Industry 4.0 wave - Relevance of SCADA in an IOT world and journey towards a true digital enterprise

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Industry 4.0 revolution has gained significance as well as mindshare of many organizations. Many organizations are exploring new ways to leverage IoT, its potential, advantages and with expectations to enhance the overall throughput of their existing process automation, by overcoming existing challenges and also integrating the entire value chain of the organization .

The paradigms of businesses haves been transformed and disrupted by digitization, and SMAC where the entire value chain is redrawn with every stake holder playing an integrated part. This is best described as the picture alongside.

All along, every segment of an enterprise was an island of processes and information with data exchange happening only on need to know basis, the biggest being the SCADA. Democratization of data in a much federated enterprise is the new age mantra of digitization. Currently in large manufacturing and process oriented enterprises like the Steel, Power, Refineries, the most often asked questions “will IoT replace Supervisory Control and Data Acquisition (SCADA) in a new era for manufacturing?”, “How can IOT help me in leveraging existing SCADA?”, “I already have process automation, have implemented any a latest technologies to enhance my existing SCADA, do I still need IOT?”.

Integrated organizations are adopting digital blocks to drive a true new age Digital enterprises

Manufacturing is a very mature, highly automated industry where technology adoption curve is very high and steep, also a place where integrated centralized systems like SCADA played a significant role. Since there is a new tsunami of data generated from IoT, which when analyzed creates a whole new value paradigm, existing SCADA systems need to be all the more relevant in not mere running the processes efficiently but to enable upstream and downstream value creation. Creating intelligent systems that **learn, adapt and potentially act autonomously** rather than simply execute predefined instructions is the direction most of the enterprises are heading to.

IOT thus paves a new path and opens new doors to a true digital enterprise by leveraging the internet, interconnected and discreet systems, allowing a strong interface between applications and hardware. SCADA has helped manufacturing industries to monitor and control their processes and provide some sort of semi integrated control, which over the past decade or so has delivered significant results in decreased operational costs and increased efficiency. The journey of driving efficiencies and operational excellence is never ending. IOT integrated with SCADA just provides that missing link.

SCADA systems have been in use for over 3 decades now. Over the time most of the managers and decision makers in these industries have not adopted the rapid technological changes which have taken place in the process industry. All along SCADA has done a great job in various industries in providing the right data to monitor and manage their and processes primarily delivering efficiencies. It also helped boost the efficiency of operations and reduce costs. Today just mere optimizing on efficiencies is not enough. With technological advances expanding the range of both systems and monitoring methods, and as the world connects via high speed smartphones, internet and associated cloud technologies, explosion of data on real time basis on every connected component in the process chain, some believe that perhaps SCADA has had its day.

Hence it's all the more natural that there is confusion among professional discussions around the role of Industrial Internet of Things (IIoT) applications. Questions like, "Can IoT replace SCADA?", "Can the two be integrated?" and "What is the difference between IoT, SCADA & PLC?" always arise.

Essentially, IoT should be viewed as a technology that is implemented on top of SCADA. IOT provides the much needed advantages of scalability, data analytics, and standardization and interoperability opportunities which help the alignment of the industry to the rapid changing business demands. IOT is to be seen as beyond SCADA for SCADA.

SCADA – then and now

First of all, let's take a quick recap of how a typical SCADA works. It is an end-to-end system that receives data from Intelligent Electrical Devices (IEDs) or Remote Terminal Units (RTUs), which are connected to sensors through a communications network. SCADA has the following minimum features:-

Graphical interface
Process mimic
Real time and historic trending
Alarm system
Data acquisition and recording
Data analysis with Report generator

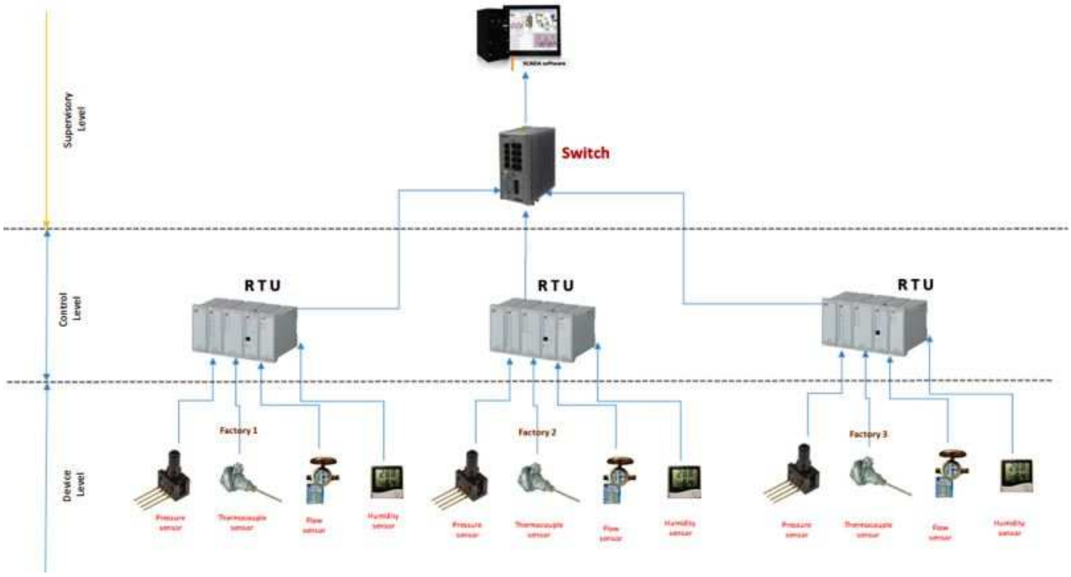
The system then analyzes this data and sends commands back to the field, with individual SCADA applications often working simultaneously. The SCADA systems interfaced with the hardware which typically is the instrumentation and field systems data acquiring systems and telemetry.

