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# The Internet of Things

The Future is Connected – Riding the Wave of IoT Growth

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Your game console talks to Netflix and other sites on the Internet. Your TV, DVR, smart-phone and tablet PC are all capable of accessing the Internet. You may very likely have a smart electric, gas or water meter that is connected to your house and able to talk to your heating and cooling systems. You can buy a refrigerator that can inventory itself and message the grocery store with an order for pickup or delivery. Your tires talk wirelessly to your car's main computer system. Your car accesses the Internet for GPS and other services. In the factory, embedded diagnostics use ubiquitous networking, both wired and wireless, to message maintenance computers and generate work orders. You wear an RFID tag in the plant so that in case of emergency, safety personnel can find you. All of this happens without you pressing one key. All of this is happening now.

They call it the "Internet of Things," and it is already changing the future of the way we live and work. First coined by Kevin Ashton in a 1999 article for *RFID Journal*, the name has become widely used, but there are many different definitions of what exactly the Internet of Things is, how it operates, and what is included in its scope.

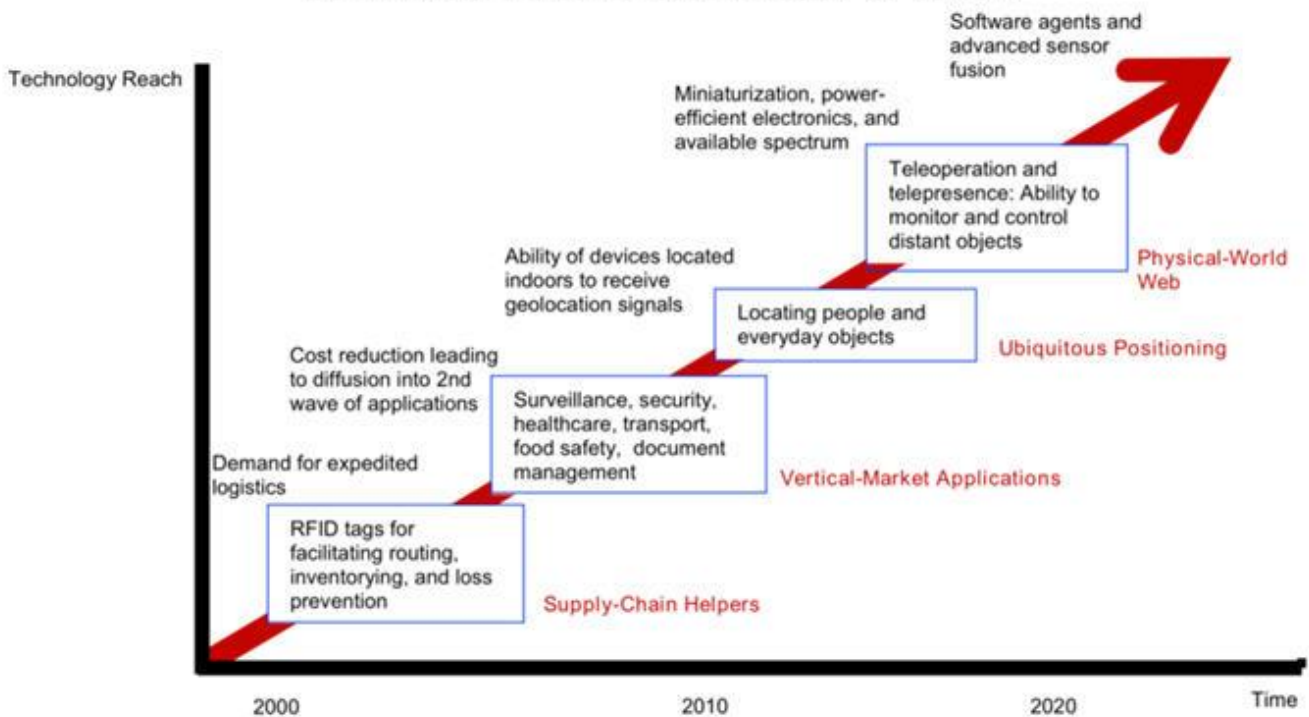
### Just What IS the Internet of Things?

SAP AG, the leading enterprise software manufacturer, defines the Internet of Things as, "a world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Services are available to interact with these 'smart objects' over the Internet, query and change their state and any information associated with them, taking into account security and privacy issues."

