INTERNET OF THINGS IN THE CHEMICAL INDUSTRY

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ABSTRACT

The Internet of things (IoT) is emerging as a disruptive technology of the 21st century-an extension of the Internet revolution which has made a tremendous impact on social and business environments. Unfortunately, not everyone in industry in general, and the chemical industry in particular, knows exactly what the Internet of things is or what impact it will have on their business. This paper presents a short essay on how the Internet of things is currently being used in the chemical industry.

Key Words: Internet of things, Chemical Industry, Internet revolution.

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1. INTRODUCTION

The industrial revolution changed the dynamics of society through rapid urbanization and the rise of cities, working women, the rise of the middle class, and the creation of new job opportunities. The Internet revolution predominately brought with it changes that were not only technological but societal and pervasive in scope. Access to information combined with global ecommerce reshaped established conventions. The next revolution that will disrupt our lifestyle, technology, and business is the Internet of Things (IoT) [1].

Although chemists as a whole were relatively slow to embrace the Internet, there has been rapid adoption of the Internet in chemical applications and widespread acceptance of the Internet by chemists since the early 1990s [2]. In 1996, the American Chemical Society published the book The Internet: A Guide for Chemists [3], which collected in one place much of the information needed for chemists to effectively utilize the Internet.

The chemical industries contribute materials to manufactured products and form the backbone of much of our economy. In the recent years, a large number of chemical companies all over the world, small and large, have opened up their offerings in the global electronic marketplace. As chemical industries explore the Internet of Things, they are experiencing a substantial return on investment in the form of equipment effectiveness, reduced quality costs, improved supply chain visibility, and much more.

2. IOT OVERVIEW

The term, Internet of Things, was first coined by Kevin Ashton, a British entrepreneur in 1999 in the context of supply chain management. He meant to represent the concept of computers and machines with sensors, which are connected to the Internet to report status and accept control commands [4].

IoT (also known as a sensor network or Industrial Internet) is a global network of interconnected devices (such as sensors, actuators, personal electronic devices, laptops, tablets, digital cameras, smart phones, alarm systems, home appliances, or industrial machines, and other smart devices) that are enabled with technology to allow interaction and communication with each other. It mainly enables the interconnection of Thing to Thing (T2T), Human to Thing (H2T) and Human to Human (H2H). By collecting and combining data from various IoT devices and using big data analytics, decision-makers can take appropriate actions with important economic, social, and environmental implications.

The IOT can be divided into three layers [5]: a perception (or sensing) layer, a network layer, and an application layer:

- The perception layer collects information from devices, radio frequency identification (RFID) tags and readers, cameras, GPS, sensors. In this layer, the wireless smart systems with sensors can automatically sense and exchange information among different devices and remotely control them.
- The network layer is mainly for messaging and processing information. The role of this layer is to connect all things together and allow them to share the information with each other.
- The application layer is the Internet of Things and the application systems. This layer provides high-quality smart services to meet customers' needs.

These three layers are illustrated in Figure 1 [5]. Technologies associated with the IoT are shown in Figure 2 [6]. These include RFID, wireless sensor networks (WSN), middleware, cloud computing, and IoT application software. These five IoT technologies are widely used for the deployment of successful IoT-based products and services [7].

3. APPLICATIONS

The Internet of things is applied in health care, automotive industries, smart power grid, smart business, manufacturing, transportation, agriculture, logistics, pharmaceutics, surveillance, etc. Here we will consider some of the key applications of IoT in chemical industries.

- **Manufacturers:** Chemical industries contribute heavily to manufactured products used by everyone. The chemical industries can implement advanced IoT sensors, control, and software applications, which will provide real-time information on their manufacturing equipment. This is useful particularly in areas where human life is endangered such as mines, chemical factories, and nuclear power plants [1]. By collecting information from IoT sensors and analyzing it, smart manufacturing (SM) increases production efficiency in factories. IoT is posed to automate, monitor, and analyze information from machinery and equipment in exciting new business ventures. Thus, the IoT provides numerous novel opportunities to advance chemical manufacturing in achieving better system performance in globalized and distributed environments [8].

- **Equipment monitoring and Control:** The IoT enables one to monitor and command machines remotely. Monitoring equipment is an important part of chemical plants. This ensures the safety of chemical production and promotes efficiency and other benefits. Sensors attached to equipment can be used to monitor various aspects of product quality. Companies that adopt IoT and 3D visualization technology are able to react more quickly to alerts and alarms, resulting in a higher overall equipment effectiveness and more efficient maintenance and production processes [9, 10].

