Cryptocurrency Grade of Green; IOTA Energy Consumption Modeling and Measurement

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***Abstract*— Over the last decade, cryptocurrencies have made a significant progress as Bitcoin. Nowadays, one of the challenges in the cryptocurrencies community is the high energy consumption of Bitcoin. Not only Bitcoin but also some other cryptocurrencies deal with this problem. This work-in-progress paper defines macro standardization for energy consumption of each transaction based on VISA and MasterCard energy consumption, IOTA energy consumption modeling, and measuring of IOTA current rate control mechanism (Proof-of-Work).**

Keywords*— green cryptocurrency, sustainability, energy consumption, payment systems, IOTA, Tangle

I. INTRODUCTION

[1] is a whitepaper for Peer-to-Peer (P2P) electronic cash system as a universal cryptocurrency, called Bitcoin, in 2008 which implemented Distributed Ledger Technology (DLT) with blockchain. DLT aims to save data as a value in decentralized network without using the centralized database [2], [3]. After over ten years, cryptocurrency gradually becomes an important payment system in the world. Nowadays, it is impressive that people are able to purchase a car, building and etc. with cryptocurrency. Bitcoin works with a Proof-of-Work (PoW) mechanism of mining backbone. PoW is a mechanism for solving mathematical puzzles and keeping safe Bitcoin network with an expensive computer calculation called mining [4].

This paper proposed a macro standardization of energy consumption per transaction for decentralized cryptocurrency in section II. IOTA is one of the cryptocurrencies which explain in section III-part A. Also, we report on our preliminary results about modeling the energy consumption of current IOTA [5] network and measuring the energy consumption of IOTA rate control mechanism in section III.

II. PROPOSED MACRO STANDARDIZATION OF ENERGY CONSUMPTION PER TRANSACTION (ECPT) FOR CRYPTOCURRENCY

Reviewing the Centralized Universal Payment Systems (CUPS) is helpful in standardization the energy consumption of a decentralized cryptocurrency. VISA and MasterCard are the world's two top CUPS [6] which we considered for our proposed standardization.

According to MasterCard sustainability report in 2017, MasterCard data centers, which process MasterCard transactions, consumed approximately 45 million kilowatt-hours of energy. MasterCard switched 65.3 billion transactions, processing each transaction with approximately 0.0007 kWh of energy [7]. In addition, according to VISA corporate responsibility and sustainability report in 2017, the company consumed a total amount of 680,560 Giga-Joules of energy globally for all its operations [8]. We also know VISA processed 111.2 billion transactions in 2017 [9]. Considering these numbers, VISA ECPT is 0.0017 kilowatt-hours (kWh).

It should be noted that MasterCard only reports its data centers energy consumption but VISA reports all parts of the company. VISA data centers continued to represent 54 percent of total consumption of electricity [8]. However, we are able to say that VISA data centers consume 0.00092 kWh for each transaction. Table I shown ECPT of CUPS;

TABLE I. VISA AND MASTERCARD ECPT

CUPS	Energy Consumption per Transaction (ECPT, kWh)
VISA	~0.00092
MasterCard	~0.00070

These estimates of VISA and MasterCard energy consumption include only theirs switching and data centers; the merchants, banks and any others involved in processing transactions consume additional energy that is not included.

This paper proposes initial macro standardization for decentralized cryptocurrency ECPT in Table II. It should be noted that the table data is dynamic and depends on future reports on CUPS.

TABLE II. PROPOSED INITIAL STANDARD FOR DECENTRALIZED CRYPTOCURRENCY ECPT

Grade of Green [a]	Energy Consumption per Transaction – ECPT
Exceptional	***ECPT < min {CUPS[b] ECPT}*** ECPT < min {Visa ECPT, MasterCard ECPT} ECPT < min {0.00092, 0.00070} ECPT < 0.0007 kWh
Excellent	***ECPT ≤ avg {CUPS ECPT}*** ECPT ≤ avg {0.00092, 0.00070} ECPT ≤ 0.00081 kWh
Very Good	***ECPT ≤ avg {CUPS ECPT} * 10*** ECPT ≤ 0.0081 kWh
Good	***ECPT ≤ avg {CUPS ECPT} * 100 (10^2)*** ECPT ≤ 0.081 kWh
Moderate	***ECPT ≤ avg {CUPS ECPT} * 1000 (10^3)*** ECPT ≤ 0.81 kWh
Poor	***ECPT ≤ avg {CUPS ECPT} * 10000 (10^4)*** ECPT ≤ 8.1 kWh
Fail	***ECPT > Poor*** ECPT > 8.1 kWh

a. Choose the best option near to ECPT

b. Centralized Universal Payment Systems

The cryptocurrency grade of green means where they stand in terms of energy consumption. While this paper only looks at this factor; therefore, many cryptocurrencies may be rated as undesirable, which does not indicate their poor performance. Of course, there should be a trade-off among the important cryptocurrency characteristics, such as green efficiency for dependability.

