Riding the Industry Digitization Wave with IoT: Challenges and Implications

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IIoT Disruption and Digital Transformation

We are living in an era of technology acceleration, where digital technologies are transforming every aspect of our personal and professional lives. One of the main drivers of this transformation is the Internet-of-Things (IoT) a revolutionary computing paradigm, which enables the delivery of novel services that leverage data from internet-connected devices, as well as intelligent (semi)autonomous interactions between machines. IoT is propelled by the proliferation of multi-purpose internet-enabled devices, which can be used to implement disruptive internet services.

The number of such devices amounts already to several billions and is growing in an exponential pace. At the same time, their functionality, sophistication, and energy efficiency are constantly improving, while their costs are falling in a rapid pace. Furthermore, there is a wide variety of internet-connected devices (e.g., ranging from low-cost sensors to autonomous robots), which serves many different purposes and applications in different settings.

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IoT is disrupting a variety of industries and processes in both consumer and industrial settings, including home automation, healthcare, transportation, smart cities and urban living, energy, manufacturing and more. According to a recent report by Mc Kinsey & Co, IoT will be generating substantially business value in all the above areas. However, the same report highlights that the lion's share of the anticipated value will be produced in the scope of industrial rather than consumer applications.

This finding is fully in-line with the rising momentum of the Industrial IoT, which refers to the deployment of IoT in industrial settings, such as factories, oil refineries and energy plants. These environments are already characterized by the presence of thousands of intelligent, multi-purpose networked objects (e.g., smart meters, machines, tools, sensors, robots, and a wide range of other types of cyber-physical systems (CPS)), which create a sound basis for the adoption of the IoT paradigm.

Moreover, there are already tangible business cases concerning the use of IoT devices in these settings, including deployments with a clear ROI (Return-on-Investment). The latter encourage adoption and facilitate relevant capital investments, which explains why IIoT business scenarios are in the short term likely to generate more value than consumer-oriented cases.

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IIoT is not merely a new case of IT-driven innovation in industrial applications. Rather, it is a whole new paradigm that is completely disrupting the industry based on the convergence of Information Technology (IT) with Operational Technology (OT).

In particular, IIoT facilitates the interconnection of all stakeholders and their devices in the industrial value chain, along with the timely and accurate processing of data stemming from them. In this way, it provides new levels of flexibility in automation, increased agility, and responsiveness in supply chain interactions, as well as use cases that have not been possible before.

For these reasons, IIoT is considered as the most important enabler of the fourth industrial revolution (Industry 4.0), which foresees the full digitization of industrial processes based on the deployment of networked cyber-physical systems (CPS) that will exchange data and services in a trustworthy manner.

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Every day, a growing number of enterprises are getting ready for the fourth industrial revolution. Industry initiatives already support their efforts, including the development of enabling infrastructures and standards. Specifically, major IT vendors such as Microsoft, Amazon and IBM are providing scalable and secure cloud infrastructures that can host and process large amounts of data and interactions between billions of devices.

At the same time, all major integrators of industrial automation solutions (e.g., SIEMENS, ABB and Bosch) are building IIoT solutions, based on the integration of IoT devices and processes in a cloud infrastructures. Moreover, OEMs (Original Equipment Manufacturers) and device vendors are continually embedding intelligence in their devices. The landscape is completed by standards development organizations (SDOs) such as the Industrial Internet Consortium (IIC), which are developing standards for IIoT solutions and services.

In this context, industrial enterprises need to ride on the wave of digital transformation to remain competitive through reducing operational costs, increasing the efficiency of their operations, and implementing new business models. To this end, they must prepare a roadmap for their digital transformation, while at the same time employing experts and establishing the business partnerships that will lead to successful implementations.

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2. Business Cases

The rise of IIoT is associated with a range of business cases and applications, which deliver proven benefits to all major stakeholders, including plant owners, plant operators and providers of industrial automation solutions.

The existence of such business cases creates a surge of demand for successful implementations, while lowering investment barriers and rendering plant managers and C-level executives willing to finance projects. In following paragraphs, we illustrate some representative examples.

