# THE COMPUTATIONAL TOOLS INTERNET OF THINGS, BIG DATA, DATA MINING AND THE ENERGY EFFICIENCY

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*Article history:* Received 18 October 2018; Received in revised form 21 December 2018; Accepted 29 January 2019; Available online 30 March 2019.

## ABSTRACT

Computer science is a tool that has allowed great advances for the development of humanity in recent decades, leading to well-being, productivity and various types of gains. In turn, with the increasing consumption of electric energy, energy efficiency has been used by more areas and sectors of society. This work aims to investigate the literatures and terminologies of Internet of Things, Big Data, Data Mining and the relationship with energy efficiency through publications and application examples these terms. A literature review was carried out based on the search for works in the area of computing and computing and its relation with energy efficiency. Considering that these themes are contemporary to the new millennium, even though the themes are recent and although several items still need to be deepened, there is a great development involving energy efficiency and the terms internet of things, great data and data mining.

**Keywords:** IoT, energy conservation.

# FERRAMENTAS COMPUTACIONAIS INTERNET OF THINGS (INTERNET DAS COISAS), BIG DATA (GRANDES DADOS), DATA MINING (MINERAÇÃO DE DADOS) E A EFICIÊNCIA ENERGÉTICA

## RESUMO

A informática é uma ferramenta que possibilitou avanços grandes para o desenvolvimento da humanidade nas últimas décadas, levando bem-estar, produtividade e diversos tipos de ganhos. Por sua vez, com o crescente consumo de energia elétrica, a eficiência energética tem sido utilizada por mais áreas e setores da sociedade. Este trabalho tem como objetivo investigar as literaturas e as terminologias de Internet of Things (Internet das Coisas), Big Data (Grandes Dados), Data Mining (Mineração de Dados) e a relação com a eficiência energética, através de publicações e exemplos de aplicação desses termos. Foi realizada uma revisão bibliográfica baseada na busca por trabalhos da área da computação e informática e sua relação com a eficiência energética. Considerando que são temas contemporâneos ao novo

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milênio, mesmo pelo fato das temáticas serem recentes e apesar de vários itens ainda precisarem ser aprofundados, constata-se o grande desenvolvimento envolvendo eficiência energética e os termos internet das coisas, grandes dados e a mineração de dados.

**Palavras-chave:** IoT, conservação de energia.

## INTRODUCTION

Informatics is an important tool that has allowed unimaginable advances for the development of humanity, leading to well-being, comfort, better productivity, allowing financial increases, among other aspects of modern society.

In this advance, it is important to emphasize that from the years of 2010, computing has taken other directions and new concepts begin to be part of people's vocabulary and everyday life.

Internet of Things and Big Data are examples of connectivity and mobile access by smartphones and handheld computers have amplified the use of information technology worldwide.

With the population increase, the concern with the environment and the good use of energy begins, with the awareness that the matrices are finite and their sources can be exhausted if they have not been put to good use.

At meetings organized by the United Nations - UN, several countries have debated the problem of generation and rampant consumption of energy for humanity.

Energy efficiency in the current days has been promoted in several sectors. The advent of technology and computer science could not be excluded because the use of computers and electronic devices use energy sources in their production and use.

This work aims to investigate the literature and terminology of Internet of Things, Big Data and Data Mining and the relation with energy efficiency, through publications and examples of application of these terms.

## MATERIAL AND METHODS

A literature review was carried out based on the search for works in the area of computing and computing and its relation with the context of energy efficiency.

We used search engines from Google Scholar and Capes' Portal of Journals. Much of it is from scientific articles and area books. There has also been a survey of websites and institutions specializing in computing and computing.

Together, we tried to obtain information and concepts to explain the themes as Internet of Things, Big Data and Data Mining.

Finally, during the searches performed with these terms, we explored existing tools and explained each of the concepts, which were presented as results.

## RESULTS AND DISCUSSION

### Internet of things

The phenomenon of electronics is part of people's lives, and could not be different from the system of shipments. The embedded electronics are installed in vehicles of any configuration, as well as medical, industrial and agricultural equipment. Applications expand into home appliances and any computing and electronic devices in communication accessories. From leisure to the professional environment, the embedded electronics are present (CUGNASCA, 2017).

Not only in the urban environment sensor technology is inserted for decision-making. The rural zone already has mechanisms connected to the Internet, in several applications such as the scheduled launch and remote access of seeds and fertilizers; records can be uploaded to a cloud computing database with breeding and herd information; the irrigation system can detect some failure and still be corrected in time without prejudice to the crop, are some beneficial examples of agribusiness and the use of communication and computer access (EVANS, 2011).

It is already a consensus that the Internet of Things - IoT is the information revolution, allowing collecting, filter data and make decisions from information processed with autonomy of modern computational systems (EVANS, 2011).

With the IoT it is possible the relationship between the computers and the environment with autonomy, through the process of connection and communication without cabling, only the objects are carriers of computational devices with this viability (SANTAELLA *et al*., 2013).

With all this technology, communication components and most sensors are battery-dependent, and much of it requires recharging to communicate with their properties without compromising the processing power of activities (AQUINO, 2015).

