Quality of Cryptocurrency Mining on Previous Generation NVIDIA GTX GPUs

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Abstract: Currently, there is a lot of previous generation NVIDIA GTX graphical processing units (GPUs) available on the market, which were ousted from by next-gen RTX units. Due to this fact, numerous fully-operational devices remain underused, which are available at an affordable price. First, this paper presents an analysis of the cryptocurrency market. Next, in this context, the results of research on the performance of NVIDIA graphics cards with dedicated software as a cryptocurrency mining platform. The research included three hardware platforms: GTX 480 x1, GTX 480 x2 and GTX 760 x1, tested under four cryptocurrencies, namely: Bitcoin, Litecoin, Monero and Ethereum. The custom-build test bench included power consumption as well as the efficiency of mining various digital currencies. Obtained results can aid any investigator interested in designing his own stand as well as configuring the environment.

1 INTRODUCTION

Cryptocurrencies are one of the biggest technological phenomena in recent years. Few of the other information technologies have spread so quickly and made similar rapid changes in their field. Cryptocurrencies are based on blockchain technology, which is an innovative application of previously existing algorithms and data structures (Mukhopadhyay et al., 2016; Szostek, 2018).

Blockchain technology opened the way for fast, cheap and global money transfer between users, without the need for the participation of the institution that performs the bank activities. The currency is completely virtual, but despite this, it cannot be duplicated in any way, and with a sufficiently large network size, any attempt to manipulate the data is practically impossible (Fang et al., 2022; Wątorek et al., 2021).

2 BLOCKCHAIN TECHNOLOGY

Blockchain is a distributed chain of records with a strictly defined structure, stored by a number of equivalent nodes and using peer to peer (P2P) communicating protocols (Di Pierro, 2017; Nofer, 2017).

Individual records, called blocks, contain information about transactions carried out between network participants with the use of cryptocurrency. Each network node has a pair of keys: public and private. They allow network operations, that is transactions.

The keys are used to generate unique addresses (wallets) on which the virtual currency is stored. Each transaction consists of: input address (or addresses), output address (or addresses), amount of transferred currency, and a single block consists of: a certain number of transactions, the previous block hash and the so-called nonce, which stands for number only used once.

The nonce is a very important element of the system because it uses asymmetric cryptography to stabilize and systematize the creation of new blocks. Finding a matching nonce is very complicated

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computationally, and it is easy to verify the already found one.

Due to the fact that the creation of new units involves real costs, like electronic equipment, electricity, it is necessary to reward for participation in the system. The reward is cryptocurrency units delivered to the node's wallet when it mines a new block. They have two sources: one is a completely new unit introduced into the network in the amount defined by a given algorithm, and the other is the so-called transaction fee.

Over time, the use of blockchain by other network participants causes a constant increase in the length of the chain, and thus increasing requirements for both RAM and non-volatile memory. So to record transactions, Merkle trees (hash trees) are used, as shown in Figure 1.

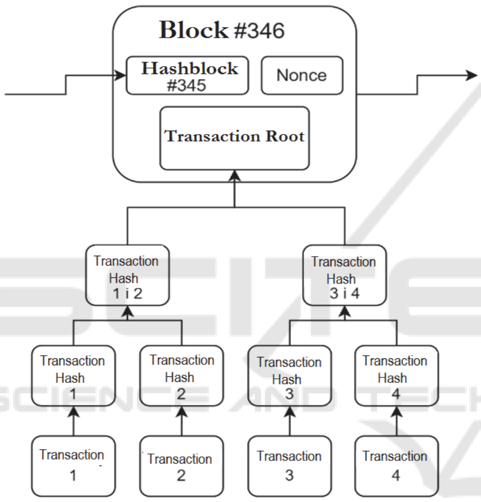

Figure 1: Blockchain as a Merkle tree.

