

**Deliverable D6.3**

**Assessment Report**

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***Abstract***

This report is the first edition of a critical evaluation of the reTHINK framework performance according to phase 1 trials. This initial evaluation is more focused on technical information collected during the trials. Initial feedback from developers and hackathon participants were also considered.

[End of abstract]

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Executive summary

This Report provides the first detailed assessment of reTHINK framework according to phase 1 implementation results. The current evaluation is more focused on technical information collected during ongoing phase 1 trials with preliminary feedback from scenario developers and participants to a mini-Hackathon. In general, the conducted assessment provides positive feedback and it is possible to conclude the project is progressing well and has already addressed some of its challenges, for example, service interoperability with minimum standardisation effort. Topics that require further work are:

* Framework and Service Deployment
* Identity Management
* Policy Management
* Discovery
* Quality of Service

The result of this evaluation provides an essential input to phase 2 activities.

List of authors

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Abbreviations

|  |  |
| --- | --- |
| API | Application Programming Interface |
| CSP | Communication Service Provider |
| DHT | Distributed hash table |
| ECDSA | Elliptic Curve Digital Signature Algorithm |
| GUID | Global User Identifier |
| IdP | Identity Provider |
| JIT | Just In Time Compilation |
| JVM | Java Virtual Machine |
| MN | Message Node |
| ProtOfly | Protocol On-the Fly |
| QoS | Quality of Service |
| KPI | Key Performance Indicator |
| RTT | [Round-trip delay time](https://en.wikipedia.org/wiki/Round-trip_delay_time) |
| SUT | System Under Test |
| VM | Virtual Machine |

# Introduction

# Technical Evaluations

This chapter provides a detailed technical evaluation for each different sub-system implemented in phase 1 and deployed in the testbed, namely the Message Nodes (Vertx, NodeJS, NoMatrix), the Hyperty Runtime, the Domain Registry, the Global Registry, the Catalogue and the IDP.

The further development of the Matrix based Message Node has been frozen after phase 1. The phase 1 assessment results have shown that the Matrix architecture causes relatively long delays for the establishment of new communication channels, but is fast once the channel is established. Since the phase 1 reTHINK framework always generated new identifiers, it was decided to freeze and postpone the Matrix based developments until the persistence and re-use of identifiers was introduced to the core-framework. The core of the Matrix based MN implementation has been transferred to a new “NoMatrix” MN, which is now also the base of the DTAG testbed installations.

The NoMatrix MN is tested here together with the Vertx and Nodejs implementations. The original Matrix MN is not covered in these tests, since due to resource constraints it is not yet feature complete.

## Message Node

### Description of Component

The Message Node provides Real Time Message Oriented communication functionalities used by Hyperties to communicate with each other. It provides different communication patterns including publish/subscribe communication and Request/Response communication.

### Methodology and setup

For the evaluation of the individual Message Nodes (MNs) a set of Karma[10] tests has been developed. These common tests are executed against each Message Node implementation and the results are documented.

The first set of tests evaluates the conformance of the MNs with the specified request/response patterns of the message API. The second set of tests evaluates the performance of the MNs in forced situations of increased load.

The individual tests are described in the following chapter.

In order to be comparable all tests have been performed on a single machine with locally deployed Message Nodes and a locally deployed Domain Registry. (This is the same setup that has been used for the tests in the previous Assessment report D6.3)

The used machine has following parameters:

* CPU: Intel Core i7-4712MQ, 2.30GHz (8 Cores)
* 8 GB RAM
* SSD
* OS: Debian (stretch)

The Domain Registry was running in its own Docker container in a custom Docker network, exposing the internal port 4567 to the host port 4567. So it was accessible from other docker containers in the same custom network as well as from the host via this port.

The individual MNs have been deployed from their pre-built docker-images available on the rethink docker-hub. All MNs have been operated as single nodes in the simpliest possible configuration. Potentially available cluster modes were not used.

### Conformance metrics

These tests evaluate the conformance of the MNs with the specified message patterns. Example requests are created according to the specification at [13] and sent to the Message Node. The corresponding responses are then compared with the expected results. Performance parameters, like the response time, are not evaluated in these tests. The following sub-sections give a short description of the individual conformance tests.

#### Stub connection and disconnection

The purpose of this test is to ensure that the Stub exposes the "status" events as specified in the Protocolstub state machine at <https://github.com/reTHINK-project/specs/blob/master/messaging-framework/protostub-state-machine.png>.

It instantiates a stub and performs a connection and then a disconnection of the stub to the corresponding MN. The tests check that the stubs are generating the correct status event sequence (“created”, “in-progress”, “live”, “disconnected”) for each connection/disconnection situation.

|  |  |
| --- | --- |
| Test 1.1 | Stub connect/disconnect |

#### Hyperty address allocation messages

The purpose of this test is to ensure the Conformance of the MN operations with the message specification for hyperty address allocationshttps://github.com/reTHINK-project/dev-service-framework/blob/master/docs/specs/messages/address-allocation-messages.md.

It checks the allocation and de-allocation of hyperty addresses by the MNs. It includes following sub-tests:

|  |  |
| --- | --- |
| Test 2.1 | allocation of a single address |
| Test 2.2 | de-allocation of a single address |
| Test 2.3 | allocation of an address block of 3 addresses |
| Test 2.4 | de-allocation of an address block of 3 addresses by given address array |
| Test 2.5 | allocation of an address block with a given “allocationKey” as identifier for this block of addresses |
| Test 2.6 | de-allocation of an address block identified by a given allocationKey |

#### Object address allocation messages

The purpose of this test is to ensure the Conformance of the MN operations with the message specification for object address allocations.

