Supporting Strong Cache Coherency for Active Caches 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
- Types of Content
  - Images, documents, audio clips, video clips, etc - Static Content
  - Stock Quotes, Online Stores (Amazon), Online Banking, etc. - Dynamic Content (Active

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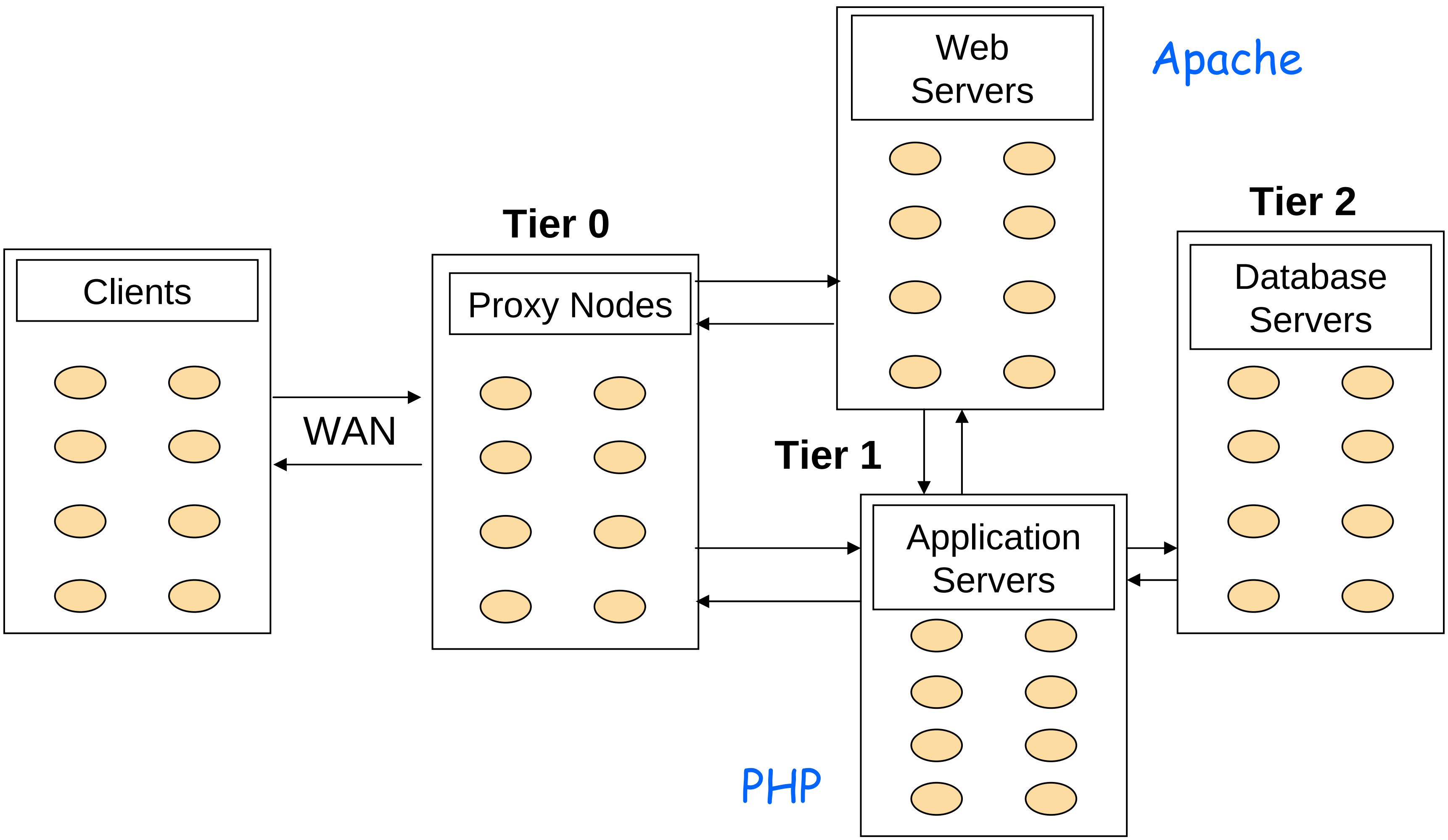
Multi-Tier Data-Centers

- Single Powerful Computers
- Clusters
  - Low ‘*Cost to Performance*’ Ratio
  - Increasingly Popular
- Multi-Tier Data-Centers
  - Scalability – an important issue

