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SUPPLY CHAIN WIDE TRANSFORMATION OF TRADITIONAL INDUSTRY TO INDUSTRY 4.0

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ABSTRACT

Industry 4.0 is the latest technological innovation of Germany which aims to improve production capability and flexibility by the integration of intelligent systems in industries. As it says, industry 4.0 is a fourth industrial revolution and it is the emerging topic for the industries and researchers. The term industry 4.0 refers not just increased industrial automation, but also to the cyber-physical systems, the internet of things and the ever-growing link between the virtual and physical worlds in manufacturing systems. This paper presents an approach to how existing production systems that are not Industry 4.0 can be transformed and expanded to Industry 4.0 factory. Within this paper, a concept is presented how production systems can be integrated in different stages and included into an Industry 4.0 environment, even though they did not have interfaces when they would have been manufactured. The concept of transformation is based on cyber physical system gateway and servers. Besides the concept itself, it also presents a validation that demonstrates where these interfaces are previously applied or integrated. We aim to synthesize sophisticated information technologies into factory and manufacturing automation. In the present context, the step wise procedure for supply chain wide transformation and some of the expected beneficial outcomes were also discussed.

Keywords: industry 4.0, cyber physical production system, supply chain, integrated network.

INTRODUCTION

Industrial Production has come to the edge of another industrial revolution [18]. That is fourth industrial revolution i.e. Industry 4.0, it is one of the German research initiatives to implement the high-tech strategy 2020 to meet the challenges of the 21st century. The first Industrial Revolution "Mechanization" as a result of the invention of the steam engine, the second "Mass production" with the help of electricity and the third "Digitization" by the use of Electronics and IT, these takes the dawn of the fourth Industrial Revolution through the use of cyber physical systems (CPS) and the Internet of Things and Services [3]. The present industrial revolution (Industry 4.0) is advancement of factories or production systems by integrating them with cyber-physical systems (CPS). The basic approach of Industry 4.0 is by using the ability of cyber-physical systems to provide intelligence and communication for artificial, technical systems which are called smart systems. The processing plants (smart factories) are still being an imagination for some industries. Future production systems must be designed by considering the requirement of individualized items and, along these lines, the need for high adaptable production processes. To achieve this challenge, Cyber Physical Systems (CPSs) [25] should be incorporated into the industries so as to make 'Smart Factory'. A machine that gives information from the general framework and from each of its segments i.e. from the floor shop to inventory network wide (supply chain wide) incorporating the client in this framework and that allows simple access for information procurement and charge execution could be a CPPS in the connection depicted previously. CPS goes with the trend of having information and services everywhere at hand, and it is highly networked in world of today. Embedded systems, such as smart phones, cars and household appliances are the inseparable part of modern life. It is possible to control only a few of them. But these systems are to shorten the process time and these can also be controlled by remote control for processing data. The traditional manufacturing systems are still in operation despite the fact that more CPPSs are introducing in shop floors each year. Generally, the life time of machine devices will be somewhere around 15 and 20 years. However, smart factories will be acknowledged much faster if the existing traditional factories can be changed into industry 4.0. This presents implementation for transformation of traditional industry into CPPSs based on a CPS and SCM wide transformation approach is presented. Section 2 explains the present state of the art, followed by Section 3 describes the concept of the CPPS enabling system. In Sect. 4 and 5, presents the transformation procedure. Section 6 gives a validation of the CPS enabling system. The benefits of transformation are presented in Section 7 and finally conclusion.

STATE OF THE ART

Today, many industries are still organized progressively from the shop floor level in the product, information, process and organizational prospective. As, the requirement of products are changing every day there is a need of advancement of these factories into latest production systems. The present model shows the step wise procedure for integration and transformation of existing production systems to the industry 4.0 by considering the full supply chain model. The considerations for this model for transformation is done from the shop floor level i.e. operator and machine level to supply chain level. As, the latest factories and technologies are mainly depending on integration and individualization of systems. So each system is considered

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as individual but all are integrated with the cyber physical systems and cloud data transformation.