CASAGRAS, an EU Framework 7 project, developed another definition in 2009: "A global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communications capabilities. This infrastructure includes existing and evolving Internet and network developments. It will offer specific object-identification, sensor and connection capability as the basis for the development of independent federated services and applications. These will be characterized by a high degree of autonomous data capture, event transfer, network connectivity and interoperability."

All the definitions of the Internet of Things have much in common. First is the ubiquitous nature of connectivity, and, second, the global identification of every object. Third, the ability of each object to send and receive data across the Internet or private network they are connected into. This isn't some science fiction story, or a futurist's speculation. It is happening right now.

## TECHNOLOGY ROADMAP: THE INTERNET OF THINGS



Source: SRI Consulting Business Intelligence

The figure shows what is happening. It started with a demand for better logistics and supply chain management. The second wave was driven by the need for cost reductions. The third wave was driven by geolocation services. The fourth wave will be driven by telepresence, made possible by miniaturized embedded electronic processors, and the next will be the ability to create mesh networks including tags, sensors, process instruments and final control devices.

### Bringing the Big Picture Down to Earth

Everyone is beginning to see the Internet of Things developing in the commercial and home sectors. The recent Apple TV commercial for the iPad that intones, "You will still do..." and lists off numbers of normal endeavors, followed by "You'll just do them differently," is a clear indicator of this. The use of iPads and other connected appliances in business meetings is growing exponentially.

In automation and control, things are not so clear cut. This is partly because of the very long lifecycle of automation systems (up to at least 30 years) and partly because some processes are highly customized. Enough value can be created using Internet of Things (IoT) concepts, though, that plants are already starting to use the technologies.



For example, look at a distillation column. Distillation columns are controlled by temperature. As the hot hydrocarbons rise, they cool to the point where they liquefy and can be drawn off as one or another petroleum product: gasoline, benzene, kerosene, and so forth. The use of inexpensive wireless temperature sensors in large quantities along the length of a distillation column will provide a very large amount of data to the operators that they have never been able to get before—and that can be used for process bottleneck discovery and process optimization. Process optimization data that has never been able to be used before is enabled by the concepts of the Internet of Things.

In a discrete manufacturing plant, consider the value of having parts self-identify with RFID tags, and automatically controlled rolling bins and forklifts moving parts and subsystems around automatically without human intervention—and always getting the right part to the right place at the right time. And then consider the further value of having all that information available in easily accessible databases wherever needed.

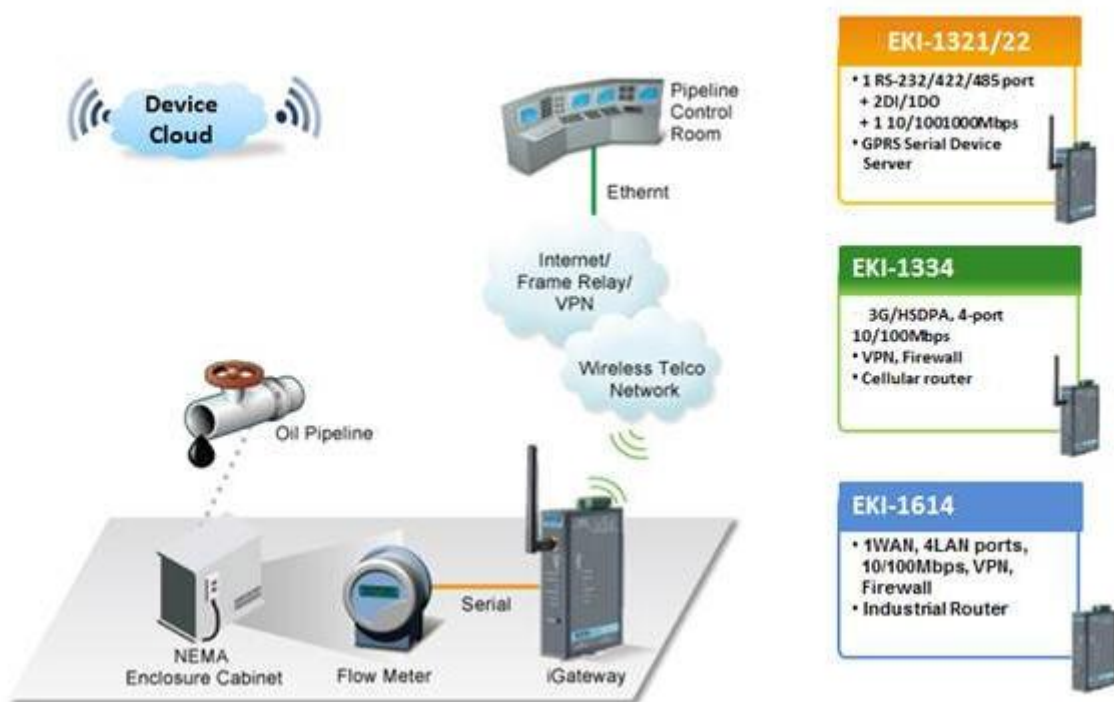
Now consider environmental monitoring. Look at the value inherent in having intelligent air, water and solid waste pollution sensors connected to the manufacturing control system, so that repair and remediation are automatically triggered if values go beyond set points.