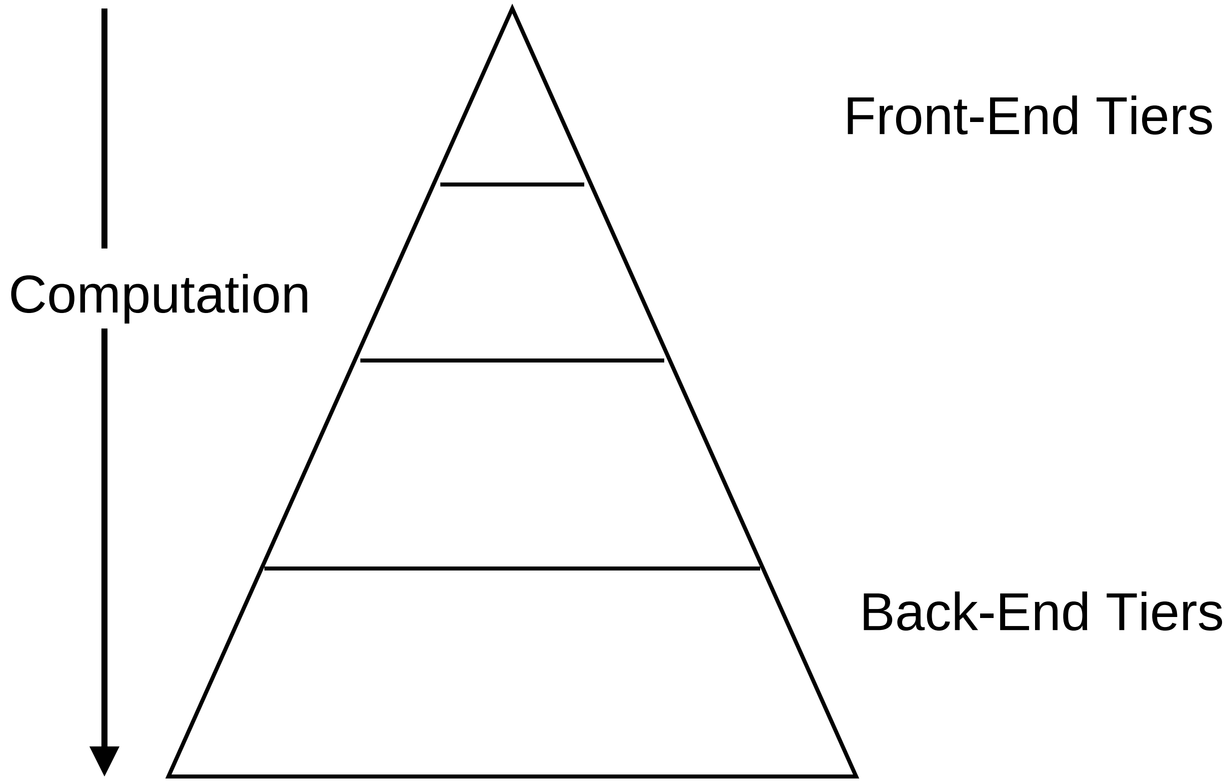
A Typical Multi-Tier Data-Center



Tiers of a Typical Multi-Tier Data-Center

- Proxy Nodes
  - Handle Caching, load balancing, security, etc
- Web Servers
  - Handle the HTML content
- Application Servers
  - Handle Dynamic Content, Provide Services
- Database Servers
  - Handle persistent storage

Data-Center Characteristics



- The amount of computation required for processing each request increases as we go to the inner tiers of the Data-Center
- Caching at the front tiers is an important factor for scalability

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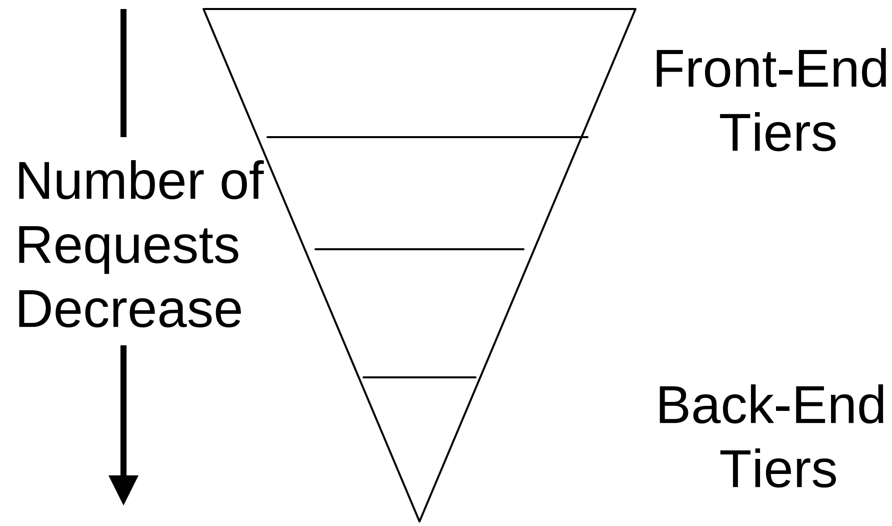
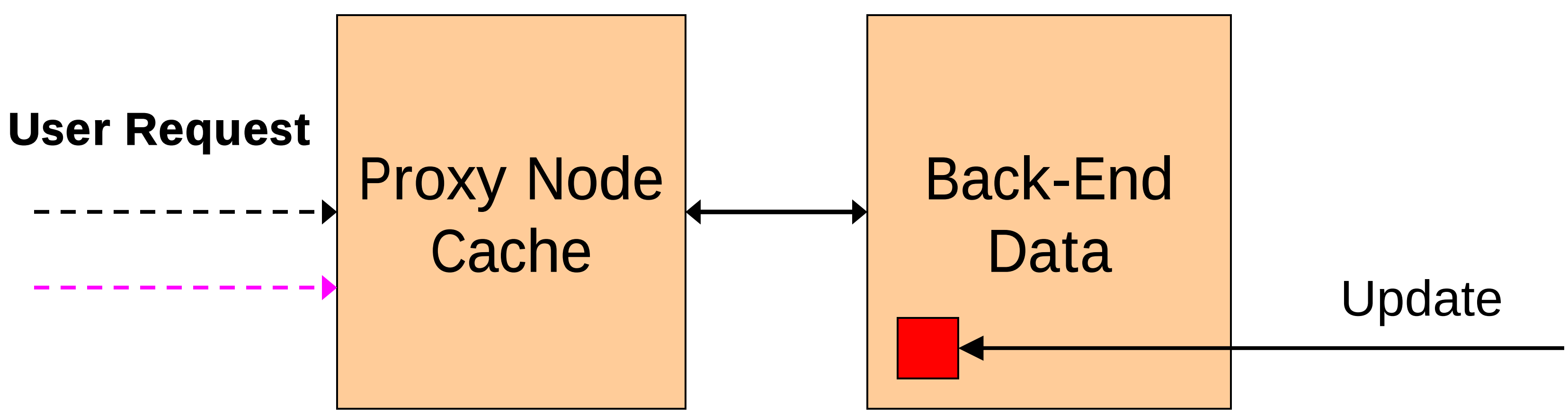
Caching