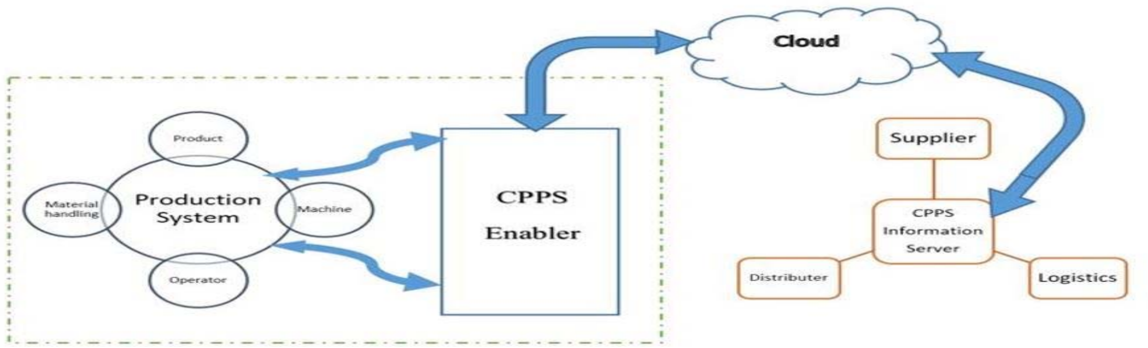

Figure-1. Network of cyber physical production system.

Communication networks of production systems

Production systems have different interfaces which can be recognized inward and outer interfaces [7]. Inner interfaces are by and large used to grow a production framework control with extra process and control usefulness. Outer interfaces are utilized to join the production framework with the encompassing production site, for the most part with systems for client connection as human machine interfaces (HMI), machine and production information securing or production administration as machine execution systems (MES) [28]. Every interface characterizes its own particular correspondence components and profiles, despite the fact that some of them are utilized seller free and others as a part of an exclusive way. Then again, the majority of today's interfaces are Ethernet-based and can be gotten to—by and large—over an IP system. That applies for interfaces in the field gadget level (e.g. Ethernet-IP) and in addition in the control level. The modern correspondence conventions can be utilized for the correspondence as a part of every level of the data pyramid of automation. On the other hand, these conventions don't fulfil the prerequisites with respect to correspondence interfaces for CPS: All displayed conventions are statically designed amid the authorizing of the production system. An instrument to consequently find and to interface with other production systems does not exist.

CPS system

Production destinations are a collection of diverse production systems that are not as a matter of course arranged to be a piece of an Industry 4.0 manufacturing plant. The change of production systems into CPPSs requires ideas and answers for the coordination of these systems. The infer components for identifying and uniting with these systems too to access and conveying information and summon interfaces.

Connecting to CPS system

Being a part of an Industry 4.0 processing plant expect the likelihood to effortlessly find and to interface with a CPPS. That suggests the discovery of accessible correspondence interfaces of the suitable production. The revelation server gives all enrolled association focuses. Nonetheless, it is ventured to know the location of the revelation server. Thus, a complete independent finding of correspondence interfaces is impractical. To augment the revelation approach, the disclosure usefulness must be coordinated in an overlying capacity. That overlying capacity seeks in a characterized IP range for usually utilized ports as a part of the computerization region to identify accessible disclosure servers. With respect to revelation usefulness it has besides to be viewed as that correspondence interfaces in the region of production systems are different. The assortment emerges essentially out of the long life cycles of production systems and the need to bolster everything about correspondence instruments the length of these production systems are being used. Consequently, the revelation capacity should be received for distinctive correspondence interfaces generally utilized as a part of the computerization range. Having distinguished the accessible correspondence interfaces of a production system, a door (CPPS empowering agent) that is in charge of getting to and transmitting information of the production system can associate with the most pertinent correspondence interface.

CPS functionality

The main gathering incorporates a wide range of functionalities that are joined with information obtaining. The procured information can be utilized for quality confirmation applications, production investigation applications, applications for blunder recognition and numerous more utilize cases. The other gathering incorporates usefulness that is effectively affecting the production system. Applications that utilize the usefulness, e.g. production system. The layout for every usefulness is pre-characterized to guarantee an institutionalized semantic. The layouts can be utilized for adding to a CPPS empowering influence to connect the current production system to the Industry 4.0 industrial facility. In the wake of having found and joined with the production system in

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the CPPS empowering agent the usefulness must be chosen which ought to be given to the CPPS Information Server. The required information of the usefulness and the current information extricated from the production system through the open correspondence channel must be blended. In view of this, two applications can convey over correspondence channels and characterized usefulness with one another.

