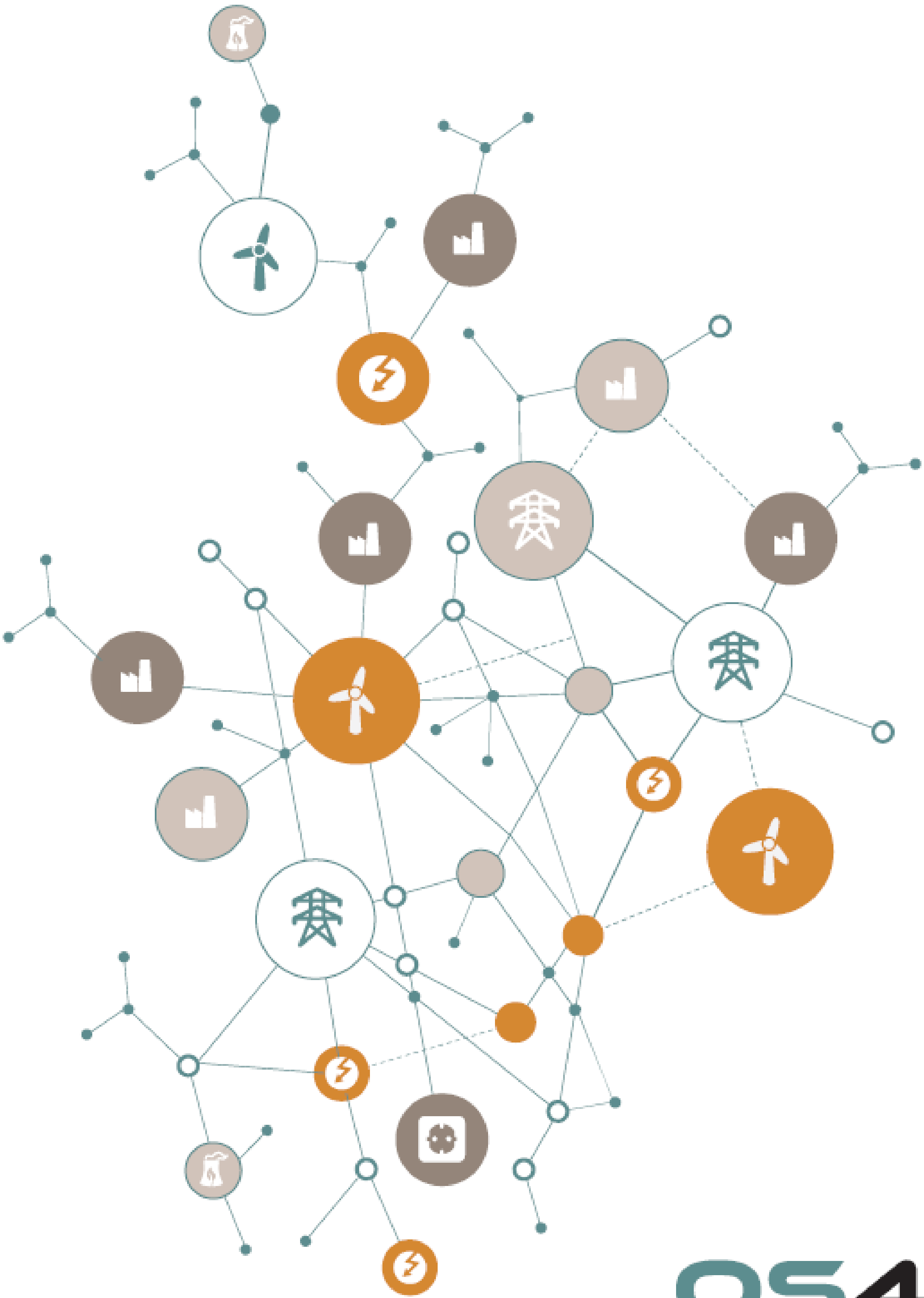
Deliverable 3.3

Communication protocol prototype simulation and validation



OS4ES

D3.3 Communication protocol prototype simulation and validation

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0.1	28.05.2016.	Stjepan Sučić	Draft ToC
0.2	05.05.2016	Miro Antonijević	Testing results
1.0	04.07.2016	Markus Breuers	Reviewed final version

Executive Summary

This deliverable provides testing of the protocol prototype described in D3.2. The deliverable includes validation for the developed communication protocol prototype and gateway for the developed communication protocol prototype regarding several criteria depending on the message exchange patterns.

This deliverable is sectioned as follows:

- Section 1 provides an introduction and table of acronyms
- Section 2 describes testing environment for the XMPP-based IEC 61850 communication API
- Section 3 provides a testing results conclusion

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1 Introduction

1.1 Scope of the document

This deliverable shows results of testing IEC 61850-8-2 communication stack described in the D3.2. The testing has been conducted for several testing environments and for different ACSI services.

1.2 Notations, abbreviations and acronyms

The following table list all notations, abbreviations and acronyms that are used in this document.

ACSE	Association Control Service Element
API	Application Programming Interface
LAN	Local Area Network
OS	Operating System
PC	Personal Computer
RAM	Random Access Memory
SSD	Solid State Drive
XMPP	Extensible Messaging Presence Protocol
WAN	Wide Area Network

Table 1 : Acronyms list

2 Communication protocol testing

2.1 Testing environment

The testing environment utilizes two or more testing machines providing IEC 61850-8-2 [1] client, IEC 61850-8-2 server and XMPP relaying server functionalities. The characteristics of the testing machines are as following:

PC 1:

- OS: Linux Ubuntu 14.4 LTS
- Processor: Intel(R) Core(TM) i7 3621QM CPU 2.10 GHz
- RAM: 8,00 GB
- SSD: 250 GB
- XMPP server: OpenFire 4.0.1

PC 2:

- OS: Windows 7 Professional SP1
- Processor: Intel(R) Core(TM) i7 3621QM CPU 2.10 GHz
- RAM: 8,00 GB
- SSD: 250 GB
- XMPP server: OpenFire 4.0.1

PC 3:

- OS: Ubuntu 12.04.5 LTS
- Processor: Intel(R) Xeon(R) CPU E5320 @ 1.86GHz
- RAM: 18 GB
- HD: 150 GB
- XMPP server: OpenFire 4.0.2

LAN network switch:

- CISCO Catalyst 2960 Gigabit Ethernet [2]

WAN network is established between Croatia (PC1 and PC2) and Greece (PC3) over public Internet. The network topology is dependable upon Internet providers.

2.2 Testing arrangements

Depending on the physical setting of the software components there are several testing environments that can be established:

1. Local-based – All software components are on the same testing machine. The communication network is not influenced by the network traffic. The message delivery latencies depend on protocol stack and operating system behaviour.

2. LAN-based - Each of the software components are on different machines but in the same Local Area Network. The message delivery latencies are dependable upon protocol stack, operating systems and LAN network latencies.

3. WAN-based - Each of the software components are on different machines and communicate over Internet. The message delivery latencies are dependable upon protocol stack, operating systems and WAN network latencies.

All testing services are tested by utilizing “ping-pong” testing technique which is illustrated in the following figures. Depending on the testing type the parameter t_{total} represents cumulative time intervals for the simulation as described in the following chapters.

