



The Role of Internet of Things (IoT) and Big Data as a Road Map for Smart Management Systems: Case Studies Across Industries

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Abstract

The Fourth Industrial Revolution began at the turn of this century. Disruptive technologies are emerging at a dizzying speed and changing the characteristics of industries and businesses by making them smart. Companies and industries will need Smart Management Systems to be competitive in the 21st century. Internet of Things (IoT) is the key to connecting and communicating amongst different parts of the smart industries using sensor-like devices, and Big data is being continuously collected and analyzed. Thus, IoT and Big Data are creating the roadmap for the Smart Management System that can achieve new understanding and insights to these smart industrial systems from analyzing and visualizing the available data. The Smart Management System will generate new possibilities for better product design, improved qualities, agile supply chain, and evermore customer satisfaction. It will also help industries to achieve a lean and sustainable system with fewer efforts than traditional approaches.

Many early adopters have already implemented IoT and currently generating Big data, and have achieved significant improvements in seeking innovation and opportunities for increased revenues; however, most of the industries are still waiting to learn from the high-profile companies who have already adopted IoT. The application of IoT in different sectors will be discussed here, and the Smart Management System will be identified in this process.

Keywords: IoT, Smart Management System, Big data, Lean, Sustainable

Introduction

Innovate or Die. (Peter Drucker, 2002)

The Fourth Industrial Revolution began at the turn of the 21st century. Artificial Intelligence and machine learning are at the forefront of this revolution. Automation and connectivity at their extreme, are the key features of a new generation of machinery called Cyber-Physical Systems (CPS). The seamless integration of computational algorithm and physical components in CPS is starting to disrupt the business and management practices in all sectors such as healthcare, manufacturing, governance and more. Internet of Thing (IoT) and Big data are the two critical ingredients in building the CPS.

Traditional Management has been based on a hierarchical organizational structure and encouraged limited industrial growth over time. Companies experienced very low success rate of introducing new products in the market due to the lengthy and expensive process of product innovations. Valuable time has been wasted due to slow decision-making process, causing loss of wealth for the company over time. Weaknesses of traditional management system can be strengthened by employing IoT; It has shown to improve the operational efficiency, forecasting, business analytics, predictive maintenance, troubleshooting and all other aspects of management significantly. This new technology-based management system is called as a Smart Management

System. Adoption of this management system will lead industries to become more efficient, productive, profitable, sustainable, lean and safer.

What is a Smart Management System?

The Smart Management System is imagined to be an intelligent system, and an instrument for encouraging collaboration among industry partners. It is flexible and adaptable to meet the need of individual partners, inspiring to grow knowledge, build skills and abilities to support the collaboration. It is idealized to be managing operations with a holistic approach throughout the supply chain and thus providing customers the fullest satisfaction. Business owners will be able to establish a fast and data-driven communication with all stakeholders, such as customers, business partners, and employees to bring innovative and customized solutions. As shown in Figure 1, the structure of the Smart Management System is founded on the *enhanced connectivity among stakeholders*; the two key technologies, *Internet of Things (IoT)* and *Big data* are the two pillars of this management system, and it is driven towards meeting the *customer needs*.

