Toward a Smarter Internet of Things

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TACTICAL BRIEF

Enabling an Intelligent Future
How the Internet of Things Will Impact Automation

The age of centralized control rooms is changing as the Internet of Things takes control software and hardware wherever it needs to be.

By Albert Huang, Vice President, Advantech

A major driver behind the growing interest in the Industrial Internet of Things (IIoT) is mobile computing, which is becoming more ubiquitous across industry as mobile devices become more powerful and bring with them the promise of more efficient operations.

Currently, there are four layers in the industrial communications hierarchy—physical, network, transport and application—that are used to transmit information from the device or sensor to the control center in industrial applications. This structure tends to make industrial network management very complicated and expensive, which is why there is so much interest in IIoT. The industrial Internet of Things promises to reduce the network structure to just the physical and application layers, allowing installed devices to send information directly to remote devices whenever they experience a fault.

The reduction in network layers in this scenario is possible not just because of fewer interactions required to relay the communications, but because bandwidth use is also reduced, in turn allowing more devices to be able to be controlled by a single remote engineer.

Once the industrial networking structure is simplified, it’s likely that as processing power increases, control software will be installed directly on the end device, thereby enabling every aspect of the device to be directly configured by a remotely located engineer.

Attaining this IIoT concept involves taking existing automation technologies and adapting them. And the technologies to make this jump already exist. By using HTML5, for example, Advantech’s WebAccess software can be configured by engineers without software programming experience. The software’s widget library, widget builder and drag-and-drop dashboard editor allow users to customize their own dashboard screens to meet their specific needs and enable it to browse and monitor WebAccess tags and statistical data using the Dashboard Viewer on any HTML5-compatible browser.

Having the ability to view information in real time from anywhere, engineers can more easily respond to emergencies and, because the sensors are polled regularly, a history of their responsiveness can be built up using spreadsheets to allow analysis of this data for identification and response to trends as appropriate.

Advantech has been developing products that fit with the IIoT vision for a number of years already, even on the hardware side of its business. Today, IIoT-enabled hardware is based around industrial computers that continuously poll connected hardware to detect faults. These hardware devices then use Ethernet or GPRS to send that data back to a centralized server where it’s received, read and analyzed by engineers.
Advances in Ethernet technology, with gigabit speeds no longer uncommon, are facilitating the use of low-power devices over RJ45 cable using Power over Ethernet (PoE). In addition, more widespread cellular data networks provide the ability to send data from remotely located hardware to be received on smartphones.

But these “edge devices” are only one part of the IIoT hardware framework. Another important part is the sensor network technology that resides in the device itself. One of the most important technologies in this area is the wireless sensor network (WSN)—the next generation of wireless data acquisition solution.

WSN combines the wireless I/O and sensor interface to collect and transmit analog and/or digital signals to the Internet. This wireless technology is based on IEEE 802.15.4 with many protocols, such as ZigBee, 6LoWPAN and WirelessHART. With different types of I/Os and sensors, signals can be measured in every situation.
The Right Questions to Ask About the Internet of Things

No matter where you are, it’s tough to escape discussion of the Internet of Things. Like any other automation topic, you need to consider the source of information when making decisions regarding your situation.

By Stephen Blank, CEO of Loman Control Systems Inc.

The automation world has been buzzing recently about the possibility of the Internet of Things (IoT) and its role in automation. Currently, I have no less than four trade publications on my desk open to recent articles on IoT. All of the publications speak of the benefits and pitfalls. (Side note: It’s interesting that most of the articles I have read have been written by manufacturers of devices and software, or by people who have a vested interest in promoting these vendors.)

In short, IoT speaks of device-to-device (or device-to-enterprise) communication. This device level communication, typically via Ethernet, allows for the collection and collation of vast amounts of data directly from a specific device. By doing this, engineers and others within the enterprise will be able to access this data for analysis, trending, data collection, etc., all with an interconnectedness of devices and infrastructure that wasn’t available before. Essentially, each device has or is a microprocessor spewing out data that (we assume) means something to somebody.

