decode

Benchmark and comparison of one-board computers and hardware specifications

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DECODE

DEcentralised Citizens Owned Data Ecosystem

D4.5 Benchmark and comparison of one-board computers and hardware specifications

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Dissemination level:		
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PP	Restricted to other programme participants (including the Commission Services)	
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Approved by: Francesca Bria, Chief Technology and Digital Innovation Officer, Barcelona City Council (IMI)

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This report is currently awaiting approval from the EC and cannot be not considered to be a final version.

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1-Abbreviations

AES – Advanced Encryption Standard
AIO – Asynchronous I/O
AWS – Amazon Web Services
GbE – Gigabit Ethernet
ICT – Information and Communication Technology
I/O- Input/Output
IoT – Internet of Things
IP – Internet Protocol (Address)
JVM – Java Virtual Machine
OS - Operative System
OSHWA – Open Source Hardware Association
P2P – Peer to Peer
PC – Personal Computer
RAM – Random Access Memory
RSA – Rivest-Shamir-Adleman (public-key cryptosystem)
SBC – Single Board Computer
SSH – Secure Shell
TLS – Transport Layer Security
TPC-B Transaction Processing Performance Council
VNC- Virtual Network Computing
WP – Work Package

2-Executive summary

The DECODE architecture rely on two types of distributed nodes. The Wallet node and the Validating node. Each type of node will require certain hardware specifications in order to support the DECODE system.

Performance tests on different devices were done in order to clarify witch type of requirements are necessary to run DECODE. The tests were targeting the main tasks that the HUBs are going to be doing such as running cryptographic algorithms, making network transactions and storing data. This information can be used by other partners as a reference to request new testing platforms or to suggest further tests. In addition, a testing rack was built to allow future tests to be performed during the life span of the project and with the capability of remote access.

The testing tool that was used for the benchmarks is the open source Phoronix Test Suite, that features tests for processor, disk, RAM and network performance.

Finally the results of the tests are presented as a comparison between the different one board computers and a summary of the minimum hardware requirement for each type of hub.

The DECODE project follows a lean methodology and therefore this document does not contain final specifications but rather guidelines that will feed into the pilot's implementation and the initial round of testing and experiments. Alterations to these specifications might take place following the first round of testing during an ongoing iterative and lean process which will not be complete until the final deployment of the DECODE platform and pilots.

3-Introduction

The DECODE architecture defines two types of nodes that will form the distributed network: Validating nodes and wallet nodes. The validating nodes contains the distributed ledger node, cryptographic functionality and P2P networking capabilities. They ensure the integrity of the network and are not linked to any particular user. On the other hand, the wallet nodes are edge nodes that participants use to interact with DECODE. Every participant will have their own wallet. The role of this node is to store encrypted the participants attributes, cryptographic material and execute DECODE transactions that will be send to the Ledger (validating nodes) for verification. They will also have cryptographic functionality and P2P networking capabilities. Despite both types of nodes share part of the architecture, they have different hardware requirements due to the application differences.

To facilitate comparison, the same set of tests will be running in all the hardware devices, even if the minimum required performance will be different depending on the type of HUB. In addition, some of the tests might have a higher relevance depending on the type of HUB being tested. For example, storage performance tests might be more relevant for the wallet nodes since they will have higher reading/writing activity storing attributes, and bandwidth performance tests might be more critical for the validating nodes.

