Stout
An Adaptive Interface to Scalable Cloud Storage

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UC San Diego

Microsoft Research[†]

June 23, 2010

Scalable Multi-tiered Services

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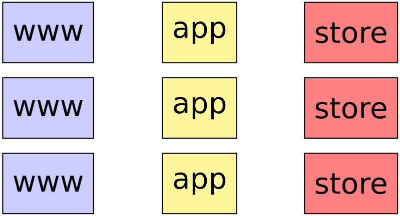

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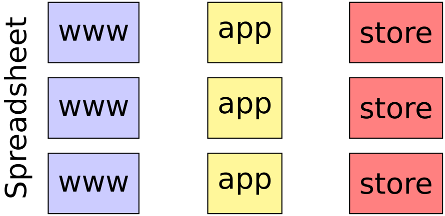

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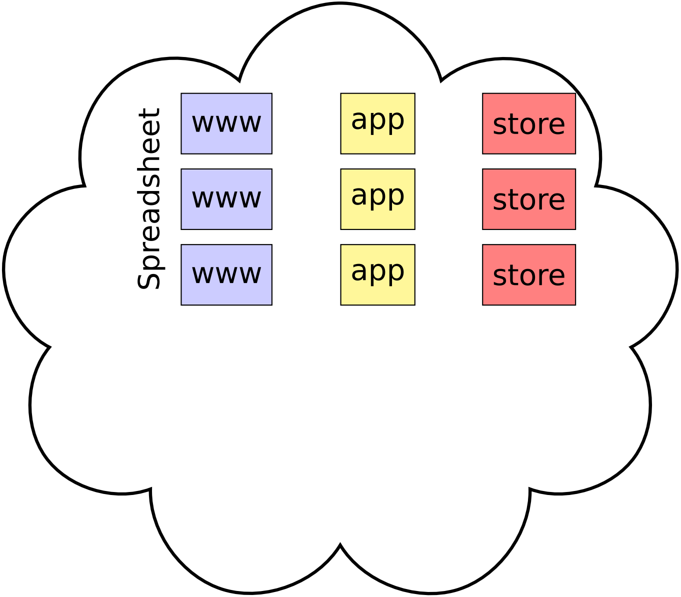

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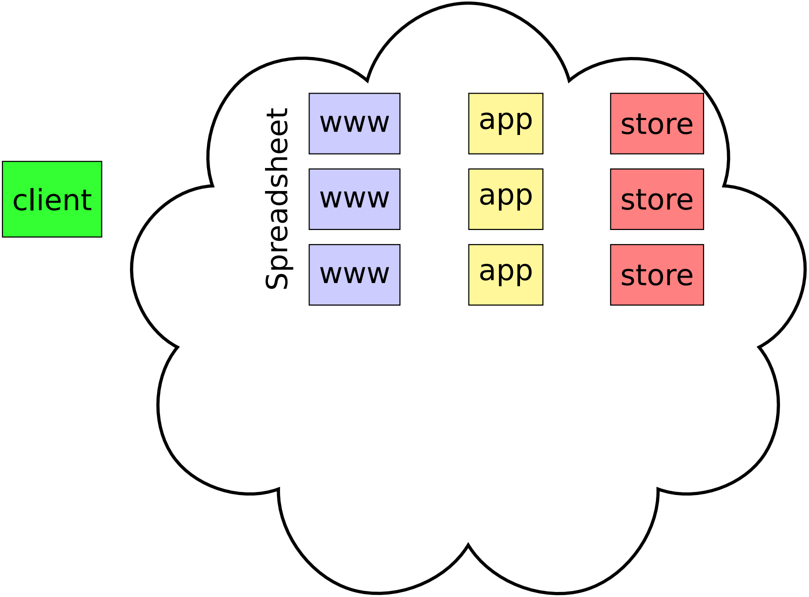

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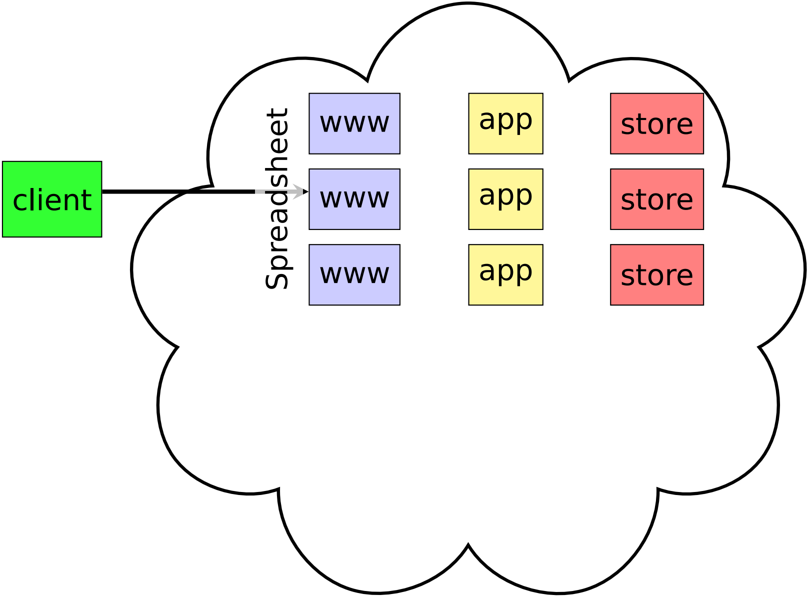

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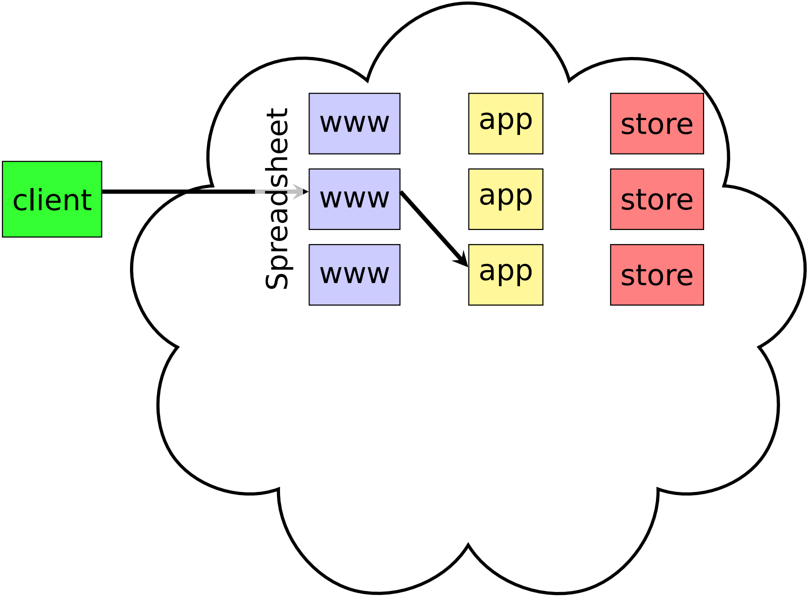

