Your IoT Primer

Bridge the Gap between OT and IT

OPTO 22
Automation made simple.

Opto 22

43044 Business Park Drive • Temecula • CA 92590-3614
Phone: 800-321-6786 or 951-695-3000
Pre-sales Engineering is free.
Product Support is free.
www.opto22.com

Form 2173-170428

© 2016–2017 Opto 22. All rights reserved. Dimensions and specifications are subject to change. Brand or product names used herein are trademarks or registered trademarks of their respective companies or organizations.

YOUR IOT PRIMER

Bridge the Gap between OT and IT

It's 3:00 a.m. on a remote wind farm in California. On the cold desert hills, six wind turbines suddenly begin spinning, but no operators are in sight.

In fact, there are no operators currently controlling them. Through an Internet connection and edge processing gateway recently installed in the wind turbine, each turbine itself is autonomously monitoring the price of electricity on a website.

In a fraction of a second the turbine determines that this moment is the most profitable to begin generating electricity to supply the grid.

At the same time, the wind turbine automatically logs how much power it's generating, how much revenue the owner should anticipate, how fast the turbine is spinning, the current wind speed, and a slew of other data to be sent to the cloud for advanced analysis, predictive maintenance, and operational forecasting.

This isn't fiction or a future projection; it's happening right now.

This is the Internet of Things.

WHAT IS IT?

You've probably heard about the Internet of Things (IoT), or the Industrial Internet of Things (IIoT), also called Industry 4.0, primarily in Europe. But what is it?

The IoT is poised to offer society the greatest opportunity for advancement since the Industrial Revolution: a world where all kinds of things are connected, communicating, and improving our standard of living. We're all going to be a part of it, and preparing for it now will let us take full advantage of its benefits.

According to Berg Insight, a dedicated machine-to-machine/IoT market research firm based in Sweden, the installed base of wireless IoT devices in industrial automation reached 10.3 million in 2014. Berg Insight predicts that the number of wireless IoT devices in automation networks will grow at a compound annual growth rate (CAGR) of 27.2 percent to reach 43.5 million by 2020. Industry giants like GE, Rockwell, Cisco, IBM, and Microsoft are investing significant amounts of capital in IoT. If you're not already seeing elements of the IoT in your work, you soon will.

A massive change is coming in the way we conduct business, from the design and manufacturing of goods to how we service customers. The IoT intends to connect industrial and manufacturing devices and systems (things or assets) together so we can:

- Share valuable data in real time
- Improve processes
- Tune systems autonomously
- Predict system failures before they occur
- Decrease downtime
- Reduce costs
- Increase profit

All while improving customer experiences and providing consumers with more value.

COMPONENTS OF IOT

Just in the last few years, new technologies from low-cost sensors to advanced analysis of massive amounts of data ("big data") have become more widespread and easily accessible. The costs of computing power and bandwidth continue to fall, ushering in mobility like we've never seen before.

With new technologies rising and the cost of technology dropping as quickly as it has over the past several decades, you now have the ability to connect almost anything to a network. You can enable low-level sensors and actuators, collect data from those devices, convert it into a routable protocol, send it across the Internet, and push it into a big-data analytics system—all in near real time.

You have visibility into your process control systems from across the globe. And that visibility is with you all the time, on your mobile device in seconds, no matter where you are.

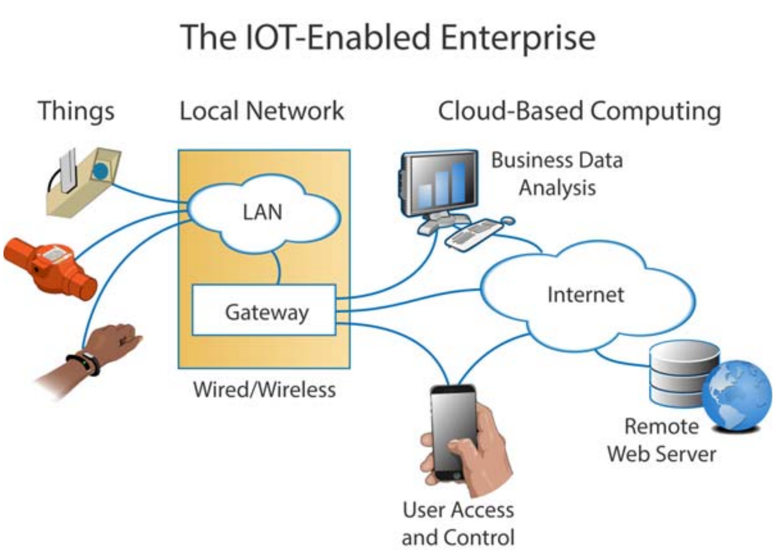
With the IoT, information flows freely from customer interaction points, to business decision makers, to resource planners, right to the manufacturing floor, and back again.

