Opportunities and Key Trends in Automation to 2020 and Beyond

Walt Boyes
Spitzer and Boyes LLC

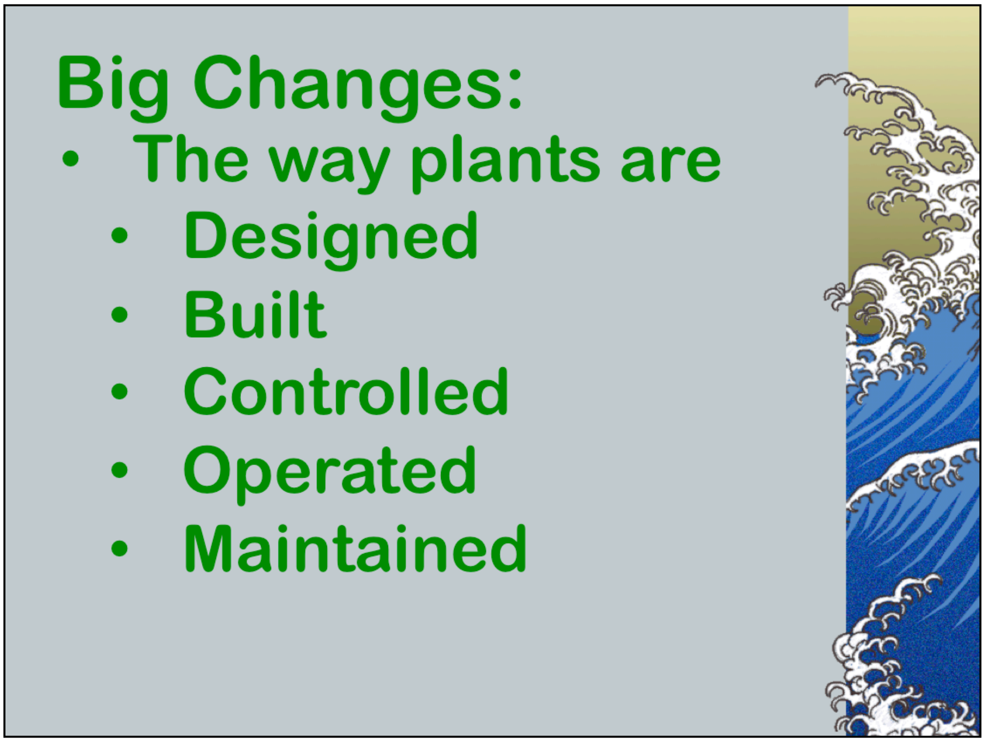
- Author
- Editor
- Pundit/Analyst
- ISA Life Fellow and InstMC Fellow

The next five to ten years will bring huge changes to process, discrete and energy industries and automating them across the entire value chain. The trends I am going to talk about are HERE. This isn't a "maybe," this is a "what is."

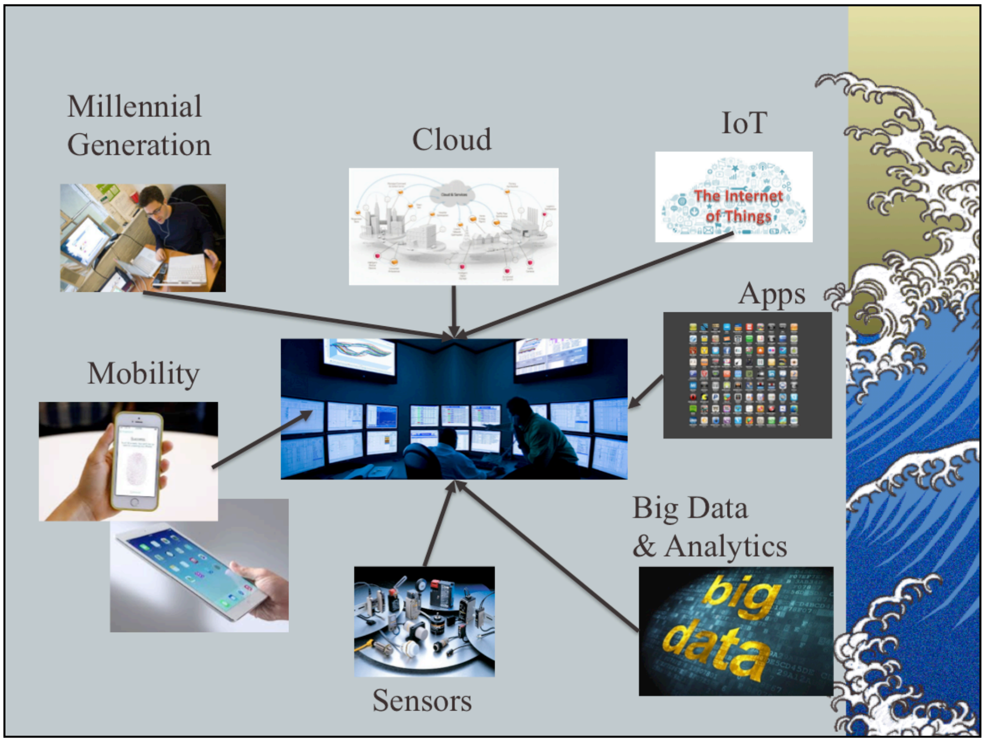
We will be facing ALL of these changes in the next 10 years. Our famous very slow movement in adopting new technologies is already breaking down. How fast did we adopt the cloud? How fast did we adopt virtual servers for DCS systems? Pretty fast, eh?

Because these trends are pan-societal in nature, not just automation trends, we will be pressured into adopting them, with very little choice. And this is not going to be bad for automation.

These will include changes in demographics, changes in social interaction, changes in sensors, analysis and control technology, changes in work practices and preferences…basically everything we know and everything we do in our automation practices.



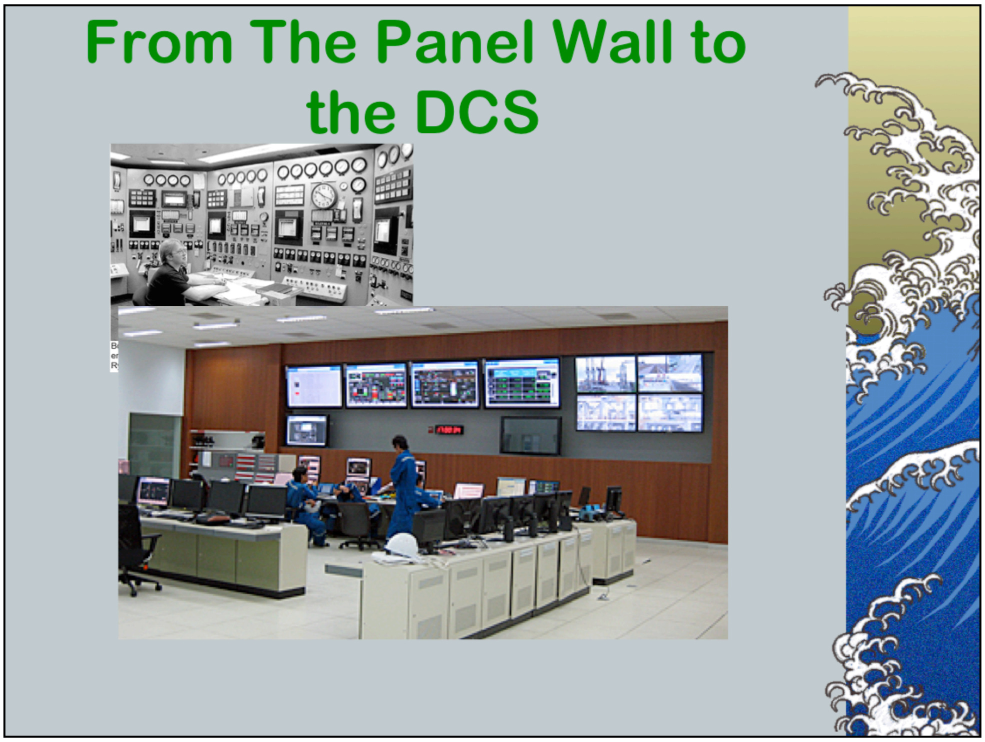
We will see big changes in the way plants are designed, built, controlled, operated and maintained.
We will see these changes in both greenfield plants and brownfield plants.
Brownfield plants will need to upgrade to new technologies in order to become or remain competitive with newer plants designed from the ground up with these new technologies.