- **Standard communication protocol:-**Common communication protocols used in industrial field are: ARCNET, CAN bus, Modbus, PROFIBUS. If SCADA software and hardware devices use same communication protocol, they can talk to each other without any other extra software drivers.
- **Standard data exchange interface** :-Common data exchange interface used in industrial field are: DDE (Dynamic Data Exchange) ,OPC (OLE for Process Control), Using standard data exchange interface, SCADA software can indirectly communicate with hardware devices via data exchange center of DDE and OPC. The advantage is that irrespective of hardware devices supporting standard communication protocols manufacturers only need to provide one DDE or OPC driver to support most of the SCADA software.
- Native driver

In early days, the SCADA systems were also used to control and monitor processes and interfacing with monolithic mainframe computers like the IBM 3090, VAX/VMS. During that era that architecture of mainframes at the highest layer of EIS, followed by SCADA, then process control computers and lowest being the instrumentation was the key. With the introduction of advanced graphical user interfaces (GUIs) and mass configuration tools, it became more efficient and accurate. :-

SCADA systems mostly comprise:

- **Programmable Logic Controllers (PLCs) and Remote Terminal Units (RTUs):** These are hardware components that interface with the machines and control them. They are responsible for interfacing with sensors in the machines. All parameters that require monitoring are available here. PLCs and RTUs are organization (s) r interfaces to the machine world.
- **Data Acquisition Systems:** These are centralized systems that collect data from PLCs and RTUs. The connectivity could be wired (Modbus, TCP) or wireless. OPC (OLE for Process Control) is a recommended way to connect to organization (s) r hardware.
- **Supervisory Systems**: Systems that allow supervisors to monitor their machines. These systems do real-time condition monitoring, raise alarms when thresholds are breached and ensure that organization(s) r machinery works optimally.
- A Typical schematic diagram of SCADA is as shown :-



SCADA – the foundation for operational excellence

SCADA systems functioned perfectly for supervisors with very high reliabilities offering the day-to-day monitoring of key processes on what is going on in in the factory, on a near real time basis. SCADA systems were much localized and dedicated with proprietary communication, no internet connectivity and there existed a china-wall separation between the application management software of the mainframes, various other enterprise applications, machines in the field and other upstream and downstream systems. Interaction of other enterprise systems with SCADA was in batch mode and mostly manually intervened.

The SCADA system performs some major functions that allows a company to successfully automate complex industrial processes such as human-machine interface (HMI), electrical communication, data acquisition, monitoring, control, data collection, calculation, and report generation. For many industries, all these functions are vital in order to have a stronger control over processes.

With the changes in the business requirements, advancements in the technology, changes in the business environment, significant drop in storage and computing power, there has been a significant demand to drive integrated systems, automated feedback and control right up the business decisions . This is where IoT solutions come in when organization(s) have more macro level questions to ask. Questions like:

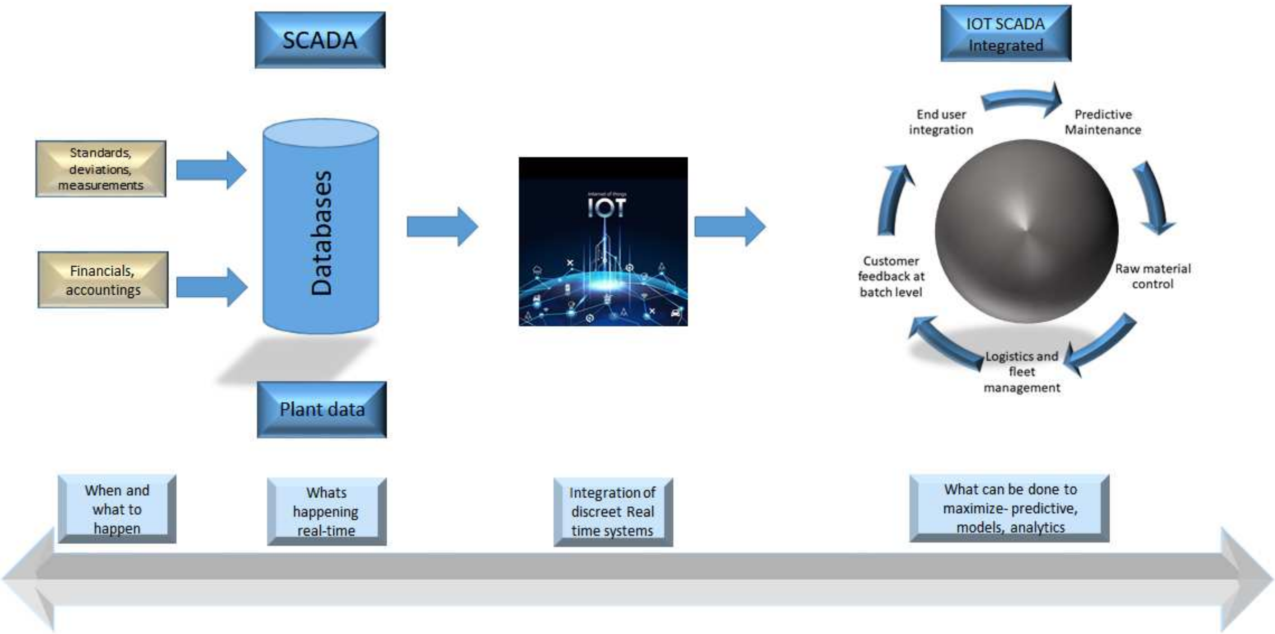
- What is my operational effectiveness across machines, assembly lines and plants? What can I do to improve it?
- What are my bottlenecks, where are they located?
- How can I eliminate these bottlenecks and can I be more proactive and predictive about these?
- What process changes can I do to improve performance, can I make these decisions based on data analytics, past performances, leverage predictive models etc.?
- How can I do a planned vs actual comparison on more factual data and decisions which are driven by analytics?
- Can I predict machine failure? How can I move from calendar-based maintenance to predictive maintenance?
- Can I leverage internet and truly make the entire decision making seamless, anytime anywhere?
- Can I have discreet systems speak and communicate seamlessly?
- Can I connect the upstream systems to the downstream systems on real-time over the internet and enhance the value chain?

These questions are extremely relevant to plant managers, production supervisors, capacity planning personnel and productivity consultants. IoT in manufacturing is meant for this audience

Position of IOT in the world dominated SCADA by can be best illustrated as below

So, SCADA systems which are predominant within heavy asset industries can be reconfigured to adopt the IOT. With three generations of SCADA – standalone, distributed and networked – some industries are starting to utilize what some known as the fourth generation SCADA application. Some also know this to be the Internet of Things.

As the fourth Industrial Revolution is making significant inroads in the consumer behavior and buying patterns, it's time to Re-align the manufacturing processes and get them integrated seamlessly. Implementing fourth generation SCADA with the disruptive capabilities of IoT seems very befitting.

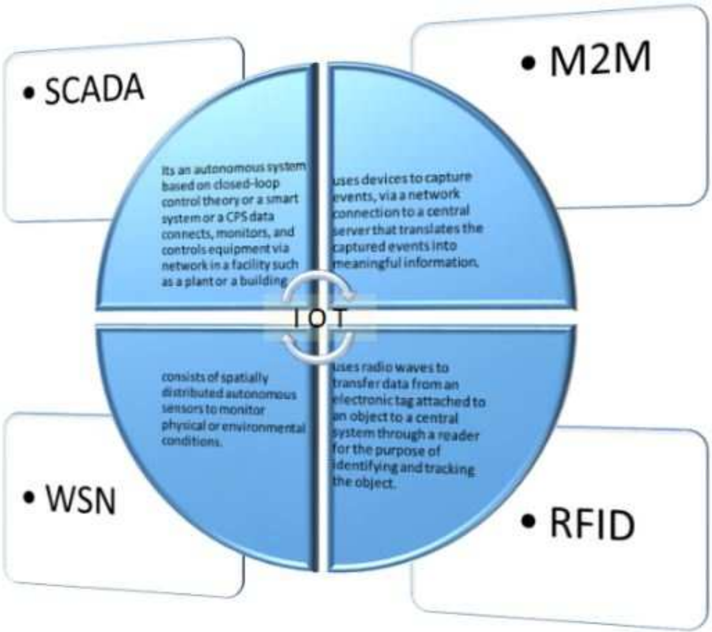


SCADA a key partner in IoT

IoT begins where traditional SCADA, DCS end.

IoT is complimentary to SCADA and DCS. Rather IOT adds value to SCADA and extends SCADA and its value chain to make business more predictable, reduce cost, wastages and improve profitability. Information generated from SCADA systems acts as one of the data sources for IoT. SCADA's focus is on monitoring and control. IoT's focus is firmly on analyzing machine data to improve organization(s) r productivity and impact organization(s) r top line.

The four pillars of IoT are M2M, RFID, WSNs and SCADA (Supervisory Control and Data Acquisition). These four discreet pillars would have been added at different points in time, with in the advent of IOT all these discreet systems are being integrated to deliver an extended as well as an enhanced value chain.



