OpenACS and EuroTcl 2023

NaviServer 5.0

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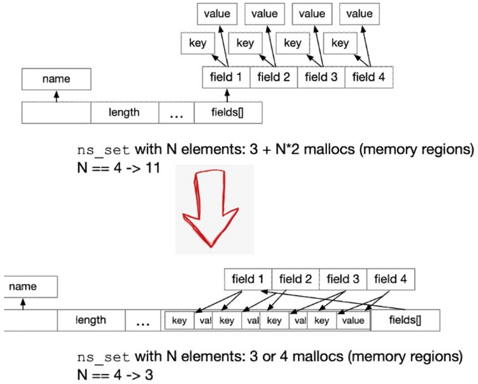
Overview

- What's new?
  - New Licence
  - Tcl9 compatibility
  - Significant code changes
  - New Major version number
- Reforms
  - Improved memory locality for ns_set
  - Persistent connections for ns_http
  - Removed usage of double-checking lock pattern
  - Clustering
- Want's next?
  - HTTP/2, HTTP/3?
  - More protocols



Why a new major number?

- NaviServer Releases:
  - 4.99.0 … 4.99.26
  - ”Running out of fingers and toes”
    (Citation of Linus Torvalds, when Linux stepped up to 3.20)
- New License:
  - Upgrade from Mozilla Public License Version 1.1 + GPL
  - to Mozilla Public License (MPL) 2.0
- Tcl 9:
  - Lifting various restrictions (32-bit signed integers -> 64-bit)
  - Substantial code changes in NaviServer necessary to make use of new capabilities
  - Release of NaviServer 5 will be after the release of Tcl 9
- New Features
  - A few set of changes cherry-picked on the next slides
  - Improved crypto functionality: E.g. support for Argon2 (winner of the 2015 Password Hashing Competition, defined by RFC 9106)
  - NaviServer 5.0 works with Tcl 8.6 and Tcl 9 (regression test with GitHub workflows)
- EOL NaviServer 4.99.*?
  - No, bugfixes still in the 4.99 branches, leading to 4.99.27 etc
  - Many NaviServer / OpenACS user are conservative

ns_set reform (1/3)

- What is an ns_set:
  - NaviServer data structure for the Tcl programmer
  - Like a Tcl dict, supporting duplicate keys, having names
  - Predates Tcl dict significantly (before 2000)

- Used for:
  - HTTP header fields
  - Configuration values
  - SQL tuples
  - …

- Example:
  - SQL query, returning 20 attributes, 1000 Tuples, e.g.: "`select * from acs_objects limit 1000`"
  - 43.000 malloc/free operations (*1000*(3 + 20*2)*)
  - This is for OpenACS installations a small query, many return 100K tuples or more

ns_set reform (2/3)

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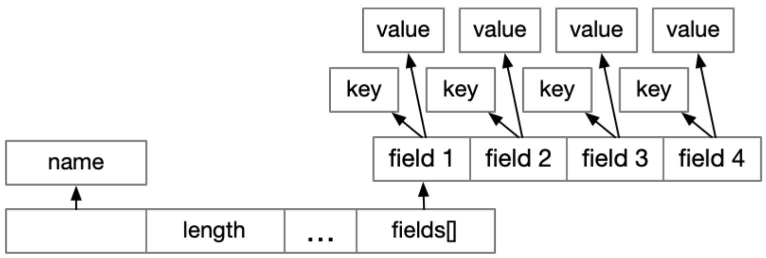
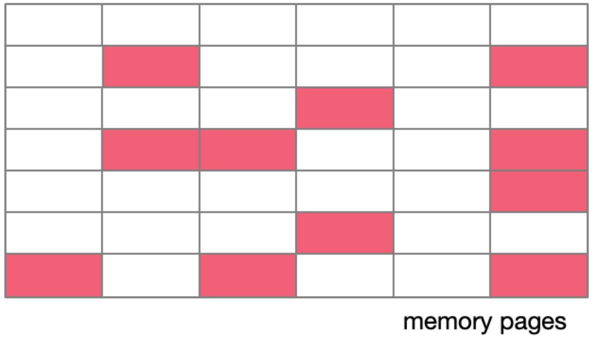
Memory pages