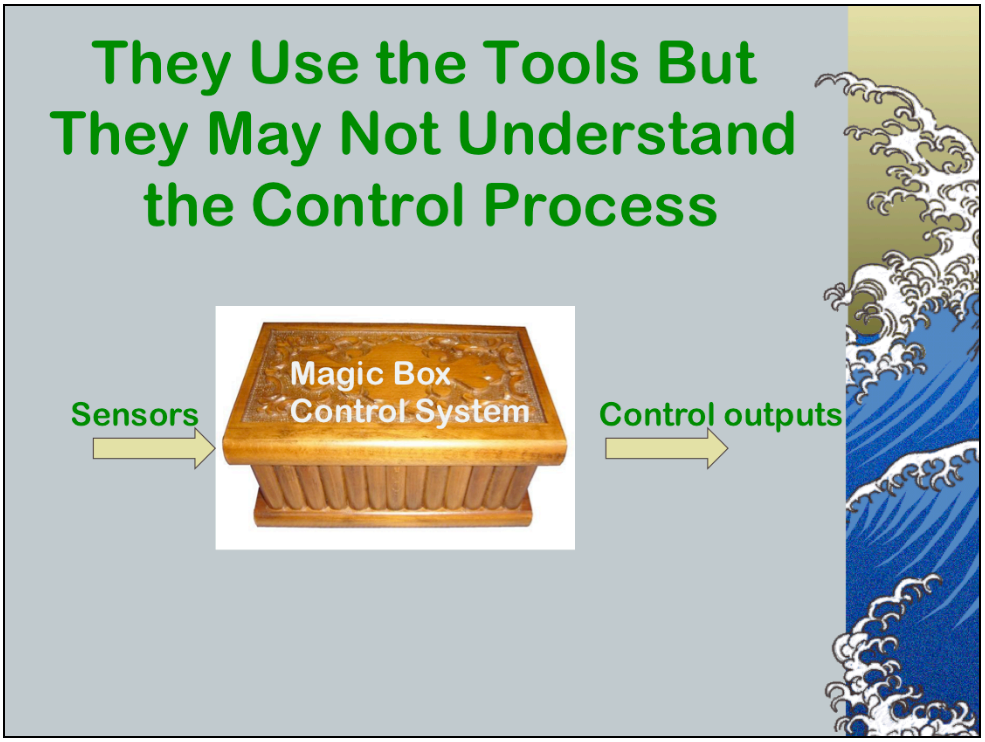
All of these trends will hit at once.

The Millenials, the Cloud, the Internet of Things, Mobility, New Pervasive Sensors, the Internet of Things, Apps and Big Data and Analytics– all at once.

The process workforce is going through the greatest change in its history. The generation that helped to build the majority of the existing process plants, and run them, is retiring or has already retired. This is the generation that absorbed their situational awareness by operating the plant manually, or with minimal control. Many members of this generation can walk through a plant and tell you that there is something wrong just by listening to the ambient noise of the process. The panel walls of the early process automation days gave this generation a god's-eye-view of the entire process that is difficult to duplicate.

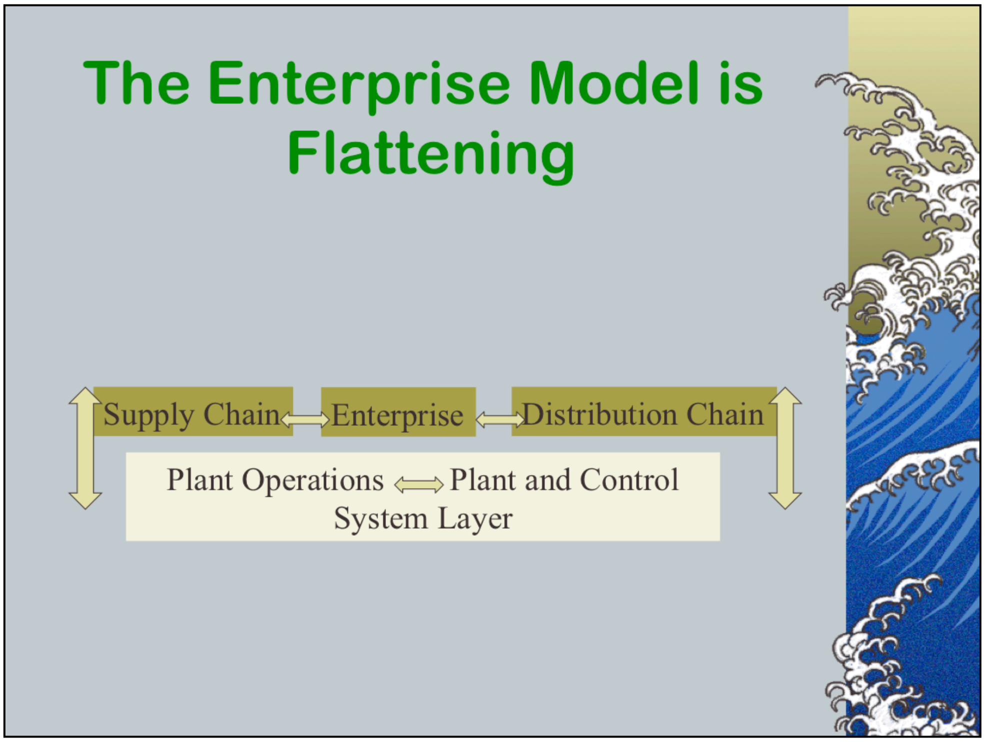


In contrast, the incoming generation of engineers and operators has no such wide-angle view of the plant. They’ve never operated the plant in manual mode, and they have been limited in their view of the plant to what is being shown on the control room screens. They are unlikely to be able to tell what is wrong with the plant, or what is right, by observation. They require readouts and alarms to tell them what is wrong. And they can’t always tell what the readouts and alarms mean in an upset condition.



