ENGINEERING AND R&D SERVICES

HCL

Industry 4.0

WHITE PAPER

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Industry 4.0 will lead to the ultimate digitization of the manufacturing shop floor

Introduction

Industry 4.0 is an initiative by the German Government to achieve the ultimate digitization in manufacturing - making all manufacturing units smart, whether big or small; and this means:

- Bringing all systems equipment to communicate on a single standard platform and exchange information - not only vertically within the company but also horizontally - with end users and vendors for planning, tracking, logistics, operations and maintenance.
- All equipment is to be smart - All machinery involved - from raw material handling to finished products - to be equipped with the necessary intelligence to record its performance, asses its health, seek replacement for components nearing the end of life, and seek assistance from experts on its own, using cloud-based services to perform at optimum levels.
- Above all, ensure that all equipment and systems run safely and securely.

A similar initiative, Smart Manufacturing Leadership Coalition (SMLC) is also being promoted in the U.S.

To implement the Industry 4.0 strategy, it would require legalization to protect IP data and to train people. This document focuses on each of the items above.

Integrating Systems and Machines

The meaningful integration of systems across companies with the single objective of improving productivity and efficiency is the biggest mission of Industry 4.0. Today, manufacturing plants have deployed many IT systems - ERP systems for planning, MES systems for production control, control systems to operate the plant, and

Industry 4.0 aims at linking or mapping the manufacturing dynamics in the value chain

many more. However, there isn't much synergy between them though they have communication interfaces. There is also very little interaction with the systems of other stakeholders such as vendors, customers and end users.

Industry 4.0 aims at linking or mapping the manufacturing dynamics in the value chain from the end consumer to major OEMs to primary, secondary or tertiary vendors of OEMs. A change in dynamics, either deliberately (like a component recall) or unforeseen (like a weather change disrupting the delivery schedule) will lead to revised automation schedules that can provide directions on deploying backup mechanisms to completely mitigate the change.

This, in turn, leads to the development of accurate models[1] covering all the aspects of business - from customer requirements to product architecture and manufacture of the finished product.

1. Models are useful because they describe or mimic reality. They typically help people analyze a situation by combining ideas with information about the specific situation being studied. Models help us to make sense of the world's complexity,

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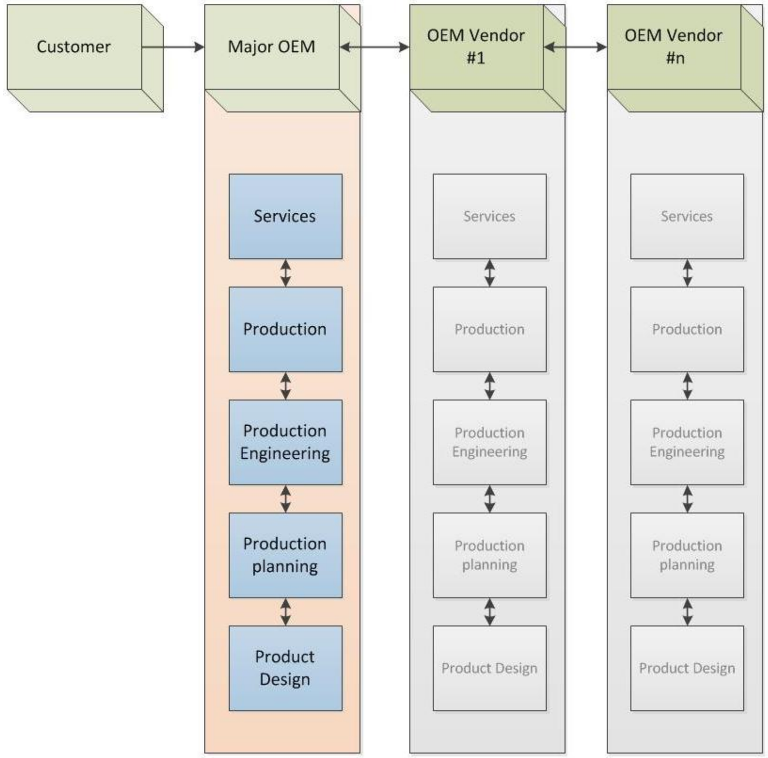

Use Case 1

Today, it is not possible to customize the standard features of an automobile for a single customer. For example, if a customer wants a different type of steering wheel, he/she would get it done elsewhere at an extra cost. In the Industry 4.0 era, once all systems and equipment are interconnected within the organizations and between vendors and end users, specific customer requests can be intimated to vendors, who in turn will produce or ship these as part of the normal delivery cycle. The equipment in the assembly line will be made aware of the change for that 'specific car to be assembled' and accordingly will run its execution. The customized car would be assembled **without any additional** manual intervention.

