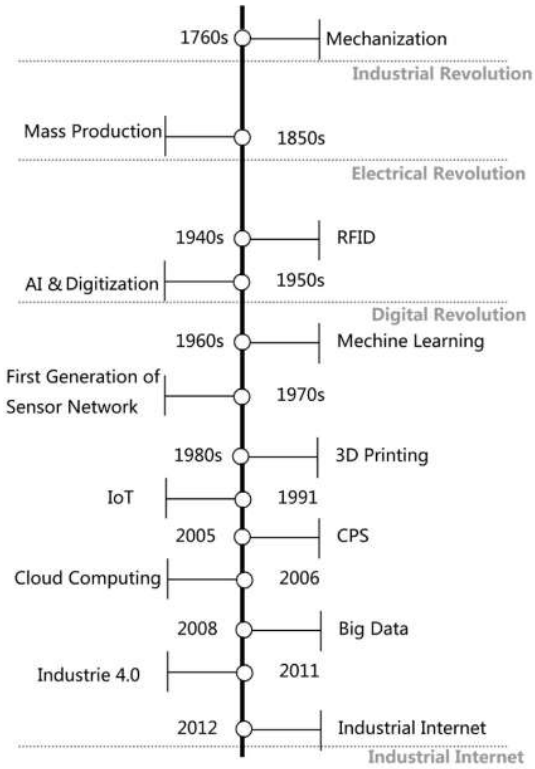
Industrial Internet System

Lecture-12

Over the last two hundred years, the world has experienced four major waves of innovations. The first wave of innovations, known as the Industrial Revolution, started in the mid-eighteenth century with the introduction of the steam engine into the industrial production process. The second wave started at the beginning of 20th century and accelerated the industrial evolution by the introduction of electricity. In the 1950s, the third wave started with the development of the modern computing technologies and the invention of the Internet that connects computers with one another. The indepth merging of the Industrial Revolution and the Internet Revolution, results in a new wave of the Industrial Internet revolution.

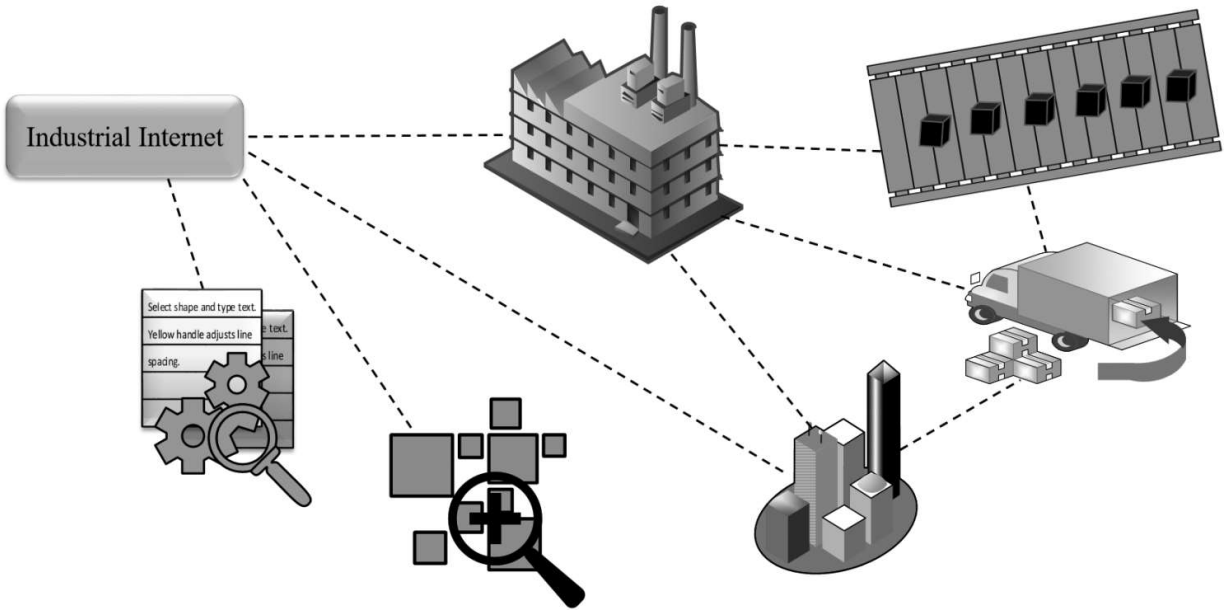
From the end of the 20th century to the beginning of the 21st century, the information and communication technologies grew exponentially, which resulted in a spectrum of new technologies such as Radio Frequency Identification (RFID (1940s), Artificial Intelligence (AI) (1950s), Sensor Networks (1970s), 3D Printing (1980s), IoT (1990s), Cyber-Physical Systems (2005), Cloud Computing (2006), Big Data (2008), etc. These technologies significantly improve the industrial production by increasing the intelligence in the sensing (RFID and IoT), networking (Sensor Network and Cloud Computing), decisioning (Artificial Intelligence and Big Data), control (CPS), and manufacturing (3D printing). With the vision of combining the advanced information technologies with traditional industries, the Industrial Internet is currently prevalent in both academic and industrial communities. In 2014, the Industrial Internet Consortium (IIC) was founded by AT&T, Cisco, Genral Electric, IBM and Intel, which sets benchmark for the Industrial Internet and promotes the development of the Industrial Internet. Many industries have given other name to the Industrial Internet. GE (General Electric) coined the name " Industrial Internet " as their term for the Industrial Internet of Things, and others such as Cisco termed it the Internet of Everything and others called it Internet 4.0 or other variants.