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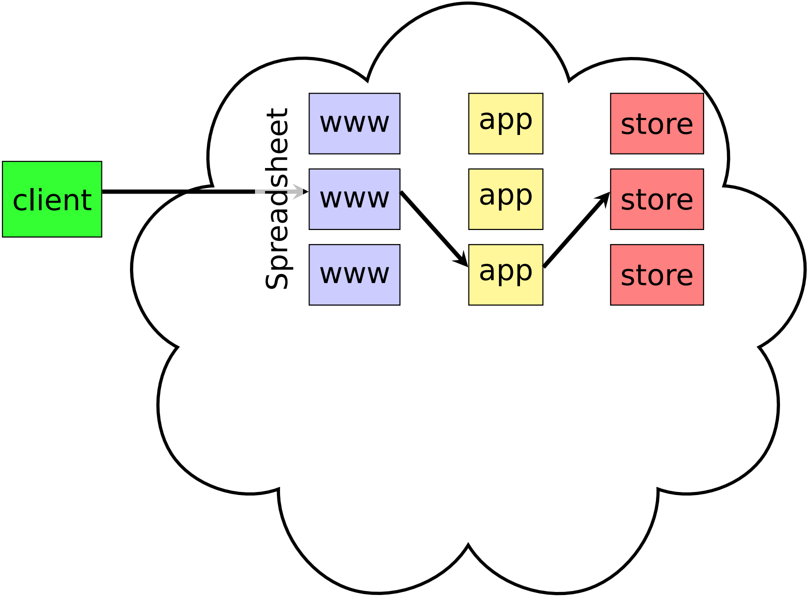

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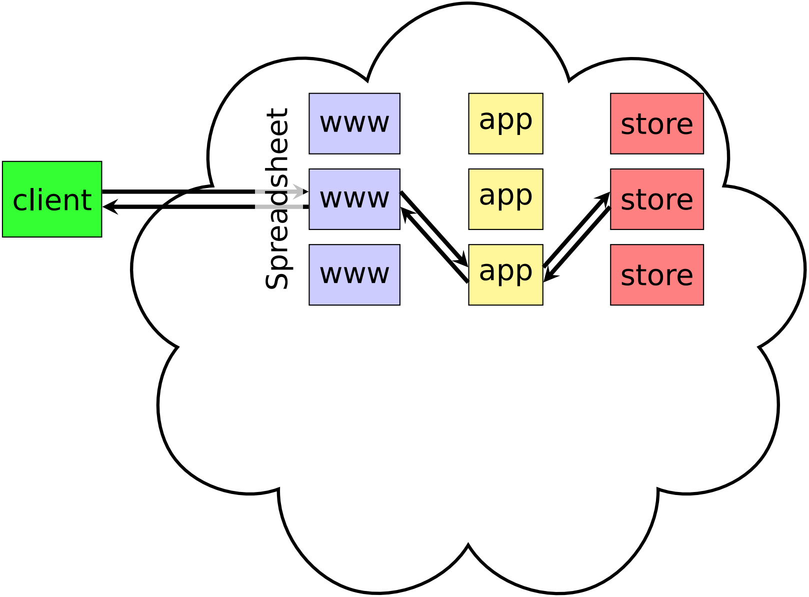

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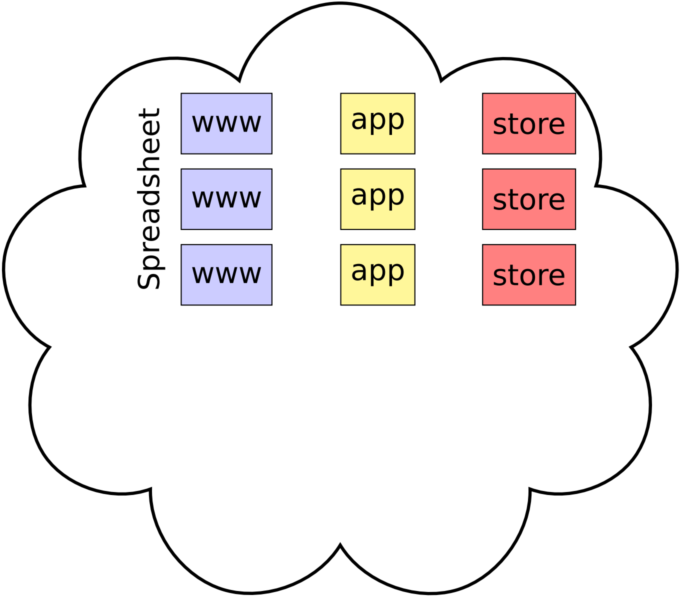

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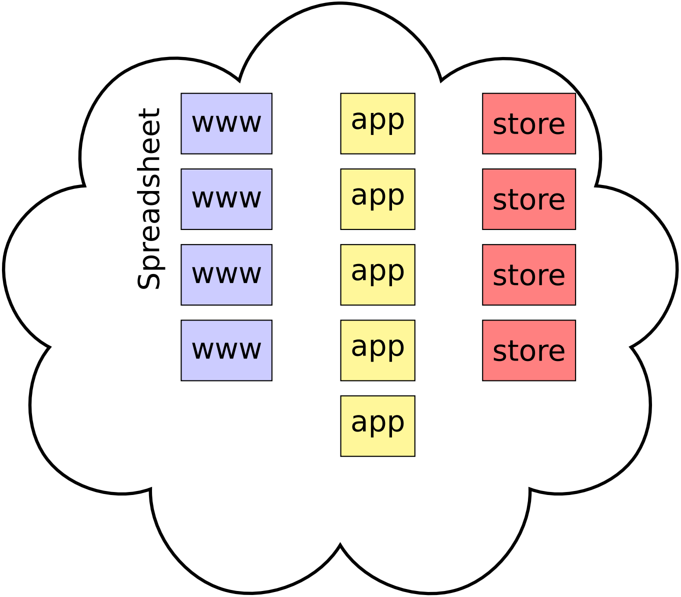

