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**June 2011**

## ThingWorx Foundations:

# The Birth of the Connected Platform

Sponsored by **ThingWorx**

# Contents

# Executive Summary

ThingWorx has created the first application platform designed to meet the needs of the connected world, a world of smart things talking to people and to each other, where an explosion of data about the state of the world floods through networks, where every person or thing has the potential to listen and to react to every other person or thing. In the connected world, we have smartphones in our hands, smart appliances in our homes, smart devices in our offices, and smart systems in our factories and warehouses. The connected world has opened up new frontiers for collaboration and collective intelligence, for process automation, for operational innovation, and for squeezing the most out of limited resources. With ThingWorx, a new kind of application can be created, one that connects people, systems, and intelligent devices in ways never before possible.

## Challenges Facing Every Business

Several developments point out the need for a new platform that can conjure value from the data and intelligence that is sprouting in virtually every arena of business and everyday life.

First, the rise in smart devices—an estimated 1 trillion by 2020—begs several important questions:

- What will we do with the intelligence of these devices?
- How will the data coming from these devices create value?
- What sort of intelligence is needed to coordinate these devices?

On their own, smart devices perform one function, one step, isolated from the larger context of a business. If smart devices are used this way, the people using them in a narrow context may get some benefit, but the larger potential remains untapped. For smart devices to lead to a smarter world, some sort of brain function must be created that understands the vast amount of data smart devices are broadcasting and then orchestrates many devices into coordinated action. The connected platform is the foundation where such brains will reside.

Second, business is becoming more complex and must manage financial performance while optimizing electrical power, water, and carbon, not just inside one company but also across an entire supply chain. Businesses need to have all hands on deck helping to manage this vast complexity. Collaborative approaches to capturing and using tribal knowledge are needed so that responses can take place faster and with more

precision. Everyone must be able to explore data and see what is happening in the entire system, to record and broadcast their thoughts, to assemble information and create analysis and automation to meet their own needs, and to share approaches that work. Just as crowdsourcing has unlocked the power of large groups to learn from each other and solve problems, so must a new kind of connected platform allow people in a company to work together in a context of security, compliance, and data integrity.

Third, operational change has accelerated to the point that the design-develop-deploy cycle of traditional software just can't keep pace. The pervasive complexity of today and tomorrow's world will not be conquered through a top down design process and a semi-annual release cycle. The amount of data and the pace of change have overwhelmed the ability of existing processes and support applications. Data is locked away and inaccessible. Companies need standardized software for well-known processes, but this must be supplemented with software that can quickly optimize complicated real-time operating scenarios. The world is continually changing and the platform that we use for monitoring, management, and automation must be built for constant adaptation.

## Capabilities of ThingWorx

The capabilities of ThingWorx were inspired by the explosion of smart things and the flood of data flowing from them and applying the lessons of social networking, consumer technology, and user empowerment to harness a connected world.

ThingWorx allows the creation of industrial social networks that allow people and smart things, smart devices, and smart systems—the kind of equipment arriving in factories and operational landscapes in increasing volumes—to send and receive messages from each other, effortlessly raising the level of awareness across the organization.

ThingWorx applications are built to match the ease-of-use and universal accessibility of the consumer world so that the most appropriate device for the task at hand—whether desktop, tablet, smartphone, or other device—can be the interface to the application.

The ThingWorx application platform enables developers to compose applications quickly, allows advanced users to mash up new solutions, and allows casual users to search activities of people and things. Putting these tools in the hands of users eliminates bottlenecks and drives innovation by shedding light on unknown unknowns.

ThingWorx changes how data from devices is captured, stored, and searched. Every data item is tagged in multiple ways so that it can be retrieved quickly, to meet the needs of different types of users and applications. In most applications built before the connected era, data was stored in structured ways to answer predetermined questions. Since most applications were designed to answer a single question and storage was expensive, a limited amount of data was captured. ThingWorx allows data to be collected in great quantities without knowing how it will be used, but it also allows data to be stored and tagged to meet predetermined uses. When a new use is found or a new pattern discovered, a search can locate the data or tags can be extended to historical data to support new uses and innovations. As more data and observations are collected, ThingWorx applications become more valuable, just as social networks become more valuable when more people join them.