Individual blocks with transactions are hashed, and the resulting values are then paired with each other and hashed again. This process continues until the so-called transaction root, a single hash value that is associated with all transactions in a given block. So nodes do not have to keep copies of all transactions that took place in the history of the blockchain and can limit themselves to the latest transactions related to a given amount of currency (Nakamoto, 2009). In such a situation, the node still has the certainty that there has been no manipulation and that the current owner of the currency is its rightful owner, thanks to the fact that the transaction is rooted in the block.

Asymmetry in creating and verifying new blocks is very important, because one cannot introduce crafted blocks into the network. Their creation is associated with the need to sacrifice computing power, and the algorithms for selecting the right block in the event of a conflict make it necessary for forgery to have more computing power than the entire network (Bastiaan, 2015). Carrying out such an attack, although demanding, is possible.

3 FIDUCIARY CURRENCY AND CRYPTOCURRENCY

There are both similarities and differences between the characteristics of cryptocurrencies and fiduciary currency, which are not covered by material goods. Similar to currencies issued today by governmental organizations such as the US Dollar or Euro, the value of cryptocurrencies is not sustained by any real commodities. In the event of a sudden drop in demand, as shown in Figure 2, cryptocurrency owners have no way of using them other than for transactions with other users.

Figure 2: The price of one Bitcoin (BitInfoCharts, 2020).

This means that the price of cryptocurrencies is highly volatile and completely depends on the current demand (Liu, 2021; Gandal and Hałaburda, 2014).

The main difference is how new units of currency are produced. In traditional currencies, it is the central bank that takes decisions based on many factors about reprinting the currency in a certain quantity. In most cases, this means that they are characterized by variable, but always present, level of inflation, i.e., the decline in the value of money associated with increasing its supply.

Cryptocurrencies do not have a central "emitter" of the currency, and the number of its units and supply are strictly defined by the algorithm, without the possibility of manipulation based on, e.g., market conditions. Typically, new cryptocurrency units are delivered to the network nodes involved in the creation of new blocks, which involves sacrificing computing power, which in turn requires investments in equipment and electricity (Li et al., 2019; Náñez Alonso, 2021).

Due to the fact that the supply of a new cryptocurrency is associated with a certain cost, inflation is significantly limited, and it is "profitable" to store it for users of the currency. The amount of currency in the blockchain is limited, and the supply of new units slows down over time, to stop completely in the rather far future (Xu et al., 2009; Risius and Spohrer, 2017, Ahram et al., 2017).

4 TESTED CRYPTOCURRENCIES

4.1 Bitcoin

Bitcoin was the first system to implement blockchain in cryptocurrency. On October 31, 2008, a person or group of people using the pseudonym Satoshi Nakamoto published an article describing his assumptions. Then, on January 3, 2009, the Bitcoin network was initiated, mining it for the first time.

The network does not take into account any central authority, and all decisions regarding the future of the system (adding more blocks) are made by consensus among all network users. The lack of a "bank" prevents institutional manipulation of the currency, such as its "reprint", it is not possible to grant loans, and the fragmented nature of the system in practice prevents from taking control by any financial organization or political.

4.2 Litecoin

Litecoin was founded in October 2011 by Charles Lee (Bitcoin Forum, 2011), based on the Bitcoin blockchain software, with a number of differences. Its creator has drawn conclusions from the first cryptocurrency, as well as several alternatives that have come and gone unnoticed in the meantime.

The most important change was the reduction of the average extraction time for a new block from 10 to 2.5 minutes. This has greatly increased the convenience of using cryptocurrency as a payment method for goods, reducing the need for long waiting for transaction confirmation. The second advantage was a significant reduction in transaction fees, thanks to which Litecoin could have a much higher financial liquidity than its predecessor. Additionally, this currency uses the Scrypt hashing algorithm, which has much higher memory requirements than SHA256.

4.3 Ethereum

Ethereum was created in 2015 by a group of people led by Vitalik Buterine. It is an innovative development of the previous blockchain implementation. Each contract added to the Ethereum blockchain can be simply treated as a class in the Speaking program, denoting a given state and transition points so that this state can be changed, assigning it using argument methods. One can also download some blockchain data, such as the current time block and, above all, information about incoming payments.