HOW DO WE GET THERE?

While this movement toward the IoT has already started taking place and grows at an exponential rate every year, it will not happen overnight. Even with the large investments

in IoT being made by so many industry giants, there are significant hurdles that need to be overcome for the benefits of the IoT to be captured.

And we won't be able to capture those benefits without major changes in the way technologies interact in our business.



OT/IT CONVERGENCE

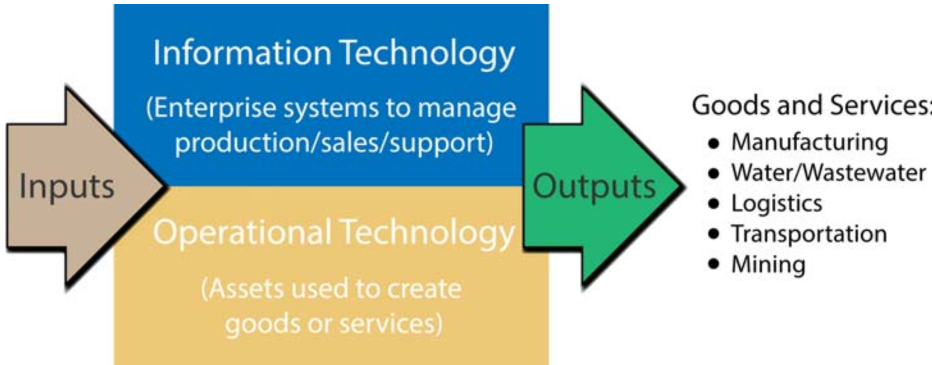
Within a given enterprise are operational technology systems and information technology systems. Both technologies and each set of systems were purpose-built, and neither was designed to work with the other.

Gartner defines operational technology (OT) as "hardware and software that detects or causes a change through the direct monitoring and/or control of physical devices, processes and events in the enterprise." That's the industrial control and manufacturing automation part of the business.

Gartner defines information technology (IT) as "the entire spectrum of technologies for information processing, including software, hardware, communications technologies and related services." That's the company computer network and databases. (In general IT does not include embedded technologies that do not generate data for the enterprise.)

To make things easier, you might sum up those definitions like this:

- **OT** is the assets a business uses to create goods or services for sale.
- **IT** is the systems used to manage the production, sale and support of those goods and services.



So both OT and IT function within the enterprise to create output (goods and services).

To create output most efficiently, they need to work together.

But in today's enterprise, there's a significant communication gap between OT and IT technologies. Each uses its own methods of connectivity, from the physical connectors and buses that data rides on, to the language each uses to convert bits and bytes into human readable and actionable information. Designed years ago, OT and IT technologies remain far apart today.

During a recent keynote address at Smart Industry 2015, Richard Soley, executive director of the Industrial Internet Consortium, pointed out that ladder diagrams for PLCs used in discrete manufacturing in 1980 are very much like the ones used today. "Thirty-five years later we still program these things with ladder, and worse, though it's got an Internet port on it now, it doesn't connect to the IT infrastructure of the plant."

Why not?

Connectivity

For decades, industrial products have been designed for long life. As a result of this long lifecycle, industrial devices installed today use varied physical communication layers, mostly proprietary to their industry.

For example, you may have a variable frequency drive on a serial network, a proportional valve on Fieldbus, and a proximity sensor on DeviceNet, each a different physical network.

One of the first steps in connecting legacy industrial systems to the IoT is to provide some type of conversion from these application-specific physical buses to open, ubiquitous physical interfaces such as Ethernet and wireless.