The Internet of Things has expanded opportunities and reduced barriers even in developing countries. However, in each nation, it will be able to explore uses according to their demands and needs in a hasty manner (BNDES, 2017).

In this context, the BNDES Benchmark Report (2017) listed the countries of Asia as Japan, China, South Korea and Singapore and the European Union in particular and with the greatest advance in the IoT ecosystem, in contrast to Russia, Sweden and the India. Whereas the North Americans and the British are having government performances and with the expressive participation of leading industries and universities in the IoT area.

The first technology associated with the IoT concept was known as Radio Frequency Identification. This technology emerged in 1940, with transconders already used in airplanes in World War II (Oliveira, 2017).

**IoT and energy efficiency**

An example of Internet of Things applied in the context of energy efficiency is the case of smart grids or smart energy networks. Intelligent energy networks allow consumers to become producers, when they have photovoltaic panels and connected meters, making distributed system generators, the mechanism shows the availability and consumption of energy in a dynamic, fast and intelligent way. Advanced Metering Infrastructure notifies the quality of the network, undesirable occurrences such as fraud and other abnormal situations, as well as enabling the instantaneous activation and closing of the power supply (BNDES, 2018).

An Intelligent Network seeks to meet the demand of end users through digital technologies, which allow continuous monitoring and control over the transportation of electricity from generation sources; In this way, IRs allow the system to be efficiently controlled by stakeholders in the electricity sector.

The BNDES (2018) refers to the data set based on Scopus:

> "A systematic review of the literature was carried out, accompanied by a quantitative-qualitative analysis. Information was measured in the period between 2001 and 2016, in addition to the analysis of the fifty publications with the highest citations. Results: It was verified the existence of 895 documents related to the subjects researched. However, few (seven papers have been identified) discuss the effective application of the

> Internet of Things to energy efficiency."

Another case of application of IoT in energy efficiency is tele-management in city lighting. This technology controls the public lighting networks if the lamps are correctly lit by the remote process, eliminating the presence of sentinels, favoring the reduction of financial and energy costs, optimized by dynamic dimerization actions (BNDES, 2018).

Much has been done to reduce energy consumption and improve the functioning of Internet of Things devices, making IoT projects viable. In an IoT project it is important to measure the cost of electricity (Oliveira, 2017).

**Big Data**

Big Data is based on the concept created by Doug Laney in the middle of 2000 using explaining e-commerce in 2001 and 2002 in the context of the three dimensions being: volumes, speeds and variety. Thus, IT organizations must convert the various approaches to be available for the treatment of each of them (Laney, 2001).

An example of Big Data is Eterni-me. The program works as if it absorbed the steps in the interaction of the internaut. As the interaction increases, the digital environment will have more knowledge and more identification will remain with the user. Over 30,286 registered users Eterni-me. (Career, 2016).

The same author (2016) comments that in addition to Eter9, there is an avatar capable of collecting data, filtering, analyzing and transferring called Eterni-me developed by the Massachusetts Institute of Technology (MIT).

According to Oliveira *et al*. (2014) in the field of modern science, the generation of high-density data effectively, has raised discussions involving society and academia, for the best use in scientific results.

Nowadays, several organizations that develop research worldwide generate high amounts of sources of information, which are later captured and accessible to other scientific institutions (RODRIGUES & ALMEIDA, 2015).

The authors conclude that in spite of the accumulation of data links speed, shortening the data exchange period is crucial due to the tendency to increase the size of data from more technical applications.

According to Granato (2013), Big Data is a concept, in which the focus is the great storage of data coming from all means, allied to the greater speed of growth of this information.

In the mid-1990s, Jim Gray acknowledged that the next challenges of "Big Data" database technology would come from science rather than commerce. Jim also identified the technical challenges that such intensive scientific data would place on scientists and the key role that computer science could play in enabling future scientific discoveries (Hey *et al*., 2009).

With advances in information technology, since the time of the internet, there has been a simultaneous increase and availability of replicated and generated data (Granato, 2013).

According to Castro (2015), Big Data is useful as a strategy in sectors such as:

- Mapping and understanding of consumers of a particular product;
- Understanding and improving the business chain;
- Professional qualification and improvement of people;
- Optimization in public health and sports performance;
- Adequate results in science;
- Improvement in machinery and equipment, in safety, urban infrastructure and precision agriculture;
- Advancement in the financial market;

For Intel (2013) Big Data Analysis is not:

"• Only technology. At the business level, it refers to exploring the vastly improved data sources to gain insights.

• Volume only. It also refers to variety and speed. But, perhaps more important, it refers to the value derived from the data.

• More generated or used only by large online companies like Google or Amazon. While Internet companies may have pioneered Big Data on the web scale, applications reach out to all industries.

• Use of relational databases to traditional single sizes created based on shared disk and memory architecture. Big Data Analysis uses a network of computing resources for massively parallel processing (PMP).