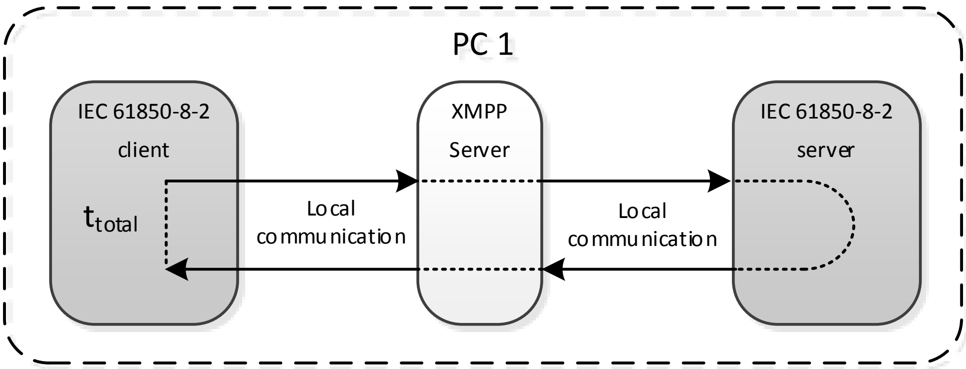

Figure 1: Local-based testing

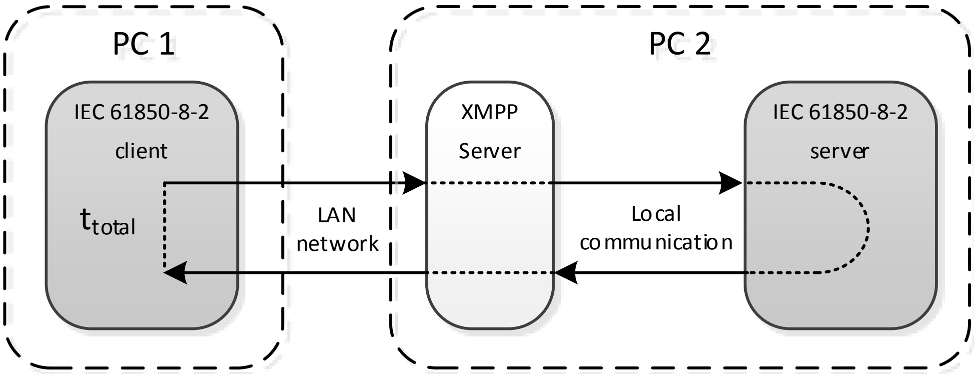

Figure 2: LAN-based testing

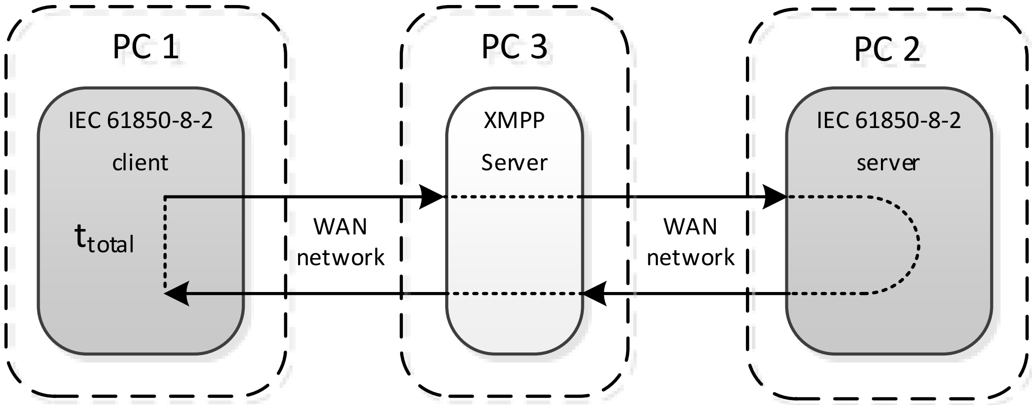

Figure 3: WAN-based testing

2.3 Request-response message testing

In case of request-response message testing the parameter t_{total} represents the total time starting when the request message was sent from the IEC 61850-8-2 client, it was relayed on the XMPP server, analysed by the IEC 61850-8-2 server, the IEC 61850-8-2 server has sent the response message that way relayed by the XMPP server and received by the IEC 61850-8-2 client. The request-response tests are done for the following ACSI services:

- Read-request
- Write-request

Each test has been repeated 1000 times in order to develop message delivery histogram. All other ACSI services based on read-request message exchange pattern (GetLDDirectory, GetLDDirectroy, ..) have also been tested. The resulting behaviour of these services are the same as for the Read-request ACSI service. Therefore, the results for the rest of request-response ACSI services have been omitted in this deliverable. The results are shown in logarithmic scale in order to emphasise outliers.

2.3.1 Read-request message testing results

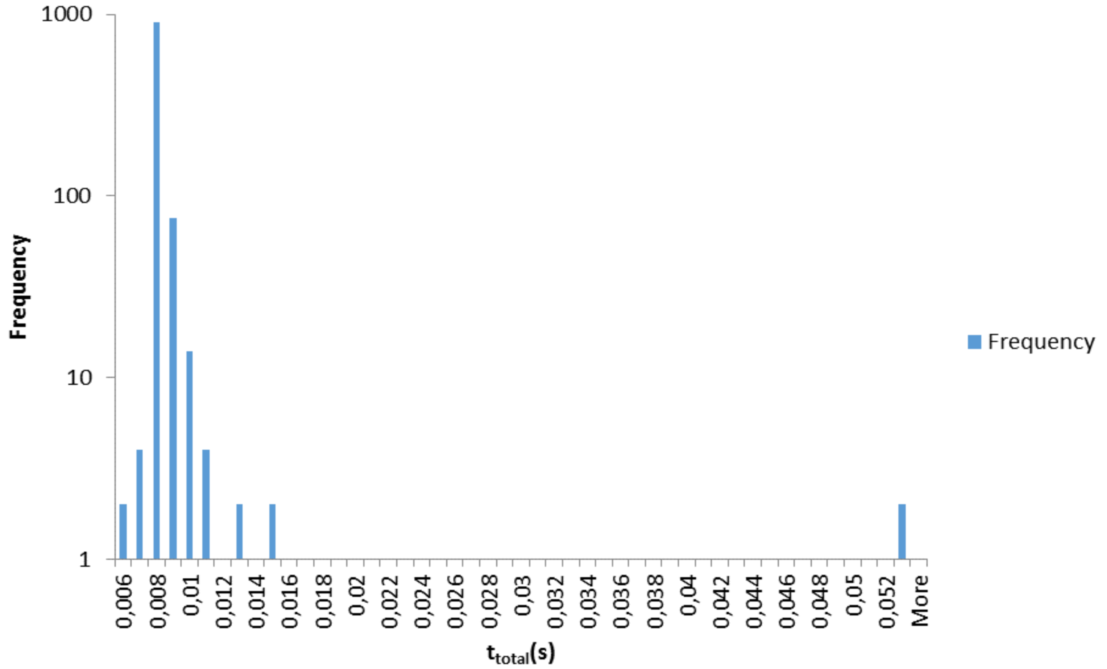

Figure 4: Read-request messages (local-based)

