CHAIN REACTIONS

THEMATIC BRIEF ADVANCED MANUFACTURING 2

THE INTERNET OF THINGS IN ADVANCED MANUFACTURING

ABOUT INNOVATION BRIEFS

CHAIN REACTIONS addresses the challenge for industrial regions to increase regional capacity to absorb new knowledge and turn it into competitiveness edge and business value. There is a strong need to help SMEs to overcome capacity shortages for innovation and integration into transnational value chains.

The project aims at empowering regional ecosystems with the knowledge and tools to help businesses overcome those barriers and generate sustained growth through value chain innovation.

During the project lifetime CHAIN REACTIONS will publish about every 6 month five thematic briefs presenting the rationale behind specific innovation deployment within selected business areas.

As demonstrated in a previous CHAIN REACTIONS brief, Artificial Intelligence (AI) has transformed the whole manufacturing worldwide over the last few years. This was achieved thanks to the development of Internet of Things (IoT) technologies. This new brief illustrates how IoT has already started the 4.0 industrial revolution, a new wave of technological changes where manufacturing production will become more and more networked, until everything is interlinked with everything.

IoT in Manufacturing

IIoT enabling full Make-To-Order manufacturing

Internet of Things (IoT) refers to an arrangement or network of physical objects being connected to the internet, collecting and sharing data between each other. They have the ability to monitor data from the surrounding, transfer it from one device to another without requiring any human or computer interaction [1].

In the manufacturing world, the application of Industrial IoT (IIoT) is primarily used to achieve efficient, make-to-order manufacturing, linking the buyer directly with the manufacturing process and all related stakeholders. This evolution to fully automated and connected lean manufacturing, is leading the effort with goals of achieving greater customer satisfaction and highly efficient production [2].

This application of IoT technologies in the manufacturing sector will allow companies to offer better quality and retain the consumer. Thus, IIoT makes it possible to anticipate the needs of buyers, connecting different stages of production and obtaining information in real time. It has the key for efficiency, reliability, and availability to make the production and manufacturing sector more competitive.

The benefits of IIoT can also include:

- Providing information in real time to avoid interruptions in the production process allowing real time decisions.
- Detect and anticipate quality problems and serious equipment incidents thus maximize asset performance and uptime and reduce or prevent waste.
- Reduce production costs by identifying inefficiencies and improve process control.

- Adapt with greater agility to market demands

SAP's approach is one example of how new business models are leveraging platform-as-a-service based on IoT technologies and creating an ecosystem of suppliers for manufacturers.

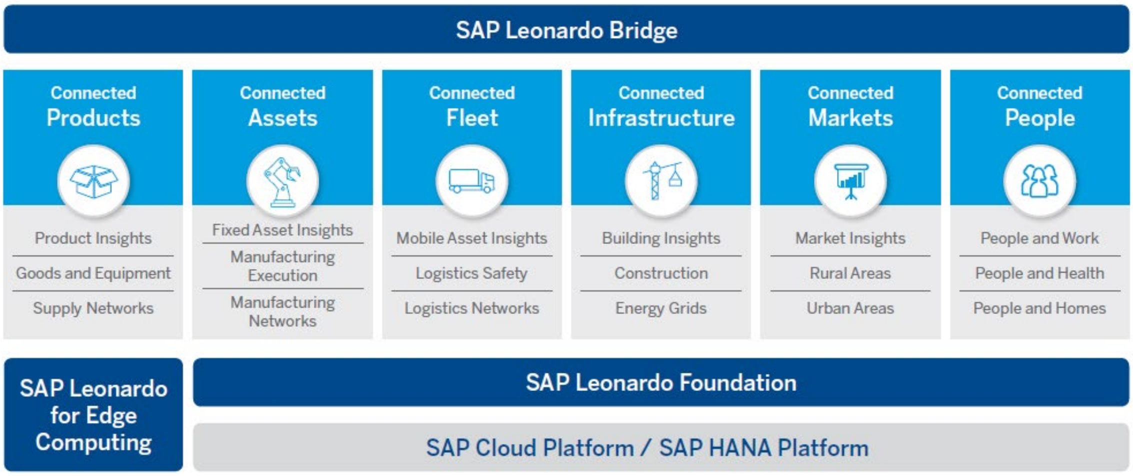

Figure 1: SAP Leonardo - Framework and ecosystem partners for IoT. [2]