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2.1 Predictive Maintenance

IIoT is revolutionizing industrial maintenance activities through enabling organizations to realize a shift from preventive and condition maintenance processes to predictive maintenance. Nowadays, most organizations employ preventive maintenance, which involves the regular inspection of the status of the equipment to undertake maintenance prior to equipment failure, as the latter has usually catastrophic impact on the quality and the efficiency of production processes.

Predictive maintenance is the ultimate maintenance vision, which is based on the prediction of parameters such as the EOL (End-of-Life) of components and equipment to schedule maintenance activities at the best possible point in time. Such predictions are based on the collection and analysis of large data volumes from vibration sensors, thermal cameras, ultrasonic sensors, acoustic sensors, temperature sensors, as well as other [sensing modalities that are indicative of the health status of assets and equipment](#).

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2.1.1 More on Predictive Maintenance

These data are in several cases combined with data about power consumption and data stemming from oil analysis for the equipment at hand. Moreover, the scheduling of the maintenance activities takes also into account the status of planned activities to identify the time instants that maximize OEE and associated cost/benefit ratios in a way that considers risks stemming from delayed maintenance. To this end, IIoT systems for predictive maintenance integrate and exploit information from asset management systems, enterprise resource planning (ERP) systems and other business information systems.

All predictive maintenance systems hinge on the processing of data from many IoT devices, which renders predictive maintenance one of the most common IIoT applications. Moreover, as predictive maintenance leads to improved OEE, reduced labor for performing the maintenance and better planning of related supply chain operations, it is increasingly considered one of the killer applications for IIoT.

2.2 Flexibility in Industrial Automation

Contrary to IT operations, industrial operations tend to be much harder to (re)configure in the light of the introduction of new technologies or even in cases where there is a need to reengineer business processes. This makes industrial automation architectures quite inflexible, which is a serious set-back against the deployment of novel automation technologies.

As a prominent example, one could consider the benefits and opportunities that are associated with the introduction of 3D printers and Additive Manufacturing (AM) in the factory shop floor, which can accelerate the production of parts as a means of reducing supply chain costs and enhancing production speed. However, the process of integrating a 3D printer in the manufacturing shop floor can take several weeks or even months. In such cases, IIoT comes to the rescue: IIoT based factory automation deployments hold the promise to become configured in IT time scales (e.g., few hours) rather than conventional factory configuration timescales.

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2.2.1 More on Flexibility in Industrial Automation

With IIoT reconfigurations take place at the cyber world based on digital technologies rather than at the physical world where processes are much more tedious and time consuming. IIoT automation systems provide a seamless link between the cyber and physical worlds, which ensures that changes in the IT configurations are properly reflected on the field.

Overall, IIoT enables a shift towards more flexible automation processes, which will greatly facilitate the integration of new technology, as well as the optimal exploitation of assets in the plant floor. In this way, IIoT will drive lean industrial operations to the next level of efficiency.

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2.3 Optimal Supply Chain Operations

Industrial organizations are constantly seeking ways to optimize supply chain operations as a means of increasing their efficiency and minimizing their costs. Despite significant advances in supply chain management systems, there is still no easy and accurate way to manage information flows across the supply chain, which leads to inaccurate forecasts, out of stock problems, bullwhip effects and many other inefficiencies.

The advent of IIoT provides opportunities for increased accuracy in supply chain operations, as it enables seamless integration and flow of information across the devices and information systems that belong to the various stakeholders.

2.3.1 More on Optimal Supply Chain Operations

In this way, supply chain processes are streamlined as part of the IIoT system implementation. Most important, IIoT-based systems can timely identify and promptly respond to unforeseen supply chain events, such as a delayed shipment, an unforeseen out-of-stock event, a machine failure and so on.

Based on IIoT, supply chain operations will become more efficient than ever before. In addition to the collection of data from various devices, IIoT will enable machines to engage in supply chain operations to significantly increase automation levels. Visionary scenarios such as machines that automatically place orders in ERPs during predictive maintenance and consumer goods that instigate replenishment processes will soon become a reality based on IIoT.