[10] show Bitcoin online energy consumption and calculate Bitcoin ECPT to 651 kWh. According to Table II, Bitcoin "Grade of Green" are *"Fail"*.

III. IOTA ENERGY CONSUMPTION MODELING AND MEASUREMENT

A. IOTA and Tangle

IOTA [5] is a feeless cryptocurrency for the Internet-of-Things (IoT) industry with no block, no chain, and no mining. IOTA's DLT type is based on Directed Acyclic Graph (DAG) which is called the Tangle [11]. [12] authors especially compared blockchain with DAG. The main application of Tangle is IOTA cryptocurrency system [13]. Tangle, with no fee in the transaction, high throughput and scalability, is one of the best choices for IoT projects that usually generate the high volume of data and massive velocity in communication [14].

The Tangle needs an explicit rate control mechanism to ensure that network does not exceed its maximum capacity [15]. Now, this rate control mechanism does its task with PoW for each transaction. The PoW functions are able to run in a node or local mode in the user device or transaction origin. This mechanism is likely to change after the Coordicide project being launched [16] but this paper considered current solution for rate control in the IOTA which is PoW.

IOTA has three important issues for energy consumption, including (1) User device in local PoW mode, (2) Node servers that run core software, and (3) the coordinator that issues periodic "milestones" which reference valid transactions to protect IOTA network against especial attacks [11]. IOTA Foundation tries to remove the coordinator in future [16]. If PoW runs in local mode, then IOTA energy consumption will be equal to the sum of all the above segments; otherwise, sum of (2) and (3) is equal to IOTA energy consumption.

$$E_T = \sum_{k=1}^{n} E_{TxOrginPow} + \sum_{k=1}^{m} E_{Node} + \sum_{k=1}^{w} E_{CoorNode} + E_{TipConf} \quad (1)$$

$$E_T = \sum_{k=1}^{m} E_{Node} + \sum_{k=1}^{w} E_{CoorNode} + E_{TipConf} \quad (2)$$

Equation (1) is the total energy consumption of IOTA for a specific time period (e.g. a year) when PoW runs in the local mode (in the origin device) and (2) is the total energy consumption when PoW is outsourced running and runs in the nodes. New transactions in Tangle, called "tips", to change tips status to unconfirmed situation should at least selected by two new tips. ETipConf in (1) and (2) is energy usage for the last tip which is significantly small to be able to ignore. Equation (1) is able to be used in the IOTA current network, because the PoW has been divided between the origin devices and the nodes, n in (1) is the number of the transactions PoW which are executed in the origin devices.

B. Measurement; IOTA PoW's Energy Consumption

In this preliminary paper, we just measure the IOTA's PoW in local mode. We also don't consider the other segments until the Coordicide project deployment. In this experiment, we used five types of the mid-range smartphone with different processors and Android versions which are shown in Table III;

TABLE III. TYPES OF THE SMARTPHONES USED IN EXPERIMENT

Device	Processor Model	RAM	Android Version
Huawei P30 Lite [a]	Hisilicon Kirin 710 (12 nm)	4G	v9.0 (Pie)
Samsung Galaxy A70 [a]	Snapdragon 675 (11 nm)	6G	v9.0 (Pie)
Huawei Nova 3e	Hisilicon Kirin 659 (16 nm)	4G	v9.0 (Pie)
Samsung Galaxy S7	Exynos 8890 Octa (14 nm)	4G	v8.0 (Oreo)
Huawei Nova	Snapdragon 625 (14 nm)	3G	v7.0 (Nougat)

a. Released in 2019

[17] measured IOTA's PoW energy consumption for the first time and ECPT result was 0.00011 kWh. Now, we improve experiment with more new devices and more count of transactions with the newer version of the Trinity Wallet [18]. We use the Trinity Wallet android application version 1.1.0 for our experiment and set the local mode for PoW (outsource proof of work was off).

The energy consumption of App usage was analyzed in two ways, (1) Batterystats, this is a tool included in the Android framework that collects battery data on device. Android Debug Bridge (ADB) can be used to dump the collected battery data to develop machine and create a report using Battery Historian tool [19]. (2) Android internal power consumption tool for each App which is included in Android version 6 and above. Fig. 1 shows Huawei P30 Lite report in Battery Historian after the sent iota has been token consecutively.