At the end, IIoT as whole will support the transition from conventional make-to-stock (MTS) to emerging make-to-order (MTO), configure-to-order (CTO)and engineer-to-order (ETO) production models. Manufacturers will become more demand driven. Such production models are a key prerequisite for supporting mass customization, as a means of increasing variety with only minimal increase in production costs [3].

The IoT Market in Manufacturing

The Internet of Things in manufacturing industry is gaining robust growth due to the rising adoption of Artificial Intelligence (AI) and other connected devices based on machine learning. Still the emergence of COVID-19 in 2020 has brought the world to a standstill and we understand that this crisis has brought an enormous impact on businesses across industries. But, if almost every sector is anticipated to be impacted by the pandemic, this shall pass and, at the end, the overall IoT trend will continue or will be even accelerated. Covid-19 has forced many companies to freeze budgets or delay IoT spending but it is expected to re-accelerate.

Major players in this market are keeping developing strategies and guidelines by completing deliberate mergers and partnerships to develop advanced IoT solutions for the manufacturing industry. Small and medium enterprises are immensely adopting IoT solutions in their manufacturing units to maintain cost efficiency, productivity, and operation advancement in their businesses and will keep doing so in the next future.

As stated from IoT Analytics' study [4] (before the Covid-19 crisis), global spending on IIoT Platforms for Manufacturing was predicted to grow from $1.67B in 2018 to $12.44B in 2024, attaining a 40% compound annual growth rate (CAGR) in seven years. IIoT platforms are beginning to replace Manufacturing Execution Systems (MES) and related applications, including production maintenance, quality, and inventory management.

The IoT components in Manufacturing

The IoT in manufacturing comprises various components working together to collect and share real-time information between machines and humans: mechanical and electrical parts, advanced sensors, network connectivity architecture, controls, software applications, and smart devices.

The application of IoT in the scope of manufacturing can be classified in two broad categories:

- IoT-based virtual manufacturing applications, which exploit IoT and cloud technologies in order to connect stakeholders, products and plants in a virtual manufacturing chain.
- IoT-based factory automation, focusing on the decentralization of the factory automation pyramid towards facilitating the integration of new systems, including production stations and new technologies such as sensors, Radio Frequency Identification (RFID) and 3D printing.

As illustrated in the following figure, the architecture or technology stack of the IoT consists of different layers. A 4-layered architecture has been defined whereby each layer contains distinct technology, software, and devices. Three layers are hierarchical or vertical, and the security layer is transversal.