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



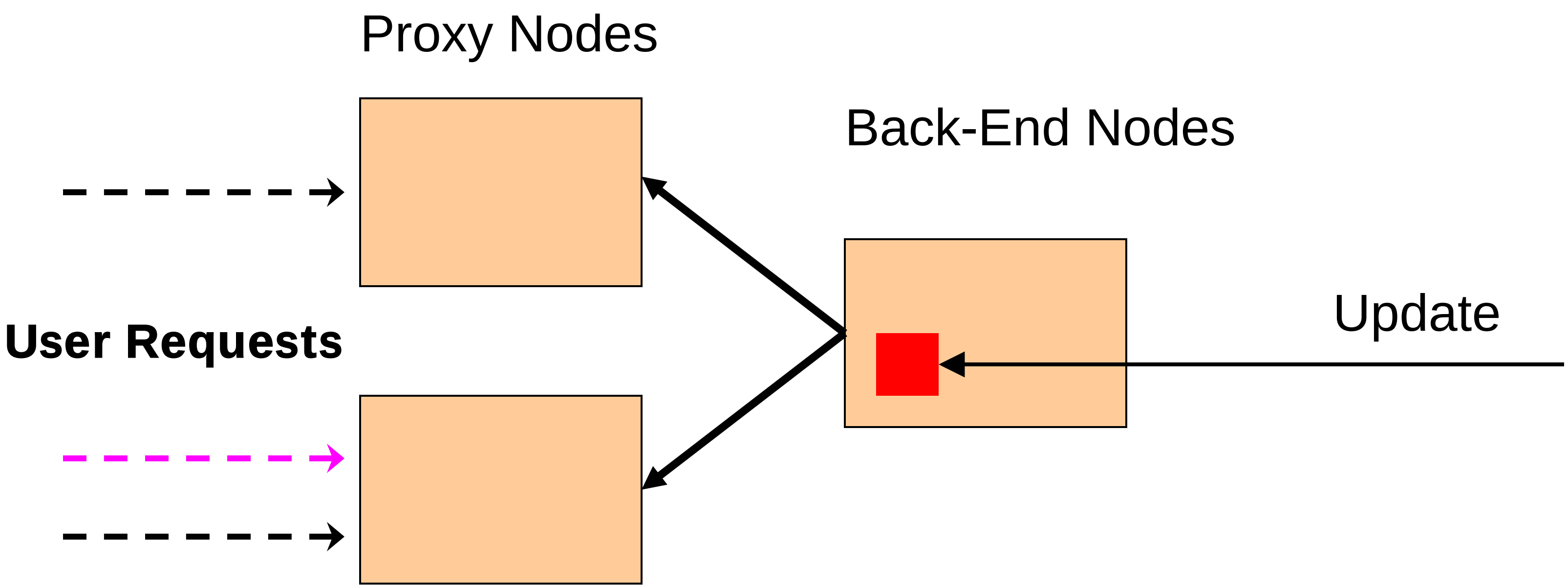
Active Caching

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



Cache Consistency

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



Cache Coherency

- Refers to the average staleness of the document served from cache
- Two models of coherence
  - Bounded staleness (Weak Coherency)
  - Strong or immediate (Strong Coherency)

Strong Cache Coherency

- An absolute necessity for certain kinds of data
  - Online shopping, Travel ticket availability, Stock Quotes, Online auctions
  - Example: Online banking
    - Cannot afford to show different values to different concurrent requests

Caching policies

	Consistency	Coherency
No Caching	✓	✓
Client Polling	✓	✓
Invalidation *	✓	✗
TTL/Adaptive TTL	✗	✗

*D. Li, P. Cao, and M. Dahlin. WCIP: Web Cache Invalidation Protocol. IETF Internet Draft, November 2000.

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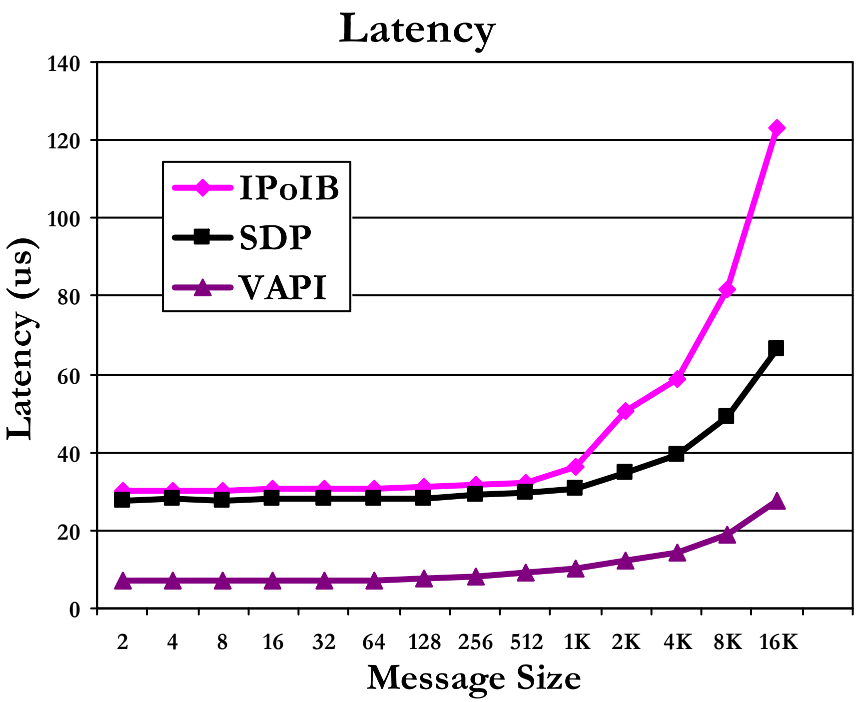
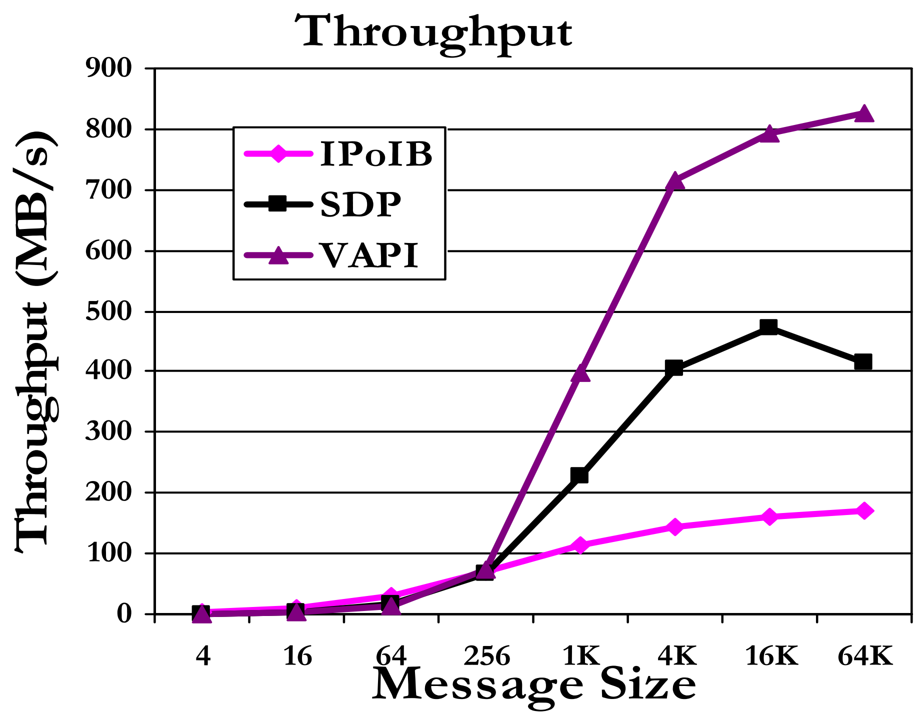
InfiniBand