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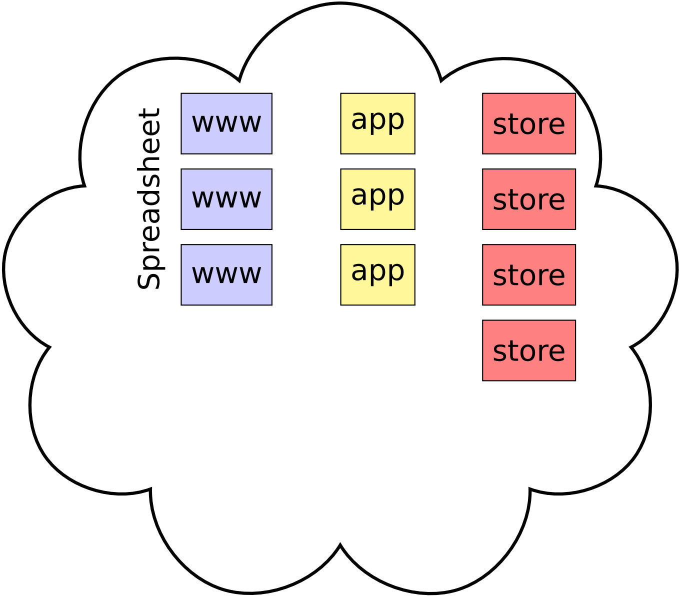

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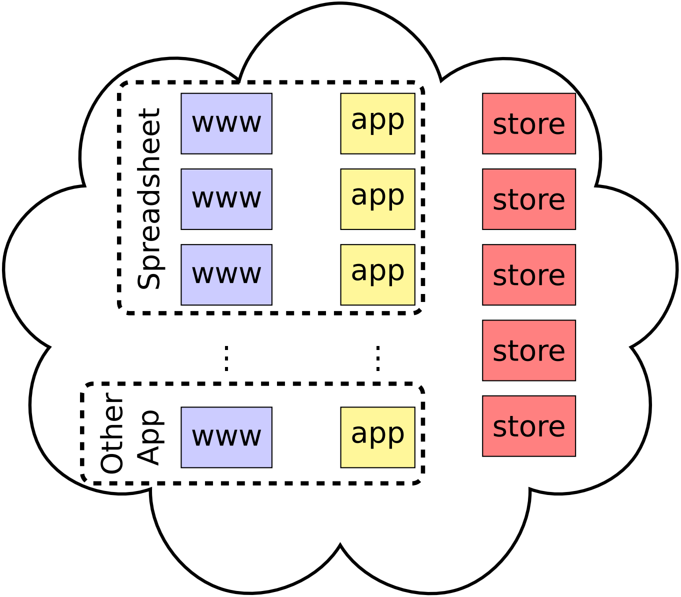

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- Simple interface
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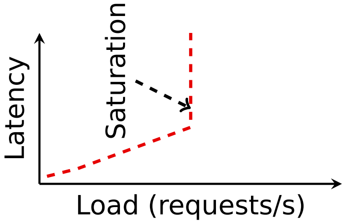

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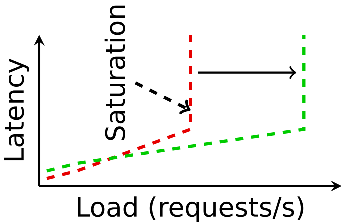
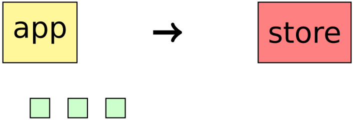


Improving Performance Under Load



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  - Disk seeks
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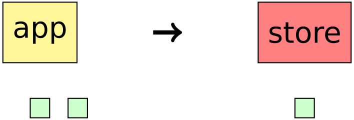

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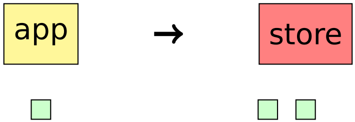

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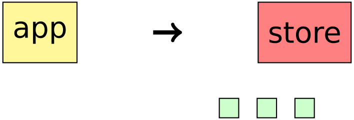

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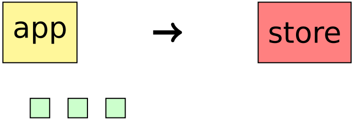

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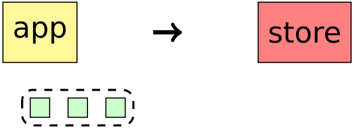

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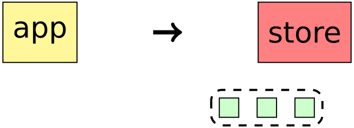

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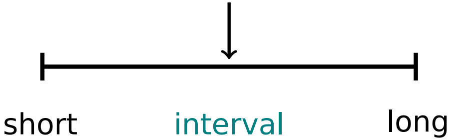

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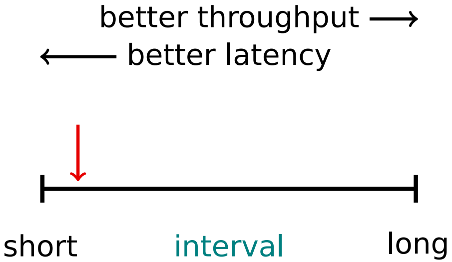

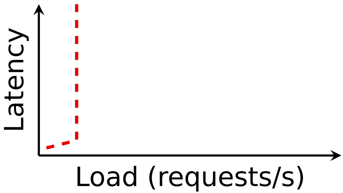

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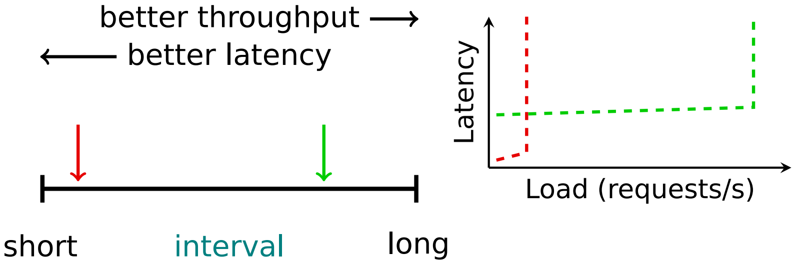

Selecting a Batching Interval

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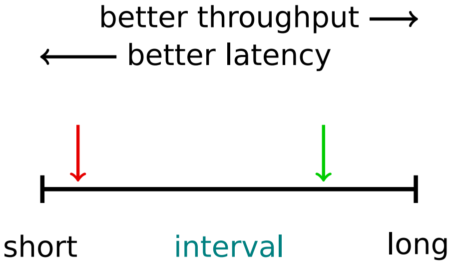
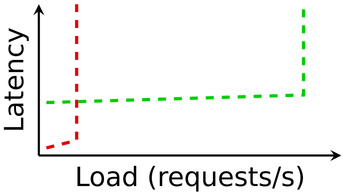
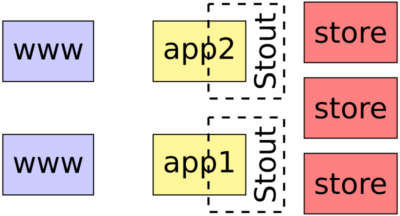
- Latency/throughput tradeoff
- Want flexible batching interval
  - Short when lightly loaded
  - Long when heavily loaded