Use Case 2

A mobile phone Chip manufacturer discovers a fatal bug in the processor, much later after the phones are sold. The mobile phone manufacturer recalls the phones that are already sold and has to implant new processors. In the Industry 4.0 era – mobile phone OEMs will be able to send the impact of the redesign to all their vendors, assess or select vendors who can implement the changes at the earliest time and with the required quality based on their manufacturing processes, track their supply, instruct their own machine for changes to be done to accommodate a new processor and provide a transparent tracking mechanism to end users affected by the recall.

Use Case 3

The Railways is a big consumer of steel; rails are made of steel. Research on recent derailment indicates its weakening due to corrosion, and it has been decided to change the specification of the rails. Steel plants and their vendors have to change their operations, processes and schedules to accommodate the changes. Steel plants and their vendors cater to customers other than the Railways. In the Industry 4.0 era, an entire steel plant operation could be available as a near perfect model, that would enable them to model the changes. The model output would start with identifying the risk factors, redefining the operating parameters for equipment used in rail manufacture, defining the operation target to vendors, estimating the cost involved, and more importantly, assessing if the new operations are within safety limits, else proposing a new set of instructions that comply with safety operations, and predicting/tracking the delivery schedules to the Railways without comprising on committed delivery or quality to other customers.

Intelligent machines - those that can monitor their health and seek assistance much before breakdown stage - are an integral part of Industry 4.0

Benefits

Such an implementation will lead to precise planning, zero wastage and complete transparency across vendors to finished manufactured items. Customers will be assured of on-time delivery, will be intimated precisely of the date and hour of the delivery and can order equipment irrespective of the complexity of the end product - be it a screw or a space shuttle.

Intelligent Machines

Another mission of Industry 4.0 is to make all equipment smart within a manufacturing unit,.

This would include:

- Sensing Key Performing Indicators (KPI) from the equipment. If it's a pump, it would sense the vibration, internal temperature, power consumed, flow output, and running hours. The equipment would have the provision to deploy sensors to measure these critical parameters. In older equipment, this would prove to be a challenge.
- Equipment should have the necessary hardware and firmware to collect data and send it to a central Data Acquisition System (DAS). DAS would be on cloud or on-premise.
- The DAS or equipment will have to be built in algorithms to analyze the health of the equipment and raise alerts on degradation of performance. This is where Big Data analytics will be used for predictive maintenance. In a more mature deployment, equipment shall seek help, using a cloud platform from the right experts who would be available online.
- Remotely controlling the equipment.

Highly networked systems need to be cyber secure and their operations should not pose any risk to human lives.

Use Case 1

In a power plant, a recently installed raw water pump has vibration sensors on the ball bearings and observes that the ball bearings have reached 80% of their useful life. Realizing that the cause of the problem lies elsewhere and not with the ball bearings (as this is a recently installed pump), it identifies the possible causes, runs diagnostic tests for all the possible causes, and if it still hasn't arrived at conclusive reasons, it will be able to send emails to the experts and act on their response, or appropriately place orders from a pre-selected list of vendors.

Security and Safety

When systems and equipment are extensively interlinked between organizations, security becomes paramount. Industry 4.0 can succeed only when networked systems are available and running all the time. Any downtime due to unauthorized instructions or restoring to normalcy after a security attack would affect the production of all upstream and downstream companies. Similarly, equipment used in production processes should be safe i.e., under no circumstance should the operation of these machines be a risk to human lives, and it is equally important that they should be highly reliable[2].

Though security and safety are already well acknowledged and appreciated by the industry, what makes them important from an Industry 4.0 context is when processes and operations are dynamically modified to suit customer requirements, security and safety checks are to be applied for each change, including the mitigation actions, and then the processes may be deployed. So,

2. Reliability refers to the probability of a (technological) system operating correctly for a given period of time in a given environment.

safety and security checks and measures will be an integral part of the Industry 4.0 DNA.

Enablers

To deploy Industry 4.0, certain enablers are required.

Processes and Frameworks

From the above example, implementing such a thing would involve all stakeholders to be on a common platform. Here, stakeholders are not only from different organizations like vendors and customers but also equipment within the company should be able to interoperate. **Cyber Physical Systems** (CPS) will be a framework that all stakeholders and their systems and equipment, will need to comply to be part of Industry 4.0, and that would range from ERP systems, control systems, building management systems, asset management systems, interfacing to Smart Grids, Smart City management systems, and more. CPS will dictate what information needs to be exchanged, how the exchange would take place, and have business rules to trigger actions. This is much more than just an IT technology framework. Defining rules and standards that would affect the manufacturing processes across the industry will be the biggest challenge.

A huge amount of R&D and effort would be required to develop this common platform. It would require bringing together domain specialists related to manufacturing - product design, production planning, operations and maintenance.