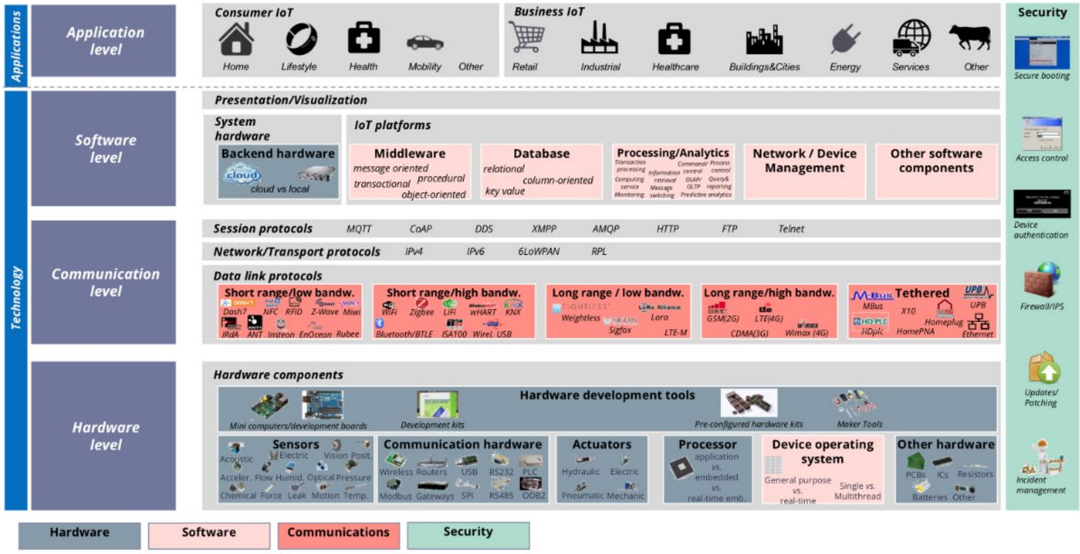

Figure 2: IoT architecture - IoT Analytics [4]

Sensors

Broadly speaking, sensors are devices that detect and respond to changes in an environment. Inputs can come from a variety of sources such as light, temperature, motion and pressure. Sensors output valuable information and if they are connected to a network, they can share data with other connected devices and management systems. Sensors are today everywhere in manufacturing and are crucial to the operation of many of today's manufacturing. They're embedded in devices and machines, bringing sensor usage to a new level and are integral part of the Industrial Internet of Things (IIoT).

The amount of new industrial equipment sold with integrated sensors has grown exponentially in recent years. The sensors are increasingly higher quality and less expensive. Exploitation of the massive volume of data generated by the sensors recently got possible thanks to the current low cost of connectivity, cloud implementation and deployment of big data platform.

Sensors can warn of potential problems before they become big industrial problems, allowing companies to perform predictive maintenance and avoid downtime. Sensors come in many shapes and sizes.

Following are the main types of sensors used in the manufacturing industry:

- Temperature Sensors: Temperature sensors measure the amount of heat energy in a source, allowing them to detect temperature changes and convert these changes to data. Machinery used in manufacturing often requires environmental and device temperatures to be at specific levels.
- Humidity Sensors: These types of sensors measure the amount of water vapor in the atmosphere of air or other gases.
- Pressure Sensors: A pressure sensor senses changes in gases and liquids. When the pressure changes, the sensor detects these changes, and communicates them to connected systems. Common use cases include leak testing which can be a result of decay. Pressure sensors are also useful in the manufacturing of water systems as it is easy to detect fluctuations or drops in pressure.
- Proximity Sensors: Proximity sensors are used for non-contact detection of objects near the sensor. Proximity sensors can for instance be used on assembly lines.
- Level Sensors: Level sensors are used to detect the level of substances including liquids, powders and granular materials. Many industries including use level sensors. Waste management systems provide a common use case as level sensors can detect the level of waste in a garbage.
- Gas Sensors: These types of sensors monitor and detect changes in air quality, including the presence of toxic, combustible or hazardous gasses. A common use case is the familiar carbon dioxide detectors.
- Infrared Sensors: These types of sensors sense characteristics in their surroundings by either emitting or detecting infrared radiation. They can also measure the heat emitted by objects.

Inxpect – Safety Sensors

The Italy-based startup Inxpect manufactures radar-based safety sensors. This type of sensor reduce the risks of accidents when working with several robots, without decreasing overall performance. Through predefined safety parameters, sensors permit robots to function only when there is no evident risk to humans, machines, or materials.

The sensor detects micro-movements in hazardous areas and creates an invisible barrier that puts the machine into safe mode in the presence of an operator. The sensors allow operators to work safely around moving machinery. It also prevents robots to restart during maintenance activities, creating a secure manufacturing environment. [5]

Radio Frequency Identification (RFID)

Due to the increasing cost of operation, manufacturers and contract manufacturers are searching for new ways to reduce costs and optimize their operations. Across the supply chain new technology implementation has been a cost saving solution, and it is no different for manufacturing operations. A lot of this growth can be associated to the adoption of RFID networks throughout the supply chain. These wireless networks are being implemented to act as “intelligent monitoring systems” that provide detailed track and trace functionality from manufacture to end consumer stages of the supply chain.