SUPPLY CHAIN WIDE TRANSFORMATION

Industry 4.0 is basically an outline for digitizing the supply chain from factory to customer. It joins logistics, production, IT, production to digitize business operations. For digitization the integration of whole supply chain is needed which can be done by cyber physical systems and internet of things (IoT) Industry 4.0 will include adaptability around the stream way an item will take as it moves toward culmination, as opposed to directions from an item to a factory on what activities should be performed at that station. In the present factories the decision making and production process is controlled by man power. Supply chain planning is still required in longer time periods in this value chain. The arranging motor considers the limit of a line and machines on that line, change over times, and different requirements, and makes a streamlined arrangement for the coming days or weeks. In any case, that arrangement accepts everything will continue without disturbance.

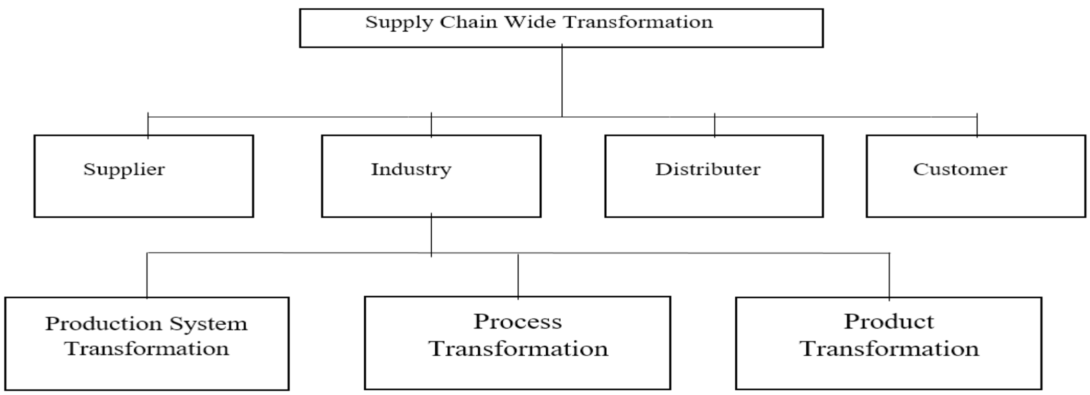

Figure-2. Supply chain wide transformation.

INDUSTRY WIDE TRANSFORMATION

The main part in the transformation of traditional or existing factories is industry wide transformation it is basically the modifications or changes to be made in Industry. This mainly involves in three phases i.e. transformation of production system, process, and product. As the industry involves in the designing, development, and manufacturing of a product, this undergoes different stages and human effort. The main challenge in the industry wide transformation is integrating the different departments, machines, and equipment's to transfer data among themselves for proper implementation and execution of operation in the production system.

PRODUCTION SYSTEM TRANSFORMATION

The production system is the place where the product is produced after moving through several steps to get a desired output. There are different types of production systems. These systems are designed according to the product which is to be produced i.e. the production systems vary product to product. In traditional industries these systems are designed by considering few aspects but in the latest advancement many aspects are being considered such as environment, pollution, product modifications and human safety.

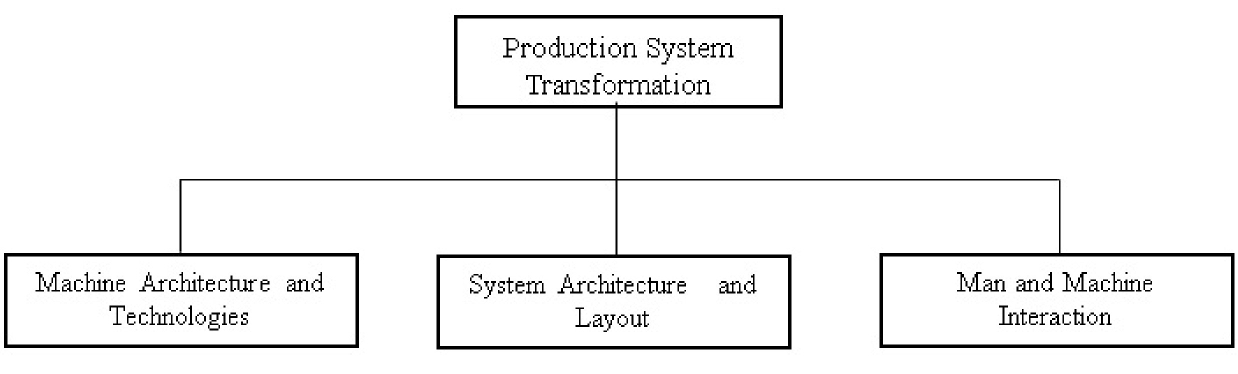

Figure-3. Production system transformation.