- 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
  - SDP

Performance

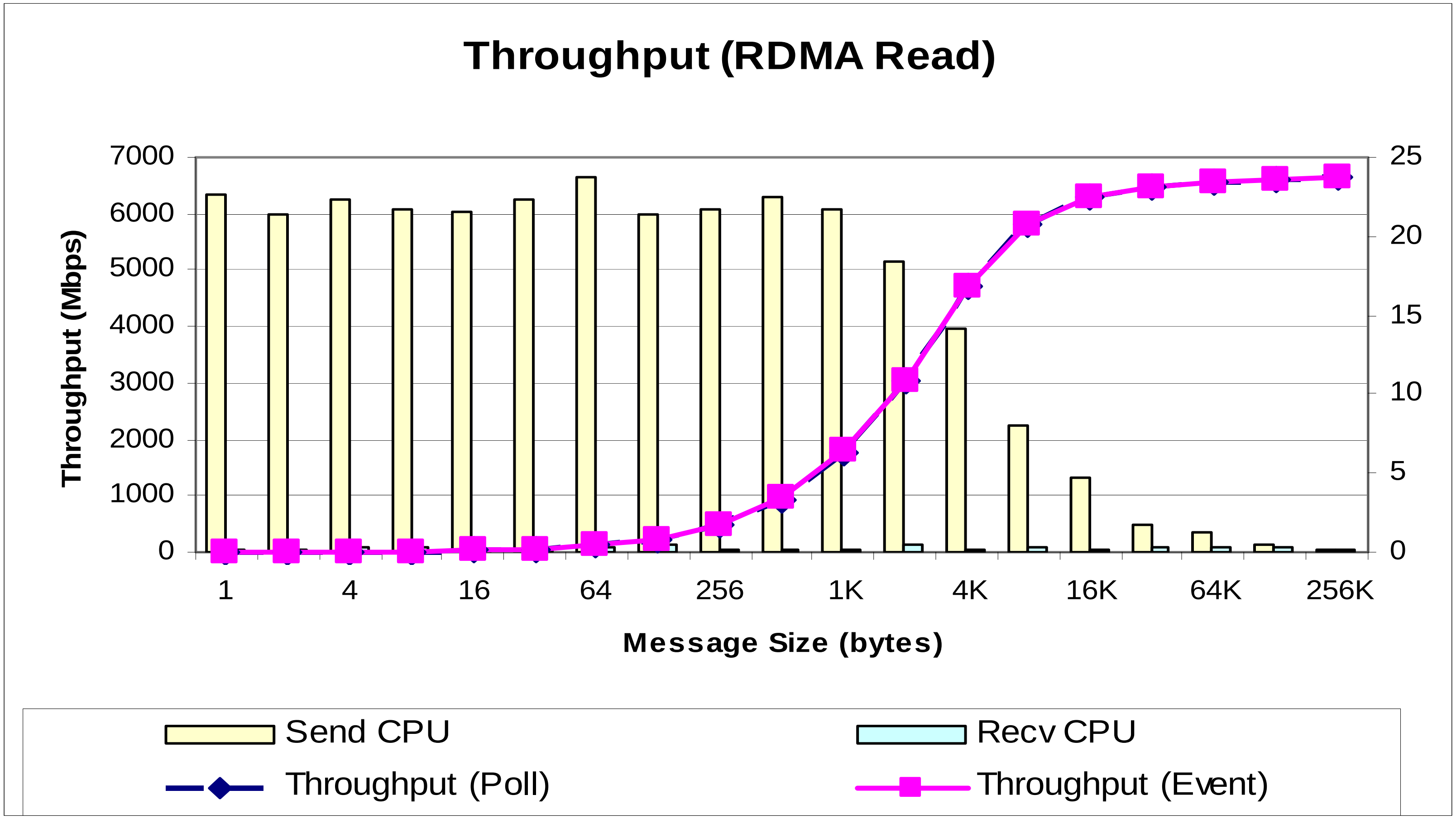




- Low latencies of less than 5us achieved
- Bandwidth over 840 MB/s

* SDP and IPoIB from Voltaire's Software Stack

Performance



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

Caching policies

	Consistency	Coherency
No Caching	✓	✓
Client Polling	✓	✓
Invalidation	✓	✗
TTL/Adaptive TTL	✗	✗

Objective

- To design an architecture that very efficiently supports strong cache coherency on InfiniBand