Timeline of key milestones of the Industrial Internet.

The Industrial Internet provides a way to get better visibility and insight into the company's operations and assets through integration of machine sensors, middleware, software, and backend cloud compute and storage systems. Therefore, it provides a method of transforming business operational processes by using as feedback the results gained from interrogating large data sets through advanced analytics. The business gains are achieved through operational efficiency gains and accelerated productivity, which results in reduced unplanned downtime and optimized efficiency, and thereby profits.

The term Industrial Internet was coined by the U.S. corporation, GE. Industrial Internet resulted from the combination of physical and digital worlds. As defined by GE, Industrial Internet is "the convergence of the global industrial systems with the power of advanced computing, analytics, low-cost sensing, and new levels of connectivity permitted by the Internet." The Industrial Internet brings together the advances of two transformative revolutions: the myriad machines, facilities, fleets and networks that arose from the Industrial Revolution, and the more recent powerful advances in computing, information and communication systems brought to the fore by the Internet Revolution. The basic concept of the Industrial Internet is illustrated in figure.



Industrial Internet

The Industrial Internet-enabled organizations use sensor nodes, software, and Machine-to-Machine (M2M) communication to collect data from material things or devices. The interconnected devices in industries, automated assembly line, real-time data collected from sensor nodes, and their analysis together can be referred to as the Industrial Internet. The processed and analyzed data provide value-added services. Industrial Internet will lead to an increase in the speed and efficiency in a wide range of industries such as aviation, railways, mining, power generation, and healthcare systems. Additionally, it will result in improved job facilities, accelerate the productivity of the manufacturing system, and promote all-round economic growth. In simple words, the industries will have optimized and centralized management of the equipment, processes, and systems in the industries. According to GE, there exist three phases in the development of the Industrial Internet, which are as follows:

(a) **Industrial Revolution**: During the first and second industrial revolution, the productivity and mechanization of factories were initiated. The efficiency of water power generation, development of steam engines, and fuel cost reduction occurred during the first industrial revolution. With the advent of the assembly lines during the second industrial revolution, mass production started. Additionally, wireless communication using cell phones were developed in the later stages during this period.

(b) **Internet Revolution**: The third industrial revolution led to the development of automation in the manufacturing system, computers, and the emergence of the internet (World Wide Web). This revolution is also known as the Computer or Digital Revolution. One of the most remarkable effects of this revolution was information exchange over large distances through the internet and smartphones.