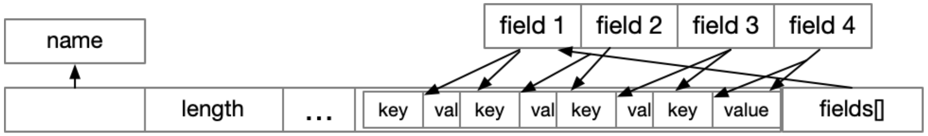
Old:





`ns_set` with N elements: 3 + N*2 mallocs (memory regions)
N == 4 -> 11

New:



`ns_set` with N elements: 3 or 4 mallocs (memory regions)
N == 4 -> 3

Improved memory locality

- Based on Tcl_DStrings
- More CPU-cache hits, improved performance
- Less memory consumption
- Less mutex locks

CPU Cache management

- Changes in pages require refetch
- Multi-threading: refetch per thread
- Especially expensive with NUMA architectures
- Memory access might differ by a factor of 5 or more

ns_set reform (3/3)

Quick test:

- Running sample query (1000 tuples a 20 attributes) in
- 1..30 threads
- Xeon Gold 6226R CPU @ 2.90GHz, 32 cores, hyper-threading enabled

Before (classical ns_set with many mallocs):

```
threads 1 total 4606.787 ms avg 3285.25 ms
threads 5 total 4595.358 ms avg 3493.07 ms
threads 10 total 4804.193 ms avg 3755.93 ms
threads 20 total 6279.524 ms avg 4569.16 ms
threads 30 total 8966.427 ms avg 6618.58 ms
```

After reform (using one Tcl_DString per tuple):

```
threads 1 total 4524.645 ms avg 3242.54 ms
threads 5 total 4251.266 ms avg 3450.09 ms
threads 10 total 4656.795 ms avg 3665.31 ms
threads 20 total 5934.105 ms avg 4671.38 ms
threads 30 total 7384.591 ms avg 5642.76 ms
```

E.g. with 30 threads, the total time improved by 17%.... with a smaller RSS.

ns_http reform (1/3)

