Architecture for Caching Responses with Multiple Dynamic Dependencies in Multi-Tier Data-Centers over InfiniBand

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Presentation Outline

- Introduction/Motivation
- Design and Implementation
- Experimental Results
- Conclusions

Introduction

- Fast Internet Growth
  - Number of Users
  - Amount of data
  - Types of services
- Several uses
  - E-Commerce, Online Banking, Online Auctions, etc
- Web Server Scalability
  - Multi-Tier Data-Centers
  - Caching – An Important Technique

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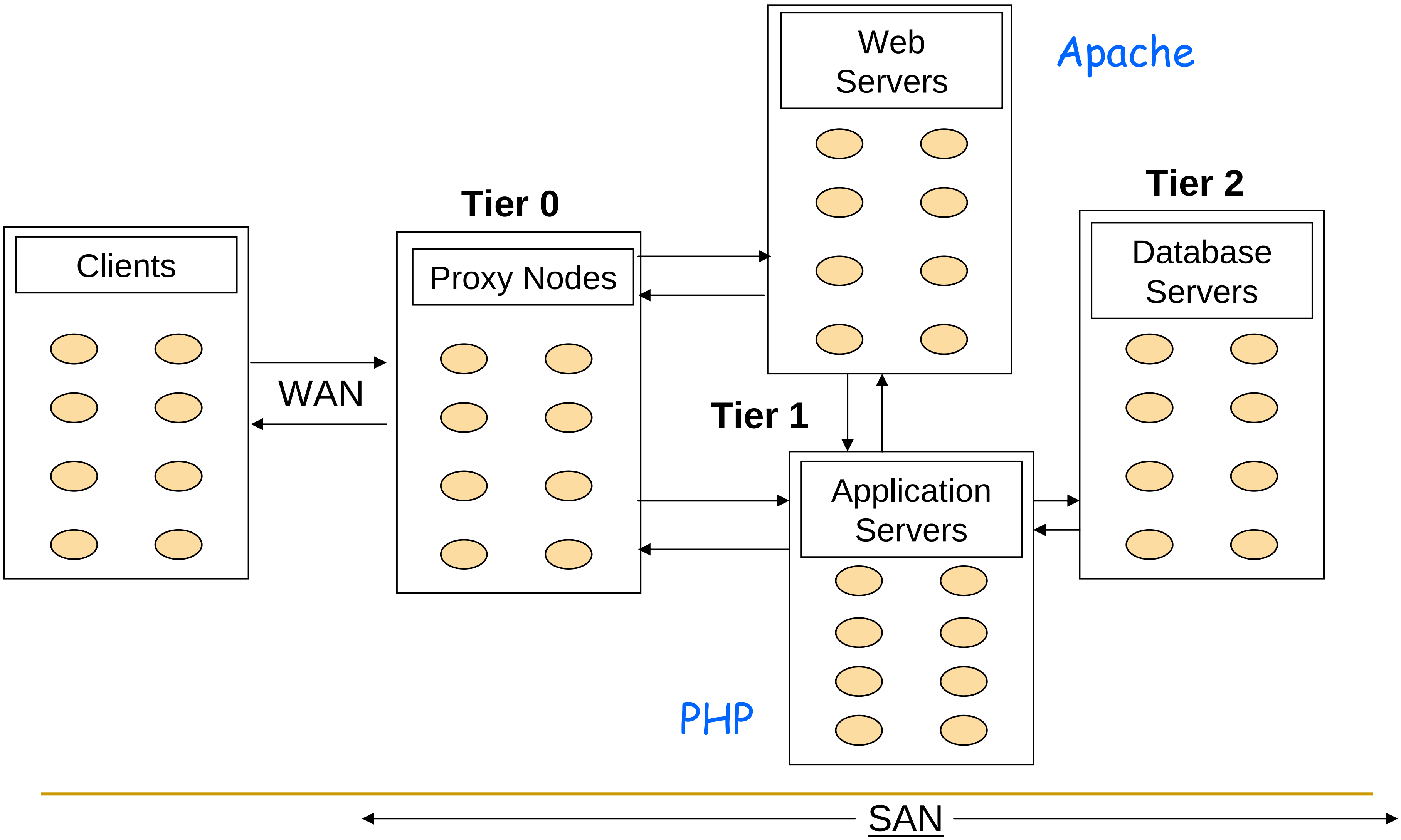
A Typical Multi-Tier Data-Center



InfiniBand

- High Performance
  - Low latency
  - High Bandwidth
- Open Industry Standard
- Provides rich features
  - RDMA, Remote Atomic operations, etc
- Targeted for Data-Centers
- Transport Layers
  - VAPI
  - IPoIB

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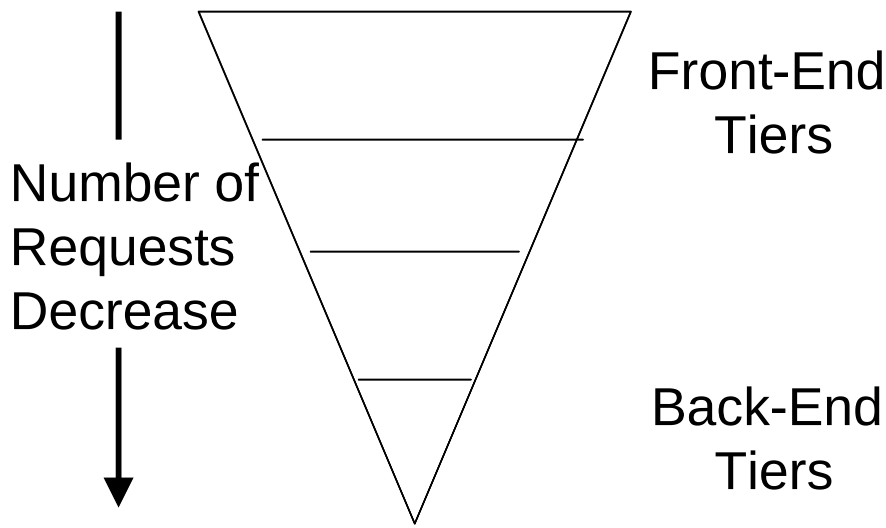
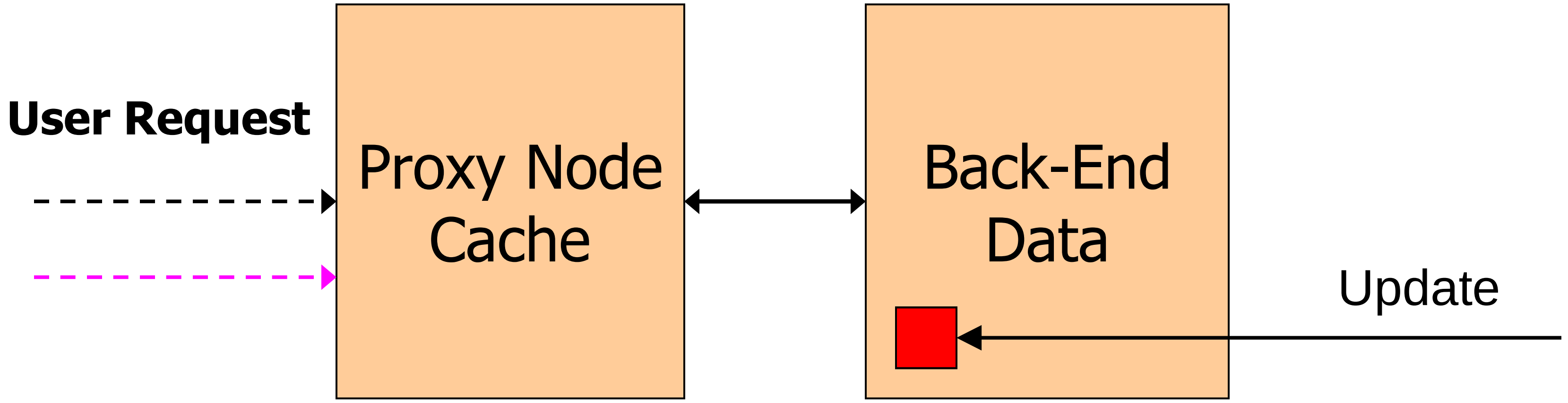
Caching