Currently, it is the second cryptocurrency after Bitcoin, having approx. 12% market share (Coinmarketcap, 2022). Its additional advantages are even easier transactional activities and further activities, namely several seconds instead of 10 minutes, thanks to which various tasks can be performed in near real-time.

4.4 Monero

Monero was founded in April 2014, and introduced several new cryptographic solutions. The most important of which are: stealth addresses and ring signatures, increasing the privacy of the recipient and sender, respectively. It is not possible to review the blockchain for this user's activity.

5 MINING PLATFORMS

New units of individual cryptocurrencies are automatically delivered to users who provide the computing power of their devices. The process is called cryptocurrency mining. There have been many changes to the way since the first cryptocurrencies appeared. The most used graphics cards were constantly being replaced by new models, in many cases also by devices of a completely different category. However, over the years the most popular type of device used for this purpose have been dedicated graphics cards.

There are three categories of devices capable of mining cryptocurrencies (Ghimire and Selvaraj, 2018):

- CPUs (Central Processing Units),
- GPUs (Graphics Processing Units),
- ASICs (Application Specific Integrated Circuits).

CPUs are rarely used for this purpose, due to the specificity of calculations performed in most blockchain algorithms. The search for a nonce in order to obtain a specific checksum is an action to promote the maximum possible number of threads, with the simultaneous relative simplicity of the actions performed. This works definitely to the advantage of the second type of chips mentioned, because graphics rendering has similar requirements to the GPU as cryptocurrency mining. There are cases where the use of CPUs can be profitable, but they make up a very small percentage of the overall cryptocurrency market. In the case of ASIC installations, they are completely self-contained when mining cryptocurrencies.

6 MATERIALS AND METHODS

Tests were carried out using graphic cards from older generations of NVIDIA GTX, and included two models, that is: NVIDIA GeForce GTX 480 and MSI GeForce GTX 760. The technical specifications of these GPUs is described in Table 1.

Table 1: Technical specification of tested GPUs.

GPU	CUDA cores	CPU clock [MHz]	Mem. clock [MHz]	RAM [MB]	T-put [GB/s]
GTX 480	480	700	1848	1536	177.4
GTX 760	1152	1150	6008	2048	192.3

Particular attention is paid to the power supply and its quality. It must be able to deliver the maximum amount of power that a single or multiple GPUs can draw from the mains. Of course, a stable Internet connection is also required.

The main criterion for selecting a cryptocurrency was its popularity, assessed on the basis of their market cap, provided by price tracking services. In addition, the technologies, on which the blockchains of individual currencies were built, were taken into account. They have a very large impact on the efficiency of mining, and in combination with the price of a given cryptocurrency, on the profitability of the entire process (Bouri et al., 2019; Caporale et al., 2018).

One of the most important parts of the blockchain is the hashing algorithm. While Bitcoin uses SHA256, the next emerging cryptocurrencies have often made significant changes in this area, introducing their own solutions. Newer algorithms are most often aimed at preventing or at least hindering the creation of ASIC devices specializing in mining a given cryptocurrency. Such activities had a large impact on the frequency of finding new blocks by blockchain participants, which makes the profitability of mining individual cryptocurrencies on different devices unalike. For this reason, the cryptocurrency mining process had to be tested with various hashing algorithms (or families of algorithms), so that in the future, when new cryptocurrencies using these algorithms are released, it will be possible to assess the profitability of using older GPUs from the NVIDIA GTX family.

6.1 Operating System

Kubuntu 20.04 LTS was selected as the operating system (OS) for cryptocurrency mining. This was the latest version of this system at the time of our studies, additionally having long time support (LTS). The configuration is described in Table 2.

Table 2: Mining software used during tests.

Cryptocurrency	Mining software	Version
Bitcoin	CGMiner	3.7.2
Litecoin	CGMiner	3.7.2
Ethereum	Ethminer	0.18.0
Monero	XMRig	5.11.4

Kubuntu is a variation of Ubuntu, one of the most popular desktop Linux distributions. This OS offers good support from cryptocurrency mining programs and easy ability to execute all necessary commands as well as monitoring via the terminal, using the Secure Shell Protocol (SSH).