### **The IoT Architecture and Cloud Computing**

Typically, the IoT consists of three architectural layers: sensing, network and application. Sensors need to have exact locations and unique network identifiers for the Internet of Things to handle the sheer volume of data that is going to be produced. In 2010 ICANN gave out the very last IPv4 IP addresses—there are over 4.3 billion IP addresses in use with multiple devices per IP address. Moving to IPv6 will allow ICANN to increase that number exponentially. According to Dave Evans of Cisco, “By the end of 2011, twenty typical households will generate more Internet traffic than the entire Internet in 2008.”

Networks will be stressed to their limits handling this volume of data. High efficiency managed network switches will be required to cope, and local data storage simply will not be enough to hold all the information being produced every minute.

Smarter, more powerful networks will be necessary to make this Internet of Things work.



Advantech industrial communication switches used to bridge the communication between cellular networks and Ethernet devices.

## Enter the Cloud

Giant server farms and virtualization of applications have given rise to a new way to visualize data storage—as a “cloud” of data in an undefined cyberspace which is everywhere. This concept solves the problem of there not being enough local storage to make the IoT practical. Since all the devices are connected to the Internet, all the data from those devices is available to anyone, anywhere with proper security credentials, instead of being trapped in a hard disk on the plant floor.

The cloud isn’t going to just store data. It will also store applications. In the cloud, virtual servers will run applications using the data from those sensors and networks, and transmit data and control information back to the plant floor, building network control system, or home.

What might some of those applications be? How about real-time process audio and video superimposed over process control data? What about real-time control of energy usage at a plant, or in a home? What about real-time geolocation of all plant assets and personnel in the event of emergencies? All of those applications can be provided as software as service (SAAS) models.

There are some examples of cloud computing applications from the consumer world. Hotmail and Salesforce.com are commonly considered among the first of the large uses of cloud computing. There are others in the industrial environment, like intelligent building control throughout a campus, or enterprise wide real-time energy control over many plants on multiple continents.

## Virtualization for the Future: “To the Cloud!”

The Microsoft commercials make it seem like the answer to every problem dealing with data and applications is to resort to the cloud. But the fact is, it seems to be true. The cloud is everywhere

and nowhere. It is in cyberspace, now a very real place. All you need to use the cloud is a high speed internet connection and access to the data and applications that are operating in the cloud.



Server Farms are already here.

The key to the success of the cloud computing design is virtualization. Especially in automation systems, the rapidly changing face of product and software design, with its less than 12-month product cycles has proven a significant problem. You have systems that are running on processors and CPUs that are many generations out of date, no longer supported, and are subject to failure, end-of-life buys on components and are essentially not repairable when the system goes down. And when a system goes down, so does throughput. Product isn't being made and money is being lost.

By virtualizing servers, both in the plant itself, and in the cloud, you can prevent downtime by making automatic switchover to another server possible. You can continue to run old software in virtual machines, thus being safe from product and software going out of date.

In addition, the safety of the systems in the plant that are running on virtual servers is enhanced. Cyber attack is much harder if the attacker has to get into the virtual server and then into the control software running on it. It is another layer of a successful defense in depth security design.

### **Using the Cloud for Critical Control**

Storing data in the cloud is one thing. Using data from the cloud in a real-time process control system is quite another. And further, to run real-time applications from a virtual server in the cloud is even scarier.

Industrial control systems are very slow to change, but even there, movement toward virtualization is proving that these systems work. What does it matter if the virtual server is located physically at the plant, or in a server farm in North Carolina, for example. It is clearly the security of the system, and the robustness and uptime of the Internet link that is critical, not the operation of the servers themselves.

