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DIGITAL MANUFACTURING, INDUSTRY 4.0, CLOULD COMPUTING AND THING INTERNET: BRAZILIAN CONTEXTUALIZATION AND REALITY

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ABSTRACT

The digital era represents significant changes in the design of IT projects with an emphasis on digital infrastructure, especially in terms of investment and professional qualification, which requires, in Brazil, the creation of specific lines of financing by government development agencies. The creation of demonstration platforms could be an effective initiative to stimulate the dissemination of the concept and the establishment of partnerships between customers and suppliers of new technologies. On the other hand, and particularly for the consumer market, corporations can create new business models and modify their relationships with their consumers, users and even competitors. In fact, today, "Thing Internet" has come to significantly

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modify the paradigms of perception, production and distribution of the capitalist world. This article discusses, covering and understanding the main reasons for the existence of this gap between theory and practice regarding digital manufacturing and adjacencies, the perspectives of technological innovations in the digital era specifically in Brazil. Its content is the result of a bibliographical review carried out from April to June 2016.

Keywords: Digital manufacturing; Industry 4.0; Clould computing; Thing internet; Brazilian industry

1. INTRODUCTION

In the 21st century, companies are living a real dilemma: besides having to produce more and better for less, now they also have to be agile in responding to the market's wishes. Life and innovation cycles are becoming smaller, requiring them to rethink severals productive strategies, from product design through prototyping to virtual fabrication through the computational simulation of the operation on the factory floor (CHRYSSOLOURIS *et al.,* 2009).

Taking this into consideration, companies leave this problem, to become more agile, and try to innovate in its internal processes with emphasis on their diferente *workflow.* As a result, industrial corporations seek to introduce new products to the market faster, improve their competitive advantages, lower costs and increase profitability.

For this use of digital manufacturing concepts, which accordingto Port *et al.* (2002), is nothing more than the approach of the productive process from the creation, through the development, simulation and manufacture of the product within computational environments developed for this purpose.

As Wave (2002, apud PORTO *et al.,* 2002), large international companies already uses digital manufacturing, such as Boeing, Daimler Chrysler and John Deere. These are already at an advanced level of use. Many others are beginning this process, but they already notice improvements in the times of responses to the market.

Also according to Port *et al.* (2002), the expansion of the use of digital manufacturing is being possible for two reasons: first, that the improvements

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developed by *software* companies and *hardware* is being possible to reduce the acquisition costs for deployment in companies; and second that the same modeling and simulation *software* technologies are advancing at a rapid pace, including highly complex topological and functional.

According to the Industrial Survey (2016), the term industry 4.0 emerged as a new industrial model, some even call it the fourth industrial revolution. Industry 4.0 or, also called, advanced manufacturing, as it is also called, involves the integration of physical and digital technologies, from the creation of products, through prototyping, manufacturing and integration with other companies in a totally digital way.

Therefore, the main objectives of this article are:

- Conceptualize digital manufacturing, industry 4.0, *clould computing* and *internet thing;*
- Bring the benefits of deploying these tools;
- Show the difficulties and impediments to the deployment;
- And to present how Brazil is inserted in this new productive environment.

Figure 1 shows the main expected benefits of adopting digital technologies in Brazilian industries, according to research conducted in companies from different segments (INDSTRIAL SURFACE, 2016).

According to the Industrial Survey (2016), the biggest barrier to the adoption of integrated digital technologies is the cost of implementation, which represented 66% of companies' responses. This is a field in which Brazil still has much to evolve, but it is a natural evolution, and it will happen.

It should be remembered that some companies are, even so, more efficient at getting more outlets for their inputs than others because they focus on waste elimination and incremental advanced technologies, motivate their employees more realistically and have better management visions. But the others must not park in their present situations and conform, on the contrary. It is inevitable to pursue evolution through efficient technology and management (PORTER, 1996, apud CARLI; DELAMARO, 2007).