It checks the allocation and de-allocation of object addresses by the MNs. It includes following sub-tests:

|  |  |
| --- | --- |
| Test 3.1 | allocation of a single address incl. check that a given "scheme" is used for the object address allocations |
| Test 3.2 | de-allocation of a single address |
| Test 3.3 | allocation of an address block of 3 addresses |
| Test 3.4 | de-allocation of an address block of 3 addresses by given address array |
| Test 3.5 | allocation of an address block with a given “allocationKey” as identifier for this block of addresses |
| Test 2.6 | de-allocation of an address block identified by a given “allocationKey” |

#### Subscription and object update messages

The purpose of this test is to ensure the Conformance of the MN operations with the Data synchronization message specification.

It checks the subscription and un-subscription for given object addresses at the MN as well as the correct publication of object update events to the subscribers. It includes following sub-tests:

|  |  |
| --- | --- |
| Test 4.0 | Test setup: allocation of an object address |
| Test 4.1 | subscription for an object address with a given body.source attribute (the given body.source must be used as subscriber url) |
| Test 4.2 | subscription for an object address without a body.source attribute (the from address of the subscribe message must be used as subscriber url) |
| Test 4.4 | update of the subscribed object by the reporter and expect correct update events on both subscribers |
| Test 4.4 | unsubscription of both subscribers, expecting correct 200 OK response |
| Test 4.5 | another update of the subscribed object and expect that no events are received by the (now unsubscribed) subscribers |

#### Registration messages

The purpose of this test is to ensure the Conformance of the MN operations with the Registration message Specification [11].

This set of tests requires a running Domain Registry component that is accessible by the MNs. The MN uses a RegistryConnector component to forward the received messages to the Domain Registry and receive back the responses.

It includes following sub-tests:

|  |  |
| --- | --- |
| Test 5.1 | Test setup: registration of an allocated hyperty address for a given userid |
| Test 5.2 | Search a hyperty by given userid |
| Test 5.3 | Search a hyperty address by given userid and scheme |
| Test 5.4 | Search a hyperty by given userid and resource-types |
| Test 5.5 | Search a hyperty by given userid, scheme and resource-types |
| Test 5.6 | Search and retrieve hyperty-data by a given hyperty address |
| Test 5.7 | Search for a non existing registry object/hyperty → expect correct error message |
| Test 5.8 | Test correct handling of keep-alive messages for an active registration |
| Test 5.9 | Subscription for update events, when the status of the registered object changes |
| Test 5.10 | Test delivery and receiving of status update events |
| Test 5.11 | unregistration of a hyperty address |

### Performance metrics

These tests evaluate the performance and robustness of the MNs in forced situations of increased load. Therefore requests are sent in loops of increasing iteration counts and with differing message sizes as fast as possible. For each of these tests, the duration is measured and used as metric for the evaluation.

Each test is executed 3 times. The results in the table are the mean values of the 3 test runs. Messages are sent out in iterations as fast as possible without any delays between messages to put the MN under stress.

#### Hyperty address allocation messages

These tests create and send an increasing number of allocation and de-allocation messages for Hyperty addresses to the MNs and expect at each time a correct 200 OK response. The sizes of these messages are already defined by the specification. They can not be smaller than specified and it also makes no sense to artificially increase their size. Therefore only the number of iterations and the number of addresses to allocate vary. Furthermore the tests with several address numbers are executed with and without an “allocationKey” parameter, which can be used to identify blocks of allocated addresses later on (e.g. for an de-allocation).

Also the time for the de-allocation of all addresses is measured.

Following measurements are performed in this set of test:

* hyperty address allocation and de-allocation requests for 1 address each for 100, 1000 and 10000 iterations
* hyperty address allocation and de-allocation requests for a block of 3 address each without an “allocationKey” for 100, 1000 and 10000 iterations
* hyperty address allocation and de-allocation requests for a block of 3 address each with “allocationKey” for 100, 1000 and 10000 iterations

#### Object address allocation messages

These tests repeat the same procedure as previously described for hyperty addresses now for object addresses too. The same comments and notes apply here as well.

Following measurements are performed in this set of tests:

* Object address allocation and de-allocation requests for 1 address each for 100, 1000 and 10000 iterations
* Object address allocation and de-allocation requests for a block of 3 address each without “allocationKey” for 100, 1000 and 10000 iterations
* Object address allocation and de-allocation requests for a block of 3 address each with “allocationKey” for 100, 1000 and 10000 iterations

#### Hyperty messages

These tests send an increasing number of messages from one allocated Hyperty to a second allocated Hyperty. Each Hyperty is connected via its own stub. This simulates the behaviour of messaging between Hyperties which are deployed in two different Runtimes.

During the tests the payload sizes are increased from 100B over 1kB to 10kB. The purpose of this test is to ensure that all messages arrive in the same order they were sent and to measure the overall needed time.

The measured time frame starts when the first message from Hyperty 1 via Stub 1 is sent and stops when the last message is received by Hyperty 2 via Stub 2.

Following measurements are performed:

* Message with payload of 100B for 100, 1000 and 10000 iterations
* Message with payload of 1kB for 100, 1000 and 10000 iterations
* Message with payload of 10kB for 100, 1000 and 10000 iterations

#### Subscription and Publication of Object updates

These tests send a publish Object update message from one reporter to a increasing number of subscribers. During the tests also the payload sizes are increased from 100B over 1kB to 10kB.

For this purpose a single reporter Hyperty is connected to the MN via a first stub and an increasing number of subscriber hyperties are connected via their own stubs, one stub for each subscriber hyperty. In the preparation phase, the reporter stub allocates an object address first and then all subscriber Hyperties send subscription messages for updates on this object and wait for their OK response.

