The weight of data: an analysis based on the impact on the environment

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ABSTRACT

The carbon footprint generated by the information and communications technology (ICT) sector is increasingly significant, emitting greenhouse gases due to high energy consumption, regardless of the way in which energy is generated, the expansion and growth in data centers, as well as the impact generated by the cryptocurrency sector that in the end represents is reflected in greater consumerism, processing, storage, and transport of information that will be somewhere in the world. Current research addresses the problems and the contrast of figures in energy consumption due to the use of a computer, data processing, the role of the user as an internet consumer, the impact of data centers both in carbon footprint, water footprint and soil footprint, the impact of cryptocurrency mining and its contribution to global energy expenditure as well as the ethical debate of new technologies. And finally, the advances in seeking to optimize energy resources, sustainable and conscious for both consumers and service providers, show the trends focused on energy optimization through software and hardware based on a judicious review of research documents.

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1. INTRODUCTION

The concern for the effects generated by human beings on the environment has been an issue that has been put on the discussion table for decades, because it is directly linkedto 4 dimensions, social, human, political, and ethical [1]. Being Alexander Von Humboldt one of the fathers of ecology who is his book "Kosmos" analyzes his discoveries from various aspects of the environment and when making a short review in databases using keywords such as pollution, environment, care and even industrial revolution, searches only take us to the late nineteenth century [2]. Although it is difficult to believe that variables such as the contamination of soils and water sources by settlement of communities, mining exploitation in its different scales and even the emergence of the industrial revolution, has not been reviewed by the scientific community highlighting its impact on the environment, it gives us a sign that the environment in the past was a relatively local concern. It has been only 50 years since the United Nations created the United Nations Environment Program (UNEP), an agency responsible for providing guidance and training on environmental issues and its preservation worldwide, therefore, in [3] past decades, who was in charge?

Philosophically science in our times has such a close link with technological development, which leads us to formulate an important aspect, is it possible to evaluate and mitigate the impact of the advance of science and technology, in favor of the environment? The use of data has become a fundamental element for digital transformation; just as oil was the engine of the twentieth century, data is the engine of the twenty-first century, a situation that has accelerated exponentially due to the situation associated with the COVID-19 pandemic [3]. The digital revolution considered an advance, is linked to the impact on the environment, since currently the emissions of polluting gases, the effects of climate change, pollution of water sources, and other natural environments are losing their ability to maintain ecological functions [4].

Recent research shows that if the rate of power consumption grows, it will even exceed hardware expenditures on data center infrastructure [5]. This will also lead to more CO_2 emissions, which have a direct impact on our environment. Here, sustainability and energy efficiency come into the picture. Sustainability seeks that computers and related resources optimize their energy consumption, servers, data centers, other infrastructure and cooling systems [3]. This study seeks to sensitize the reader that the data generated by both governments, industries and the user as a consumer, generates a significant impact on the environment; it is everyone's responsibility to evaluate our place on the internet if we remain part of the problem or part of the solution. This document is organized as follows: section 2 presents a review of the method implemented, in the subsections of this same numeral the contribution of the electrical system, the role of the user as a consumer, the impact of data centers, as well as the impact of cryptocurrencies, in the section 3 of results and discussions, raises the changes that generate motivation as solutions to pollution, finally in the section 4 conclusions, talk about how the study generates awareness about the use of information and communications technology (ICT), as well as the optimization techniques currently developed, friendly to the environment.

2. METHOD

The research applies a descriptive exploratory methodology taking as main source scientific references from Elsevier, WoS, and Scopus between 2018 and 2022 mostly. Among the main references that motivate this study is a systematic survey on energy-efficient techniques in sustainable cloud computing [3] abroad review of problems in energy consumption, carbon footprint generated by data centers and the role of the end user in the weight of the information we consume. According to studies cited by Sovacool *et al.* [6] the data growth rate between the years 2017 to 2022 was 26% being factors such as the automatic playback of videos on social networks such as Facebook®, Instagram® among others, cause an increase in traffic by just touching one of many factors. According to 2020 reports reveal information and communications technologies could account for more than 14% of global greenhouse gas emissions by 2024, which would be equivalent to more than half of the current carbon footprint of the global transport sector [7]. Touching on variables such as cellular communication, the European average of smartphone use is 6 to 12 minutes every hour as pointed out [6]. To this is added the incessant implementation of fifth generation (5G) which offers higher download speed, greater efficiency and more devices connected to the internet, allowing the user to visualize greater interaction and response times in entertainment systems, increase in transmission services, with exponential expectations in data volumes and processing [4].