In the present context the transformations can be done by considering mainly three elements i. Machine Architecture and Technology, ii. System Architecture and Layout, iii. Man and Machine Interaction.

Machine architecture and technologies

The machine architecture must be according to the technology using and the product to be produced. In present scenario of industry 4.0 the machines should have the facility of enabling the Ethernet for data acquisition and interacting with the server system (CPPS) to communicate among themselves. As, in this industry 4.0 technology mainly focuses integration of systems for making the process easier and faster the process of the production mainly depends on the integration of the systems. The machines should be enabled with the sensors for communicating with the product for which operation to be done at that time and how to continue. The system is to be designed in such a way that the system can be able to modify the changes occurring unexpectedly in the production process.

System architecture and layout

System architecture and layout is the arrangement of the machines or equipment’s in a way that the process and the material handling should be optimized. As industry 4.0 gives a good solution when compared to the traditional industries, industry 4.0 technology gives good boost for the material handling systems as they are multipurpose and designed according to the movement of different products at a time. The layout should be changed for transformation as the traditional factories or present industries have a single purpose handling systems. The new system architecture and layout gives good profit and makes production system a multiproduct production system by the arrangement of machines and material handling systems the number of machines of similar types can also be reduced. Computerized and adaptable assembling procedures that are incorporated with clients and business accomplices in backing of item life cycle changes – will affect current processing plant design.

Man and machine interaction

The interaction between man and machine is very low in industry 4.0 as compared to the existing factories. In the present factories from the level of worker to the higher authorities has to take decisions for the problem solving. Industry 4.0, as it is an automated and integrated system the decision and operations are continued automatically as these systems are integrated. The interaction of man and machine in industry 4.0 is mainly in the assembly lines of a production industry, because in assembly line the operation are to be made by the decision process and Can also be depend on product to be produced. When compared to the man and machine interaction the industry 4.0 is the human safety technology.

Process transformation

Process transformation is the sequential procedure by which the product is produced in the production industry. In transformation of existing industry, the process is to be transformed in to the smart process by the establishment of the integrated systems which can communicate and cooperate with the remaining systems. The process should be in such a way that the system should be comfortable for the multiple product production. The smart products in industry 4.0 technology are to be produced in small lots and different aspects. For this the transformation mainly focuses on three aspects for making the products smart, the process should be environmental free and some environmental regulations should be followed for this transformation. The remaining elements to be considered are process improvement i.e. what are the present processes and the improvements needed for that process. New technology is also a decision making element that mainly focuses on the industry for transformation. For which technology we are going to transform, what are the needs, which types of new equipment’s required and what processes to be changed for this transformation are the main things to be focus in this process transformation in any industry.

Environmental regulations

The environmental regulations in any field of advancement in technology are mainly focusing on the environment. Now the environmental free industry, pollution free industries are the main research areas in any types of industries, because when we compared with the previous industries they didn’t much focused on this environment just they improved technology. We can say this environmental can give the great difference in traditional industries and the industry 4.0 environment. The industry 4.0 factory is an environmental friendly which uses all smart things including the machines for production and distribution of products. In every industry the main thing we have to consider in context of environment is the machine, resources used for production. For transformation, firstly the industries should focus on machine and resources.

Process improvement

Process improvement in transformation mainly focuses on the difference in the present process and the process to be transformed. The availability of infrastructure and need of requirements are according to industry 4.0. The position of available machines, need of changing position and workers. Designing of process of new factory for establishment of different equipment’s, tools, machines etc. In the industry the process should be designed in the manner that working stations integrated CPS could decrease cycle times to find the difference of highest possible capacity usage per working station and a constant flow of goods.