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2.4 Improved Quality of Operations

The digitization of industry enables the collection of large amounts of data about the quality of industrial processes. Such data include for example product performance and integrity parameters, soft parameters associated with job management and the personnel involved, as well as a wide range of measurements from production lines. Several of these measurements are derived from sensors and metrology processes, which can be perfectly supported by IIoT systems.

IIoT facilitates not only the collection, but also the analysis of this data towards process optimization. Moreover, it enables the execution of actuating services based on quality parameters, such as tuning of the rate of operations of a machine as a means of fine-tuning the quality of the processes.

Overall, IIoT boosts the convergence of metrology, quality control, and automation, towards more effective and higher quality processes.

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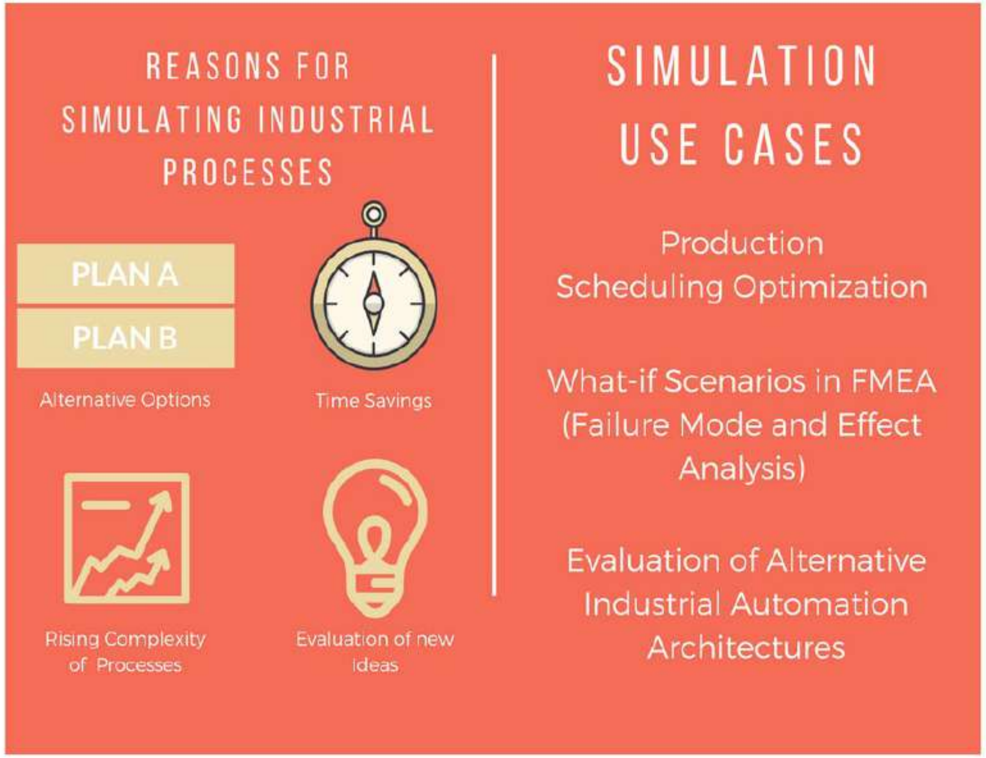
2.5 Simulation of Complex Processes

Industrial processes tend to be complex, as they involve many systems and field devices, which are interacting as part of non-trivial physical processes. Likewise, the evaluation of changes to these processes is a difficult task, as it is challenging to implement / test scenarios associated with automation or even commission and engineering of new systems.

To alleviate this complexity, plant owners and operators employ simulation, as a means of executing what-if scenarios and taking optimal decisions.

The advent of IIoT and CPS makes simulation processes easier and more effective than ever before. The main reason for this is that they enable the collection of large amounts of digital data for the various systems, devices, and processes, along with the subsequent analysis of these data using advanced analytics.