Solution: Stout

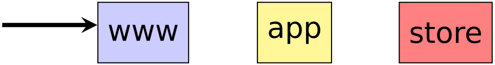


- Stout is a storage interposition library
- Our contribution is a technique for independently adjusting the batching interval

Outline

1. Introduction
2. Application Structure
3. Adaptive Batching
4. Evaluation

Overlapped Request Processing



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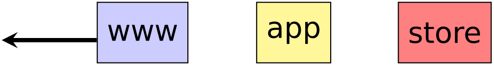


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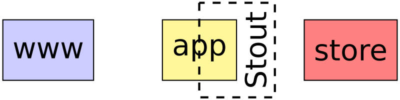


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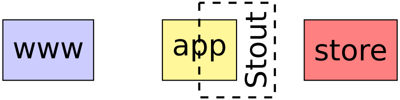


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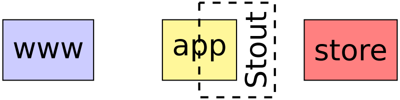


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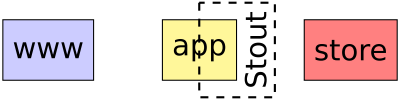


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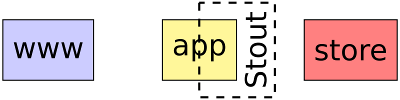


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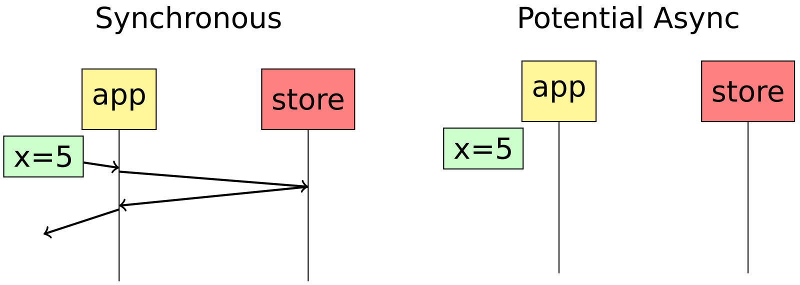

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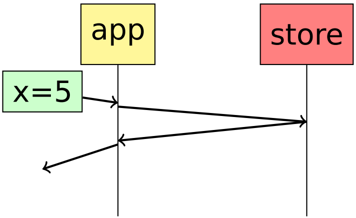

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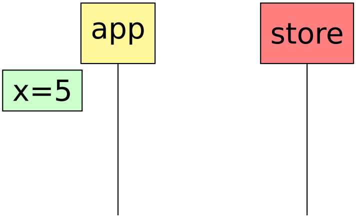

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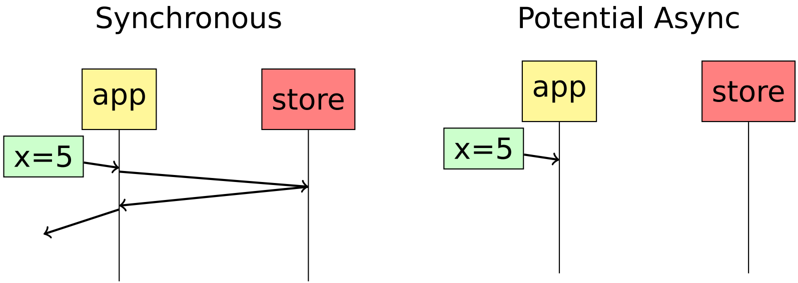

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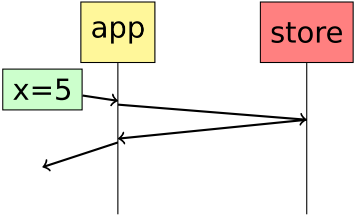

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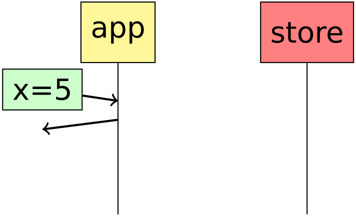

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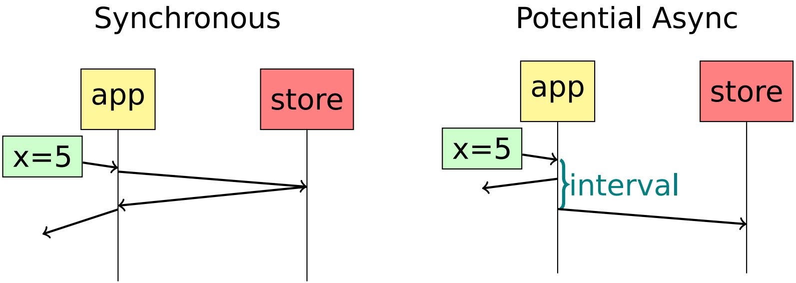

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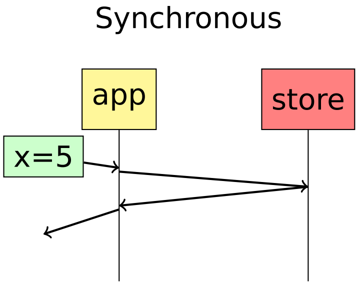

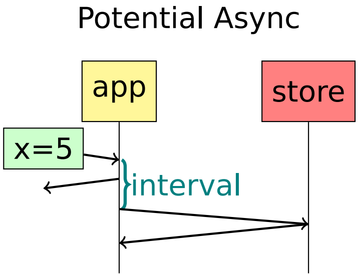

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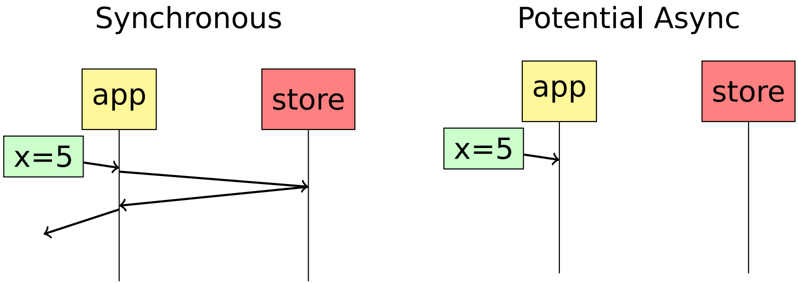