Radio frequency identification (RFID) is gaining significant interest from the manufacturing industry. It has become an increasingly recognized technology, with its real time tracking ability at a much greater level of accuracy and provides more value across a supply network. RFID-enabled technology with an associated system structure has emerged to provide solutions which apparently close the gap between the physical flow of materials and the information flow in the production system. As manufacturing supply chains rapidly enter the virtual world of the networked RFID system, their information systems are sharing the fundamental information that require intelligent tracking and tracing performance.
To make RFID a more viable solution for manufacturers, changes have been made to handle

their extreme operating environments. New and improved radio frequency tags were designed that can withstand extreme heat and cold, high pressures, hazardous locations and extreme moisture levels. With these improvements also came cost reductions as adoption started to increase on a much larger scale.

RFID can be used in manufacturing to address different objectives [6] :

- Ensure inventory traceability by tagging components and finished products
- Track and monitor equipment by placing RFID tags on this equipment thus helping to locate lost or misplaced assets and increase asset utilization
- Monitor waste levels from production lines though tagging component inventory, WIP and finished goods.
- Reduce carrying costs by improving data accuracy, allowing manufacturers to implement Just In Time inventory management strategies.
- Carry data related to predetermine shipping routes. As production is completed this data can be used to assist in staging outgoing shipments. This data accessibility expedites the shipping process and reduces required labor.
- Track and manage staff activity. RFID badges can be used for granting access to restricted zones.
- Control and monitor large machinery activity (RFID is integrated with machinery control systems).

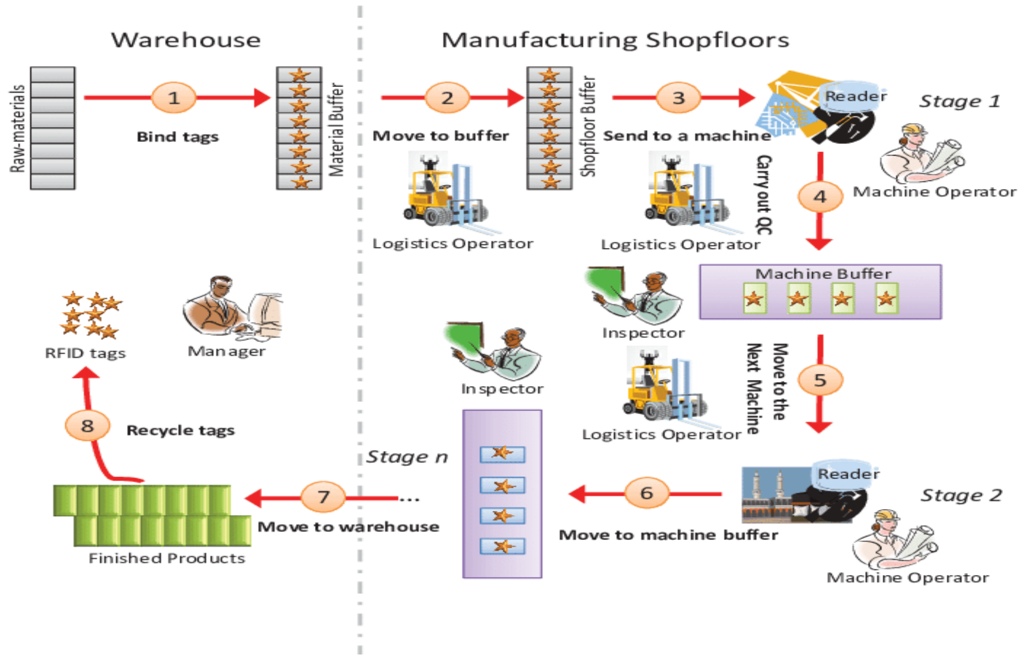

Figure 3 - RFID-enabled Real-time Production [7]