This provides flexibility and speed in the analysis of various scenarios and their implications prior to taking decisions. As a prominent example, digital data can be used to evaluate different production scheduling decisions or even asset management decisions as part of FMEA (Failure Mode and Effects Analysis) processes.



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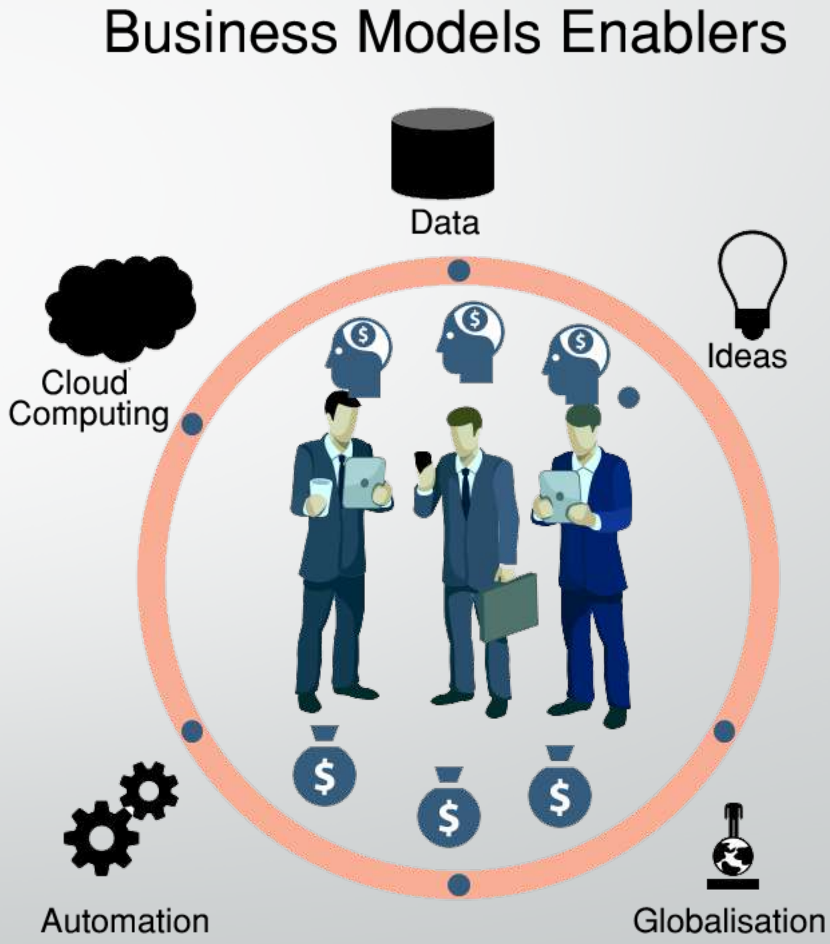
2.6 New Business Models

IIoT enables plant operators and equipment manufacturers to implement and offer new business models around their products and services. Such business models are for example based on the streaming and integration of products' data within cloud computing infrastructures, which could be latter accessed on-demand and in a pay-as-you-go fashion.

In this way, product manufacturers can provide added-value services to their customers, such as predictive maintenance suggestions, product health monitoring information, recommendations for optimal operations and more. Automotive manufacturers and white appliances vendors are already experimenting with such business models. The expanded use of the IIoT paradigm will enable their realization and wider use in the coming few years.

The above list of business cases is not exhaustive, yet it is representative of IIoT's capabilities, which opens new horizons in plant operations, supply chain interactions and product offerings. Most important, these use case are already proven through successful pilots and enterprise deployments.