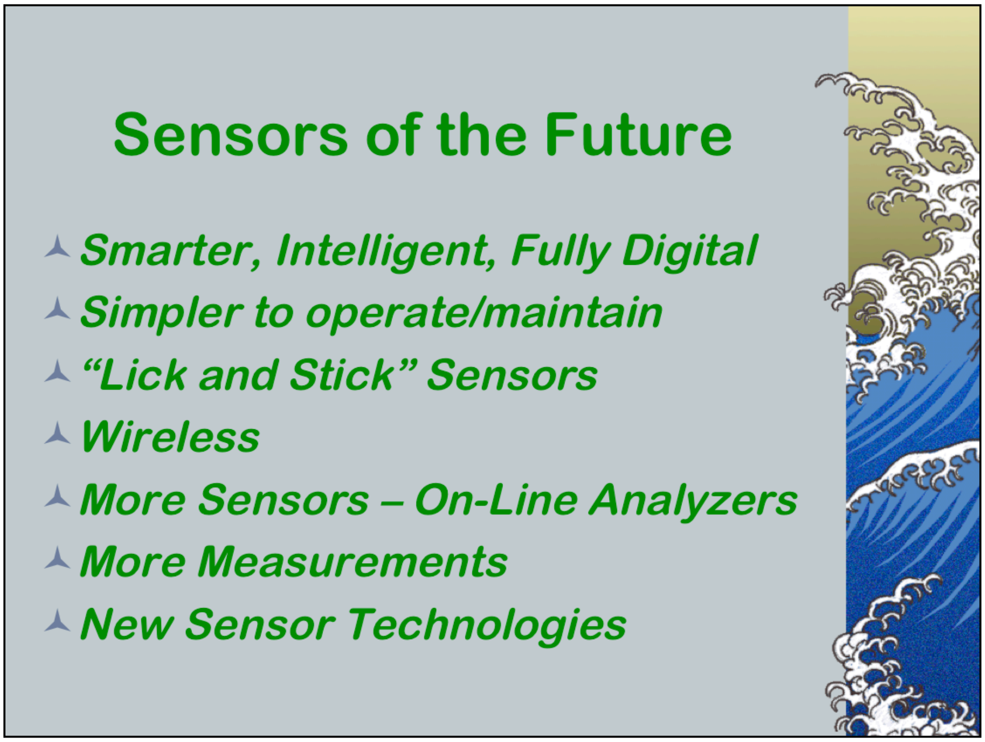
Many of these engineers and operators have never participated in building a greenfield plant, and they have limited knowledge of how the sensors and controls actually work. They use the tools, but they don't always understand them. This is a problem for design and selection of proper sensors and final control elements, as well as learning how control algorithms work, and why they do. In developing countries, as can be seen by reading the automation related groups on LinkedIn and Control.com posts, people with titles such as "automation engineer" and "chief instrumentation engineer" show woeful ignorance of how things work, and what they need to know to do their jobs.

This new generation of operators and engineers want to be taught differently, and to work differently than their predecessors. They see the use of mouse-keyboard-display technology as mostly limiting. They want to be able to use mobile devices, and they want to learn by doing, rather than being taught step by step and mentored. It will be our job to teach them to replace the situational awareness we've always had with a new one of their own devising.



The typical Purdue model of the process plant is flattening, and will become a two-layer model: the plant layer and the enterprise layer. One of the important changes will be that the data produced by the sensors and the control system will be bidirectional. We will be able to control the plant directly using business variables as the feed forward component, and the measured process variables as feedback and cascade control components.

And smarter control systems, using modular procedural control, will make it possible for operators to work at a higher organizational level than "building the watch."



Sensors, analyzers and transmitters will become a more significant element of automation as the Industrial Internet of Things becomes an actuality. Sensors will become simpler to operate, less costly, wireless and have more native intelligence than at present. We will need to measure many more physical properties, compositions and conditions of plant assets. This is only two or three design cycles away, and is a design imperative. New sensor technologies and new sensor designs, influenced by MEMS, Lasers and nanotechnology, will make these simpler, cheaper sensors possible.

Sensors and transmitters will become field controllers in themselves, and will be capable of datalogging, and historicizing, as well as providing diagnostics and calibration for themselves.

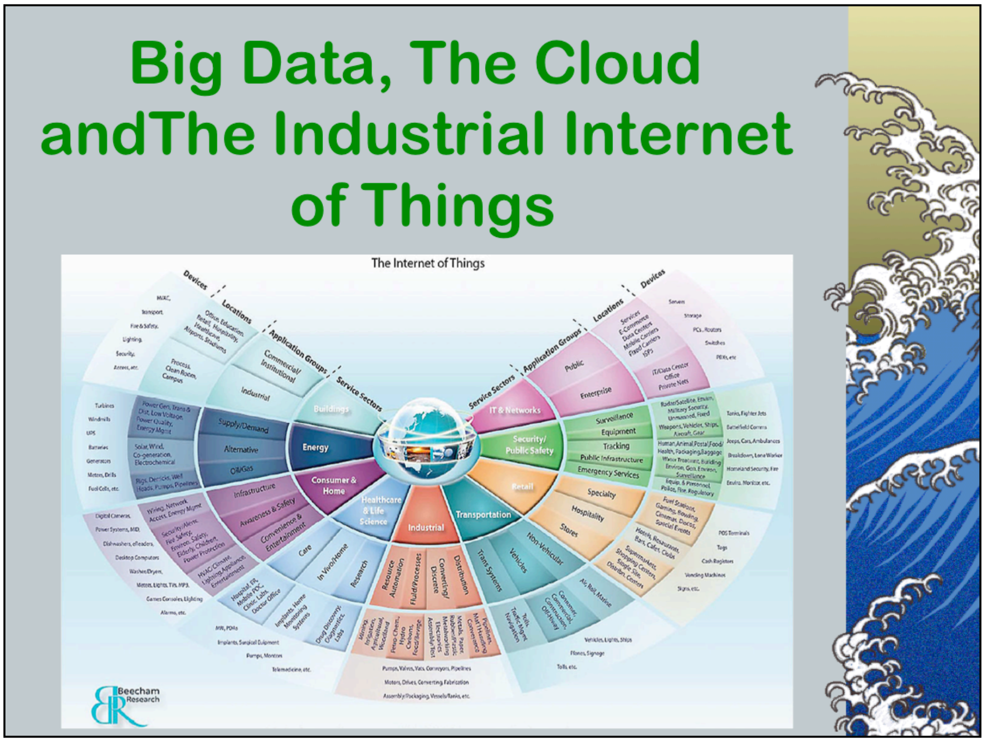
Sensors will be designed that can be linked into large sensor arrays, providing higher accuracy and repeatability than a single sensor and transmitter can today.

Safety instrumented systems will benefit from better sensor technology and sensor cost, as well as better diagnostics.

The concept of “soft sensors” will continue to grow, and make possible more control from virtual measurements.

Sensors will no longer be linked by analog output. Sensors will increasingly become fully digital, either wired, or more commonly wireless.

Analyzers will become simpler, and more field capable. They will divide into “laboratory analysis” and “online analysis.” The concept of “at line” analysis will disappear.



