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Brief Overview of Automated Industrial Plant: A Review

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***Abstract*— An overview of Automated Industrial Plant and its architecture has been discussed briefly in this paper. The content herein is very educative at introductory stage to concept of Industrial Automation and Informative about latest trends in Industrial Automation. Automated Industrial Plant is more advanced when compared with IoT and can serve the function of a node in a global setup of IoT. However, an Automated Industrial Plant should serve as a precursor to IoT, by which certain underlying characteristics of Automated Industrial Plants can serve as solutions to a lot of research problems in IoT.**

Keywords— **Industrial Plant, Precursor, Automated, Internet of Things, Research Problems, Underlying Technology.**

I. INTRODUCTION

The origin of industry structure could be traced back to the origin of man at what time he had learnt to till ground and cultivate crops [1], move farm produce and younger ones from one place to another and teach younger ones to hunt and survive jungle life, acquire skills and utilize literary records [2]. Modern industries like hospitality, health, food processing and tools and machine making could as well be associated with certain activities of man at his origin [2, 3]. These activities had evolved and developed with time through acquired skills into disciplinary euphoria which had resulted in such inter-disciplinary standards that industries would dictate their terminologies. It had brought about atmospheres in which industrial processes or procedures are achieved (equipment could work perfectly) through automation, except may be in plant maintenance and management, without human intervention or with little human intervention [4], in areas including planning, engineering, production, mechanical and electrical systems and the information technology components for the entire production process, in other to maximize added value along the entire process chain [5].

In [6], Automation is defined as "a set of technologies that results in operation of machines and systems without significant human intervention which would achieve superior performance compared to manual operations. Encyclopedia Britanica defines Automation as "the application of machines to tasks once performed by human beings or, increasingly, to tasks that would otherwise be impossible. Although the term mechanization is often used to refer to the simple replacement of human labour by machines, automation generally implies the integration of machines into a self-governing system.""

Automation is defined in [7] as "the independent accomplishment of a function by a device or system that was formerly carried out by a human". The human-automation-human factor requirements were listed as what automated system should provide the user with, which are:

- Sufficient information on intent, function, output and operating mode,
- Automation failure or degradation,
- Alert on selected potentially unsafe mode,
- Restrict actions in manual task mode,
- Allow manual over fold,

Such that humans "should remains in control while automation plays subservient role, therefore functions are automated only if they improve system performance without reducing human involvement, situation awareness or human performance in carrying out the intended task safely, efficiently and effectively".

Industrial Automation is equally referred to as Industrial Control Systems (ICS) in [8] and was defined as "A term which encompasses the several industrial and facility control and automation systems". "It is a collection of personnel, hardware and software that can affect or influence the safe, secure, and reliable operation of an industrial process" according to ISA-99/IEC 62443. Types of Industrial/Facility Automation and Control were listed therein as:

- Supervisory Control and Data Acquisition and Energy Control (SCADA); used for control and data acquisition over a large area of coverage.
- Distributed Control Systems (DCS); control, monitor and manage sparsely distributed industrial processes which are been operated as integral whole.
- Process Control Systems (PCS) ; it controls, monitor and manage industrial processes.
- Building Automation / Building Management Systems (BMS) ;"control system used to manage security, safety, fire, water, air conditioning in a building or facility".
- Instrumentation and Control (I & C) ; automation application devices for operating, monitoring, measuring or managing equipment, and
- Safety Instrumented Systems, or Safety Systems, or Protection Systems (SIS); maintain safety of processes based on specific conditions.

One of the main reasons of applying automation is the desire to produce at less cost than competitors thereby employing fewer workers, achieving continuous production apart from maintenance down time, achieving more production and relief of people from tedious and hazardous jobs. Some negative effects of automation are loss of low skill level jobs and higher investment commitment [9].

