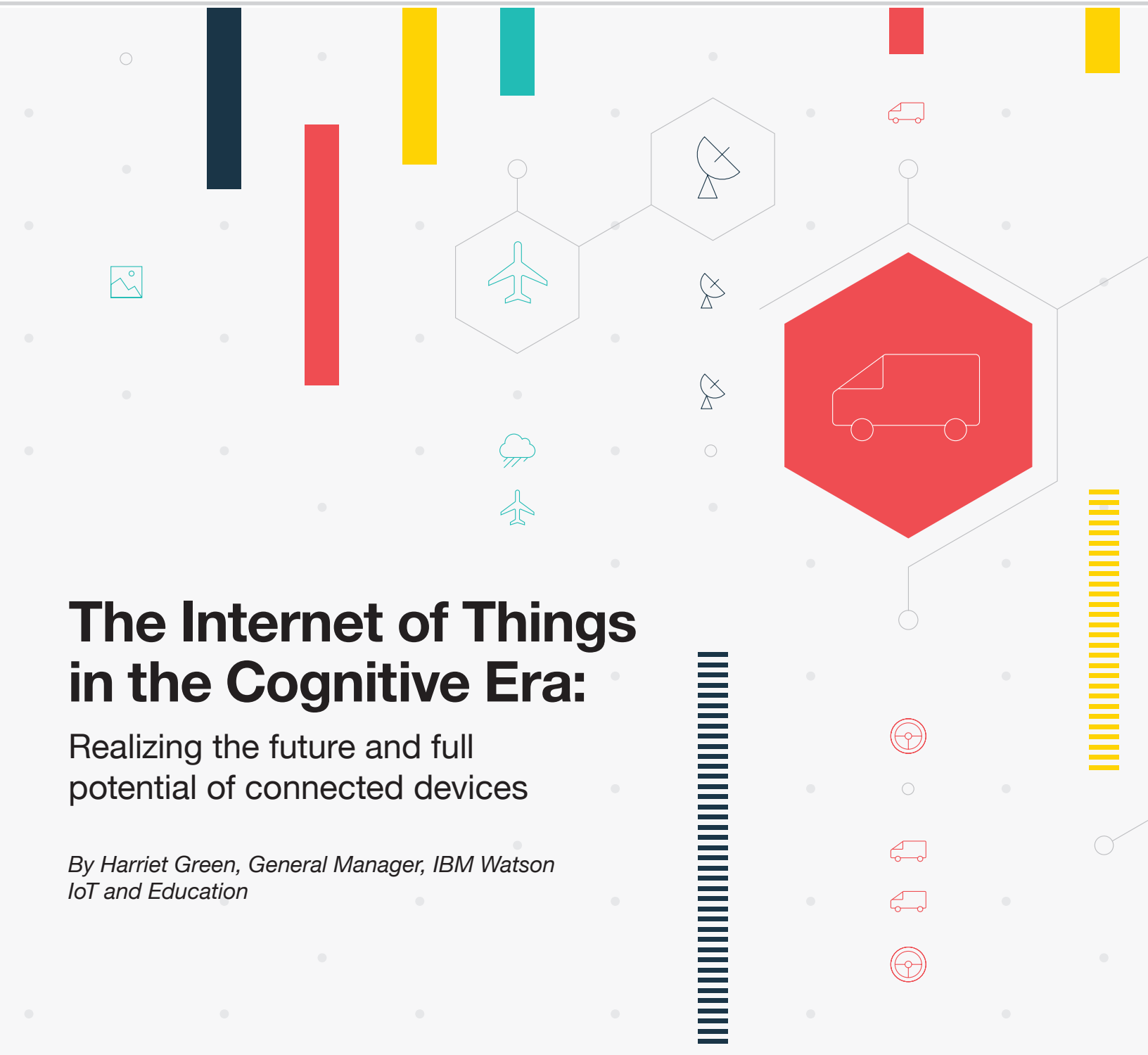

The Internet of Things in the Cognitive Era:

Realizing the future and full potential of connected devices

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December 2015

In ten short years, the Internet of Things has made the leap from conceptual to actual. Early predictions for IoT that once seemed like hyperbole are starting to feel more like understatement, as analysts are scrambling to revise their estimates of the IoT's potential upwards.