# The Mandate for a Connected Application Platform

The world is awash in technology. Anyone suggesting that we need more technology must be ready to defend that assertion. In most companies, someone will reasonably ask, "Can't we use the technology we have already paid for, and know how to use, to do the same thing?"

In short, the answer is "No." The current generation of technology cannot handle the explosion of smart devices, the need to capture and leverage the knowledge of the organization, and the need to change applications quickly.

## The Explosion of Smart Devices

Cisco estimates that one trillion devices will be connected to the Internet by 2020. We already see the thin end of this wedge with smartphones, webcams, tablets, and other general-purpose devices. An explosion of special-purpose devices will follow, especially in industrial settings.

If these devices all transmit data, how can we keep track of all these data sources? How can we track when and where data was collected? How will we use these new sources to create a competitive advantage? How can we make the data searchable so that users can find what they need on their own? Traditional data warehouses are not up to handling this data challenge.

Intelligent devices only exacerbate the problem. To provide value in a connected world, a platform must handle a spectrum of devices from the completely inert to the highly intelligent. See Figure 1 for an informal categorization.

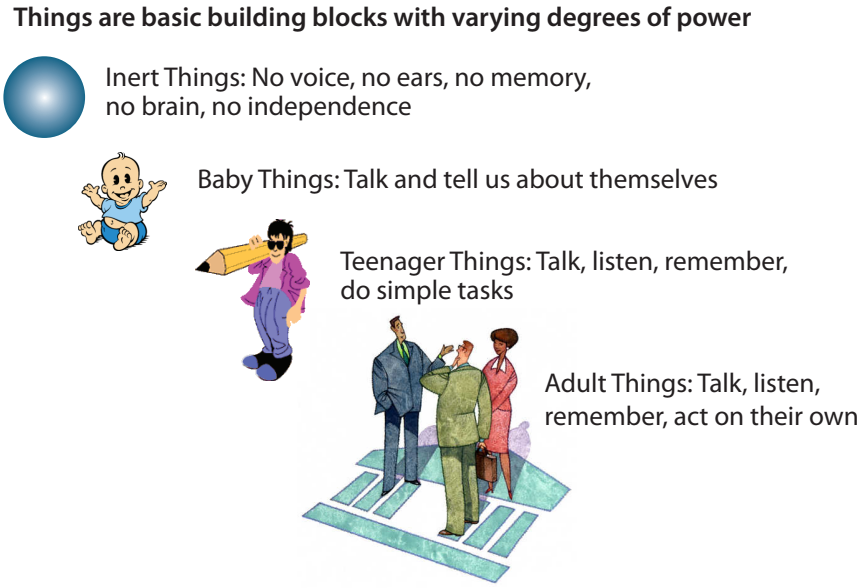


***Figure 1. The Continuum of Intelligent Devices***

A connected application must supplement the intelligence of a device and add any missing capabilities to address the business situation at hand. If an intelligent device can report its temperature and can respond to speed up and slow down commands, what happens when you need to keep track of the devices upstream and downstream? Speeding up a device could mean sending too much material to the next device. Shouldn't the device be able to find out the speed of the next device in line before speeding up? What if more than the temperature needs to be adjusted? A connected application must be able to surround any intelligent device with new ways to store data and new functionality to allow its intelligence to be put to work effectively in a specific situation.

## Operating in a Resource-Constrained World

The trend toward using metrics such as Power Usage Effectiveness to track sustainability in data centers, which are major consumers of power, is reaching every domain. Consumer product companies are trumpeting efforts to protect the environment. Business advocates such as Jack Welch, former CEO of General Electric, advise busi-

nesses to make the most of green trends because consumers want better environmental performance, not only because of regulatory mandates.

How will optimization of power, water, and carbon be achieved? Will an ERP-like application emerge to provide a solution that can be tailored to every operating environment? Not likely.

The only way to track and optimize the use of resources is through connected applications that accept data from thousands of sources, present it to a large group of people who work together to make sense of it, and then take action to improve performance.

While standard software provides high-level models of information related to sustainability, sustainability software will require connected applications to address the complexity of real-world operating environments.

### Business Applications Are Showing Their Age and Inflexibility

Most companies were transformed by the arrival of standard business applications like ERP and CRM. These systems of record introduced new forms of automation, but problems related to total cost of ownership and lack of flexibility became evident years later. These applications are complex and evolve over years. Configuration is expensive and time-consuming. The design-test-deploy cycle of applications prevents them from responding to rapidly changing operational requirements. They were not built to change at the pace of today's connected world. Retrofitting them to support texting, mobile devices, social networking, and collaboration rarely creates satisfying results. Connected applications incorporate all these elements at the platform level.