- Can avoid re-fetching of content
- Beneficial if requests repeat
- Important for scalability
- Static content caching
    - Well studied in the past
    - Widely used



Active Caching

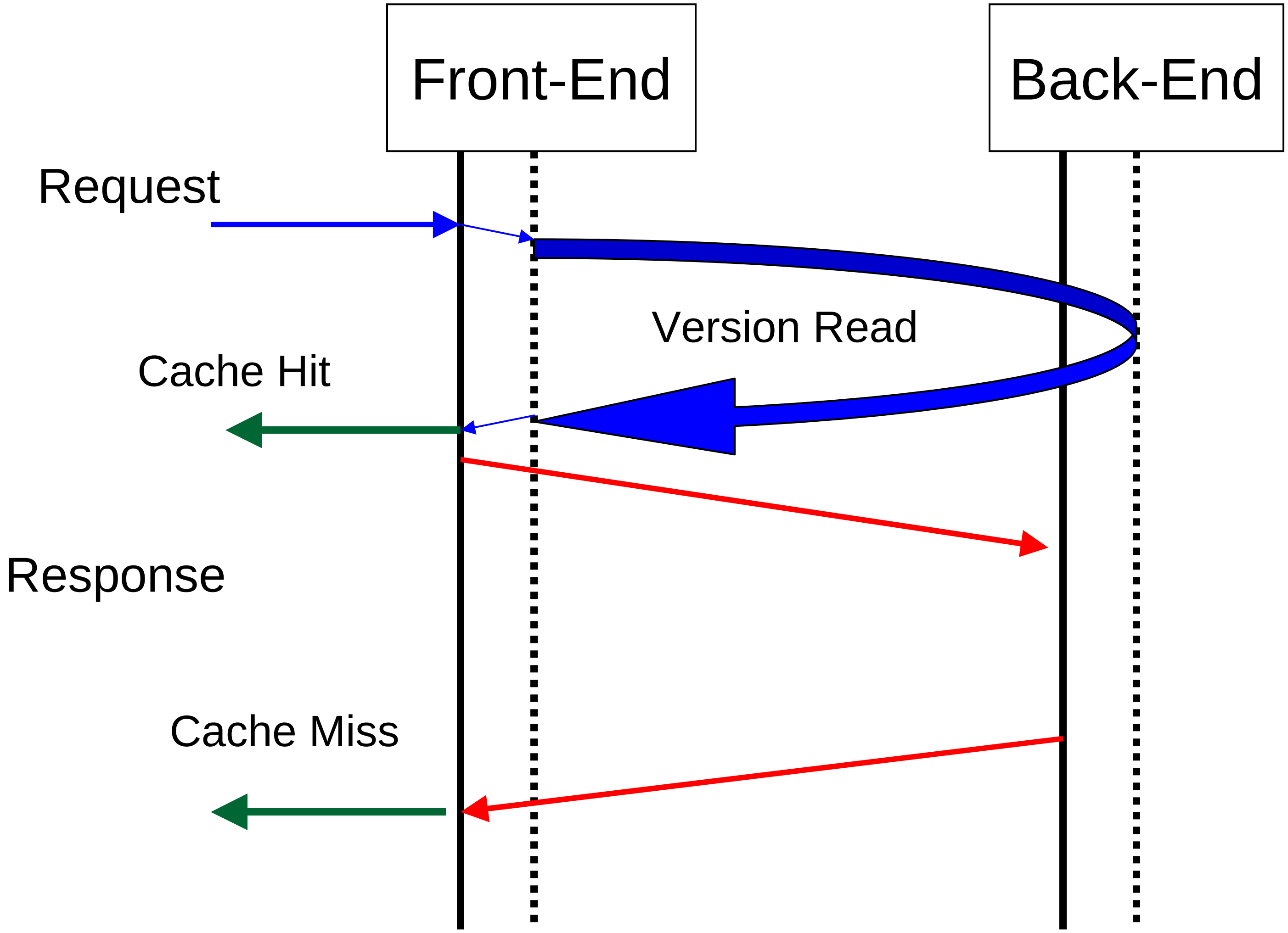
- Dynamic Data
  - Stock Quotes, Scores, Personalized Content, etc
  - Complexity of content
- Simple caching methods not suited
- Issues
  - Consistency
  - Coherency



Cache Coherency

- Refers to the average staleness of the document served from cache
- Strong or immediate (Strong Coherency)
  - Required for certain kinds of data
  - Cache Disabling
  - Client Polling

