Automation World® TACTICAL BRIEF

IIoT Ecosystem

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Research Advances on The Internet of Things

The Industrial Internet Consortium launches an asset efficiency testbed and Georgia Tech announces the founding members of its Center for the Development and Application of Internet of Things Technologies.

By David Greenfield , Director of Content/Editor-in-Chief, Automation World

It's not just manufacturers' interest in the Industrial Internet of Things (IIoT) that continues to drive the concept further—it's the high levels of ongoing research being conducted by industry and academia.

Recently I wrote about the predictive maintenance testbed being conducted by National Instruments and IBM with the Industrial Internet Consortium (IIC) to prove how IIoT-related technologies and concepts are a critical and practical part of an effective predictive maintenance strategy.

Now the IIC has announced the start of its Asset Efficiency Testbed, which is designed to collect real-time asset information and run analytics to make the right decisions in terms of operations, maintenance, overhaul and asset replacement. IIC reports that Infosys, a member of the IIC, is leading this project with contribution from IIC members Bosch, Intel and PTC.

The Asset Efficiency Testbed will launch in two phases, according to the IIC. In the first phase, the testbed will be created for a moving solution, in this case, aircraft landing gear, and will focus on the integration of technologies. In the second phase, the testbed will address fixed assets, like chillers, with the goals of finalizing the architecture and opening up the interfaces.

The IIC says the Asset Efficiency Testbed will "monitor, control and optimize the assets holistically … to help determine optimal maintenance scheduling, reduce downtime, improve asset productivity, reduce capital and operational expenditures, and use energy efficiently."

In other IIoT-related news, the founding members of the recently established Center for the Development and Application of Internet-of-Things Technologies (CDAIT) at the Georgia Institute of Technology were announced. The founding members are AirWatch, AT&T and Samsung Electronics.

Housed at the Georgia Institute of Technology in the Georgia Tech Research Institute, the Center for the Development and Application of Internet-of-Things Technologies (CDAIT) is a global, non-profit, partner-funded center that fosters interdisciplinary research and education while driving general awareness about the Internet of Things. It aims at efficiently identifying, understanding and solving for its sponsors challenges and problems that may arise along the IoT value chain. CDAIT bridges sponsors with Georgia Tech faculty and researchers as well as industry members with similar interests.

"Our center will greatly benefit from having a continuous and close dialogue with premier technological companies of the caliber of AirWatch, AT&T and Samsung Electronics," said Alain Louchez, CDAIT managing director. "With their help, we are looking forward to making significant contributions to the IoT industry."

From Smart Manufacturing to Manufacturing Smart

Why manufacturing is a core enabler of the Internet of Things.

By Alain Louchez and Dr. Ben Wang , Georgia Institute of Technology

Recent initiatives at the national level, whether in the United States (e.g., the announcement of the Advanced Manufacturing Partnership Steering Committee 2.0 in September 2013 by President Obama following the initial launch in 2011) or abroad (see the recent development of the Industry 4.0 project in Germany), underscore the direct impact of intelligent manufacturing on economic growth and competitiveness.

It has been recently suggested [by Michael Mandel in a Progressive Policy Institute memo] that a "network of sensors in a factory, for example, hooked to powerful data analysis capacity, could greatly improve the productivity and flexibility of production, and perhaps lead to a rebirth of manufacturing in the U.S." Meanwhile, at the M2M Summit in Düsseldorf, a presentation from the Association of Telecommunications and Value-Added Service Providers (VATM) of Germany claimed that "no doubt about it: Industry 4.0 is needed to keep Germany competitive." The German Federal Ministry of Education and Research adds on its website that Industry 4.0's goal "is to develop completely new business models and tap the considerable potential for optimization in the areas of production and logistics."

In a seminal Time magazine message, Dr. Sujeet Chand of Rockwell Automation and Dr. Jim Davis of UCLA in July 2010 clearly stated that "smart manufacturing marries information, technology and human ingenuity to bring about a rapid revolution in the development and application of manufacturing intelligence to every aspect of business. It will fundamentally change how products are invented, manufactured, shipped and sold. It will improve worker safety and protect the environment by making zero emissions, zero-incident manufacturing possible."

