Power-Efficient Model of Blockchain Applications in Mobile Systems

Manuel Figueroa, *ITCR,* Esteban Leandro, *ITCR*

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Instituto Tecnológico de Costa Rica

{*mfigueroacr, elc790*}*@gmail.com*

***Abstract*—Since security has become a major concern in the everyday use of technology. The impact of mobiles and the growing dependency that the general population has in mobile devices and systems has increased its potentially harmful impact of a security breach. Most of the interaction between users with systems, including banking and e-commerce are made using mobile devices. Recently the introduction of the blockchain technology as an effective security solution for many applications that involve transactions, also as hardware evolves those mobile devices now have larger processing capabilities that make it possible to run blockchain based solution in the mobile space. A definition of a power model allow us to describe, understand and predict the expected behavior of the power consumption demand in those kind of solutions and will help the system designers to estimate how the devices will behave in terms of power consumption. Also, it will help application designers to define the scope of its application in terms of performance and power consumption when it is executed in a mobile device and a high compute rate is expected to perform the blockchain mining process.**

***Index Terms*—LaTeX mobile systems, blockchain, power modeling.**

I. Introduction

A. Blockchain

Blockchain has been introduced in the last years as a technology method for data security problems, where there are several implementations of it, like Bitcoin Wallet [1], Ripples or Ethereum [2], as many others crypto currencies.

Besides that, deleting the intermediary from the equation through a bank transaction between an account to another and giving that control to the users has been an interesting approach, where there is a big pool of users that approve those transactions if those are valid to be added to the block chain, with the difference that nobody knows which is the origin user and the destination user, the inly information needed is that a virtual wallet is sending some money or crypto currency to another wallet identified by an address.

After a transaction is created is grouped into blocks, and the links between blocks and their content are protected by cryptography and cannot be forged. Once that the transaction is inside the blockchain, there is no way to erase it.

B. Mining

Kroll et al. [3] explain that the mining process requires vast computing power as only a "brute force, trial and error" method can be used to calculate the SHA-256 hash. Every two weeks, the complexity of the challenge is adjusted to ensure that, on average, a block is mined every 10 minutes. The financial incentive of 25 bitcoins is offered to the first miner to successfully calculate the hash.

This technique may lead money earnings but also requires alot of computing resources consuming, as electricity, also this technical hardware and software equipment is not available in every country, sometimes there is a cost of buy in them when the mining team is in a place that makes them get it from exterior. But worth to mention it as part of the whole blockchain and crypto currencies possibilities.

C. Blockchain and Internet of Things

This concept adapts to the blockchain and mobile relation, as there are daily millions and millions of devices moving transactions from one side to another, using bank accounts or orher payment methods which may several waits from clients, time consuming and more. Millions of mobile devices can avoid the bank intermediary by handling their transactions inside the blockchain.

As stuff and not just people are related with the Internet every day, blockchain is a very advanced technique to interconnect transaction systems, as monitoring systems, health, finance, education and more.

Modern Internet of Things(IoT) software systems, like interconnected transportation systems, generate a lot if data every day. The data exchanges may charge a fee for handeling the transactions inside the wallets, which may also elevate costs, security concerns and privacy of several transactions for a single entity [4].

D. Contribution

In this paper, we describe a new algorithm that enable any kind of mobile devices, including Android and iOS mobile operating systems, to run transaction applications with several amounts of traffic (our tests are based on two hundred transactions per second), where the mobile device can handle that amount of traffic and keep the user interface without lacks or interruptions to the user. The 70 percentage of the transactions used to test the algorithm were on devices with Linux based operating systems.

All transactions used in this experiment used non bank accounts between source and destination accounts, but blockchain in order to add every transaction to the chain where will be approved by other users.

The performance shown is superior than bank systems in 30 percentage as the experiments show. We think this is part because the bank software systems sometimes are old, or even new sometimes data need to be moved from one side to another using cronjobs or tasks schedulers which is not in real time.

Our approach avoids all this waiting times, given an algorithm which can be used in several markets that includes monetary transactions, via your cellphone or anu mobile device.

II. Background

A. Mobile Blockchain Systems

According to [5] a blockchain system can be seen as a distributed database of records. The system provides a public layer that keeps a record for every single event that have been executed among the participant parties. Each new transaction added to the blockchain requires a process to be included as a new block in the blockchain. That process requires some kind of validation, usually solving a proof-of-work puzzle. That kind of implementation is expensive and it has been hard to include a proper blockchain system in mobile architectures due to the lack of computing power and the limited energy of current mobile devices. For that reason some other approaches [6], [7] have been studied to enable blockchain application to be used in the mobile devices. In those approaches, the authors claim that is a good idea to offload the mining process to an edge computing service provider, this will eventually enable any device to participate as an active node in the blockchain network even if they are no capable of performing any mining process at all. In that scenario the network must be supported by an external service and that will reduce the *free-network* concept. The mobile devices will participate as dumb clients and the entire blockchain process will be performed in the cloud. Also this novel approach and will be excellent to support e-commerce initiatives and will not limit the participation of users due to lack of computational power.