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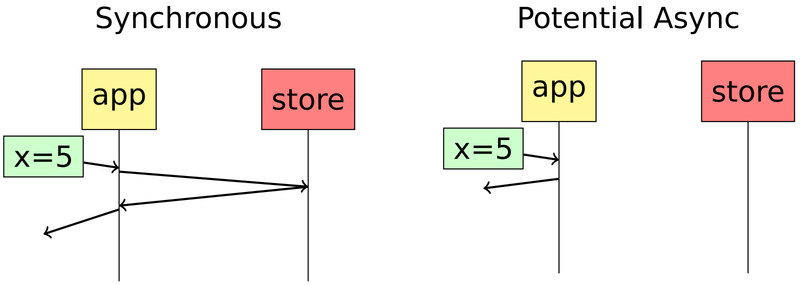

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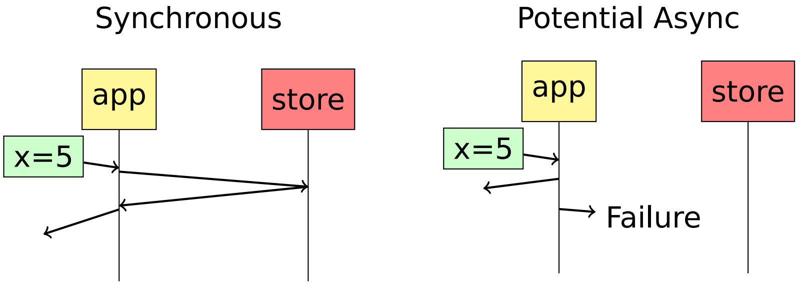

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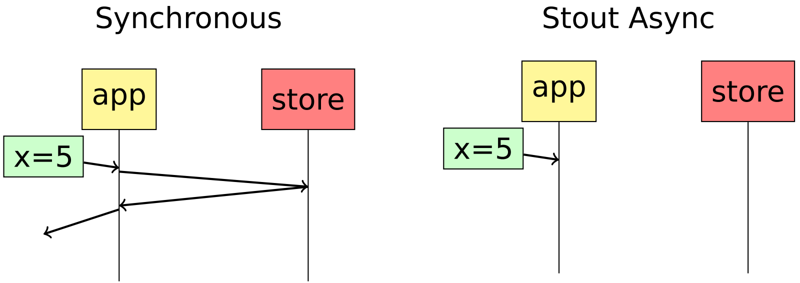

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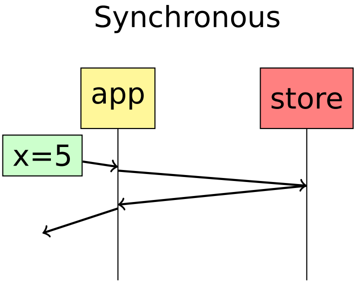

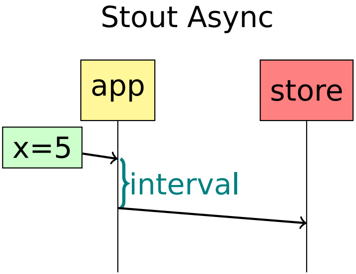

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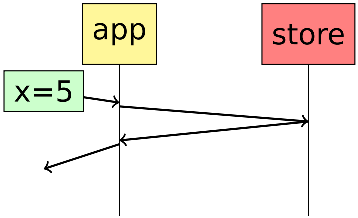
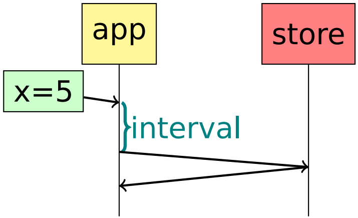


Stout Async



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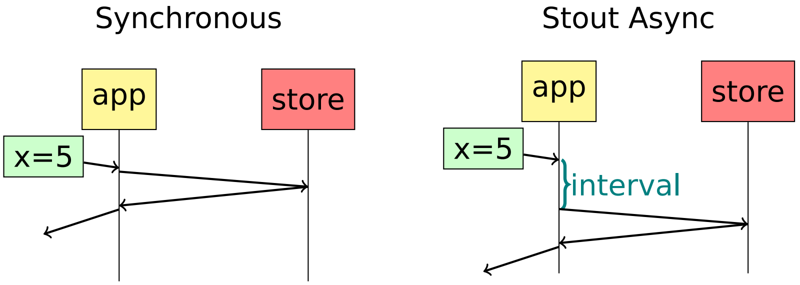

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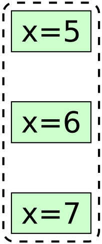
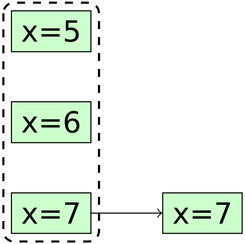


Benefit: Write Collapsing

- Batched commits enable further optimization
- Can write most recent version only
- Reduces load at the store

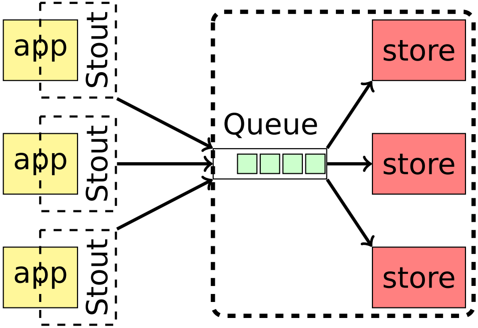


Outline

1. Introduction
2. Application Structure
3. Adaptive Batching
4. Evaluation

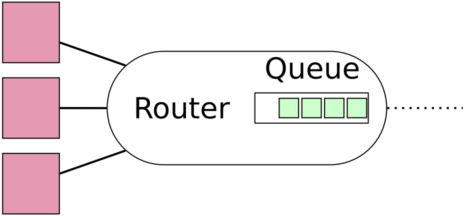
Adapting to Shared Storage

- Storage system is a shared medium
- Independently reach efficient fair share
- Delay as congestion indicator
  - Rather than modifying storage for explicit notification



Delay-based Congestion Control

- Unknown bottleneck capacity
- Traditional TCP signaled via packet loss
- Delay-based congestion control triggered by latency changes



Applications to Storage

	Networking	Storage
Mechanism	Change Rate	Change Size
ACCELERATE	Send Faster	Batch Less
BACK-OFF	Send Slower	Batch More