## Questions Facing Every Business

In most industries, especially connected industries such as manufacturing, life sciences, oil and gas, logistics, food, and power generation, smart devices are arriving at an accelerating rate. But in order to make use of these devices, companies must find answers to the following questions:

- How can we make use of smart devices and smart systems?
- How can we coordinate smart devices with existing systems and devices?
- How can we use the flood of data from smart devices and systems?
- How can more people help us manage and optimize our business?

- How can we empower people to design their own solutions?
- How can we maintain agility without sacrificing compliance and security?
- How can we build an operating environment that can rapidly adapt and evolve?

Companies that answer these questions will be the first to find their way to the pervasive visibility, flexible automation, and collective intelligence of the connected world. Packaged application vendors won't be able to show the way. Innovation must be created by adapting the unique processes and operating environments of each business.

## The Anatomy of a Connected Application

ThingWorx is founded on the premise that solutions for the challenges of the real-world industries will come from connected applications with the following characteristics:

- Data from smart devices and systems must be recorded and tagged with as much contextual information as possible
- The functionality and memory of smart systems and devices must meet the needs of multiple business scenarios
- People and smart devices and smart systems connect to form industrial social networks
- People and smart devices add content and context to the system, creating an ever-increasing repository of collective intelligence
- People and smart devices and smart systems can subscribe to messages from each other
- Messages can contain structured payloads that reflect the complexity of their information set
- Search must be extended beyond keywords to include tag-based query and analysis capabilities
- Each group must have a development environment tailored for its needs:
  - Developers need tools to create applications and building blocks
  - Subject matter experts need to mash up solutions
  - Casual business users need to search for relevant information

- Security and compliance policies must be enforced to restrict access to sensitive data and functionality

A connected application resembles a network with distributed functionality in many nodes as shown in Figure 2. It is not like a monolithic application where all functionality and data reside in a central location. That said, each node might have a special purpose, to monitor many other nodes or to provide some special-purpose functionality.