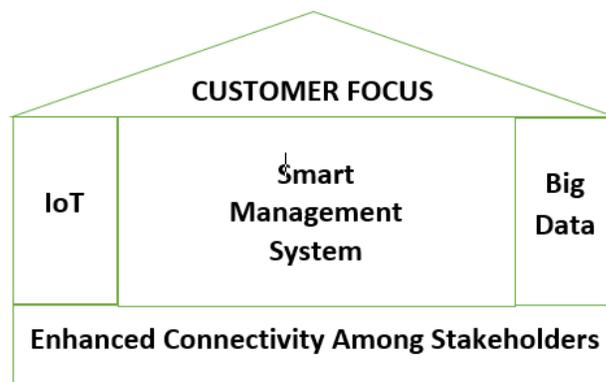


Figure 1: Structure of Smart Management System

The Foundation: Enhanced Connectivity among the Stakeholders

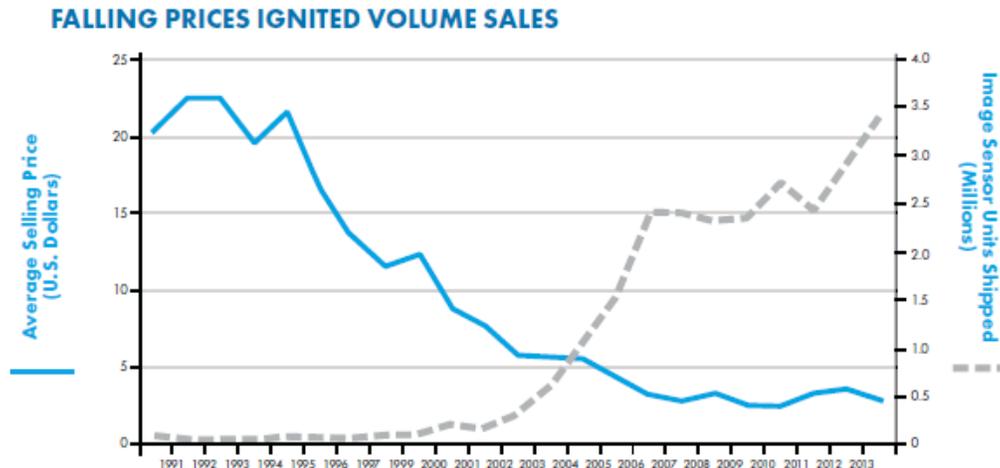
As discussed earlier the Smart Management Systems will be based on *enhanced connectivity among the stakeholders*. Generating and sharing data will create an efficient and transparent system that will customize management solution for the individual client. The wireless aspect of this system will make it possible to operate remotely and through mobile networks. Large data set can be stored in the cloud platform and accessed from anywhere throughout the Globe. The

language barrier will be eliminated since sensors and soft-wares will be using some form of universal language. Management operations can be performed through a centralized location anywhere in the world using *cloud computing*, or locally by *edge computing*, as intended to be used in autonomous vehicles (Castellanos, 2018). Seamless communication between humans, machines, and robots (industrial or other kinds) will help to streamline the operation management process.

The Two Pillars: Internet of Things (IoT) and Big Data

Internet of Things (IoT) and the Big data are apprehended as two pillars of the Smart Management System. IoT will be connecting and be communicating with different parts/stakeholders of the business operations with the sensors and other communicators, thus creating a cyber-physical system (CPS). The CPS will be generating massive data, in real time and continuously, which is called Big data. The new analysis techniques called *Big data analytics* have also emerged to manipulate these voluminous data that include not only numbers but photos, texts, tweets etc.

As mentioned earlier, CPS contains IoT objects, also known as smart objects (Fortino & Trunfio, 2014). It consists of a network of physical components that are embedded with actuators, electronics, sensors, soft wares and wireless network connectivity, which enables the physical components to communicate to each other remotely by exchanging data. The term “Internet of Things” was coined early as 1999 by British technology pioneer Kevin Ashton. IoT objects or smart objects can to capture data via sensors and transmit data via internet. In 1982, a Coke machine at the Computer Science Department of CMU was the first IoT object that was connected via the internet. However, with the turn of the century, it was possible to apply IoT to various industries (Maxey, 2016) to create IoT or smart objects. This technology has matured in the last decade since the cost of sensors has reduced significantly since the millennium. Figure 2 shows the growth of sales of image sensors over last two decades based on the decline in average selling price (Dubravac, 2015).



Source: DuBravac, Shawn. "Digital Destiny." P. 78

Figure 2: Falling Prices of Sensors and resulting increase in sales.

The emergence of various disruptive technologies such as machine learning, deep learning and other big data analytics combined with the availability of fast processors and cheaper sensors resulted in tremendous success and spread of the IoT or smart objects (Maxey, 2016). These objects are instrumental in connecting the network of industry partners, consumers and other stakeholders of the businesses, thus taking a pivotal role in the Smart Management Systems.