6.2 Mining Pool Payout Model

There are several payout models offered by cryptocurrencies. PayPerShare (PPS) is a model that accrues a reward for pool share upon receipt of each properly completed user unit of work (share). However, there are more favorable variants where, in addition to the block mining rewards, they also receive some transaction fees (Farell, 2015; Liu et al., 2022):

- Full Pay Per Share (FPPS) – profit from transaction fees is calculated on the same basis as the block reward.
- Payer Share Plus (PPS+) – transaction fees are distributed to users on the basis of the Pay Per Last N Shares (PPLNS). Receiving a portion of the transaction fees is especially important with Bitcoin, where the rewards per block are relatively small.
- Pay Per Last N Shares (PPLNS) – the pool operator shifts the risk to the users. Instead of rewarding them on receipt of each unit of work, payment is made only after the pool has actually extracted the block.

When selecting a pool, the PPS payout models were preferred, because they better meet the requirements of this study. High randomness, characteristic to PPLNS, may adversely affect the reliability of research results, and in order to minimize its impact, very long tests should be run, which, with the expected low performance of the cards used, could result in unnecessary losses. Then, attempts were made to select the best offers among the available ones, i.e., those with low fees to the pool and those requiring no additional verification, such as providing a telephone number. The list of utilized model pools is described in Table 3.

Table 3: Cryptocurrency pools used during test.

Cryptocurrency	Mining pool	Model
Bitcoin	SlushPool.com	FPPS
Litecoin	LitecoinPool.org	PPS
Ethereum	SparkPool.com	PPS+
Monero	MinerGate.com	PPS

6.3 Test Bench

The test stand could consist of a maximum of 13 GPUs. First, it was planned to start with a version of a single graphics card. The implementation of any of the other variants depended entirely on the results of the profitability tests, due to the additional costs of purchasing other necessary components, including: power supplies, motherboard, CPU, etc.).

At an early stage of work, 3D models of the test environment were made using SketchUp for Web, as shown in Figure 3. Each model assumed the use of the number of cards being a power of 2, except for the last one, reaching the limit of 13.

The miner platform used for the tests, apart from one of the above-mentioned GPUs, consisted of:

- Intel i5-750 CPU,
- Hynix DDR3 16 GB RAM,
- Asus P7P55D Deluxe motherboard,
- Hitachi 500 GB hard drive,
- XFX 750W power supply.

Each research scenario lasted 12 hours. This length was chosen because it allows easy extrapolation of results to larger time units (days, months, etc.), while remaining long enough to observe any fluctuations.

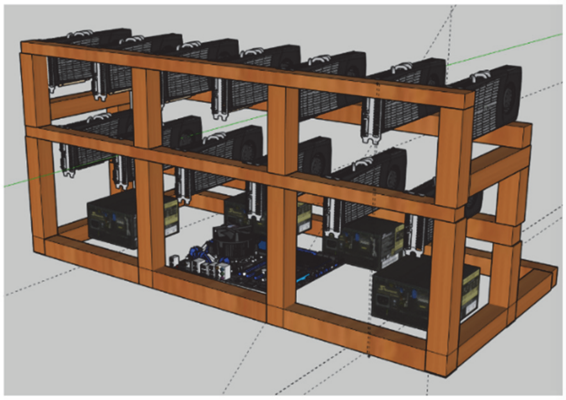

Figure 3: Test bench used during test.

7 RESULTS

The research was carried out for several sites, described as no. 1, no. 2, etc. After finding the optimal parameters for all stations, the main research scenarios were started. The configuration for Bitcoin is described in Table 4, where the number of treads was equal to 2.

Table 4: Optimal parameters for Bitcoin.

Suite no.	GPU	Intensity	Hash index	Job unit
1	GTX 480 x1	16	132.7 Mh/s	2.1/min
2	GTX 480 x2	16	266.5 Mh/s	4/min
3	GTX 760 x1	14	162.5 Mh/s	2.5/min

Whereas, the configuration for Litecoin is described in Table 5. In case of all suits, the number of threads was equal to 1, and the intensity was set to 11.

