Enabling Cyber-Physical Systems for Industry 4.0 operations: A Service Science Perspective

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Abstract*: Based on the Internet of Things (IoT) and Smart Technologies, manufacturing industries are witnessing the fourth Industrial Revolution, the Industry 4.0 (I4.0), and digital transformation is a keystone in this change. Cyber-Physical Systems (CPS) are strategic in thoroughly digitalizing companies, and I4.0 operations depend on CPS efficiency. Digital plants are held by digital technologies that provide excellent tools for improving product security and supply chain security but requires structured information management to maintain the CPS in its highest level of efficiency. These systems are overly complex and hard to handle when several CPS need to be combined as in a large factory, where several machines must work together to achieve a common goal. This research addresses these issues, and we propose an information management framework of industrial CPS that, towards the industrial efficiency, affords an increase in value for all stakeholders. The framework structures the information through the introduction of two innovative value co-creation concepts: (i) Fingerprint (FP-I4.0), a virtual vehicle that can carry two types of structured information and (ii) Cockpit4.0, an interaction entity between the various service systems, applied from cradle-to-cradle. Validated through the Service Science Theory, we conclude that the proposed empirical framework may boost up CPS efficiency and, from it, I4.0 operations will be more effective.

***Keywords*: Industry 4.0, Cyber-Physical Systems, Smart Objects, Service Science, Service System**

I. INTRODUCTION

Industrial revolutions have always been characterized by features related to brand new technologies that rapidly change in a significant way the paradigm of industrial forms of production and cause economic and social phenomena that deeply and significantly change humanity. Some authors describe the fourth industrial revolution as the era of digitization or Industry 4.0 (I4.0). This paradigm shift is possible due firstly to the explosive growth of Industrial Technology and Information and Communications Technology (ICT) in recent decades and due to the continued work of industry to implement and promote them. The fourth industrial revolution combines physical systems, digital systems, and biological systems into an intelligent production network in which different components interact and work together, changing the way we look at the world.

IoT illustrates the digitization of Industrial Systems and Processes, Products, and Supply Chains [1]. It also addresses the inevitability of communications via the Internet – the Internet of Things (IoT) and Internet of Services (IS) – to achieve the best flexibility and individuality of production processes. Thus, I4.0 is the result of advanced technologies that make solutions flexible, intelligent, and completely independent.

The growing interconnection between the physical and the cyber world is becoming a central feature of the modern economy [2] nowadays. The term I4.0 has attracted the attention of several stakeholders: the ones related to the industry, as well as governments and academics [3]. It seems to identify a modern collaborative form of production [4], supported by the interconnection of digital technologies, such as the IoT, Big Data, additive production, artificial intelligence, among others technologies. This interconnection of systems is generally called a Cyber-Physical System (CPS). It is usually defined as transformative technologies that manage interconnected systems between their physical resources and computational skills [5]. Given recent developments that have led to an increase in the availability and accessibility of available sensors, data acquisition systems and machine networks, the cutthroat nature of today's industry forces more plants to move on the way to high-tech methodologies implementation. Therefore, the increasing use of sensors and machines in a network allows the continuous production of a large amount of data, the Big Data [6]. Against this backdrop, and to achieve the goal of intelligent, resilient, scalable, and self-adaptable machines, CPS can be further developed through an optimized machines network and improved Big Data management [7].

The incorporation of CPS into production, logistics and services in modern industrial procedures is generally perceived to operate correctly to transform today's factories into an "Industry 4.0" plant with substantial economic potential [8]. However, in a factory operating in I4.0 mode, the volume of information, complexity, and interpretation in real-time can reduce the efficiency of the Cyber-Physical System, and this is a problem that needs to be addressed. From this CPS efficiency reduction, the following research question arises: *What information management model must be adopted to increase the CPS effectiveness*?

Service Science (S|S) is an emerging and transdisciplinary scientific area that uses abstract entities, called Service Systems, as the object of study.

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