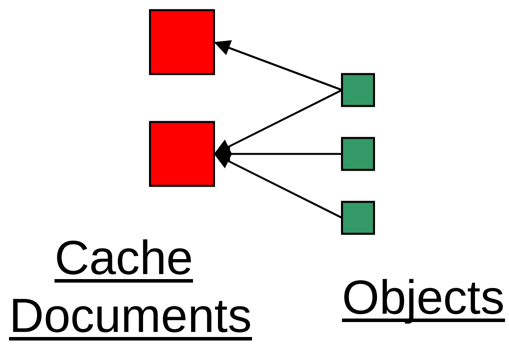
Basic Client Polling *



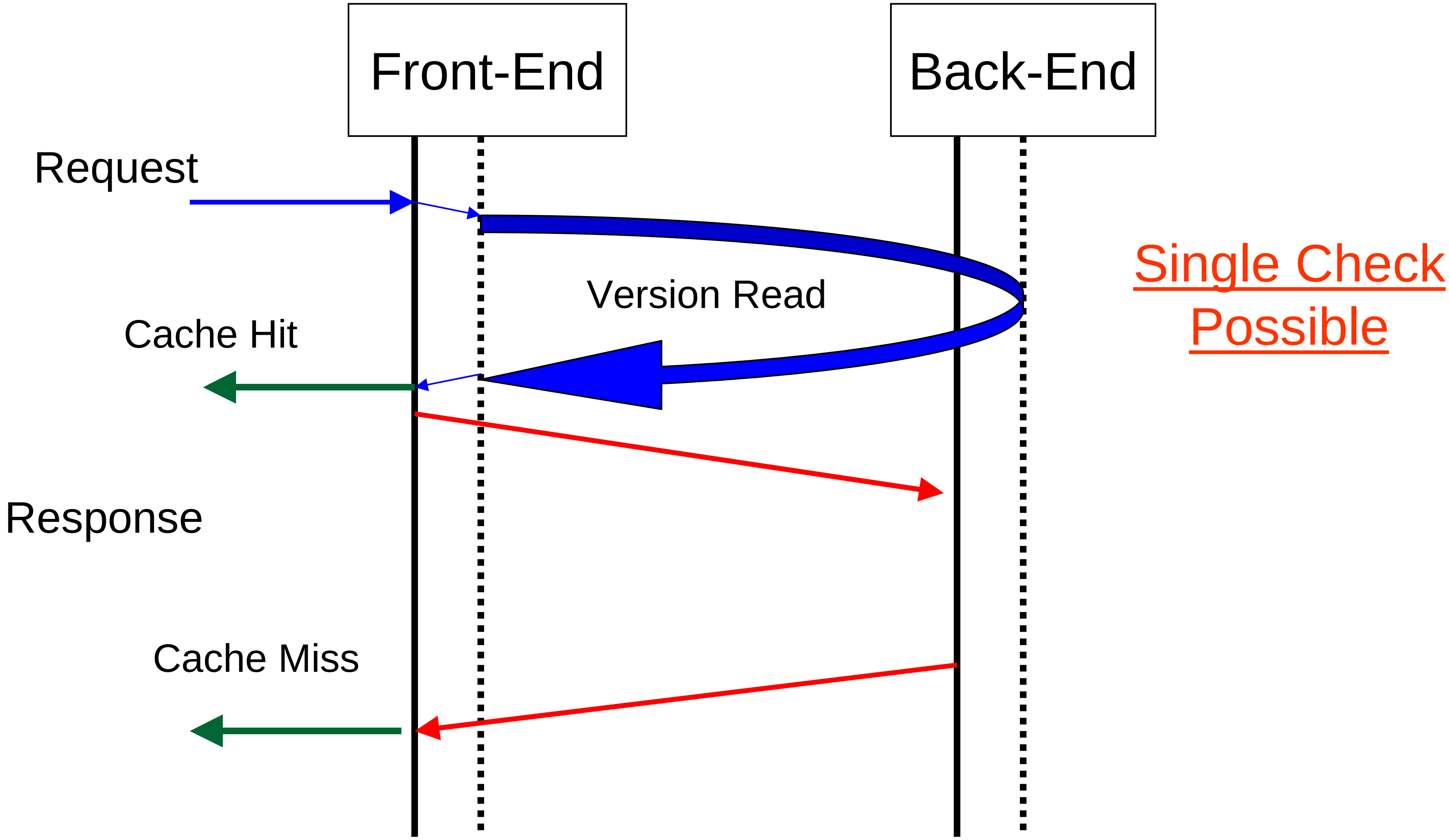
[* SAN04: Supporting Strong Cache Coherency for Active Caches in Multi-Tier Data-Centers over InfiniBand. Narravula, et. Al.]()

Multiple Object Dependencies

- Cache documents contain multiple objects
- A Many-to-Many mapping
  - Single Cache document can contain Multiple Objects
  - Single Object can be a part of multiple Documents
- Complexity!!



Client Polling



Single Lookup counter essential for correct and efficient design

Objective

- To design an architecture that very efficiently supports strong cache coherency with multiple dynamic dependencies on InfiniBand

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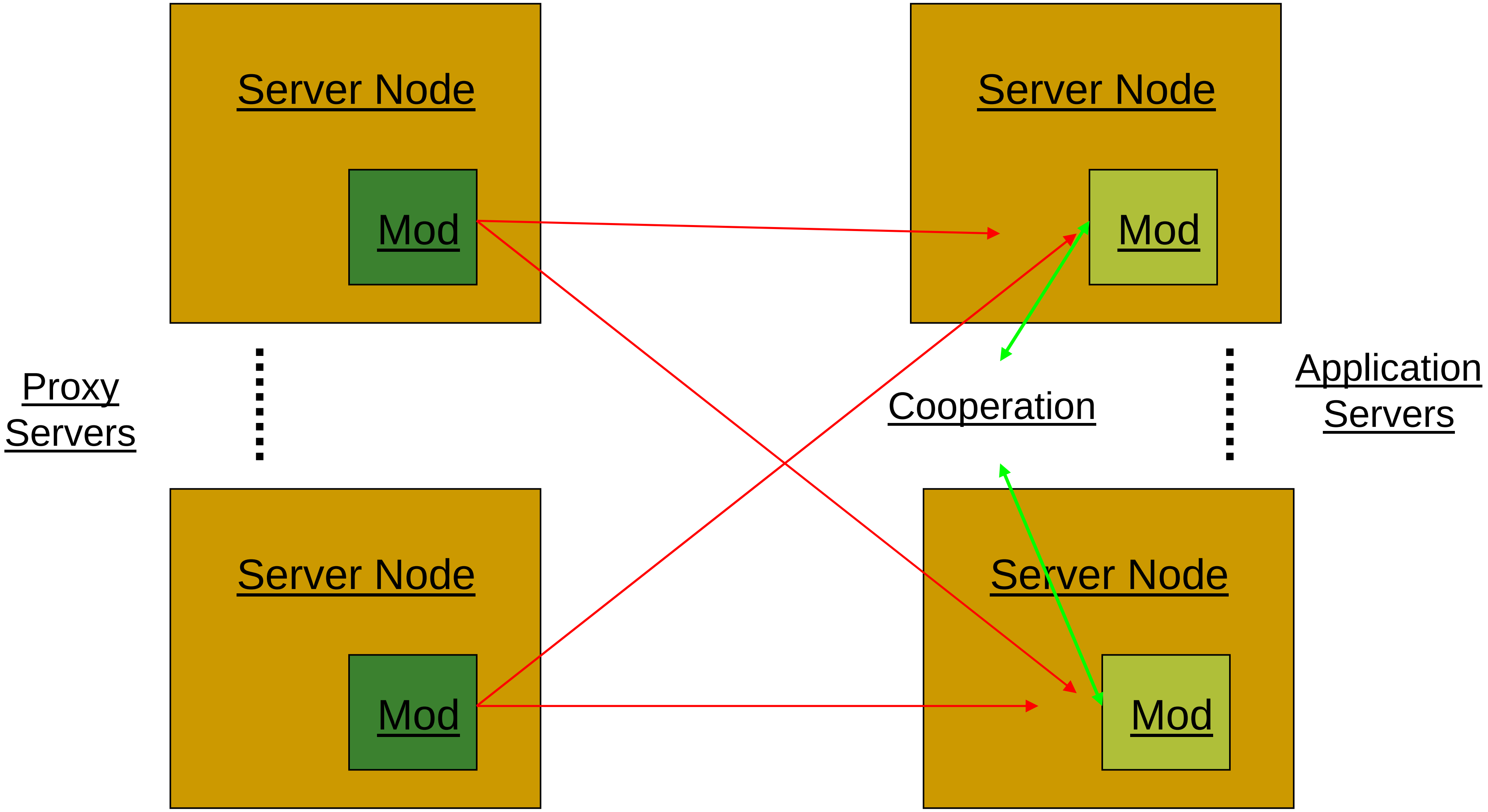
Basic System Architecture