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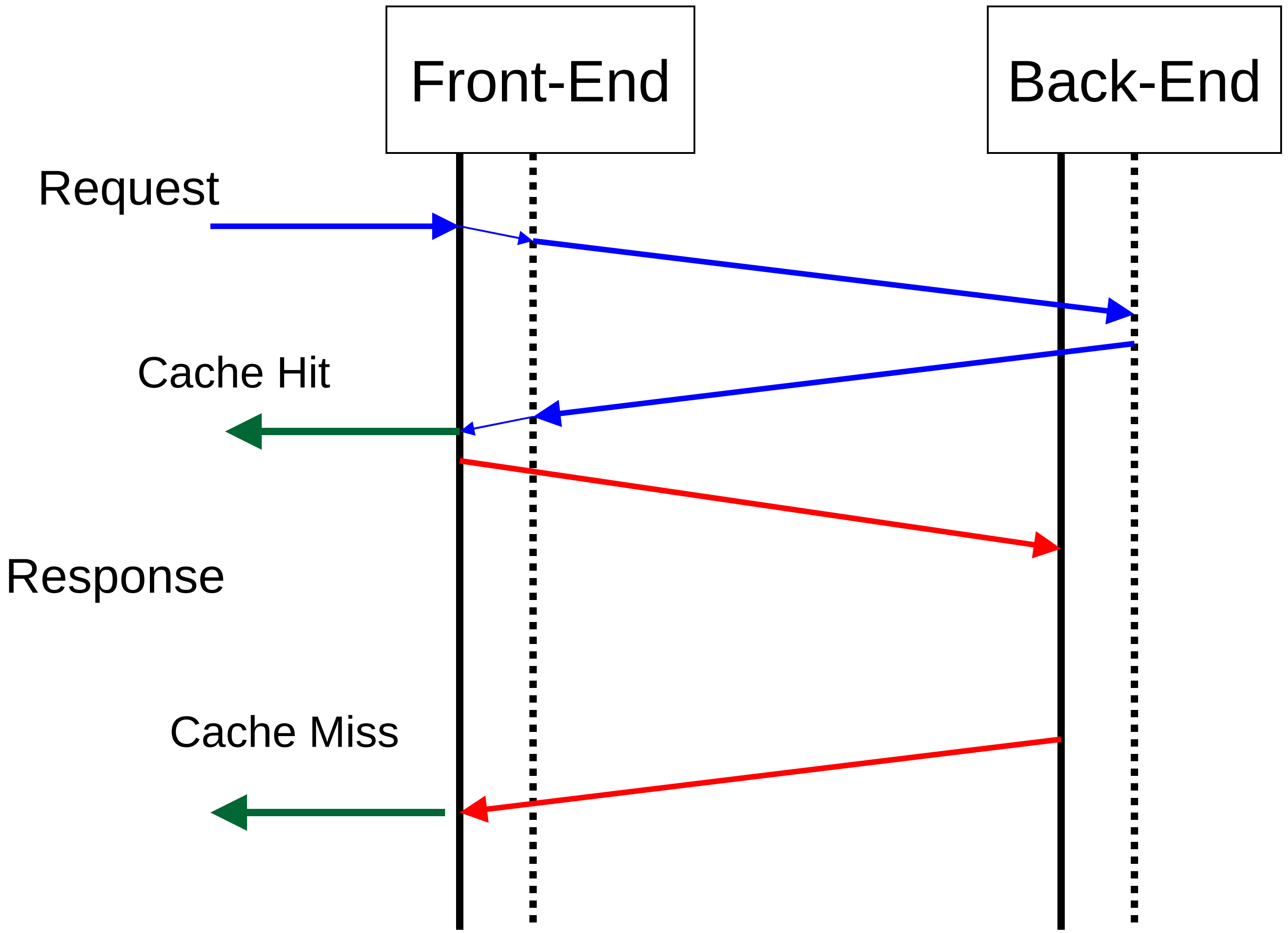
Basic Architecture

- External modules are used
  - Module communication can use any transport
- Versioning:
  - Application servers version dynamic data
  - Version value of data passed to front end with every request to back-end
  - Version maintained by front end along with cached value of response

Mechanism

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

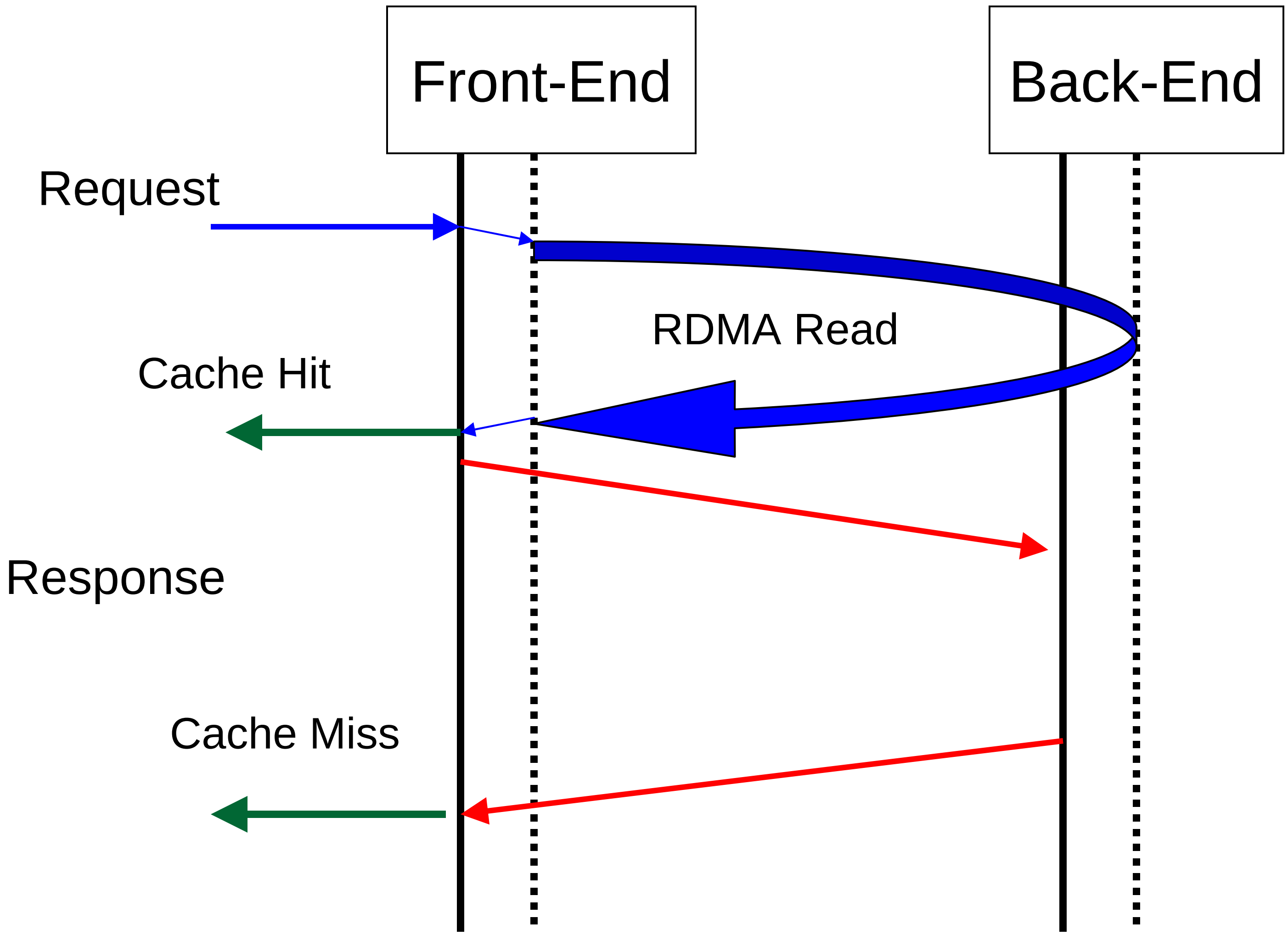
Architecture



Design

- Every server has an associated module that uses IPoIB, SDP or VAPI to communicate
- VAPI:
  - When a request arrives at proxy, VAPI module is contacted.
  - Module reads latest version of the data from the back-end using one-sided RDMA Read operation
  - If versions do not match, cached value is invalidated