With so many applications for RFID technology it's not surprising that there are numerous companies manufacturing RFID tags and readers. RFID tags come in various frequencies (certain frequencies are being more common for particular applications). Certain RFID manufacturers only manufacture passive RFID tags (without internal power source and powered by the electromagnetic energy transmitted from an RFID reader), while other larger manufacturers manufacture practically every variety of tag and reader. The most known and trusted manufacturers of RFID technologies worldwide include Motorola, Zebra, Alien and RFID4U.

FEIG ELECTRONIC - RFID/barcode reader

FEIG ELECTRONIC is a typical example of a company specialist in contactless Identification

(RFID). Based in Weilburg, Germany, and with a workforce of around 400, the company contributes to advancements in technology with innovative solutions for a wide range of applications and industries. The unique identification of equipment and machines using RFID transponders or barcodes enables transparent documentation over the entire life cycle. Rapid identification of parts by means of the mobile RFID/barcode reader ECCO+ simplifies the workflow. The ECCO+ RFID/barcode reader detects HF and UHF RFID tags as well as barcodes. ECCO+ can also read and rewrite RFID transponders. Data is transmitted via Bluetooth or WLAN to a notebook, tablet PC, smartphone or Smart Glass. Because the device has been specifically designed for use in harsh environments, it is almost completely impervious to shocks or vibrations and can be easily operated, even when wearing thick work gloves. [8]

Predictive Maintenance

In terms of application, the market is divided into emergency & incident management, real-time workforce tracking & management, logistics & supply chain management, asset tracking & management, and predictive maintenance. Out of these, the emergency & incident management segment procured 20.1% IoT in manufacturing market share in 2018. But the predictive maintenance segment is likely to dominate the market by gaining the largest share owing to its dependence on the valuable information and insights that are achieved by the persistent equipment condition monitoring systems. [9]

Indeed, while the application of IoT technologies can bring benefits across the value-chain, it is arguably in the area of predictive maintenance that the most significant impact can be derived. Improving automatic control points in production is essential to locate faults, evaluate and correct them.

When various machines have embedded sensors, it automatically improves most of the industry's operations. For instance, if a system breaks down, the connected sensors will locate the issue and automatically trigger a message to the manufacturer. In addition, the use of IoT can also let a manufacturer predict future breakdowns or unsafe operating conditions through high-quality in-built sensors.

These sensors typically work by calculating the surrounding temperature, sound frequencies and vibrations of the machine to see if it's working within the normal given conditions or not. Also called as condition monitoring, the process is usually carried out through technology since doing it manually costs time, resources and money. The use of sensors makes it easier to analyze, store it in the cloud and predict it later through machine learning.

Location Tracking

IoT can also be used in manufacturing for location tracking. Indeed, workers spend a large amount of time finding tools, equipment and goods in the inventory. This time can be saved by deploying location-tracking sensors in each of the company's equipment.

Manufacturing products means thousands of goods into the inventory on daily basis. These products when are searched for and organized take a whole lot of time, causing inefficiency in the entire working cycle. Thanks to IoT, companies can come together to bring technology to measure their competence and save massive resources in the production lines. Using location-tracking sensors, manufacturing workers are now able to use the equipment to look for products and find their place of storage. [1]

Collaborative Robots

Using IoT technologies, a new generation of inexpensive robots are today working cooperatively with people in production environments. Human collaboration is getting possible because these robots are inherently safe sensing. They note when humans and other obstacles are in their path, and automatically stop to avoid causing damage. The simplified programming of these robots means they can be deployed without hiring specialized engineers.