Managing business operations has always been dependent upon data, which was used in gathering information, creating knowledge and thus helping managing businesses successfully. In traditional management, surveys are the main source of collecting data. It has been costly to collect and analyze data, and accuracy of either is not guaranteed due to the limited amount of dataset and the secondary method of data collection via surveys. The business solutions based on this type of data are neither fully optimized nor the best. Introduction of IoT has changed everything about the data - collecting, storing, analyzing and forecasting.

Since the beginning of the 21st century, the volume and variety of data set have been growing rapidly due to the availability of inexpensive and variety of information-sensing IoT objects. Big data represents this type of voluminous data, that is being generated on a super-fast pace on real-time, from a variety of IoT objects, and in various forms (McAfee, et al., 2012). It is increasingly becoming an integral part of all industries. Storing big data has also been growing at a fast pace to keep pace with its generation. Traditional data processing soft wares are inadequate in analyzing these large data set, and hence, *Big data analytics* has evolved that uses modern techniques in processing the big data. Application of Big data analytics has been a recent development in the field of Business Process Management (BPM). The goal is to create a data-driven knowledge base to monitor, optimize, and forecast business operations. Some of the techniques used to navigate Big data are *A/B testing*, *machine learning*, *deep learning*, *natural*

language processing, etc. Many research activities are being undertaken by industries, institutions, and governments in establishing new theories and technological tools to observe and monitor Big data in real time and deploy data visualization techniques for forecasting and decision-making process. One example of the outcome of the Big data analytics was shown by analyzing the *Google Search* data set. The increase in search volume for financially relevant search items tends to precede substantial losses in the financial market (Preis, et al., 2013). Much of the Big data, such as pictures, video, tweets, etc. are still untapped due to lack of appropriate techniques, and anticipated to be very useful in better understanding customer's needs and desires.

Benefits of the Smart Management System

Over the years, management philosophies and policies were developed to meet the need of industries. Most of the times new management philosophy started out in one industry and took considerable time to be picked up by other industries to emulate success. For example, *Lean Philosophy* was first conceptualized in *Toyota Automotive Company* after world war II. After a few decades of its continuous success, it was slowly adopted in automotive industries in the US and Europe. It took several more decades for other industries to appreciate the value of Lean. Even today various industries and businesses are in the process of implementing Lean in their operations. Although successful once it is in place, implementing *Lean* is difficult and time-consuming proposition to an already established business (Roy, 2018). On the contrary, the Smart Management System is based on technology, and hence implementation is easy and fast to any industry. It is also becoming more affordable over time, and will offer all benefits of earlier management philosophies combined and more. Automation in all aspects of operations and management will be a growing part this type of management system. Figure 3 shows some of the benefits of the Smart Management System that are also listed below:

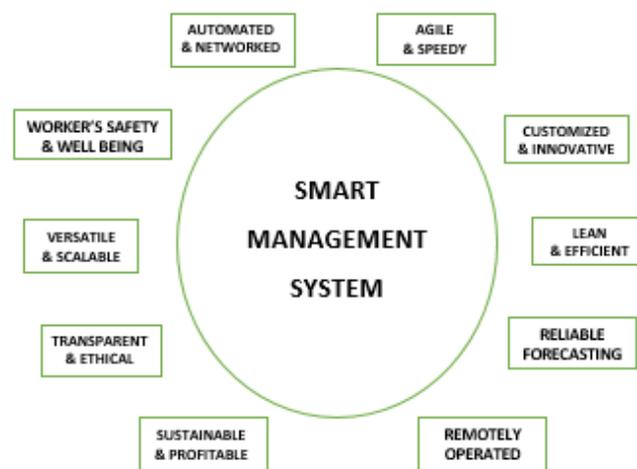


Figure 3: Benefits of the Smart Management System

1. Automated and Networked:

Automation is intrinsic to the Smart Management System, since it is based on IoT technology. The level of automation can be raised incrementally based on client's need and desire. The labors in the 21st century will growingly consist of human and robots (and other automated devices) working together. For example, Amazon now employing largest fleets of industrial robots (Kiva) partnered with human workers, thus increasing Amazon's capability up to 70% faster than a nonautomated environment. The robots perform picking and delivery, while human work on process improvement such as directing lower volume products to be stored in a more remote area. In 2015, Amazon reported 30,000 robots were working together with 230,000 human employees. The company has been increasing number of robots over the years to raise the level of automation in the system. Kiva is the first commercially available, large-scale autonomous robot system (Wurman et al., 2008). The Smart Management System is appropriate for managing similar operations which are partially automated.