While this technology isn’t really new, we are now seeing a full-on of discussion of the concept and the beginnings of its implementation in the industrial world. Most of the major vendors are starting to promote IoT, while organizations such as the International Society of Automation (ISA) are working on standards and best practices. Even Microsoft, traditionally late to the party, is on the bus.

Whether you are adopting IoT now or simply plan to in the future, here are some of the questions IoT suppliers will ask you, along with the related question you should be asking yourself to arrive at the real answer:

1. What do you want to monitor? The more important question is: Why do you want to
Continued
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monitor this?

2. What devices do you want to connect? The question that should be asked: What information do you need from your devices?

3. Who will use the data? Again, the more important question is not “who” but “will” they use the data?

4. How will the infrastructure be setup? More importantly, who will maintain this infrastructure?

5. What security will you have in place? A better question: What will happen when someone hacks into your system and how will you recover?

IoT, along with “Industry 4.0” and other technology-related initiatives can and will revolutionize the factory floor. As with any new technology (or even new implementations of existing technologies) many questions need to be asked and considered. Make sure that you are asking the right questions for your enterprise. These are not necessarily the questions that vendors want to answer.
Modular Control Architectures Eliminate Restraints

A new approach would have a common I/O network shared by all controllers and all field devices to support a deterministic communication standard.

By Mark Sen Gupta, Senior Consultant, ARC Advisory Group

Control architecture has changed little over the past 40 years. However, advances in processing power, network technologies, and software will enable greater value for end users in the near future by changing the way controllers are implemented and interface to the field. ARC Advisory Group believes that these new controller architectures, which support our evolving collaborative process automation system (CPAS) vision, will improve simplicity, flexibility and efficiency.

With few exceptions, the basic architecture of a process (DCS) or discrete (PLC) control system consists of a set of I/O cards logically connected or assigned to a single control processor housed in dedicated hardware. This has been the general state of affairs since the first digital controllers were introduced over 40 years ago. Initial control system incarnations consisted of a card rack in which a local real-time control processor communicated to a set of I/O directly coupled to the same backplane.

As network technologies advanced, systems began to employ architectures in which a single control processor might support several card racks of I/O connected via proprietary, deterministic protocols. Still widely employed today, this predominant architectural approach is effective, but potentially wasteful.

Generally speaking, every control processor is limited by three main parameters: the ability of the controller to handle I/O scans, diagnostics and program execution in a timely fashion; the capacity to store code, I/O maps and program variables; and the ability to handle the data transfer with the I/O and the Level 2 network. This often results in wasted potential.

An application may reach the limit of the number of supported I/O for a single controller, but the controller may be able to support much more logic processing than the application requires. This means that the user has probably paid for processing that is either not required or unable to be properly used. Alternatively, logic-intensive applications, like some batch applications, reduce the amount of I/O the control processor can support. If the application requires high availability, the extra hardware and software required amplifies the waste.

For remote I/O applications, the user may be required to have multiple racks of co-located I/O assigned to different control processors. Alternatively, the user might choose to have all the field data pass through one processor and pass those values (or other relevant field data) to another controller with available processing capability.

Controller and I/O interfacing

Unlike most current architectures, a new approach would have a common I/O network shared by all controllers and all field devices. This network would support a deterministic communication standard...
Modular Control Architectures Eliminate Restraints

and allow any controller to address any field device. It would even allow multiple controllers and/or other applications to access the same data without intermediaries and permit peer-to-peer communications between field devices. The I/O network would support both traditional (analog) and intelligent (digital) field devices. Because such a network would support peer-to-peer communications, some applications would be implemented at the field level.

Through this decoupling of previously dedicated I/O and controllers, end users would be able to buy the appropriate amount of I/O for each physical area without the constraints of the controllers. Controllers would less likely have unused processing and/or unused I/O connectivity. Details that would need to be worked out include the number of network connections an I/O device or a controller could handle, network efficiencies, speed impediments, and how to migrate existing users. However, ARC does not believe that these are insurmountable challenges.