ABB - Connected industrial robots

ABB is a Swedish-Swiss multinational which is, among others, active in automation. ABB produces industrial robots and manufacturing services for a variety of industries, ranging from automotive to electronics and, increasingly, the food industry. On top of making and selling such industrial robots, ABB provides a series of related services. In the case of ABB this was mainly in building a connected industrial robotics environment and offering with connected services thanks IoT technologies. In the past, ABB only could offer maintenance and support services to its customers when they had an issue with an industrial robot after the facts. From a technological perspective the whole service initiative was done by using an API of the Jasper Control Center (Cisco) in connection with the service business system.

The rise of IIoT security and safety investments

The Industrial Internet of Things comes with specific security challenges. Cybersecurity is one of the key reasons slowing down Industrial Internet of Things (IIoT) adoption. IoT security gets so much attention now that it is expected to temporarily have an impact on IoT productivity gains of companies as they are pushed and poised to invest far more in security. Moreover, regulations are coming and te whole IoT ecosystem with hardware manufacturers, solution providers and integrators is inevitably looking at security in a higher degree.

IIoT security does not just encompass data or transactions of course and requires that holistic approach. Along with the fourth industrial revolution, the new industrial Internet of Things landscape has emerged with millions of connected devices globally. Securing IIoT in manufacturing means affording protection to an enormous number of connected assets. IoT cybersecurity is not an isolated concept: it is interconnected with diffrent security disciplines, e.g. IT security, OT security and physical safety making the task even broader. As a result of shifting from closed to connected cyber-physical systems, manufacturing companies will need to handle the issue of the typical vulnerabilities in those systems.

These potential cybersecurity and physical safety concerns which are associated with IoT devices will pressure the companies to increase spending on IoT security, which will temporarily neutralize business productivity gains.

Hand in hand with 5G and IPv6

Since a few years there is a real technological 5G race going on. 5G is the next generation of cellular mobility and comes with a different architecture and far higher data transfer speeds than 4G while offering the kind of bandwidth that is needed for IoT. Several large industrial IoT companies are looking at the possibilities and adoption of 5G as the center of a heterogeneous network environment. 5G is in fact not designed for IoT but is a core key enabler for the deployment of IoT, even if is expected that 5G will only become mainstream towards the end of the 2020's. 5G is not just about higher data transfer rates, it is also about reliability, latency and what is known as edgeless computing.

The Internet of Things also go hand in hand with IPv6. IPv6 (Internet Protocol version 6) was a key step in the evolution of the Internet and the Internet of Things. IPv6 allows for 100 possible Internet addresses for every item on the face of the Earth. The number of available IPv4 addresses did not suffice anymore for IoT deployment. IPv6 will therefore essentially makes sure that we don't run out of IP addresses for IoT, and in particular for IIoT.

Conclusion

Industrial IoT (IioT) has the ability to radically transform manufacturing with the next decade. IIoT solutions will enable connected supply chains, informed manufacturing plants comprising informed people, informed products, informed processes, and informed infrastructures, thus enabling the streamlining of manufacturing processes. They will help in providing manufacturers a comprehensive vision to monitor complexities keep on arising at every intermediate point in the manufacturing process and assist in developing real-time adjustments. Furthermore, they will enable manufacturers to upgrade the current running operations by creating and tracking new business models.

As the global market, industry dynamics and even recent Covid-19 pandemic push manufacturers to reconsider operations, IIoT is increasingly becoming essential. More and more data will be created from connected equipment systems supported by the rising adoption of technologies such as artificial intelligence (AI). The industry giants are investing hugged amounts of money in the creation and implementation of IoT in manufacturing processes to enhance reliability and quality, as well as lower their overall manufacturing cost.

The cost and performance of machine-to-machine communications itself has improved dramatically with IoT applications, making it also possible for SMEs to create holistic and responsive manufacturing. Many IoT solutions are therefore emerging for manufacturing, but they are not necessarily being funded or reviewed by IT. The company's end users may have the best understanding of the business use cases for IoT for but it could a negative if IT consultations on security, scalability, and support get skipped.

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