The measured time frame starts when the Reporter Hyperty sends the update message and stops when all subscribers have received the corresponding update message. The order in which the subscribers receive the update message is not considered as test criteria.

Following measurements are performed:

* Update Message with payload of 100B for 100, 200, and 1000 subscribers
* Update Message with payload of 1kB for 100, 200, and 1000 subscribers
* Update Message with payload of 10kB for 100, 200, and 1000 subscribers

### Summary of MN Assessment

#### Conformance test results

The following figure summarizes the results of the conformance tests for all 3 Message Nodes.

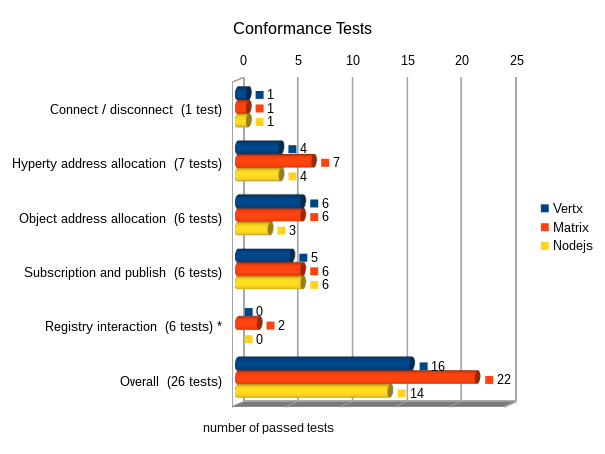


Figure 1: Overview of specification conformance test results

***Connection and allocation / de-allocation tests:***

All 3 nodes pass the basic connect and disconnect test.

The Vertx and Nodejs nodes have not yet implemented the de-allocation of hyperty addresses. Therefore neither passes all tests in the second block.

The Nodejs also has not yet implemented the de-allocation of object addresses. This is the reason why this node does not pass all tests in the third block.

***Subscription and publish:***

These tests did work well in all 3 nodes, except that the Vertx node returned an unexpected response code (500) for the un-subscription of a subscriber.

***Registry interactions:***

The recent Specification of the Registry interaction messages are not fully adapted in the current implementation of the RegistryConnector component, which is used by all 3 nodes. Especially the proposed advanced search mechanisms are not yet implemented as specified. That’s why the registry interactions of all 3 nodes are not yet finished and some tests fail for that reason.

Additionally the Nodejs node expects the “to-address” of registration related messages to end with a “/”, which is not specified this way. Therefore the hyperty address registration and lookup do not work.

The Vertx node did not connect successfully to the Domain Registry at all, though the configuration of the registry URL was done in the config file. This might have been a configuration issue, which needs further elaborations.

#### Performance test results

***Allocation and de-allocation of Hyperty addresses***

The following 2 figures provide a summary of the performance of the MNs in terms of allocation and de-allocation of hyperty addresses.

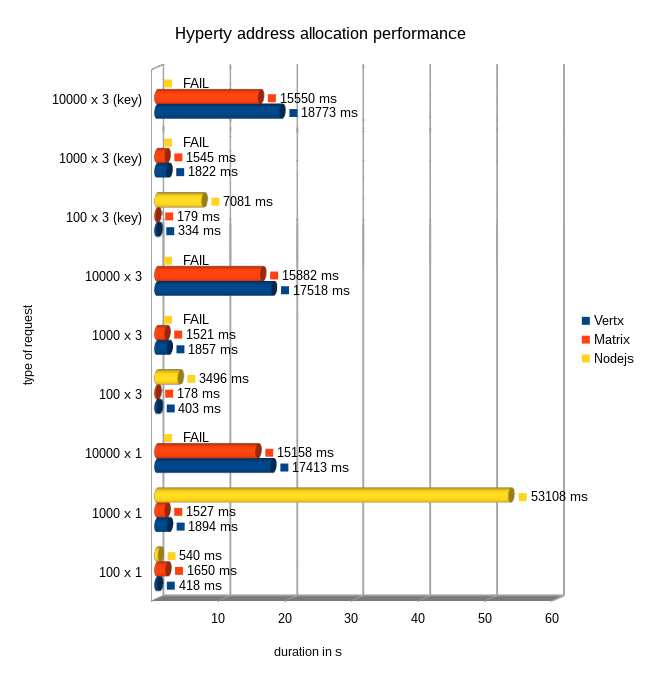


Figure 2: Performance of Hyperty address allocations

The performance of the Vertx and Matrix MNs for the allocation of hyperty addresses are at the same level with an advantage for the Matrix MN.

The Nodejs MN performance for these operations is lower and fails for higher number of iterations with “out-of-memory” errors, so that the tests did not pass.

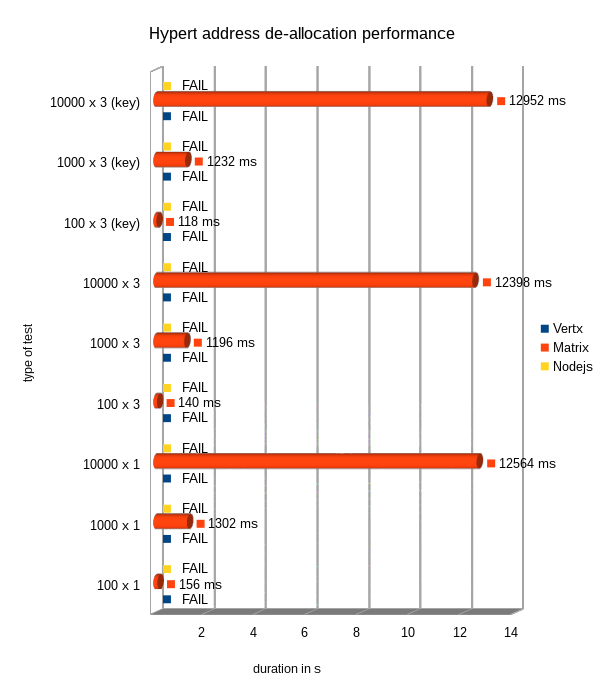


Figure 3: Performance of Hyperty address de-allocations

The de-allocation of hyperty addresses is not yet implemented in the Vertx and Nodejs MNs. Therefore only the Matrix MN passed this test. The performance of the de-allocation in the Matrix MN is slightly better than the allocation performance.