Cache Lookup Counter maintained on the Application Servers

Basic Design

- Home Node based Client Polling
  - Cache Documents assigned home nodes
- Proxy Server Modules
  - *Client polling* functionality
- Application Server Modules
  - Support “Version Reads” for *client polling*
  - Handle updates

Many-to-Many Mappings

- Mapping of updates to dynamic objects
- Mapping of dynamic objects with Lookup counters
- Efficiency
  - Factor of dependency

$$\text{Lookup counters} \longleftarrow \text{Objects} \longleftarrow \text{Updates}$$

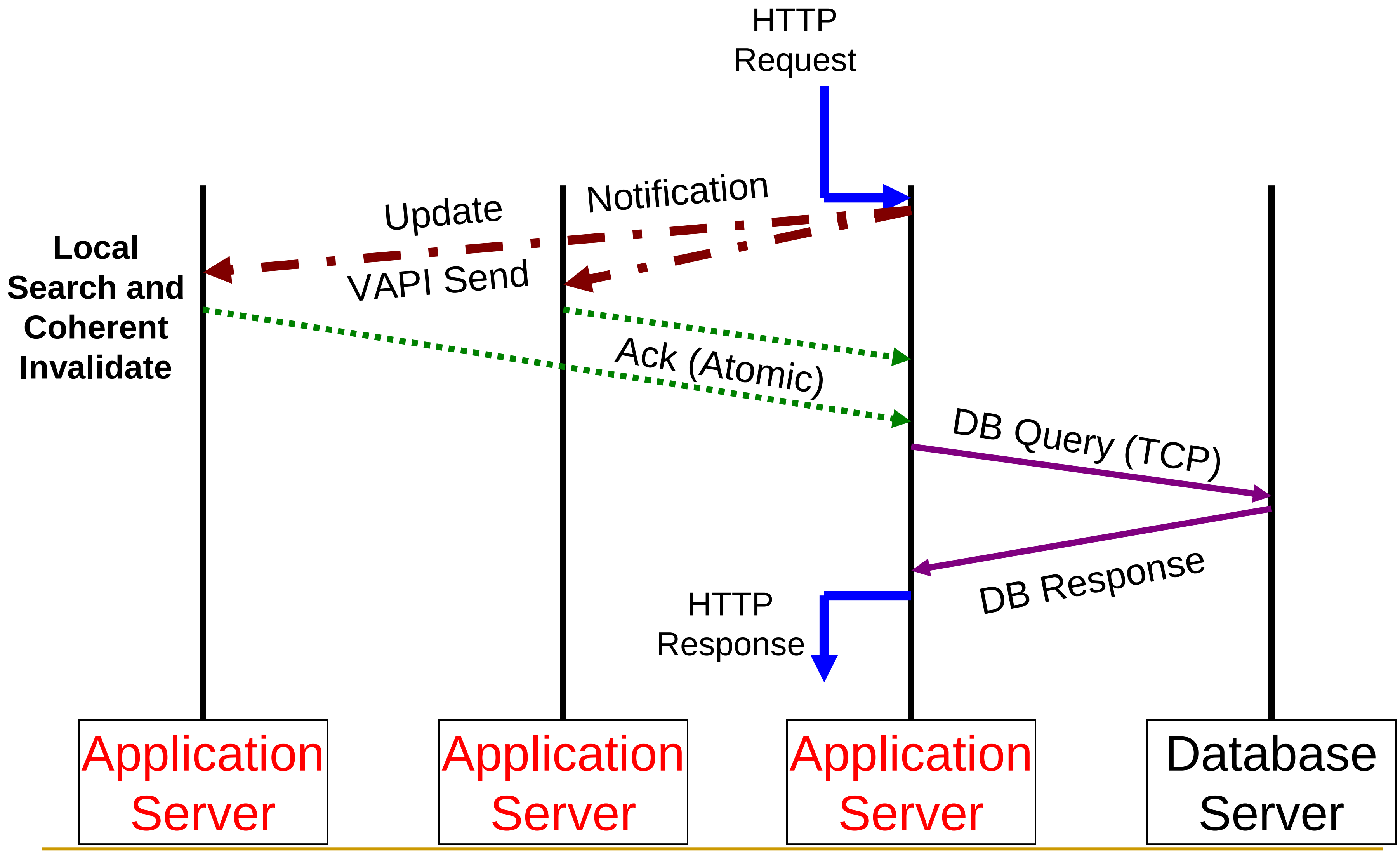
Mapping of updates

- Non-Trivial solution
- Three possibilities
  - Database schema, constraints and dependencies are known
  - Per query dependencies are known
  - No dependency information known

Mapping Schemes

- Dependency Lists
  - Home node based
  - Complete dependency lists
- Invalidate All
  - Single Lookup Counter for a given class of queries
  - Low application server overheads

Handling Updates



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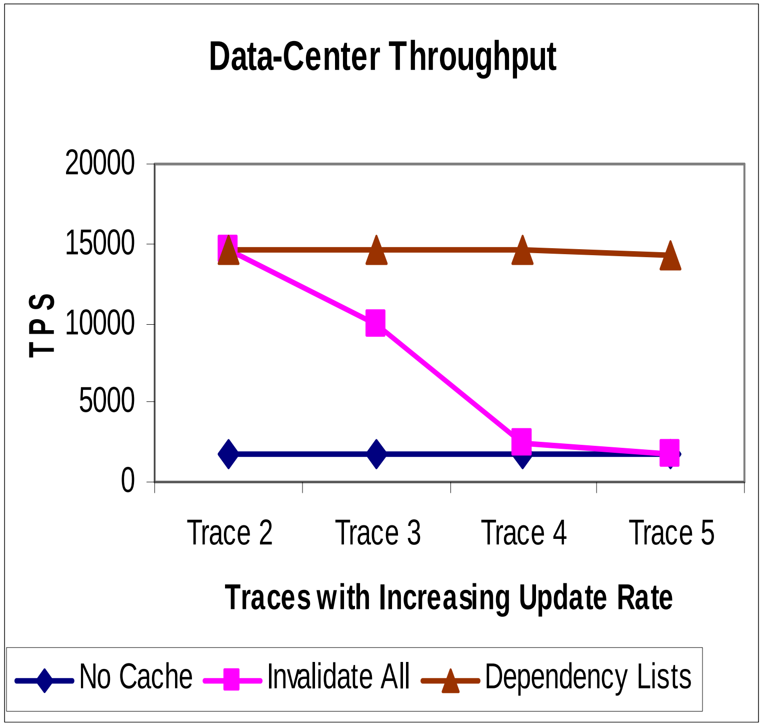
Experimental Test-bed