Categories of automation based on flexibility and level of integration in manufacturing process operations are stated in [6] as:

- Fixed Automation: Continuous flow and discrete mass production systems using mechanization of fixed and repetitive operations to produce large volume of similar parts uses it, especially in distillation processes, belt conveyors and transfer lines.
- Programmable Automation: Electronic controlled changeable sequence of operations and configuration of machines using software. Investment is less and typically used in batch process and mass production process like Steel rolling mill and Paper mill.
- Flexible Automation: Computer controlled flexible manufacturing systems, where a production machine receives setting pattern and control commands from the computer. Used in batch processes of low and medium product volumes, like Multipurpose CNC machines and Automated Guided Vehicles (AGV).
- Integrated Automation: Plant automation in which all processes are computerized using computer control and digital information processing, using computer aided design and manufacturing, computerized process planning, automated storage and retrieval and material handling, and computerized scheduling and production control. Used in Advanced Process Automatic Systems and Computer Integrated Manufacturing (CIM).

Companies would adopt process and production automation [4] in anticipation of improving areas of:

- labour productivity, work safety and product quality ,and/or
- Reducing areas of cost of labour, manufacturing lead time, routine manual tasks, processes that couldn't be achieved manually and labour shortage.

It simply improves method of production and creates better jobs at all times [10], which had being modelling our attitudes and ways to work. It as well improves production efficiency and merchandise marketability. This evolutionary trend had definitely brought about increased precision, increased production with minimal manpower, reduced cost of production and increased rate of production. In addition, they proffer flexible system architecture specific expansion of process control functions through additional functionalities for batch processes, material transport, asset management, security applications and process data analysis/management [5].

Pervasiveness of computer and computing technology has further advanced this fit into Computer Aided Manufacturing (CAM) [10] which is a seamless integration of manufacturing and production stages in one tool by taking advantage of the general purpose nature of Control Personal Computers (PCs) in a digital factory that would, in addition to afore mentioned benefits, achieve management objectives. However, Messrs. Siemens had strived to achieve these functions through its open system architecture's Totally Integrated Automation (TIA), which is founded on "comprehensive automation solutions of Integrated Engineering and Safety, Industrial Communication and Data management and Industrial Safety" [5]. It has equally been stated in [10] that "dynamic creativity in automation reduces unexciting and monotonous tasks". The remaining part of this paper is divided into Automated Industrial Plant, Some Automated Plants, Market Classification of Automation Industry, Brief Overview of SCADA, Internet of Things and Industrial Internet(IoT) and Conclusion.

II. AUTOMATED INDUSTRIAL PLANT

Automation varies in degree and nature in its scope of adoption [11] in production processes and manufacturing. Though functionally scalable which, apart from technology and machinery availability, has often waited for creation of required material improvements and design changes, after which it foster advanced stages of vocation that does not require operators with the former higher level of skills. "Increased productivity as an outcome of process automation and drive technologies might not necessarily have negative impact on employment schedules but rather otherwise" [5, 11]. It, however, has been argued in [11], in contrary to certain opinions which might have overlooked inefficient engineering procedures and several characteristics that are undesirable for automatic manufacturing like discretion, in support of the proven fact that "volume does not make automation practicable". [12] expresses the intent goal in Industrial Automation as" to enable the enterprise wide integration of systems to reduce or eliminate information and reporting gaps, to eliminate 'double entry' of information, to achieve completely paperless transactions, to capture billing and production data automatically, and to ensure that key personnel are always up-to-date on the company's operation"; as has been implemented in an automation solution in concrete plant by Command Alkon Incorporated in [12]. Furthermore, Operation and Quality should be secured with uncompromised manufacturing standard and testing procedures.

Some attractive characteristics that have popularized Plant Management integration into automation systems which are equally provisioned in plants' requirements are

efficient and concurrent workflow, software requirement across discipline and departments, timely innovation and consistent data management in engineering and operating phase, holistic object oriented solution for the entire life cycle of an industrial plant, continually consistent and transparent data flow, increased system availability, entirely life cycle phase integrations from design to basic and detailed engineering, open software architecture that facilitates optimal integration of third party systems, bidirectional data exchange between parties through uniform data platform, global mobile access to all plant information, efficient and intelligent process flow diagrams through use of templates and knowledge base for the definition and review of rules for the error-free creation of process flow diagrams (PFDs), revision management and tracking of changes, intelligent connection technology and use of device libraries, creation and management of classes based on standards, automatic update of parts, automatic integration of parts and specifications, simplified material and parts in management, easy and fast cabinet planning including automation solutions, creation of cabling diagrams based on templates and auto loops, simplified engineering through auto routing and auto connection functions, . . . among other features[13].