We'll also need to aggregate smaller, simpler devices like non-networkable sensors or electric circuits into a networked gateway device, in order to transmit the sensor-level signals onto standard network interfaces and then into the primary Internet communications protocol: TCP/IP.

Communications and languages

As a result of the purpose-built, application-specific nature of manufacturing and automation systems, the vast majority of devices found on the plant floor today use their own custom and often proprietary protocols to meet application requirements.

While a custom protocol can be useful in a single given application, for example closed-loop process control, it creates yet another hurdle in accessing the data required to realize the benefits IoT offers.

In contrast to OT, IT enterprise networks use the same open standards and protocols found on the Internet. The Internet was founded on open communication standards like TCP/IP. Application-specific protocols are layered on top: HTTP/S, SMTP, SNMP, MQTT, and so on.

The Internet uses programming languages like JavaScript, Java, and Python and presents information using technologies like HTML5 and CSS, all of which are open. (For a brief description of these technologies, see "Terms used in this primer" on page 10.)

To realize the promise of the Internet of Things, OT and IT technologies must converge, allowing connection and communication.

Perhaps in the short run, OT and IT can converge using solutions such as protocol gateways, OPC servers, and middleware. However, in the long run, OT/IT convergence

> **Though it's got an Internet port on it now, it doesn't connect to the IT infrastructure of the plant.**
>
> **- Richard Soley, Industrial Internet Consortium**

will demand a flattened architecture and seamless communication between assets, using open, standards-based communication protocols and programming languages.

IOT AT THE EDGE

According to a recent press release by research firm Gartner on Gartner.com, 6.4 billion connected "things" will be in use in 2016, up 30 percent from 2015. And all of these devices are going to generate data. Zettabytes of data.

But is it useful data? And are modern networking technologies up to the task of moving that much data across the Internet?

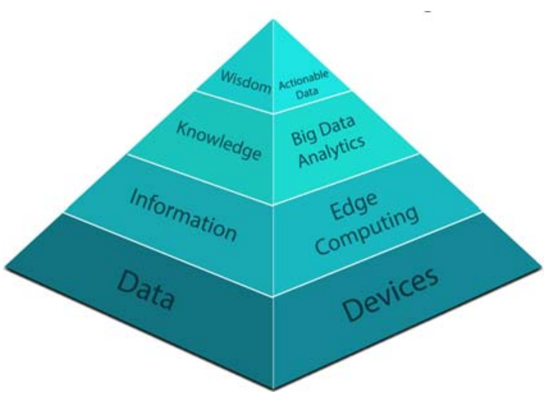
The Data-Information-Knowledge-Wisdom pyramid (below) shows us the journey from raw data to wisdom. On the Internet of Things, actionable data is wisdom: what to do, when and how to do it; how to improve business processes, reduce cost, increase profit.

The IoT is going to produce massive amounts of raw data from billions of sensors, actuators, and devices. How do we sort through the data to filter out what we need and turn it into wisdom—into actionable data?

The answer is **edge computing**.

The majority of IoT devices will be connected at the edge of the network, the place where OT and IT physically converge. The data that OT devices generate must be mined for what is useful to the enterprise and forwarded to cloud computing systems for big-data analysis, and useless data must be discarded to reduce bandwidth and noise.

Information Overload in the Information Age



In the long run, OT/IT convergence will demand a flattened architecture and seamless communication between assets, using open, standards-based communication protocols and programming languages.

Unfortunately, most of today's OT assets like individual sensors and machines don't have the computing power required to process and filter the data they generate. At best they are passthrough devices, data in and data out, with no intelligence.

More intelligent OT assets like PLCs tend to focus on single-task automation functions and have not been designed to share that manufacturing data with other systems. So the current Internet of Things requires third-party systems that act as data brokers between OT and IT assets.

These third-party brokers understand both OT and IT languages and protocols, but they often require a great deal of programming and application development support.

The real vision of OT/IT convergence is for autonomous and direct communication—for assets, things, nodes, and servers to communicate directly with each other without the need for protocol gateways, OPC servers, and middleware.