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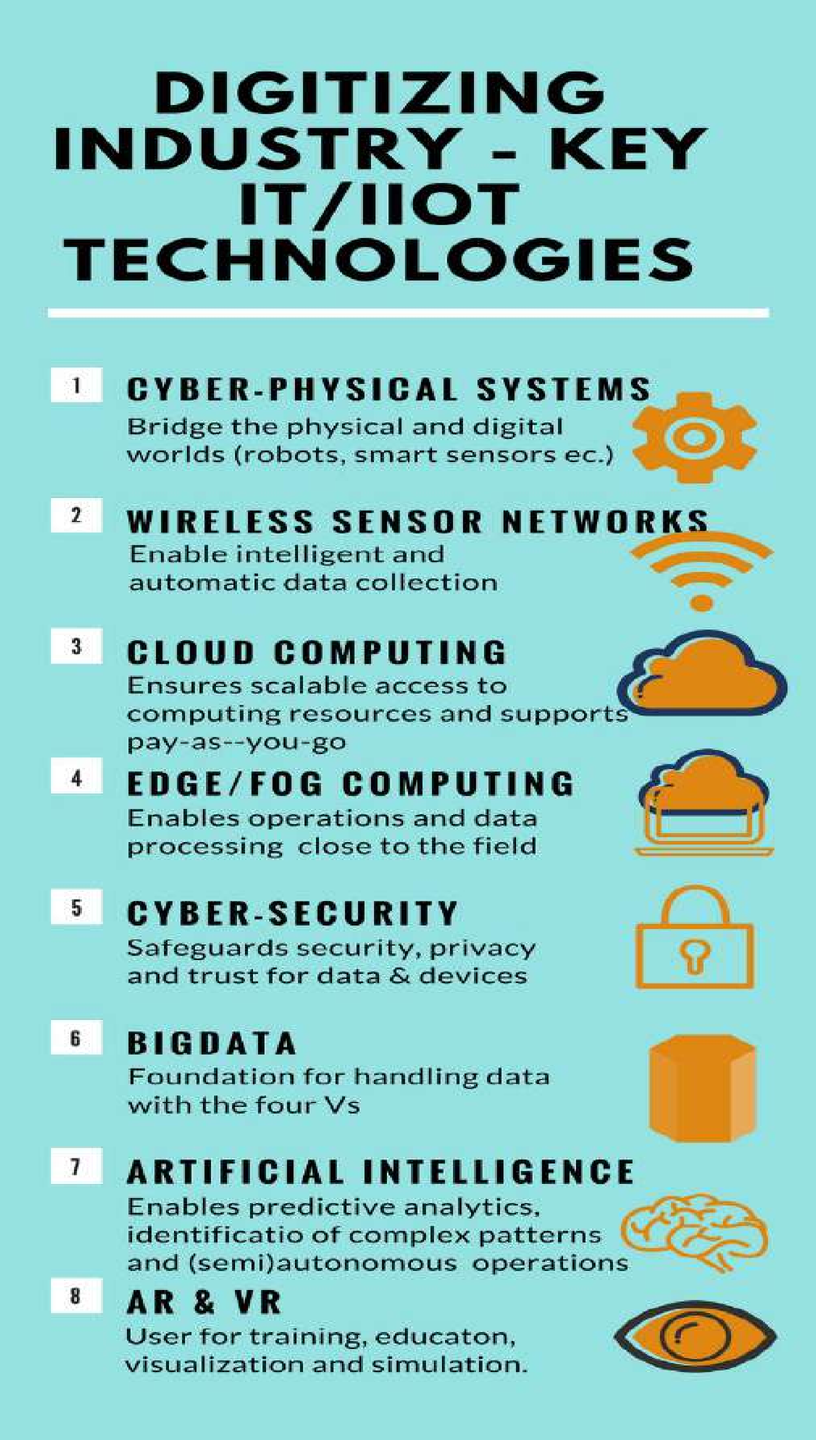
3. Technology Enablers & Building Blocks

As evident in the description of the business cases, IIoT is empowered by several technologies, which are complementing each other:

- **Cyber-Physical Systems (CPS)** are enabling the IIoT paradigm through bridging the physical world (e.g., physical processes, field devices) with its digital representation. Manufacturing robots, intelligent machines with digital interfaces, smart sensors, actuators with embedded intelligence and networked field devices are all prerequisite elements for a successful IIoT deployment.
- **Wireless Sensor Networks (WSN)** technology is a core element of IIoT services. It enables scalable, programmable, and automatic data collection about the status of machines, devices, and processes. Based on the evolution of WSNs, high performance and power efficient data collection processes can be supported.
- **Cloud computing,** as IIoT deployments need to take advantage of the scalability, capacity and pay-as-you nature of the cloud. Most of the above-listed business cases are deployed in the cloud through direct integration of services and data streams within some cloud computing infrastructure. Moreover, the cloud is the key enabler for all emerging business models that are based on demand-access to data and other digital resources.
- **Edge/Fog computing,** which is commonly deployed when processing data close to the field is required. Edge computing is gradually becoming the primary architectural model for IIoT, since it enables real-time data analysis close to the field, while still being able to exploit the capacity and scalability of the cloud.

- **Big Data** technologies are an integral element of several of the presented business cases, given that most of them are data intensive. Maintenance and simulation processes require for example the processing of large numbers of high velocity streams, which originate from a wide range of heterogeneous data sources. In such cases, Big Data technologies are employed to handle the volume, variety, velocity, and veracity of the data streams.
- **Artificial Intelligence (AI) techniques** are also part of the listed business cases, especially when there is a need to produce accurate predictions or even to identify complex knowledge patterns. AI techniques be a special part of Big Data analytics techniques, which blends nicely with IIoT's multi-sensor, multi-device operations.
- **Cyber-Security** as plant owners and operators are very sensitive about the security of new IT systems and devices in their plant floors, while at the same time being concerned about protecting datasets. As a result, IIoT infrastructures and applications should be deployed with strong cyber-security features for securing interactions and protecting datasets in-line with corporate policies, but also in-line with applicable security laws and regulations.
- **Additive Manufacturing (AM),** which can be a valuable addition to most of the above listed business cases, through expediting the processing of printing and making available components and assets entailed in an industrial process. Although not an integral part of IIoT, IIoT processes benefit from integration with AM.
- **Augmented Reality (AR) and Virtual Reality (VR),** which provide advanced and ergonomic cyber-representations of the status of equipment and processes. AR and VR are driven by the availability of data as part of the IIoT paradigm. They can be used for training and remote support.



4. IIoT’s Deployment Challenges

IIoT’s affiliation to a host of leading-edge technologies is only one of the factors that renders successful deployment challenging. Other challenges include the lack of knowledge and awareness about IIoT, the need for compliance with legacy systems and the absence of a smooth migration path. These challenges are discussed in following paragraphs.

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4.1 Poor Awareness and Lack of Knowledge

IIoT technologies are much more closely related to IT rather than OT technologies. As a result, field workers have a very limited knowledge and understanding of IIoT and its potential benefits. This knowledge gap cannot be easily remedied, despite industrial solution integrators' efforts to raise awareness about them.

The latter efforts are sometimes perceived as overhyped by plant owners and operators, who are generally conservative and quite reluctant to adopt leading edge IT technologies. Moreover, awareness initiatives are in most cases addressed to large enterprises rather than to SMBs (Small Medium Businesses).

Awareness raising activities towards end-users are a key prerequisite for successful IIoT implementations. The IIoT message must therefore be conveyed to plant owners and operators (notably SMBs) using simple language that focuses on the business benefits rather on technical concepts.

Likewise, solution integrators should invest on educating their potential customers, prior to collaborating with them in the definition of a digital transformation strategy. Overall, end-users must be convinced that IIoT can provide them with quality, cost, timeliness benefits at the same time, otherwise they will be reluctant to deploy IIoT systems and processes.

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4.2 Adaptation and Migration of Legacy Systems

IIoT assumes that field devices are CPS systems, which provide digital data and interfaces to the digital world. While several such devices exist and even more are emerging, a clear majority of machines and devices in the plant floor are not CPS systems. Hence, they provide no easy way for interfacing to them through IT systems, while there are not offering IT-based access to their capabilities.