A few years later, this same emphasis on operational efficiencies is still very much front and center in the manufacturing discussion. Bernd Leukert, head of Application Innovation and a member of the Global Managing Board of SAP AG, commenting on Industry 4.0 in a December 2013 interview (Industry 4.0 Is Not An Optional Exercise) points out that "the use of smart devices will drive a new wave of digitalization, awareness and automation that will re-invent the manufacturing industry; it will fundamentally change how products are ordered, built, and consumed thereby creating a new kind of normal."

Smart Manufacturing

The technologies used for the implementation of "smart manufacturing" or "smart production" span a wide spectrum of domains. They are often referred to as Internet of Things (IoT) technologies, i.e., the combination of a sensing/actuating device with a communication network (wired or wireless) and a software application to move, read and interpret data.

The causality between IoT and the transformation of manufacturing was underlined in a recent roundtable between executives at Robert Bosch and McKinsey experts on the Internet of Things and the Future

of Manufacturing. According to McKinsey Partner Dr. Markus Löffler, "the Internet of Things has already set in motion the idea of a fourth industrial revolution—a new wave of technological changes that will decentralize production control and trigger a paradigm shift in manufacturing."

Thomas Friedman in a September 2013 article for The New York Times ("When Complexity Is Free") describes how Smart Manufacturing (without using the expression) and the Internet of Things (he uses the expression along with "Industrial Internet", GE's moniker for it) are transforming GE. Shorter feedback loops, collaboration and crowdsourcing, and pervasiveness of sensors are stretching the confines of manufacturing.

What is particularly striking in Friedman's paper is the involvement of scientists, engineers and marketing experts in manufacturing; it is a collaborative undertaking that is no longer left to technicians alone. It is about the optimization of the whole value chain along which costs are cut and revenues generated. "With all this data," Friedman explains, "GE is developing new service businesses that offer not just to man-

age an airline's or railroad's engines, but how fast all its planes or trains go, how flight and train schedules are coordinated and even how its equipment is parked to get optimal performance and energy efficiency."

Imrovements in advanced sensing and actuating; automation; coordination of systems of systems; end-to-end supply chain performance; and process integration aim at making the production of goods adaptable, agile, customer-driven, collaborative, resource-efficient, responsive and safe. This is quite a challenging order that is both deep and wide, which might meet with some resistance here and there. Nevertheless, the objectives and directions are clear.

The stakes are high, Dr. Jochen Köckler, Member of the Managing Board at Deutsche Messe — the organizers behind Hannover Messe 2014 — cannot be more explicit: "flexibility and efficiency – these are the keys to continued survival in a highly competitive international market. Therefore, the task now is to take the next steps – and, more important, the right steps – to ensure that industry realizes its vision of smart, flexible factories."

Accelerate Deployments While Reducing Risks

The Panduit **Integrated Network Zone System** enables network communications between the control room and manufacturing floor within an industrial facility. Integrated with an Allen-Bradley Stratix switch, the pre-engineered, tested and validated system reduces deployment time up to 75%.

Do you need an assessment?

Manufacturing Smart

However, while IoT technologies are growingly and significantly overhauling the boundaries of manufacturing, the influence of manufacturing on IoT is no less impactful.

It is important to recall that IoT is (and nothing more than) a metaphor that captures a dramatic societal metamorphosis. IoT is about the integration of everyday objects in the communications space on par with humans. According to this vision, all the things, however big or small, that surround or are part of us would have the potential to be reached and, possibly, activated and interfaced with remotely. This is a result of converging trends such as but not limited to the arrival of IPv6 (Internet Protocol version 6) in June 2012. IPv6 can accommodate 340 trillion trillion trillion (undecillion) IP addresses (that's a lot of them!)

This has led around the world to an ebullient exuberance regarding the size and attractiveness of the market. Innovators and inventors have rapidly come up with creative solutions in all aspects of the economic fabric. Some of them have been widely highlighted for their ingenuity and novelty such as thermostats, pill bottles, car parking applications, hand-washing stations, scales, dog collars and all kinds of wearable solutions to name a few.

As this new frontier is being conquered with the type of unbridled enthusiasm that was probably inherent to the intrepid pioneers of the American West, we are still in the burgeoning phase of a long cycle. In August 2013, Gartner released its Hype Cycle for Emerg-

ing Technologies for the year. It showed IoT with over ten years to go before "mainstream adoption starts to take off", which Gartner describes as the "plateau of productivity".

It stands to reason that for something to be adopted, it needs to be there in the first place. This cannot happen without advanced manufacturing providing the building blocks of the future IoT-centered society, i.e., "smart" capabilities. Any and every object will need to have embedded in them "potential for intelligence."