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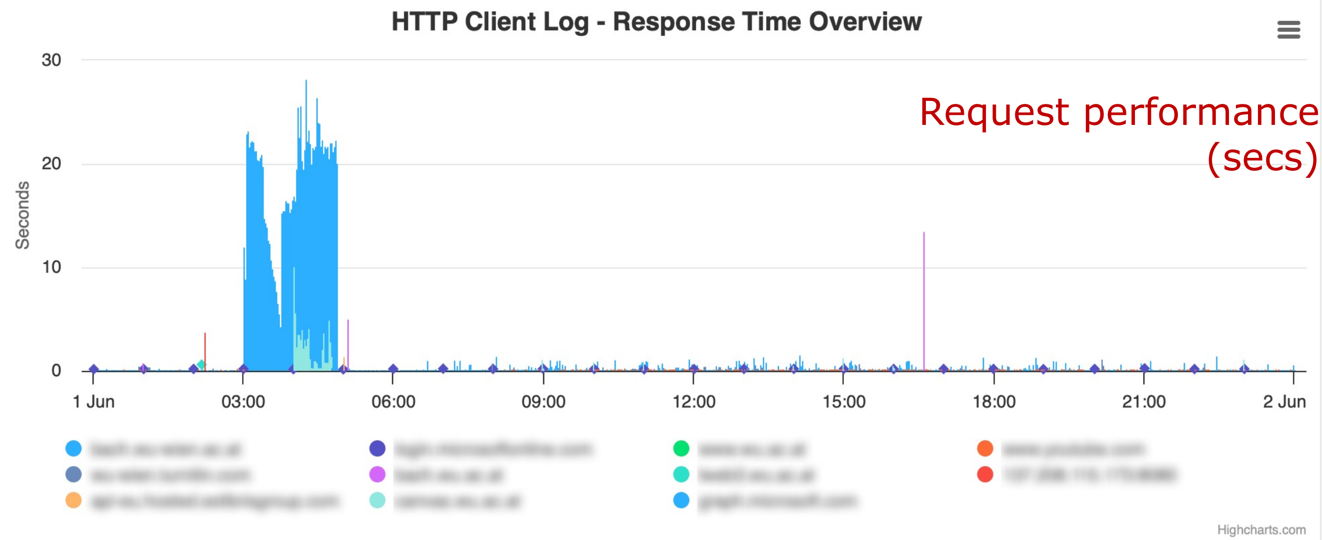
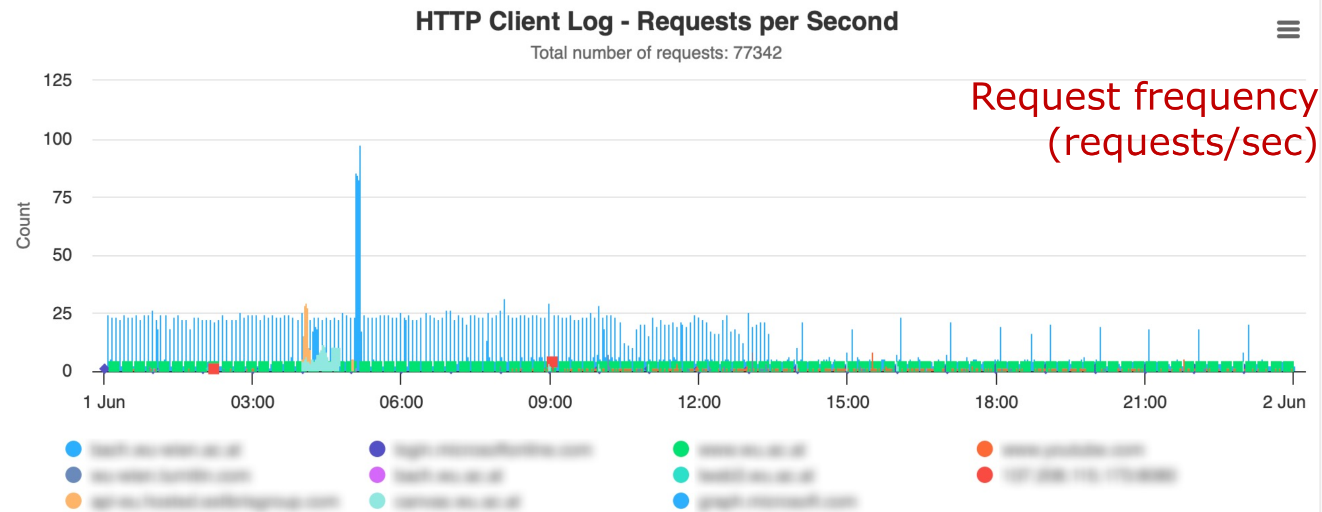
- What is ns_http:
  - Webserver performs as a web client requests from other servers
  - Cloud services, authentication, …
  - REST interfaces
  - Based on low-level server streaming infra-structure
  - Significantly faster than curl (esp. for high number of requests)
  - HTTP client request log (similar to access.log)
- What is new in NaviServer 5:
  - Persistent connections
  - Managing pool of connections, sharing across threads
- Challenges:
  - Requires strict error and parsing implementation (request pipelining)
  - Handling of streaming HTML (no content length provided)
  - Handling of incorrect replies
  - Handling of “100 continue”
  - …

ns_http reform (2/3)
Data visualized by NaviServer nsstats module

Often significant usage (up to several 100K client requests per day)



Here: bulk synchronization via ns_http with other systems mostly over night



ns_http reform (3/3)
Data visualized by NaviServer nsstats module

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Statistics per server

Performance

Amount of Data

Status codes

Summative Statistics

Host	Requests	Avg Time	Sent	Received	200	201	202	204	400	403	404	408	429
[illegible]	5	742.46ms	706.82MB	11.06KB	4	1	0	0	0	0	0	0	0
[illegible]	3974	128.25ms	1.3MB	3.23MB	2532	0	0	0	7	0	0	0	1435
[illegible]	64246	122ms	19.86MB	294.07MB	64246	0	0	0	0	0	0	0	0
[illegible]	5	3.82s	1.46KB	3.87MB	5	0	0	0	0	0	0	0	0
[illegible]	8275	232.25ms	17.53MB	63.53MB	8274	0	0	0	0	0	0	1	0
[illegible]	3	189.84ms	5.37KB	2.2KB	1	0	0	1	0	0	1	0	0
[illegible]	24	176.96ms	9KB	58.04KB	24	0	0	0	0	0	0	0	0
[illegible]	1	594.84ms	375B	1.66KB	1	0	0	0	0	0	0	0	0
[illegible]	136	231.7ms	11.09MB	72.48MB	67	23	46	0	0	0	0	0	0
[illegible]	190	6.21ms	31.54KB	2.03MB	190	0	0	0	0	0	0	0	0
[illegible]	483	107.89ms	60.86KB	595.25KB	482	0	0	0	0	1	0	0	0