B. Power Monitoring

According to [8] the bitcoin miners are considered electromagnetic alchemist, because they can convert massive amounts of megawatt-hours of electricity into the world's fastest-growing currency. Because of the calculations required to hash a transaction block and correctly include it in the chain it is estimate that a bitcoin transaction consumes more than 5,000 times as much energy as using a Visa credit card. Even when the computers are constantly getting faster and more power efficient, the bitcoin algorithm increase the difficulty of the hashing procedures to keep the chain integrity and security by making almost impossible to introduce malicious blocks by outrunning the entire network and producing a new longer chain with the fraudulent blocks. That causes a huge impact in the power consumption of the platform, and it is estimates in a total of 73.12 TWh or the same as the entire consumption of Austria [9].

Actually some strategies are implemented to solve this amount of power required to include a new block in the blockchain, some of them are related to change the proof-of-work algorithm to something more power efficient like Algorand [10], using the Bizantine agreements technique to reach consensus, and others like proof-of-learning [11] that use rankings of machine learning systems.

It is possible to measure the power consumption of a component using the Ohm's law that will express a value in *Watts* and can be expressed as the following equation:

$$Power(Watts) = V * I$$

where V is the volatage given in *Volts* and I is the current given in *Amperes*. We can use performance monitoring counters (PFC) [12] to measure the amount of power required by a blockchain network with local nodes, and therefore estimate the total amount of power required when it scales up.

To the best of our knowledge there is no a commercial implementation of a blockchain system running on mobile devices, perhaps an hybrid scheme would be feasible, and the MobiChain [13] is an approach that can run the mining process using mobile nodes.

It is part of our interest to know what is the power modeling of a mobile blockchain system using other consensus mechanisms and verify if that would make them and attractive option to be incorporated in mobile e-commerce platforms.

III. Implementation

A. Algorithm Explanation

The main advantage of our algorithm implementation is to use a different way to perform the proof-of-work blocks validation, since that is the part that requires the larger amount of time to be performed and also the larger amount of consumed power due to the difficult mathematical puzzle to be performed by the participant nodes.

Our approach consists in to implement the blockchain validation using a bizantine agreement approach proposed by [10] using a similar proof-of-stake approach. According to that implementation the power of mining is given by the amount of tokens that the participant has in the system. A peer with more tokens has the major possibility of getting a new block added to the system, and it is based in the supposition that the peer with the larger amount of tokens is interested in keeping the security of the whole platform in good shape.

Since the amount of required computing power to perform those bizantine agreements is considerably lower than the proof-of-work then we can presume that the expected performance will be higher than the algorithm proposed by [13] and also with a lower power consumption requirements.

B. Experiments

All of our experiments will be performed using a set of 5 Kindle Fire 10, with a 1.2GHz quad-core processor, and 1GB RAM, and a set pf 5 Samsung Galaxy S5 with a 2.5 GHz

quad-core processor and Qualcomm Adreno 330 GPU with 450Mhz core processor and 2GB RAM.

We choose those devieces because they represent the average specs of a current date smartphone, and since the mobile devices increase its computational power every year we can also expect that results will be better in the future.

In our experiment, we create a blockchain of 8000 blocks and use the mentioned set of mobile devices to mine thee block.

The expected result of the algorithm is to mine that chain of blocks under 3 days of time to beat the time presented by MobiChain in [13].

C. Results

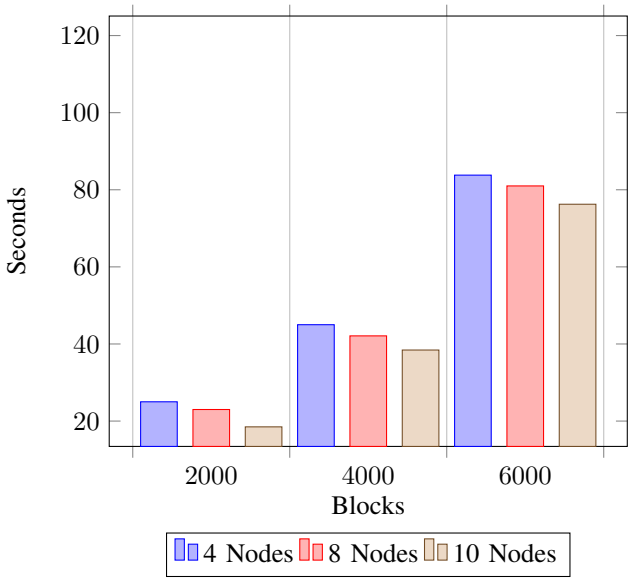
In this section we show the expected results of the exection of our algorithm processing a set of 8000 blocks using a combined network of mobile devices as descripted above.