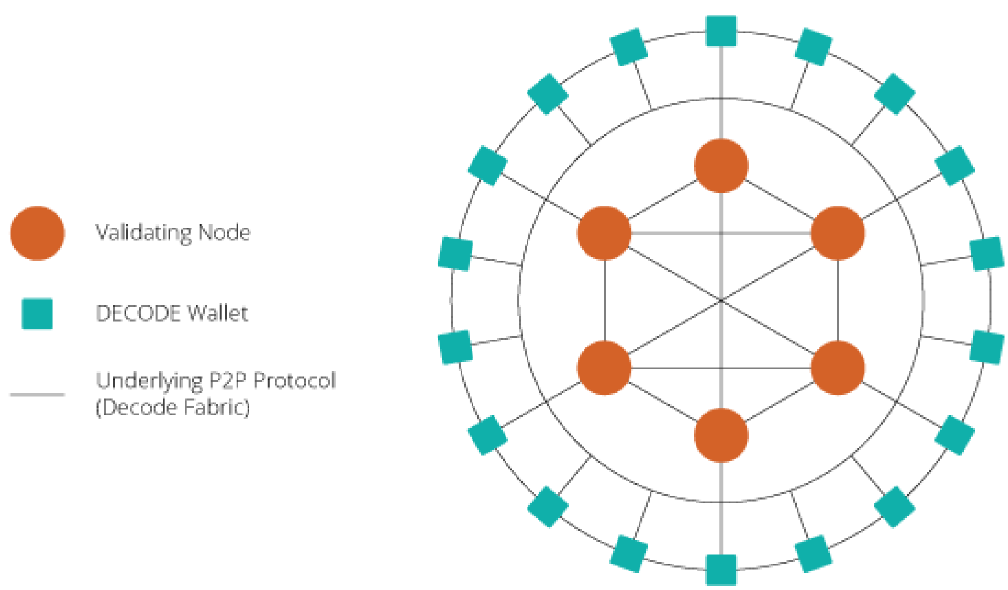

Illustration 1: DECODE HUB architecture

The outcome of this deliverable will be the definition of the minimum hardware specifications to run DECODE.

The following chapters will describe the selection of tests and benchmark tools to be applied to the different hardware devices and will continue with a description of the hardware targets for the tests. Finally the results of the tests will be presented together with the analysis of the results and the concluded specification list.

4-Test description and selection

In general terms, the elements of the DECODE network will need to have the following requirements

- Ability to run DECODE OS (Validating nodes and some wallet nodes)
- Network connectivity
- Processing power and memory to support:
  - cryptographic operations
  - embedded web server operations
  - execution of smart rules language
- Local storage in the initial phases at least enough to store attributes (Wallet HUB)

The Wallet will be either a standalone application that participants will download to their devices or be hosted by operators. This software is yet to be defined at the time of this deliverable, but we can assume that it will be running cryptographic, storage and network operations with the rest of the network.

The evaluation tool selected to test the mentioned operations is the Phoronix Test Suite [1][2](PTS). PTS is an open source automated benchmarking tool for Linux and other operative systems developed by Phoronix media. It features a Disk test suite, Networking test suite and Processor tests suites including cryptographic performance.

The exact requirements of the Hubs will be determined as the project moves forward. But with these assumptions in mind the following selection of tests were selected for the benchmark.

Phoronix Test Suite

Disk Tests:

Test Name	Description
Gzip Compression	This is a test of 7-Zip using p7zip with its integrated benchmark feature.

[1] https://www.phoronix-test-suite.com/

[2]https://openbenchmarking.org/tests/pts

SQlite	This is a simple benchmark of SQLite
Apache	This is a test of ab, which is the Apache benchmark program
PostgreSQL pgbench	This is a simple TPC-B like benchmark of PostgreSQL.
Compile Bench	Compilebench tries to age a filesystem by simulating some of the disk IO common in creating, compiling, patching, stating and reading kernel trees
IOzone	Tests the hard drive / file system performance.
Dbench	Dbench is a benchmark designed by the Samba project as a free alternative to netbench, but dbench contains only file-system calls for testing the disk performance.
FS-Mark	FS_Mark is designed to test a system's file-system performance.
Flexible IO Tester	fio is an advanced disk benchmark that depends upon the kernel's AIO access library.
Tiobench	Tests the hard drive / file system performance.
PostMark	This is a test of NetApp's PostMark benchmark designed to simulate small-file testing similar to the tasks endured by web and mail servers
AIO-Stress	AIO-Stress is an a-synchronous I/O benchmark created by SuSE
Unpack-Linux	Measures how long it takes to extract the .tar.bz2 Linux Kernel package.

Network Tests:

Test Name	Description
Loopback TCP Network Performance	This test measures the loopback network adapter performance using a micro-benchmark to measure the TCP performance.

Processor Tests (Crypto):

Tests	Description
Botan	Botan is a cross-platform open-source C++ crypto library that supports most all publicly known cryptographic algorithms.
GnuPG	This test times how long it takes to encrypt a file using GnuPG.
OpenSSL	OpenSSL is an open-source toolkit that implements SSL (Secure Sockets Layer) and TLS (Transport Layer Security) protocols
Gcrypt Library	This is a benchmark of libgcrypt's integrated benchmark with the CAMELLIA256-ECB cipher and 100 repetitions.
John The Ripper	This is a benchmark of John The Ripper, which is a password cracker.

RAM Tests:

Tests	Description
RAMspeed SMP	This benchmark tests the system memory (RAM) performance.
t-test1	This is a test of t-test1 for basic memory allocator benchmarks
Cachebench	Cachebench is designed to test the memory and cache bandwidth performance.