***Allocation and de-allocation of Object addresses***

The following 2 figures provide a summary of the performance of the MNs in terms of allocation and de-allocation of Object addresses.

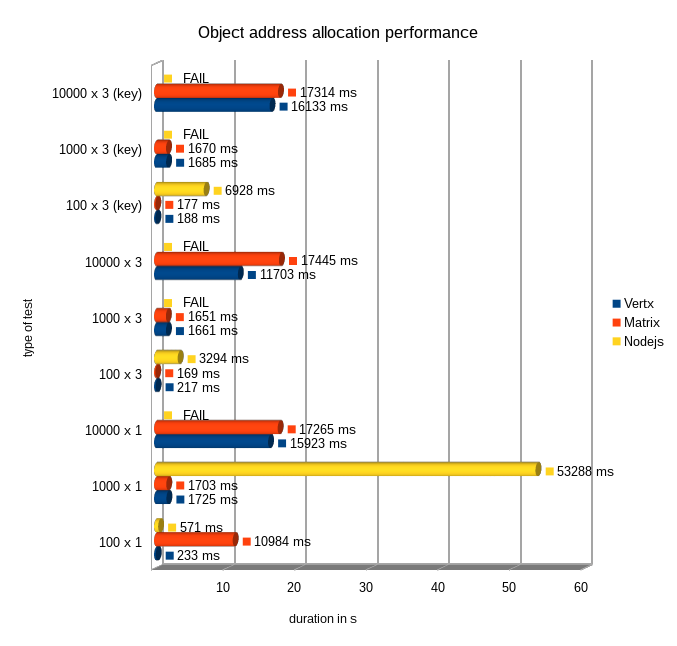


Figure 4: Performance of Object address allocations

The results for the object address allocations are comparable with the ones for the hyperty addresses. The Vertx and Matrix MNs are again on a comparable level (with a small advantage for Vertx this time), while the Nodejs MN is considerable slower and fails for higher iteration numbers with out-of-memory errors.

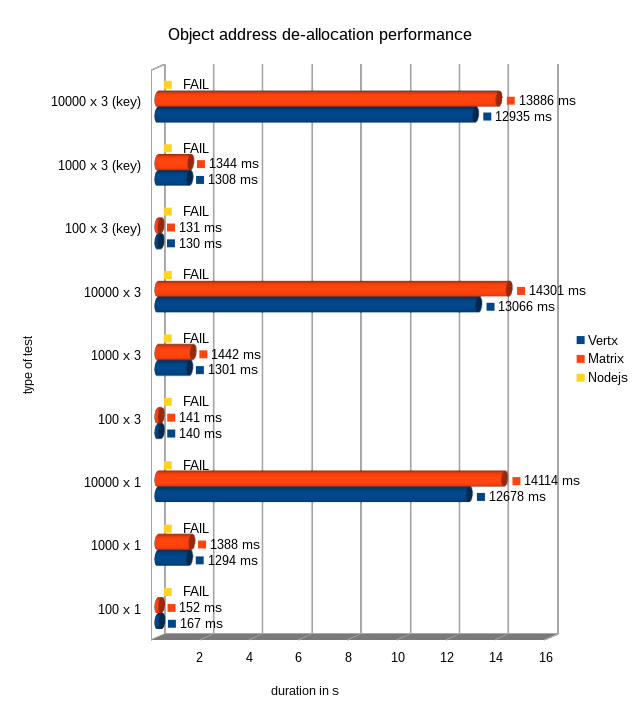


Figure 5: Performance of Object address de-allocations

The Nodejs node does not yet implement the de-allocation of Object addresses, therefore it fails these tests. The Vertx and Matrix MNs are again on a comparable level with a small advantage for the Vertx node.

***Hyperty messaging performance***

The following figure summarizes the results of the performance for the sending of message with different sizes from one Hyperty to another.

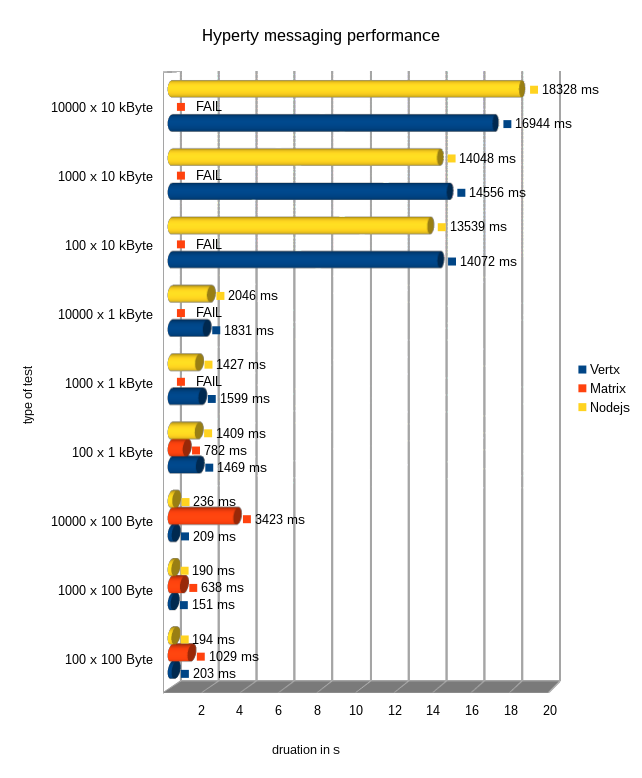


Figure 6: Performance of Hyperty messaging

The results for the Hyperty Messaging show the Vertx and Nodejs nodes on a comparable level with no clear advantage for one of them.