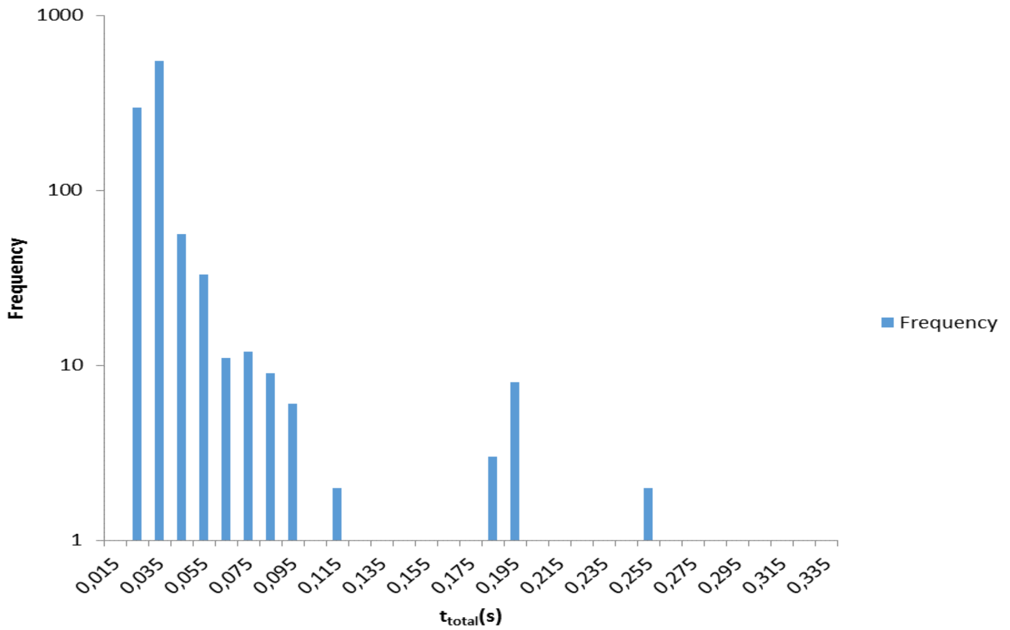

Figure 5: Read-request messages (LAN-based)

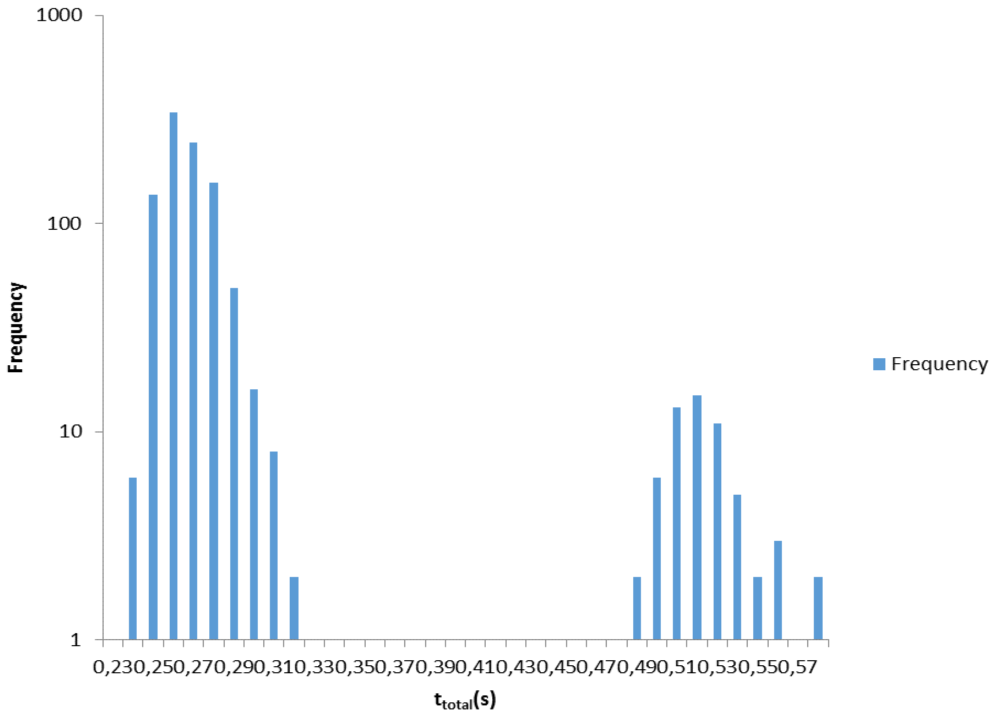

Figure 6: Read-request messages (WAN-based)

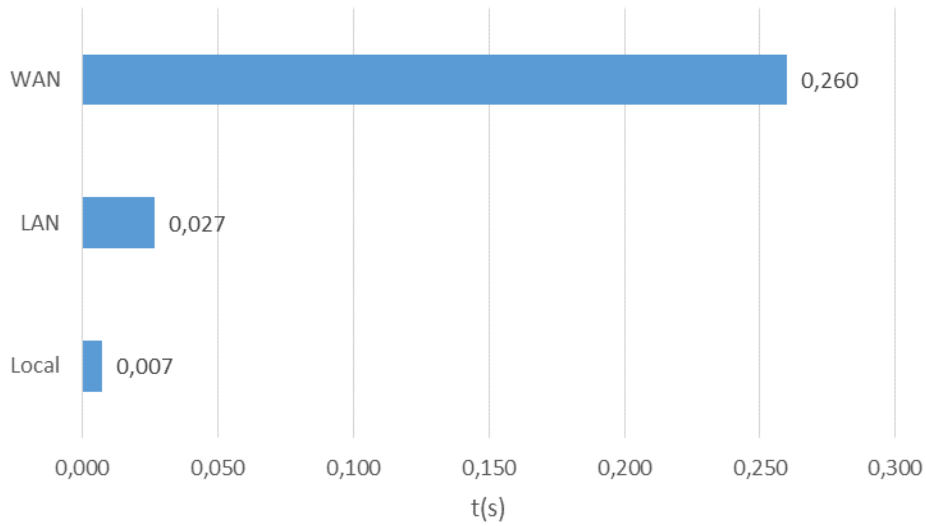

Figure 7: Read-request messages (median comparison)

As it can be seen from Figure 7 the median value for Read-request messages is significantly below 500ms what is defined as class B latency in D2.2.