• A substitute for relational databases or data processing centers. Structured data remains critical to business. However, traditional systems may have the ability to manipulate the new sources and contexts of Big Data (Intel, 2013). "

With the high demand for large data arrays in non-semi-structured or non-structured formats, new NoSQL-based applications (Not Only SQL) have the meaning of "not just SQL." The terminology can also be useful for availability and scalability needs with reference to DBMSs that do not adopt the relational model and have greater flexibility when compared to ACID (Lócio *et al*., 2011).

According to Toth (2011), the ACID concept has the following properties: Atomicity in data security, Consistency, Isolation and Durability in exchange and data traffic.

The National Electric Energy Agency - ANEEL has an energy generation database. The data are collected from documents relevant to several normative resolutions published by ANEEL (Garcez, 2017).

According to the same author, much of this data is made available publicly, in the form of tables and graphs or even treated using appropriate statistical tools. The data obtained are used to have guidelines and energy policies for Brazil, known as the Generation Information Bank (BIG).

**MapReduce**

When analyzing the data that have high frequencies, certain algorithms were created as Big Data techniques, so the decision-making is accelerating so that the processing of large amounts of data is done in a timely manner (Araújo & Montini, 2016).

A new concept used for Big Data is MapReduce, created by Jeffrey Dean and Sanjay Ghemawat and other members of Google's research department.

Prior to the development of MapReduce, Google researchers deployed hundreds of special-purpose calculations to process large amounts of raw data, such as crawled documents, Web log requesters, etc. to calculate various types of derived data such as inverted indexes , multiple representations of the graphical structure of Web documents, summaries of the number of pages tracked per host, and the set of queries most frequent on a given day (Dean & Ghemawat, 2008).

The same authors conceptualize that MapReduce is an associated programmatic and implementation model for building and managing large data sets. Users specify a map function that processes a key / value pair to generate a set of key values / intermediate broker and a shrink function that merges all the associations of variables to the same intermediate key. Many real-world tasks are expressed in MapReduce.

For Andrade (2012) programs based on MapReduce have good acceptance in situations where there is fragmentation, partitions in problems that may be within other problems. Thus, the procedure can be performed by the Map and Reduce

functions separately or with several data together, and finally still large volumes of data can be parceled out to have execution in the various Map and simultaneously in parallel time.

**Big Data and Energy Efficiency**

The work of Rodrigues (2013) aimed to characterize the energy consumption in workstations that process data in high volumes. The author used Hadoop as an implementation of the open code programming model and MapReduce as a characterizer.

Some solutions using Hadoop can be applied to energy efficiency plans.

In the work of Silveira *et al*. (2015) in a literature review with the Big Data theme, the authors make reference to Inácio and Dantas that addresses energy efficiency as a medium for the evolution of high performance computing at the service of business. In this same period the authors do not find much diffusion in the Brazilian scientific literature, in relation to Big Data.

The use of data flow to increase energy efficiency and to advance the production of alternative energy sources are topics from the book Big Data for lay people of writers Judith Hurwitz, Alan Nugent, Ferne Halper and Marcia Kaufman of 2016.

**Data Mining**

The terminology used for Data Mining - MD makes an analogy to the ore and contrasts with the mines and the data, the tools and the application of algorithms, so that they have treatments coming from some database (equivalent to the deposit and then mining by the activities of its extraction, and stoning etc.). These data, which are initially only values collected for example by a humidity sensor, can be treated and provide some kind of result, or if there is some response, for someone seeks certain information (Castro & Ferrari, 2016).

According to Camilo & Silva (2009), Data Mining has become a support tool with a fundamental role in information management within organizations. Handling data and analyzing information in a hasty manner has become unfeasible due to the large volume of data that is collected daily and stored on a historical basis.

From the study and the mining of data, the discovery and validation happens, and then a new knowledge arises, collaborating to improve products, systems, process and business, etc. Data Mining is, therefore, the means by which the phenomenon of discovery is manifested (Silva *et al*., 2016).

According to Maimom & Kokach (2010) Data Mining is the nucleus of the technique known as Knowledge Discovery in Databases - KDD, involving the inference of algorithms with data exploration, developing the model with the purpose of discovering norms that were not previously known.

KDD is an analysis and modeling of massive data repositories. KDD is an important technique that identifies and organizes valid, new, useful and understandable patterns of large complex data sets. The model is used to understand phenomena from the data, analysis and projection from certain predictions (Maimom & Kokach, 2010).

KDD terminology was coined in the late 1980s in reference to the broad concept of searching for understanding from databases (Goldschmidt *et al*., 2015).

According to (Goldschmidt *et al*., 2015), a KDD application has three components:

• Problem of the application of the KDD process;

• Availability of resources capable of having satisfactory methodologies;

• Obtaining answers and applications for solutions.

When analyzing the data that have high frequencies, certain algorithms were created as Big Data techniques, so the decision-making is accelerating so that the processing of large amounts of data is done

in a timely manner (Araújo and Montini, 2016).

## CONCLUSIONS

Considering that these themes are contemporary to the new millennium, even though the themes are recent and although several items still need to be deepened, there is a great development involving energy efficiency and the terms Internet of Things, Big Data and its Data Mining.

With the significant increase in connectivity, as demonstrated in this paper and also with increasing energy consumption, these areas of study tend to become closer in the not-so-distant future.

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