The Internet of Things (IOT):

The Internet of Things is a culmination of advances in connectivity hardware, data networks, cloud computing and big-data processing. IoT begins where SCADA, DCS, and Historians end.

A typical factory is an extremely heterogeneous environment that has grown organically over several years and in some cases over decades. Some of the challenges seen are:

- Machines with different kinds of PLCs and RTUs that support different connectivity protocols.
- Multiple SCADA systems from different vendors, each controlling a specific line or a set of lines. Machine data is available but there are data islands. SCADA systems also store a finite amount of data so historical data is not preserved for deeper analytics.
- Data is stored but the context of the data, the various “environmental” considerations are not captured
- The SCADA systems are always at a point in time data, Integration and driving analytics for data from SCADA, cognitive data, unstructured data is possible only in the IOT world.
- Legacy machines that are not connected as they lack the right kind of instrumentation.
- Assets like Energy Meters, weather monitors, usage patterns, etc. that have never been connected due to cost overheads. Yet the information that they give out is vital.
- Existing data Historians can be a data source.

IoT platforms act as a federated data store of all these diverse data sets. They give organization(s) a single source of truth for driving business decisions, adapting business demands and initiate automatic production changes both internally and externally on a much more dynamic and informed ways.

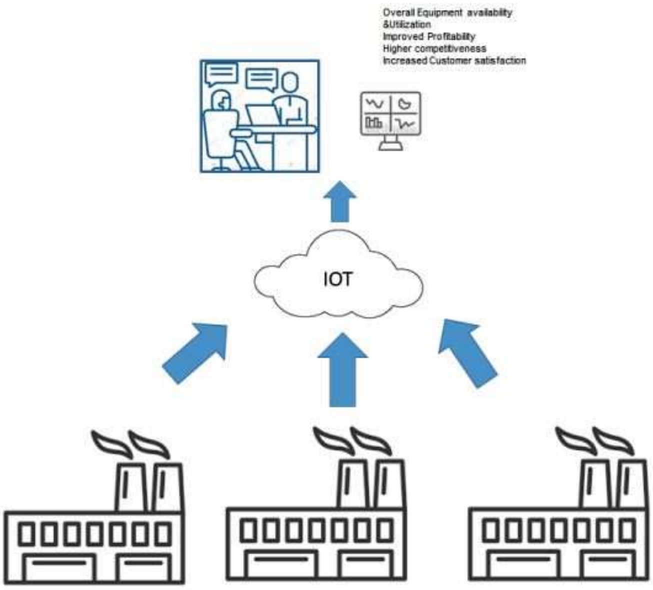
IoT platforms have the following capabilities.

As IoT gains focus and traction, a lot of existing SCADA systems and Historians are providing IoT like features. However, they can never replicate the capabilities of a platform built ground up with IoT in mind. Along the way, SCADA systems have redesigned themselves to keep up with all the emerging technologies that surround everything. The next big question is how companies, that used traditional SCADA systems, will move to the modern ones, which also include IoT deployments. Well, like any other transformation intiative, a carefully planned strategy is required.

The first step is to identify a right IOT platform which has the ability to provide a diverse set of adapters and connectors that can connect to various machines, SCADA, DCS, and Historians.

- **Metadata driven architecture.** Organization(s) can connect anything: machines, vehicles, barcode readers, solar panels, weather stations and have the ability to process data across all these sources together.
- **Complex Event Processing (CEP):** The ability to do real time complex stream processing of data from multiple sources.
- **Big-data processing and machine learning:** The ability to analyze large amounts of machine data. The ability to apply modern supervised and unsupervised machine learning algorithms to predict outcomes
- **Extreme scale:** The ability to ingest and process massive amounts of machine data. This allows organization(s) to connect anything of relevance.
- **Cloud-first and SaaS first:** Built with the cloud in mind and provides flexible, affordable pay-as-you go plans. Systems that provide the ability go private when the situation demands.
- IOT can create the much needed plat form interface for discreet SCADA’s to interface and interact as shown below

Here are some of the factors organization(s) need to have in mind when migrating to a modern SCADA/IoT system.



- **Device type –** First thing to do is to decide which of the IoT devices will remain in-house and which ones will be moved to the cloud. As most of them are storing valuable information and data, security is essential wherever the devices will be located.
- **IoT Standards –** There are certain IoT standards that organization(s) must take into consideration when moving to modern SCADA systems. Some of them are OMG Industrial IoT standards, which is working with the Data Distribution Service, the Threat and Risk Model standard and the IEEE IoT-related standards, which identifies the common areas between IoT domains.
- **Network Segmentation –** This is a crucial step in ensuring business continuity. We all know that network segmentation can save a business. If something goes wrong, it is better to have only one segment down rather than the entire network.
- **Predictive analysis –** This technology plays a major part in bringing out the best functionality in SCADA systems. Choosing predictive analysis solutions will give organization(s) a glimpse into the future and insight into organization(s) system's weaknesses and solve problems before they become one.
- **Key Use cases:** - Identify the key use cases which have the highest impact on business outcomes, provide significant competitive advantage and also there is a strong ROI and financial justification for such an investment.
- **Define enterprise cloud strategy** – Before deciding which type of cloud organization(s) choose, private or public, organization(s) need to consider which one is the best for organization(s) business needs. Do organization(s) need enhanced security? Then the private cloud might be best. Do organization(s) need speed and scalability? Then organization(s) should consider a public cloud. If organization(s) business requires more than just speed or security, then organization(s) should consider hybrid cloud which comprises a mix of both cloud options.