VAPI Architecture



Implementation

- Socket-based Implementation:
  - IPoIB and SDP are used
  - Back-end version check is done using two-sided communication from the module
- 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 software

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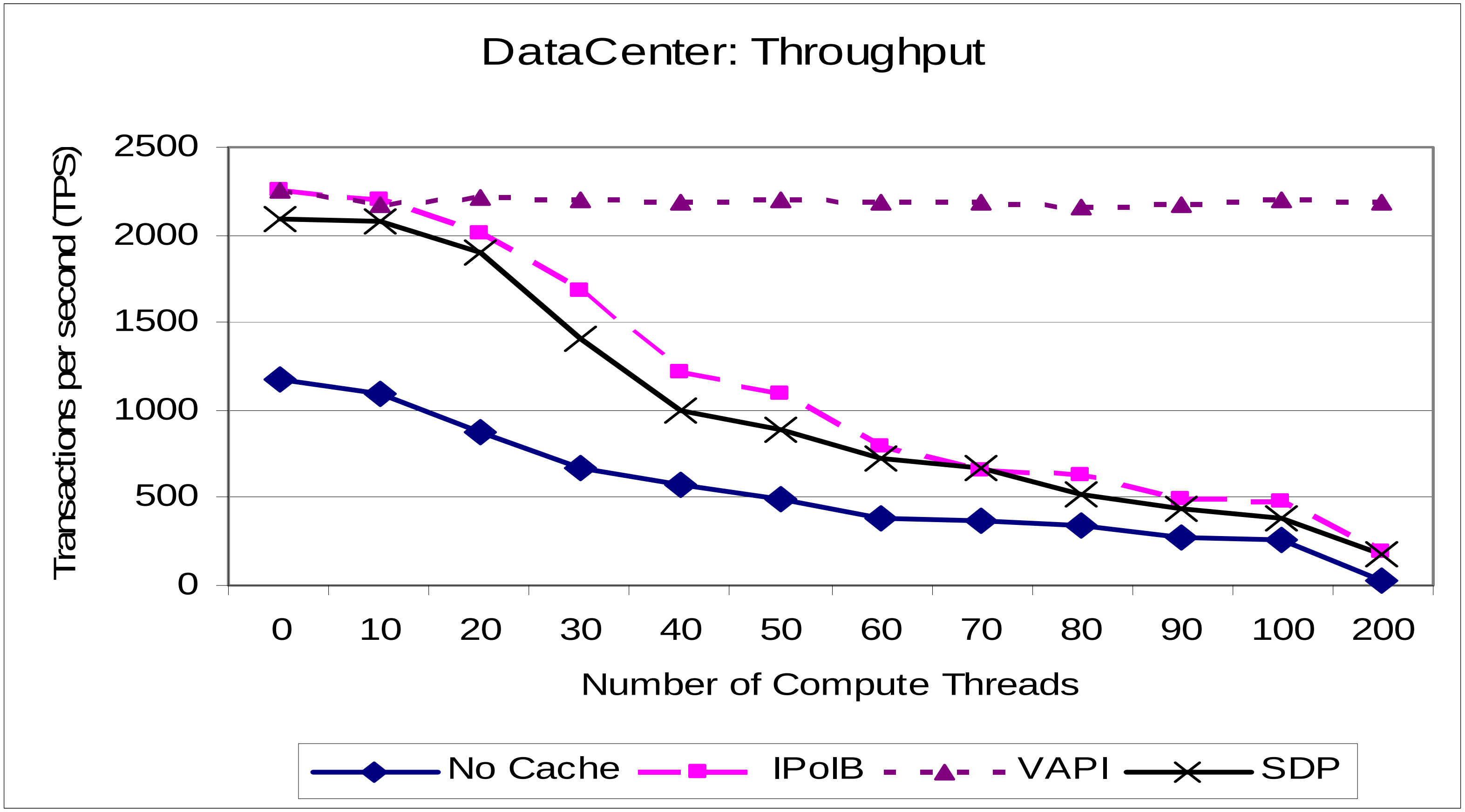
  - Data-Center Throughput
  - Data-Center Response Time
  - Data-Center Break-up
  - Zipf and WC Trace Throughput
- Conclusions