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ESTÁGIO/FOCO	BENEFÍCIO	INDÚSTRIA	POR PORTE DA EMPRESA		
			PEQUENAS	MÉDIAS	GRANDES
Eficiência	Reduzir custos operacionais	54	41	51	63
	Aumentar a produtividade	50	39	47	58
	Otimizar os processos de automação	35	21	29	46
	Aumentar a eficiência energética	18	10	18	22
Eficiência/ gestão	Maior visualização e controle dos processos de negócios (cadeia de valor, produção, etc.)	17	11	16	21
	Melhorar processo de tomada de decisão	24	16	23	28
Desenvolvimento/redução *time to market*	Reduzir tempo de lançamento de novos produtos	10	6	10	12
Produto	Melhorar a qualidade dos produtos ou serviços	38	36	38	39
	Desenvolver produtos ou serviços mais customizados	24	21	24	26
	Criar novos modelos de negócio	6	9	6	5
Meio ambiente	Melhorar a sustentabilidade	8	7	8	9
Trabalhador	Compensar a falta de trabalhador capacitado	7	10	9	5
	Aumentar a segurança do trabalhador	19	13	17	22
	Reduzir as reclamações trabalhistas	4	4	5	4
Não sabe/ não respondeu		28	39	30	21

Nota: A soma dos percentuais supera 100% devido a possibilidade de múltiplas respostas.

Figure 1: Benefits expected when adopting digital technologies.
Source: Industrial Survey (2016).

So Torquato and Silva (2000, apud CARLI; DELAMARO, 2007) says the technology then appears as crucial and central factor in the search for better competitive advantage. Companies that wish to evolve have no other choice but to advance in technological and managerial levels.

Based on the above here, it rose the following research questions for this article: As the digital manufacturing and industry concepts such as 4.0, *clould computing* and *internet thing* can collaborate to improve agility in response time to market desires? How is Brazil inserted in this new mode of process management and business product development?

2. INDUSTRY 4.0

The global manufacturing trend in developed countries is to use the Industry 4.0, which is the use of digital technologies, *Cyber-Physical Systems* (CPS), which are systems with storage information with ability to interact information with autonomy and knowledge-based intelligence For the competitiveness of the industry (TORO; BARANDIRAN; POSADA, 2015).

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CPS refers to the convergence of the physical world to the digital world (cyberspace), when applied to the production *Cyber-Physical Production Systems* (CPPS), where industry related technologies 4.0 established a real impact on the current and future industrial manufacturing systems. Figure 2 represents a view of some of the most important technologies involved (TORO; BARANDIRAN; POSADA, 2015).

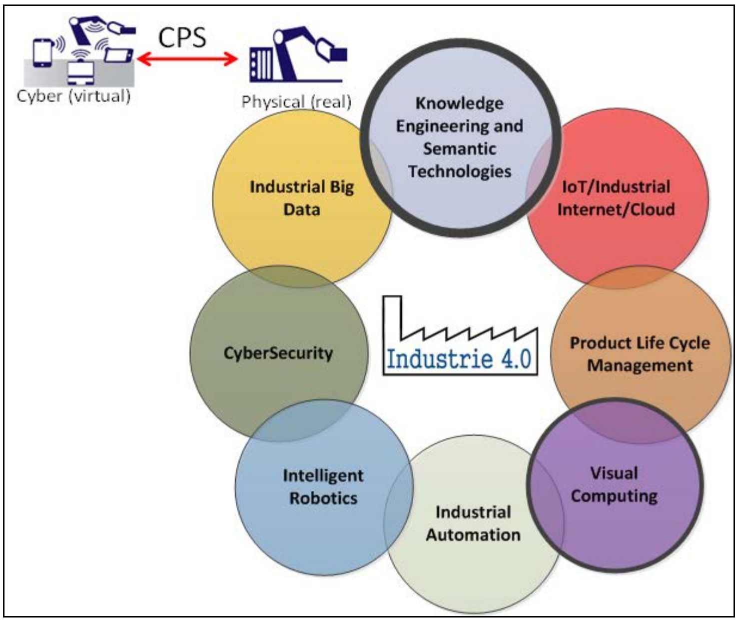

Figure 2: Technologies Cluster in the industry 4.0.
Source: Toro, Barandiaran, Posada (2015).

With the emergence of CPS, several controllers aims to increase productivity in industry 4.0, including, SOPS *(Self Optimizing Production Systems),* which can be defined as a system that has the ability to change the production process and adapt Parameters assigned in the project to optimize production at a lower cost. (Brettel *et al.,* 2016). Figure 3 shows the productivity vs. quantity relationship comparing the traditional method with the SOPS method.