External servers often source of sudden performance bottlenecks

Removed occurrences of Double-Checking Lock Pattern

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- Double-Checking Lock Pattern
  - Goal: reduce the overhead of acquiring locks
  - Testing the locking criterion before acquiring the lock.
- The Problem:
  - The pattern assumes a total store order (TSO), or the usage of “fences” (insert assembly)
  - In some language/hardware combinations, the pattern is unsafe (**RISC-V** has per default a weak memory order)
  - On x86: TSO, pattern is safe.

Newer architectures do aggressive optimizations, such as
1) compiler reordering instructions,
2) hardware reordering instructions,
3) cache coherency

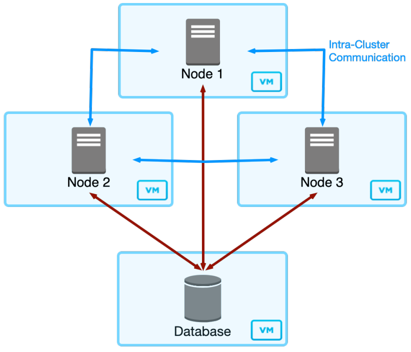
- NaviServer:
  - Two major variants of the double-checking lock pattern:
    1. start-up initialization
    2. lazy initialization of heap data (actually values kept for mutexes/locks, etc.)
  - Case 1: a posix/windows call can be used (pthread_once(), InitOnceExecuteOnce())
  - Case 2: requires more rewriting, lazy programming style.

```
/*
 * Core one-time server initialization to add a few Tcl_Obj
 * types.  These calls cannot be in NsTclInit above because
 * Tcl is not fully initialized at libnsd load time.
 */

if (!initialized) {
  Ns_MasterLock();
  if (!initialized) {
    Tcl_Obj *tmpObj = Tcl_NewIntObj(0);

    NS_intTypePtr = tmpObj->typePtr;
    Tcl_DecrRefCount(tmpObj);

    NsTclInitQueueType();
    NsTclInitAddrType();
    NsTclInitTimeType();
    NsTclInitMemUnitType();
    NsTclInitKeylistType();
    initialized = NS_TRUE;
  }
  Ns_MasterUnlock();
}
```

Large Scale NaviServer Configurations

- NaviServer provides detailed statistics, such as:
  - Mutex/RWLock statistics (see conference last year)
  - Requests (per connection pool)
  - Cache (requests, hits, flushes, savings, …)
  - Database (per DB pool, statements, performance, …)
  - …

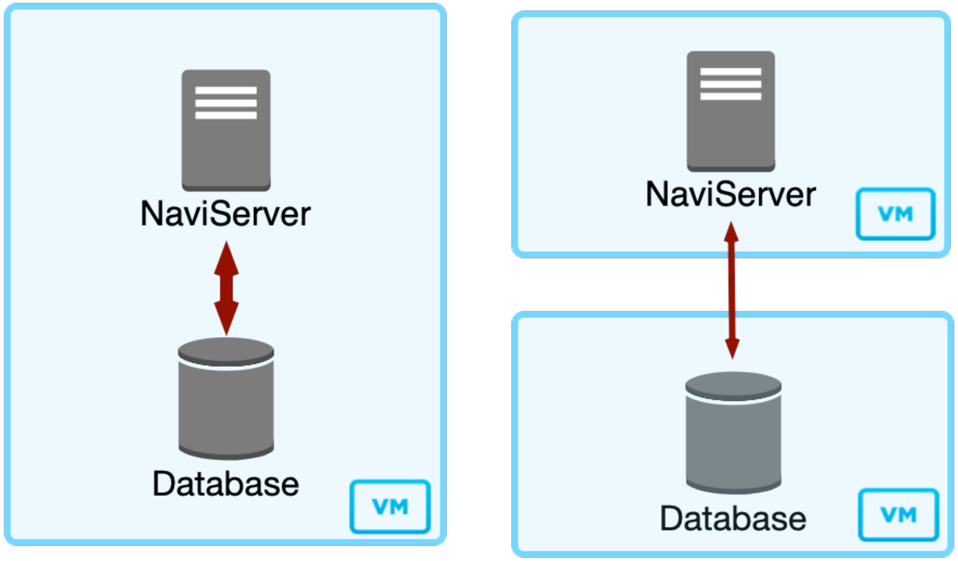
- OpenACS 5.10.1 has no cluster management:
  - Up to 5.10.1: static configuration, based on IP addresses
  - Not feasible for e.g. cloud operations
  - In 5.10.1: dynamic cluster configuration:
    - Additional cluster nodes can be registered/deregistered
    - Cluster join control via cluster secret