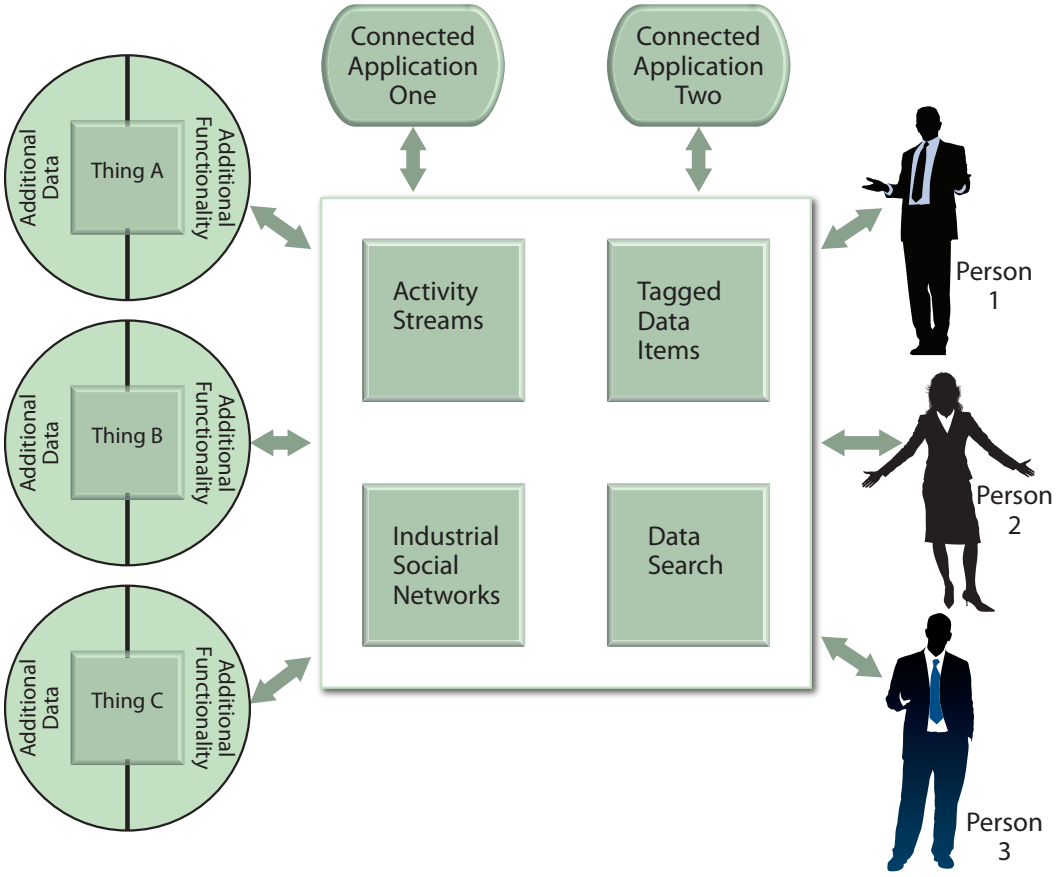


***Figure 2: The Anatomy of a Connected Application***

A connected application increases the awareness of every node in the industrial social network. People can be proactively notified of activity. Smart devices and smart systems can be made aware of what others are doing.

A connected application is much more like Facebook or LinkedIn than ERP or CRM. A stream of activity is generated by all the applications and users can move from a notification to an application to take action or to a search interface to find more data.

Users can adapt connected applications themselves. In this way, connected applications become a repository not only of data but also of tribal knowledge about how to manage a business.

A connected application is a powerful new way of serving the needs of businesses and answering the questions facing every business (listed earlier in this paper). In the next section, we take a step back and look at the broad effects of connected applications.

# The Lessons of the Connected Era

It is important to understand what has been learned in the past twenty years about how to make software work to support a business. Each of these lessons had a major impact on how ThingWorx built its platform to meet the needs of the connected world.

The lessons include:

- How big data is changing the way we run our businesses
- How user-driven innovation, the practice of putting the tools to construct solutions into the hands of end users, creates better solutions faster
- How agile development methods, the practice of building solutions in small increments, have evolved to shorten time to benefit and to spur innovation
- How collective intelligence can be applied in a corporate setting to increase awareness and let people participate in capturing knowledge, diagnosing problems, and designing solutions
- How the rise of mobility and consumerization extends ambient awareness, increasing responsiveness and spurring innovation

## The Challenge and Opportunity of Big Data

Most companies have ignored one of the most valuable sources of big data: web server logs. It turns out that by looking through web server logs, companies involved in ecommerce can get a real-time window on how consumers use websites. But web server logs arrive in huge volumes. The records must be sifted to find the meaningful bits that explain what consumers are doing.

Now imagine hundreds or thousands of such sources of data. That is the case at companies with many smart systems and devices. Even with the perfect tools for sifting through this data, it is a massive task to understand what is important and what is not. To handle big data, powerful tools for relating, tagging, searching, and understanding data must be put into the hands of as many people as possible.

## User-Driven Innovation: Conquering Sticky Knowledge

MIT Professor Eric Von Hippel has shown in his research that putting the tools to create solutions in the hands of end-users leads to dramatically higher levels of innovation. Von Hippel explains that requirements for the solutions end-users need are locked in their brains. He calls this phenomenon sticky knowledge. When users can construct their own solution, they don't have to communicate this sticky knowledge to others and can experiment until they find exactly what they are looking for. Environments as diverse as BI dashboards, mashups, and trading systems have shown the power of direct control by end-users. The solutions end-users build become a repository of knowledge about specific tasks. In addition, systems that support user-driven innovation dramatically widen the population of people who can build solutions.

## The Evolution of Agile: Operating Environments Built for Change

Agile development methods have become quite popular because they employ an incremental development process that is improved through direct feedback from the end-users of the system. Agile development methods preserve stability in the face of rapid change.

While traditional applications evolve and are updated in product cycles that last months or years, connected applications are constantly moving forward and changing. Inspired by agile methods, it is possible to create systems that can change rapidly but also preserve operational reliability.

The example of Etsy, a consumer ecommerce site, shows how these principles can be put into practice. Etsy allows people to sell craft items, and the site takes in more than $300 million in revenue each year. The engineering department uses a continuous deployment model to constantly change and update the site. Code is deployed on the site more than 2,400 times per year. While Etsy is an extreme case of rapid change, it does illustrate an important pattern for connected applications: you have to evolve fast if you want to stay ahead of the competition.