To enable direct asset-to-asset or thing-to-thing communication and truly bridge the OT/IT gap, manufacturers will push intelligence down directly into OT assets and enable those assets with IT communication capabilities, protocols, and languages.

We already see increasing capabilities as OT assets are beginning to be developed from the ground up with IoT applications in mind. Over time, we'll see not only communication technologies but also increasing intelligence, allowing assets on the edge to interpret and filter their own data into information, and then expose it via standard formats documented as web APIs.

Indeed, to fully realize the benefits IoT has to offer, OT assets will need to be designed with web technologies built directly into them, such as HTTP for interaction, SSL/TLS encryption and authentication for data security, and JSON for data format. This approach is available today and is called RESTful architecture.

GETTING STARTED WITH THE IOT TODAY

If you're excited about the possibilities the IoT offers for your application—or if you just want to be prepared for the future—here are some ideas to get started now.

Start small

The Internet of Things is a big concept with lots of moving parts. Developing a strategy to begin implementing IoT in your business doesn't have to be complicated. Start small and experiment.

The IoT is a concept, an idea, not a hard-and-fast set of rules. It's a method of looking at disparate systems and asking ourselves, what if those two machines could talk to each other? What could we learn if we could quickly pull any data we wanted and look for correlations between datasets? Over time, getting different devices to communicate with each other will become easier and easier.

Educate

A good place to start is to learn about new technologies that are involved with the IoT. If you're coming from the process control and industrial automation side of the OT/IT convergence, it's a good idea to bone up on your basic networking skills.

- Learn how Ethernet switches and routers move data across the internet.
- Know what an IP address is and understand the potential need for IPv6.
- Get an overview of various web technologies and programming languages.

You certainly don't have to be a networking expert. But a general familiarity with these technologies will only make your life easier as the OT/IT convergence picks up momentum.

Be aware that important new skills will be required in your organization. Networking is one of those; other key skills are in programming languages and architectures (such as RESTful), and definitely in network security.

Redesigning OT assets

To connect OT with IT, we must design OT assets to use technologies such as application program interfaces (APIs). An API is a set of routines, protocols, and tools for building software applications; it specifies how software components should interact.

To have OT assets communicate autonomously and directly with each other, they'll need to use Internet protocols like these:

MQTT—to collect device data and communicate it to servers

XMPP—to enable the near-real-time exchange of structured yet extensible data between two or more devices on the network

DDS—a fast bus for integrating intelligent machines

AMQP—a queueing system designed to connect servers to each other

YOUR FIRST IOT PROJECT

Identifying the need

Each IoT application is different, depending on your business. And unfortunately there is no one-size-fits-all solution for developing your IoT project. However, one of the objectives of the IoT is to increase efficiencies, and that's a good place to start.

Here's a general 3-step strategy you can apply for developing your first IoT project.

1. Identify potential. Walk around your facility, talk to your operators, and identify laborious manual processes such as pen-and-paper data collection and Excel spreadsheet data entry tasks.

Also identify potentially useful data that is currently siloed and unavailable to other systems and business decision makers. Good examples might be environmental data, production data, or data related to your batch process.

2. Collect data. Look for opportunities to collect this data at an asset or "thing" level. For example, is there a sensor you could install to more closely monitor and log your process? The cost of sensors has come down substantially, allowing increased visibility in all aspects of automation.

Instrumenting equipment is the first step to getting enhanced levels of information from the plant, remotely monitoring assets, and analyzing production and reliability.

3. Centralize and analyze. Identify a way to aggregate the data into a central repository. This may require some type of IoT gateway or protocol converter and a database to house the information.

Once you've centralized the data, you can analyze opportunities to optimize processes. For example, develop a report to cross-analyze your newly found sensor data with production output. Do certain variables in the process relate to a higher or lower yield?

Justifying the investment

As the IoT becomes clearer, it's easy to be overwhelmed by the potential costs and complexity associated with IoT applications. It's important to remain focused on whether a project will benefit the enterprise by reducing cost or improving quality. You should be able to clearly demonstrate a measurable return on investment.

For example, perhaps you could connect a power monitoring device to your plant's main power feed and start monitoring power usage. Once you've started collecting power monitoring data, over time you'll be able to determine exactly what it costs in real time to turn on a motor, run a process, or have the building air conditioning set to 78 degrees.