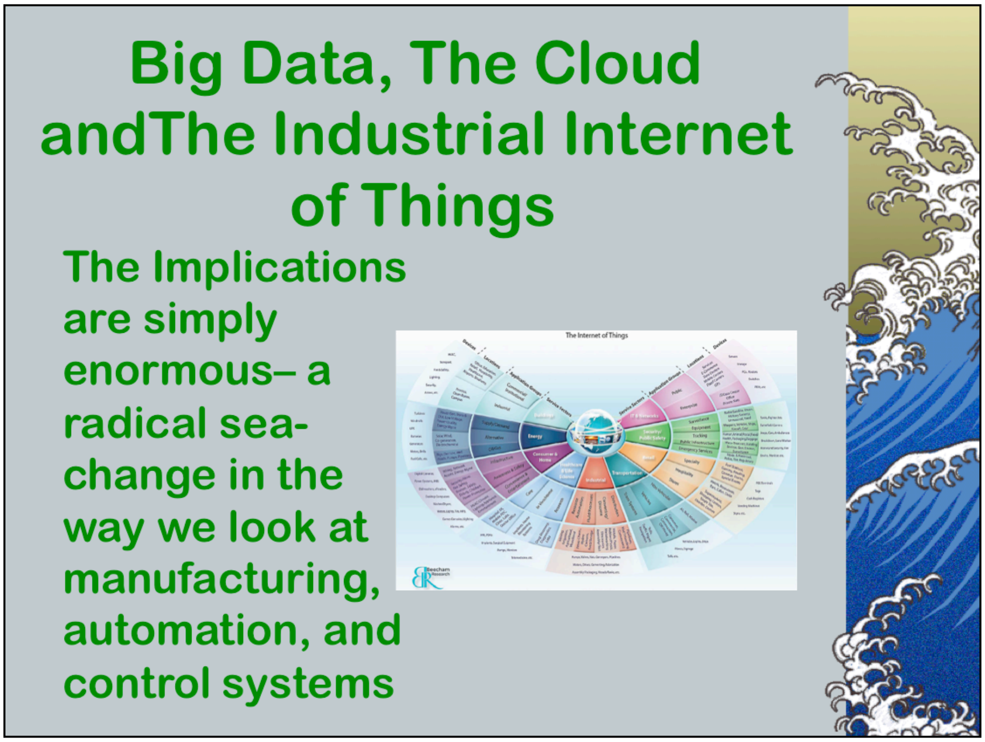
The Industrial Internet of Things, working with Smart Manufacturing systems, will be able to produce a revolution in the way manufacturing is done, especially in discrete manufacturing and batch processing, but also effect a considerable change in process manufacturing as well. Based on the way the Internet of Things is designed, an "app-based" design approach may well produce the agile, limber process environment and process control systems that have been called for in the past ten to fifteen years.

The aggregation of sensors and data in the Industrial Internet of Things will first be able to revolutionize the process control lifecycle. Completely automating maintenance work orders, diagnostics and calibration will be among the first major effects of the IIoT. Connecting to vendor purchase networks automatically, for replacement and repair will be another major effect. This will permit maintenance and operations personnel to concentrate on causing the control system to work in an optimized fashion, and not spend time collecting and aggregating data and inputting data into dissimilar systems.

Using RFID technologies, inventory can be made entirely automatic. Delivery of raw or intermediate materials using robot-guided vehicles can also be made practical and will improve time to market and agility. RFID technologies can also be used to improve worker and asset safety, by providing location services both of personnel and critical assets such as fire trucks and safety gear.

The IIoT will also affect how simulation and modeling can interact with the real time process. Models can be much more detailed, with the huge amounts of data available from the IIoT, and simulation can be morphed into ways to meta-control the process in real time.

http://smartmanufacturingcoalition.org Smart Manufacturing Leadership Coalition has quantified the issues of Smart Manufacturing (also called Manufacturing 4.0).



The implications of the Internet of Things, Big Data, and the Industrial Internet of Things are enormous. They will create a completely different vision of control systems and how to control process plants based on the amount of data and the availability of data, and the ability to mine and refine that data into usable information.

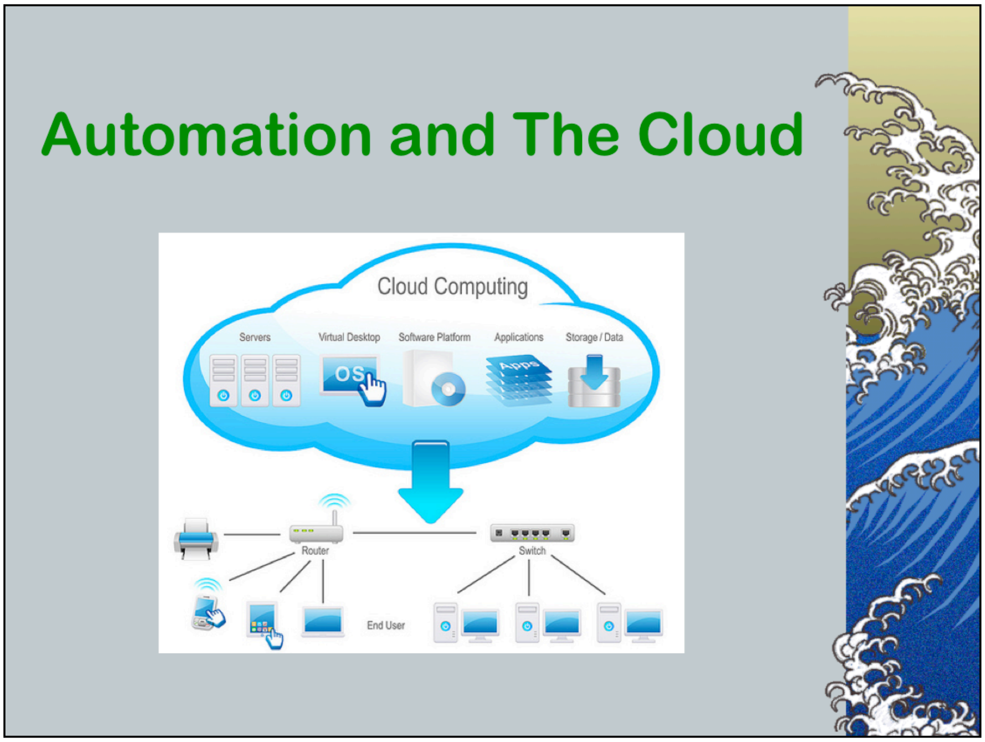
The theory of Big Data brings to process control and manufacturing not only the concept of complex systems, but the complex systems themselves in practice.

The IIoT will make the entire sensor network, including final control elements, and the safety instrumented system, and the control system a single complex system. Adding to the complexity will be the integral interconnections to the supply chain, and to the enterprise. This will especially be true if, as is predicted, it will become commonplace for the business systems to be seamlessly connected to the control systems.

This clearly has implications for the design and operation of plant control systems. Control systems have always been somewhat isolated from the business systems of the plant, as the Purdue model and its many variants have shown. The Industrial Internet of Things will force the control system to be a part of a "network of networks," and be capable of interfacing easily and in an agile manner, with all the other networks that surround it in the business enterprise, however large.

The automation system vendor, as some already have, must embrace the IIoT by whatever name the vendor wants to call it. The vendor must also embrace the theory of Smart Manufacturing, again, by whichever of the many names currently in use the vendor prefers to use.

The IIoT will finally do for sensors and networking what the PC did for control systems. The introduction of the PC produced a COTS (Commercial Off The Shelf Systems) platform onto which the control system software could run. IIoT will provide the COTS sensors and networks that will be usable with no or minor modification in the industrial environment. The reason for this is that the sensors and networks will have to be more robust, not less, than the current technologies for sensors and sensor networks because they will be used in electric grid, building automation, and home automation systems where the level of training and support will be significantly lower than the standard in process automation.