Similarly, remote Client [12] would "allow up to three additional remote users to access one batch system at the same time, which might meant that plant monitoring, tune up, task design management, diagnostics, and troubleshooting are possible anywhere, anytime. Remote Client users could as well perform tasks like Remote Batching with the addition of remote batching hardware without interfering with normal operation while master records would be created, updated, or deleted for customers at the same time". Most reports could be previewed or printed remotely to the user's location.

Safety is an endearing and important issue in automated control systems, for both personnel at site of automated equipment and prevention of damages to the equipment [14]. Latest regulatory codes by local, national and regional regulatory bodies in control system equipment, installation and operation have to be abided with in other to reduce safety challenges, most importantly as applicable in sections of the Fire Protection (FP) code and the codes of the Electrical Manufacturer's Association (EMA). Control Systems should use lockout/tagout procedure that would shut off or isolate any energy sources (like the main electrical feed and any pneumatic, hydraulic or mechanical energy storage device) in the course of maintenance. Good grounding practice prevents electrical shocks in as much as it reduces electromagnetic and radiated noise interference to sensitive electronic devices. Protective devices could be used for faulted conductors to prevent fire. "Supervisory Control And Data Acquisition" (SCADA) system, which comprises of Programmable Logic Controller (PLC) and Input-Output (I/O) interfaces that are linked to Central Control PC, is most appropriate if application requires data for reference, traceability, history, trending, meeting regulations, etc.

Automation has actually become "a tool to manage the plant, decrease energy consumption, reduce costs, cut emissions and provide quick and precise information from the field to support production and business decisions" as an integrated enterprise wide energy efficient solution according to Messrs. Schneider in [15]. This technology is scalable for haven created room for future expansion, Integrated because system components could work together with any chosen technology partner, flexible thus it could take care of any unique requirements and Collaborative by which it could deliver information in the forms that we want them to be seen. In short, it is a system that drives increased return on assets while meeting the needs of all applications. Unique features as Global Data Access, high availability, smart devices especially in form of power and energy meters, real access to plant before problems impact on supply chain, transparent communication between all system's components and industrial protocols, dedicated device network and instrumentation buses, distributed architecture along with hot-standby redundancy, offers substantial methods, as required in process automation.

The recent trend, in converting plants into smart plants requires that there should be appropriate integration of all the systems to foster improvement and leverage on its importance in increasing safety as well as efficiency [16]. The safety shutdown system is a prevention safety layer, which could automatically and independently prevent hazardous incidence from occurring, and protect personnel and plant equipment against potentially serious harm. In view of which "another level of safety in Fire and Gas system is used to reduce the consequences of a hazardous event after it has occurred" [16], by which the desired safety integrity level (SIL) could be achieved.

Application of intelligent tools has eliminated conventional methods that required stopping the process because, staffs are now able to monitor and analyse operation conditions while process is still running [17]. "In addition to versatile reporting, analysing and data storage application, the Metso information management system offers tools for efficient performance, condition and environmental monitoring" as buttressed in [17]. They explained further that with the addition of intelligence, staff could plan maintenance schedule in advance which would have kept disruption in process at minimal. "In practice, everything except changing big mechanical units can be carried out remotely. This saves a lot of time and decreases the customer's costs," Jyri Tiihonen from Metso comments in [17]. Automated reporting through which information could be produced directly for the plants environmental reporting in other to compile monthly reports directly from the system in less than one day is utilized therein, as in Enterprise Resource Planning (ERP) platforms. Remote control of power production units in SCADA systems that handles both software and hardware techniques based on Personal Computer (PC) resources, Programmable Logic Controllers (PLCs), Remote Terminal Units (RTUs), Smart Sensors, data communication and transfer devices is a way of optimizing power production plant [18].