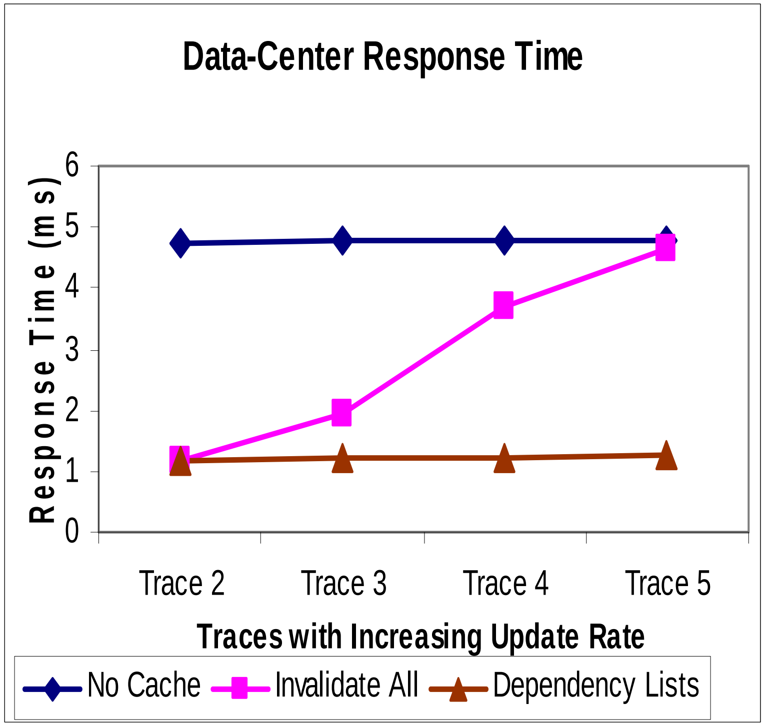
- **Cluster 1**: Eight Dual 3.0 GHz Xeon processor nodes with 64-bit 133MHz PCI-X interface, 512KB L2-Cache and 533 MHz Front Side Bus
- **Cluster 2**: Eight Dual 2.4 GHz Xeon processor nodes with 64-bit 133MHz PCI-X interface, 512KB L2-Cache and 400 MHz Front Side Bus
- Mellanox InfiniHost MT23108 Dual Port 4x HCAs
- MT43132 eight 4x port Switch
- Mellanox Golden CD 0.5.0

Experimental Outline

- Basic Data-Center Performance
- Cache Misses in Active Caching
- Impact of Cache Size
- Impact of Varying Dependencies
- Impact of Load in Backend Servers
- Traces Used
  - Traces 1-5 with increasing update rate
  - Trace 6: Zipf like trace