5-Hardware selection for the tests

A Hardware device or HUB in DECODE can be any of the following:

- Physical server or PC
- A virtual machine in a public or private cloud infrastructure (e.g. AWS, Google Cloud, Azure)
- A single board computer for e.g. OlinuXino-LIME2.
- A smart card running limited cryptographic code
- A mobile device such as a phone or tablet

Validating nodes are more likely to be running on a physical server, or on a virtual machine in a cloud infrastructure. To simulate a validating node tests should be installed on a physical server (PC) running DECODE OS (Devuan).

Wallet nodes on the other hand are more likely to run on mobile devices, commercial laptops or, as in the IoT pilot, on a single board computer. To simulate the standard user using a wallet software the tests were installed in a commercial laptop. For the IoT scenario, the benchmark suite was installed in a selection of single board computers.

The selection of hardware devices is listed below:

Validation Nodes

- Multi Core CPU – 64-bit (x64), 1.5 GHz clock speed [Model TBD]

Standard wallets

- Lenovo ThinkPad T60, Linux Ubuntu

IoT Wallets:

- A20-OlinuxinoLime2
- RaspberryPi3
- Odroid XU4
- Banana pi BPI1

Further tests will be required to study Android/IOS performance and validation nodes performance. These tests will happen in the future and therefore will not be covered in this deliverable.

A summary of the specifications of the hardware devices that were tested are presented in the table below.

Device	CPU	Core	RAM	Storage	LAN
A20-OlinuXIno-Lime2	Allwinner A20	2xA7@ 1Ghz	1GB-DDR3	Built- in 4GB-eMMC & SATA connector	GbE
Raspberry PI 3	BCM2837	4xA53 @ 1.2GHz	1GB LPDDR2	MicroSD slot, up to 32GB	10/100
Odroid-XU4	Exynos5422	4xA15@ 2GHz 4xA7@1.4GHz	2GB	eMMC slot & MicroSD slot up to 64GB	GbE
Banana Pi BPI-M1	Allwinner A20	2xA7@ 1Ghz	1024MB	SATA connector & MicroSD slot, up to 32GB	GbE

Illustration 2: Raspberry Pi 3 (Left) and Banana Pi (Right)

6-Hardware setup and system installation

Illustration 3: Arduino Test Rack

A testing platform for the embedded boards was set up in order to facilitate several iterations of tests, both for the deliverable and for future benchmarking of updated OS and the wallet software. The platform consist of a rack where all the boards are connected to one router, creating a network that allow the access of each board remotely via SSH. A script was prepared to launch all the tests one after the other without any human intervention. This script can be modify to run a different set of tests and boards. Since the Phoronix suite gives numerical data, there is no need to run any graphical interface for accessing the test result. However a VNC network can be put in place in case some graphical interface is required. This option will be explored in the future.

This set up will serve as a platform for a peer-review of the DECODE OS, Wallet software and other applications developed for DECODE from the other partners.

In addition, partners of DECODE can be given access to this platform in such a way that they can run the different tests themselves in case further benchmarking is required. Arduino will be responsible of keeping the testing platform operative, manage the remote access accounts to the test rack and increase the number of embedded devices if necessary.

The script for the automatic test will be uploaded to GitHub. The result of the tests will be uploaded to openbenchmarking.org contributing to the community with the information obtained from the tests.