2.1. The contribution of the electricity system

A big problem adding is the energy consumption, for this reason in recent studies indicate the downtime of a corporate computer is approximately 70%, taking into accountthat the average computer in the off state, consumes 1.5 W, 2.5 W in sleep, and 60 W while it is on. Another paradigm confirms that going to sleep, shutdown and idle often requires more power and performance [3]. According to Pothitou *et al.* [8], techniques such as on-screen power management allow to reduce power consumption when not staring at the screen, being a not very decisive incentive, but a contributory measure that leads to energy savings of a computer, if we take it to corporate environments of hundreds and hundreds of computers.

2.2. The role of the end user as a consumer

In his writings [7] he points out thecontinuous growth in data traffic, justified by the proportion of the world's population with internet access increasing at a rate of 18.8% in 2010 compared to 58.8% in 2019; another problem raised is the way in which digitalization leads to a dematerialization of the user and such dematerialization results in a lack of awareness; a good example can be related to physical garbage, this is visible by the pollution it generates, its bad appearance, smell, attraction of rodents and diseases, which generates a tangible impact, unlike virtual environments that do not generate an impact to be intangible, for this reason this can promote or hinder self-attribution of responsibility of the user to adopt more ecological behaviors in front of the use of the Internet, this can be evidenced according to statements of [3]. 30 minutes of watching Netflix® equals (1.6 Kg of CO_2) is the same emissions of driving almost 4 miles in a vehicle. For this reason, if the intrinsic motivations related to enjoyment or leisure and the extrinsic motivations related to data and cost savings are considered [7], as users, do we make efforts in favor of the environment?

Is it possible for the user to prefer his personal comfort or make a personal sacrifice in the face of preserving the environment? Can consumers lack knowledge about the environmental impact of their use of the internet be justified?

The behavior of the user as a consumer is a factor that must be analyzed, for this reason [7] evidence in his studies to the user, reluctant to accept his responsibility, waiting for governmental or business solutions that allow a care of the environment or worse still if the user considers that the solutions are restrictive, tends to become skeptical about efficiency and reject the initiatives that network administrators, data centers, and largetechnology corporations tend to care for the environment, the reduction of the carbon, water or soil footprint among others. The next part in common is the data they generate; it is known that data must be used and treated to have value, this leads to energy consumption and storage; [9] frames data in critical, redundant and obscure, the latter known as (unnecessary, unstructured or inert). For this reason, the more a user stores data, the better it is for certain service providers, according to research from Hewlett Packard enterprise, only about 6% of all data generated by a user is used, which translates into 94% of a large repository cyber that would cause carbon footprint in unused data [3].

2.3. Impact of data centers

Data centers are the brain and heart of the internet because they are the ones who process store and transmit data, without them it is very difficult to have availability of all the information that is used by users in the network [3]. These data centers have a factor inside that is the processing capacity, studies reveal that the central processing unit (CPU) is the one that consumes more energy and emits more heat [10]. In turn, they indicate cooling and ventilation systems consume on average about 40% of the total energy used [11].

It is essential to analyze both the direct and indirect impacts that a data center can generate, which is why [4] it has analyzed the sustainability impacts in data centers in local communities taking variables such as equipment manufacturing, cable laying, construction of buildings, and even the applications given after its commissioning in the cryptocurrency sector, piracy, espionage, until its dismantling and finally with the waste generated from it. In turn, displacement of local populations by land or high energy consumption and impacts on jobs with local human resources during their opening and subsequent closure, bearing in mind that data centers can have an average life of between 9 to 10 years [3]. A variable that must be added to is the heat generated by data centers, this heat must be dissipated or extracted, one of the ways are the cooling systems, devices that are added to energy consumption, being according to studies those who have most of the electricity consumed by the system [12].

At present there is a battle between the growth of demand and improvements in service efficiency, to this we must add the geopolitical problems that this implies, but why this statement? The carbon footprint depends directly on the energy source applied in the data centers; one solution to this cooling problem is to locate the data centers in low-temperature areas to make use of the climate that reduces cooling costs [3]. Geopolitical problems such as Greenland's autonomy, and the search for places of low temperatures that allow the global concentration of infrastructure in countries other than the US. In the future, the US or China will allow intrinsic effects such as efficient and resilient data networks, better internet speeds, data centers with greater capacity and improved connectivity that unfortunately contrast with higher rates of virtual asset laundering, cryptocurrency mining, proliferation of ransomware and the "dark web", susceptibility to digital terrorism or piracy among others [4].