IIoT deployments must therefore make provisions for the integration and adaptation of legacy machines and systems. This is very crucial towards protecting existing investments, but also towards providing a smooth migration path to the Industry 4.0 era. The adaptation of legacy systems is likely to involve the implementation of low-level interfaces to the machines, as well as their modelling in an Industry4.0 compliant way.

Beyond the integration of legacy systems, there is a wider need for a smooth migration to the new reality. Nowadays, most industrial automation architectures, industrial maintenance processes, quality control system architectures and supply chain processes have not been designed with IIoT in mind.
Therefore, there a need of rethinking, revising and reengineering some of these processes in the light of CPS systems and IIoT workflows, while at the same time devising smooth migration paths from existing processes to the revised ones. Unfortunately, beyond some general guidelines, this migration process needs to be tailored to each different plant, since a "one-size-fits-all" migration solution is not available.

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4.3 Security, Privacy, and Trust

As already outlined, cyber-security is an integral element of IIoT. Nevertheless, this is not enough to alleviate end users' security and data protection concerns. Despite IIoT's strong security features, plant owners are usually hesitant to accept a transfer of corporate data to a cloud infrastructure.

Likewise, they are skeptical about introducing new technologies and devices in their plant floor, as they question their trustworthiness. Overall, strong security and data protection will be needed to realize the shift towards IIoT-enabled plants.

Along with secure technical implementations, there will be also a need for a cultural shift towards accepting IoT and cloud security solutions.

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4.4 Leveraging Standards

Both end-users and providers of IIoT solutions can greatly benefit from an ecosystem of standards-based tools and techniques, which will support robust and sustainable IIoT deployments. Despite the recent emergence of a pool of standards from organizations like the Industrial Internet Consortium (IIC), standards-based implementations are still in their infancy.

Most of the existing implementations and case studies have been deployed based on proprietary technologies, which can be a set back to the extensibility and technological longevity of IIoT solution. Furthermore, early adopters are not offered with access to a full spectrum of required standards.

As a result, the pace of standardization creates a deadlock that hinders wider adoption and IIoT. In this respect, practical standardization initiatives and implementations such as IIC's testbeds could boost the resolution of this deadlock.

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4.5 Strategy Shaping and Paradigm Shift

IIoT is not a single project, but rather a long-term strategic commitment that impacts all the future projects of an organization. This is because IIoT signals a paradigm shift for all industrial processes, which imposes a new way for doing things in the plant floor and the supply chain using CPS, IoT and cloud computing technologies.

For example, an IIoT strategy mandates that all automation and control projects will be data driven and implemented in the cloud. In this context, industrial organizations need to develop a long-term strategy about IIoT adoption, while sticking to the mandates of this strategy.

This implies long terms investments and commitments, which challenge adoption decisions. Nevertheless, adoption roadmaps can always start small, while thinking big, to encourage gradual investments that will follow business validation milestones.

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5. Talent Gap in IIOT Technologies

5.1 Senior Engineering Talent Gap

IIoT implementations employ a host of leading-edge technologies, such as the ones listed above. Despite the hype around these technologies there is still a significant talent gap about them, which makes it very difficult for plant operators and providers of industrial automation solutions to employ the right people i.e. people possessing the skills and experience required for the successful delivery of complex IIoT projects. Nevertheless, in the case of industrial organizations the problem becomes even worse, due to the need of combining digital literacy with knowledge about complex industrial processes.

As an example, the implementation of data intensive IIoT projects (notably Big Data projects) requires teams with multidisciplinary skills in the areas of data mining and analytics, database systems, industrial processes and more. Assembling such teams is one of the major challenges faced in the transition to Industry 4.0. Also, the skills shortage phenomenon is not limited to technical personnel.

It's more than just having the ability to work in multi-disciplined teams or matching corporate culture. First, one must realize that each team is unique. By identifying the values and motivations, relational communications skills, and decision-making traits of the team, potential candidates with a strong match to that team will produce the best results.