Or perhaps you want a daily report emailed to you showing production count, raw material inventory, and average production time. All of this data can be captured through IoT technology and brought right to your mobile device.

Another easy project to implement could help you save water. If you're in charge of the irrigation system at your facility, you could set up a simple intelligent system that checks the weather forecast on a website before turning on the sprinklers. The cost savings in reduced water usage (not to mention the impact on the environment in a dry area) are a great way to justify the cost of your first IoT project.

Again, it doesn't have to be complicated. And technologies to accomplish all of these applications are available today, off the shelf.

It's like magic, but it isn't. It's the Internet of Things.

It's going to change everything, and we're all going to be a part of it.

ADDITIONAL RESOURCES

Want to learn more about the Internet of Things? Here are some interesting reads.

The IoT: ITBusiness: The Internet of Things is Already Transforming Industries

The IoT: Harvard Business Review: How Smart Connected Products are Transforming Companies

IoT security: ICS-CERT: Recommended Practices

Network security: Opto 22 Network security blog series

The TCP/IP model: What it is and why you should care

RESTful architecture: What RESTful Actually Means

Edge computing: Government Technology: Is Edge Computing Key to the Internet of Things?

Networking basics: Guide to Networking *groov*

HOW CAN OPTO 22 HELP YOU?

At Opto 22, our goal is to compress the time, complexity, and space between OT and IT.

For over 40 years, we've brought commercial, off-the-shelf technologies to industrial systems all over the world. We pioneered the use of PCs in controls back in the 1980s, Ethernet networking at the I/O level in the 1990s, and machine-to-machine connectivity in the 2000s. Today, we bring systems information to your mobile device.

Opto 22's engineering focus is on building hardware and software tools you need to bring the benefits of the IoT to your legacy systems—simply, reliably, and securely.

At the lowest level, our SNAP Ethernet I/O system offers an easy and cost-effective way to bridge the real world with the digital world, through a comprehensive collection of input and output modules designed to connect with virtually any electrical, electronic, mechanical, or environmental device. This I/O system converts these raw signals to useful digital data and shares it over the standard networks and protocols understood by IT.

Where edge computing, decision making, autonomous control, data collection, and logic solving need to occur, consider programmable automation controllers such as our SNAP PACs. Complete with a built-in HTTP/HTTPS server and RESTful API, easy-to-use flowchart-based programming, significant processing power, and a large library of protocol and communications capabilities, PACs can help you get your IoT project up and running quickly and affordably.

When it comes time to visualize, notify, and mobilize your information, our *groov* platform offers a simple, effective way to build operator interfaces that can be viewed on any screen, from your smartphone to big-screen HDTV. *groov* logs events and notifies you when events occur in your plant, in your remote assets, or within your building.

All Opto 22 products are backed by decades of expertise in applications like process control, discrete manufacturing, remote telemetry, data acquisition, and supervisory control. All our products are supported by Opto 22 engineers at no charge and available worldwide.

ABOUT OPTO 22

Opto 22 was started in 1974 by a co-inventor of the solid-state relay (SSR), who discovered a way to make SSRs more reliable.

Opto 22 has consistently built products on open standards rather than on proprietary technologies. The company developed the red-white-yellow-black color-coding system for input/output (I/O) modules and the open Optomux® protocol, and pioneered Ethernet-based I/O.

In early 2013 Opto 22 introduced *groov,* an easy-to-use IoT tool for developing and viewing mobile operator interfaces—mobile apps to securely monitor and control virtually any automation system or equipment.

In addition to SSRs and *groov,* Opto 22 is best known for its high-quality I/O and SNAP PAC programmable automation controllers, which include a RESTful API.

All Opto 22 products are manufactured and supported in the U.S.A.

Because the company builds and tests its own products, most solid-state SSRs and I/O modules are guaranteed for life.

The company is especially trusted for its continuing policy of providing free product support, free training, and free pre-sales engineering assistance.

For more information, visit opto22.com and groov.com or contact **Opto 22 Pre-Sales Engineering**:

Phone: **800-321-6786** (toll-free in the U.S. and Canada) or **951-695-3000**

Email: systemseng@opto22.com

TERMS USED IN THIS PRIMER

Terms are listed from the bottom (physical layer) up.