IDC now predicts that by 2020, the IoT network will consist of more than 29 billion connected devices.[1] And experts are estimating that the data from these devices will yield insights that drive economic value of more than $11 trillion by 2025.[2] Some experts still feel these numbers are too conservative.

According to a McKinsey & Company report,

> "The Internet of Things has the potential to fundamentally shift the way we interact with our surroundings. The ability to monitor and manage objects in the physical world electronically makes it possible to bring data-driven decision making to new realms of human activity—to optimize the performance of systems and processes, save time for people and businesses, and improve quality of life."
>
> **McKinsey & Company**

The early applications of IoT are undoubtedly delivering great value. They are reshaping customer experiences by putting consumers into context, and offering new avenues for engagement. They are boosting operational efficiency with new insight into the entire value chain. And they are creating opportunities for new, disruptive business models to emerge.

Though it is still early, evidence of this value is mounting. For example, the U.K.'s utility provider, National Grid, is using IoT to proactively and predictively maintain the health of the electricity network in real time. Robert Bosch is developing intelligent, interconnected automotive products to deliver on the promise of smarter vehicles.[3] And Vodafone is gathering and analyzing information from sensors in Spanish cities to improve nearly every system that facilitates life in urban areas -- mobility, emergency management, energy, water, education, and healthcare.[4]

And yet, there is a sense that we are merely scratching the surface. Nearly 90 percent of the 6,000 exabytes of data being generated at the edges of these networks is currently being wasted.[5] For example, only 1 percent of the data from an oil rig with 30,000 sensors is examined in the hunt for anomalies.[6] Some feel there is far greater value in using the discarded data to learn about these complex systems, combine it with other sources of information such as weather and news events, and use the resulting analysis to drive decisions on everything from predictive maintenance to oil rig design to long-term capital investment. To make these more ambitious applications of IoT a reality, we will need a more powerful, sophisticated way of processing the growing volume and variety of IoT data. We need the Internet of Things to be smarter. We need to get more value from data it produces. And we believe that cognitive computing – systems that learn at scale, reason with purpose, and interact with humans naturally -- is our best, and perhaps only, opportunity to fully exploit this burgeoning resource.

The foundations of IoT

The Internet of Things is undeniably large and complex. But the strategic approach to capitalizing on IoT is relatively straightforward. IBM has worked with more than 4,000 IoT adopters in the automotive, oil and gas, utility, transportation, aerospace and defense industries for the last decade. Consistent patterns emerged – most critically, that any successful implementation requires a cohesive strategy that addresses four critical areas of IoT in an integrated manner:

Devices and Networks – Data is the currency of IoT, and the secure capture and transmission of information from "things" is critical to the success of any IoT strategy. This requires interoperable, open standards-based systems. And in the IoT, everything becomes an access point on the network, which creates new security and privacy challenges. To protect your network, you must understand how that data will move – from device to device, across data centers, and even across borders – and develop security and privacy protocols that will reliably collect the data in compliance with regulatory obligations.

Data – IoT platforms are the control points for overall IoT operations. They collect, integrate, and otherwise manage the data itself. And they structure the processes that will be used to analyze that data. Your platforms should be built to handle multiple data streams from disparate sources. They should be cloud-based. And they should structure and prepare the data for deep analytics.

Applications and Analytics – In order to use the data to solve specific problems, you will need competency in data analytics and application development. Your analytical capabilities will extract the insight from the information, finding patterns and correlations. And your applications will render it useful to key stakeholders – anyone from facilities managers to product designers to your customers themselves. To do this requires a robust analytics engine and a fast and affordable development environment.

Industry-specific Expertise – While there are some IoT solutions that will apply across industries, many applications of IoT data will be specific to a particular industry. The development of your IoT applications needs to be guided by experts that understand the strategic goals of your organization, and the competitive context in which you are operating. True transformation occurs when this deep understanding of an industry is combined with technical facility.

Why cognitive?

At its heart, the Internet of Things is a data challenge. The traditional approach to programmable computing – in which data is shepherded through a series of pre-determined, if/then processes to arrive at outcomes – simply cannot process the degree and kind of data needed to fulfill the true promise of IoT. Programmable systems thrive on prescribed scenarios using predictable data. And this rigidity limits their usefulness in addressing many aspects of a complex, fast-paced world, where the value of data decreases exponentially every second it goes unused.