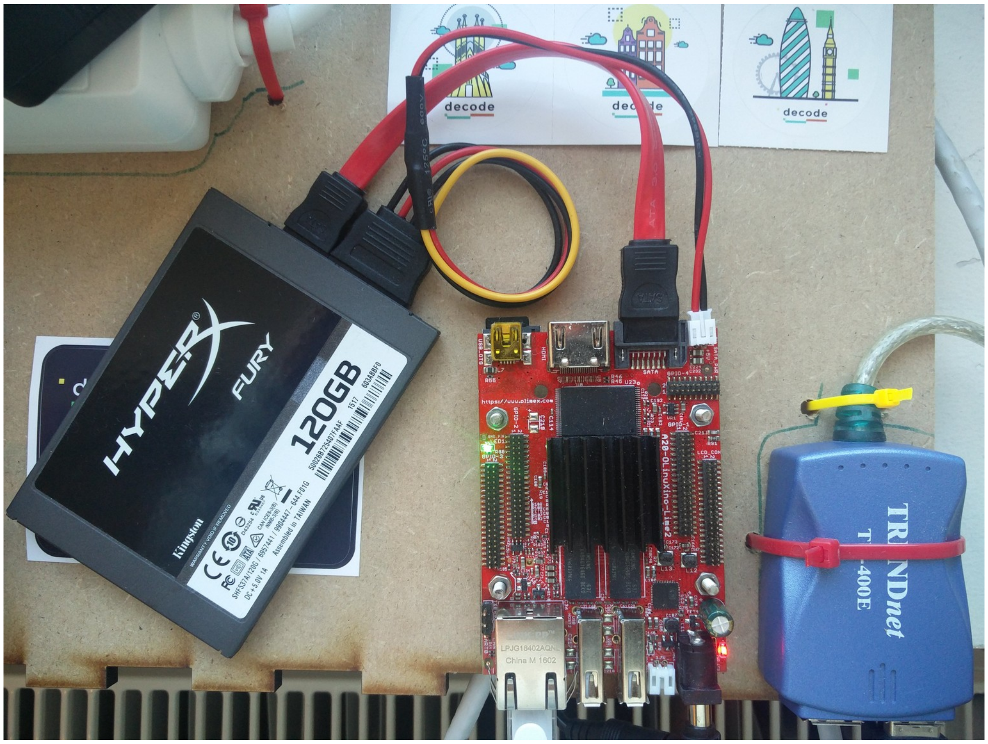

Illustration 4: A20-OLinUXino-LIME2 with SATA Drive

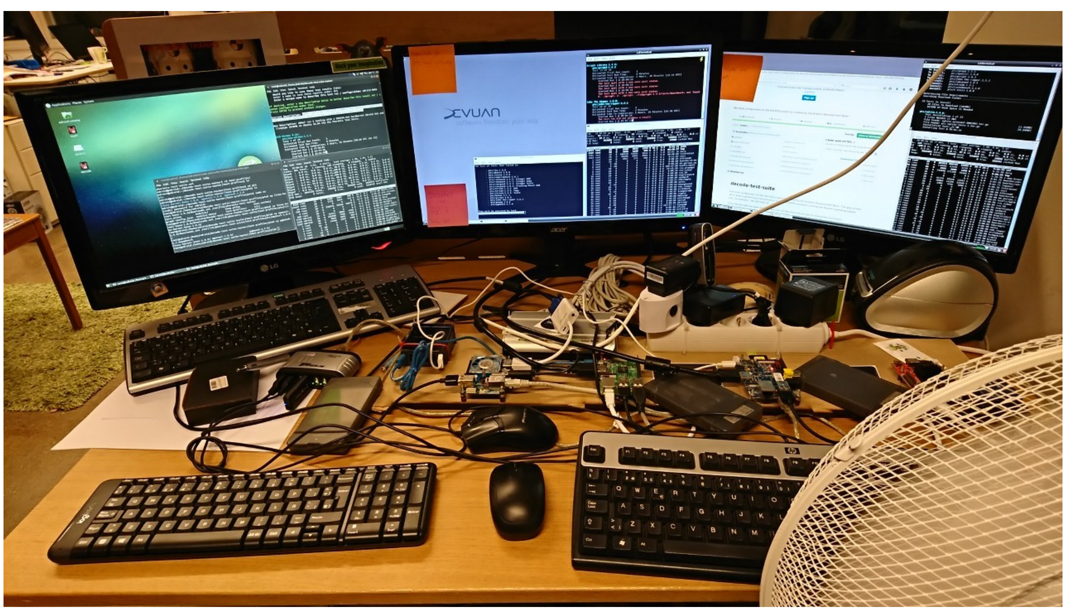

Illustration 5: Test rack running the tests

7-Tests results

This section will be dedicated to present the results of the performance tests that were carried on the selected HUBs. The following table describes the list of tests performed by board.

Test / Board	Olimex	RPi3	BPi	Odroid-Xu4
pts/compress-gzip	X	X	X	X
pts/sqlite	X	X	X	X
pts/apache	X	X	X	X
pts/pgbench	X	failed	failed	failed
pts/compilebench	X	X	X	X
pts/iozone	X	X	X	X (odrois-0001 test)
pts/dbench	X	X	failed	X
pts/fs-mark	X	X	X	X
pts/fio	X	X	failed	X
pts/tiobench	X	X	X	X
pts/postmark	X	X	X	X
pts/aio-stress	X	X	X	X
pts/unpack-linux	X	X	X	X
pts/network-loop-back	X	X	X	X
pts/botan	failed	failed	failed	failed
pts/gnupg	X	failed	X	failed
pts/openssl	X	X	X	X
pts/gcrypt	X	failed	X	failed

pts/john-the-ripper	X	X	X	X
pts/memory	RAMspeed worked, Stream failed	RAMspeed worked, Stream failed	Both failed	RAMspeed worked, Stream failed
pts/t-test1	X	X	X	X

8-Conclusion

The following table shows a summary on how the different boards scored in relation to each other for each test. Used a scale of 1 to 4. In order to determine how good is one board for a certain test in comparison to the others, it is needed to check the actual graphs from the corresponding appendix.