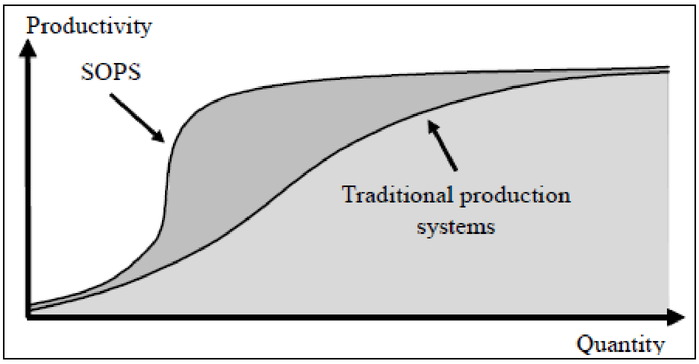

Figure 3: Relationship between productivity and quantity.
Source: Brettel *et al.* (2016).

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The self-optimization process is performed periodically, but not necessarily in a specific sequence, where in the 1st phase, it analyzes the current system data, in the 2nd phase, determines the objectives, or generates other goals that are independent of the current ones, in the 3rd stage adjusts the operation, and thus closes the optimization cycle in accordance with Figure 4 (BRETTEL *et al.,* 2016).

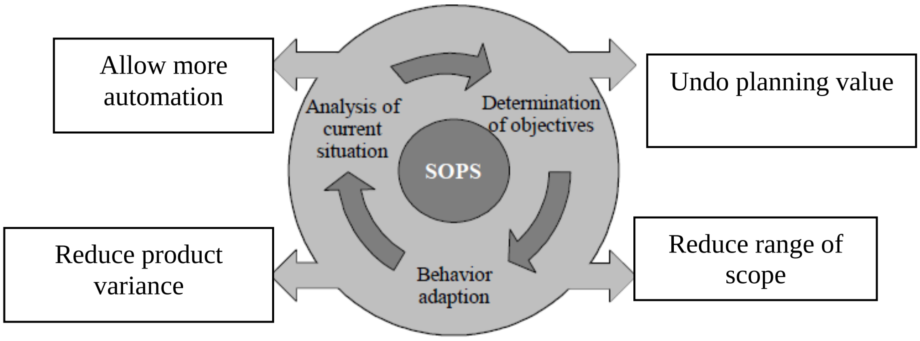

Figure 4: Self-optimization process.
Source: Brettel *et al.* (2016).

According to the CNI (2016), advancing 4.0 Industries in Brazil depends on the know how by the companies of scan gains, both with regard to increased productivity and opportunities for new business models, flexible and cost Production and reduction of the time of launch products on the market. The focus on processes becomes even clearer when evaluating the benefits that companies spe With the adoption of digital technologies. Such. The main benefits expected are: to reduce operating costs, increase productivity, and optimize processes with automation (CNI, 2016).

3. INTERNET OF THINGS (IOT)

Technological development is advancing, and companies are anticipating the needs and desires of consumers who are eager for new experiences and products. This is not a futuristic vision, is simply a forecast scenario that realizes to the current century and which is founded by the *Internet* of Things (IoT), or as it is known, *Internet of Things (IoT)* (SEGURA; HILDELBRAND, 2014).

The term *Internet of Things* (IoT - IoT) was coined in 1999 by Kevin Ashton, co-founder of the Auto-ID *Center of the Massachusetts Institute of Technology* (MIT). (LACERDA: LIMA-MARQUES, 2015). The meaning of communication between machines (machine to machine - M2M) requires the use of network resources and its

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infrastructure such as *hardware, software* and remote applications, for purposes of monitoring and control of machines and the environment.

The connection potential between intelligent objects and the way you interact with them and with the environment today is changing significantly, is called this phenomenon *Internet* of Things (SEGURA; HILDELBRAND, 2014).

In a recent article, Ashton (2009) stated that the original idea of IoT provided for the connection of all physical objects to the *Internet,* with the ability to capture information through radio frequency identification (RFID) and sensing technologies, which allow to observe, Identify and understand the world regardless of people and their limitations of time, attention and precision. The idea of a global network of connected objects that exchange information with each other is wide and makes many different technologies and applications meet the *Internet* name of Things (SINGER, 2012).

The great potential of IdC according to Lacerda e Lima-Marques (2015) is the power that gives objects of daily use to capture, process, store, transmit and present information. Networked, objects are capable of performing actions independently and generate data in exponential quantity and variety, as the product of interactions. In this context, information becomes part of the environment, and new forms of performance of the people in the world are configured.