2.4. The impact of cryptocurrency mining on the environment

Cryptocurrencies are by far a contributor in internet traffic, studies show a growth of the Bitcoin of 200% as of November 2021, with an estimated consumption of 4.58 Tera Watts hour (TWh), considering that the 1% increase in the volume of world trade, increases the carbon and energy footprint by 24% in the long term [13]. Other studies analyze the energy consumption and carbon footprints in cryptocurrencies such as Bitcoin from between 29.96 TWh to 135.12 TWh, equivalent to the energy consumption of Sweden and Thailand. These indices are not outdated if the cryptocurrency market is considered as a 24/7 business of operation, reaching Bitcoin the 50th position in carbon footprint emissions globally [14].

Otherwise, the electronic transactions per day of the main exponents of the cryptocurrencies Bitcoin and Ethereum, are around 1.25 million and 0.4 million transactions per day respectively, against its adversary Visa® that is around 500 million transactions per day. This at first glance is incomparable, but it is paradoxical when we cross the energy consumption in TWh of Bitcoin with 135.12 TWh, 55.01 TWh of Ethereum, and Visa® with 197.57 TWh, which leads us to reason the excessive consumption generated by cryptocurrencies in the world as indicated [14]. To this is added several related studies in [14] pointing out a percentage of participation among the BitCoin mining countries in the world, to China with (46%), USA (16.8%), Kazakhstan (8.2%), Russia (6.8%), Iran (4.6%), Malaysia (3.4%), Canada (3%), Germany (2.8%), and Ireland (2.3%) [15].

2.5. New technologies of ethical debate

The increasing use of new technologies reflects greater user satisfaction with better informed decision-making. Technologies such as big data, cloud, and ICT have generated a better future for all. However, no one can ignore the growing negative impact on environmental safety generated by its high consumption of non-renewable energy, waste production and CO_2 emission [1]. Due to the rapid growth of cloud computing and the growing use of the internet, IT industries have the fastest growing carbon footprint which already accounts for 2 to 3% of global electricity and contributes around 2% of the current carbon footprint [16].

Big data, cloud and other IT technologies promise to counteract the consumption of natural resources such as energy and water with greater efficiency [17]. This may be true, for example, of efficiency in decision-making in industrial processes and automation, but historically as technology advances, pollution and energy demand increase. The more the digital divide is reduced in developing countries, the more people will be connected to the network and consume digital services, data traffic will increase and, with it, the carbon footprint and environmental pollution [7].

3. RESULTS AND DISCUSSION

This study shows several evidence on the impact of information technologies on the environment and is especially interested in showing why this is being discussed publicly, and those who know about the subject focus on the carbon footprint impact of data centers [18], the role of the consumer and the management of data, network consumption, and cryptocurrencies, because direct and indirect variables converge there [19]. Sustainable development brings with it tools of help, proof of this in [20] a useful algorithm is proposed to track the flow of carbon emissions generated by data centers, which is necessary, since every day the damages to the environment materialize; studies carried out by [14] evidencen the consequence generated by the carbon footprint triggered by a trend in increasing global temperature, incessant droughts, propensity to natural disasters, shorter winters, longer summers, shorter springs and autumns.

3.1. Changes that generate motivation

It would be disrespectful to draw an absolutely murky and discouraging picture, fortunately as it points out [7], Facebook®, Google®, and Apple® have adopted a 100% renewable commitment in many of their data center, processing, and storage processes, in turn [3] points out according to information from Amazon web service (AWS) as of 2019 it started changes in its global infrastructure focused on creating 100% renewable energy through the use of efficient energy. Another approach is the diverse possibilities that arise [21] in the way in which the generation of electrical energy that is supplied to data centers can be efficiently improved, with on-site generation and off-site generation (generation located at a prolonged distance from the data center) being the 2 options available; among these possibilities are wind turbines, photovoltaic sources, hydroelectric energy and biomass generation (the latter is the use of organic matter from animals or plants in order to generate heat or electricity). This supported by innovative energy storage techniques such as Lithium or Hydrogen (the latter very efficient and friendly to the environment) [22].

For this reason, internet data centers are considered the best alternative for the use of renewable energy, maintaining computer services of low latency and high reliability [20]. Therefore, another alternative that contributes in terms of cloud computing and data centers is virtualization, considered the most promising approach to save energy [10]. Thus, allowing to considerably reducing the implementation of physical infrastructure [3].