Ethernet—A local-area networking (LAN) technology used to digitally connect computing devices. Typically deployed over Category 5 or 6 twisted-pair copper cables with RJ45 connectors at each end, and composed of transceivers to control the passing of bits over the wire while avoiding data collisions. See IEEE 802.3, CSMA/CD.

Wireless—Commonly referred to as Wi-Fi, used in applications as a wireless alternative to a copper-based network such as Ethernet. Wireless uses ultra-high-frequency radio waves to communicate and transmit data. See IEEE 802.11.

TCP/IP (Transmission Control Protocol/Internet Protocol)—The most widely used communication protocol of the Internet and local area networks (LANs); broadly responsible for establishing and maintaining connections, formulating data packets to send, and reordering packets on receipt. Noted for its ability to be routed through many different networks.

IP Address—An Internet Protocol address, which is a numerical identifier for a networked device on a TCP/IP network. Typically made up of four 3-digit numbers separated by decimal points (IPv4), with a newer version made up of six 3-digit, decimal-separated numbers (IPv6).

HTTP and HTTPS (Hypertext Transfer Protocol & HTTP Secure)—An application protocol used for distributed, hypermedia information systems, and the foundation of data communications on the World Wide Web. HTTP is a text-based protocol, is based on a command/response model, and is easily identified by the preface "http://" in communications, such as in the address bar of your web browser. HTTPS is HTTP communications on a connection encrypted by transport layer security to prevent eavesdropping of transmitted data.

MQTT (Message Queuing Telemetry Transport)—A lightweight, simple messaging protocol originally designed for low-bandwidth, high-latency communication over TCP/IP connections. Based on a publish/subscribe model rather than a command/response model like HTTP. MQTT requires a broker to facilitate publishing and subscribing to data topics, whereas HTTP is client/server.

SSL/TLS (Secure Socket Layer/Transport Layer Security)—Protocols to encrypt data transmissions over networks, the latter by exchanging symmetric keys to perform authentication.

JavaScript—An object-oriented, cross-platform scripting language that's generally easier to use and faster to code than structured or compiled languages like C and C++. JavaScript code can be embedded into HTML pages, and most web browsers provide JavaScript engines to run the code.

node.js—An open-source, cross-platform runtime environment that executes JavaScript applications on web servers. Allows programs written in JavaScript to be run across many different platforms including Windows, OS X, Linux, and Unix.

HTML (Hypertext Markup Language)—A web language used by web servers and web browsers to present information to users. HTML pages are served to web browsers (clients) from a web server. HTML code served on an HTML page tells a web browser how and where to display text and other resources on a web page.

CSS (Cascading Style Sheets)—A file used to tell a web browser how to format a web page. A link to the file is embedded in the web page, and the browser uses the information in this file to format attributes of the web page such as fonts, colors, border positioning, and so on.

API (Application Programming Interface)—A set of protocols, routines, and tools that web-based applications can use to communicate with other web-based applications. For example, when a Google map is embedded on a web page, that web page is using the Google Maps API to pull the data from Google Maps and display it on the web page.

JSON (JavaScript Object Notation)—The primary data format used for asynchronous communication between web browsers and web servers. JSON was primarily developed to replace browser plugins such as Flash and Java applets. JSON is a request/response method web browsers can use to ask for information from web servers.

REST (Representational State Transfer)—A set of architectural constraints used to develop web applications. Designed as a common development standard for applications used on the Internet, REST confines developers to a specific set of rules to follow.

RESTful Architecture—When a website or API is conforming to the constraints of the REST architecture, it is said to be a RESTful system.

MADE IN THE USA
OPTO 22 www.opto22.com
43044 Business Park Dr. Temecula, CA 92590-3614
SALES sales@opto22.com
800-321-6786 • 1-951-695-3000
SUPPORT support@opto22.com
800-835-6786 • 1-951-695-3080

© 2016–2017 Opto 22. All rights reserved. Dimensions and specifications are subject to change. Brand or product names used herein are trademarks or registered trademarks of their respective companies or organizations.