- **Energy management:** Energy constitutes a major expense for chemical manufacturing. Energy costs account for major production and monitoring opportunities. The IoT can be put to use in this regard. Sensors connected to IoT can be used to monitor energy consumption, help control costs, and ensure regulatory compliance. Actively managing energy consumption results in greener operations and effective utilization of resources [9].

- **Cybersecurity:** Since chemical plants may be potential targets for terrorist attacks, cybersecurity should be a top priority. Chemical companies must consider physical security, industrial systems security, and data security. Using IoT, chemical companies can bring data together easily, enabling them to quickly identify unauthorized access and prevent further intrusion. This way they can prevent hackers from gaining access to sensitive data [11].

- **Technologies:** Due to the fierce competition within the chemical industries, it is imperative that they employ all the technology they have available to control costs and improve efficiency. The IoT provides significant opportunities for deploying technologies at affordable cost. It is helping to simplify business processes and provide more insight into processes that can help improve quality, reduce downtime, decrease the costs of maintenance, and increase on-time delivery [9]. Using the technologies to connect devices, plants, assets, people, products, and processes is helping chemical industries to make data-driven decisions and stay competitive.

Other chemical industry-related applications include quality assurance, integrated supply chain, logistics, and smart environment.

4. CHALLENGES

The effective use of the Internet as a communications venue challenges chemical producers. There are major challenges to overcome before the IoT will become widely employed in chemical industry. Infrastructure challenges are the most daunting in many economies. For example, most satellites are not equipped to deal with high bandwidth in real time and the batteries in GPS packs do not last more than nine months [12].

The IoT presents special security risks because the Industrial IoT is so dependent on both the public Internet and private intranets. Each layer of the IoT is vulnerable to attacks. In order to achieve a reliable and secure IoT environment, a number of privacy principles and security protocols must be implemented [13]. Security is a critical factor in the widespread adoption of IoT technologies and applications. As shown in Figure 2, security includes privacy, trust, and data confidentiality [14].

Another challenge is that the IoT is a very complex heterogeneous network because it involves various types of networks with various communication technologies. This leads to a related problem of lack of common platform or technological standards in some areas, while other sectors are divided and fragmented. Standardization is important for system integration. This involves standardizing RFID technologies, sensor networks, Near Field Communication (NFC) technology, communication protocols, and IoT [15]. The rapid growth of IoT makes the standardization nearly impossible.

Complexity-related issues will expand exponentially as the number of devices connected to a system increase over time [13]. A challenging issue for the chemical industries is understanding how to monetize IoT services. Data management is a key challenge because IoT sensors and devices are generating massive amounts of data that need to be processed and stored.

Despite the challenges, the capabilities of the IoT are already quite impressive. The ways in which chemists, chemical engineers, systems designers, and implementers respond and handle these challenges will have significant impact on how IoT develops in chemical industry.

5. CONCLUSION

The IoT is enabled by the latest developments in Internet protocols, RFID, smart sensors, and communication technologies. The main advantage of the IoT concept is the high impact it will have on various aspects of everyday-life of potential users. The IoT will gradually allow for the automation of everything around us.

The US government and government of other nations such as the UK, China, and India are taking drastic measures to incorporate IoT into many industries. This action will have impact on various government projects such as smart cities, smart manufacturing, smart materials, smart transportation, smart power grids, smart agriculture, etc.

The next wave in IoT in the chemical industry is the so-called Internet of Chemical Things (IoCT). This is basically a growing network of computers, mobile devices, online resources, software suites, and a host of other machines, all interconnected to users through the Internet. IoCT is changing how we do chemistry and business. While in its infancy across many chemistry laboratories and departments, it is posed to have great impact on all of us [16]. However, it will take a while to figure out how to effectively use this technology.

REFERENCES

[1] R. Bhatnagar, "Role of IoT & its impact on various industries in India," *Data Quest*, April 2016.

[2] L. D. Xu, W. He, and S. Li, "Internet of things in industries: a survey," *IEEE Transactions on Industrial Informatics*, vol. 10, no. 4, November 2014, pp. 2233-2243.

[3] G. Wiggins, "Chemistry on the Internet: the library on your computer," *Journal of Chemical Information and Computer Sciences*, vol. 38, October 1998, pp. 956-965.