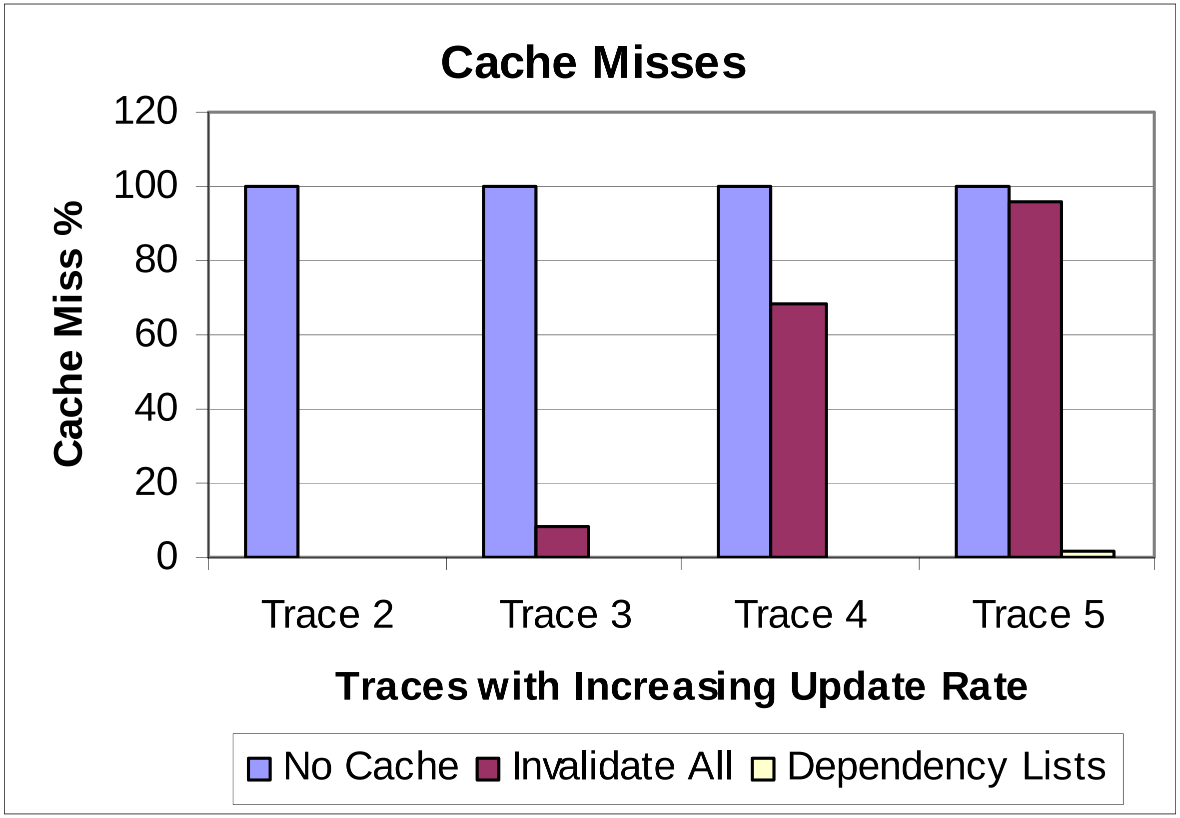
Basic Data-Center Performance





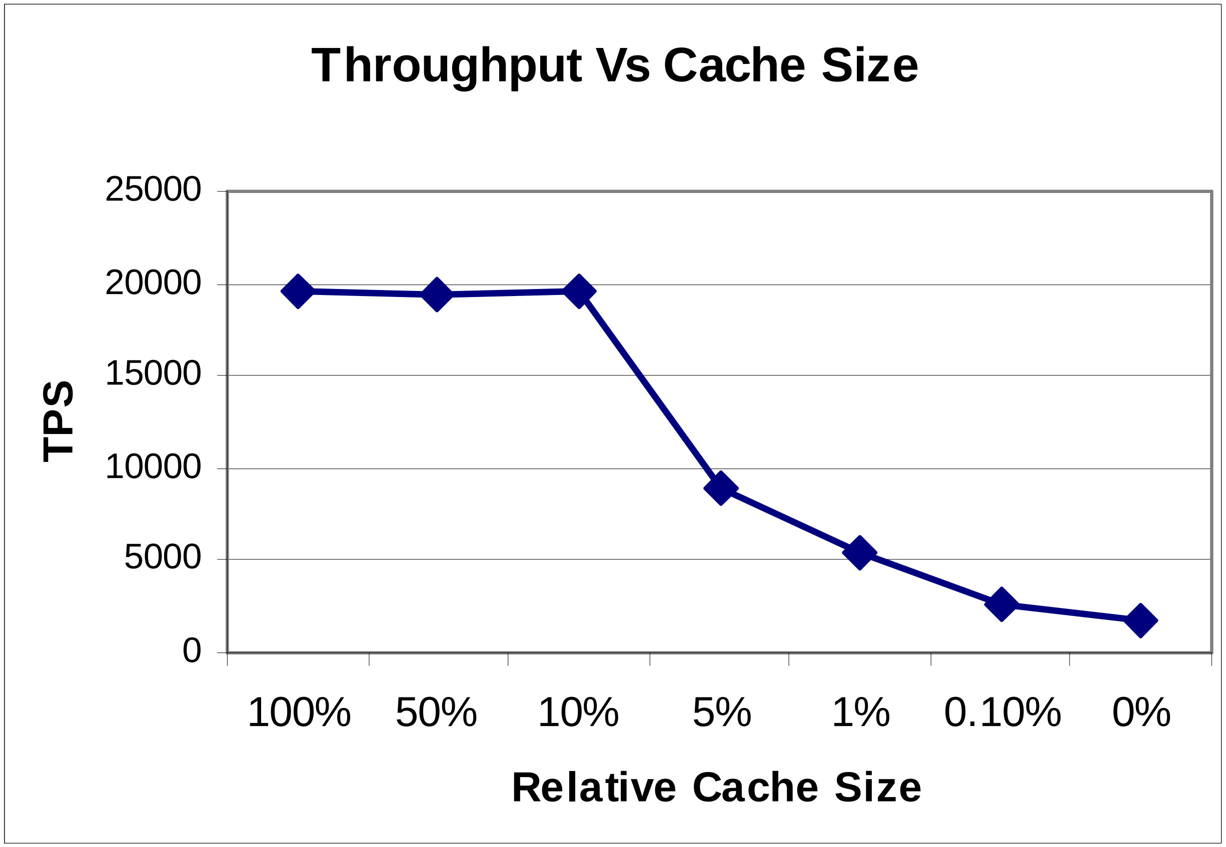
- Maintaining Dependency Lists perform significantly well for all traces

Cache Misses in Active Caching



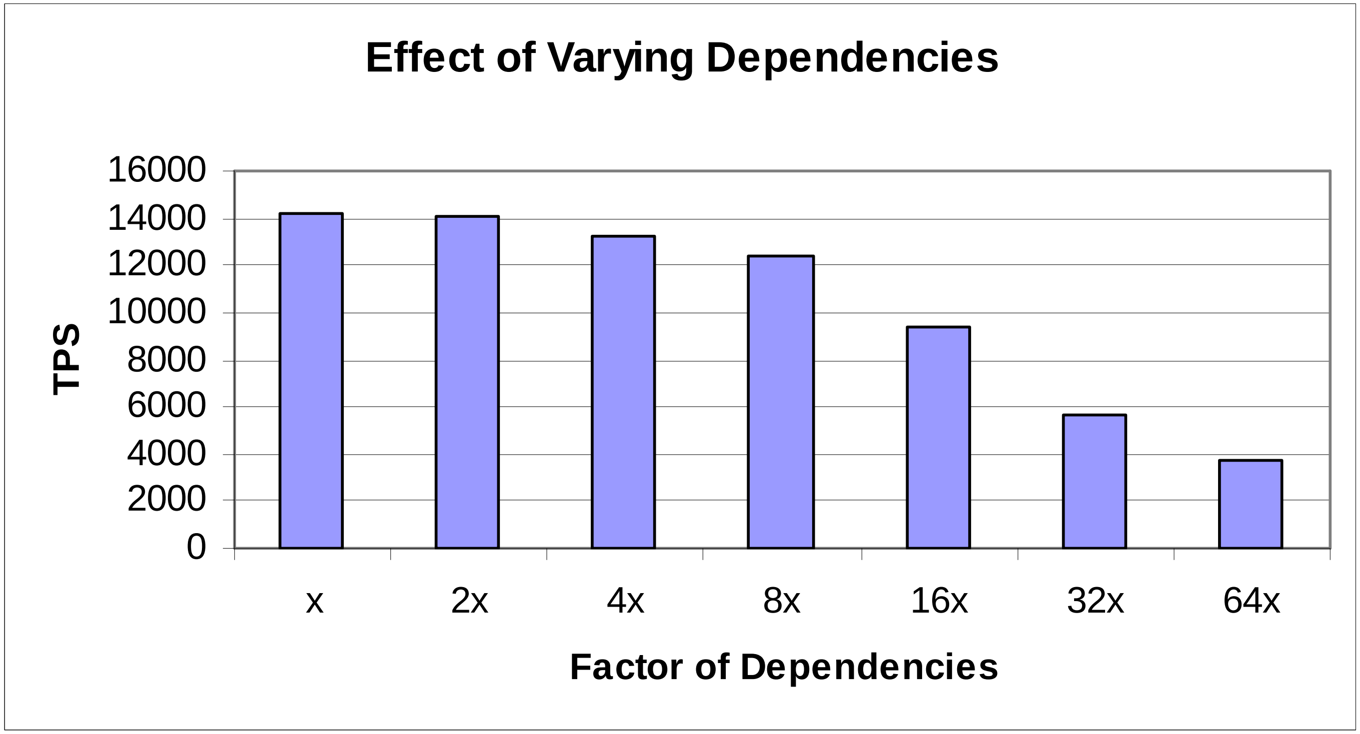
- Cache misses for Invalidate All increases drastically with increasing update rates