2.3.2 Write-request message testing results

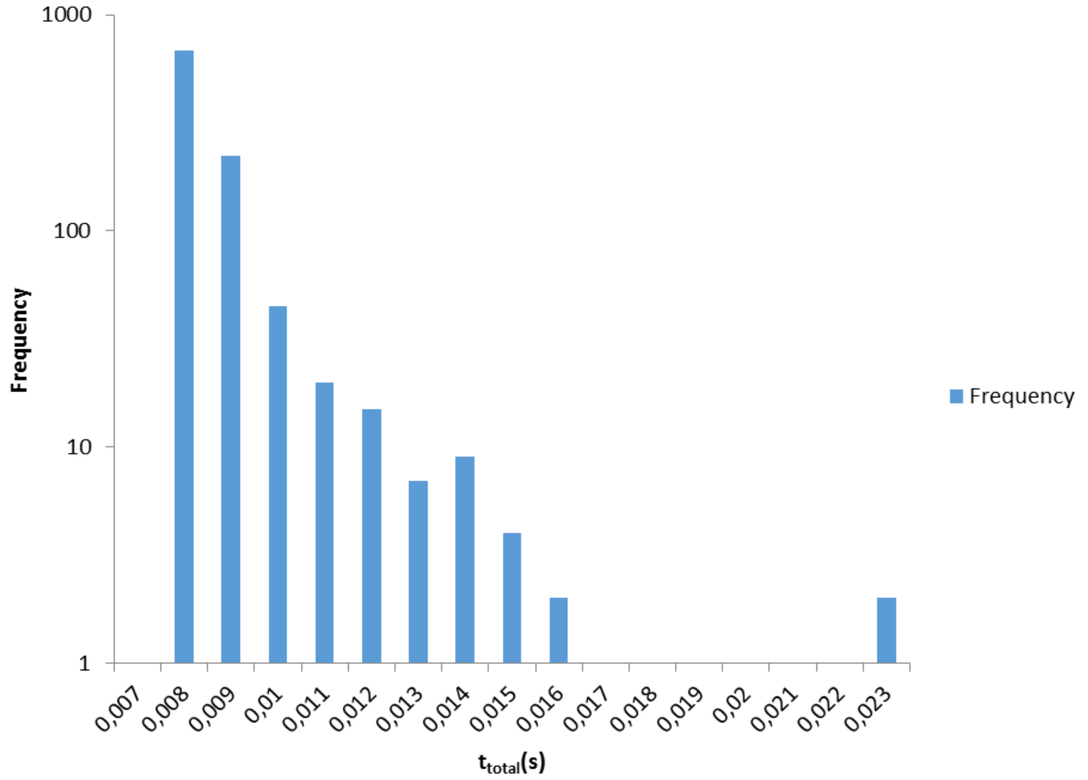

Figure 8: Write-request messages (local-based)

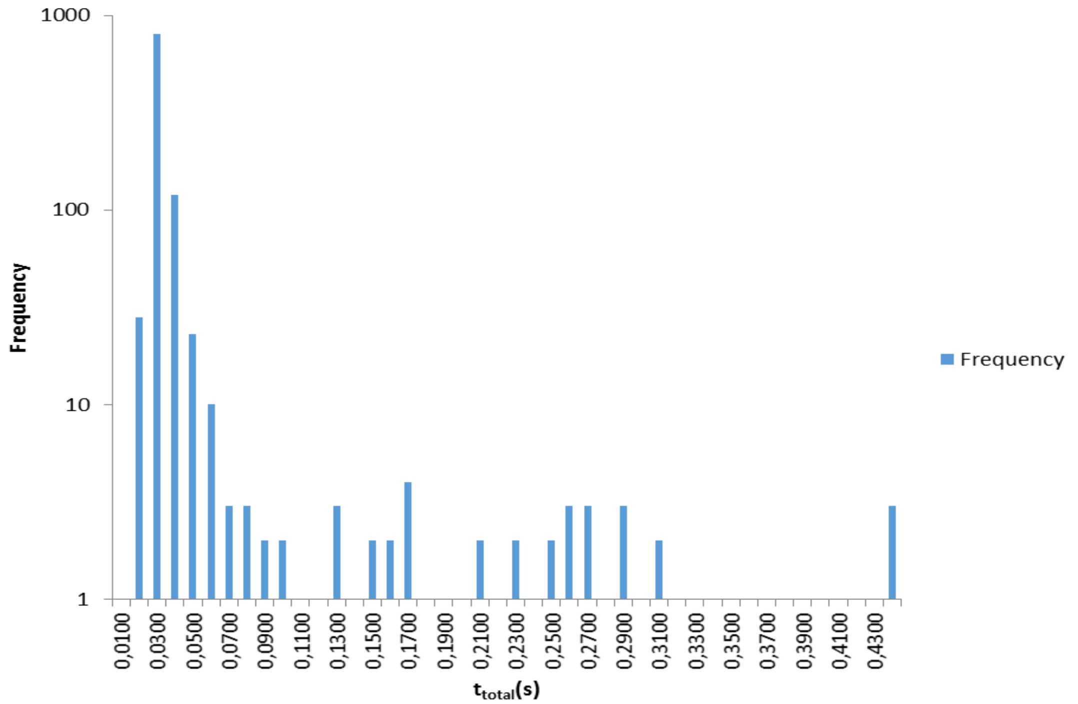

Figure 9: Write-request messages (LAN-based)

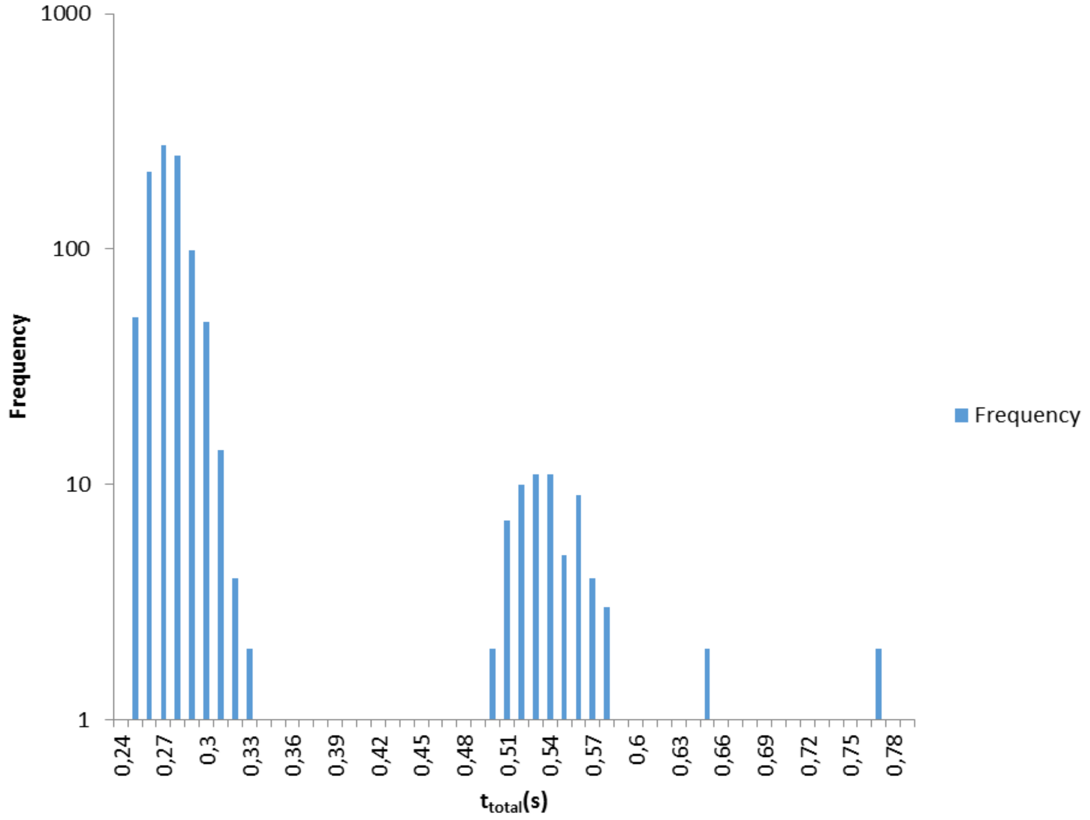

Figure 10: Write-request messages (WAN-based)

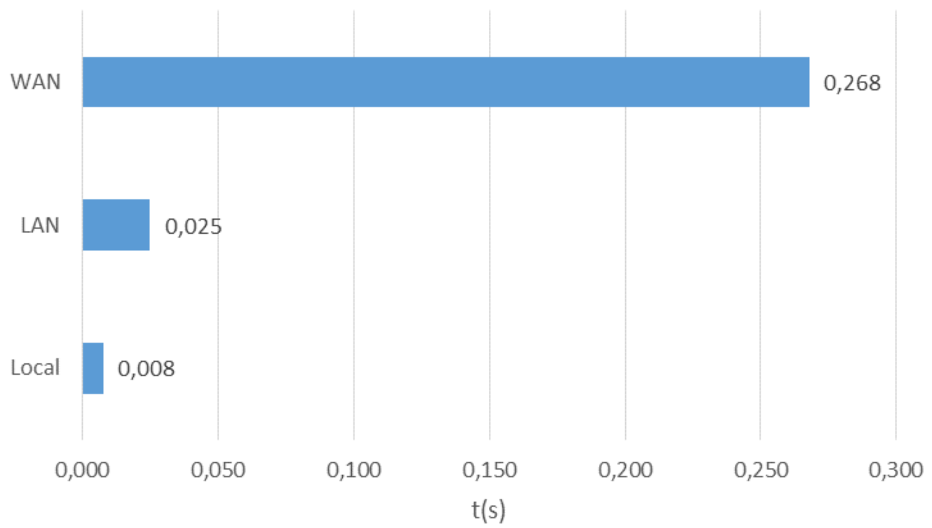

Figure 11: Write-request messages (median comparison)

As it can be seen from Figure 7 the median value for Write-request messages is significantly below 500ms what is defined as class B latency in D2.2.