Control in the cloud

The cloud, as used in the IT world, isn’t deterministic enough, available enough or fast enough for most Level 2 control applications, though it may be in the future. However, the decoupled architecture would enable a “local cloud” or virtualized control platform much like today’s virtualized IT environments. This architecture could meet the requirements of determinism, availability and speed of response.

In this scenario, ARC envisions a set of hardware hosting multiple real-time control instances or hosting a single control entity that grows with the application. The hardware would run a real-time virtualization platform similar to the corresponding IT equivalent, and could be dispersed throughout the facility. This platform would ensure real-time communications between the virtualized controller instance(s), and between the controller instance(s) and the I/O. In a manner similar to IT virtualization, the platform would also handle load balancing and failure mode recovery.

PoE+ Managed Switches

Advantech’s EKI-9300 series of industrial managed Power over Ethernet switches come with full Gigabit capability and are idea for high quality video transmission when used with an IP camera which is powered by the PoE switch. With all these features and a high bandwidth, the EKI-9300 series is a trustworthy option for surveillance systems and more.
Realizing IoT Solutions with Advantech

Modular Control Architectures Eliminate Restraints

The hosted controller instance(s) would run in a real-time manner similar to current controller implementations, with each instance running similar execution environments to today’s equivalents. From a user standpoint, the interface to these controller interfaces could be nearly identical. Because of the purely software nature of the controllers, they could be licensed just like any other virtualized software platform, “spun up” nearly as quickly, and the virtualized instances could be managed with tools similar to the current IT virtualization tools.
Industrial PCs: The Brains of Industry 4.0?
As the intelligent system used to make data-based decisions, greater use of industrial PCs is needed to truly achieve a connected factory.

By George Dickinson, Analyst, Industrial Automation, IHS

If you’ve been paying attention to the world of industrial automation and its associated press, you cannot help but have noticed that one of the hottest themes currently is “connectivity”—Industry 4.0, the Connected Factory, and the Internet of Things.

Most of the excitement here seems to be concentrated on more, smarter sensors and better communication and connectivity. However, there is more to Industry 4.0 than covering every available surface with sensors and connecting everything with miles of Ethernet cabling or wireless networks.

Having a large number of sensors generating countless lines of data is all very well. But this data needs to be put to use. No one will spend money networking a factory unless there is some clear benefit. This means that the data needs to be used to increase efficiency, which means that once data is collected it needs to be analyzed, and the salient points identified. Once this has happened, actions need to be taken based upon the content of the data. Is there a problem? Does something need to be done? Does someone need to be alerted? What changes need to be made? Ideally, these decisions can be made with little or no human input.

Therefore, for a connected factory to be of any use, intelligent systems are needed that are able to make such decisions themselves. These systems will need both the processing power to handle the data, and an open, flexible software platform that can act intelligently based on the data they receive. With their powerful processors and open software, industrial PCs would appear to be ideally suited to meet this need.

In addition to these capabilities, the flexibility of an industrial PC will be a vital factor. Software will need to be carefully customized to meet the needs of each connected factory or plant, to ensure that the right decision is made in a huge variety of possible situations. Flexible systems will also support a wider scope of how a plant is used, allowing manufacturing to switch between different products more easily, to drive greater factory efficiency.

According to a recent study by IHS, the market for industrial PCs is forecast to grow strongly, by more than 8 percent a year to 2018. Although some of this growth will be due to more traditional factors, the journey toward Industry 4.0 will also be important, expanding sales into applications that may not have previously used an industrial PC—applications where previously other forms of control might have been used, but which now need the additional capabilities of an industrial PC to meet the demands of Industry 4.0.

This will help to drive development of both the hardware and software of industrial PCs. In addition to processing and acting upon data intelligently, industrial PCs must be able to present the data in a sim-
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Industrial PCs: The Brains of Industry 4.0?

ple and clear format. It is very easy for operators to become overwhelmed with the sheer volume of information a connected factory can generate. It is entirely feasible that an operator could miss an important alert in a sea of numbers, if important information is not presented clearly.