With Remote Network Access provisions in Remote Product Services (RPS) solutions "physical presence of operators are not required to effect thresholds changes to PLCs, monitor operator screens of Distributed Control Systems (DCS), achieve account data inquiry from pipeline custody transfer system, technical services from corporate application experts and implement advice for maintaining operations and productivity, that are readily achieved in process oriented and discrete control systems by leveraging centralized/distributed resource pool and service plant network segments remotely"[19].

RPS solutions gives corporate IT universal control of remote network and compliance reporting, and Plant automation department's easy connectivity and best of breed software tools to solve problems in optimal way. "Modern advances in network access tools for automation systems and Windows-based HMIs have made possible creation of centralized data centre that integrates asset management data mining and TCP/IP networking support. These integrated capabilities allow plant managers to collect and extract detailed information on performance and throughputs and generally simplify Operations, Provisioning and Maintenance (OP&M). RPS should also be extended to all remote locations, including vendors and remote internal expertise. A centralized RPS tool enables standard corporate practices to be created for remote monitoring and management without concern for the device type, the tools that are used, or the location from which the services are being performed" as explained in [19]. This could be achieved as well in emerging platform of ILS technology's Virtual Service infrastructure (VSI)[19] that "enables service organizations to utilize the Internet as an efficient service delivery transport infrastructure to perform advanced proactive monitoring and on-demand management access for remote devices located on remote and protected networks. In addition, VSI allows critical data-centre and industrial automation organizations to utilize without modification existing applications and tools. It also enables them receive third party support services without any changes to their network security configurations and practices" [20].

Industrial Automation Enterprise Control System as provided by Invensys infusion software suite [20] "complies with industry standards and guidelines (like VGB, KKS, TSSA, TUV, NFPA, etc.) with seamless integration of fault tolerant and triple modular redundant (TRM) technologies. They as well exhibit security enhancements that have met the NERC Critical Infrastructure Protection (CIP) standards that allowed users to take advantage of Microsoft Active Directory network services on a domain based network topology. These provides the following security feature: hardened workstation BIOS settings and O/S images, active directory group policies, unique user or machine login/passwords, virus scan, malware detection, station assessment tools (SAT) for workstation audits assessments, host intrusion prevention, powerful and configurable firewall, application blocking, hardware port (device) control and rouge machine detection". They as well offers custom gateway like "GE GSM for GE gas and steam turbine interfaces", functional interface to smart field devices like "HART, profibus, and Foundation Field bus including Control in the Field (CIF)" based on Field Device Tool (FDT) Open System standards.

III. Typical Automated Plants

In modern days, automation is found in every aspect of our life. These application areas include:

- Cement Factory: the role of cement in infrastructure development can never be over emphasized being an important input in construction industry. Application of automation is more cost-effective [31], [22].
- Chemicals and Petrochemical plants: they are a key component of the world's economy. Manufacturing activities at enterprise level are integrated to control activities with increased emphasis on computer networks [23].
- Fero-alloy Plants: they are very important in steel making. Efficient and safe running of process plants are achieved through Instrumentation and Automation [24]. The outcome is improved flatness of cold strips, flexible schedules, improved stability, excellent product performance and increased lifetime of rolls [25].
- Food Processing: one of the most complex highly automated beverage manufacturing process is brewing beer because reliable sensors are require in other to achieve non quality fluctuated high quality product [26].
- Nuclear Power Plant: Instrumentation and Control system in conjunction with the personnel are the central nervous system of a nuclear power plant [27]. It is possible to operate Sequencing Batch Reactor (SBR) plants more effectively with the help of modern Supervisory Control and Data Acquisition (SCADA) systems [28].
- Petroleum Refinery: offshore oil and gas is complex combination of advanced equipment, structures and workforce. Implementation of robotics and automation in oil and gas foster efficiency, maximum production and capabilities for further exploration [29].
- Thermal Power Plant: Natural gas with light fuel oil as backup serves as fuel for the combined cycle power plant [30]. Fast and easy availability of information is crucial especially if disturbance happens, from either external or internal source, [31].
- Waste Water Treatment: automation systems are required to provide effective monitoring and control of waste water treatment processes [32].
- Water Treatment: PLC's automatic control is normally adopted in water treatment systems. It utilizes communication networks, computer monitoring and video surveillance [33].