The location of data centers is another mitigating factor, which is why many data centers are migrating to Nordic places, in order to take advantage of the cold, in order to keep the system, cool during the day and night [6]. When [3] outdoor air temperature and humidity meet cooling criteria, fans can replace air conditioners, as studies show in data centers based on direct air-cooled containers, a 20.8% decrease from an air-cooled data center. Sajid *et al*. in [23] propose a model of management and distribution of workloads based on Blockchain, which seeks to minimize the transfer times of any work from a data center to another located in a geographically distant place, ensuring the process of optimizing energy costs regardless of whether the data center is powered by solar energy, wind, battery bank or even diesel plants, in order to reduce energy consumption. Consequently, Zhao *et al*. [5] it proposes an optimal method of programming in energy regulation that can reduce operating costs between 19.62% and 66.96%, regulating energy and managing energy consumption in the data center during different periods of demand, this complements the studies carried out by [24] with the development of a cellular non-volatile static random access memory (NVSRAM) that provides faster on/off speed with reduction in its static and dynamic power between 15% to

28%. Another successful contribution, according to studies conducted by [25] reduc IR approximately 11% in the average energy cycle life cycle of a cellular equipment, in order to increase the life of the device.

Correctly and according to projections of [26] a cost reduction in the primary energy involved in the manufacture of semiconductors for the internet of things (IoT) is expected in the near future, this due to the decrease in the size of the chips in the nanometric and micrometric scale, pin density, lower packaging and more complex but efficient manufacturing processes such as the introduction of extreme ultraviolet lithographic technology [27]. This solution is accompanied by making the function and effectiveness of the networks more efficient, for this reason [28] it proposes the design of a graph-based learning model for the detection of anomalies in IoT networks, which shows a reduction in energy consumption from 35,000 mJ to 18,000 millijoules (mJ). Processors are another contributing factor to consumption, reported by [29] achieving power savings of up to 16% compared to existing power management techniques and $2.4 \times acceleration$ with 25% additional power to meet high performance compared to power management for a microprocessor with up to 32 cores.

Parallel it is important to add that not only the carbon footprint is part of the measurements that affect the environment in the field of ICT [30], as evidenced [16], the water footprint and the soil footprint, is essential in the impact, for this same reason this same author indicates for 2015 the global average water footprint for the use of the internet was 2.6 billion liters of water or the equivalent of filling 1 million olympic swimming pools; on the other hand, the average land footprint for internet use in 2015 was 3400 square kilometers of land, equivalent to joining Mexico City, Rio de Janeiro, and New York. It is important to highlight that not only suppliers, service providers, network infrastructure administrators are responsible, users through their dynamics of network use, are the ones who need to be aware of the costs of their actions in the network and the advantage that brings to make small changes in behavior and habits, as it raises [16] with substantial alternatives that allow mitigating the footprint of carbon, water and soil, among which we find, turn off the video during a virtual meeting, reduce the quality of HD transmission services to standard, reduce the time in the use of video games, limit time on social networks, eliminate unnecessary emails and unnecessary content from cloud storage services, eliminate automatic video streams, either by reducing their quality or by looking for an audio-only service among many others [31]. Finally, the regulatory and standardizing bodies contribute with standards that allow to guide with good practices for mechanical, electrical and computer systems in data centers through the documents of the International Telecommunications Union (ITU) with the recommendations L1300, L1400, L1410, and L1420 as well as documents generated from the International Organization for Standardization (ISO) with standards 30131, 30132, 30133, 30134 [32].

4. CONCLUSION

A study is presented that aims to open a scientific discussion on the impact of the weight of data on the global environment. At the same time, raise awareness of the appropriate use of ICT by users in their role as consumers. Since the nature of many changes in carbon footprint reduction contrasts with improved quality of service features, the risk of losing customers by service providers is latent. Software-based optimization techniques such as optimization algorithms, among others, do not require large infrastructure,being friendlier to the footprint generated in the environment. In contrast to hardware-based optimization that leads to reducing environmentalfootprints, in the end the impact cannot be considerable, since new costs and production and operation processes are born. The studies presented, for the most part, do not involve networks in high demand states or peak states, being an essential factor in the study of mitigation.

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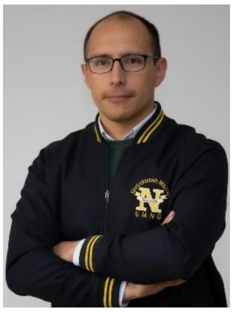

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