Algorithm

if perf < recent perf

    BACK-OFF

else

    ACCELERATE

Algorithm: Estimating Storage Performance

if perf < recent perf

  BACK-OFF

else

  ACCELERATE

$$\frac{\text{batch size}}{\mathit{latency} + \text{interval}}$$

Algorithm: Estimating Storage Capacity

if perf < recent perf

BACK-OFF

else

ACCELERATE

if backed-off

$$\frac{EWMA(\text{batch size}_i)}{EWMA(lat_i) + EWMA(\text{interval}_i)}$$

else // accelerated

$$MAX_i\left(\frac{\text{batch size}_i}{lat_i + \text{interval}_i}\right)$$

Algorithm: Achieving Fair Share

if perf < recent perf

  BACK-OFF

else

  ACCELERATE

Algorithm: Achieving Fair Share

if perf < recent perf

BACK-OFF $\longrightarrow (1+\alpha) * \text{interval}_i$

else

ACCELERATE

Algorithm: Achieving Fair Share

if perf < recent perf

BACK-OFF $\longrightarrow (1 + \alpha) * \text{interval}_i$

else

ACCELERATE $\longrightarrow (1 - \beta) * \text{interval}_i + \beta * \sqrt{\text{interval}_i}$

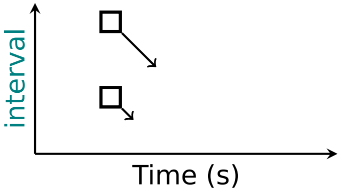
Algorithm: Achieving Fair Share

if perf < recent perf

BACK-OFF $\longrightarrow (1+\alpha) * \text{interval}_i$

else

ACCELERATE $\longrightarrow (1-\beta) * \text{interval}_i + \beta * \sqrt{\text{interval}_i}$



Outline

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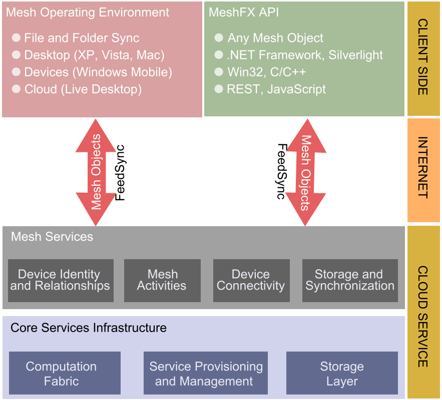
Evaluation

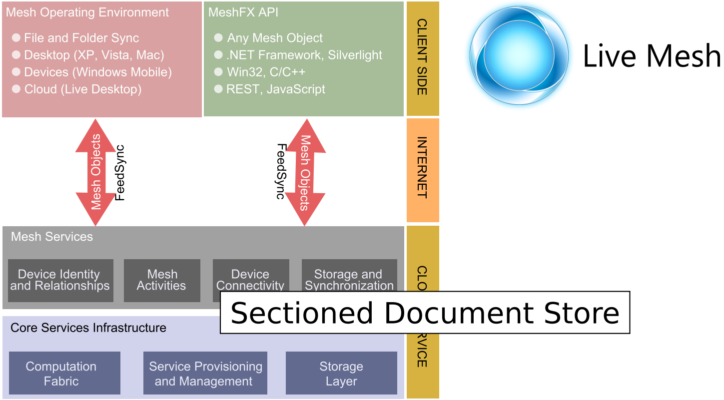
- Baseline Storage System Performance
  - Benefits of batching
  - Benefits of write-collapsing
- Stout
  - Versus fixed batching intervals
  - Workload variation

Evaluation



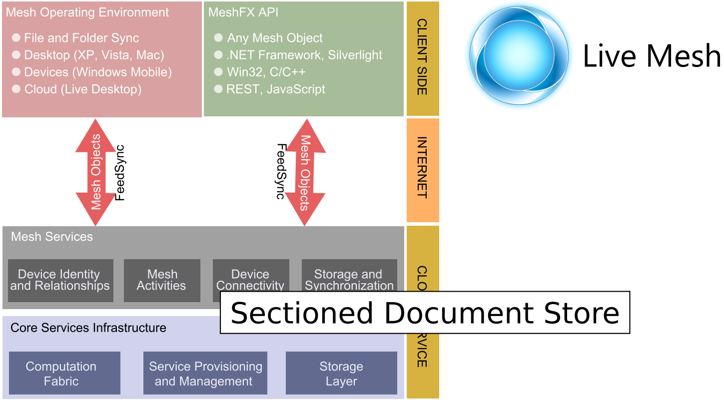
Live Mesh

Evaluation



Mesh Operating Environment
File and Folder Sync
Desktop (XP, Vista, Mac)
Devices (Windows Mobile)
Cloud (Live Desktop)
MeshFX API
Any Mesh Object
.NET Framework, Silverlight
Win32, C/C++
REST, JavaScript
CLIENT SIDE
Mesh Objects
FeedSync
FeedSync
Mesh Objects
INTERNET
Mesh Services
Device Identity and Relationships
Mesh Activities
Device Connectivity
Storage and Synchronization
Core Services Infrastructure
Computation Fabric
Service Provisioning and Management
Storage Layer
Sectioned Document Store
Live Mesh

Evaluation



Our Workload

- 256-byte documents: IOPS dominated
- 50% read, 50% write

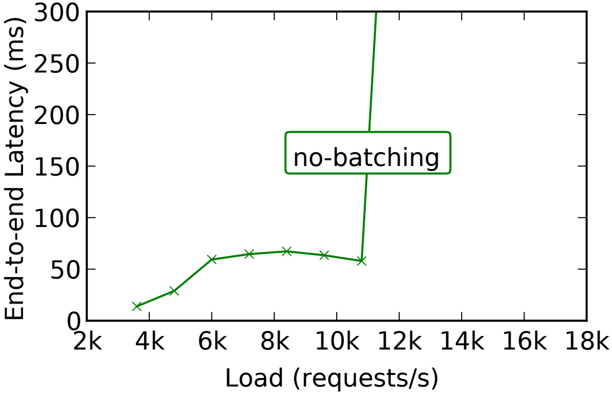
Evaluation: Configuration

Evaluation Platform

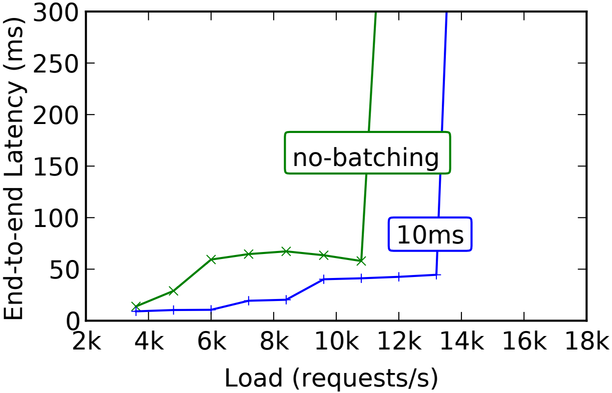
- 50 machines
  - 1 Experiment Controller
  - 1 Lease Manager
  - 12 Frontends
  - 32 Middle Tiers
  - 4 Storage (Partitioned Key-Value w/MSSQL as storage)