As discussed above when describing "smart manufacturing", some companies, GE being one of them, are already inserting remote sensing as an integral component of the product to offer a host of services that enhance their value proposition to their customers.

Likewise for electric utilities, advanced manufacturing brings to life a new generation of power electronics, adding value to both suppliers and consumers of electricity through enabling seamless two-way data and electrical flows.

But "manufacturing smart" will in all likelihood go beyond proprietary ecosystems.

What we are suggesting here is that we expect market (in addition to regulatory) forces will be pushing for incorporating IoT capabilities that can be universally exploited beyond the initial intended use.

In much the same way as new houses come equipped with electric outlets (and still perhaps with phone jacks and cable TV outlets); cars with on-board diagnostics (OBD) reporting capabilities (in addition to,

in some countries, a mandated emergency-calling device); television sets and computers with all kinds of connectors and ports, all products, including the most mundane ones, will probably include tags, sensors and/or actuators that could be activated, very likely through third parties, to enhance the so-called consumer experience.

An interesting project at ETH Zurich, which aims at exploring potential uses of smart meter data in order to offer new services to end users while taking into account privacy constraints, is a current example that illustrates how innovation can be induced from IoT functionalities already in place.

Should this vision (i.e., a push for embedding IoT capabilities) bear out, manufacturing will be redefined as it broadens its scope to not only include optimized processes and systems, at the heart of "smart manufacturing", but also sensing and actuating capabilities, central to the emerging IoT-shaped society.

Printed, organic and flexible electronics might be one of the catalysts needed to adjust manufacturing processes to IoT. Commenting on a new report from IDTechEx on "Printed, Organic & Flexible Electronics: Forecasts, Players & Opportunities 2013-2023", Faye Rivkin of Industry Market Trends (IMT, October 8, 2013) notes that "printed electronics will allow manufacturers to replace some components with cheaper, higher performing alternatives or even completely replace a conventionally-manufactured device," observing that, as a result of several technological advances, the "components, includ-

ing transistors, antennas, circuits, connecting components, displays, sensors and batteries, are lighter and have more functionality than conventionally-manufactured electronics."

We need, however, to remain cautiously optimistic. When it comes to the Internet of Things, printed electronics certainly has attractive selling points but also still some limitations (see Dr. G. Venkatesh's article in the July-September 2013 issue of the Journal of the Indian Institute of Science on "Semiconductor Solutions for the Internet of Things: The Role of Event Detection, Asynchronous Design, Energy Harvesting and Flexible Electronics"). And yet the fact remains that costs are declining and performance is improving. What if, in a not too distant future, printed electronics devices could become a cost-effective proposition for IoT deployment and take over all the functionalities of active RFID or those found today in Real Time Locating Systems (RTLS) and machine-to-machine (M2M) modules? The possibilities are intriguing and certainly worth exploring.

In parallel to printed electronics and to a much broader degree, the" disruptive transformation of electronics design and manufacturing" that could be brought about by what IBM calls the "new software-defined supply chain", which rests on 3D printing (a.k.a. additive manufacturing), intelligent robotics and open source electronics, could alter significantly the speed of the integration and the magnitude of the IoT capabilities embedded into products (see Executive Report from IBM Global Services, July 2013). According to Partha Bose, IBM's Leader of

Global Electronics Practice, "the defining feature of this new era will be a shift from a "hard-wired" manufacturing model to one defined and controlled by software."

As Paul Brody, IBM's Global Business Services Vice President and Global Electronics Industry Lead, during his presentation on IBM's "brand new analysis" on software-defined supply chain at the St. Petersburg International Economic Forum, ominously predicted: "it [open source electronics environment] won't just improve the ease of customization development; it's going to start making products truly exceptionally smart. When you can put the equivalent of an entire PC on a door knob or a toothbrush, it's going to make these products smart. And these products are going to be network-connected!" The words revolution and upheaval come to mind.

The global manufacturing industry, tested by swift and sweeping technological advances, is in the throes of a monumental transformation, which will end up shaking society up and build the foundation of an internet where most things can be identified, interconnected and activated, i.e., the IoT.

Regardless of how it happens, manufacturers have a vested interest in inserting IoT capabilities inside their finished products. Third parties will be able to provide new value added services, very importantly, throughout time, thereby magnifying the value of the original product, if the manufacturers cannot to do so, e.g., for lack of resources or simply being out of the market.