Table 5: Optimal parameters for Litecoin.

Suite no.	GPU	Shaders	Hash index	Job unit
1	GTX 480 x1	530	60.1 kh/s	56.7/min
2	GTX 480 x2	1060	121.3 kh/s	142.5/min
3	GTX 760 x1	1266	70.1 kh/s	71.3/min

The following parameters were measured: GPU hash rate, total network hash rate, number of shares accepted, number of shares rejected, number of hardware errors, GPU memory allocated, GPU load, GPU temperature, fan speed, cryptocurrency units generated and power consumption.

The above data, with the exception of power consumption, was read from individual miner programs or from utilities supplied with the graphics card drivers. Whereas, power consumption measurements were carried out using the GreenBlue GB202 power meter, as shown in Figure 4.

Figure 4: GreenBlue GB202 power meter.

Each research scenario lasted 12 hours, because it allows easy extrapolation of results to larger time units. After collecting all the data, calculations were started to check the overall profitability of the process.

Using data on cryptocurrency prices as well as online exchanges and equipment on auction websites, a summary of the following data was prepared:

- The value of the generated cryptocurrency units in PLN.
- Value of the equipment used in the research.
- Cost of consumed electricity.
- Total profit or loss.

Quite surprisingly, only in case of the Litecoin it was possible to obtain a non-zero amount of cryptocurrency from all assembled suits. As it turned out, the Ethereum was not compatible with the tested equipment, due to insufficient size of the GPUs memory, therefore eventually it was omitted from the study. Obtained results are shown in Figure 5-8, where respective lines represent:

- Red – Bitcoin currency suite no. 1,
- Black – Litecoin currency suite no. 1,
- Yellow – Monreo currency suite no. 1,
- Green – Bitcoin currency suite no. 2,
- Blue – Litecoin currency suite no. 2,
- Magenta – Bitoin currency suite no. 3,
- Cyan – Liteoin currency suite no. 3,
- Dotted Red – Monero currency suite no. 3.

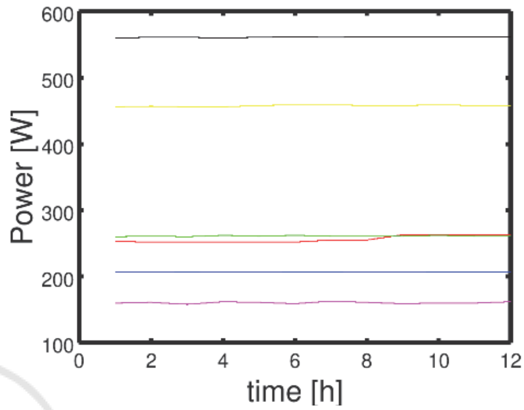

Figure 5: Power consumption for different suites.

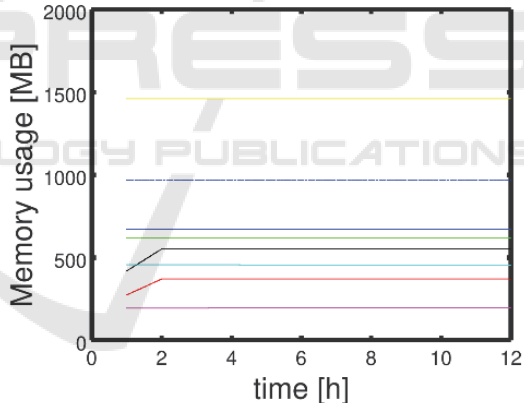

Figure 6: Memory usage for different suites.

Suite no. 2 gives slightly different results as compared to suite no. 1, but the most important parameter, i.e., the amount of cryptocurrency, is still equal to zero (except for Litecoin). This suite had additional minor custom software modifications, e.g., changing the version of XMRig Miner to 5.11.0 from version 4.6.2. Suite no. 3 obtained slightly different results, but the amount of cryptocurrency was still equal to zero (except for Litecoin once again). In this case, a software update was necessary in order to test the Monero cryptocurrency (GPU driver 440.33.01, CUDA 10.2, XMRig v6.3.2, xmrig-cuda v6.3.2).