The Matrix MN messaging performance is much lower and fails especially for bigger messages and higher iteration numbers. The main reason for the fails was a wrong order of events on the receiving side which caused the individual tests to abort immediately. The high message latency is a consequence of the Matrix.org main architecture, which is based on http/https as internal transport protocol.

***Hyperty messaging performance***

The next figure shows the results of the performance measurements for the delivery of object update messages to a variable number of subscribers.

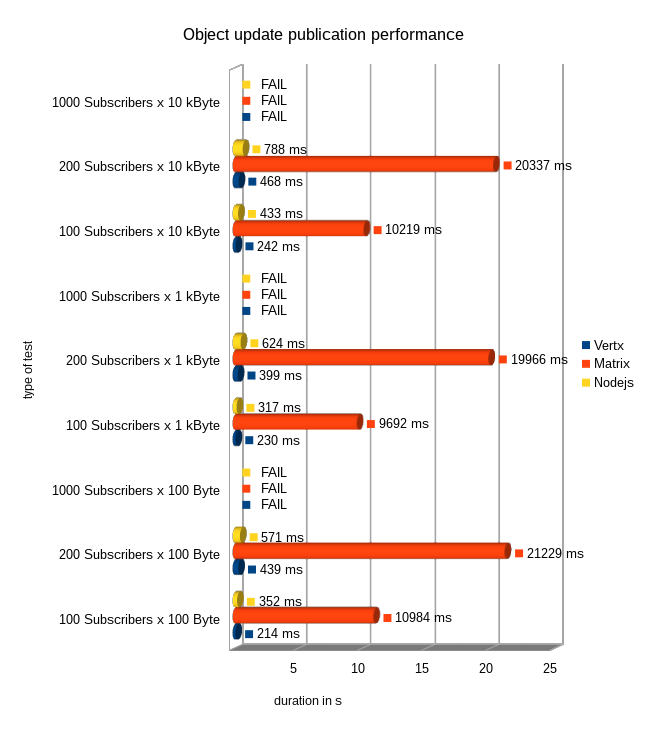


Figure 7: Performance for object update messages to N subscribers

Also here the high messaging latency of the MatrixMN can be noticed (for the same architectural reason as mentioned before), while the Vertx and Nodejs nodes perform on a comparable level of very low latencies with an advantage for the Vertx MN.

More of interest is that the tests with 1000 subscribers fail for every MN. This is caused by the fact that the stubs of all 3 MNs connect to their MN backends via WebSockets. Since the Karma tests were performed in a browser all 3 stub-types are concerned by browser resource limitations, especially the maximum number of allowed parallel WebSocket connections. This limit currently seems to be around 250, which caused the tests with higher numbers of subscribers to fail.

#### MN Assessment conclusions and recommendations

Currently Vertx can be recommended as “all purpose” MN with a good performance also for high number of clients and Object and Hyperty address allocations and subscribers. The missing parts for the de-allocation of hyperty addresses should be implemented.

According to the measurements, the NodeJs MN seems to a good choice for fast messaging demands with a rather low number of clients and allocated Hyperty or Object addresses. Also this node should implement the missing parts for the de-allocation of hyperty and object addresses.

The opposite recommendation is suitable for the Matrix MN currently which performs well for high number of clients and allocated Hyperty or Object addresses but with low performance demands.

Nevertheless all 3 nodes already proved to be operational in the scope of the available example applications like the WebRTC Connector or multiparty chat. The performed performance tests were used to show the current limits of the available MNs.

In general the work on the specification of the advanced features for the registry interactions must be continued and then be implemented in all 3 nodes.

# References

1. Deliverable D2.1, “Framework Architecture Definition”, 31-07-2015.
2. Deliverable D2.2, “Data Models and Interface Specification of the Framework ”, 30-08-2015
3. Deliverable D3.1, “Hyperty-Runtime-and-Hyperty-Messaging-Node-Specification”, 30-09-2015.
4. Deliverable D4.1, “Management and Security features specifications”, 30-09-2015.
5. Deliverable D3.2, “Hyperty Runtime and Hyperty Message Node Phase 1”, 29-02-2016.
6. Deliverable D4.2, “Implementation of Governance and identity management components for phase 1”, 29-02-2016.
7. Deliverable D5.1, “Service Scenarios Specification”, 29-12-2015.
8. Deliverable D5.2, “Initial Hyperties and Service Scenarios implementation”, 29-06-2016.
9. Deliverable D6.1, “Initial Hyperties and Service Scenarios implementation”, 29-06-2016.
10. Karma testing tool, https://karma-runner.github.io/1.0/index.html; last accessed June 2016.
11. Registration Message specification, <https://github.com/reTHINK-project/dev-service-framework/blob/master/docs/specs/messages/registration-messages.md>; last accessed June 2016.
12. Hello World Hyperty, <https://github.com/reTHINK-project/dev-hyperty/tree/master/src/hello-world>; last accessed June 2016.
13. Messages Specification: <https://github.com/reTHINK-project/dev-service-framework/tree/master/docs/specs/messages>; last accessed June 2016.
14. Autobench GitHub Repository. Available online: <https://github.com/menavaur/Autobench>; last accessed June 2016.
15. Httperf GitHub Repository. Available online: <https://github.com/httperf/httperf>; last accessed June 2016.
16. Httperf Man Page. Available online: <http://www.labs.hpe.com/research/linux/httperf/httperf-man-0.9.ps>; last accessed June 2016.
17. WebRTC Security architecture, <https://tools.ietf.org/html/draft-ietf-rtcweb-security-arch-12>; last accessed June 2016.
18. [Domain Registry user manual](https://github.com/reTHINK-project/dev-registry-domain/blob/master/docs/DomainRegistryUserManual.md), <https://github.com/reTHINK-project/dev-registry-domain/blob/master/docs/DomainRegistryUserManual.md>; last accessed June 2016.
19. [HAProxy](http://www.haproxy.org/) GitHub Repository. Available online: http://www.haproxy.org/; last accessed June 2016.
20. Apache Cassandra site. Available online: http://cassandra.apache.org/; last accessed June 2016.
21. agmoyano/OpenIDConnect GitHub Repository. Available online: <https://github.com/agmoyano/OpenIDConnect>; last accessed June 2016.
22. PhPOIDC Bitbucket Repository. Available online: <https://bitbucket.org/PEOFIAMP/phpoidc> ; last accessed June 2016.
23. Message Node detailed tests results
    1. Vertx Tests