Test / Board	Olimex	RPi3	BPi	Odroid-Xu4	Notes
pts/compress-gzip	3	4	2	1	
pts/sqlite	1	4	2	3	
pts/apache	4	2	3	1	
pts/pgbench	1	X	X	X	
pts/compilebench	2	4	1	3	In read compiled tree wins olimex
pts/iozone	2	4	3	1	For specific tests BPi becomes the best
pts/dbench	1	3	X	2	
pts/fs-mark	1	4	2	3	
pts/fio	1	3	X	2	In average, odroid and olimex are close
pts/tiobench	3	4	2	1	
pts/postmark	2	4	1	3	

pts/aio-stress	2	4	1	3	
pts/unpack-linux	3	4	2	1	
pts/network-loopback	2	4	3	1	
pts/botan	X	X	X	X	
pts/gnupg	2	X	1	X	
pts/openssl	2	4	2	1	Bpi and Olimex scored the same
pts/gcrypt	2	X	1	X	The difference is of less than 0.01%
pts/john-the-ripper Blowfish	2	4	3	1	
pts/john-the-ripper DEC	3	1	2	4	
pts/john-the-ripper MD5	4	3	2	1	
pts/memory (RAMspeed)	3	2	X	1	The olimex results are at the end of the appendix
pts/t-test1	4	1	3	2	
pts/cachebench read	X	3	2	1	
pts/cachebench write	X	2	3	1	

Note: X means that the test could not be performed. Reasons for a test not working differ between boards and tests. In some cases a basic feature at the OS level may have been disabled for security reasons (like access to the Linux function shmget), in some others the test to be performed makes no sense due to the architecture (like trying to read memory blocks of a certain size when the architecture doesn't support it).

While a classification 1 to 4 is not optimal for expressing the complexity behind the tests performed, it gives an idea of which boards did better in which cases. Put in order, the boards obtained the following average grades (counting the tests not performed as value 0 and not weighted in the average calculation):

1. Odroid: 1,48
2. BPi: 1,64
3. Olimex: 2
4. RPi3: 2,72

Some of the aspects to note from the tests performed are:

- The Olimex board is the only one that used a Sata drive interface to the external drive storing the test results, however this didn't stop other boards from scoring better in some of the IO tests having to do with writing or reading data from the drive
- The Odroid board was running a standard Linux Mint distribution and not the official Devuan one. However it should not the a big issue in terms of performance according to a conversation maintained with Dyne along with the realization of the tests
- The BPi board does include a Sata interface, however it was not possible for us to make it work. It seemed to be a failure of electrical nature, in other words, when plugin in the external Sata drive, the board would suffer a reset
- The Devuan OS image for the BPi board hadn't solved the connectivity via ethernet, therefore this board required to use an external WiFi peripheral in order to connect
- The BPi board suffered of overheating, we installed an external fan to cool it down, but it is more than possible that a simple heat sink would have been enough to ensure proper functionality
- Given the different architectures of the processors, one could expect the Odroid board to perform better than the others, since it has two cores with 4 processors each (one could say it is an 8 cores processor, to some extent), however this is not the case since some of the dual core processor boards (Olimex and BPi) have faster cores what compensates for their reduced amount of cores

- Our results are comparable to the ones to be found at http://www.hardkernel.com/main/products/prdt_info.php where it is possible to see the comparison RPi3 and Odroid by the hand of an independent third party

Considering availability (the Odroid board is much harder to get than the other ones), technical features and test results at once, one could say that the board that had the best scores is the BPi. It is our understanding that Decode's software development team prefers to be using the Olimex board because it presents less resistance (doesn't overheat and the Sata connector works out of the box) and its technical features aren't that far from the ones of the BPi.

However, there are different aspects to take into account that none of the boards present like on-chip Ethernet support, what would ensure a 1Gb connection, better support of different memory sizes and types, a well as native wireless connectivity is something that all of the boards under test lack. Besides except for the Olimex board, none of the others could be considered to be Open Source Hardware. Therefore we -Arduino- suggest to consider testing yet another board like the Khadas Vim, which happens to fulfil all of the above, as a way to identify the right processor to use when designing the Decode board.

Future work

The information obtained from the tests will be used to design and prototype an IoT wallet HUB that will be presented in April and used in the pilot implementations.