2.3.3 Unsolicited message testing

Unsolicited message testing is based on sending unbuffered and buffered reports with different dataset sizes ranging from 10 to 100 elements in dataset. Each test has also been done for 1000 times in order to develop message delivery histograms. Each of the tests also shows the message utilization rate where it can be seen which dataset arrangement is optimal for mapping the process data number into single dataset. The parameter t_{total} represents the total time starting when the request message was sent from the IEC 61850-8-2 client in order to enable report control block, relaying the request through XMPP server, analysing request by the IEC 61850-8-2 server, sending reports by the IEC 61850-8-2 server, relaying the reports by the XMPP server and receiving reports by the IEC 61850-8-2 client. The results are shown in quartile arrangement (1^{st} – orange, 2^{nd} – yellow, 3^{rd} – green, 4^{th} - dark red).

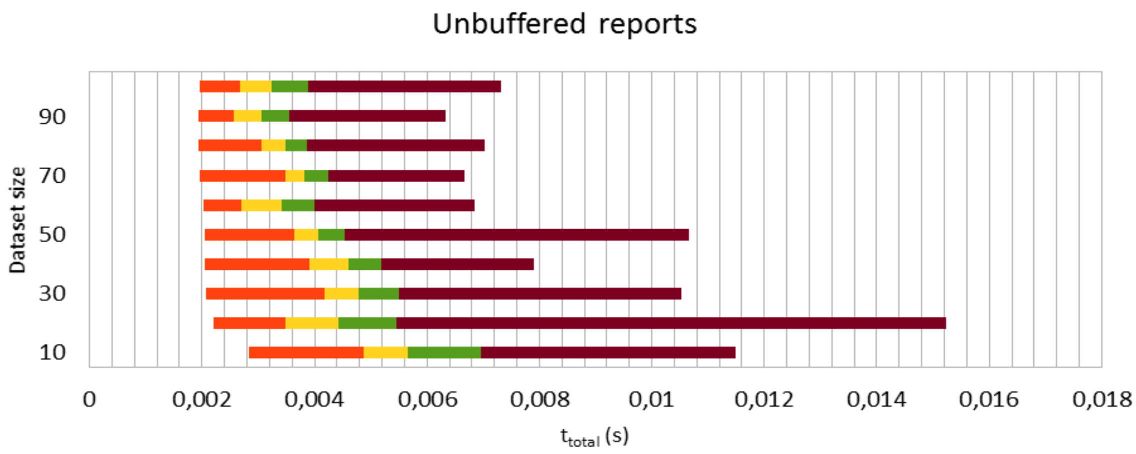

Figure 12: Unbuffered reports (local-based) – 1000 messages

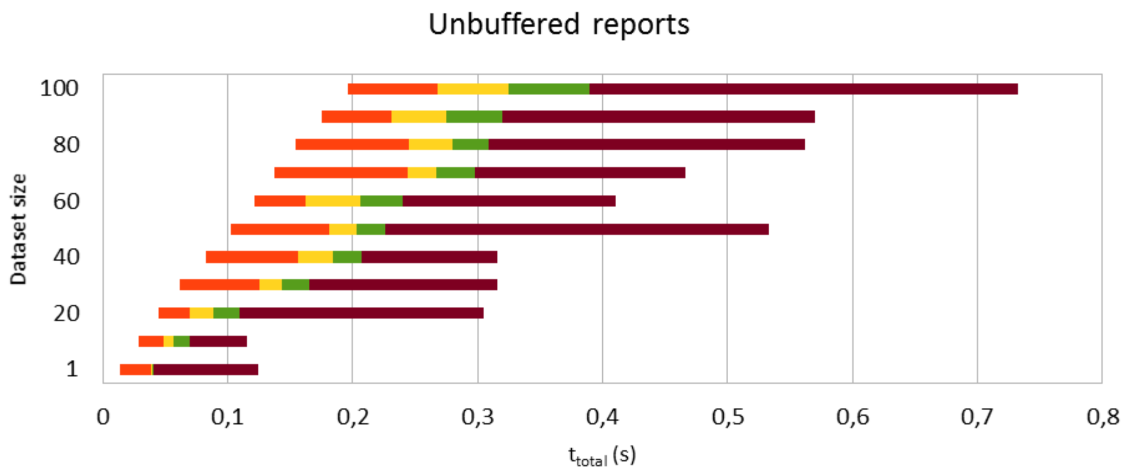

Figure 13: Unbuffered reports (local-based) – process data utilization

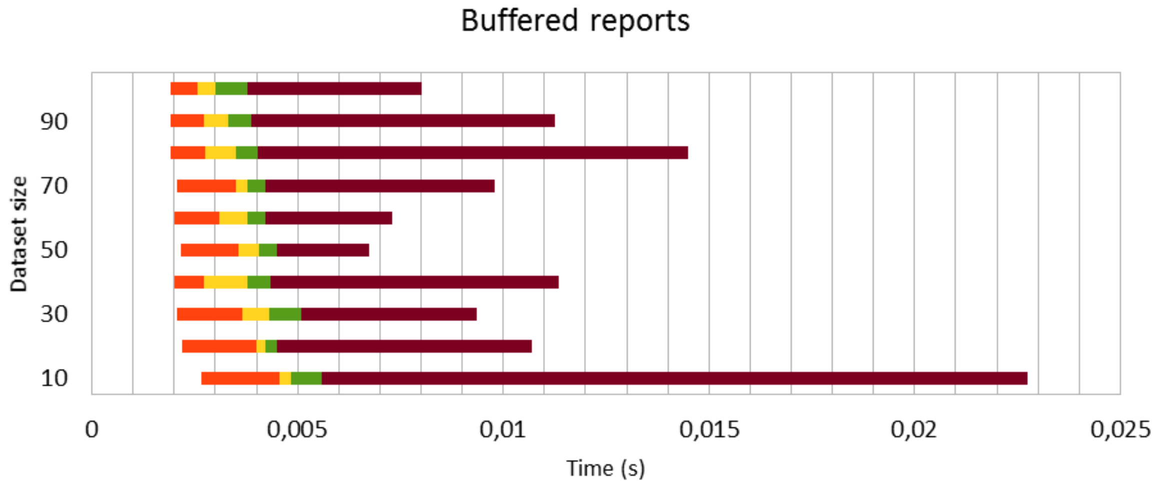

Figure 14: Buffered reports (local-based) – 1000 messages

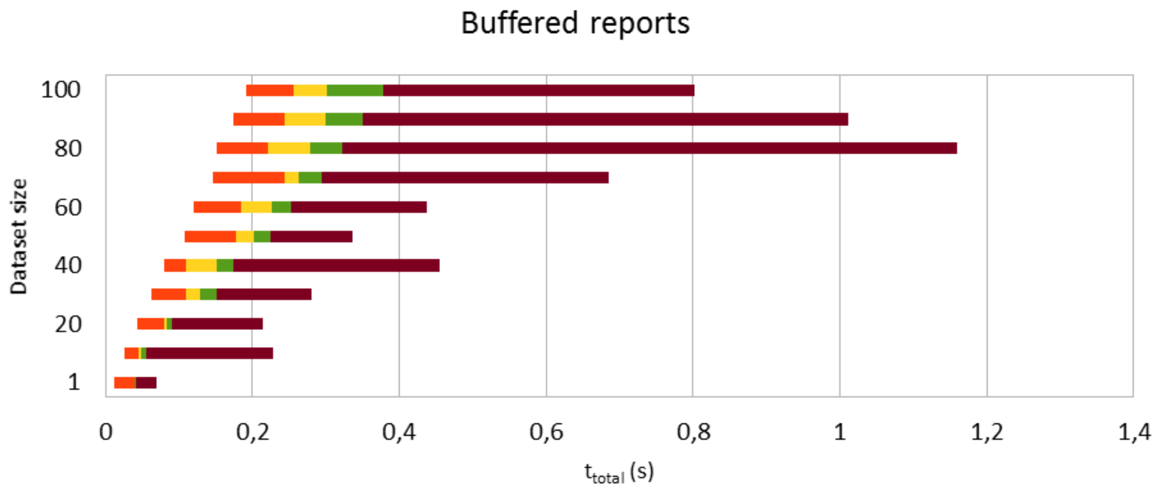

Figure 15: Buffered reports (local-based) – process data utilization

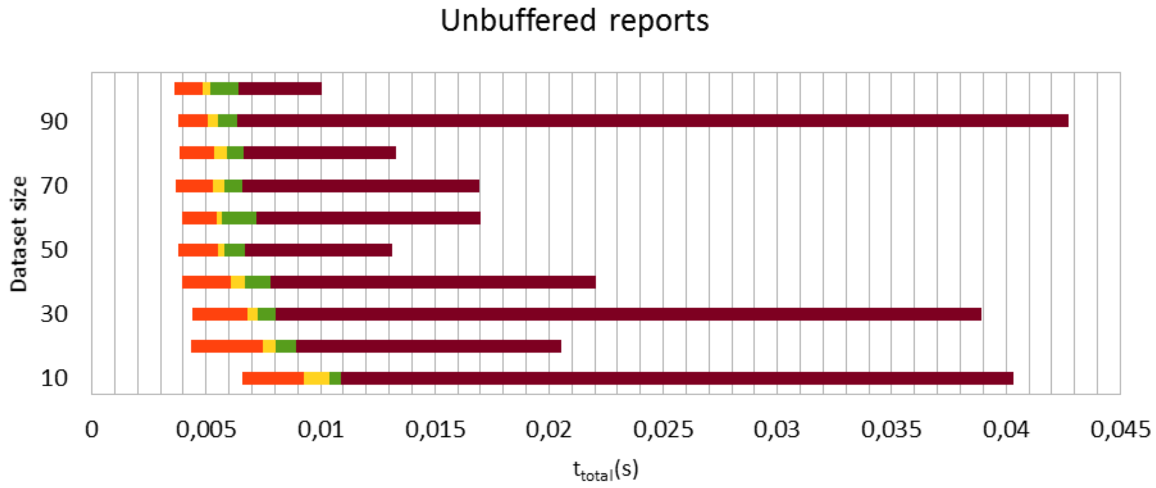

Figure 16: Unbuffered reports (LAN-based) – 1000 messages

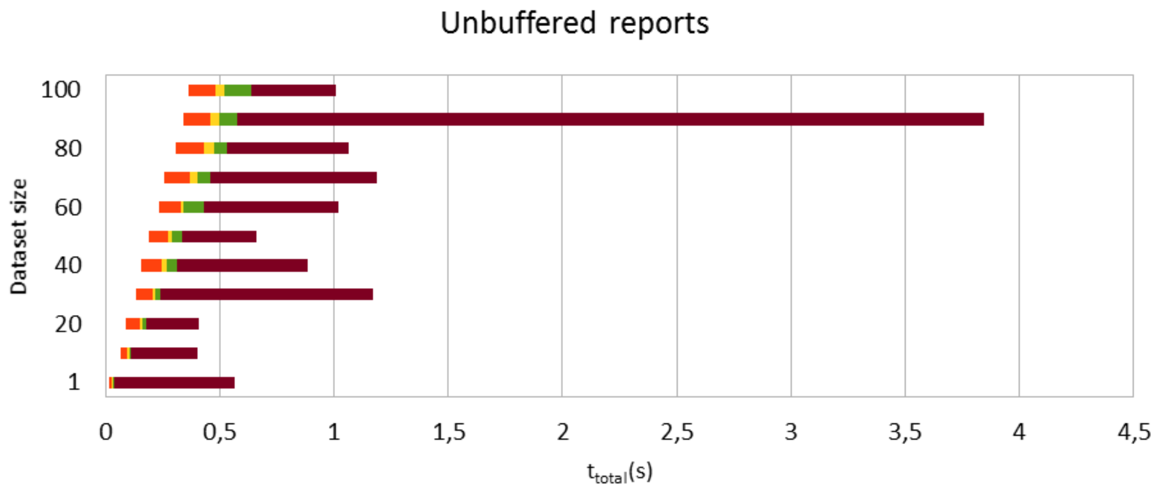

Figure 17: Unbuffered reports (LAN-based) – process data utilization

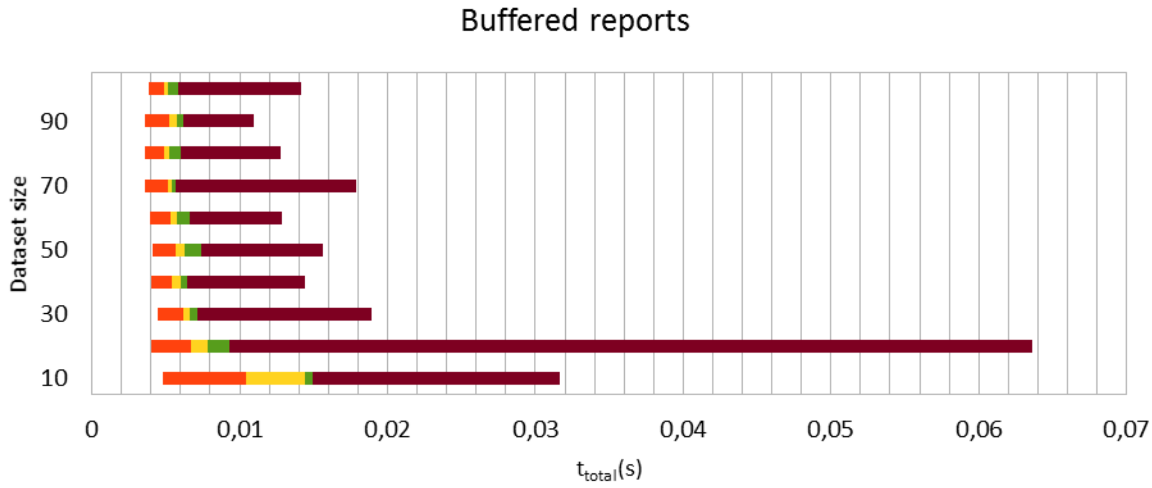

Figure 18: Buffered reports (LAN-based) – 1000 messages

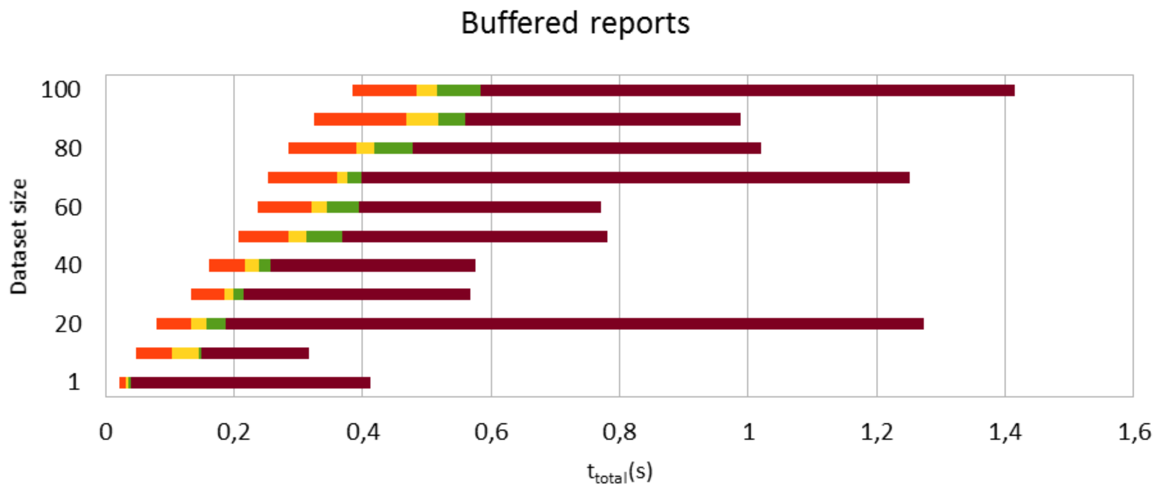

Figure 19: Buffered reports (LAN-based) – process data utilization