This is amenable to engineering and system design.

### **So What Do We Do With the Internet of Things and the Cloud?**

The commercial and home uses of the Internet of Things are increasing on a daily basis, even if people who use IoT don't quite realize they are doing it.

In the world of Automation and Control, the opportunities are quite literally endless, but several broad areas come immediately to mind.

#### **Process Optimization**

The reason we continue to do single-loop control is that in the 1920s, when the first pneumatic single loop controllers were designed, it was too complicated to use more than one variable. In modern plants, we still use single loop control, even though more than half of the transmitters installed since about 1990 are actually capable of producing more than one Process Variable (PV). We call these devices multivariable transmitters. Also the cost of transmitters of very high accuracy is high enough to make it necessary to select not more than one or two variables to monitor, and just a few places to do it in.

Remember our distillation tower? What would happen if the tower were literally covered with temperature sensors, all wirelessly connected and all talking to a control system that can tweak performance of the tower in real-time based on the new level of data it is being provided? Advanced process control and model predictive control are often based on the inputs from virtual sensors, and they work well. How much better would those optimization control schemes work if they were seeing real-time data from hundreds of sensors simultaneously? That would be enough data to do real-time high definition modeling and output the value of the model to the controller.

#### **Optimized Resource Consumption**

Things have changed from the time a refinery engineer famously said, “Control energy consumption? Why? We make energy here... it’s free.”

It is never free, and even refineries and power plants where energy is “made” have recognized that sustainability requires the optimization of the resources they consume. Networked sensors and automated feedback mechanisms can change usage patterns for scarce resources, including energy, by controlling energy and water and even product usage on a real-time basis. This can even enable the use of dynamic pricing.

### **Automated Supply Chains**

Supply chain optimization has been theorized for thirty years and put into practice well over a decade ago, at least in large companies like General Motors, Toyota, and famously, at Wal-Mart. The IoT will make it possible to completely automate the operation of many supply chains, by assigning locator identification to each part or product as it is made, and using automatic delivery and storage devices, move the parts and products to exactly where they are supposed to be, just in time for them to be used. These devices are already here. See <http://www.goodfruit.com/Good-Fruit-Grower/December-2005/Packers-use-technology-for-efficiency-and-quality/> for a robot bin stacker. What the IoT will do is to make the robot talk bi-directionally with the production management system, and vary its program based on real-time input from the PMS.

### **Complex Autonomous Systems**

The most demanding use of the Internet of Things involves the rapid, real-time sensing of unpredictable conditions and instantaneous responses guided by automated systems. You can visualize this in traffic control and highway safety. In fact, several upscale automobiles offer systems like this to deal with a driver falling asleep at the wheel, an unexpected obstacle, or other unpredictable event. Commercial and military aviation systems use these principles now.

In fire departments, this technology is already being used as the intelligence behind geographically based locators for firemen who may be in distress. Several instances have been reported of rescue squads automatically called for by automated devices that detect movement of the fireman. When he or she doesn’t move for over three seconds, the rescue squad is notified.

In automation and control systems, these systems will be used increasingly in the area of process safety, providing real-time sensing of impending abnormal situations, as well as a means to deal with them appropriately faster than the operator can do it by hand. This will make it easier to achieve the goals of the ISA106 standards for procedure-based automation. The autonomous systems that the Internet of Things makes possible will lead to an entire new generation of intelligent alarm management systems that will be able to warn operators of impending failure and move the process away from catastrophe.

### **When Do We Get This?**

So, when will we see these wonders? The Internet of Things has been developing on a global basis for almost 15 years now, and it appears that the growth curve is a tipping function, that is, there will be a point after which the growth will become significantly faster and unstoppable. It is likely that Ming Chin Wu, president of Advantech, is correct. He said that the tipping point would be

sometime in 2010. With the enhanced government support for the part of IoT called Smart Grid, he is almost certainly right.

We will see, indeed we are already seeing, the growth of ubiquitous networks connected to all objects with each unique object having its own identifying address wherever it is, through IPv6 or some other methods like RFID and the other Automatic Identification and Data Capture (AIDC) technologies. As the growth of these networks continues the infrastructure robustness necessary for critical applications will develop automatically. The Internet of Things is here, now.

To listen to a podcast about the “Internet of Things” by Mark Lochhaas of Advantech and Walt Boyes of *Control* magazine, visit

<http://www.controlglobal.com/multimedia/2011/InternetThings1102.html>.