(c) **Industrial Internet**: The amalgamation of CPS and the evolution of Internet-based technologies led to the development of the Industrial Internet. Therefore, it is generally assumed that Industry 4.0 or the 4th industrial revolution evolved from these technologies

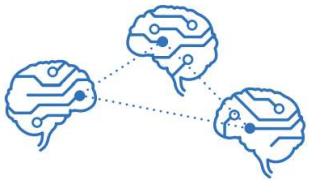
Intelligent machines, advanced analytics, and connected people are the key elements behind the development of Industrial Internet. The interconnection among these key elements and their combination improve the overall economy through optimization of the processes, minimization of product costs, and real-time analysis of data. The real-time data helps to provide deeper insights and improve the system operation in various industrial sectors.
The three key elements of the Industrial Internet are:

INTELLIGENT MACHINES

New ways of connecting the word's myriad of machines, facilities, fleets and networks with advanced sensors, controls and software applications.

ADVANCED ANALYTICS

Harnessing the power of physics-based analytics, predictive algorithms, automation and deep domain expertise in material science, electrical engineering and other key disciplines required to understand how machines and larger systems operate.



PEOPLE AT WORK

Connecting people, whether they be at work in industrial facilities, offices, hospitals or on the move, at any time to support more intelligent design, operations, maintenance as well as higher quality service and safety.

The catalysts behind the development of Industrial Internet are as follows:
(a)The investment in the deployment of sensor nodes, required instruments, business processes, and updated user application interfaces will promote the development of new technologies.
(b) The security of sensitive information, data, and intellectual property (IP) requires a robust security system.
(c) To instigate the growth of new talents such as advanced engineering studies, data scientists, and software experts promote industrial development.

Applications of Industrial Internet:

As the rise of the Industrial Internet, different applications related to the industrial production process becomes more and more intelligent enabled by the advanced information technologies. The advent of the Industrial Internet also brings industrial control systems online to form large end-to-end business and analytics solutions. These end-to-end systems are referred to Industrial Internet Systems (IISs), which cover the area of energy, healthcare, manufacturing, public sector, transportation and related industrial systems. Industrial Internet has brought a wave of transformation in the industrial sector with the help of available resources such as smart sensor nodes, software, and M2M communication. It has a wide range of applications in various industries which are as follows:
Aviation industry: Industrial Internet helps in the management of crews, reduction in fuel consumption, maintenance of the flight engine, timely flight repair, and cancellation and schedule of the flights. The optimization of operation and assets upgrade the safety of workers at each of the stages of operation.
Transportation: The real-time analysis of collected data, predictive analysis of the data, and software availability result in the reduction of the maintenance costs, breakdown of engine, and optimization of train schedules. The optimal scheduling of trains results in cost optimization, optimum supply management, and maintenance of timing. Further, with the integration of advanced technologies, the on-road safety of vehicles and drivers can be improved.
Healthcare: With the exponential growth in the world's population, it is quite challenging to maintain healthcare standards. Internet connectivity has resulted in the availability of the reputation of doctors,

upgradation of the healthcare system, and improvement in the treatment outcomes. Thus, the Industrial Internet enables a safe, secure, and efficient healthcare system.

Public Sector: In the era of the Industrial Internet, the public sectors face the opportunities to integrate with the advanced information and communication technologies to reduce costs, reduce waste, improve public safety and service qualities for citizens. Citizens can use their mobile devices to request different public services. Through information and communication technologies, the public sector can provide more convenient services to citizens to link the public areas with virtual world to achieve a better management, education and maintenance. The sensor-embedded public facilities enable intelligent public services such as smart traffic management and monitoring, improving public education, public administration, public safety, crime prevention and emergency response. Typical services like E-Government, Environmental Services, Education Services, public safety.

Power Production: To enhance the production of power, maintain reliability, safety, and optimize the utilization of fuel are the primary objectives of the Industrial Internet. Power outage is a common problem throughout the developing world. To detect the location of the faults in power lines, or the faulty transmission line equipment is a difficult task. However, with the help of the Industrial Internet, as each of these devices is interconnected, the detection of faults can be managed in real-time.

Challenges of Industrial Internet:

Despite the potential vision of the Industrial Internet, many significant research challenges remain to be addressed before widespread deployment of the Industrial Internet, including the mixed criticality, fault tolerance, scalability, scalable collaboration, functional safety, security challenges, and legacy long-lived industrial systems

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2. Li, Jian-Qiang, et al. "Industrial internet: A survey on the enabling technologies, applications, and challenges." IEEE Communications Surveys & Tutorials 19.3 (2017): 1504-1526.