If one takes a closer look at how existing SCADA is implemented and operational, we can see some preliminary elements of IoT – supervisory control and data acquisition. We can safely say that SCADA represents some of the pillars on which the Internet of Things has been built. However at every new age transition stage, one need to be aware of the current capabilities and limitations of SCADA:-

- SCADA systems are not scalable. The Internet of Things has the ability to bring in and process large amounts of data from things and machines. IoT allows any company to connect any device and third party services. All the data is collected into an IoT platform, accessed securely with login credentials. Several people from companies and industries can access to the data (or subset of data or subset of devices). Even in the cloud, new resources can be generated.
- SCADA is a system used for a day-by-day operations in a control room or similar. Nevertheless there is no data analysis to check the performance, integration with CRMs or ERPs and finally there is no contextual information connected to the SCADA. On the other hand, IoT is all about data analysis, Big Data processing on the top of the data, such as AI algorithms, ML and predictive.
- Protocol such as OPC, OPC-UA and others are the standards today on the industry. On the top of that, on IoT there are a dozen of other protocols that can help industries to get connected or to get real-time notifications. MQTTS, HTTPS or CoaP with TLS can help industries plus bring a security layer needed to encrypt the messages and information.
- Integration among devices and manufacturers are not easy on SCADA systems. Usually in Domestic Automation, organization (s) need to have devices from the same manufacturer with the same version. If that does not happen, it's usually almost impossible to easily integrate devices on the current SCADA. There is no presence of horizontal platforms that are operable across devices. On the other hand, on IoT this is one of the most beneficial features for an industry. Standard protocols such as MQTT enables platforms to communicate with each other even if there is a different vendor.

Ease of installation, reduced cost, increased data accuracy and worldwide remote control and monitoring are all things that IoT offers heavy asset industries. However, as IoT is a relatively new technology in relation to SCADA and PLC, its capabilities are naturally adaptable to modern industry demands. That being said, when SCADA began, it allowed manufacturers' systems to work together in real-time, much like IoT is doing now.

Therefore, it's very much apparent that the strength of SCADA systems and its technological capabilities are still relevant even in industry 4.0. Where it falls short, however, is processing to the rest of a business to create a truly connected ecosystem. The question shouldn't be about getting rid of or replacing SCADA, but rather extending SCADA, into what? Currently, IoT is revolutionizing SCADA by offering more standardization and openness. IoT is also providing scalability, interoperability and enhanced security by introducing the concept of the IoT platform. Essentially, both platforms are used to increase overall productivity by integrating smart maintenance. As well as waste reduction, increase in efficiency, a decrease in downtime and the extension of equipment life.

	Traditional SCADA	IOT
Scalability	In SCADA systems, due to the **traditional architecture**, the perfomance is fixed for a given number of devices, cost of extending is prohibitively high and very rigid hard wired protocols which akes newer models difficut in integrate. It's a fixed architecture with a fixed mandate to deliver	IOT implements the Serverless architectures , where the application designs incorporate third-party "Backend as a Service" (BaaS) services, and/or that include custom code run in managed,containers on a "Functions as a Service" (FaaS) platform . IOT architecture has the ability to ingest and process a huge amount of data from sensors and allows to connect anything of relevance using protocols like MQTT, HTTPS, XMPP, COAP, REST etc. which is powered by on-demand scalability due to this serverless architecture. IOT is a platform driven architecture, coponent driven with extensive plug and play features.
Data Analytics	The main SCADA usage is for day-by-day plant operation and ingestion and storage of a finite amount of data without preservation of historical data for deeper analytics. There is history collection and most of the unstructured data is a recent phenomenon.	IoT involves long-term data retention to further analyze the data to predict maintenance schedules, reduce overall downtime, and extending equipment life. On top predictive analysis and preventive maintenance, capabilities are part of it which is supported by Machine Learning . analytics and statistical modeling features module.
Standardization	SCADA systems mostly use OPC for data gathering, it is a standard that has stood the test of time but its major disadvantage is that it relies on DCOM technology and devices cannot collect/exchange data with each other regardless of the footprint.	The primary goal of Industrial IoT is to standardize sensor networks, data gathering, and aggregation. IoT standards such as OPC UA are already being used to define real-time secure communication within a plant having different control devices and sensors from different vendors. Security is baked into IoT standards with support for MQTT, HTTPS, RAML etc.
Interoperability	In SCADA systems, devices not made by the same manufacturer cannot easily integrate. At times, even different versions from the same manufacturer present challenge in making them work interchangeably. Hence SCADA provides distributed business processes which work in siloes.	Industrial IoT ecosystems still remain fragmented but there are protocols such as MQTT which enable platforms to communicate across devices regardless of vendor.IOT standards offers a lot of protocols and interfaces which can interact seamlessly, provide literalkly infinite flexibility to add, drop devises and integrates the hardware and software homogenously.