NaviServer Cluster with 3 Nodes, DB and NaviServers on different VMs

- Various trade-offs:
  - When DB and NaviServer are on the same machine
    - Communication with DB is fast
    - Maintaining cache coherency is relatively simple (all in one NaviServer instance)
    - NaviServer is excellent in making use of a high number of cores
  - But
    - What if this reaches limits?
    - Machines with many cores are still quite expensive
    - Can the throughput be doubled?
    - What are the consequences on response times (also on idle systems)?

Performance differences:
NaviServer and DB on the same or different VMs



Single NaviServer,
DB and NaviServer on the same VM

Single NaviServer,
DB and NaviServer on different VMs

- Common pattern: Database Server
- For cluster setups, DB is typically on an own VM
- Performance implications depend on application
  (e.g. how many SQL statements/request, cost of SQL requests)
- Network latency of assign 10 ms can cause throughput decrease by a factor of 20 based on pgbench, (see: https://www.cybertec-postgresql.com/en/postgresql-network-latency-does-make-a-big-difference/)

Empirical data from 3 sample OpenACS installations

	openacs.org	server1	server2
requests	448,029	7,642,282	4,308,318
response time/req (ms)	6.27	118.84	90.15
cache saving/req	5,3	69,45	113,72
cache flushes/req	0.0001	0.2406	1.3901
# SQL statements/req	3.93	38.66	22.33
SQL time/req	2.05	28.32	43.07

- Data collected when running servers over 4 days
- “server1” and “server2” are large sites, serving per day 1 mio requests or more
- Significant database use (server1: ~38 SQL statements per request, server2: ~22)
- Very few cache invalidations per request on OpenACS.org, very high on “server2”

Difference in response time and performance when running SQL server on a different VM

	openacs.org	server1	server2			
response time	6.27	118.84	90.15	1.00	1.00	1.00
remote SQL	8.32	147.16	133.22	1.33	1.24	1.48

	openacs.org	server1	server2			
max throughput (reqs/s	7022	505	666	1.00	1.00	1.00
remote SQL	5291	408	450	0.75	0.81	0.68