The following table shows the amount of time (in seconds) expected by the network to complete a block chain of certain number of blocks. The amount of Kindle devices used is represented by *#K* and the amount of Samsung devices is represented by *#S*

# Blocks	4 Nodes 2 K + 2S	8 Nodes 4K + 4S	10 Nodes 5K + 5S
2000	25	23	18.5
4000	45	42.1	38.43
6000	83.8	81	76.25
8000	120	110	106

TABLE I
BLOCKCHAIN CREATION TIME

The results presented here are estimated using 3 cores per node and equal number of threads per core by calculate the validation proof of every block prior add them to the chain. The network latency will not be considered since every node in this experiment are under the same network using a 1Gb/s speed connection.



D. Power Consumption

Using the power consumption variable, we want to note that since our algorithm uses a slightly more power efficient proof-of-work mechnism the amount of energy used by our mobile devices network is considerably reduced against the other studied approaches.

This is because the hashing mechanism to validate the blocks integrity use the bizantine agreeement factor similar to the expained in [10].

The power consumption results matrix used by the network can be verified by this table:

	4 Nodes 2 K + 2S	8 Nodes 4K + 4S	10 Nodes 5K + 5S
Modeled Power (Watts)	2,8	2,9	3,0
Measured Power (Watts)	2,51	2,78	2,85

TABLE II
POWER CONSUMPTION OF THE MOBILE NETWORK

IV. RELATED WORK

In another similar work, Suankaewmanee et al. [13] studied the performance of a mobile commerce application using blockchain technology in terms of computation energy, time consumption, and memory utilization. They introduce a mobile-commerce application using blockchain technology, the name was MobiChain, used for secured transaction. They develop an API which allows the mining process to be performed on mobile devices effectively.

Also, in [14] they describe approaches to modeling the energy consumption of both Proof of Work in Bitcoin and non-proof-of-work coins and associated consensus algorithms based on parameters including the size of the network, the number of messages sent per transaction, and the computing cost of such a consensus protocol.

The authors in [15] conducts a formal analysis of the newly proposed temporal ”rolling” blockchain using the B language. It will examine the security principles of the proposed model and conduct an in-depth analysis of the results, which will be compared to the security principles of traditional blockchain networks. Their aim is to demonstrate that our proposed model is a possible replacement to the traditional blockchain, and is capable of solving the scalability issue without introducing any additional security issues into the core data structure.

In [16] the authors consider an edge computing enabled mobile blockchain network, where IoT devices or mobile users can access and utilize resources or computing services from an edge computing service provider to support their blockchain applications. First, they present overviews of blockchain and edge computing architecture, respectively. They propose a prototype of an edge computing system for mobile blockchain. Then they propose pricing schemes for the edge computing services for mobile blockchain.

V. FUTURE WORK

Arguably the most important piece of work to conduct in the future is to make this proposed algorithm live, running on a complete market with thousands of transactions per day

in a single or multiple devices. This will then let us examine in greater detail whether the assumptions in this paper hold true against a real world adversary, who controls various percentages of the network and other variables that may affect the obtained results.

The deployment onto a real world transactions network would also allow us to see whether our solutions to known issues and limitations hold true, or if new issues surface. It would also allow more research into possible secutiry vectors, such as an offline or online Internet connections between several mobile devices generating movements on the block chain.

Another key research area is implementing this algorithm, for example on a distrusted reputation network, to accurately model how the roll of the blockchain should be performed: i.e. whether a simple time period is sufficient, or if a more sophisticated model is required to allow millions of crypto or normal currency transactions to be processed in mobile devices.

As a major barrier for large-scale IoT blockchains is the transaction time, future research could be conducted to find out how the size of blockchain networks impacts the transaction time and what trade-offs between the energy usage and the transaction time may be on large-scale blockchains.

VI. Conclusions

As mentioned before our novel approach to brings a power efficient and high performance blockchain implementation for mobile devices and it could be an useful platform to integrate secure transactions like e-commerce and currency exchange among heterogeneous network of mobile users without the requirement of external centralized validation.

The security of a blockchain system is given by the difficulty to be hacked and overrun by malicious participants to introduce fraudulent blocks to the transactions history. Since our algorithm actually ensures the participants should be able to make transactions with a high confidence of honesty between peers, we think that this will be the standard of future mobile trading and transactional exchanges by the blockchain method.

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