Along the way, new challenges (e.g., in the areas of standardization, security, privacy, education, training, regulation, law and policy) will appear more or less rapidly on the horizon, standing in the way of this vision's implementation. But it is a safe bet that they will be overcome, albeit perhaps at a slow pace (see Gartner's hype cycle for emerging technologies). The terrain surveyed in this article nevertheless leads to very appealing mileposts, i.e., simplification, efficacy, efficiency, and, at the end, profitability. As a result, progressive manufacturing companies should be in the process of putting in place an efficient ecosystem that allow them to smartly manufacture smart things!

Pre-Configured Industrial Distribution Frame (IDF)

The **Pre-Configured IDF** is specifically engineered to deploy and protect rack mount Ethernet switches in industrial applications. Extra-depth allows room for cable management, power management, and switch stack cables and accommodates up to 5 switches. The innovative design provides consistent equipment deployment with faster installation and can significantly lower the risk of downtime due to switch overheating.

Do you need an assessment?

Network of the Future

Though there's no way to tell exactly what the network of the future will look like under the effects of the Internet of Things, there are three universal network aspects worth focusing on to prepare yourself—and your network—for the future.

By Michael Bowne , Director of technology marketing, PI North America

What will automation networks look like in the next five to 10 years? Wherever the Internet of Things (IoT) trend leads us, the underpinnings of future industrial networks that are universally beneficial to adopters will focus on simplification, uptime and innovation.

Simplification

Using open standards in an automation network allows for manufacturers of all sizes to realize the same benefits as proprietary network solutions. Taking this a step further, what if the network were truly plug-and-play? What features would be required to enable such a network? Here are two in particular: effortless configuration and commercial off-the-shelf (COTS) hardware.

When using industrial Ethernet, effortless configuration can better be described as "allowing IT support without needing it." For example, today a machinery maker delivers a machine with an automation solution and network configuration. The plant operator (end user) integrates the machine into his plant. This requires changes to the plant's network configuration so that it conforms to his local IT requirements.

In the network of the future, the machinery maker will use a temporary network configuration to qualify the machine before sending it to the end user. The end user will be able to simply connect it, and the communication relationships are dynamically established at

runtime. So there's still work to be done separating the automation solution and network configuration. Within Profinet, however, we've already taken the step of using name-based addressing. This makes it easier for the end user to get up and running, and a big step in the right direction toward true plug-and-play.

Another way to accomplish truly plug-and-play connectivity is through COTS hardware. This is not to suggest hardware from your local electronics store should be used, only that it could be. Why? Because though an inexpensive switch made for your home or office would work just fine, it might last only 5 minutes in a production plant. Industrialized products, with the same COTS technology built in, can withstand the moisture, vibration, dust and overall harsh environment.

What exactly is that COTS technology in the network of the future? For example, already within Profinet we have technology in place to ensure the real-time transmission of production data, while coexisting on the same wire as IT data (e.g. TCP/IP, more on that later). That technology might become more mainstream with what's known as Time Sensitive Networking (TSN).

For production data, the Profinet protocol is still required at the application layer. Its transmission, however, along with any other traffic, could be handled by TSN. TSN, as of this writing, is still very new, but has the potential to ensure real-time transmission of data like Profi-

net does today. If it becomes COTS technology, then this greatly clarifies the path between IT and operation technology (OT) by extending their common physical layer (Ethernet) upon which protocols like Profinet and others reside.

Uptime

What good is a manufacturing environment if it isn't up and running? In the network of the future, 0 percent downtime will be taken for granted. How do we maximize productivity by ensuring network uptime? Again, two features stand out as solutions to these issues, and are fortunately already available today: scalable redundancy and scalable security.

The most basic way to ensure uptime is at the physical level: by using a ring-shaped network. This topology creates two connections for every device. However, don't try this at home! Doing so would cause Ethernet packets to go around in circles, eating up bandwidth and causing major headaches. Technologies like Media Redundancy Protocol (MRP) account for this by managing traffic, and in the event of a broken connection in the ring, convert the ring to a line topology.

Such recovery can take tens or a hundred milliseconds. Going further, in Profinet "bumpless redundancy," the failover time is 0 ms. In bumpless redundancy, a sender uses two frames, going in opposite directions around the ring. So, even with a failure, a frame will still arrive at the receiver. To ensure 100 percent uptime, redundant devices and even redundant controllers can be installed, thus expanding upon simple network redundancy.