The Vertx MN was deployed as docker container on the test machine according to the instructions at <https://github.com/reTHINK-project/dev-msg-node-vertx>. The configuration was done via the configuration file node.config.json.

***NOTE:***

The Vertx MN expects message Ids to always be Numbers instead of Strings as it is specified. Since this is a relatively minor deviation some tests have been “relaxed” in order to let the MN pass the tests. This should be addressed in phase 2.

* + 1. Vertx conformance tests

**1. Stub Connection and Disconnection**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Test** | **Result** | **Comments** |
| 1.1 | connect / disconnect | **OK** |  |

**2. Hyperty address allocation messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 2.1 | allocate single hyperty address | **OK** |  |
| 2.2 | Ignore scheme | **OK** |  |
| 2.3 | de-allocate single hyperty address | **FAIL** | Timout, Not implemented |
| 2.4 | allocate block of hyperty addresses | **OK** |  |
| 2.5 | de-allocate block of hyperty addresses | **FAIL** | Timout, Not implemented |
| 2.6 | allocate block of hyperty addresses with allocationKey | **OK** |  |
| 2.7 | de-allocate block of hyperty addresses by allocationKey | **FAIL** | Timout, Not implemented |

**3. Object address allocation messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 3.1 | Allocate single object address | **OK** |  |
| 3.2 | de-allocate single object address | **OK** |  |
| 3.3 | allocate block of object addresses | **OK** |  |
| 3.4 | de-allocate block of object addresses | **OK** |  |
| 3.5 | allocate block of object addresses with allocationKey | **OK** |  |
| 3.6 | de-allocate block of object addresses by allocationKey | **OK** |  |

**4. Subscription and publish messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 4.1 | Allocate object address | **OK** |  |
| 4.2 | subscribe for object address with body.source | **OK** |  |
| 4.3 | subscribe for object address without body.source | **OK** |  |
| 4.4 | publish attribute update and receive update on both subscribers | **OK** |  |
| 4.5 | unsubscribe both subscribers | **FAIL** | Returned code 500 instead of expected code 200 |
| 4.6 | publish second attribute update and don’t update on both subscribers | **OK** |  |

**5. Hyperty registration messages**

**NOTE:**

The domain registry considered was not well configured due to missing information in the documentation. Thus, the Vertx MN did not connect to the domain registry, resulting in timeout errors.

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 5.1 | register hyperty address | **FAIL** | timeout |
| 5.2 | read hyperty address by user | **FAIL** | timeout |
| 5.3 | Keep registration alive | **FAIL** | Timout |
| 5.4 | Read hyperty address by user and type | **FAIL** | Timout |
| 5.5 | Read hyperty address by user and object scheme | **FAIL** | Timout |
| 5.6 | Unregister hyperty address | **FAIL** | Timout |

* + 1. Vertx performance tests

**Note:**

The hyperty address de-allocation tests have been disabled for the Vertx MN, because they are not implemented and would cause the overall test to fail.

**1. Allocate /de-allocate Hyperty addresses**

NOTE: Since the de-allocation of hyperty addresses was not implemented yet by the Vertx MN, the de-allocation tests have been commented out for now to let the overall test-suite proceed.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **No. of addresses per iteration** | **With alloc. Key ?** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1k** | **10k** |  |
| 1.1 | Allocate | 1 |  | 418 | 1894 | 17413 |  |
| 1.2 | De-allocate | 1 |  | **FAIL** | **FAIL** | **FAIL** | Not implemented yet |
| 1.3 | Allocate | 3 |  | 403 | 1857 | 17518 |  |
| 1.4 | De-allocate | 3 |  | **FAIL** | **FAIL** | **FAIL** | Not implemented yet |
| 1.5 | Allocate | 3 | x | 334 | 1822 | 18773 |  |
| 1.6 | De-allocate | 3 | x | **FAIL** | **FAIL** | **FAIL** | Not implemented yet |

**2. Allocate /de-allocate Object addresses**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **No. of addresses per iteration** | **With alloc. Key ?** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1k** | **10k** |  |
| 2.1 | Allocate | 1 |  | 233 | 1725 | 15923 |  |
| 2.2 | De-allocate | 1 |  | 167 | 1294 | 12678 |  |
| 2.3 | Allocate | 3 |  | 217 | 1661 | 11703 |  |
| 2.4 | De-allocate | 3 |  | 140 | 1301 | 13066 |  |
| 2.5 | Allocate | 3 | x | 188 | 1685 | 16133 |  |
| 2.6 | De-allocate | 3 | x | 130 | 1308 | 12935 |  |