Information generated from SCADA systems acts as one of the data sources for IoT. SCADA's focus is on monitoring and controlling. Whereas, IoT is more focused on analyzing machine data to improve organization(s) productivity and impacting organization(s) top line. IoT is essentially a culmination of advances in the connectivity of hardware and data networks that SCADA provides. In short, IoT begins where SCADA and PLC end.

So, while the IoT market is still in early production, it can coexist with SCADA. IoT is bringing about a wave of new business models and technologies that are changing the landscape of SCADA. However, the SCADA paradigm has always been one that is flexible to industry shifts.

Adapt, Adopt and Integrate

Admittedly, the current legacy SCADA platform is lacking particular innovations, it is monolithic and extremely dedicated and designed to be task oriented with very less options to integration upstream or downstream, the need for IoT would be far more immediate. SCADA is currently being influenced by IoT concepts and solutions that are quickly being integrated into SCADA architecture. This is done so seamlessly that we won't ever notice a difference.

However, SCADA is still currently limited to the factory floor. Data taken from the factory devices are being viewed only inside the plant. Whereas IoT takes that data, offers insights to the users, across the value chain right from the raw materials to the end user and makes it available anywhere, anytime. This, in turn, enables new business models to be created.

How IoT can help scale up SCADA?

If organization(s) already have a SCADA system in place, organization(s) can integrate the IoT solution with organization(s) SCADA system and collect data from a Data Acquisition Systems (DAS) machine. By leveraging the power and scalability of IoT, organization(s) can use collected data to create a wide range of reports such as Overall Equipment Effectiveness reports, Production Data reports as well as utility reports (gas, water, power).

In the future, it's likely that SCADA systems will evolve into those of IoT. Equipment and PLC will become more intelligent and will be able to integrate different cloud platforms. This will enable new security platforms that will further secure any data that is recorded. This means that improvements that will save money can be performed.

SCADA is more about allowing humans to interact remotely with a process. Whereas IoT is generally used as a machine-to-machine communication tool. Rather than something that exists primarily to present information to a human. That is just a small part of its process. IoT ensures that information is shared with both people and machine, rather than just people. In short, it makes sure that everyone and everything is kept in the loop at all times.

The comparative analysis

In the end, both SCADA and IoT involve sensors and data acquisition. Although they do differ in many aspects, they both share the one common goal. The optimization of use and, eventually, better control over some devices or a process. The whole idea of a smart grid leads to SCADA and IoT integration. As SCADA is not a full control system, rather a computer system that gathers and analyses real-time data, it is useful in monitoring and controlling a plant or industrial equipment. SCADA primary objective is to control the processes based on the supervisory capabilities, maintain the deviations within limits, gather information about a certain deviation, transmit to a central site and alert the central control center. .It will then carry out any necessary analysis and control and display the information in a logical and organized fashion for humans to then interpret and use accordingly.

Since the Internet of Things is made up of a network of physical devices connected via electronic embedding, software setups, sensor-actuators and network connectivity which all act in unison on a set protocol. A set of algorithms and rules, for the objects to connect and exchange data. IoT allows objects to be sensed or controlled remotely across different networking infrastructures. Therefore, it creates opportunities for more direct integration of the physical world into computer-based systems. The IOT also offers the capabilities to integrate batch and real time with a seamless tools of analytics, actuators and intelligent machines. This results in improved efficiency, accuracy and economic benefit and also cuts down on human intervention.

Both platforms offer an abundance of advantages, as well as some vulnerabilities. It is predicted that by 2020, 50 billion devices or things will be connected to the internet. Therefore, the dynamics of an Internet-based control system are becoming a living reality. Industry 4.0 is an era in which emerging trend automation and data exchange in manufacturing technologies are allowing for a shift from traditionally implemented SCADA to an IoT implemented one. With SCADA, cyber-physical systems, the Internet of Things, cloud computing and cognitive computing, Industry 4.0 is an era that will change the dynamics of the entire automation industry.

Next phase of manufacturing- Has SCADA had its day?

The good news is that SCADA is here to stay and the Internet of Things is the next phase of smart manufacturing that upgrades SCADA by making it more intelligent and smart. IoT complements both distributed control system (DCS) and SCADA by widening existing capabilities like real-time data capturing, anomaly/machine breakdown alerts, real-time control, data logging, data analysis, and visualization.