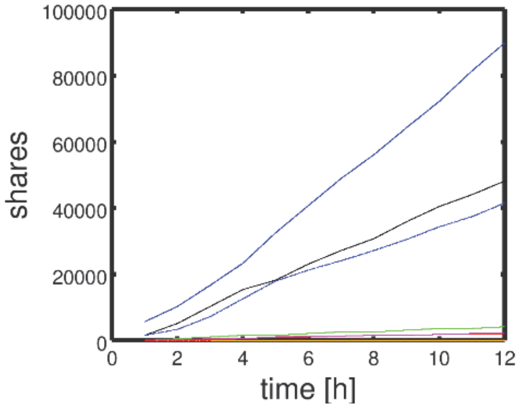

Figure 7: Shares for different suites.

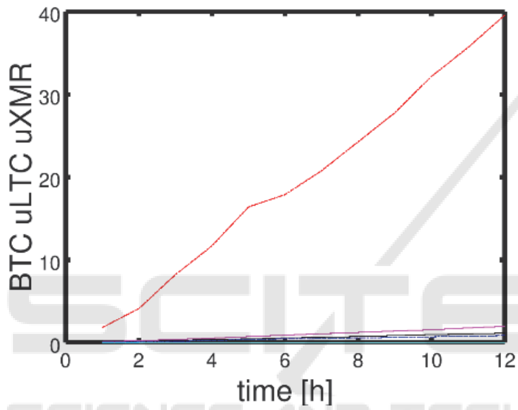

Figure 8: Mined cryptocurrency for different suites.

Table 6 summarizes the cryptocurrency price per unit at the time of performing the tests. Whereas, Table 7 and 8 sums up the earnings and profitability (loss) in Polish Zloty [PLN].

Table 6: Cryptocurrency price per unit.

Cryptocurrency	Unit	Price
Bitcoin	1 BTC	38875.72 PLN
Litecoin	1 LTC	183.78 PLN
Monero	1 MXR	324.88 PLN

Table 7: Cryptocurrency mining earnings.

Suite no.	Bitcoin [PLN]	Litecoin [PLN]	Monero [PLN]
1	0	0.000206	0
2	0	0.000358	0
3	0	0.000152	0.012865

As shown, there is a great disproportion between respective cryptocurrencies, ranging even up to a couple of hundreds of percent, with Bitcoin being the priciest one.

Table 8: Cryptocurrency mining profitability.

Suite no.	Mined cryptocurrency [PLN]	Energy consumption [kW/h]	Energy price [PLN]
1	0.000206	9.6	6.43
2	0.000358	12.2	8.19
3	0.013017	7.5	5.05

From all the cryptocurrencies tested during the study, only Litecoin enabled to obtain a non-zero amount of cryptocurrency from all 3 assembled suites. Therefore, further calculations will focus mostly on it.

8 DISCUSSION

Figure 9 and 10 shows the annual increase in the amount of currency in the mining process and the time required to withdraw the first income from the pool. In in the case, the minimal pool is equal to 0.1 LTC, which currently corresponds to approx. 20 PLN.

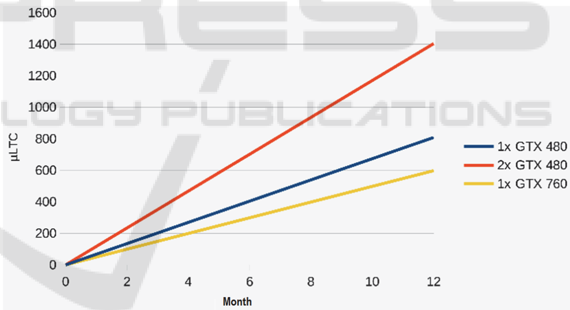

Figure 9: Litecoin cryptocurrency mining performance.