This will be a challenge for software developers because they will need to develop interfaces to display the information that operators need to know in an efficient and ergonomic way, while keeping the interface easy to use for operators used to previous interfaces. However, though the connected factory will greatly increase the amount of information available, an intelligent system should be able to filter it to run a plant or factory, requiring only limited input from operators.

The goal of industrial automation, even from the early days of water wheels and mechanical looms, has always been to replace human workers with more efficient machinery. The logical end goal of lights-out manufacturing is closer than ever. However, to achieve this, factories will require intelligent systems that can respond correctly to potential problems without human involvement. Greater use of industrial PCs just might be the answer to taking the next step toward the future industrial automation.

Advantech Corporate Video

Founded in 1983, Advantech is a leader in providing trusted, innovative products, services, and solutions. Advantech offers comprehensive system integration, hardware, software, customer-centric design services, embedded systems, automation products, and global logistics support.
The Internet of Things (IoT) and big data are two hot topics with respect to commercial, industrial, and other applications. The term “IoT” was coined in 1999 and refers to the world of devices connected to the Internet, which is the method by which much of big data is collected, concentrated and curated. Big data additionally refers to the analysis of this information to produce useful results.

A primary driving force behind the IoT and big data has been the collection and analysis of data concerning consumer behaviors in order to find out what people buy and why. An example of this is the loyalty cards that shoppers use at grocery stores and other retail outlets. Using these cards, retailers and their suppliers can ascertain what customers buy which products, and can then use this information to increase sales and profits.

Commercial off-the-shelf (COTS) technologies, such as the PC and various Microsoft operating systems, have long migrated to industrial automation applications in the manufacturing sector. This is also the case with the IoT and big data, as the COTS technologies that underpin the implementation of these concepts are migrating from the commercial sector to industrial automation.

This white paper will first show why manufacturers should integrate the IoT and big data into their industrial automation systems, and then it will reveal how this can be done using products and systems available today. The white paper will conclude with a look at the future of the IoT and big data, illustrating how these concepts will help create the factory of the future.

Why Implement the IoT and Big Data?

The commercial and governmental sectors are showing how the IoT and big data can be used to improve operations, but how can these concepts be profitability extended into manufacturing and other related industrial sectors?

It helps to first define where this data is coming from, figure 1 shows some of main vertical markets where big data is collected. These markets include but aren’t limited to agriculture, electricity, forestry, water treatment and virtually every type of manufacturing facility.

FAAs Sanat Joshi explains in ISA’s InTech, “Big data is the new norm for enterprise analytics and it is pervasive across many industries.” He says that data becomes big “when the volume, velocity, and/or variety of the data exceed the abilities of your current IT systems to ingest, store, analyze, or otherwise process it.” Big data typically conveys an individual perspective of perceived magnitudes of information greater than expected, and may express a conundrum of comprehension and utilization.

Data input originally came from limited human-based measurements, observations and manual data entry—but most data today is automatically generated by sensors, with the trend of field sensors
Continued

IoT and Big Data Combine Forces

becoming more numerous and smarter with more reporting capabilities continuing to grow.

Once this rapidly expanding stream of data is collected, it then needs to be concentrated and curated, terms that will be explained in detail later in this white paper. This curated data must then be visualized and analyzed in order to improve operations, a process that will also be expanded upon.

Table 1 lists how manufacturing and other related vertical industry operations can be improved by the intelligent implementation of the IoT and big data. These operational improvements will result in better products, increased throughput, less downtime, and lower costs. Figure 2 lists some of the specific areas of manufacturing that will benefit including but not limited to production, process control, and packing, and test and inspection.

Table 1: Why Implement the IoT and Big Data?