Automation is making way in other, non industrial plant, areas of life like homes, offices, café shops, domes and more.

IV. Market Classification Of Automation Industry

The Market nomenclature of automation industry would better be considered in two parts: Automation in manufacturing sector and automation in industrial process control. Manufacturing of modern products like cars, computers and cell phones would have been a more complex one without automation's impact in safety and productivity.

The major providers of these automation facilities includes Honeywell, ABB, Siemens, Mitsubishi Electric, Emerson attest, Schneider Electric, Parker Hannifin, Omron, Endres + Hauser, Bosch Rexroth, and Invensys. The three recent areas of focus by the automation industry as revealed in [34] are "Energy sufficiency, Machine safety and Information consistency" as illustrated in Figure 1. Energy efficiency is a priority because of several reasons among which is higher energy cost, partly because of environmental policies and protection of corporate image from the side of general public since they had become more conscious of environmental policies ever than before, and being realized in form of energy management systems deployment in places like smart grid. Machine safety is opening up new ideas as applications in machine control and steering, especially in process automation at field level.

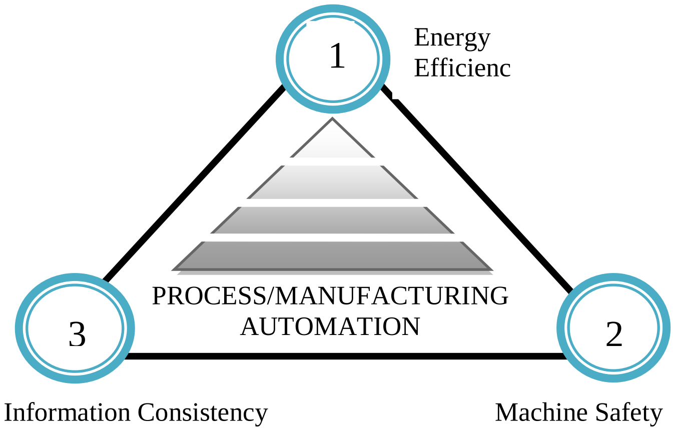

Figure 1 : Technology Trend (courtesy: Roland Berger Strategy Consultants.)

Information consistency offers optimization potential in collation and analysis of process data, "which serves as the core organ facilitating operability in new automation solutions", according to [34] and because of which Manufacturing Execution Systems (MES) and Product Lifecycle Management (PLM) products are having rising demand.

Siemens Power Generation has being marketing web based power plant Instrumentation and Control (I & C) systems like SPPA-T 3000 [35] for power plants. It is a fourth generation control system device; a system with Internets three tier architecture of Presentation, Processing and Data. It had been noted in [35] that modern software architecture reduces load procedure of automation servers by third order of magnitude and that data inconsistency had become a thing of the past, as only an instance of item of information is stored in the system which has as well reduced engineering workload. This SPPA-T 3000 facilitates provision of the right information at the right time and place haven supported computerized maintenance management system and enterprise resource planning systems, and delivered operational result at the lowest cost, according to [35].

Industrial Automation has effects on people, Society, Environment, Energy and Resources. The Automation Engineer is responsible for the effects of Industrial Automation in form of damages in industrial automation systems designed by him, violation of generally accepted guidelines and regulations (regulations of the VDE, etc.), Safety of automation systems [36].

The future of automated plants is cited in [37] to be determined by "Process efficiency and resource utilization, Maintenance cost, Process modification and expansion and Safety and security". The risk and recovery cost of safety and security treats were listed therein to be "terrorism, identity theft, workplace accidents, industrial sabotage, environmental and product liability, and natural disasters" can be minimized through proper planning and design of safeguards according to [37].