In addition, utilizing mental agility testing for department and division leaders enhances the likelihood of hiring success.   Too many organizations rely upon matching responsibilities and requirements on a resume and job history. It's not about what skills and experiences a candidate has. By identifying the objectives and desired outcomes of the role, you can assess whether a potential candidate has the record of similar accomplishments and business acumen to meet or exceed those objectives.

5.1.1 More on Senior Engineering Talent Gap

So how do Board members, CXOs, and VPs go about recruiting to meet your needs? You could and should use employee referrals and your network of contacts. You could use job boards, recruitment process outsourcing (offshore RPOs) to save initial cost or utilize several contingency search firms.

Most Executive Hiring Managers hate these latter approaches as they get in boxes filled with “flypaper”. Are you aware that these firms have a required number of sendouts of resumes/CVs they must send each day? Surely your experience tells you that job boards deliver the worst in “C players” – the unemployed, underemployed, and “want to-be” who can be easily replaced by robotics and/or software automation as they provide no real value other than just being a “body”.

Using a performance based retrained search firm saves you money in the long term. First, they don’t use job boards and rarely work with active job seekers. The successful are rarely unemployed and are quite happy where they are now. They significantly contribute to their employer’s IP, revenues, and building products/services that deliver real solutions to customers in their market space.

A good retained search consultant never accepts a typical job description as the basis of a search. He or she starts out with a Discovery Process to identify the need, objectives, and measure the behavioral traits of the team.

5.2 Executive Talent Gap

There is a shortage of senior department managers and corporate executives with a deep understanding of the digital transformation of industrial IoT. Without competent and knowledgeable executives, companies cannot get the most out of the fourth industrial revolution.

IoT upper management need to be aggressive in strategy that disrupts the old hierarchal in teams, roles, and business processes. This requires agility and risk assessment. By properly defining your potential market and thus creating new business models in the digital transformation, leadership must create a strategic vision that builds solutions for their customers.

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6. Conclusion

- Not all companies who seek to integrate IoT or build IoT product and services will succeed. But this next great Industrial revolution, powered by IoT as Industry 4.0. To succeed, a full range of leadership skills is needed to integrate IoT into the business and the extended enterprise. This kind of talent cannot only be acquired, it needs to be grown.

- In the next eBook, we'll cover 10 questions to ask before engaging a retained search firm to make sure you choose the right one who knows your industry and can deliver results that not only meet, but exceed your expectations

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John holds a Ph.D. in Electrical & Computer Engineering from the National Technical University of Athens (2000) and is currently Associate Professor at the Athens Information Technology (2006-present) and Honorary Research Fellow at the University of Glasgow, UK (2014-present).

Dr. Soldatos has played a leading role as software engineer, systems architects, technical project manager and principal consultant, in the successful delivery of more than fifty (50) (commercial, industrial, research and consulting) projects, for both private & public sector organizations, including complex integrated projects on Internet-of-Things and Enterprise Data Analytics.

He is co-founder of the open source IoT platform OpenIoT. He has published more than 180 articles in international journals, books, and conference proceedings, while he has written numerous posts and articles for blogs, newspapers, and magazines. He is the editor and co-author of the recently published book, “Building Blocks for IoT Analytics” (November 2016).

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Charles co-founded NextGen Global Executive Search in November 2009 with an objective to develop a recruitment and assessment system that delivered executive and senior level “A players” to clients in the wireless industry.

Prior to NextGen, Charles is a pioneer in developing predictive methodology and bilateral matching systems in recruitment, having built two search firms acquired by larger entities.

Charles has assisted many companies worldwide in acquiring exceptional talent. He has successfully found the “needle in the haystack” for IoT network operators, embedded wireless modules for industrial IoT, 4G / LTE / 5G wireless ecosystem and IoT data and devices, and artificial intelligence platforms and applications for IoT.

We solve business issues, increase shareholder ROI, and extend market entry / market share by recruiting “A Players” – the top 10% that produce 8 to 10 times more than “B players” in C-level and functional leadership roles. Having successfully recruited those who not only met, but exceeded client expectations, those searches and discussions is the inspiration for the publication of this e-book guide.