1. Predictive health monitoring
2. Less downtime
3. Lower reject rates
4. Improved quality
5. Higher throughput
6. Improved safety
7. More efficient use of labor
8. Enable mass customization

Industrial packaged equipment is typically automated with embedded controllers or programmable logic controllers (PLCs), and both types of controllers are commonly available with Ethernet connectivity. Even individual sensors, analyzers, radio frequency identification (RFID) hardware, vision systems, and other devices are becoming “smarter” and are offering network connectivity. Thus, more data than ever is available from the factory floor and process plants. On top of this, automation components have more memory, processing power, and standard functionality on-board.

This combination of information and capabilities can be harnessed by a top-level predictive health monitoring system. Motor run times and start counts, valve actuation counts, and other tracking metrics can be configured to alert the user when equipment requires service. More detailed diagnostics such as temperature and vibration monitoring can trigger a useful warning of imminent trouble. In fact, many devices now include powerful diagnostic information on-board, just waiting to be tapped by end users.

For manufacturing industries, uptime is crucial. Enhanced diagnostic capabilities directly lead to reduced downtime as problems can be identified quickly or even before they fully emerge. With a wide enough range of system information, predictive analysis methods can potentially alert the user to trouble before it even happens. As Kevin Ashton puts it in RFID Journal, “If we had computers that knew everything there was to know about things - using data they gathered
without any help from us - we would be able to track and count everything, and greatly reduce waste, loss, and cost.”

In fact, for less severe problems it is entirely possible for systems to proactively and automatically adjust themselves or take corrective actions, all without any required human interaction. Such a system would obviously result in lower reject rates, improved product quality and higher throughput.

Even though the IoT and big data may just seem like autonomous functions once they are implemented, their positive impact on operations personnel can be substantial. The ever expanding availability of sensed information means there is a reduced need for operators to venture out into the field, especially vital in hazardous environments such as refineries. Additional data from IoT devices can also lead to improved process control that makes operations safer.

Self-diagnosing systems mean that maintenance technicians can spend less time troubleshooting dead ends and more time performing hands-on repairs. Predictive health monitoring allows repair events to be scheduled in a coordinated manner that minimizes production impacts, and reduces the human toll associated with events such as third-shift emergency repairs.

Combining the IoT and big data can even facilitate new capabilities. For instance, systems configured with enough intelligence can offer “mass customization”, which uses computer-aided manufacturing methods to enable individually customized products produced with efficiencies and costs approaching mass production. Customers can thus have access to a new variety of customized products at a less than a full-custom price, while manufacturers are able to tap new markets and realize increased profits.

While speed is important in harvesting big data from the IoT, it’s important to point out that determinism is the
real goal. Determinism implies that each action can reliably predict another action. The more information we have, the more deterministic we can become since we can correlate more inputs to derive more accurate output predictions.

More accurate predictions will in turn improve prognostics and health management and other predictive technologies. This ever-improving automated sense/predict cycle leads to increased productivity due to reduced manual data collection and interaction. Better quality products are made closer to specifications and tolerances, with lower reject rates and higher throughput.

But all these benefits can’t be realized until data is first collected, which starts at the sensor level.

Collection

It’s obvious how designers are incorporating sensors into countless devices used throughout our everyday lives. Smartphones react to user inputs by tracking the smallest of gestures, automobiles constantly monitor vehicle motions to achieve stability control, and buildings vary environmental controls to provide both comfort and energy savings.

In some ways, the vast availability of sensors and their produced data has provided kindling for the IoT and big data fire, while the automated method of querying these sensors, largely over the Internet, has sparked the fire to life.

When looking from a system-wide perspective, the sensing function can be considered to exist at the lowest level, or out on the “edge”. Table 2 offers a list of common sensor types, and shows how the IoT sees the world.

Table 2: Types of Sensors

1. Temperature
2. Pressure
3. Level
4. Flow
5. Density
6. Proximity
7. Position, angle, displacement, distance, speed, acceleration
8. Vision
9. Vibration
10. Current, voltage and other power parameters
11. pH and other analytical values
12. Moisture, humidity and other weather conditions

The classic four measurements for production processes are flow, level, pressure, and temperature. Additionally, chemical, pharmaceutical, water treatment, and food industry processes will rely on analytical measurements of pH, dissolved oxygen and many other specific variables. Environmental and facility control systems will look for temperature, moisture, humidity and other weather conditions.