12× www 32× app 4× store

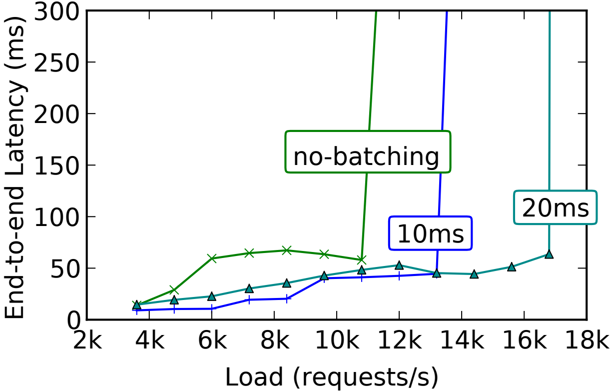
Baseline: Importance of Batching



Baseline: Importance of Batching

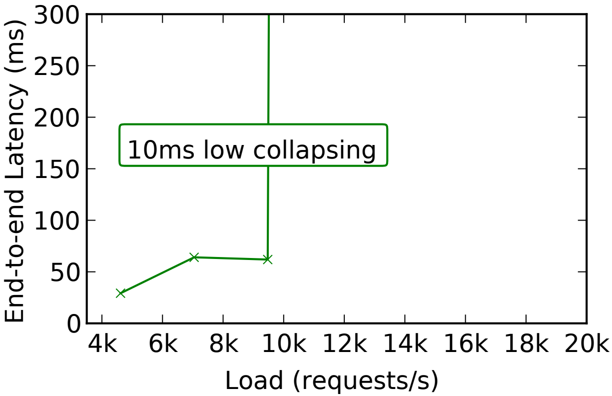


Baseline: Importance of Batching



- Batching improves performance

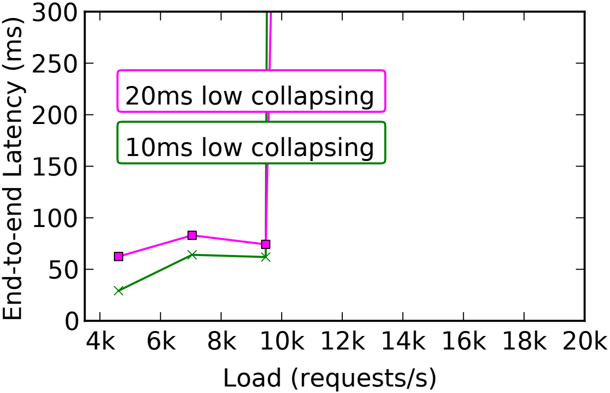
Baseline: Importance of Write-Collapsing



Low collapsing 10k Documents

High collapsing 100 Documents

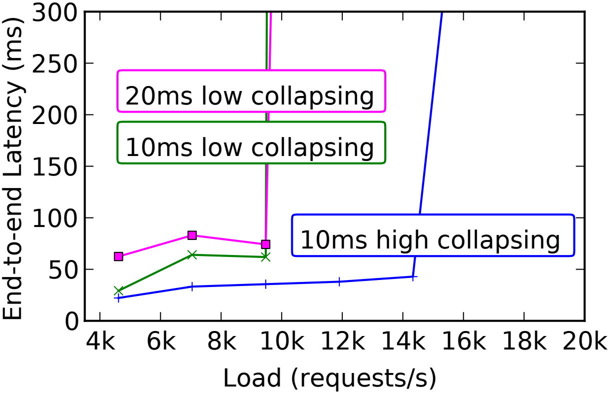
Baseline: Importance of Write-Collapsing



Low collapsing 10k Documents

High collapsing 100 Documents

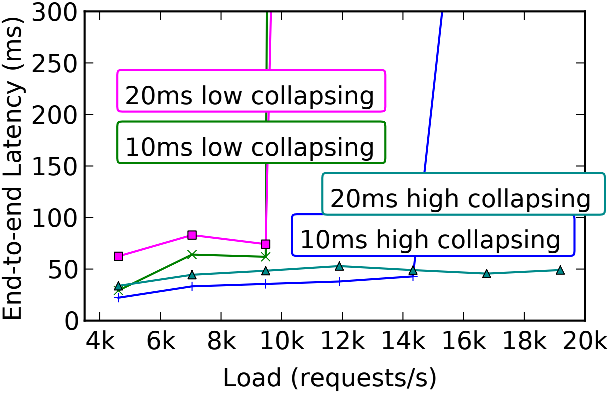
Baseline: Importance of Write-Collapsing