Experimental Test-bed

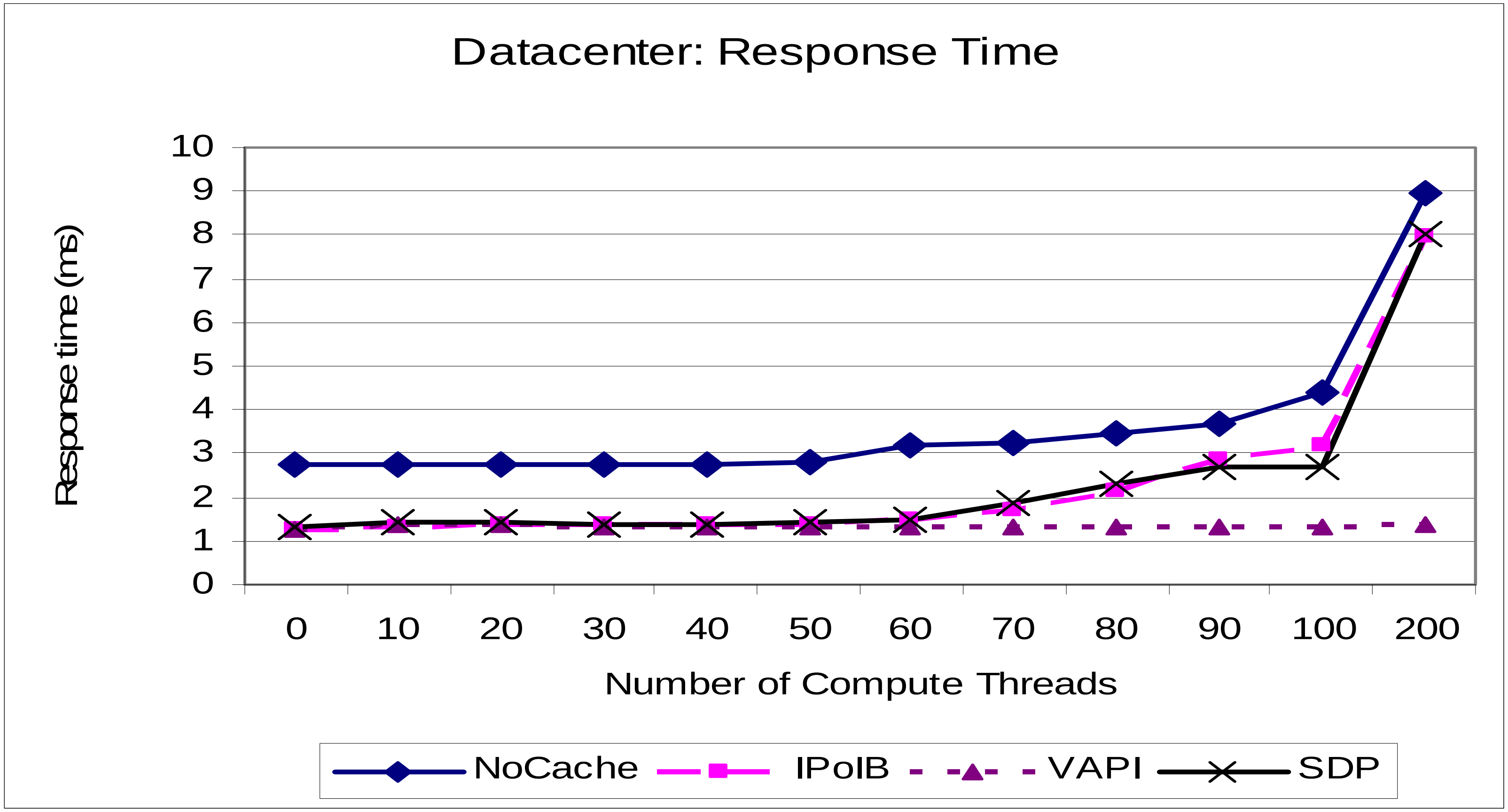
- Eight Dual 2.4GHz Xeon processor nodes
- 64-bit 133MHz PCI-X interfaces
- 512KB L2-Cache and 400MHz Front Side Bus
- Mellanox InfiniHost MT23108 Dual Port 4x HCAs
- MT43132 eight 4x port Switch
- SDK version 0.2.0
- Firmware version 1.17

Data-Center: Performance



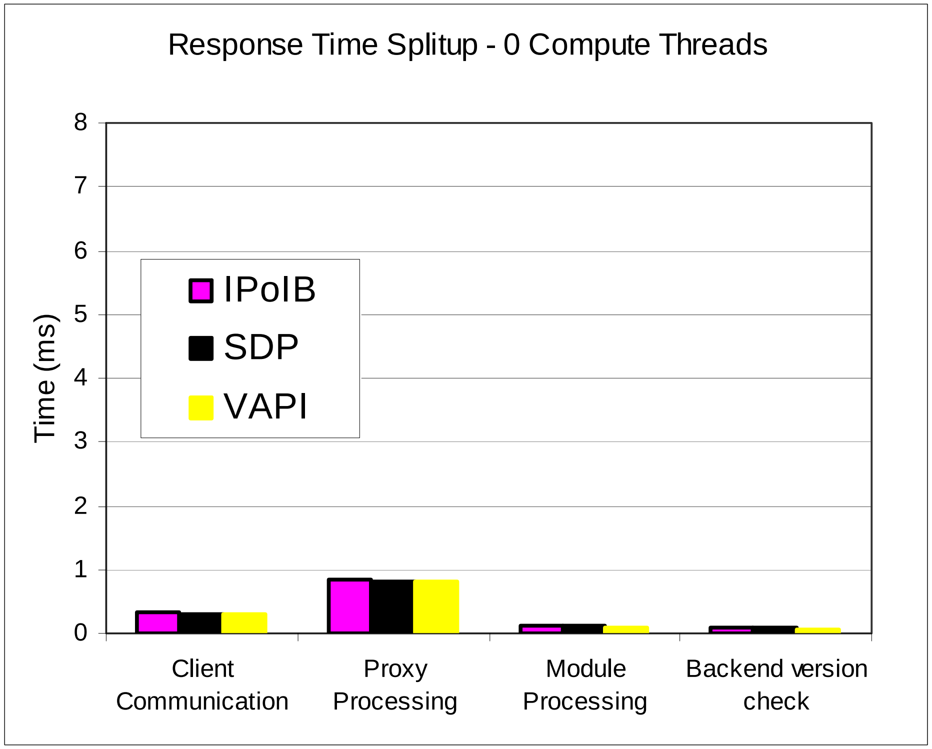
- The VAPI module can sustain performance even with heavy load on the back-end servers