Extending into the mechanics of many types of equipment and ma-
chinery, there are various sensors for measuring position, angle, displacement, distance and proximity. Speed and acceleration sensors monitor the change of those same sensed values over time, while vibration sensors monitor the frequency and/or amplitude of motion.

For electrically driven equipment, sensing devices report the instantaneous current and voltage values and other related power parameters. Even more esoteric is the use of vision sensing systems to track produced parts, verify quality, or simply read tags. Vision systems in particular can generate huge amounts of image data.

Sensors generate numerous types of signals, but these various signals must all be transduced from the raw measurement into a useful signal format for transmission. A classic method of transmitting a single analog value is to use a transducer that scales the value into a 4 to 20 mA signal wired to a control system analog input module.

More advanced “smart” transducers can convert the sensed signal into a standard digital communications protocol, Ethernet-based in many cases. Signal converters are also available that can effectively upgrade legacy type signals and equipment by transforming proprietary or obsolete serial signals to modern open network protocols.

“Smart” transducers or sensors are preferred for several reasons. Not only can the primary sensor signal be monitored, but very often there are additional process values available that prove useful. For example, most smart pressure, flow and level instruments include temperature measurement, very useful for signal compensation and general health monitoring. Smart sensors and instruments usually also collect and transmit diagnostic information including device status, alarms and events.

Finally, sensors and transducers networked via serial or Ethernet links can provide simplified installation, particularly for wireless variants. There are many paths to collect data, and this data must then be concentrated.

Concentration

Data typically journeys from networked sensors to some form of data storage or concentration device. This device or devices can exist in a number of locations. Classically, the data would be deposited in large PC server or mainframe systems in a control room or mission control center. Table 3 identifies some other data concentration options.

Table 3: Types of Data Concentrators

1. Data loggers
2. Embedded controllers
3. Embedded PCs
4. PLCs
5. Multi-variable instruments and transducers
6. Smart sensors

Older data loggers, many still in use today, consist of round or scrolling paper charts with ink pens tracing information, similar to an analog...
earthquake seismograph. Today’s data loggers are fully digital and offer numerous improvements.

Solid state data loggers can accept large quantities of input channels, capturing values at defined sampling intervals with the capacity to store tens of thousands of data values in volatile or non-volatile memory. This type of device makes it practical and economical to extend data logging to remote locations. These data loggers may be network-connectable, or may have removable memory cards or USB connectivity for archiving the stored data to a higher-level system.

Embedded controllers are often used as a dedicated means to automate equipment. Although primarily tasked with cost-effective machine control, these controllers often have sufficient memory and processing capabilities to also perform data logging. Similarly, embedded PCs have more than enough power to perform automaton and data logging tasks, and often are configured with rotating or solid state hard drives that can provide significant data storage capacity.

PLCs are used in many of the same applications as embedded controllers. Historically, a PLC’s strong suit has been reliable, flexible, and high-speed control of machinery. They have also been a common gateway for providing raw data to higher level data concentrators.

Recent years have found PLC processing power and memory capabilities increasing, and in fact the most capable PLCs are now often called process automation controllers. Whatever the moniker, the latest PLCs offer impressive non-volatile storage capabilities, and some even offer historian modules that plug into the PLC chassis. For many cases, this makes the PLC itself a viable option for concentrating data.

And looking back for a moment at sensing devices, the most capable of these often have onboard data logging. Often these devices can log to memory cards or USB memory, or they can be networked into a higher level data concentrator.

Just as there are myriad options for collecting data, there are more options than ever for concentrating the abundance of this information. Data concentration can be scaled to meet the need, ranging from many smaller field devices all the way up to large centralized or distributed...
PC-based systems. It’s becoming more straightforward to reduce the amount of manual human intervention required to obtain useful data, which in turn drives up the quantity and quality of data available for curation, and eventually interpretation.

