot
  - In the local area, *NFS is in its element*; OceanStore isn't
- But with tentative update support and batching, OceanStore pretty good
  - Tentative updates let client go on while waiting for agreements
  - Batching allows inner ring to keep up
  - *Within a factor of two of Java-based NFS*

Macro Benchmarks: Nationwide Andrew



- In the wide area, *OceanStore is its element*; NFS isn't
  - Even simple OceanStore is nearly within a factor of two
  - Numbers with batching and tentative updates forthcoming
  - Should outperform NFS

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  - Batching allows inner ring to amortize signatures over many updates
    - *Get large update throughput with small updates*
    - Secure and space-efficient
- Provides a lot more functionality than competition
  - Higher durability and availability than NFS
  - Cryptographic data integrity
  - Versioning allows logical "undo"