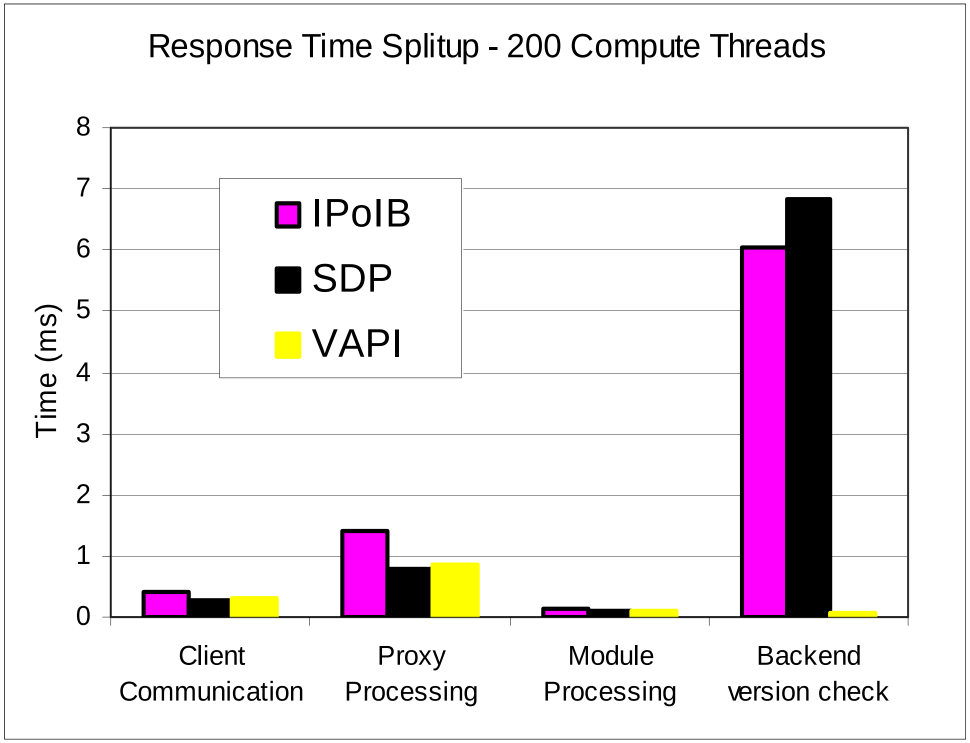
Data-Center: Performance



- The VAPI module responds faster even with heavy load on the back-end servers

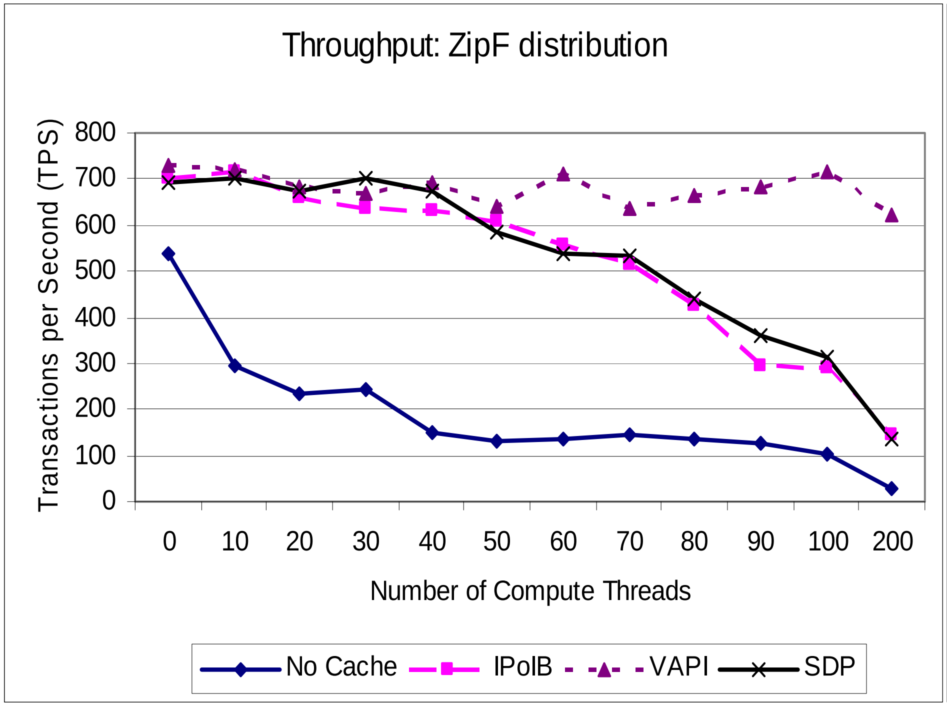
Response Time Breakup

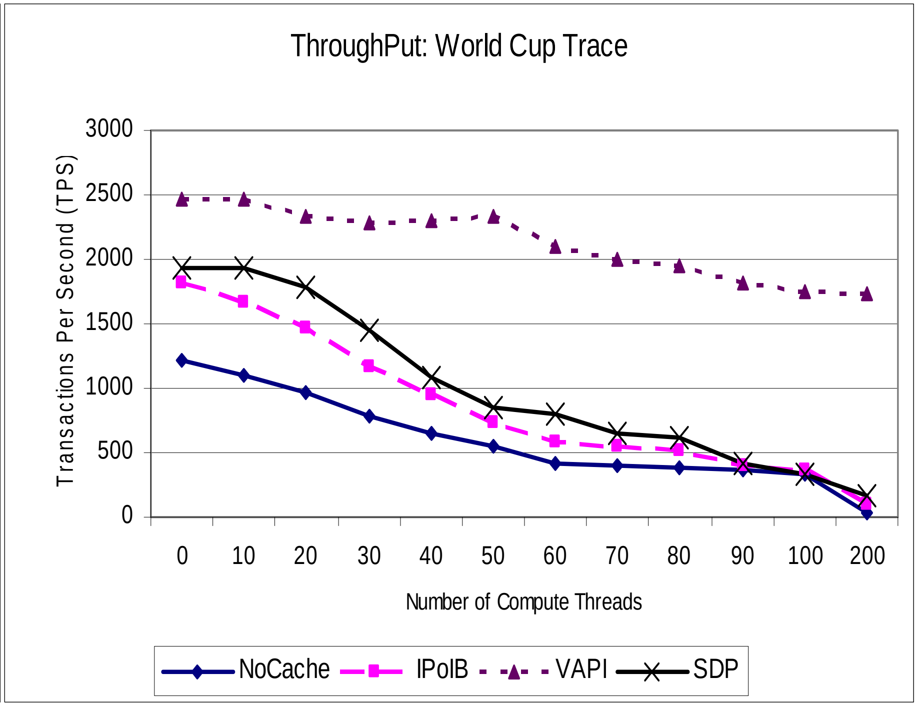




- Worst case Module Overhead less than 10% of the response time
- Minimal overhead for VAPI based version check even for 200 compute threads

Data-Center: Throughput





- The drop in the throughput of VAPI in World cup trace is due to the higher penalty for cache misses under increased load
- VAPI implementation does better for real trace too

Conclusions

- An architecture for supporting Strong Cache Coherence
- External module based design
  - Freedom in choice of transport
  - Minimal changes to existing software
- Sockets API inherent limitation
  - Two-sided communication
  - High performance Sockets not the solution (SDP)
- Main benefit
  - One sided nature of RDMA calls

Web Pointers

NBC **home page**

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