Impact of Cache Size



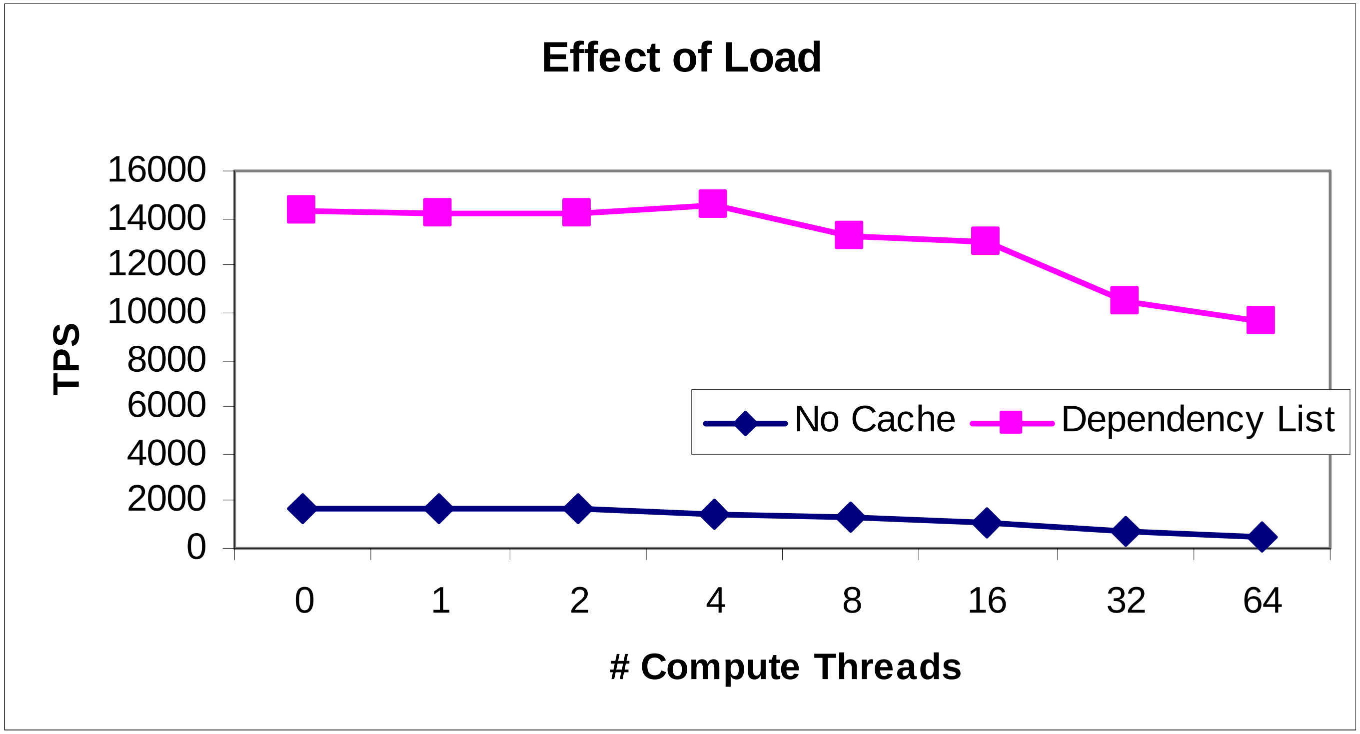
- Maintaining Dependency Lists perform significantly well for all traces
- Possible to cache a select few and still extract performance

Impact of Varying Dependencies



- Throughput drops significantly with increase in the average number of dependencies per cache file

Impact of Load in Backend Servers



- Our design can sustain high performance even under high loaded conditions with a factor of improvement close to 22

Conclusions

- An architecture for supporting Strong Cache Coherence with multiple dynamic dependencies
- Efficiently handle multiple dynamic dependencies
  - Supporting RDMA-based Client polling
- Resilient to load on back-end servers

Web Pointers

NBC home page

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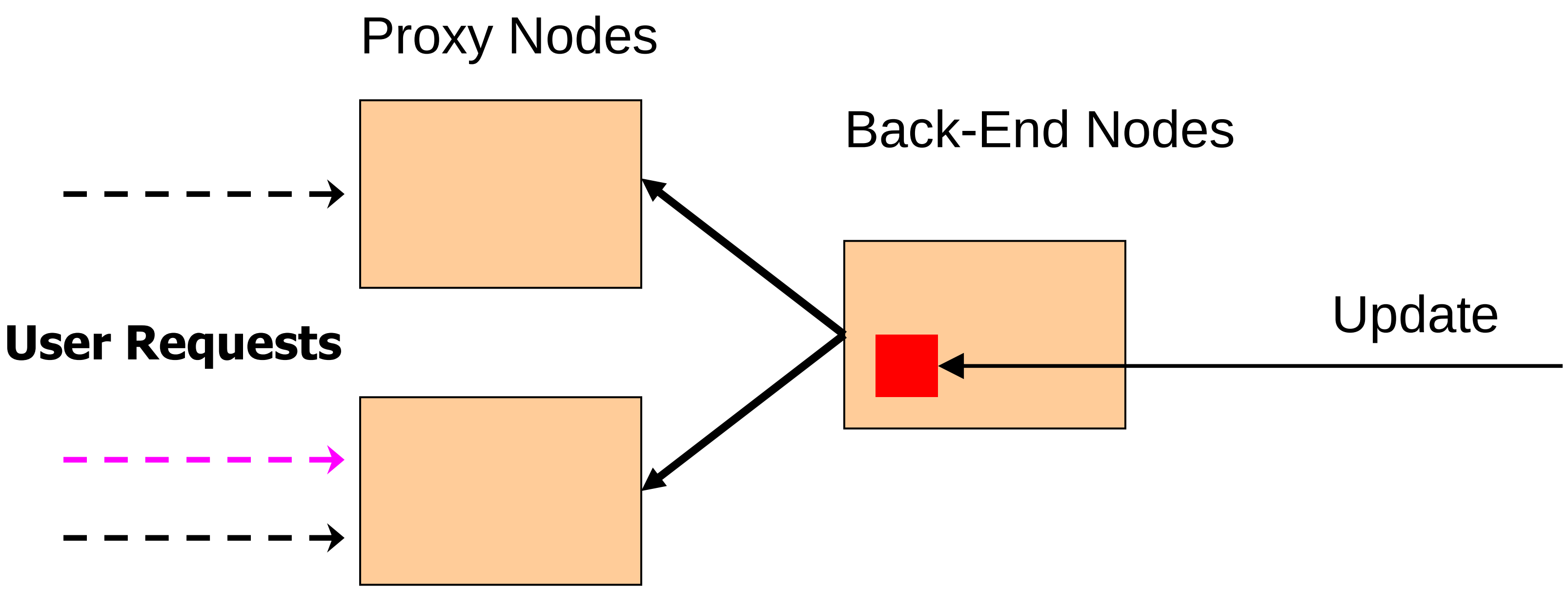
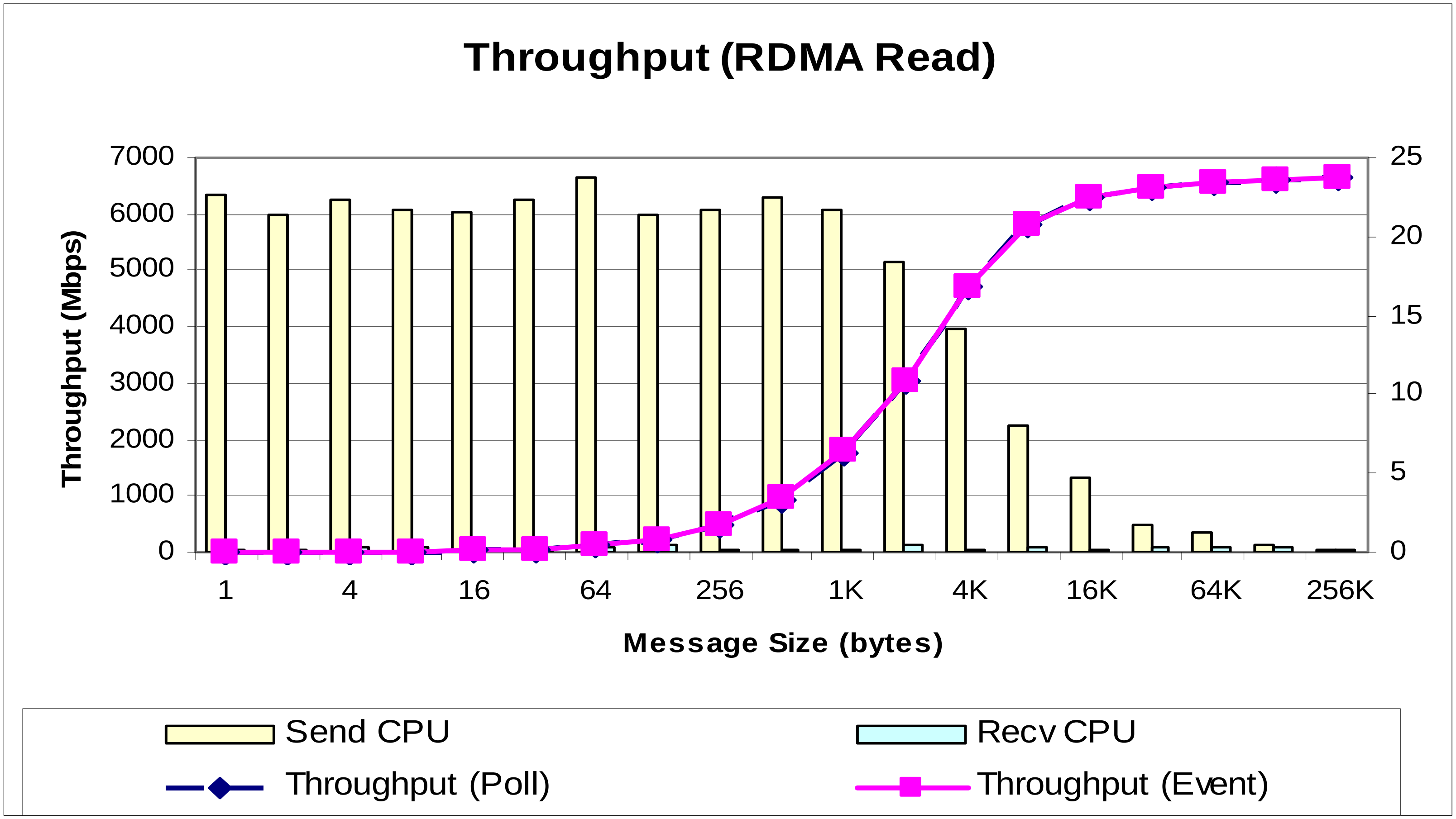
Back-up Slides