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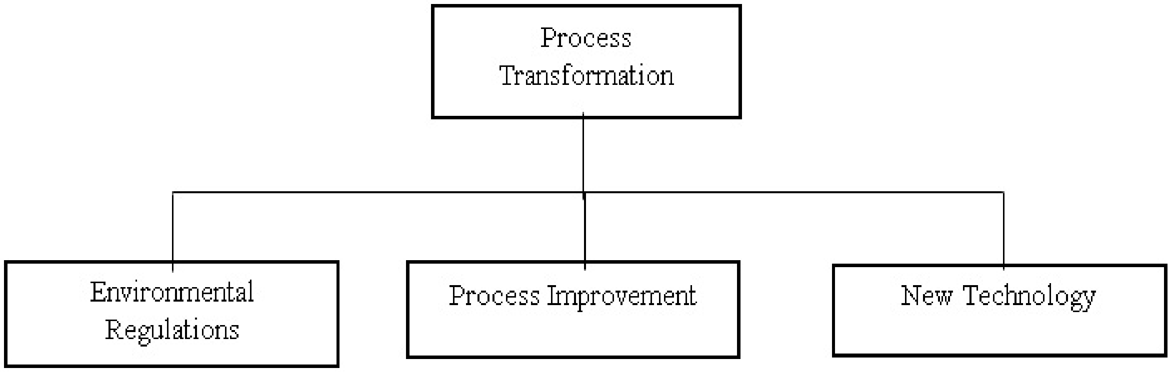

Figure-4. Process transformation.

New technology

The technology is the technique for improving the existing method or model for better quality and profit in the view of industry. In the present transformation the industry has to collect the data about the technology for designing the transformation procedure. Industry 4.0 transformation this technology gives a clear idea of smart systems, smart products, smart machines, smart operator etc. For the transformation to new technology our main view should be of producing smart products the modifications should be done according to the product to be produced but the common things needed are CPS system, storage systems, material handling systems compatible with industry 4.0, technician etc.

Product transformation

Product transformation is the process of changing the traditional product to the smart product. Smart products are the products which contain the data of processing by which it should be processed and these products can communicate with the systems. Smart Products could gather process information for the investigation amid and after its production. Rather than manual information securing for quality stream mapping it is conceivable to assemble data individualized per product and production line consequently. From one viewpoint, along these lines of information securing is less work serious and then again, information is more exact [19]. The key elements in the product transformation process is transforming of technological features of the product by enabling the latest technology, transforming of the material used for production i.e. quantity, quality, time of requirement and place of requirement, and transformation of information of traditional factories to industry 4.0 about the process of production and carrying the product to further stages. The stages of product transformation are shown in figure below.

Technological features

The traditional factory products do not contain any information in it. But the products of industry 4.0 are containing information and process data in it. The present transformation can be done by enabling the RFID chips for each product for communicating with the systems and to inform the machines about the operation to be done. The present scenario of the production process the product plays the key role of travelling and transporting the data of process to each machine in the system in which it has to undergo the operations to be the finished product. The technological features of the transformation are also involving the advantages and barriers of the product transformation because of availability of multiple types of transformation processes which can be applied for automation of the existing factories.

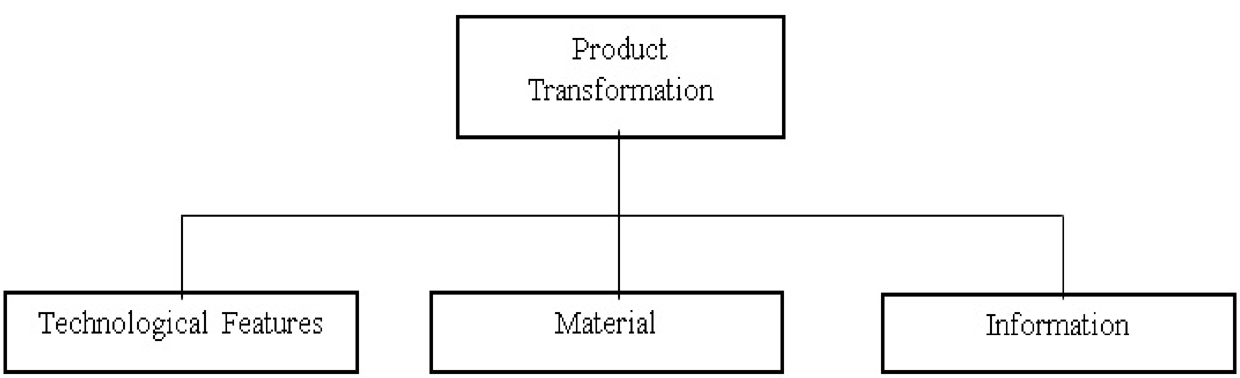

Figure-5. Product transformation.