Cognitive computing has no such limitations. Rather than being explicitly programmed, cognitive systems learn from interactions with us and their experiences with their environment. This enables them to keep pace with the volume, complexity, and unpredictability of information generated by

the Internet of Things. In addition, cognitive systems can make sense of the 80 percent of the world's data that computer scientists call "unstructured" – think videos, audio, even blogs and Twitter feeds. That means we are now able to illuminate aspects of the IoT that were previously invisible – patterns and insight culled from disparate sources – allowing us to make more informed decisions.

When cognitive computing is applied to the Internet of Things, the result is what we call Cognitive IoT, which we define as systems that infuse intelligence into, and learn from, the physical world. The end result is deeper, more meaningful insight into the world around us – our context -- from how variations in weather affects your business in unexpected ways to the hidden patterns in how people are talking about your brand.

But it's not just the input that sets Cognitive IoT apart. In addition to generating answers to numerical problems, cognitive systems can present unbiased hypotheses, reasoned arguments, and recommendations. They understand your goals, and can integrate and analyze the relevant data to help you achieve those goals.

> "The real value that the Internet of Things creates is at the intersection of gathering data and leveraging it," writes Daniel Burrus, Author of *Flash Foresight: How to See the Invisible and Do the Impossible*. "All the information gathered by all the sensors in the world isn't worth very much if there isn't an infrastructure in place to analyze it in real time."[7]

IBM researchers foresaw the inherent shortcomings of programmable software decades ago when work on cognitive systems first began. Our answer to this bottleneck is Watson, the first and most complete cognitive platform in operation today. When Watson defeated *Jeopardy!* champions Brad Rutter and Ken Jennings in 2011, it did one thing — natural language Q&A, based on five technologies. Today, Q&A is only one of many Watson capabilities available as an application programming interface. Since then, we have developed more than two dozen new APIs, powered by 50 different cognitive technologies.

This is a critical distinction between IBM's approach to cognitive computing and other current approaches to Artificial Intelligence. Cognitive computing is not a single discipline of computer science. It is the combination of multiple academic fields, from hardware architecture to algorithmic strategy to process design to industry expertise. All of which enables five fundamentally new characteristics of the Internet of Things to emerge:

1. Deep human engagement: Cognitive systems facilitate more fully human interactions with people – based on the mode, form, and quality your customers or business partners prefer. They take advantage of the IoT data available today – such as sensor data, weather information, web interactions, transaction history, loyalty program patterns, electronic medical records, and data from wearables – and add to that picture details that have been difficult or impossible to detect: tone, sentiment, emotional state, environmental conditions, and the strength and nature of a person's relationships. They reason through the sum total of all this structured and unstructured data to find what really matters in engaging your audiences. Through this continuous learning,

you can offer customers deeper engagements that deliver greater and greater value, and become more natural, anticipatory, and emotionally appropriate.

2. Extended expertise: Your industry's and profession's knowledge is expanding at a rate faster than anyone can keep up with – journals, new protocols, new legislation, new practices, and entire new fields. A clear example is found in healthcare, where it is estimated that in 1950, it took 50 years to double the world's medical knowledge; by 1980, seven years; and in 2015, less than three years. Meanwhile, each person will generate one million gigabytes of health-related data in his or her lifetime, the equivalent of about 300 million books.

Cognitive systems are designed to help your organization keep pace, serving as a companion to enhance your workforce's performance. Because these systems master the language of professions – the language of medicine, or retail, or manufacturing – they can both understand and teach complex expertise. This reduces the time required for your employees to become experts.

3. Products and services infused with cognition: Cognition enables you to introduce new classes of products and services that sense, reason, and learn about their users and the world around them. This is the true promise of Cognitive IoT, because it allows for continuous improvement and adaptation, and for augmentation of capabilities not previously imagined. This is already happening with cars, medical devices, appliances, and even toys. Simply put, where code and data go, cognition can now follow.

4. Cognitive processes and operations: Cognition transforms how your company operates. Business processes infused with cognitive capabilities capitalize on the phenomenon of data, from internal and external sources. This gives them heightened awareness of workflows, context, and environment, leading to continuous learning, better forecasting, and operational effectiveness – along with decision-making at the speed of today's data.