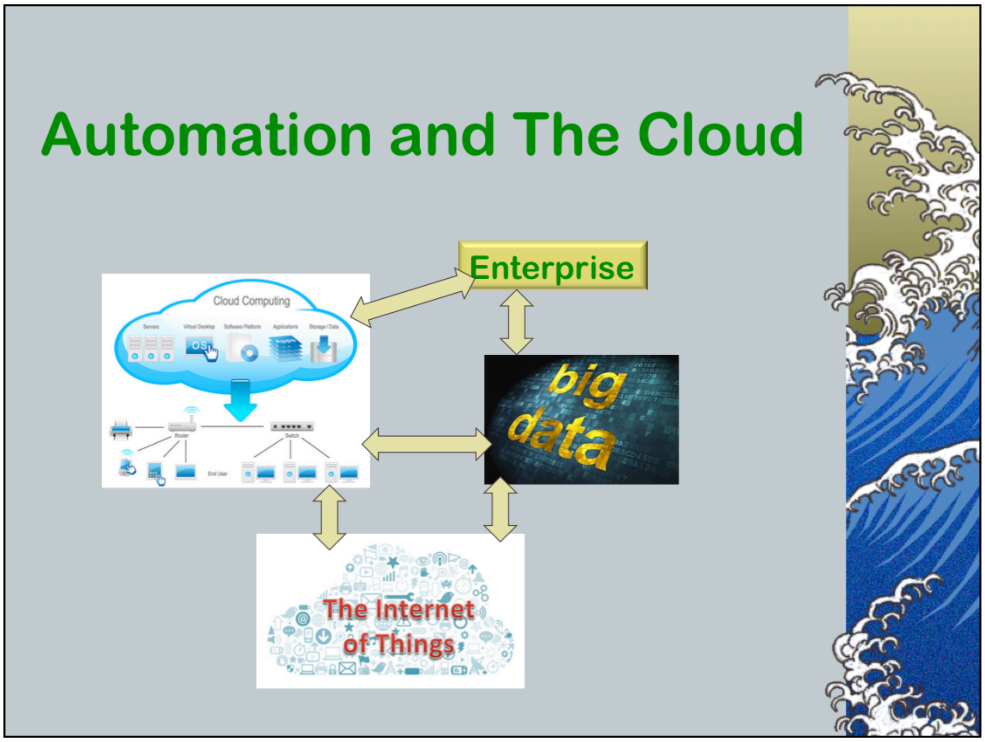
Cloud computing is another of the enabling technologies that will permit the Industrial Internet of Things and Big Data to be used in process and factory automation. With due attention to security issues, storing massive quantities of data in the cloud will permit companies to find and use that data from anywhere they operate. Putting data in the cloud preserves it safely from weather- or attack-related incidents at a plant site, and permits quick resumption of production as soon as hardware is restored.

There will be a new business opportunity for the process industries: organization and development of cloud databases.

Like Lexis-Nexis for legal and business information, there will be a need for one or more companies whose focus is on providing the largest amount of and highest quality of data to asset-owner and process automation companies, so that this data can be used in order to operate process facilities. Databases as disparate as weather and injury statistics can be used to predict behavior at a process plant.

Cloud computing will also drive databases toward interchangeability and interoperability. New means of connecting databases together, better than OPC or static APIs must be developed and widely used.

In the process industries, there are already cloud-based monitoring and some control offerings. SCADA systems have been designed that are intended to be cloud based and interconnectible with many control systems and historians. Historians themselves are clearly and easily adaptable to being cloud-based.

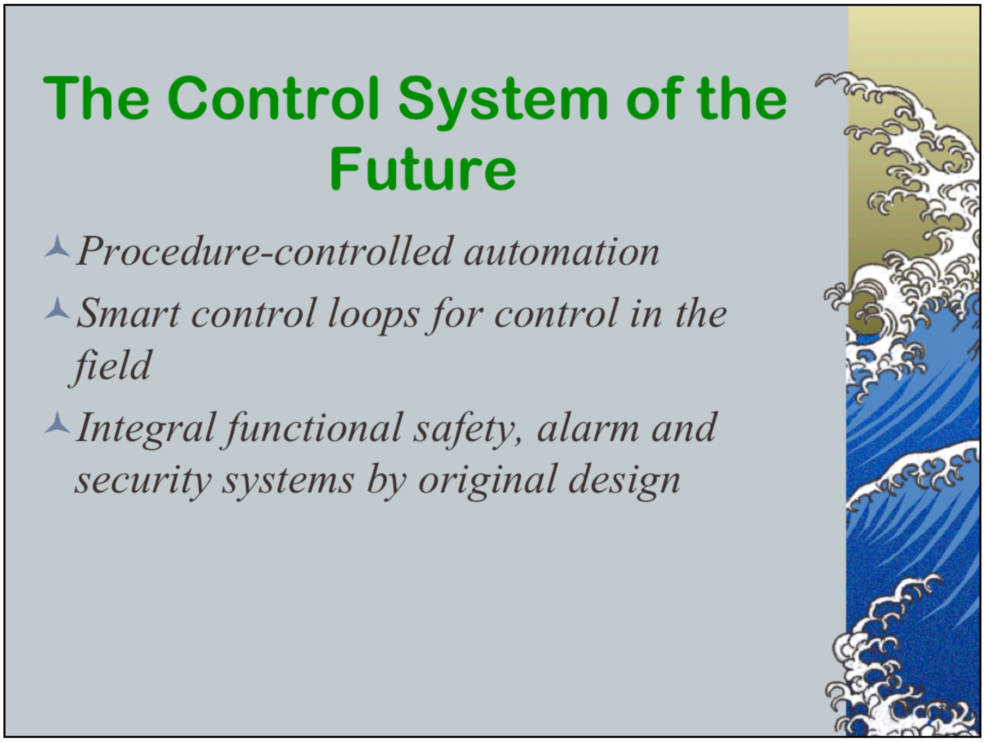


The Cloud, Virtualization and Big Data as strategic game changers

Big Data and the cloud, along with virtualization and the trends toward simpler and smarter instrumentation and controls are strategic game changers for both asset owners and process and factory automation vendor companies, and system integrators and service companies.

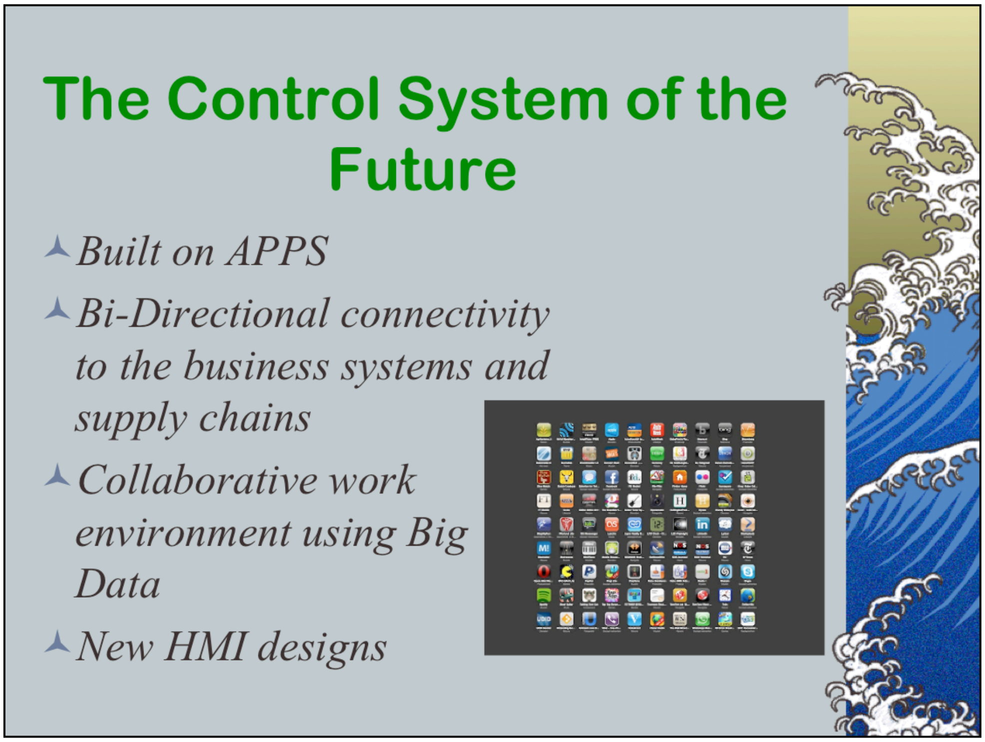
The massive amount of data that is becoming available will permit many things that have not been possible in the control systems and operation of plants in the past.