According to Segura and Hidelbrand (2014), following the evolution of computing for the IoT and *Internet* all. Currently, in approximate numbers, it is estimated that 10 billion "things", out of a total of 1.5 trillion, are connected. It is estimated that there are 200 connectable "things" per person in the world. For this research CISCO company, it appears that in 2000 there were around 200 million "things" connected to the *internet* and, thanks to technological advances and the creation of mobile media and portability systems, forecast The year 2020 will reach about 50 billion connected devices in the network, as shown in Figure 5.

Nassar and Vieira (2014) identified the technology as pillars of the *internet* of things, such as RFID *(Radio Frequency Identification),* NFC *(Near Field Communication)* wireless networks and wireless sensors. However, they also highlighted a broad portfolio of devices, networks and technology services would build the *internet* of things, joining the real world to the digital.

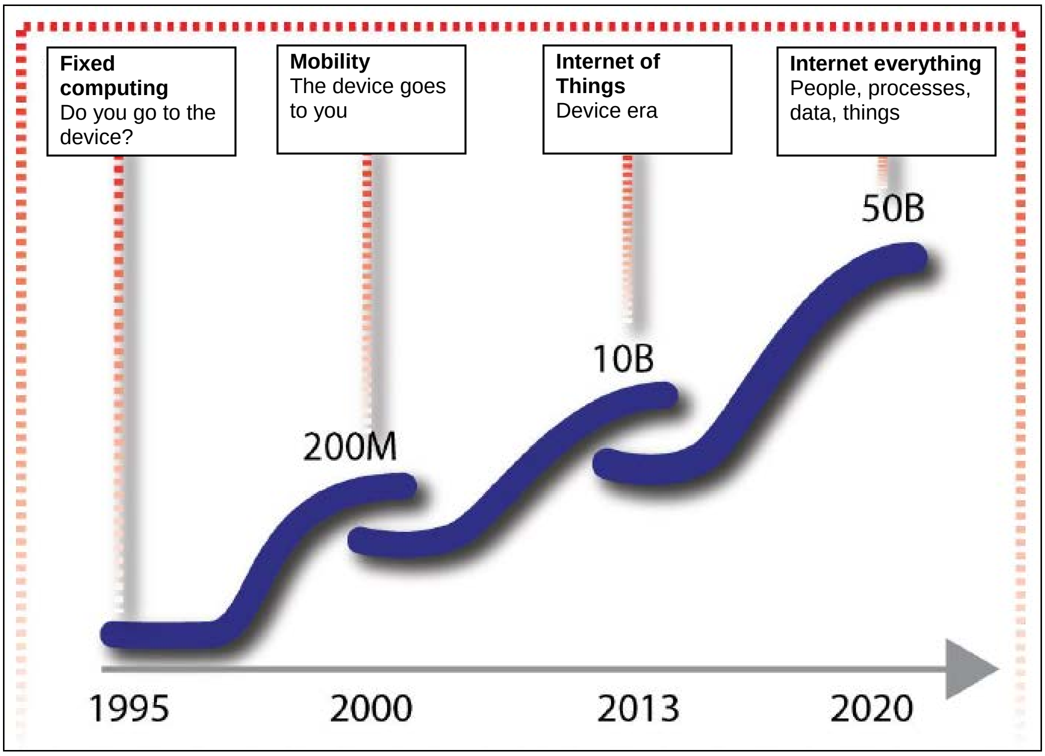

Figure 5: Fixed computing evolution internet all.
Source: Segura, Hidelbrand (2014).

The NFC and RFID technologies are integrated into electronic devices to influence the user experience in a variety of applications, making it possible to make payments, access to turnstiles, obtaining and transmitting content (NASSAR, VIEIRA, 2014).