2. Agile & Speedy:

Agility is one of the key characteristics for survival in the 21st century. Companies need to be very *agile* to be able to anticipate or react quickly, and become flexible to adapt to change in the marketplace (Cusumano, 2010). Continuous communication within and outside the company is crucial to anticipate the market trend and adapt to the change quickly. The Smart Management System helps to establish a reliable and fast communication system throughout the supply chain. With the anticipated introduction of super-fast 5G wireless communication, speed, volume, and clarity of communication among business stakeholders will be unparalleled. Few countries such as Japan and South Korea are leading in introducing 5G technology followed by US and China (Roy, 2018). System integrations will also eliminate unnecessary steps in business operations, thus streamlining the management process to make the company agile.

3. Customized and Innovative:

Product innovation has been a lengthy and expensive process for companies where the success rate of a new product is meager (Krishnan and Ulrich, 2001). Corporations have been bound by the limited number of responses of the surveys that try to understand customers. Often, there is bias in the study resulting inaccurate assessments. Implementation of IoT will eliminate this shortcoming. It will generate factual and unlimited data that will provide a deep understanding of customer needs. It will lead to innovation and customization of products that will be truly satisfying to customers.

4. Lean & Efficient:

Lean has been one of the most successful management techniques in the automobile industries and has been followed by various other sectors. The lean philosophy is based on identifying wastes in any operation and removing or reducing it by using multiple techniques to increase efficiency and customer satisfaction. However, introducing lean in established industries has been

challenging and time-consuming (Roy, 2018). Smart Management System provides the lean alternative that can be employed faster and with less difficulty. The system integration created by this system will remove wastes from the operation to make it lean and efficient.

One of the main challenges of industries is to provide efficiency along with customer satisfaction (Heikkilä, 2002). The increase in operational efficiency coupled with customer satisfaction is probably the most notable effect of implementing Smart Management System. A few reasons for increased productivity are: continuous connectivity and monitoring business operations in real time, faster wireless communication, increased network of smart objects, automated decision-making process, but also by growing network of IoT objects that can be monitored in real-time remotely.

5. Reliable Forecasting:

Forecasting is one of the essential requirements of operation management. There are many mathematical and statistical models for predicting which have not been entirely reliable for many reasons. A few of them were the number and validity of the data source upon which those models were built, and the time lag between the data generation and forecasting. Big data generated in Smart Management System will produce reliable forecasting. Also, potential benefits of collaborative forecasting (Aviv, 2007) can be achieved among the supply chain stakeholders.

6. Remotely Operable:

It is one of the essential benefits of Smart Management System that is achievable due to the application of IoT. Many multinational companies (MNCs) have spread their operations across geographical boundaries. However, there has always been difficulty in operating a well-maintained supply chain and branch offices around the globe until the growth of wireless technology in the recent years. The Smart Management System is capable managing remote operations successfully with the help of IoT which includes wireless technology.

7. Sustainable and Profitable:

Rachel Carson warned us about the degradation of the environment in her book *The Silent Spring* (Carson, 1962). Since then, consumers, particularly the millennials have been demanding environment-friendly products and processes from the industry. Pollution from industries is at a peak in some countries such as China and India, endangering the quality of life for citizens. However, actual sustainability is more than making environment-friendly products and processes; it also involves corporate social responsibilities, including its employees, customers and local and communities. Sustainable industry practices focus not only on company profit but also the well-being of the 3P or the *Triple Bottom Line*, i.e., Planet, People and Profit (Heizer et al., 2017). Smart Management System is instrumental in ensuring sustainable practices by minimizing harm to planet and people while maximizing profit for the companies.

8. Worker's Safety and Well-being:

Worker's safety has always been the primary concern for industries, particularly construction, heavy machinery, mining and similar industries. According to the data from Bureau of Labor Statistics, the overall nonfatal injury and illness are on the decline over last decade. OSHA has been effective in reducing the total nonfatal injury over time. However, approximately 2.9 million nonfatal injuries and illnesses were reported by private industry employers in 2016 (BLS, 2017). It can be further reduced using Smart Management System with the help of new technologies. A few companies are using wearable IoT objects to monitor and alert workers and managers regarding the dangers at the construction sites as a part of the Smart Management System.