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Material

For every machine or system that should need the material to produce a product, the material needed will depend on the type of product to be produced. In this system we are not talking about the type of product but the properties and movement of the product. The properties of the material using in traditional factories and the industry 4.0 do not vary much but the difference is in the quantity, time of purchase, logistics etc. The material purchasing and the remaining properties in the industry 4.0 environment will be checked automatically and the orders will be done by the systems. The main server which we integrated with all the systems will check over all the things i.e. requirements. Everything in this environment is carried out by the intelligent system decision process.

Information

Industry 4.0 is the technology mainly based on management of the information of value chain and storing in the cloud. As the existing industries do not maintain or manage the information and it do not depend on it for the process purpose. In the latest technology the main preference should be given to information because in industry 4.0 the product cannot move further step without data. So, the primary challenge is to manage the data throughout the supply chain by means of big data storage system. Primarily the data should be collected, processed, and stored by itself by means of cyber physical system and big data techniques. The data is communicated and transformed and communicated by the server systems of cyber physical system, the storage will be done by the big data systems.

Table-1. Comparison of technical features of industrial formation.

Element	Traditional	Industry 4.0
Resources	Limited Resources. This is a fixed line and mass production. The resources needed should be estimated.	Multiple Resources. To produce multiple types of products with small lot sizes. Multiple types of resources should available in the system.
Material Handling	Fixed Material Handling. This is a fixed handling system only the movement of material is done in fixed unless manually routed.	Dynamic Handling. The material handling system movement can be changed for different products.
Connectivity or Interaction	No Interaction. The machines are not connected and they don’t have any type of interaction.	Integrated Connection. The systems are connected each other and the communication between machines are possible.
Data Management	Limited Data Management. The data is managed only at some particularly at some levels of the system i.e. high level management of the industry.	Full Data Control. The data is fully managed at individual departments and also total system. The supply chain wide data is managed by cloud storage.
Product	Single Product. Only particular (single) product is produced and in mass production.	Multiple Products. Multiple types of products are produced on the same line of production.
Decision Making	Manual Decision Making. The decision making is manual at all the levels of the system.	Automatic Decision Making. The decision making process is carried out by the system at all stages of production and manual involvement is less. The decisions are accurate.

VALIDATION

The idea of the CPPS empowering influence has not been acknowledged overall yet. So far just parts have been approved in diverse activities as depicted in the accompanying sub-areas.

Connection

The association usefulness of the CPPS empowering agent is actualized in the "Evergreen" undertaking. "Evergreen" is a system for the advancement of merchant free graphical client interfaces. The "Evergreen" application acknowledged by the "Evergreen" structure is separated into two sections: the graphical client interface, called "Evergreen" GUI, and a correspondence door, called "Evergreen" Server that actualizes diverse correspondence component subordinated to a reflection layer to associate with distinctive control and automation frameworks in an institutionalized way. "Evergreen" executes the depicted idea of disclosure usefulness. Revelation is once

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acknowledged for the correspondence convention OPC UA that is utilized for the correspondence between the "Evergreen" Server and the production framework control and, also, for a SOAP correspondence interface that is utilized for the correspondence between the client interface and the "Evergreen" Server. The disclosure usefulness for OPC UA depends on the UA Discovery usefulness however stretched out by the programmed look for the revelation server correspondence point by examining a given IP extent and regularly utilized ports as a part of the computerization region. The disclosure usefulness for the SOAP interface is a self-ruling component: while checking the given IP range and ports like the OPC UA revelation usefulness, the SOAP revelation capacity conveys SOAP solicitations knowing conceivable reactions. At the point when recognizing a reaction that is novel for the "Evergreen" Server, it distinguishes this filtered station as a normal correspondence purpose of an "Evergreen" Server [28].