[4] M. N. O. Sadiku, and S. M. Musa and S. R. Nelatury, "Internet of Things: An Introduction," *International Journal of Engineering Research and Advanced Technology*, vol. 2, no.3, March 2016, pp. 39-43.

[5] H. Li and Y. Liu, "Research on the chemical logistics management information platform based on Internet of things," *Proceedings of International Conference on E-Product E-Service and E-Entertainment*, November 2010.

[6] S. S. Tabrizi and D. Ibrahim, "Security of the Internet of things: an overview," *Proceedings of the 2016 International Conference on Communication and Information Systems*, December 2016, pp. 146-150.

[7] I. Lee and L. Lee, "The Internet of things (IoT): Applications, investments, and challenges for enterprises," *Business Horizons*, vol. 58, 2015, pp. 431-440.

[8] Z. Bi, L. D. Xu, and C. Wang, "Internet of things for enterprise systems of modern manufacturing," *IEEE Transactions on Industrial Informatics*, vol. 10, no. 2, May 2014, pp. 1537-1546.

[9] S. M. Bachrach (ed.), *The Internet: A Guide for Chemists*. Washington, DC: American Chemical Society, 1996.

[10] S. Guertzgen, "How IoT could transform the chemical industry," *Digitalist Magazine*, July 2015.

[11] H. Wang et al., "The research of chemical plant monitoring base on the Internet of things and 3D visualization technology," *Proceedings of the IEEE International Conference on Information and Automation,* Yinchuan, China, August 2013.

[12] N. Kshetri, "The economics of the Internet of things in the global south," *Third World Quarterly*, vol. 38, no. 2, 2017, pp. 311-339.

[13] P. Miller, "Get Ready for The Internet of things industry has an opportunity to lead the revolution," Chemical *Processing*, May 2014,

https://www.chemicalprocessing.com/articles/2014/connected-plant-get-ready-for-the-internet-of-things/

[14] D. Miorandi et al., "Internet of things: Vision, applications and research challenges," *Ad Hoc Networks*, vol. 10, 2012, pp. 1497–1516.

[15] E. Borgia, "The Internet of Things vision: Key features, applications and open issues," *Computer Communications*, vol. 54, 2014, pp. 1–31.

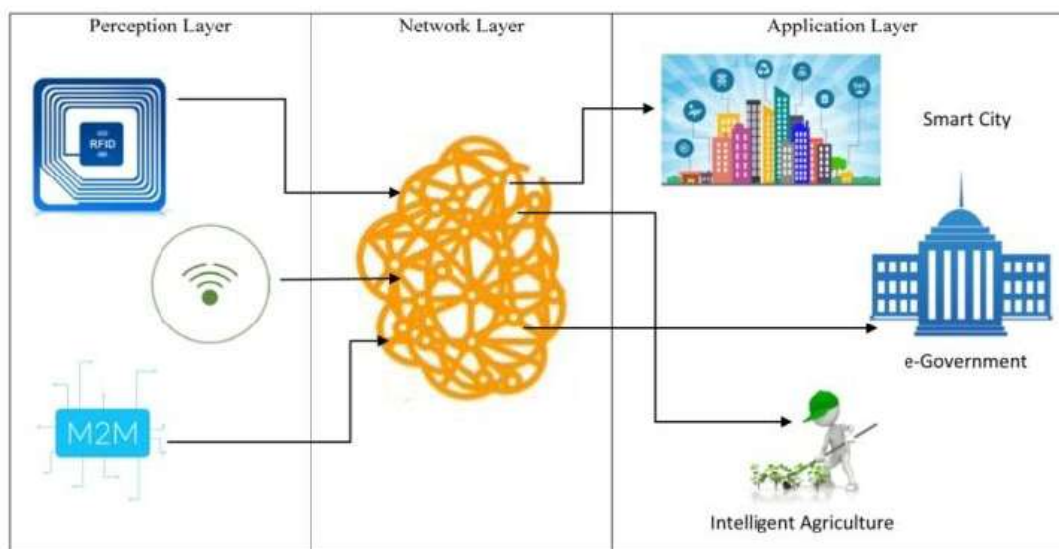[16] S. V. Ley et al., "The Internet of chemical things," *Beilstein Magazine*, vol.2, no. 1. 2015.
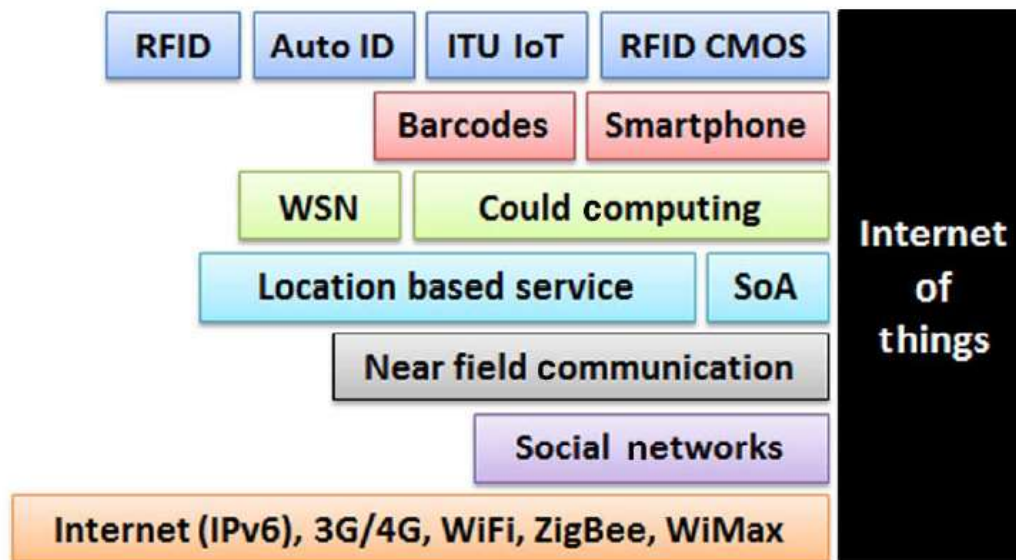
Figure 1. The IOT layers [5].