A single sensor develops an enormous amount of data. One sensor, monitored every second, produces 86,400 readings per day, 31.5 million readings per year.



For years, the ASM Consortium has published an RSS feed with daily data on fatal and injury incidents. It works out to about 200 people killed and nearly 1000 people injured globally every year in the process industries. These incidents usually occur in startup or shutdown situations, or when there is a failure of a process component and the operators make mistakes in dealing with the emergency.

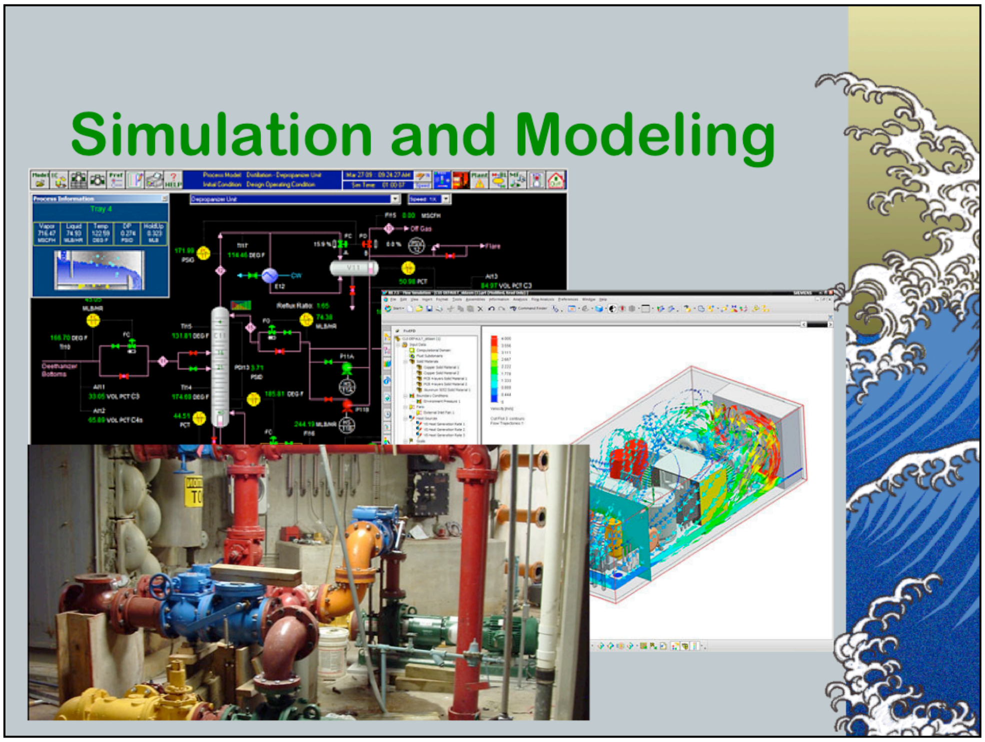
We can't continue this, and it is obvious that manual operation of a refinery or chemical plant simply doesn't work. The systems are too complex. The same thing happened in aviation years ago, and the solution is essentially the same… procedure controlled automation systems that know what operating state is, and what failover state is, and how to achieve safe and graceful failover and recovery from fail state back to operational state. This will require that safety systems be an integral part of the control system because they drive the change of state from operational to fail. Alarm management systems need to be very different, and not add ons "because we can."



Instead of the monolithic control systems built on Windows, we will see control systems designed to use Big Data and the Cloud made up of apps very much like the apps you can buy in the Apple and Google app stores. If you have need for the app, you get use of it, otherwise you don't see it. Apps are easier to program, to upgrade, because they don't interact with the other apps except through specified, open APIs. It is likely that control systems built up of apps like Legos will have some security advantages, too.

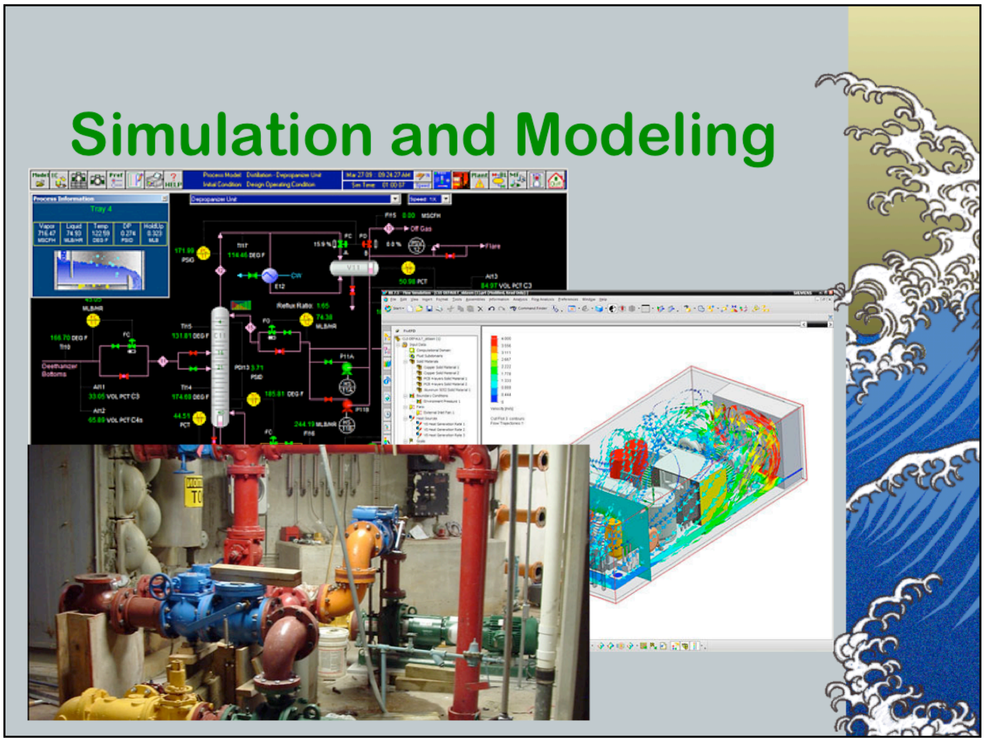
The systems will have bidirectional connectivity to the business systems and supply and distribution chains so that product agility will be maximized. This will also be true of the collaborative work environments companies are already trying to build into their systems, but with access to Big Data analytics.

HMI designs that are decoupled from the actual control system are already in use, and their use will grow. Mobile HMI uses including Google Glass-type devices will grow.