Curation

Once data has been harvested from sensors, and concentrated onto some type of storage system, it becomes important to organize the information in a manner that helps users make sense of it. The activity of “curating” this data typically involves the use of database software. Curating is usually accomplished at the PC server level, since database management is an advanced software function that requires equally capable hardware.

Some of the most well-known commercially available business databases include Oracle Database, Microsoft SQL Server, Microsoft Access, SAP Sybase, and IBM DB2. These software packages are used throughout industry for maintaining all sorts of data, and they offer a platform for querying and analyzing information.

However, not all data is exactly the same. In the business and commercial world, data often consists of customer information, financial transactions, product stock numbers, stocking quantities, and shipping information. This transactional data requires very secure data storage, with relatively slow rates of data collection. Interruptions to data access and other functions aren’t critical.

When we look at the manufacturing world, we find that a large amount of the information obtained from sensors consists of time-series information where each sample is the value of a sensor with a timestamp. This real-time data is sampled repeatedly. Process data may also include alarm values and discrete process events. Manufacturing data must be stored and accessed in real-time, and uptime is critical.

With so much information potentially available, it’s critical to capture what is most important. Control Engineering finds that “Lost in the big data flood are indicators that can help plants understand the dynamically changing risks and avoid some of the $10 billion losses the U.S. chemical and petrochemical industry experience annually (due to unexpected shutdowns).” Without informed analysis, full value is not received from the effort and expense spent in collecting, concentrating and curating data.

There is a class of operational or industrial databases or historians that have developed specifically to address the needs of manufacturing processes. These software packages are optimized to address tag-based data (such as might be obtained from IoT devices), and to log large amounts of time-series data at high speed. Another characteristic of process historians is that users can choose the desired sample rate and precision. Careful configuration of these attributes can allow the historian to compress the data storage size, and reduced database sizes improve query response times.

Curated data is commonly available within an organization over
the facility or company network, which is often referred to as an “intranet” or a “private cloud”. The Ethernet is considered a “public cloud”, but there are secure methods to link multiple facilities or data sources using it.

Easy access to historical database information and the ability to retrieve this data in a variety of useful ways (such as raw value, average value over a given period, and a graph of values over a given period), powers higher level analysis of big data.

**Visualization and Analysis**

To a great extent the data collection, concentration, and curation activities occur silently and unseen after initial configuration. These activities must be in place to act as a foundation for visualizing and analyzing information. However, simply presenting users with large tables of values from a historical database will not help most people to understand the data, since most people are more visually oriented towards graphical representations of data such as charts, graphs and other symbols.

Data scientist Nate Silver, interviewed by Jon Gertner in Fast Company, relates that “The flood of data means more noise (i.e., useless information) but not necessarily more signal (i.e., truth).” He goes on to state that “People blame the data, when they should be asking better questions.” The right data visualization tools can help users understand data and ask the right questions, and to quickly interpret and act upon the answers.

Fortunately, more options than ever are available to display quantities of information and help users make sense of it (Table 4). At the field level, many analyzers and data loggers offer local displays or come with associated operator interfaces. These devices often allow users to view trends of data, alarms and events.

### Table 4: Types of Visualization and Analysis Tools

1. Smart phones
2. Tablets
3. Operator Interface Terminals
4. PC-based HMIs
5. Data loggers
6. Transducer and analyzer displays

For data coming from an embedded controller or a PLC, a local operator interface terminal (OIT), which is a dedicated device as opposed to a typical PC, is a good choice for displaying data and alarms for the related equipment or area (Figure 4).

If the controller/OIT is provided by an equipment manufacturer or system integrator, there is a good chance that useful local indications, data logging/trending, and alarming capabilities will be built-in and thus readily available without any extra effort required by the end user. For many applications, the point where visualization and analytical performance really gains traction is when software on a PC plat-
form taps into historical data. The software historians mentioned in the “Curation” section offer their own visualization and reporting tools, and most PC-based HMI packages include these and other data analysis features. Operators can trend various data points over chosen time ranges, and effectively perform their own investigation of the available data.