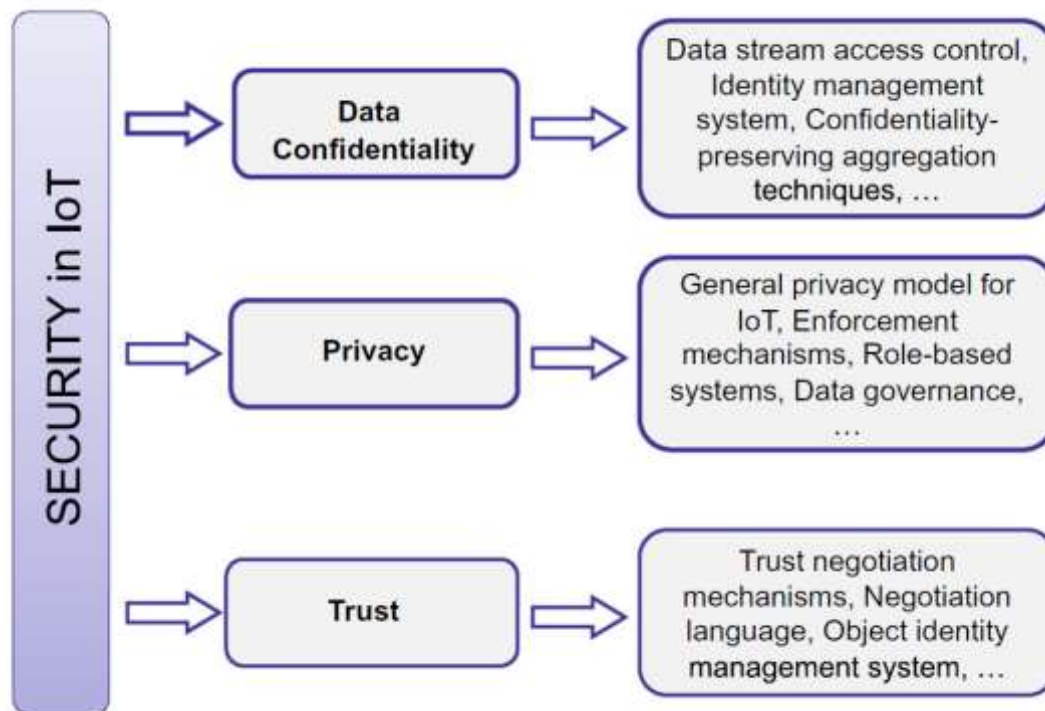**Figure 2. Technologies associated with IoT [6].**

Figure 3. A representation of security challenges in Internet of things [14].

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