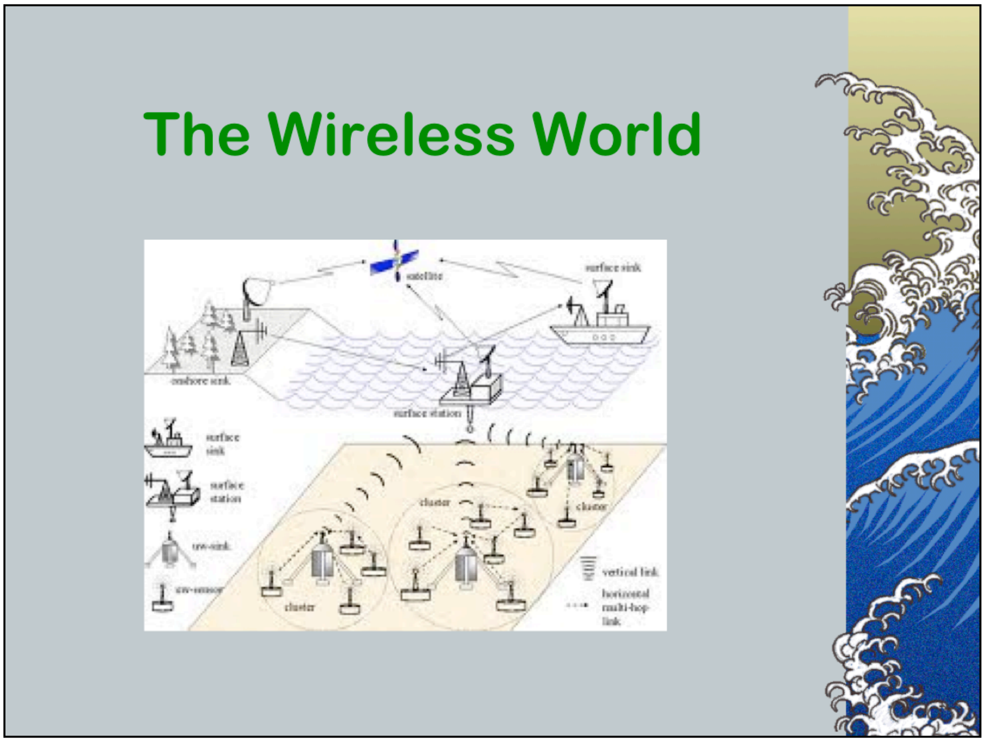
. Simulation and modeling are not just for designing or training any more, but can form the basis of the control system familiarization routine, like they have in military and aviation environments.

As the number of sensors in a process rises, the amount of data that can be fed into a model also rises. High power computing environments, in-plant or in the cloud, can take that data and use it in much more complicated models than we can now, and apply the resultant information immediately in a sort of meta-control loop. Imagine being able to use a model with thousands of sensor inputs as a control input. Imagine having a fractionation tower with hundreds of temperature and pressure sensors, and maybe some online chemical analyzers, all feeding data to a real time model of the tower. The information that is obtained can be used, first, to control the performance of the tower, and second, to improve design parameters for fractionation towers in the future.



It is in simulation that we will see enormous change. From these real time models, simulation systems will be developed that are highly accurate and replicate the actual real world operation of the process—and do it in real time. Experiments have already been done on 3D virtual reality simulation, and there are several installations in daily use. But simulation will become so inexpensive that no process plant or factory system will be without one for training, modeling, and what-if exercises. The cost of the technology to implement 3D virtual reality is now approximating game console cost, with COTS components. It is the cost of mapping the system, physically, which is still exorbitant. The uses of mobile devices, like Google Glass™ and its successors, will make it easy to walk through the plant and document its operation and components in as inexpensive a way as it has become to develop 3D virtual reality itself.

Finally, the jump from using high-resolution models and ultra high definition simulation with 3D virtual reality is small to the use of those interfaces for actual plant operation. This will completely change the situational awareness capability of the operator. The complete long-term effects of this change are difficult to enumerate. Instead of the operator needing to call somebody to go look at a problematic sensor or control, which in the past often divided operators into "inside" and "outside" operators based on who was in the control room, the operator can simply use his god's-eye view and inspect the issue in real time,

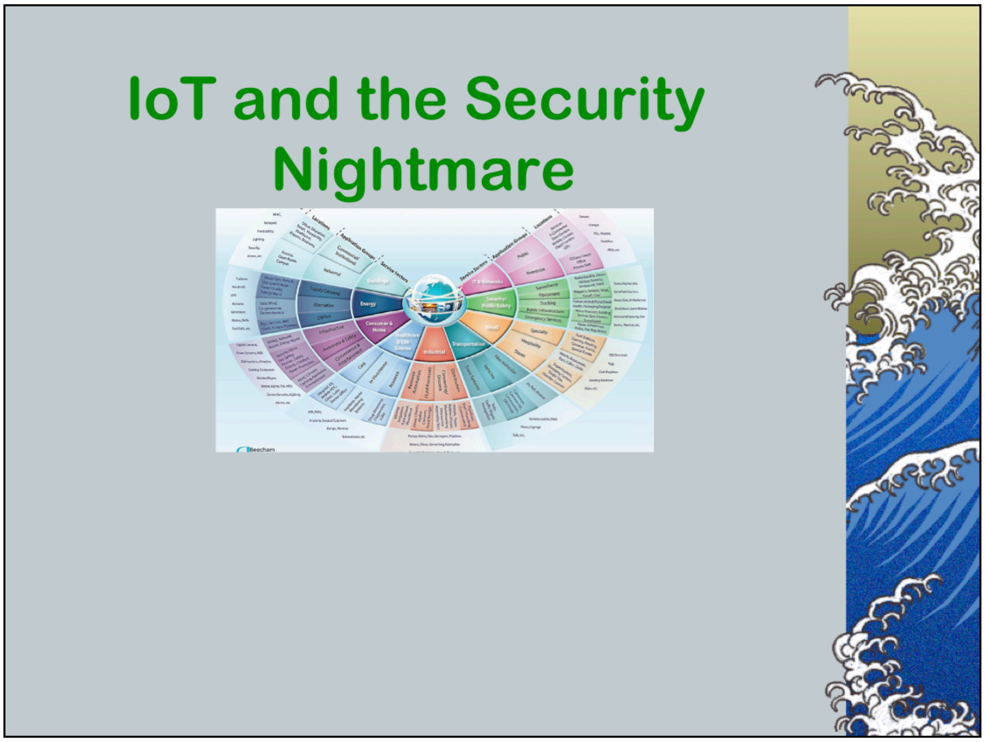


The war over wireless is over. It appears that plants will use combinations of WiFi, cellular wireless, WirelessHART, ISA100, and other protocols in combination, depending on the application and its requirements. There are some signs that the next generation of wireless field devices will be a combination of some WirelessHART capabilities into the ISA100 package. But the reality is that wireless itself, not just the protocol, is being used and designed for by the mainstream of plant engineering and design. Now it is time to reap the promised rewards. End users need to be shown how to use wireless for advantage.

Most of the advantages the Industrial Internet of Things and uses for Big Data in the process automation industries will require the use of wireless sensors. The reason for this is apparent when the cost of installation of wired sensors, especially in hazardous areas or in remote locations, is considered.