**3. Hyperty messaging**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1000** | **10000** |
| 3.1 | 100 Byte payload | 203 | 1469 | 14072 |  |
| 3.2 | 1kByte payload | 151 | 1599 | 14556 |  |
| 3.3 | 10kByte payload | 209 | 1831 | 16944 |  |

**4. Subscription and Object update publication**

The results for this test were constrained by the limited Websocket resources in browser.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **Duration in milli-seconds for different no. of subscribers** | | | **Comment** |
| **100** | **200** | **1000** |
| 4.1 | 100 Byte payload | 214 | 439 | **FAIL** | Limited Websocket resources in browser |
| 4.2 | 1kByte payload | 230 | 399 | **FAIL** | Limited Websocket resources in browser |
| 4.3 | 10kByte payload | 242 | 468 | **FAIL** | Limited Websocket resources in browser |

* 1. Matrix Tests

The Matrix MN was deployed and configured as a docker container according to the descriptions at https://github.com/reTHINK-project/dev-msg-node-matrix.

* + 1. Matrix conformance tests

**1. Stub Connection and Disconnection**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Test** | **Result** | **Comments** |
| 1.1 | connect / disconnect | **OK** |  |

**2. Hyperty address allocation messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 2.1 | allocate single hyperty address | **OK** |  |
| 2.2 | Ignore scheme | **OK** |  |
| 2.3 | de-allocate single hyperty address | **OK** |  |
| 2.4 | allocate block of hyperty addresses | **OK** |  |
| 2.5 | de-allocate block of hyperty addresses | **OK** |  |
| 2.6 | allocate block of hyperty addresses with allocationKey | **OK** |  |
| 2.7 | de-allocate block of hyperty addresses by allocationKey | **OK** |  |

**3. Object address allocation messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 3.1 | Allocate single object address | **OK** |  |
| 3.2 | de-allocate single object address | **OK** |  |
| 3.3 | allocate block of object addresses | **OK** |  |
| 3.4 | de-allocate block of object addresses | **OK** |  |
| 3.5 | allocate block of object addresses with allocationKey | **OK** |  |
| 3.6 | de-allocate block of object addresses by allocationKey | **OK** |  |

**4. Subscription and publish messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 4.1 | Allocate object address | **OK** |  |
| 4.2 | subscribe for object address with body.source | **OK** |  |
| 4.3 | subscribe for object address without body.source | **OK** |  |
| 4.4 | publish attribute update and receive update on both subscribers | **OK** |  |
| 4.5 | unsubscribe both subscribers | **OK** |  |
| 4.6 | publish second attribute update and don’t update on both subscribers | **OK** |  |

**5. Hyperty registration messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 5.1 | register hyperty address | **OK** |  |
| 5.2 | read hyperty address by user | **OK** |  |
| 5.3 | Keep registration alive | **FAIL** | Timout, Mismatch of RegistryConnector implementation and Specification |
| 5.4 | Read hyperty address by user and type | **FAIL** | Timout, Mismatch of RegistryConnector implementation and Specification |
| 5.5 | Read hyperty address by user and object scheme | **FAIL** | Timout, Mismatch of RegistryConnector implementation and Specification |
| 5.6 | Unregister hyperty address | **FAIL** | Timout, Unclear reason: Does not receive a response from the domain registry |

* + 1. Matrix performance tests

**1. Allocate /de-allocate Hyperty addresses**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **No. of addresses per iteration** | **With alloc. Key ?** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1k** | **10k** |  |
| 1.1 | Allocate | 1 |  | 1650 | 1527 | 15158 | Initialization delays in the 100 iteration run |
| 1.2 | De-allocate | 1 |  | 156 | 1302 | 12564 |  |
| 1.3 | Allocate | 3 |  | 178 | 1521 | 15882 |  |
| 1.4 | De-allocate | 3 |  | 140 | 1196 | 12398 |  |
| 1.5 | Allocate | 3 | x | 179 | 1545 | 15550 |  |
| 1.6 | De-allocate | 3 | x | 118 | 1232 | 12952 |  |

**2. Allocate /de-allocate Object addresses**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **No. of addresses per iteration** | **With alloc. Key ?** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1k** | **10k** |  |
| 2.1 | Allocate | 1 |  | 169 | 1703 | 17265 |  |
| 2.2 | De-allocate | 1 |  | 152 | 1388 | 14114 |  |
| 2.3 | Allocate | 3 |  | 169 | 1651 | 17445 |  |
| 2.4 | De-allocate | 3 |  | 141 | 1442 | 14301 |  |
| 2.5 | Allocate | 3 | x | 177 | 1670 | 17314 |  |
| 2.6 | De-allocate | 3 | x | 131 | 1344 | 13886 |  |

**3. Hyperty messaging**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1000** | **10000** |
| 3.1 | 100 Byte payload | 1029 | 2347 | **FAIL** | Wrong order of messages |
| 3.2 | 1kByte payload | 638 | **FAIL** | **FAIL** | Wrong order of messages |
| 3.3 | 10kByte payload | 3423 | **FAIL** | **FAIL** | Wrong order of messages |

**4. Subscription and Object update publication**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **Duration in milli-seconds for different no. of subscribers** | | | **Comment** |
| **100** | **200** | **1000** |
| 4.1 | 100 Byte payload | 10984 | 21229 | **FAIL** | Limited Websocket resources in browser |
| 4.2 | 1kByte payload | 9692 | 19966 | **FAIL** | Limited Websocket resources in browser |
| 4.3 | 10kByte payload | 10219 | 20337 | **FAIL** | Limited Websocket resources in browser |