These products can be configured to offer desired reports and readouts, or can be dynamically operated by users on the fly. Some modules allow users to develop advanced equations using process data in order to solve a problem or optimize an operation. This empowers researchers, scientists, and manufacturing personnel to optimize their operations.

Data analytics, which in manufacturing applications is defined as using statistics to monitor an industrial process, has many aspects. In a ControlGlobal.com article, Greg McMillan and Stan Weiner describe just a few effective methods of data analysis such as principle component analysis (PCA) and partial least squares (PLS). “PCA is used for early fault detection and employs two statistics to explain if the process is within control limits.” Additionally, “PLS is used to predict the end-of-batch quality.”

Another development in this arena is the proliferation of web-based visualization products. This allows “big data” to be harnessed by any user with a web browser and the proper credentials. Products such as Advantech’s WebAccess offer rich graphics and animation, a library of objects with connectivity to a variety of data sources, and reporting features (Figure 6). Browser access to these types of web servers ensures simplified deployment throughout an organization.

Some companies, such as Tableau Software, are taking this trend a step further with desktop and web-accessible software that promises drag-and-drop ease of performing data analysis. This effectively opens up the field of data analytics to everyday users, allowing them to “tell stories with data”. This type of innovation will enable a wider audience to exploit the IoT and big data productively.

And no discussion of visualization would be complete without touching on the expanding role that smartphones and tablets play in connecting to automation, historian, and database software. How fast are mobile devices impacting the world? According to Joe Feeley in ControlDesign.com, “By the end of this year alone, the number of mobile-connected devices will exceed the earth’s population.”

Most visualization software products offer mobile modules that enable portable devices to connect to the host system over the Internet or an intranet. Mobile applications offer much of the same functionality as their big brother PC-based applications, but in a format appropriate to the device size. In some cases, users may find that their preferred operator interface experience is to use their own portable device wherever they go instead of booting up their laptop or seeking out a public PC.

A popular method of summarizing the results of collection, concentration, and curation is to create a simplified visual “dashboard”. Just as
in a car, a graphical dashboard shows essential operating parameters of the system and warns of critical problems. There is much more information beneath the surface, but the dashboard distills the key elements to show the most important facts about what is happening, allowing users to quickly interpret conditions and make smart decisions.

**Conclusion**

The IoT and big data are empowering extensive changes in the manufacturing and automation world. Writing for Automation.com, Bill Lydon indicates that European sources are calling this “industry 4.0”, indicating “that industry is entering a fourth industrial revolution” of higher technical integration. The internet of things is creating a bridge between the virtual and the real world.

Typical automation system designs have previously incorporated a top-down approach, with relatively limited control actions to maintain specific process variables. As the IoT and big data allows sensed information to become more rich and readily available, and as the capability has increased to capture and analyze that information, the ability to control processes becomes far more powerful and far-reaching.

For example, a traditional synchronous manufacturing process consists of all items moving down the production line and being handled identically. However, consider an alternate scenario where the item being produced boasts an IoT smart tag with memory, embedded with the requirements of that item.

This would enable asynchronous manufacturing, where the part/subassembly/batch carries its own information and drives the manufacturing process. In fact, German government agencies are working to formalize an object structure to facilitate exactly this type of “smart” manufacturing, and the IoT and big data are two of the most important tools for enabling this bottom-up interactive manufacturing approach.

IoT and big data are reworking the relationship of machines-to-machines as well as people-to-machines. Many new hardware and software technologies have been developed to bring field sensor information from the very edge of the process, to collect it in a distributed or centralized manner, and to curate it through databases and historians. Each of these data harvesting tasks is becoming more automated, which removes the elements of delay and error associated with manual readings and data entry.

Improving and automating data collection, concentration and curation enables end users to take full advantage of visualization and analysis software to make their operations more efficient. As key components of these activities, the IoT and big data are forces ready to be harnessed with today’s products and systems to improve the efficiency, safety and profitability of manufacturers worldwide.