Low collapsing 10k Documents

High collapsing 100 Documents

Baseline: Importance of Write-Collapsing

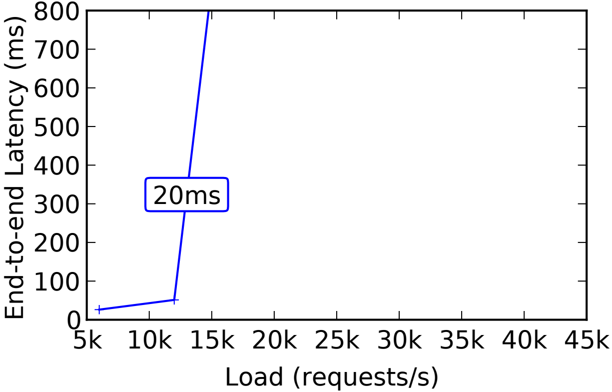


Low collapsing 10k Documents

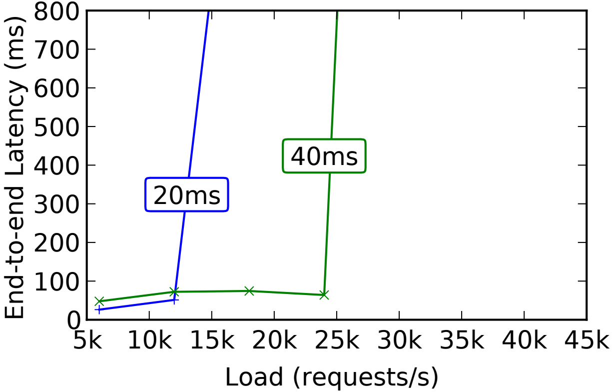
High collapsing 100 Documents

- Improvement dependent on workload

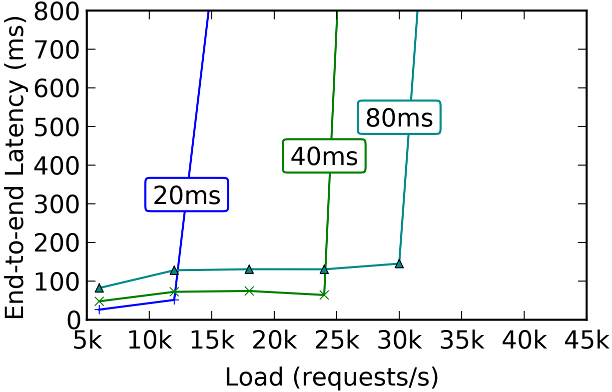
Evaluation: Stout vs. Fixed Intervals



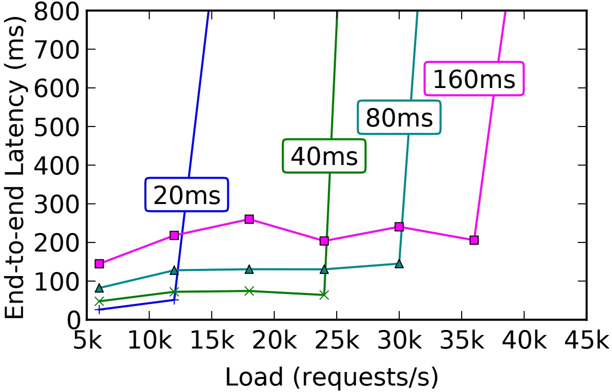
Evaluation: Stout vs. Fixed Intervals



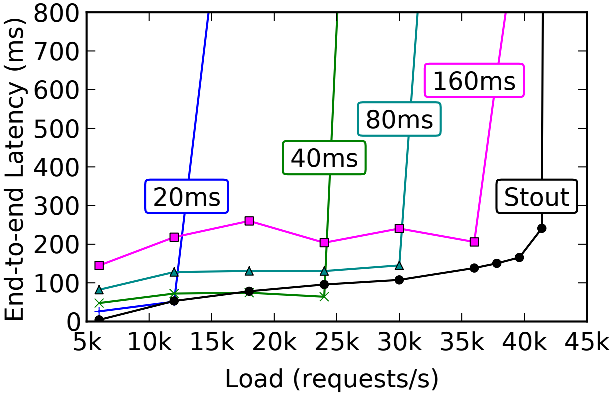
Evaluation: Stout vs. Fixed Intervals



Evaluation: Stout vs. Fixed Intervals

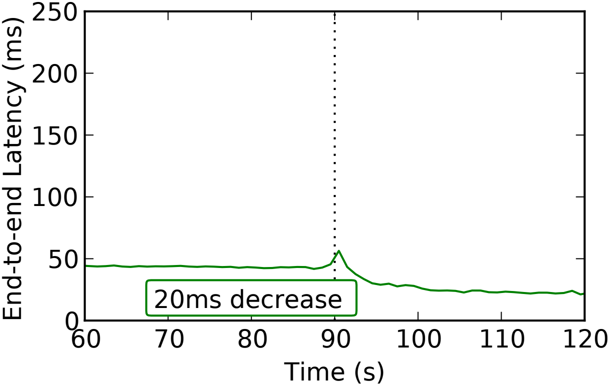


Evaluation: Stout vs. Fixed Intervals



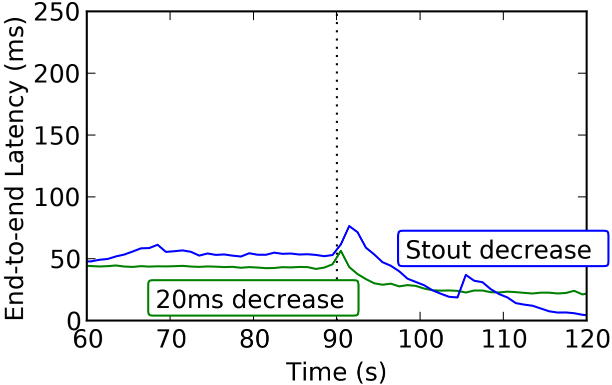
- Stout better than any fixed interval across wide range of workloads

Evaluation: Workload Variation



Decrease	12k requests/s → 8k requests/s
Increase	12k requests/s → 18k requests/s

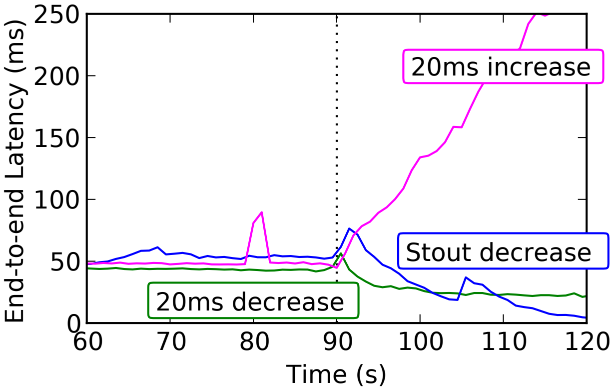
Evaluation: Workload Variation



Decrease 12k requests/s → 8k requests/s

Increase 12k requests/s → 18k requests/s

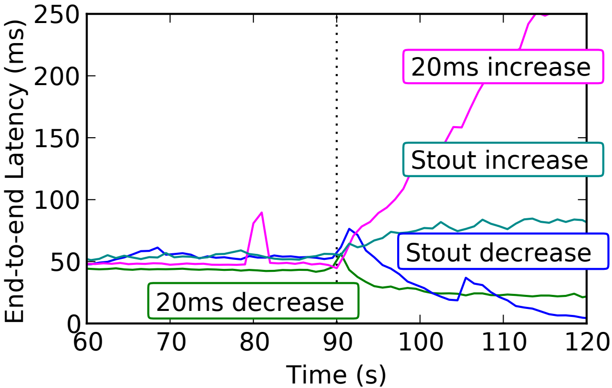
Evaluation: Workload Variation



Decrease 12k requests/s → 8k requests/s

Increase 12k requests/s → 18k requests/s

Evaluation: Workload Variation



Decrease 12k requests/s → 8k requests/s

Increase 12k requests/s → 18k requests/s

Additional Evaluation

- Fairness (Jain's Fairness index of 0.96)
- Stout achieves similar performance with:
  - PacificA
  - SQL Data Services

Conclusion

- Batching improves storage performance
- Current practice is fixed latency/throughput tradeoff
- Stout introduces distributed adaptation technique
- Achieve 3× higher throughput over low-latency fixed interval for modified Live Mesh service

Questions?