* 1. NodeJS Tests

The Nodejs MN has not been deployed in a docker container but instead in a local environment as described at <https://github.com/reTHINK-project/dev-msg-node-nodejs>

* + 1. Nodejs conformance tests

**1. Stub Connection and Disconnection**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Test** | **Result** | **Comments** |
| 1.1 | connect / disconnect | **OK** |  |

**2. Hyperty address allocation messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 2.1 | allocate single hyperty address | **OK** |  |
| 2.2 | Ignore scheme | **OK** |  |
| 2.3 | de-allocate single hyperty address | **FAIL** | Not implemented |
| 2.4 | allocate block of hyperty addresses | **OK** |  |
| 2.5 | de-allocate block of hyperty addresses | **FAIL** | Not implemented |
| 2.6 | allocate block of hyperty addresses with allocationKey | **OK** |  |
| 2.7 | de-allocate block of hyperty addresses by allocationKey | **FAIL** | Not implemented |

**3. Object address allocation messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 3.1 | Allocate single object address | **OK** |  |
| 3.2 | de-allocate single object address | **FAIL** | Not implemented |
| 3.3 | allocate block of object addresses | **OK** |  |
| 3.4 | de-allocate block of object addresses | **FAIL** | Not implemented |
| 3.5 | allocate block of object addresses with allocationKey | **OK** |  |
| 3.6 | de-allocate block of object addresses by allocationKey | **FAIL** | Not implemented |

**4. Subscription and publish messages**

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 4.1 | Allocate object address | **OK** |  |
| 4.2 | subscribe for object address with body.source | **OK** |  |
| 4.3 | subscribe for object address without body.source | **OK** |  |
| 4.4 | publish attribute update and receive update on both subscribers | **OK** |  |
| 4.5 | unsubscribe both subscribers | **OK** |  |
| 4.6 | publish second attribute update and don’t update on both subscribers | **OK** |  |

**5. Hyperty registration messages**

**NOTE:**

It seems that the Nodejs MN expects the address of the domain registry to end with a “/”, which contradicts the specification. This seems to be the cause for the failed tests 5.1 and 5.2.

| **No.** | **Test** | **Result** | **Comments** |
| --- | --- | --- | --- |
| 5.1 | register hyperty address | **FAIL** | The MN seems to expect a trailing “/” at the domain registry URL (i.e. the to-address of the message) |
| 5.2 | read hyperty address by user | **FAIL** | The MN seems to expect a trailing “/” at the domain registry URL (i.e. the to-address of the message) |
| 5.3 | Keep registration alive | **FAIL** | Timout,  Mismatch of RegistryConnector implementation and Specification |
| 5.4 | Read hyperty address by user and type | **FAIL** | Timout,  Mismatch of RegistryConnector implementation and Specification |
| 5.5 | Read hyperty address by user and object scheme | **FAIL** | Timout,  Mismatch of RegistryConnector implementation and Specification |
| 5.6 | Unregister hyperty address | **FAIL** | Timout,  Unclear reason: Does not receive a response from the domain registry |

* + 1. Nodejs performance tests

**Note:**

The address de-allocation tests have been disabled for the NodeJS MN, because they are not implemented and would cause the overall test to fail.

**1. Allocate /de-allocate Hyperty addresses**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **No. of addresses per iteration** | **With alloc. Key ?** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1k** | **10k** |  |
| 1.1 | Allocate | 1 |  | 540 | 53108 | **FAIL** | Out of memoryconne |
| 1.2 | De-allocate | 1 |  | **FAIL** | **FAIL** | **FAIL** | Not implemented |
| 1.3 | Allocate | 3 |  | 3496 | **FAIL** | **FAIL** | Out of memory |
| 1.4 | De-allocate | 3 |  | **FAIL** | **FAIL** | **FAIL** | Not implemented |
| 1.5 | Allocate | 3 | x | 7081 | **FAIL** | **FAIL** | Out of memory |
| 1.6 | De-allocate | 3 | x | **FAIL** | **FAIL** | **FAIL** | Not implemented |

**2. Allocate /de-allocate Object addresses**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **No. of addresses per iteration** | **With alloc. Key ?** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1k** | **10k** |  |
| 2.1 | Allocate | 1 |  | 571 | 53288 | **FAIL** | Out of memory |
| 2.2 | De-allocate | 1 |  | **FAIL** | **FAIL** | **FAIL** | Not implemented |
| 2.3 | Allocate | 3 |  | 3294 | **FAIL** | **FAIL** | Out of memory |
| 2.4 | De-allocate | 3 |  | **FAIL** | **FAIL** | **FAIL** | Not implemented |
| 2.5 | Allocate | 3 | x | 6928 | **FAIL** | **FAIL** | Out of memory |
| 2.6 | De-allocate | 3 | x | **FAIL** | **FAIL** | **FAIL** | Not implemented |

**3. Hyperty messaging**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **Duration in milli-seconds for different no. of iterations** | | | **Comment** |
| **100** | **1000** | **10000** |
| 3.1 | 100 Byte payload | 194 | 1409 | 13539 |  |
| 3.2 | 1kByte payload | 190 | 1427 | 14048 |  |
| 3.3 | 10kByte payload | 236 | 2046 | 18328 |  |

**4. Subscription and Object update publication**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Test** | **Duration in milli-seconds for different no. of subscribers** | | | **Comment** |
| **100** | **200** | **1000** |
| 4.1 | 100 Byte payload | 352 | 571 | **FAIL** | Limited Websocket resources in browser |
| 4.2 | 1kByte payload | 317 | 624 | **FAIL** | Limited Websocket resources in browser |
| 4.3 | 10kByte payload | 433 | 788 | **FAIL** | Limited Websocket resources in browser |