Adopting Enterprise Resource Planning (ERP), Plant Automation provides the ability to integrate process information, business procedures and decision making because it has replaced major software needs in all function areas like manufacturing and all scales of production, given more visibility on data across the entire corporation and obtaining competitive advantage [38, 39]. An ERP system helps in the integration of the company's set of information into a single platform due to the way in which it has succeeded in combining business management techniques and practices with the new information technology, providing the transparency of data and the access to the necessary information. It has created value through the following functions apart from integration of firm's activities: "use of best practices, enable standardization, eliminate information asymmetries, provides online and real time information, allow simultaneous access to the same data for planning and control and facilitates intra-organizational and inter-organizational communication and collaboration" and more[39]. It actually integrates all the business processes within an enterprise: manufacturing, distribution, accountancy, finance, human resources, stocks, maintenance and logistics. Improved forms of ERP at different stages in its course of development were called Enterprise Application Integration (EAI), Business Process Integration (BPI), and Enterprise Nervous System (ENS). ERP utilization fosters better communication within a company, improving interaction and team work among departments, in manufacturing planning, purchases, sales and customer relations. It can be modelled as two fundamental features that co-exist: integration (which is a communication technique in form of source code, local and global computer networks, internet, e-mail, workflow, automatic configuration tools, protocols and data bases) and functionality (which provides business process flow within functional modules such as general accountancy, debtors, salaries, stocks, supplies, and manufacturing planning). ERP resource is modular in nature: the operation support module comprises of procurement planning, production planning, distribution planning, supply orders, plant orders, shipment orders, material inspection and warehouse, production scheduling and control, and shipment scheduling and control; the ERP cross industry modules comprises of both administration support (Finance, Human resource management and miscellaneous) and management support (strategic planning, budgeting, activity based costing, balanced score card and management dashboards); and extended ERP modules comprising of customer relation management (CRM), sales, customer care, product life cycle management (PLM) and supply chain management (SCM) [39,40]. By this order, business process of a whole enterprise could be served by a single software system which makes information to flow seamlessly. In what case, information would be unique and being shared, there by establishing data synchronization and eliminating redundancy, multiplicity and inconsistency, which would account for single source of management system that has tracked all updates and made them available to all modules. “Ironically, the very ERP can cripple a company, if not implemented properly” [41]. It has been established in [42] that ERP software upgrade is an essential activity in its lifecycle which may be occasioned by its failure to serve as the primary source of critical data and delivering of analytics and reporting functions that would help companies make better decisions. ERP’s wide area of application span across both industrial and non industrial areas as they are being provided in web service and service oriented form in various commercial products like JD Edwards, SAP, Oracle and Baan, as highlighted in [43]. ERP platform had its origin from Electronic Data Interchange (EDI) which had allowed information exchange over communication networks within and across the boundary of an enterprise, which has as a legacy system being preserved in form of business semantics by combining EDI and extended Markup Language (XML) in recent time [43].

Therefore, Industrial Plants are been automated by implementing a type of Industrial Automation and Control in their designs. Such implementations includes Sensors and actuators of different types, flow and speed measurement devices, electro valves, temperature measurement devices, tachometers, limit switches, drives and drive controllers, level switches and several others.

V. BRIEF OVERVIEW OF SCADA

SCADA acquire data from remote devices and remotely control them from a SCADA host software platform in a supervisory system that also integrates “graphical displays, alarming, trending and historical storage of data, it provides process control locally in other to support control strategy and implement remote method of capturing data and events (alarms) for monitoring the processes” [44]. The four distinct levels or stages in SCADA as explained in [44] are:

- Field Instrumentations :
- PLCs and/or RTUs :
- Communications Networks: is fundamental to SCADA in other to transmit data from remote PLC/RTU to the SCADA Host at a Central Control Room (CCR),
- SCADA Host Software: It has been the mechanism to view graphical display of remote devices and their technical status/characteristics, logs of online and real time alarms generated from them, and historical trend of the whole process for reasonable period of time (a month or quarter of a year). Accounting, Maintenance management and purchasing requirements can be automated using data generated by the Host software to implement Enterprise Resource Planning (ERP) system. “An open standard has as well been developed in recent years that provides secure encrypted and authenticated data exchanges between remote assets and SCADA Host platform[44].”