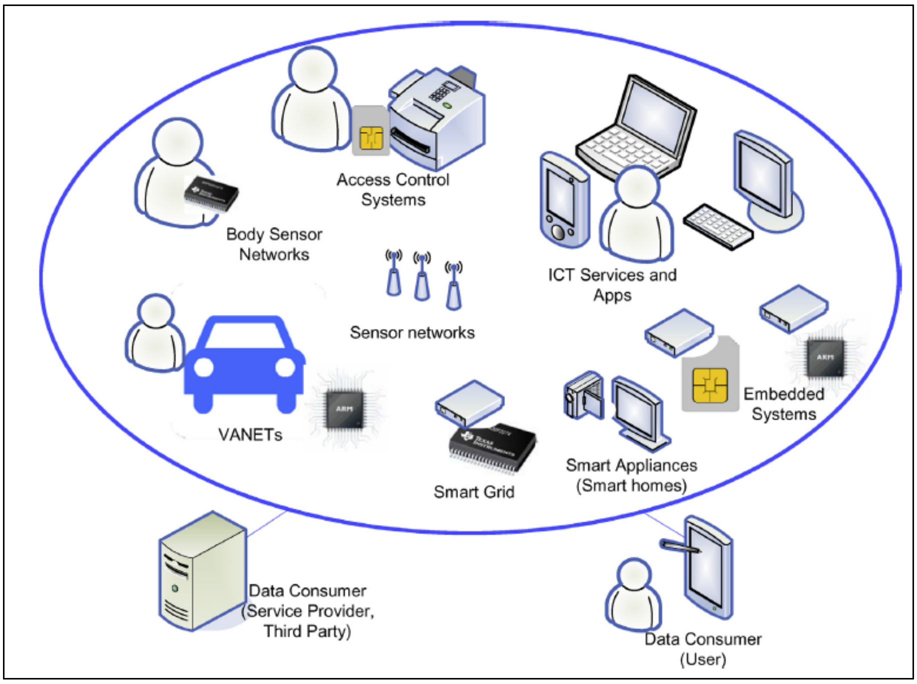

Figure 6: Technologies and applications in an IdC environment.
Source: Malina *et al.* (2016).

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Security on the *Internet* of things has to be addressed due to the high possibility of risk to it, such as espionage, unauthorized access, data modification, data falsification, as can be seen in Figure 6 (MALINA *et al.,* 2016).

In fact, machines connected to machines access data from sensors and electronic devices in untold quantities and proportions. On the other hand, they may also be invisible to the human eye. And so the *Internet* of Things installs itself as a great innovation for humanity, and at the same time, almost invisible to the eye. In fact, today, the *Internet* of Things came to significantly change the perception of paradigms, production and distribution of the capitalist world (SEGURA; HILDELBRAND, 2014).

4. DIGITAL MANUFACTURING

Digital Manufacturing *(Digital Manufacturing)* or Digital Factory *(Digital Factory),* seeks to improve products and production engineering processes through integration. The main technology in this concept is simulation. Different types of simulation, such as discrete events or 3D animated simulation, can be applied in virtual models for various tasks and planning stages with the aim of improving product and process planning at all levels, according to Kuehn (2006).

Also according to Kuehn (2006), Digital Manufacturing, also known as Digital factory, or *Digital Factory,* it is a concept that has an integration that improves character products and production engineering processes. Fábrica Digital integrates the following processes:

- Product development, testing and improvement;
- Development and improvement of production processes;
- Design and improvement of the plant;
- Planning and control of productive operations.

The concept of digital manufacturing is focused on the integration of methods and tools to plan and test the product and the production process with the use of integrated computer systems that include tools for 3D modeling and visualization, simulation and analysis to create products and define process According to the concepts of Engineering (KUEHN, 2006).

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For Bracht and Masurat (2005), Digital Manufacturing can be conceptualized as all the computer-aided tools, connected through a central database, necessary for the planning of new products and production plants, in such a way as to Operation of the factories.

Digital Manufacturing system in recent years has been growing, generating the emergence of more effective solutions that present more realistic simulations of production *layouts,* processes, assembly lines, robot cells and industrial automation controls (WAURZYNIAK, 2007).

The Digital Manufacturing due to the technological advances has become a reality within the companies that end up using this concept partially without realizing it (DALTON-TAGGART, 2005)

Many companies have invested in process technologies and in their possible outcomes, for example, CIMdata in 2004, obtained revenue from tools and services associated with Digital Manufacturing of approximately US $ 400 million. The *Tecnomatix Technologies Inc.,* Northville, Mich during 2004 invested approximately $ 100 million in revenue. The company *Dassault Systemes, Woodland Hills,*Calif., Earned revenue of approximately $ 80 million. According to CIMdata, Digital Manufacturing will be one of the fastest growing segments in the PLM market and will exceed the value of revenues of US $ 1.3 billion over the next five years. (MILLER, 2005)

According to Miller (2005), Digital Manufacturing is one of the few alternatives with the potential to radically transform business, making them more competitive.

The concept of digital factory and digital manufacturing, the process seeks to achieve a competitive edge engineering for the company, through better development. Because innovative engineering accelerates product design and production process (KUEHN, 2006).