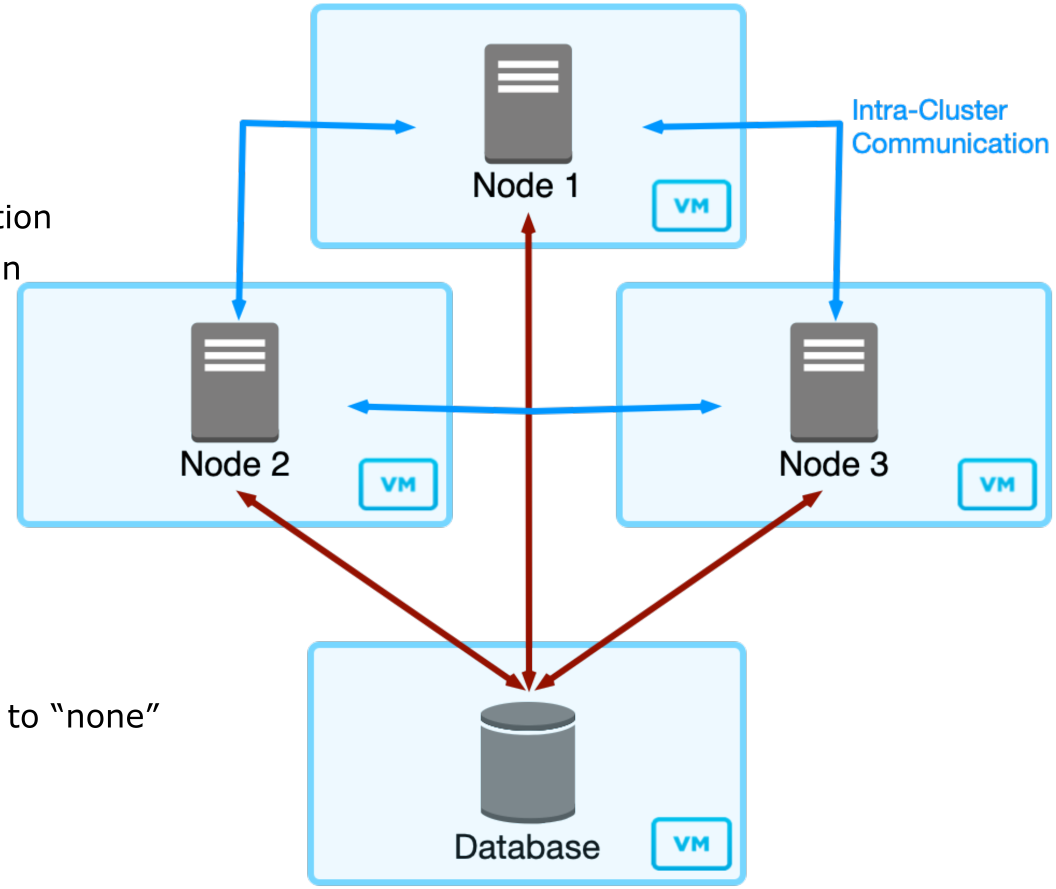
- Assumption:
  - remote SQL causes double latency per SQL statement (factor of 2)
  - For your applications: always best to measure, depends on local/cloud environment, etc.
- Average response time for openacs.org dropped by 30%, but still, it is fast enough, we are far from requiring max throughput.
- Drop of max throughput for ”server1” and “server2” might be sometimes already an issue, but probably, still OK

Performance differences:
NaviServer Cluster

- Example: 3 Nodes
- Database on a separate server

- For cache coherency:
  - Requires intra-cluster communication
  - Via HTTP/HTTPS/UDP/COAP built-in in NaviServer
  - Persistent connections handy and preferable
  - Requires updated applications, using "clusterwide" flush operations

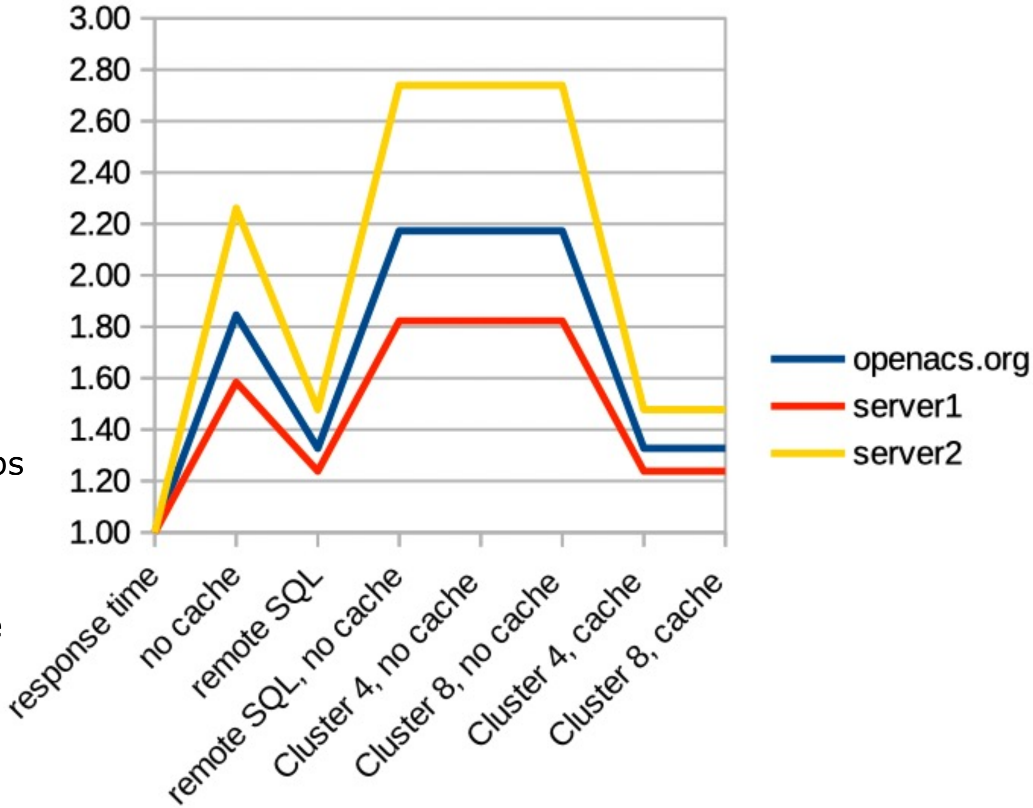
- Alternatively:
  - Avoid caching
  - Setting parameter "cachingmode" to "none"
  - Avoids most of intra-cluster communications with its overhead
  - But base performance degrades