Gateway of CPPS

The idea of the passage is a fundamental piece of the CPPS empowering agent as it is the key module to empower production systems to be a piece of an Industry 4.0 industrial facility, despite the fact that they are not arranged to be a CPPS. A complex door notwithstanding the "Evergreen" Server has been acknowledged in the venture "Cloudplug" [1]. A "Cloudplug" is a portal acknowledged on a standard equipment stage, which can be utilized as a part of the production environment. Its fundamental undertaking is the transmission of production system information into the cloud. The cloud entryway actualizes an OPC UA Client for getting to the production system control and an instrument to push the got to information into the cloud target.

CPPS information server

The idea of the CPPS Information Server of the CPS empowering influence is acknowledged in the "pICASSO" venture [20]. The acknowledgment depends on an OPC UA Server whose location space can both be gotten to by means of an OPC UA Client and a scripting interface. To associate with the CPPS Information Server, the OPC UA Client needs certain data concerning this procedure. In light of secure associations, there is a verification technique (e.g. by testament) to concede access. The accreditations for confirmation must be perceived or even made by the server which is going to create a namespace for another customer as of now. The structure of this namespace is characterized by the idea of the CPPS Information Server and is indistinguishable for every customer. It gives hubs to store qualities to essential arrangement data and the scope of usefulness of one customer. Taking into account formats the CPPS Information Server can grow the customer particular namespace by customer enlisted usefulness. Then the customer can utilize this up-dated namespace to distribute the information of its usefulness. This extension of the customer namespace with usefulness formats by the server is acknowledged over the scripting interface. These scripts began occasion activated when another customer join with the CPPS Information Server. The conduct is utilized as a part of the "pICASSO" undertaking not just too powerfully enroll and unregister the usefulness and correspondence channels of one customer however to trade information straightforwardly inside of the OPC UA Server that is utilized as CPPS Information Server. The formats of the CPPS Information Server made for the "pICASSO" task are known not venture accomplices. Hence every customer which is created by an accomplice knows how to get to the usefulness of a sure customer of another accomplice that distributes perfect information.

Functionality templates and applications

The venture "Cloudplug" utilizes a layout to characterize which correspondence interface has been chosen to join with the production system. Further the format characterizes which sort of correspondence channel is utilized to speak with the production system and how the correspondence channel qualities towards the information devouring application are designed. One objective of the undertaking is to dependably give a correspondence channel to the client of the "Cloudplug" that meets his prerequisites getting it done. Further, the format utilized by the "Cloudplug" determines which information is traded between the production system over the "Cloudplug" and the information devouring application. With the data gave in the format, the sink of the information can progressively make the got information structure and spare the information in an information base for investigation.

BENEFICIAL OUTCOMES OF TRANSFORMATION

Industry 4.0 high-tech strategy and technology have to produce smart products by using the smart infrastructure, smart machines and smart production system. The transformation of the traditional factories to industry 4.0 will give the benefits as it is the advancement of existing factories. Some of the benefits are listed in **Error! Reference source not found.**.

CONCLUSION

Industry 4.0 factory is an environment in which all systems are interconnected and sharing information with each other. Here the advantage is the needed information is available with the product. This approach is by the automation of the cyber physical production systems for integrating the systems. In this cyber physical system environment, the production systems are linked among themselves for easy accessing and fast exchange of data. However, only the less number of industries having installed cyber physical systems, that are integrated systems. For this reason, this paper presents a step wise approach to show how the present and traditional production systems can be transformed to be part of an Industry 4.0 factory. The approach mainly consists of enabling the cyber physical systems and connecting them throughout the supply chain for communication of man, machine, and product. First the establishment and connection of cyber physical production system is proposed that allows integrating systems and their communication interfaces. The step wise transformation of full supply chain is explained and some expected beneficial outcomes also listed.

Table-2. Beneficial outcomes of industrial transformation.

S. No	Outcomes	Benefit
1	Flexibility	As this is a flexible system different types of products can be produced at the same time.
2	Productivity	As the system is flexible the productivity will be more it leads to fast production.
3	Resource and Energy Efficiencies	This system is efficient the resources used by this system will be low i.e. less wastage and it can save energy.
4	Transparency	As this system is integrated and intelligent system it automatically identifies the problems and also gives the solution.
5	Integration	By integration of the systems the time delay will be decreased and the production rate will increase.
6	Profitability	As these systems are flexible, productive, transparent the profit will be increased.
7	Environmental Friendly	These systems are building environmental friendly as they are pollution free systems. These systems didn't exhaust any pollutant.

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