Recent increase in cyber attacks on industrial control systems, as usage of commercial off the shelf Information Technology (IT) solutions’ increases, “are normally targeted at industrial control systems like DCS, PLC, SCADA and Human Machine Interface (HMI), thereby disrupting industrial activities, either to pay for personal grievance or in other to achieve monetary gain, political gain, competitive gain or social gain” [45]. Schneider Messrs has recommended Defence-in-Depth Approach to combat this Cyberattack menace in the Industrial Automation platform in [45]. The six key steps in this approach are:

- Security Plan: policies on risk assessment, risk mitigation and recovery from disaster,
- Network Separations: protection of industrial systems from enterprise requests and messages,
- Perimeter Protection: Firewalls, authentication, authorization, VPN and antivirus software to prevent unauthorized accesses.
- Network Segmentation: application of switches and VLANs to create sub-networks and restriction of traffics between networks.
- Device Hardening: password management, user profile definition and deactivation of unused services to enhance security of devices,
- Monitoring and Update: surveillance of operator activities and network operations, and regular updates of software and firmware.

VI. INTERNET OF THINGS/INDUSTRIAL INTERNET

Advances in Industrial Internet are traditional approaches that have leveraged on the strength of peculiar advanced analytics of industries and power of real time historical data. The embodiments of Industrial Internet are intelligent machines approaches, advanced analytics and ubiquitous connectivity of people, either at home or at work [46]. It had been estimated in 2012 that its application in industrial sectors had accounted for 23.3 trillion dollars’ activity in the economy of the United States [46]. It enhances robust and sustainable global growth in rapid closing of productivity gap between advanced and emerging nations [46]. Marriage of computing, information and telecommunication systems with wide spread instrumentation, monitoring and analytics is an incentive to apply new solutions arising from internet base innovations to cub inefficiencies in realizing full capability of machines, which are greater at systems' levels than individual physical machine's level. It optimizes inspection, maintenance and repair processes in asset management [46].

The concept of IoT require transmission of enormous data, which shall transmit accurate meaning whenever they are context aware, are processed, analyzed and sheared by devices in different geographical locations. Context aware system uses subset of information that can characterize the situation under which the data was collected, and make a device to be well adaptive to its environment [47].

A typical IoT ecosystem contains the following myriad types of sensors: Micro-electromechanical Systems (MEMS), Reeds, Magnetic, Seismic, Acoustic, Light, Imaging, Thermal, Temperature, Humidity and Chemical (Gas-Molecular, Luminescent and Electrochemical). Artificial Intelligence in which biology is used as the template for mathematical and computational model, allow machines to learn from experience and adapt it to their responses [48].

According to Daniel and Jordan [49] Internet of Things is a concept in which Internet is a platform for devices to communicate electronically, either with other devices or with human beings, using low cost technologies in sensing, processor driven devices, cloud computing and ubiquitous wireless connectivity platforms which might be inconspicuous to an average persons because the changes on the environment is subtle, because intelligence is built into infrastructures. They stated that it offer opportunities to address many of today's societal challenges, in form of new products and services that protect the environment, conserve energy, and embed sensing capabilities and intelligence in company products, increase agricultural productivity, enhance safer and faster transportation, help in realising better and more affordable healthcare, enhancement in public safety and timeliness of information. They further buttresses on importance of IoT in offering unique opportunities in environmental protection issues of clean water, air pollution, deforestation, landfill waste, sewers, and complex environmental trends by their data models using applications devices like air quality egg for air quality outside a person's home or office, solar powered big-belly trash cans that alert sanitation crews when full, invisible track which help prevent illegal forest logging, Australia's Integrated Marine Observing System for exploration of oceanic conditions on marine ecosystem and climatic change of waterways, smart farm system where every process can be monitored to reduce waste and improve agricultural productivity in form of precision farming, water-bee irrigation system as a smart irrigation system that collects data on soil content and other environmental factors from a network of wireless sensors to reduce the water waste, smart-bob in grain bins that electronically measure and report on level of contents in the bins, z-trap insect traps that help farmers remotely monitor insect population and protect the crops from insect damage, energy solutions that enable clean energy technology and market dynamics which encourage energy efficiency practices such as running appliances at off-peak times, smart electricity meters that provides real time and two way communications between customers and the utility companies, wireless bridge sensor to reduce risk by monitoring bridge's health, advanced national seismic systems in buildings uses accelerometer and real-time data analysis to monitor the structural health of buildings in earth quake prone areas, onstar's automatic crash response in vehicles that detect a crash and automatically alert emergency responders. Google glass head mounted computer worn as eye wear to access internet and communicate and record surroundings with voice commands, Hikob road sensor that provides real time information on road conditions which can also alert drivers of potential hazards through road signage or traffic signals, park-sight as a network of self powered wireless parking sensors that collect and report real time information on the occupancy of individual parking spaces, a small Delphi connect device for vehicles to monitor and control vehicle remotely via the Verizon LTE network, Mimo baby monitor body suite monitors body temperature and motion and breathing patterns use Bluetooth wireless communication to relay data to a base station, lively elderly monitors composed of activity sensors that monitors the daily behaviour of an individual living alone, HyGreen hand-washing stations as hand washing reminder and recording system designed to prevent diseases from spreading within hospitals through which hospital staff are accountable for hygienic standards, small and flexible reminders [flash lights, audio to monitor and maintain personal garden electronically [monitors pH, water temperature, air temperature, light and humidity], sensor-enabled GE company's Egg Minder that detects number of eggs and how long they have been there . . .