9. Versatile and Scalable:

Versatility is one of the best quality of this management system. It applies to any industry or institution. Smart Management System can be customized to suit the size of the company, number of customers, locations such as local or global, or degree of automation. Scaling up or down and the system integration can be achieved relatively quickly. Scalability has recently gained significant attention, particularly in IT and manufacturing communities (Putnik et al., 2013). Smart Management System is scalable; hence it can facilitate business growth or reduction rather easily to provide flexibility for the business owners.

10. Transparent and Ethical:

Transparency is the key to good business practices. Not only does it improve the productivity of business, but it also helps to better manage an organization. Companies gain the trust of their customers, thus nourishing customer relationships. Transparency delivers value to the customer and increases customer satisfaction (Eggert, 2003), which leads to profitability. Smart Management System creates a transparent business model which encourages ethical behaviors among the business stakeholders and collaborators, thus increasing the reputation of industries.

A few case studies of the Smart Management System:

Industry leaders those are at the forefront of re-engineering their business strategies are predicted to emerge as the winners. Companies are making substantial investments in experimenting with different approaches and opportunities to capture value in this growing market (Batra et al., 2018). Following are a few examples of industrial applications of the Smart Management System based on AIG case studies (AIG Part II, 2016) and Cisco (Cisco, 2017):

- **IBM:**

The traditional business strategies and models are changing faster than companies can keep up. IBM is helping customers to understand the potential of the IoT by providing the technological infrastructure. For example, IBM has partnered with Whirlpool, a renowned appliance maker to shake-up the home appliance market. Using IBM Watson IoT Cloud Whirlpool can analyze the data stream generated by the sensors of their appliances and obtain meaningful insight resulting in customized services for consumers. Big data analytics helps Whirlpool to understand the customer need better to fine tune the performance of their appliances, optimize the supply chain and enhance service delivery. IBM's predictive maintenance capabilities is another resource for Whirlpool to access multiple data sources in real time to predict any potential issues, avoiding quality and customer-satisfaction matters and reducing maintenance costs. The company is also confirming its commitment to sustainability by donating to *Habitat for Humanity* every time a load of laundry is washed by its customers.

- **ABB Group:**

Switzerland based ABB Group is a global leader in power and automation technologies. Their robots are being used globally to increase efficiency and safety across a wide array of industries. However, customers lose a fortune when these robots and devices need repairs or upgrading. Customer demands the operational efficiency along with minimizing downtime for repairs and upgrading of their devices and robots.

As a part of Smart Management System, ABB has adopted IoT technology to monitor more than 5000 devices in the field, in real time. Instead of sending technicians in person for diagnostic services, ABB has decided to offer several Cloud-based IoT solutions that provide real-time monitoring of individual machine remotely, as well as longitudinal analysis that allows accurate prediction for requiring maintenance. *ABB Ability* platform was developed for customers to monitor and collaborate with the company in improving quality of services. ABB's proactive monitoring and preventative maintenance system are saving its customers on maintenance and repair cost in addition to eliminating downtime expenses. For example, ABB's gearless mill drive is used for mining operations, and failure of these machines may delay the operations for days or even weeks resulting in substantial losses in the mining operation. Remote monitoring and preventive maintenance of this device are saving fortunes for the clients.

- **Cisco:**

Cisco, the worldwide technology leader, has been in the forefront of transforming cities around the world to make them smart. The "smart cities" have lower pollution, safer streets, and better quality of life for citizens. Cisco announced ten cities (Adelaide, Bangalore, Bucharest, Copenhagen, Dubrovnik, Jaipur, Kansas City, Paris, Schenectady, Trencin) around the world that have decided using their Cloud-based service to connect traffic, parking, lighting, water management and environmental sensors in real time. According to Cisco, insights from the

data collected from sensors can help city agencies making operations more efficient, reduce costs and respond quickly to emergencies (Hamblen, 2016).