Iota token was sent for 20 times with each device and for 100 times in total. This measurement includes Sync Account, Preparing Inputs / Outputs, Validate Receive Address, Get Transaction to Approve, Complete Proof of Work, Final Validating, and Broadcasting which are steps of sending iota token in Trinity. The average result of this experiment is shown in Table IV.

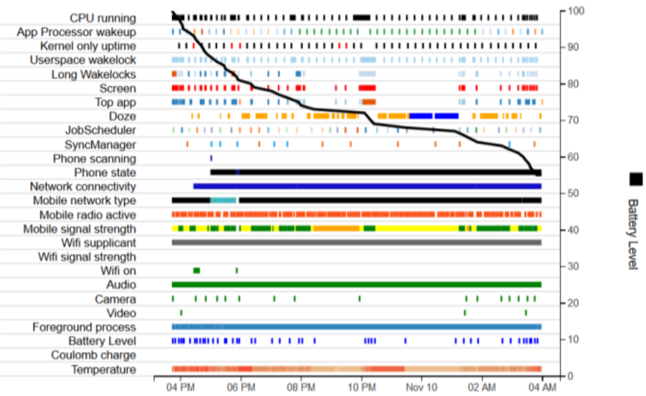

Fig. 1. Huawei P30 Lite report in Battery Historian V2

According to Table IV, IOTA current rate control mechanism (PoW) consumes approximately 0.00016 kWh for each transaction. The result shows a 45% increase in energy consumption compared to [17] the experiment. There are two smart phones in Table IV that released in 2019. They have the highest ECPT in the experiment and this is one of the main reasons for the increase. Therefore, according to Table III, so far the energy consumption of the IOTA PoW is in the *"Exceptional"* grade of green.

TABLE IV. RESULT OF THE EXPERIMENT OF TRINITY WALLET POWER CONSUMPTION

Device	**Average Consume per Transaction**		
	Ampere (mAh)	**Voltage (mV)**	**Energy (Wh)**
Huawei P30 Lite	65.95	4036	0.266
Samsung Galaxy A70	41.53	4023	0.167
Huawei Nova 3e	28.26	4108	0.116
Samsung Galaxy S7	36.71	3965	0.145
Huawei Nova	31.68	4031	0.127
Total	**40.82**	**4032**	**0.164**

The results of Table IV do not include the IOTA Nodes and IOTA Coordinator energy consumption. However, we look at the amount of energy that consumes in VISA and MasterCard data centers and don't consider the whole organization. In addition, according to [16] the IOTA consensus mechanism will be changing in the near future and it is unclear how many transactions per second are able to handle with IOTA network.

IV. CONCLUSION AND FUTURE RESEARCH

This paper proposed Initial macro standardization for cryptocurrencies energy consumption per transaction. This standard divides the ECPT to seven grades of green, from *"Exceptional"* to *"Fail"*. Many cryptocurrencies may be graded as undesirable in green efficiency, which does not indicate their poor performance and there should be a trade-off among the cryptocurrency characteristics. Moreover, this paper modeled IOTA energy consumption and measured IOTA current rate control mechanism (PoW) energy consumption in smartphones, Fig 2 shown the result.

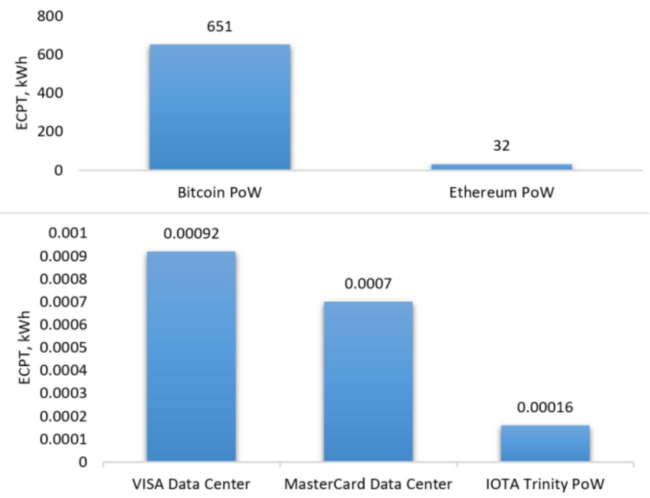

Fig. 2. ECPT comparison

In future work, we will propose a green quality model and suggest several ways to have green cryptocurrencies. In addition, measuring the energy consumption of all parts of the IOTA network and evaluating the energy consumption of other cryptocurrencies and their protocols are among our future goals.

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