NaviServer Cluster with 3 Nodes,
DB and NaviServers on different VMs

Performance implications for sample OpenACS installations

- Request Latency Comparison: comparing
  - Single server
  - Caching/no caching
  - Local SQL/remote SQL
  - Cluster nodes with 30 threads each
  - Cluster configuration with 4 nodes
  - Cluster configuration with 8 nodes
- Observation:
  - "server1" per-request performance drops most, when caching is deactivated (factor of 2.2)
  - Per-request performance of base configuration (DB + server on the same machine is best)
  - Caching benefits outweigh intra-cluster communication overhead



Throughput implications for sample OpenACS installations

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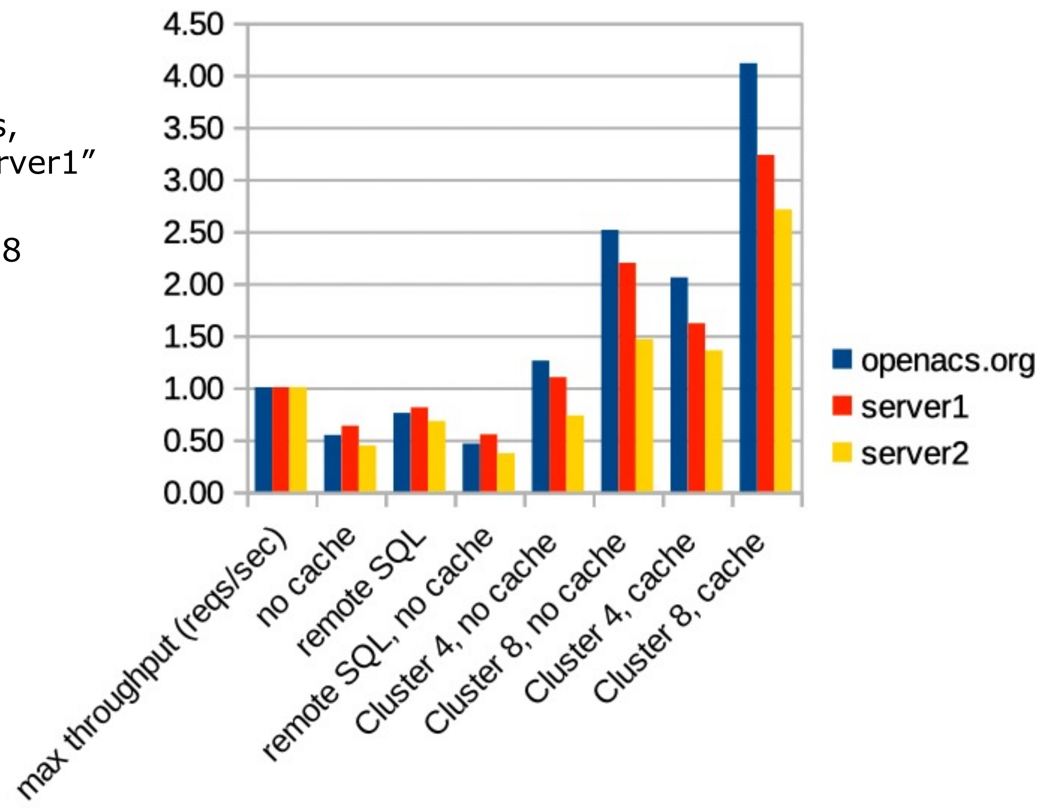
- Throughput Observations:
  - With cluster "no cache" configurations, throughput of "openacs.org" and "server1" is already higher with 4 nodes.
  - Throughput can be doubled with 4 to 8 smaller cluster nodes
- Additional benefit:
  Higher availability in cluster configuration
- Caveats:
  - Is DB sufficiently scalable?
  - Statistics are collected from single VM installations