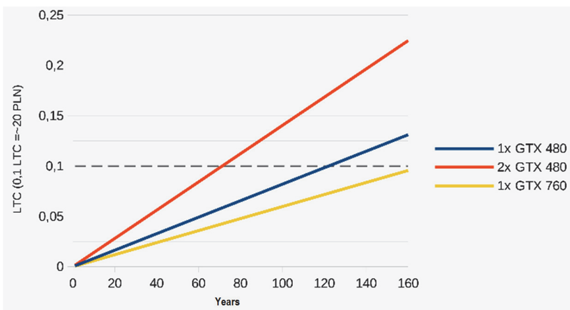

Figure 10: Litecoin mining time to first payout.

Also for Litecoin, measurements of the hash index and the amount of obtained cryptocurrency were averaged in order to know the hash rate value at which the process of mining this currency becomes profitable. Linear dependence of both values was assumed, because all fluctuations have already been taken into account thanks to averaging. The result of this analysis is shown in Figure 11.

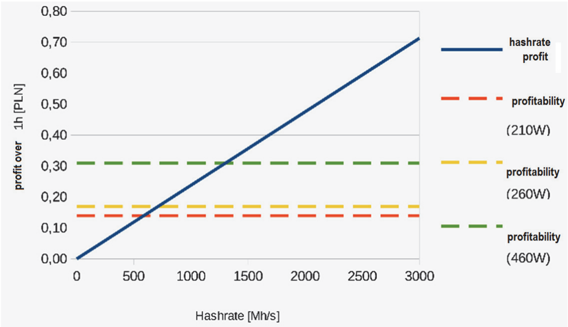

Figure 11: Hashrate vs profit in PLN for Litecoin.

Figure 12 shows the rate of return on investment for a Monero cryptocurrency miner, expressed as the number of years needed to fully cover the costs, including electricity (250W power consumption).

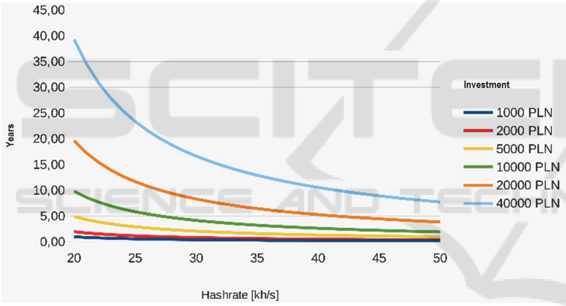

Figure 12: Number of years required to cover the costs of the miner platform.

9 SUMMARY

The aim of this work was to analyze the cryptocurrency market and perform a series of tests concerning the performance of previous generations of NVIDIA GTX graphics cards used as miners. After the software installation, tests were carried out to find the optimal configuration for 3 hardware configurations, including: NVIDIA GeForce GTX 480 x1, NVIDIA GeForce GTX 480 x2 and NVIDIA GeForce GTX 760 x1. Initially, the investigation was intended for 4 cryptocurrencies: Bitcoin, Litecoin, Monero and Ethereum.

For the first three (Bitcoin, Litecoin, Monero), a negligibly low or zero amount of cryptocurrency was obtained, while the fourth one (Ethereum) could not be evaluated due to insufficient graphics memory. The collected data shows that older models of graphics cards do not give any chance of profit in case of any cryptocurrency.

In the optimal scenario (Monero), and the most efficient platform (no. 3), the mining process would have to last about 2 years to obtain the equivalent of PLN 20, with electricity costs of approx. 1880 PLN. Such bad results of the GPUs used in the tests are due to the rapid development on the chip market and the dominance of dedicated ASIC devices for the most popular cryptocurrencies, which offer several times better performance.

It should be also pointed out that owners of cryptocurrency miners tend to operate in countries with cheapest electricity, which provides a significant advantage. As shown, previous generation GPUs would surely prove to be still feasible when processing rich multimedia content, i.e., audio-visual content or 3D graphics editing, etc. Further source of inspiration for future studies may be found in (Jacob et al., 2021; Goodkind et al., 2020; Kumar, 2021; Fadeyi, 2019; Gundaboina et al., 2022; Bastian-Pinto et al., 2021).

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