To take an example, ISA-95 is an international standard for the integration of enterprise ERP systems and control systems that are used in operations. ISA-95 consists of models that define what information has to be exchanged between systems for sales, *IoT and 3D printing are enabling tools in Industry 4.0*

finance and logistics, and systems for production, maintenance and quality. ISA-95 would be one of the many standards that manufacturing systems will need to comply with in Industry 4.0. Similar to ISA-95, standards need to be defined for the exchange of data from systems used in Design -> Planning -> Operations -> Maintenance. Such standards would define the model to exchange data among organizations, and with customers.

Modeling

Modeling of equipment and processes to simulate a real time scenario is a critical element of CPS. CPS will rely on models to study the change required and suggest the directions to all stakeholders. A company that has to manufacture a few pieces of a product with a different specification will rely on models to do an impact analysis and accordingly instruct all its equipment of the changes to be made. The models will be adaptive and self-correcting from real world inputs.

Internet of Things (IoT)

IoT is going to be the technology platform for interfacing all smart equipment. In the first place, existing equipment requires more sensors for measuring their health, which could be vibration, temperature, and power consumption at all vulnerable points. The IoT framework would collect data from all sensors, store this in a cloud platform, make data available to users, and perform data analytics to predict equipment health. CPS would entirely operate on the IoT backbone.

3D Printing

In 2015, Aeronautical engines are going to be 3D printed. To quickly realize unique customer expectations, 3D printing will be

Challenges are many in Implementing Industry 4.0. Certainly it will be capital intensive

more frequently used. In mass production, it would be possible to instruct the 3D printers to produce one component to a different specification compared with the rest.

Conclusion

Industry 4.0 holds out promises that would completely automate manufacturing by interconnecting systems across organizations. Systems and equipment would have the necessary intelligence to dynamically configure themselves to be adaptable to varied customer requirements.

All this is not going to happen overnight, and there are challenges:

- The standards to communicate with vendors and customers across different industries - from product design to product services - has to evolve.
- Existing capital intensive equipment has to be made smart if it is not possible for them to be replaced with newer smarter versions.
- People need to be educated on the new way of working. Emphasis will be on learning to harness the new systems and processes and that would require a lot of unlearning and learning a new way of making products.
- Reliable secure systems need to be in place
- Challenges will eventually be overcome and Industry 4.0 will be the new normal for manufacturing, providing tangible benefits in:
    - The ability to cater to any customer need with the desired quality
    - Productivity and efficiency
    - Manpower/ required skill sets in manufacturing

References

1. "Recommendations for implementing the strategic initiative INDUSTRIE 4.0", German Federal Ministry of Education & Research
2. ISA95 processes, http://www.isa-95.com/

HCL ERS's Role in Industry 4.0

Industry 4.0 is very relevant to HCL's ERS Group who are very cognizant of this emerging way of manufacturing. Though it is only a project initiative in Germany, the manufacturing world will be watching its growth, and success and will soon follow.

CPS will be one huge elephant that will evolve, largely propelled by work done by the Industry 4.0 Working Group. Services around CPS will grow exponentially. This is where HCL and IT services will play a major role. To elaborate:

1. Making existing equipment smart . Not all equipment used in manufacturing have sensors to measure their critical parameters and send the data to central servers for analytics and data archiving. OEMs have to deploy retrofits to their existing equipment and this will be a big area for HCL ERS in Industry 4.0. Retrofits will involve
    - Mechanical: Design for installing sensors
    - Electrical: Hardware and firmware design to read sensor data and wire/wirelessly transmit it to a central server
    - Coming out with a common platform to make equipment smart. All OEMs come out with different variants of a basic model and it would be necessary for design to cover all such variants.

2. Needless to say, as each equipment is going to send real time data. Big Data analytics is going to be an integral part of Industry 4.0.

3. Application Development around CPS. As CPS will define the standards for information flow among manufacturing units within and across organizations, developing applications using CPS, termed as Orchestration[3] will be one big need by manufacturing units. MES systems have to closely be integrated not only with ERP systems but also with control systems , CRM systems, and most importantly, should comply with CPS standards.

4. Modeling of Systems and Equipment . For CPS to succeed, the models need to exactly replicate real time situations. Model development will be another area for engagement for HCL ERS. Using past data, system constraints, provisioning for wear and tear, the developed model algorithm will accelerate exponentially as Industry 4.0 evolves. Modeling will not be restricted to equipment alone. Modeling of manufacturing flows, simulating vendors and other external agencies, like the Government, the municipalities, and power and utilities suppliers are all part of modeling under CPS.

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3. Orchestration' will mean more than web services. It should explicitly include the setting up of shared services and applications in collaborative inter-company processes and business networks. Issues such as safety and security, confidence, reliability, usage, operator model convergence, real-time analysis and forecasting will all need to be reviewed for the orchestration

Author Info

Mahesh Subramanian

Mahesh is from the ERS Industrial Practice Group in HCL. His current areas of interest are in Functional Safety and Internet of Things.