The three issues restricting the use of as many sensors as Big Data will require are cost of sensors (which is coming down), cost of wiring (wireless, here) and the cost of installation of the physical sensors themselves. The first two are being managed. Sensors are becoming less costly, and wireless sensors are becoming ubiquitous and robust and usable in many applications where wired sensors were required. The problem is the installation of the sensor. Many sensors require an intrusion into the pipe or vessel, and that can quickly become so expensive that the variable will simply not be measured.

The ready availability of many inexpensive, non-invasive, wireless sensors will be necessary for the real implementation of the Industrial Internet of Things, and

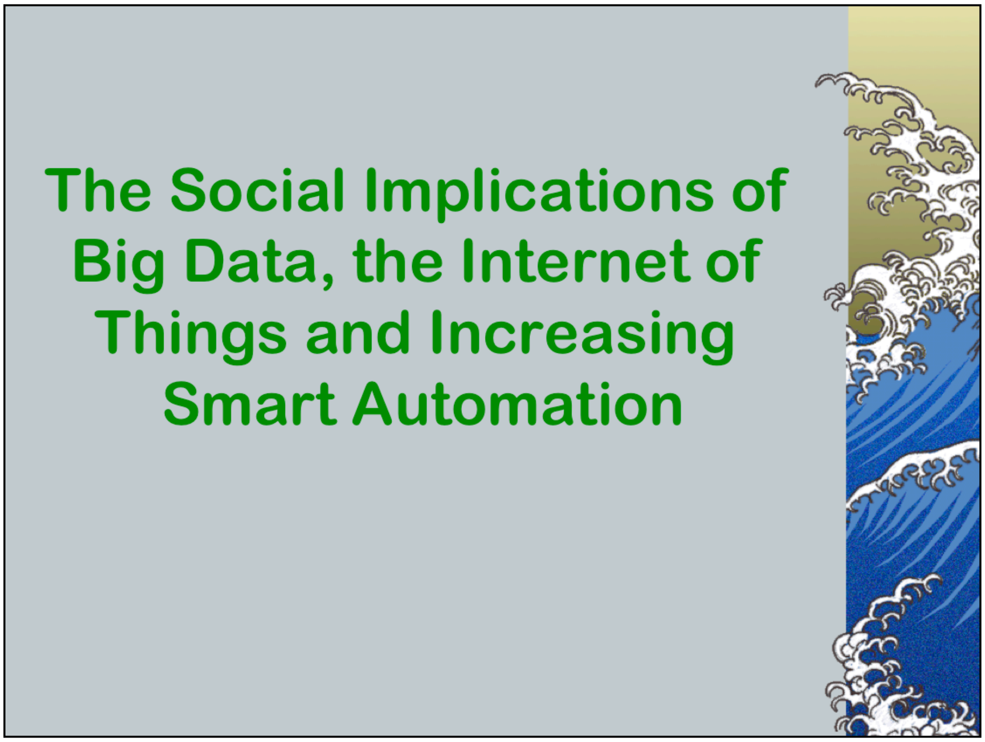


As you can imagine from the picture, the Internet of Things and the Cloud have provided us a security nightmare. We can’t use the plant-centric security prescriptions we came up with in ISA99, because the network is not plant centric anymore. It is a WAN, covering many physical locations, and even some virtual ones. And for each device node in the network, you increase the threat surface geometrically. We will have to work out a security design for an entirely new organization of process technologies.

Services Offerings

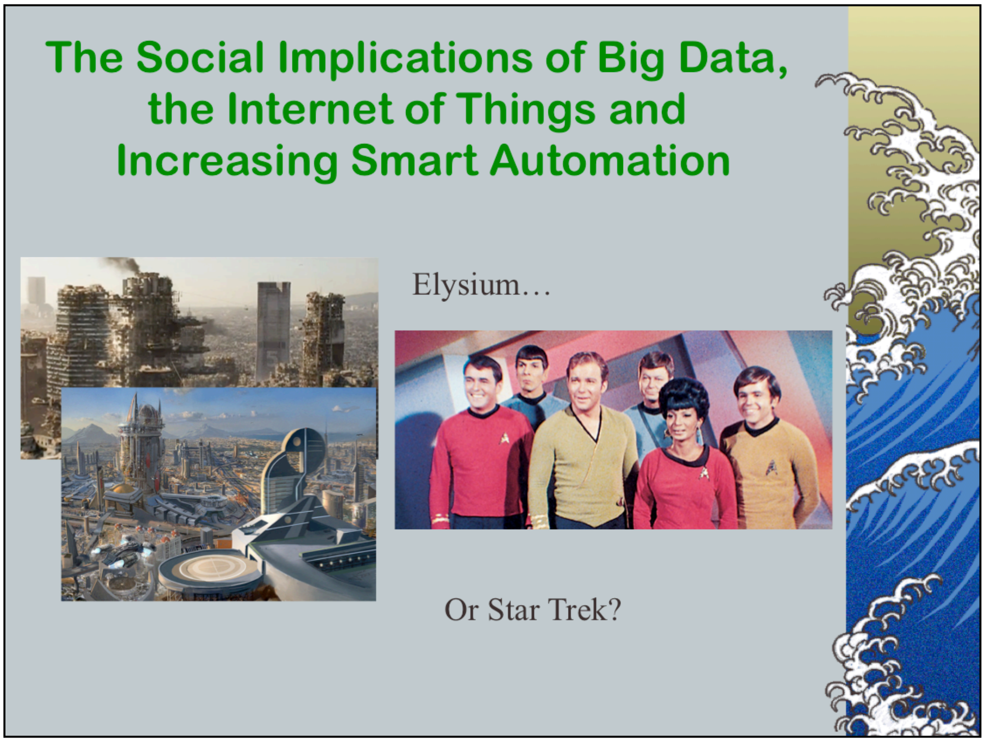
- *S(oftware)aaS*
- *A(pps)aaS*
- *OP(ERATION)SaaS*
- *Data goes to the cloud and asset owners buy how much of it they need to use. Apps stay in the cloud, and owners buy use time. It is Tymshare come again!*

MAC/MIC/MEC practices, for both vendors like Yokogawa and independent Control System Integrators have become a very important and powerful tool in providing process technology to asset owners. Instead of asset owners, EPCs and general contractors having to learn by doing, they can bring on board early in the project, somebody who does integration every day. MAC/MIC/MEC groups can do automation in a seamless fashion, provide best of breed products, and because they do it all the time, they don't have to re-learn their skills for every project. And their skills stay current.



Continued growth and extension of automation, both in factory automation and process automation, as well as in consumer and commercial activities is estimated to put between 25% and 45% of the working population in the developed countries out of work—permanently– through no fault of their own, within the next 10 to 15 years. We have always been able to retrain most of the people laid off due to increasing automation, but we will be automating those jobs, too. We are faced with a permanent group of people who will not be able to earn a living. We are going to have to decide what to do.

It is analogous to the problem of the horse, as described in the YouTube video, Humans Need Not Apply. In 1900, let's say, there were 10 million horses working in the United States. By 2014, there are probably fewer than 1 million. Horses could not be retrained to become cars and tractors. Think about what that might mean, including for your own job and career.



The endpoints of the continuum we face are the 99% of the population living in burned out cities with broken infrastructure, while the 1% live in Elysium… or the “we’re so rich as a society that nobody NEEDS to work” of the Star Trek universe. Where we line up along that continuum is going to determine the quality of life for ourselves and our children. Think about it.

Questions?

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