Daniel and Jordan in [49] specify integral components of future internet or Internet of Things as "real world integration and heterogeneity of devices and networks, mobility of entity of interest, nodes and networks and scale management. It as well extends to distributed intelligence in business processes supported by a cross layer of service via middleware and we service enabled devices and continuous sense making in these dimensions of human-to-human interaction by semantics of static web contents, human-machine interaction by semantics and internet of services of 3D contents, and machine-to-machine interaction by internet of services of internet of things contents". This would invariably brings about better processes and better decision making as IoT exploits services on smart products and internet of services exploits open service platform and enterprise and cloud services.

The IoT is considered to be an integral part of future internet in [50, 52] in which services and service platforms provide the glue and key to interoperability. It is therein considered to be "A world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Service are available to interact with these smart objects over the internet, query and change their state and any information associated with them, taking into account security and privacy issue."

Elgar in [51] explains basic idea of IoT as "virtually all things with embedded system characteristics (otherwise called smart things) that posses features of computer in internet connectivity". Though the is recently made popular because of hardware development in aspects of characteristics like reduction in size, cost and energy consumption, hardware dimensions, that might not interact directly with human beings that have lead to miniaturized and inexpensive embedded hardware [51, 52]. It was therein discovered a tendency of numerous computer enabled devices that requires new network infrastructure other than the Internet which has as well allowed the entirety of physical world to generate data automatically. This calls for alternative technologies and standards like "evolving IPv6, 6LoWPAN, Handle System or InternetO", in which communication is predominantly Machine-to-Machine (M2M) paradigm.

In [52], Fiedemman and Christian describe IoT as a vision that extend internet to cover every day objects of the real world. Linked physical items could now serve as ubiquitous internet access points, opening new opportunities and technical/social changes. IoT is built on symbiosis of several complementary technologies as a platform, such technologies as:

- Communication and cooperative technologies such as Wireless Personal Area Networks (WPANs),
- Addressable such as Domain Name Services (DNS),
- Identity, such that things are uniquely identifiable,
- Sensors and Actuators to engage in instrumentation and control functions,
- Emdedded technology as found in smart objects,
- User Interface and Signage technology, and
- Tracking technology as in Global Positioning Systems.

VII. CONCLUSIONS

In conclusion, there are close similarities in structure, constituent components, inter operability and interconnection resources of such components, underlying platforms and functional requirements between an Automated Industrial Plant and an outfit of IoT. Nevertheless, Automated Industrial Plant is more advanced and can serve the function of a node in a global setup of IoT. Therefore, an Automated Industrial Plant can serve in context as a precursor to IoT. It is therefore believed that certain underlying characteristics of Automated Industrial Plants can be solutions to a lot of potential problems in IoT. Envisaged area of future work in this direction shall include detailed analysis of SCADA, hardware, industrial layout, programming model and software programming techniques of PLCs etc.

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