The single biggest perceived challenge to a converged network is security. In business systems, security objectives are typically ranked in terms of priority as follows:

1. Confidentiality
2. Integrity
3. Availability

In many automation systems, the ranking of security objectives in terms of priority is completely opposite:

1. Availability
2. Integrity
3. Confidentiality

To achieve scalable security, IT and OT need to agree on a security architecture that should be:

• As simple as possible but not simpler (Albert Einstein).
• As uniform as possible—if a rule is applicable in one case, it must also be followed in comparable cases.
• Understood and supported by all parties involved.
• A daily activity and not a one-time-only task.

If these can be reached, the network of the future can be a reality by allowing automation and business systems each to maintain their security objectives.

Continued
Network of the Future

Innovation

In the network of the future, OT and IT need to share the same foundation (Ethernet) while exposing their data for vertical integration. The beauty of Ethernet is it allows enterprises to use the right protocols for the right task.

There will always be different protocols used for different tasks. As network architectures continue to evolve, these protocols will begin to share the same infrastructure. That common infrastructure is standard unmodified Ethernet. So long as an automation protocol uses standard unmodified Ethernet, the benefits "come for free" as Ethernet matures.

For example, the IEEE has continually updated the 802.3 Ethernet specifications to increase the bandwidth from 10 Mbps to 100 Mbps to 1 Gbps and beyond. Profinet is one such protocol that uses standard unmodified Ethernet. As higher-bandwidth Ethernet is installed to accommodate multiple protocols, this speed increase happens automatically.

It is not just the infrastructure that needs sharing to further innovation in the network of the future; it's also the platforms. If Ethernet is the "how," then protocols for the data are the "what." Profinet handles the controlling and gathering of data from devices within production systems. Via proxies, it also gathers data from non-Ethernet devices. Meanwhile, standards like OPC UA enable the communication between, within and from production systems. When used in tandem, they complete the clear path from shop floor to top floor and into the cloud where analytics can be applied.

IntraVUE

Automation networks are susceptible to interruptions which often result in downtime, and lost production. While conventional tools are frequently unable to detect many types of network interruptions, IntraVUE provides the capability to identify and report information critical to improving uptime of the Industrial Ethernet infrastructure.

Do you need an assessment?

Top 3 Reasons You Need Industrial Network Training

By Dan McGrath, Sr. Business Development Manager Panduit

At the Rockwell Automation TechED and Cisco Live back-to-back conferences in early June in San Diego, there were some exciting announcements for automation and manufacturing IT professionals as well as new people entering the field. Suddenly, industrial automation networking is the hot new learning opportunity and here are three reasons why: At the Rockwell Automation TechED and Cisco Live back-to-back conferences in early June in San Diego, there were some announcements that can help bring those dreams to life with some exciting new options for automation and manufacturing IT professionals as well as new people entering the field. Suddenly, industrial automation networking is the hot new learning opportunity and here are three reasons why:

1. Thousands of new jobs being created in every industry

Internet of Things, anyone? Industries are reinventing their business with Internet Protocol. In many industries, existing talent needs to be reskilled to fill gaps associated with the huge increase in connected devices – both industrial and non-industrial – that are making up the Internet of Things. Cisco estimates 2 million jobs by 2022 with 220,000 new engineers needed every year until 2022. Industrial networking skills are required for engineers and technicians across many industries and jobs with system integrators, machine builders, and in plants and factories.

2. Training and Certification paths for industrial networking are finally here

Cisco certifications are highly regarded by employers and employees alike as they have proven value in identifying, recruiting and retaining talent. As transitions to IP have transformed data centers, enterprises, voice, video, etc., the role of certifications in career building are more than justified. IP networks have reached the tipping point for industrial application, and the launch of new Industrial Networking Specialist and CCNA Industrial exams and specialized instructor-led courses from Rockwell Automation are a true training hit with sell outs in first couple months of launch.

3. E-learning breaks down barriers

Too cool for school? Not all can make time to attend week-long training classes right away. Now you can get more easily get context on industrial network design vocabulary, scope, and subject matter before tackling the instructor-led certification courses on configuration and troubleshooting. Industrial IP Advantage has just released the first track of its new web-based training. Trainees can go through the interactive, 20-minute modules on their own time and tackle subjects such as the physical layer (copper, fiber), network topolo-

Continued
Top 3 Reasons You Need Industrial Network Training

gies, security concepts, and practical design guidance from Converged Plantwide Ethernet architectures. Most engineers or technicians as well as manufacturing IT professionals will find benefit from a better understanding of industrial network design basics, and e-learning makes it more accessible and cost effective than ever.