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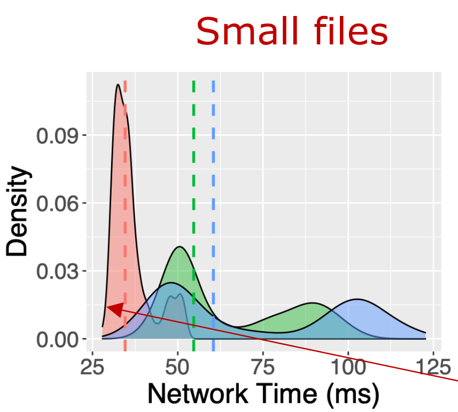
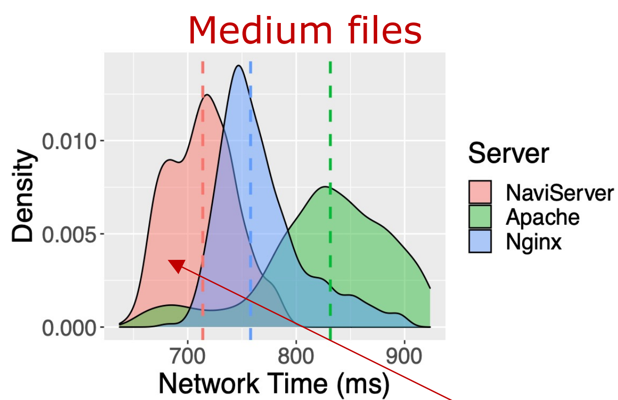
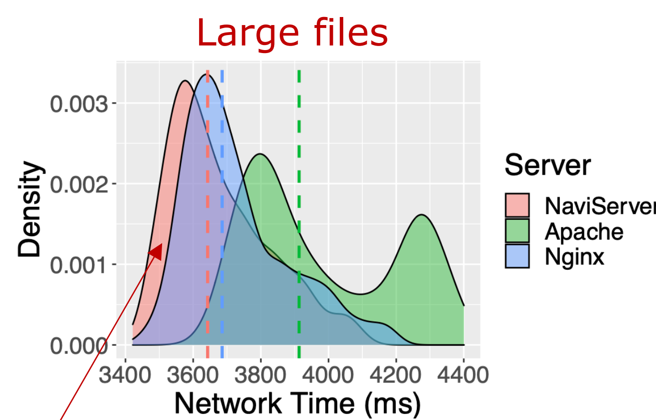
Experiment: HTTP/2 for NaviServer

Master Thesis of Philip Minić:

- Prototype version of NaviServer with HTTP/2 support
- Better performance than Apache and nginx with HTTP/2







NaviServer

Status

- Still experimental
- HTTP/3 (QUIC) is part of OpenSSL 3.1
- Still frequent changes in OpenSSL QUIC code base
- Little reason for HTTP/2 when HTTP/3 is available

Summary

- NaviServer 5
  - Overcomes many of the restrictions of NaviServer 4.99*
  - Strong integration with new Tcl 9 functionality
  - Many new features
- Learning from observation
  - Installations become more complex and distributed
  - Detailed monitoring eases
    - Configuration
    - Debugging
  - Still much to do!
  - Questions?

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