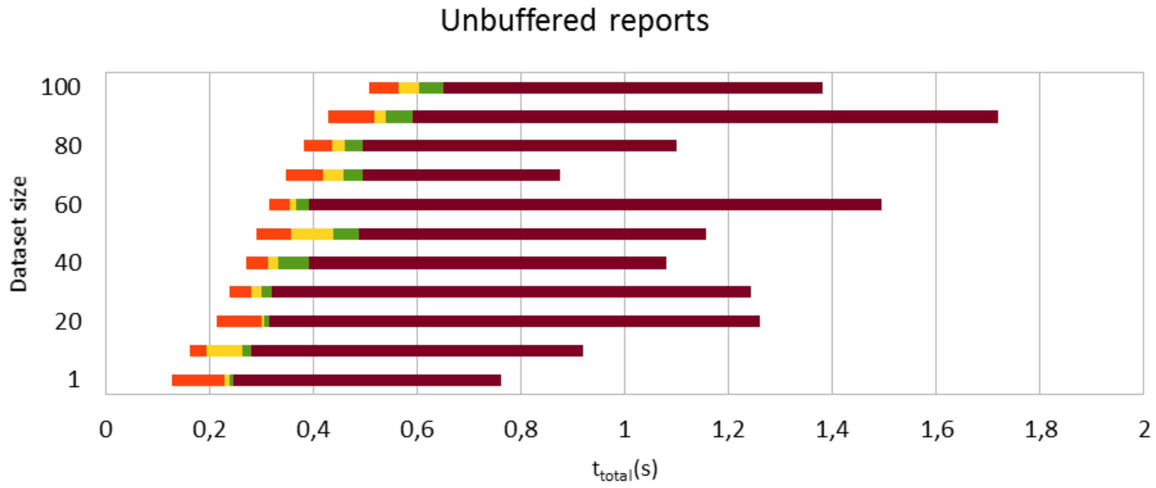

Figure 20: Unbuffered reports (WAN-based) – 1000 messages

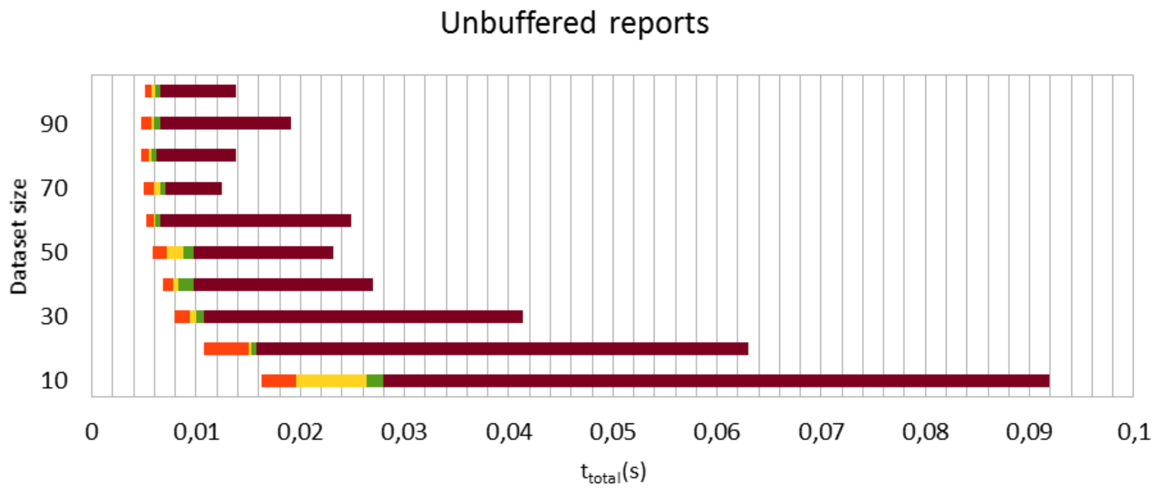

Figure 21: Unbuffered reports (WAN-based) – process data utilization

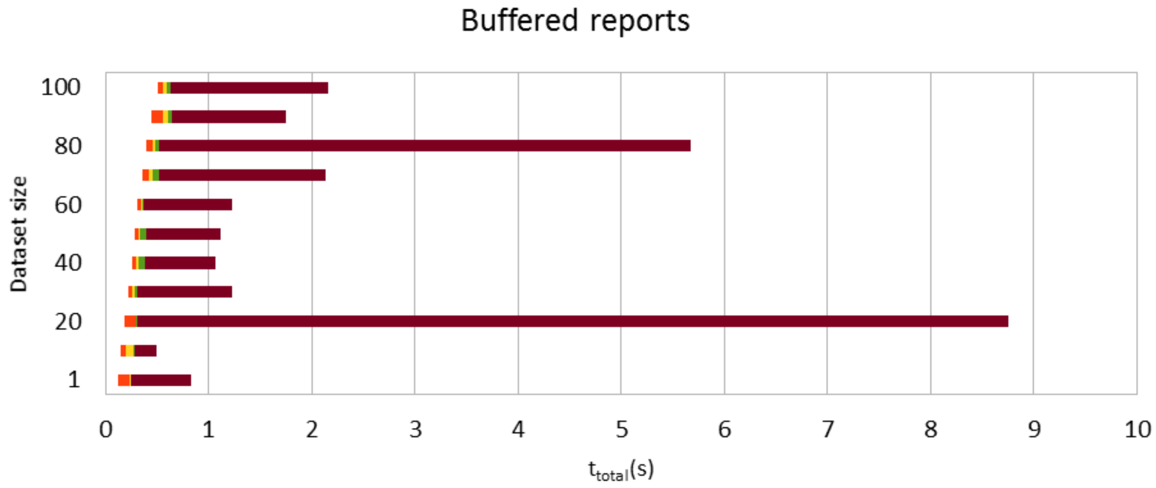

Figure 22: Buffered reports (WAN-based) – 1000 messages

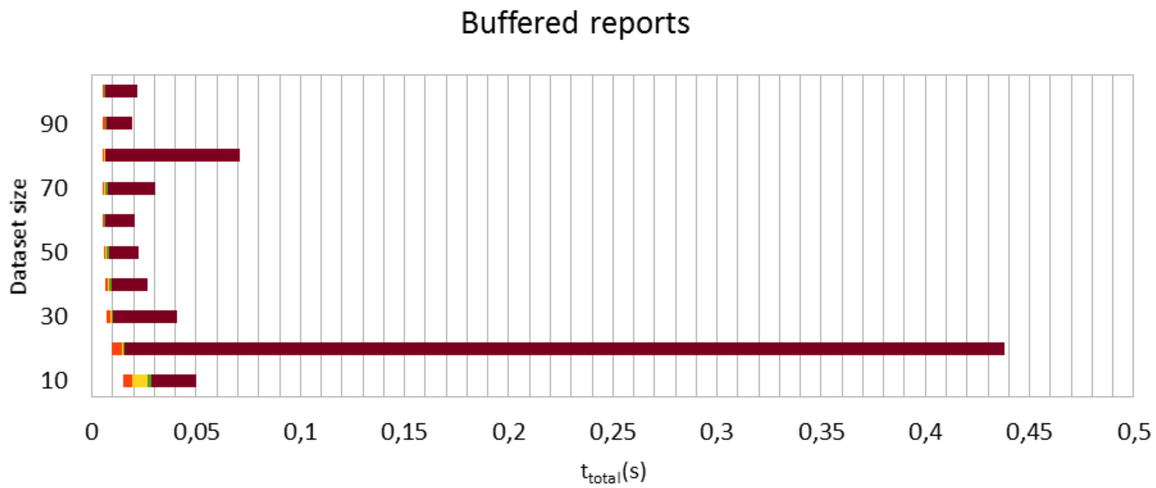

Figure 23: Buffered reports (WAN-based) – process data utilization

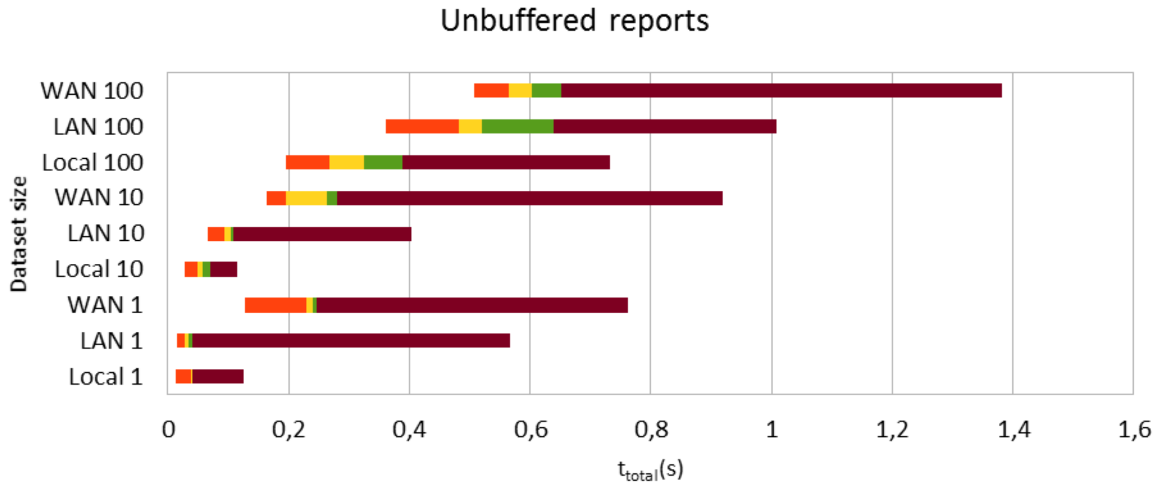

Figure 24: Unbuffered reports – comparison

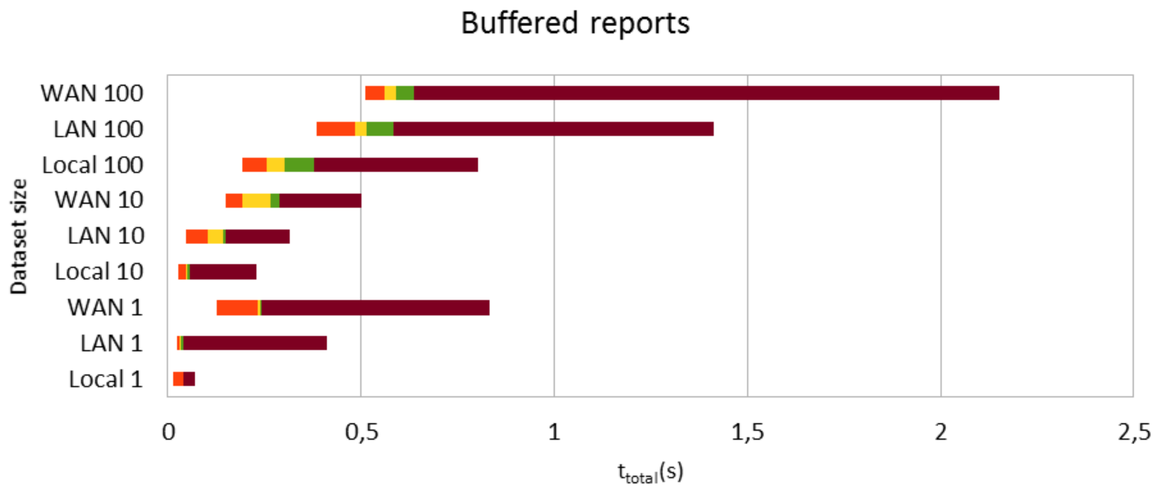

Figure 25: Buffered reports – comparison

The comparison figure shows that report messages also fulfil B class requirements defined by D2.2. The Process data utilization shows that the optimal data set size is 50-60 process data (value, quality, timestamp pairs) elements per dataset.

3 Conclusion

This deliverable describes methods and procedure for testing IEC 61850-8-2 communication protocol stack. For this purpose ”ping-pong” tests have conducted for request-response services and variable load tests for the unsolicited services. As the result of these tests have shown it can be concluded that the IEC 61850-8-2 stack developed as a part of OS4ES project is capable of fulfilling class B requirements defined by D2.2 and is a suitable IEC 61850-8-2 implementation for the OS4ES use cases.

Bibliography

[1] "IEC, Communication networks and systems in substations – Part 8-2: Specific Communication Service Mapping (SCSM) – Mappings to Web Services, IEC TR 61850-8-2 ed1.0, 2016, draft."

[2] "Cisco Catalyst 2960 Series Switches," *Cisco* [Online]. Available: http://www.cisco.com/c/en/us/products/collateral/switches/catalyst-2960-series-switches/prod_bulletin0900aecd80322c22.html.

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