Don't let summer slip by without dreaming. Your career might depend on it.

Learn more and sign up for the Industrial IP Advantage e-learning course here.

The Internet of Things and the Importance of Modeling and Simulation

A look at why modeling and simulation capabilities are becoming an indispensable element of the Internet of Things toolbox.

By Dr. Margaret L. Loper and Alain Louchez , Georgia Institute of Technology

Among the plethora of projections concerning the Internet of Things (IoT), the pervasive thread in all of them is the sheer size of the expected associated market a few years hence. While the path to get there is still marred with uncertainty and uneasiness on how the whole process is going to unfold, there is common agreement that in a world where almost anything and everything is becoming potentially connectable the number of communications links and smart endpoints (sensors, actuators, etc.) as well as the induced complexity will be of a significantly different order of magnitude from those currently experienced.

But there are other considerations.

Multifaceted Complexity

By its very nature, IoT is entering a completely new territory (especially in consumer IoT) that is not fully mastered. At the same time IoT technologies aim at integrating (everyday) objects into the communications space, they also bring about a new set of challenges. For example, when it comes to wearables, new antennas and connectors in all kinds of form factor must be designed, with possible non-trivial ergonomic and health implications.

In addition, as it has been widely reported, IoT devices are also vulnerable to cyberattacks, sometimes with devastating consequences including but not limited to privacy breach. This risk needs to be rigorously researched and minimized.

As a result, the way IoT solutions are going to be designed, developed and deployed is bound to go through a radical transformation. Related methods and procedures will have to incorporate sound and thorough analysis, and technological and financial considerations will dictate that IoT innovations be modeled and simulated before going live.

As far as IBM is concerned, modeling and simulation (M&S) is already core to IoT's "here and now": "Modeling and simulation is a vital ingredient in creating the connected products at the heart of the Internet of Things. It can support early evaluation and optimization of designs and ongoing verification as changes occur—to make sure the right product is developed and delivered with the required speed and quality" (IBM website).

The human mind is lazily comfortable with linearity, for instance when "things will change the same way they did in the past". In this type of environment, forecasting is straightforward; modeling is simple and simulation does not provide useful insight.

However, in a universe fraught with "nonlinearities" of the kind shaped by a fast-growing pool of intelligent objects interacting with each other and submitted to a variety of contingent disturbances,

extrapolations are no longer clear-cut. We are all experiencing this type of random output in traffic-related situations: how many times have we done things early "to beat the traffic", well aware that during peak-hours leaving ten minutes later does not necessarily mean arriving at destination ten minutes later? Given the IoT complexity and scale, M&S is no longer a luxury, it is a necessity.

IoT System Engineering Essential Requirement

By many accounts, the Internet of Things is viewed as a "system of systems" or even "systems of systems". Like in any other system engineering endeavor, M&S is a critical foundational building block; it is used early in the lifecycle to determine the efficacy of a proposed product. It is an effective means of defining product requirements, and can be used to test and confirm the viability of meeting requirements, as well as to verify the performance of a product.

M&S is all the more needed since it takes place among the continuous and unstable interaction between enterprises and their environment. Enterprises are complex adaptive socio-technical systems. They consist of many independent agents, whose behavior can be described by social, psychological, and physical rules, rather than dictated by the dynamics of the entire system. The overall enterprise system adapts and learns often resulting in emergent patterns and behaviors. Given that no single agent is in control, complex enterprise system behaviors are often unpredictable and un-controllable.

It follows that creating a model, executing a simulation and performing experimental runs should become prerequisite steps in any IoT-related project or undertaking.

Use cases abound in the IoT ecosystem where M&S sheds useful light on the contemplated project. Healthcare, manufacturing and traffic management are a few examples among many where M&S is growingly playing a key role. M&S is critical to understand their complex issues, and support exploration of a wide range of decision possibilities in these systems.

Healthcare providers are faced with a fundamental transformation of the way they get paid for their services – pay for outcome is replacing fee for service. As financial incentives evolve, providers must concentrate on prevention and wellness to diminish risks of chronic diseases. M&S enables quick and cost-effective exploration of alternative healthcare delivery mechanisms (including use of IoT technologies) and their impact on key economic and health outcomes.