5. Enhanced exploration and discovery: Ultimately, the most powerful benefit the Cognitive IoT will deliver is far better "headlights" into your increasingly volatile and complex future. Such headlights are becoming more important, as leaders in all industries are compelled to place big bets. By applying cognitive technologies to vast amounts of data from the Internet of Things, you can uncover patterns, opportunities, and actionable hypotheses that would be virtually impossible to discover using traditional research or programmable systems alone.

So how does this play out within an industry context? Imagine a clothing retailer looking to enhance the in-store customer experience. Gathering data about online shopping habits is easy. But in-store behavior has traditionally been far more difficult to quantify. With Cognitive IoT, a store can combine traditional sources of structured data – supply chain, inventory, RFID tags, and point of sales – with new sources of less quantifiable information – in-store foot traffic, social media, and even weather data – to get a more complete understanding of customer behavior. A cognitive system can correlate the data, identify patterns, and make specific, unbiased recommendations on everything from store

layout and merchandising to supply chain management and product design.

That's a challenge in its own right, but what about scaling to a heavily populated urban area? Cities across the globe are doing just that – turning to IBM Research and the Cognitive IoT to help them better address pressing environmental and pollution challenges.

It's called Green Horizons and it started in China last year before expanding to India and South Africa, among other locations, in late 2015. Our scientists use machine learning and advanced IoT capabilities to ingest and learn from vast amounts of Big Data generated by sensors in environmental monitoring stations, traffic systems and weather satellites. Watson understands this data and uses it to tune a predictive model that shows where pollution is coming from, where it is likely to go, and its potential effect. That allows city planners to make informed decisions on how to improve air quality.

In fact, in the first three quarters of 2015, the Beijing government was able to achieve a 20 percent reduction in ultra-fine particulate matter.

Cognitive computing contextualizes the information generated by the Internet of Things by allowing more and different data to be integrated and analyzed. While the decisions it informs can be automated, most applications of the technology will work in concert with human expertise; a kind of powerful, always-on advisor, reducing the amount of time it takes to make IoT data actionable.

The path to Cognitive IoT

For many industries, even those with mature IoT networks, Cognitive IoT can and should be the aspiration. But there are steps that must be taken to fully capitalize on this ambition:

- **Develop a cognitive strategy**

Cognitive IoT can fundamentally transform your business, but only if the vision is fully articulated. Your specific goals must be established within the competitive context of your markets. Critical data sources must be identified, along with the products, services, and processes that can fully benefit from cognitive. And experts must be available to train cognitive systems.

- **Set secure, scalable and open IoT foundations**

In order to build cognition into the objects, products, systems, and enterprise resources that matter, your IT core must be open and stable. Public, private and hybrid cloud resources underpin this work, along with trusted security from the core to the edges of the network.

- **Develop expertise, applications and solutions**

Collecting and securing IoT data is only half the battle. Putting it to work is where your benefits will accrue. To do this, applications should be written to align closely with your strategic goals, but allow for the kind of serendipitous discovery for which cognitive computing is known.

Conclusion

IBM has pioneered work in the Internet of Things for the better part of a decade now. We have committed more than $3 billion to bringing cognitive capabilities to the IoT. We have relationships with nearly every company and industry that is doing meaningful work in IoT. We have the only complete cognitive platform in Watson. And our planned acquisition of The Weather Company will provide us with a platform of platforms -- high-volume, real-time, low latency, mobile-enabled IoT capability that can be used across industries.

In addition, we are opening nine Watson IoT Client Experience Centers around the world to convene the world's foremost data scientists, engineers, clients and business partners. These centers will allow the world to explore pioneering applications of Cognitive IoT. And we have made available four new Watson APIs, specifically designed for Cognitive IoT applications -- Natural Language Processing; Machine Learning; Video/Image/Audio Analytics; and Text Analytics – to facilitate this work.

Combined with our deep industry expertise, and a security services division trusted by more than 10,000 clients in 133 countries, we are committed to efficient, secure, and fully Cognitive IoT solutions.

The purpose of the Internet of Things is to connect us more closely with the physical world. It shares information with us about the cars we drive, the tools we use, and the buildings we live in. But without cognitive computing, the usefulness of this information would be limited by its own complexity and scale. We would only be able to see slivers of insight. The rest would remain in the dark.

That's why we believe that cognitive computing is essential in realizing the true value of the Internet of Things. And in so doing, together we will discover answers to questions we never thought to ask.

To learn more about the Cognitive IoT and Watson's role in it, visit ibm.com/iot.

Sources

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