Let’s see how IoT takes SCADA systems to the next level and he traditional SCADA systems stack up

Traditional SCADA	IoT takes it to the next level
Autonomous commands	Data aggregation
Remote monitoring	Predictive analytics (what will happen in the future)
Supervisory control	moe informed control based on historic data, patterns and hueristics,Offers prescriptive analytics (What organisation(s) should do and when
Alarms and alerts	Data creates value in multiple applications
Reporting	Enabling analytics, builds predictive models, multiple what-if analysises, new business models
Decrease operations and maintenance costs	

SCADA systems have been doing a great job in monitoring and controlling industrial- and facility-based processes that exist in the physical world, but IoT can process organization(s) r data and bring the intelligence and insights hidden within it.

With the growing number of connected devices, the need for gathering, exchanging and analyzing data has substantially increased. Industrial companies have started observing a growing need for increased interoperability and information transparency to stay ahead of the competition and cut operational costs. Currently, many ISVs provide an IoT platform that is hardware agnostic and use SCADA and other traditional systems as a data source wherein security and supervisory control are not compromised but enriched within existing infrastructure. Open and secure connectivity options such as AMQP, MQTT, REST, and OPC UA Pub/Sub make such a merged IoT architecture. While SCADA's focus is on controlling and monitoring machines, IoT's focus is on analyzing machine data to increase efficiency that directly impacts a company's bottom line. SCADA works as secure IoT Gateways (or call it Message Oriented Middleware (MOM)), which enables companies to connect edge devices across multiple sites and bring data on a single platform to perform analysis for making better decisions.

At the same time, one should also understand that SCADA has some limitations and that can be overcome with IoT. For example, factories are heterogeneous by nature and it is difficult to manage the disparate nature of the industrial digital ecosystem from a single place. This is where IoT comes into play as it fosters interoperability and data transparency.

Digitization is changing the way manufacturing companies work but SCADA will still be useful in terms of collecting and monitoring the day-to-day operations of a factory or process. IoT empowers SCADA systems and helps manufacturers store an infinite amount of historical data in the cloud for deeper analytics that bring out hidden information to solve long time unresolved problems.

SCADA in the Smart Factory

The frank reality is that SCADA as an operator interface, and the features that make it obligatory (such as schematic visualization, alarming, data logging, real-time control and the passing of data to data historians), are not going to be completely negated by IoT technology. Not anytime soon. There's no doubt edge computing will begin to engulf certain control features and rationalize the amount of data we choose to push into the cloud over time, but the Industrial Internet of Things will not negate the need to securely open and close valves, start or stop motors or reset an actuator. At least not for assets and processes that require high-speed data collection and control. That's the key. One cannot compare IIoT solely with Data Acquisition (DA), yet forget about Supervisory Control (SC) and the need for reliability, security, fast aggregation and complex data storage. There are of course certain IoT communication protocols, as given below that would need to be present to support the SC + DA elements via the IoT.

Instead of arranging all of the IoT Protocols on top of existing architecture models like OSI Model, the IOT protocols are categorized into the following layers to provide some level of organization:

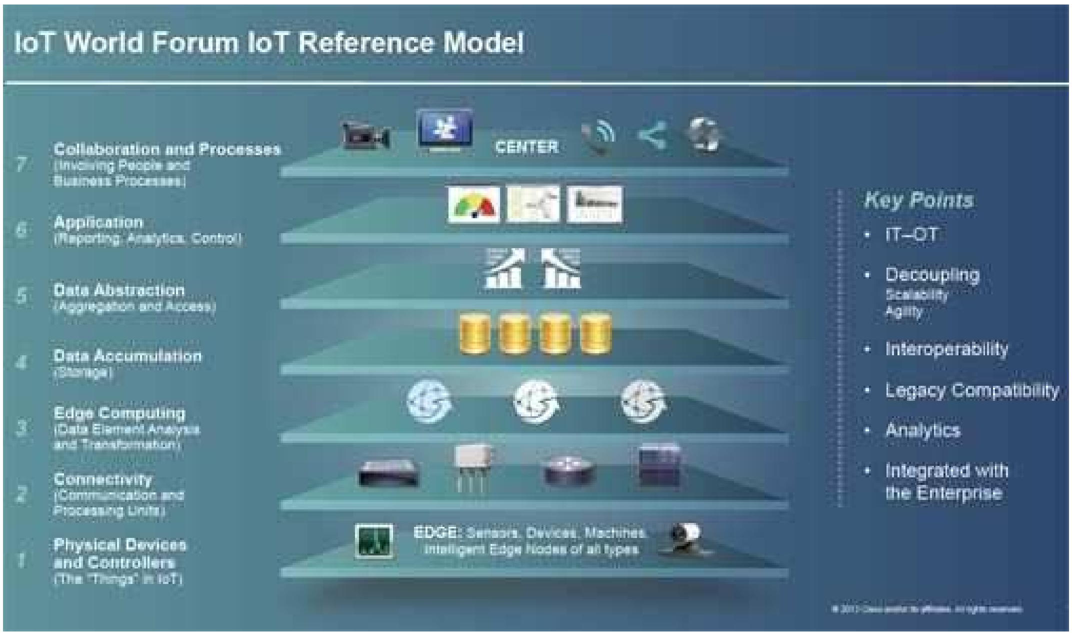
- **Infrastructure** :- (ex: 6LowPAN, IPv4/IPv6, RPL)
- **Identification** :- (ex: EPC, uCode, IPv6, URIs)
- **Communication/Transport :-** (ex: Wifi, Bluetooth, LPWAN)
- **Discovery**:- (ex: Physical Web, mDNS, DNS-SD)
- **Data Protocols** :- (ex: MQTT, CoAP, AMQP, Websocket, Node)
- **Device Management :-** (ex: TR-069, OMA-DM)
- **Semantic** :- (ex: JSON-LD, Web Thing Model)
- **Multi-layer Frameworks** :- (ex: Alljoyn, IoTivity, Weave, Homekit)