Researchers at the 8th International Conference on Digital Enterprise Technology in Stuttgart, Germany in March 2014, that was focused on disruptive innovation in manufacturing engineering towards the 4th industrial revolution (embodied in the arrival of the Internet of Things) outlined that "the simulation-based technologies constitute a focal point of digital manufacturing solutions, since they allow for the experimentation and validation of different product, process and manufacturing system configurations." M&S is also help-

ful for global manufacturing, which is increasingly characterized by complex supply chains providing components and subsystems that are eventually combined to form final systems products for customers. One type of related risk is the possibility of counterfeit parts, designed either with malicious intent or intent to defraud, which can seriously impact product reliability, safety and lifecycle cost. Comprehensive upfront M&S provides a referential non-defect baseline.

Traffic congestion is a primary issue facing many of today's urban and suburban areas. M&S can provide transportation facility managers with real-time and near-future arterial performance measures. For example, an approach using online data driven, microscopic traffic simulation utilizing point sensor data can provide real-time performance measures. Combining current and forecasted performance information will enable greater efficiency in the use and operation of existing transportation facility capacity.

Modeling and Simulation Are Central to the Return on Investment

While it makes technological sense to walk before running, i.e., to model and simulate before deploying, it must also make financial sense. Akin to insurance, M&S looks expensive before adversity strikes. IoT-focused businesses must understand that embracing M&S in project development and management is good business practice. A systematic process must be established.

It is noteworthy, perhaps as a guiding path for the private sector, that even at the Department of Defense, where M&S is a vital enabler of successful military operations, the need for well-structured, ROI-like metrics is paramount: "successful Department of Defense (DoD) Enterprise modeling and simulation (M&S) investment requires structure, persistence, and common valuation for effective execution." (See: Calculating Return on Investment for U.S. Department of Defense Modeling and Simulation, I. Oswalt et al., April 2011).

Increase Your Network Security

Prevent unauthorized access or accidental breaches by establishing a robust physical network infrastructure that offers barriers to network-wide security risks through the use of an integrated physical and logical architecture that includes Panduit Micro Data Centers

Do you need an assessment?

Next steps

M&S is a broad discipline with a wide range of technologies and methodologies. Academic and business resources in the field typically focus on a specific aspect with a different purpose (e.g., discrete event simulation in industrial systems vs. continuous simulation in electrical and computer engineering). There is a need for an all-encompassing approach, especially in the IoT arena.

M&S education and training might become even more critical as the effects of the IoT revolution, as recently underlined by Henry Kissinger in his latest book ("World Order", Penguin Press, New York, 2014, p.343) "extend to every level of organization /../ and governments, wary of ceding the new field to rivals, are propelled outward into a cyber realm with as yet few guidelines or restraints."

We could very well imagine that a battery of additional M&S-based tests might be required to verify that the injection of IoT devices in cyberspace does not increase the national cyber vulnerability. Currently, Machine-to-Machine (M2M)/IoT devices already need to comply with a broad array of certification requirements coming from government agencies (e.g., in the US, FCC, to make sure that the device does not emit interfering signals), associations (e.g., PTCRB (PCS Type Certification Review Board) to ensure that the device does not harm the cellular network), carriers (e.g., radiation tests specific to each operator) and possibly other entities.

"Cyberspace has become strategically indispensable. At this writing, users, whether individuals, corporations or states, rely on their own judgment in conducting their activities," Kissinger observes. "The Commander of U.S. Cyber Command has predicted that 'the next war will be in cyberspace.' It will not be possible to conceive of international order when the region through which states' survival and progress are taking place remains without any international standards of conduct and is left to unilateral decision" ("World Order", p. 346).

This article expresses the views and opinions of the authors and does not necessarily represent the position of Georgia Tech, the University System of Georgia, or the State of Georgia.

Dr. Margaret L. Loper is the Chief Scientist of the Information & Communications Laboratory (ICL) at the Georgia Tech Research Institute. She is also the editor of the recently-published book on Modeling and Simulation in the Systems Engineering Life Cycle, Springer, 2015, which leverages the work of Georgia Tech research and teaching faculty to cover the breadth of M&S used in systems engineering. The book offers a helpful starting point for engineers and managers involved in the development of IoT systems.