Cache Consistency

- Non-decreasing views of system state
- Updates seen by all or none

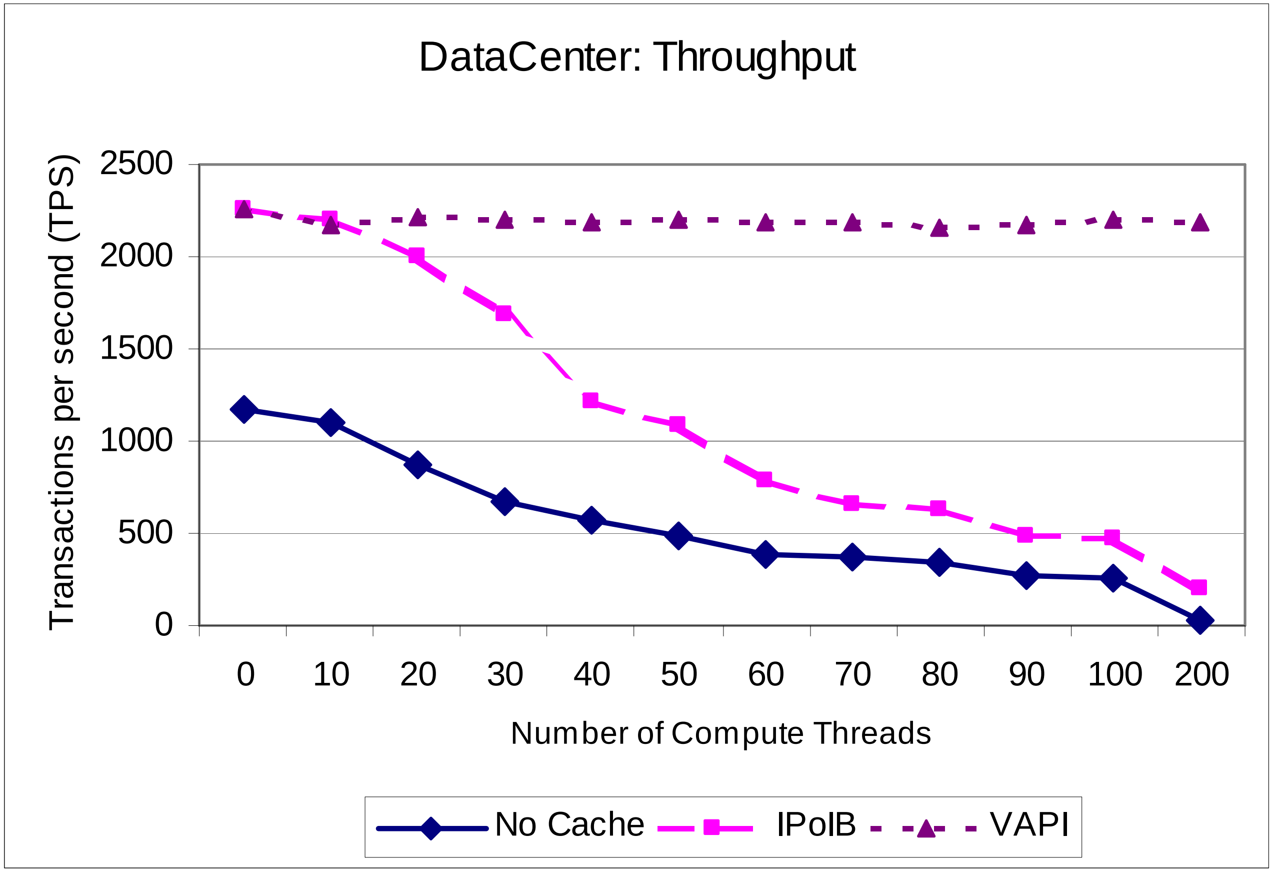


Performance



- Receiver side CPU utilization is very low
- Leveraging the benefits of One sided communication

RDMA based Client Polling *



- The VAPI module can sustain performance even with heavy load on the back-end servers

* SAN04: Supporting Strong Cache Coherency for Active Caches in Multi-Tier Data-Centers over InfiniBand. Narravula, et. Al.

Mechanism

- Cache Hit:
  - Back-end Version Check
  - If version current, use cache
  - Invalidate data for failed version check
  - Use of RDMA-Read
- Cache Miss
  - Get data to cache
  - Initialize local versions

Other Implementation Details

- Requests to read and update are mutually excluded at the back-end module to avoid simultaneous readers and writers accessing the same data.
- Minimal changes to existing application software