4th Generation SCADA: Embracing IoT

Some SCADA/Visualization technologies have a propensity to play outside the traditional SCADA / process control arena, and have been doing so for a while. With the rate in which connected devices are gathering, exchanging and analyzing data, the need for interoperability and information transparency has grown. Certain progressive, and hardware agnostic, ISV's have always embraced this need and now natively support key Industrial Internet of Things (IIoT) protocols. Their platforms are able to fulfil the role of a macro-level control and analytical toolset that can unite the IT and OT. Supervisory control and security are not sacrificed but embellished within existing infrastructure.

SCADA vs. IoT It is these tools that can and will act as secure IoT Gateways (or Message Oriented Middleware (MOM)), to seamlessly unite edge devices (possibly multi-site) into single analytical view-of-the-world. Remote configuration, open and secure connectivity methods such as REST, MQTT, AMQP and OPC UA Pub Sub are the key to fueling this merged IoT architecture. One of the most apt, yet rudimentary question(s) anyone wanting to bi-directionally control their equipment via the IoT must ask, is, therefore "can, or in the near future will, my current control system platform support open IoT protocols and run natively in the Cloud, without the need for a Virtual Machine (VM) environment?"

To drive rapid adoption and standardizing the entire ecosystem of IOT, the importance of sensors and powerful edge devices was emphasized at the 2014 Internet of Things World Forum (IoTWF) in Chicago with the introduction of a seven-level IoT Reference Model. The model was developed by the IoTWF Steering Committee, which includes Intel, Rockwell Automation and Schneider-Electric. The lowest level of the reference model consists of physical devices and controllers, and includes sensors, devices, machines and other intelligent nodes.



The heterogeneous nature of the factory of the future paves the way for these additional IoT platforms that can truly unite and manage the disparate nature of the industrial digital ecosystem. After all, interoperability, information transparency and decentralized decisions are three of the four design principles that underpin Industry 4.0 (Herman et al, 2016).

- **Interoperability** - The ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things (IoT)
- **Information Transparency** - The ability of information systems to create a virtual copy of the physical world by enriching digital plant models with sensor data. This requires the aggregation of raw sensor data to higher-value context information.
- **Technical Assistance** - First, the ability of assistance systems to support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber-physical systems to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.
- **Decentralized Decisions** - The ability of cyber-physical systems to make decisions on their own and to perform their tasks as autonomous as possible. Only in case of exceptions, interferences, or conflicting goals, tasks are delegated to a higher level.

The 'What Ifs'?

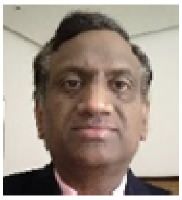
These common trending 'what if' hypotheses which drives the adaption and adoption of IOT in the existing paradigm of SCADA. What if we could…?

- Unite disparate SCADA systems (vendors, versions and protocols)?
- Collect exposed data via web services and IoT communication protocols whilst controlling our process securely in real-time?
- Bi-directionally control a variety of cost-effective IoT devices via a secure IoT Gateway?
- Provision IoT devices and deliver software updates remotely
- Tap into unconnected or ignored energy data sitting in the field or database?
- Apply complex business logic and predictive maintenance algorithms to our operational data and assets without investing in expensive analytical alternatives that require huge data lakes
- Filter inconsequential and subordinate alarms across multiple alarm servers, devices and systems?
- Run post-filtered data, from analytics at the edge, into organization (s) r cloud-based control system

Conclusion

Digitization is bringing about changes in the way manufacturers operate. For over 20 years, the 'Purdue model' of Computer Integrated Manufacturing has ruled effectively as the foundation of how manufacturing systems are architected, designed and implemented. Its hierarchical, monolithic and isolated model is slowly shifting as a peer-to-peer model of collaboration, interchange and co-existent via the IoT opens up. IOT enhances SCADA into the new world of SMAC, leverages the power of big data and breaks down the barriers between the decision management systems and the machines. IOT brings SCADA a lot closer to the business relevance and goes beyond mere efficiencies.

About the author



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