Digital Manufacturing establishes the connection between the product design, CAD *(Computer Aided Design)* defines what will be done, Digital Manufacturing defines how it will be done and the ERP / MRP *(Enterprise Resource Planning / Material Requirement Planning)* defines when will done thus forming the Digital manufacturing cadeia.A uses data from engineering materials structure*(engineering Bill of materials (EBOM))* to create the structure of production of materials

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(manufacturing Bill of materials - (MBOM)) and the process structure (*Bill Of Processes (BOP)).* These two structures, plus the management of productive resources - such as tools, machines, work centers, human operators and robots - generate data grouped into products, processes and resources of the productive plant that are created and maintained in the central data repository (ROWE, 2006).

According to DE CARLI and Delamaro (2007), Digital Manufacturing, help in reducing product development cycles and manufacturing costs, accelerated *time-to-market,* increase product quality, improvements in the dissemination of knowledge of the product, support initiatives *Design-for-X,* as *Design-for-Manufacturability* or *Design-for-Assembly.*

5. CLOUD COMPUTING

With the advance of society, basic and essential services are almost all delivered in a completely transparent way. Utilities such as water, electricity, telephone and gas have become essential to daily life and are exploited through the use based payment model, according Vecchiola *et al.* (2009).

Existing infrastructures let you deliver such services anywhere, anytime. Recently, the same idea of usefulness has been applied in the context of information technology and a consistent change in this direction has been made with the spread of *Cloud Computing* or Cloud Computing (SOUSA; MOREIRA; MACHADO, 2009).

Cloud computing comes from the need to architect complex IT infrastructures, where users perform installation, configuration, and upgrade of software systems (SOUSA; MOREIRA; MACHADO, 2009).

Many companies are looking to acquire *Cloud Computing* due to the possibility of reducing costs and increasing flexibility in the management of the IT environment (TAURION, 2009; IBM, 2013).

The *National Institute of Standards and Technology* (NIST) defines cloud computing as:

> A convenient model to allow on-demand access to the network, or to a shared set of configurable computing resources (For example, networks, servers, storage, applications, and services) can be quickly provided and released with minimal management, effort or interaction with a service provider (NIST, 2011).

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According Gatner (2013), spending on *cloud computing* services reached 677 billion worldwide by 2016. Among the most important aspects allowed the cloud is that it allows to be viable the implementation of a large number of machines to groups and small organizations.

Among the benefits pointed out by the companies in national soil are: higher productivity (55%), cost reduction (54%) and more flexibility (49%) (COMPUTERWORLD, 2012). The *Cloud Computing* provides extensive infrastructure enabling users of these services make changes, try more and interact with agility, not concerning by getting or improving infrastructure, eliminating the waste of time (SACILOTTI; MADUREIRA; SACILOTTI, 2013).

Today, *cloud computing* is seen as a very promising model for computing that helps to solve serious issues within IT and with wide access to the network where resources are available, and accessed through standard mechanisms that generate the use of heterogeneous platforms (e.g., *desktops, laptops, smartphones and tablets)* (SACILOTTI; MADUREIRA; SACILOTTI, 2013).

6. FINAL CONSIDERATIONS

Analyzing the concepts and comparing the Brazilian reality, it is clear that the country has much to evolve to reach international levels of productivity and thus to be able to efficiently implement the concepts addressed. Today, in the 21st century, there is a big gap between what preaches digital manufacturing and other concepts and what companies actually apply in Brazil.

There is a great distance between what is practiced in developed countries and in Brazil, and between what is taught in some universities and what business reality shows to be practicable. One of the reasons, as seen in the text, is the lack of investment in skilled professionals and cutting-edge technologies. But this is only possible when entrepreneurs also have some support from government and public policies that foster development. And these policies today are far removed from the developed countries' model.

Thus it notes that computing as a service has been growing in business and thus can provide services directly to users through the *Internet* according to their needs. Digital manufacturing and its technologies prove to be an adequate tool that

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generates knowledge and aims to optimize processes to meet the demands of the competitive market that companies are experiencing today.

It is important before any implementation of these technologies in the company, to make an analysis, ie, it is necessary to present the recommended functionalities for each company, consultants experienced in deployments, knowledgeable about the software to be deployed and the proposed solution since each company has its Particularities. This is very important making it a mandatory prerequisite.

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