Thus, Cisco is implementing Smart Management System to improve quality of life for citizens. For example, the town of Cary in North Carolina has created a “Living Lab” where town officials can actively monitor the number of parking spots using *Cisco Kinetic for Cities* digital platform for future planning. Cisco is continuing to upgrade and add new functionalities to its digital platform. One of the new features provides enhanced support for public safety. Cisco Capital has partnered with Digital Alpha Advisors, APG Asset Management and Whitehelm Capital and launched a *City Infrastructure Financing Acceleration Program* with \$1 billion assets to make it easier, faster and more affordable for cities to fund and adopt technologies that will transform their communities (Cisco, 2017).

These are only a few examples of a variety of industries who are early adopters of Smart Management System. Its versatility makes it applicable to different types of industries and governing institutions. However, there are some caveats in the path of this new technology-based management system that needs to be addressed and are discussed below:

Caveats of Smart Management System

Despite the adoption of IoT by the industry leaders most businesses are still taking measured steps in embracing new technologies. Industries are not quite convinced about benefits that can be gained from this new technology-based Smart Management System. A few of the reasons are listed as follows:

- The absence of standardization and guidance in implementing IoT,
- Unavailability of a common language for machines to communicate,
- Lack of rules and regulations regarding Big data ownership among stakeholders,
- Deficiency of ensuring privacy and strong cybersecurity.

Among industrial sectors, only a few companies took a big leap of employing IoT. However, for most of them, it is difficult to navigate through the field of new technology without standardization or proper guidance. New knowledge regarding cloud platforms, interfaces, hard wares, etc. are being generated continuously, and it is hard to find and hire employees who have adequate training. According to National Association of Manufacturer (NAM) over next decade, 2 million jobs in manufacturing sectors are expected to go unfilled due to skill gap.

However, the concern which keeps business owners awake at night, or causing them to hesitate to employ this technology is the lack of cybersecurity. Consumer’s privacy is being often compromised, and is a primary concern for industries. Current laws are not adequate to regulate illegal use of private information. Hackers and cybercriminals are finding new ways to access confidential information every day. Damages to the businesses due to cyber-attacks have been on

the news frequently. Cyber-crime cost businesses \$400 billion every year (Gandel, 2015). Many research is currently being pursued to invent security framework for different sectors, such as for smart homes and smart buildings (Pacheco, 2016). Companies need to step up to ensure consumer confidence by eliminating these drawbacks and by building a robust Smart Management System.

Conclusion

Smart Management System will provide appropriate management techniques for the industries in the 21st century, based on the two key technologies: IoT & Big data. Affordable sensors and fast wireless connection continue to radically increase numbers and variety of IoT or smart objects. Consequently, Big data are increasingly becoming available to the industries for analysis, visualization, and optimization. Thus, together IoT and Big data are creating a roadmap for Smart Management System.

Companies are collaborating to embrace the emerging technologies, for example, Daimler and ThyssenKrupp are changing the industry using IoT solutions provided by IBM and Microsoft. John Deere is fostering collaboration across the agriculture industry with IoT innovation that impact each step of farming, from seed to market. (AIG Part II, 2016). Cybersecurity and privacy, data ownership, and unification of machine languages are a few drawbacks that need to be resolved by the industry owners and government.

The Smart Management System concept should be a part of the engineering management knowledge since it truly provides a management concept based on technology, thus bridging the gap between engineering and management. The courses on IoT and big data analysis are recently being offered in engineering and business schools in leading universities, and from a few open source platforms. However, a holistic approach of Smart Management System is yet to be offered. It is therefore of utmost important that the future managers are given the opportunity to learn Smart Management System and how to use them in managing the digitally transformed industries of the 21st century.

The benefits of Smart Management System outweigh the risks. It offers a simplified, technology and data-based management option that is innovative and superior to the traditional management. Automaton will be an intrinsic part of this system since it is based on IoT. IoT is breaking down the barriers within and between industries. A new set of tools and changing customer expectations are pushing companies to collaborate and share information in creating innovative solutions. Smart Management System is in the process of building a super-efficient, streamlined, data-driven, and highly automated futuristic management system that will guide businesses for years to come.

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