## Collective Intelligence and the Power of Ambient Awareness

Social networking in our personal lives has shown how being presented with a constant stream of activity collected from many people in our network makes us more aware of what others are doing and thinking. In a corporate context, this idea has been generalized to the concept of an activity stream, which informs us of much more than friend requests and who likes what, but also tells us about business activity such as changes in the status of deals, meetings that occurred, and the problem at the plant in Ohio. Activity streams expand awareness and improve communication. Every person in a social network becomes more aware of what is happening and can take more effective action and make better decisions. ThingWorx takes this idea one step further and adds smart things to the networks. When you allow people and things to share and comment on each other's activities, when all of the data in the streams is easily searchable, you empower a wide range of users to discover patterns and add information to the system. The founders of ThingWorx describe these broader applications of social networking mechanisms as "collective intelligence."

Connected applications are built to take advantage of the mechanisms that create collective intelligence such as activity streams. Each user of a connected application can see the important messages from the things and people that are using the same applications, and can comment on them. It is then possible to go from a notification into an application to help understand more deeply what is happening or to search for more information.

At first the effect of collective intelligence is an ambient awareness that helps existing business processes run more efficiently. As time goes on, the amount of data and commentary increases to the point that awareness leads to new ideas for how to reengineer processes. With connected applications that are trading messages with payloads of information back and forth, new forms of automation become possible.

Collective intelligence works because it dramatically expands the number of participants in an operational system. When more people join the action, results improve. When the world becomes more complex, more people must join the process of observing and managing that complexity.

## Mobile Consumerization

The rise of smartphones and tablets and ubiquitous access is transforming the way people live and work. With mobile devices expected to represent more than 50% of

all Internet access by 2013, connected world applications *must* embrace mobility, not as an afterthought but as part of their architectural DNA. When consumers find they can use their email, calendar, and contacts from a service like Yahoo! or Google on the web, on their phone, and on an iPad, it raises the bar for business solutions. Solutions that are not ready for multi-device flexibility and do not make an effort to imitate the ease-of-use in the consumer world are begging for trouble. The payoff for mobility and ease-of-use is an expansion of the "ambient awareness" that underlies collective intelligence.

Any solution on the drawing board right now must take into account most or all of these lessons. ThingWorx created a Connected Application Platform that takes all of these lessons into account. The next section explains how that platform works.

## The Anatomy of a Connected Platform

A connected application platform must work differently from existing software. To understand what a connected application platform is and how it works, let's review the differences between traditional and connected applications.

**Connected applications are more like networks than black boxes.** Often we think of an application as a black box (Figure 3). In such applications, data storage, application logic, and user interfaces are collected in one unit and designed for a very specific purpose. This architecture was an important step forward in its day but has led to the rigid stove-pipe/siloed nature of applications today. This is not how connected applications work.

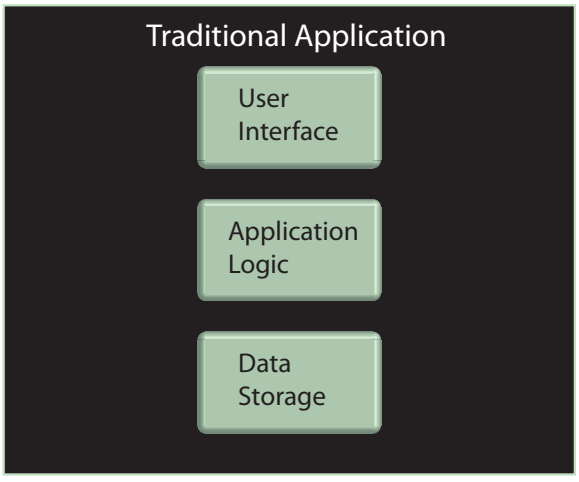


***Figure 3. A Traditional Application Is Like a Large Black Box***

A connected application is a collection of distributed components that communicate with each other. Some components are the data and functionality surrounding a smart thing or smart device. Other components monitor activity and notice if something important happens. Still other components collect important events and present them to a user. Any one component in a connected application may participate in many different applications. Connections between components and applications are based on streams of messages so that decisions about which applications are connected to which can be made as new ideas occur. In traditional applications, most decisions are made at the time of initial design, which reduces adaptability (see Figure 4).

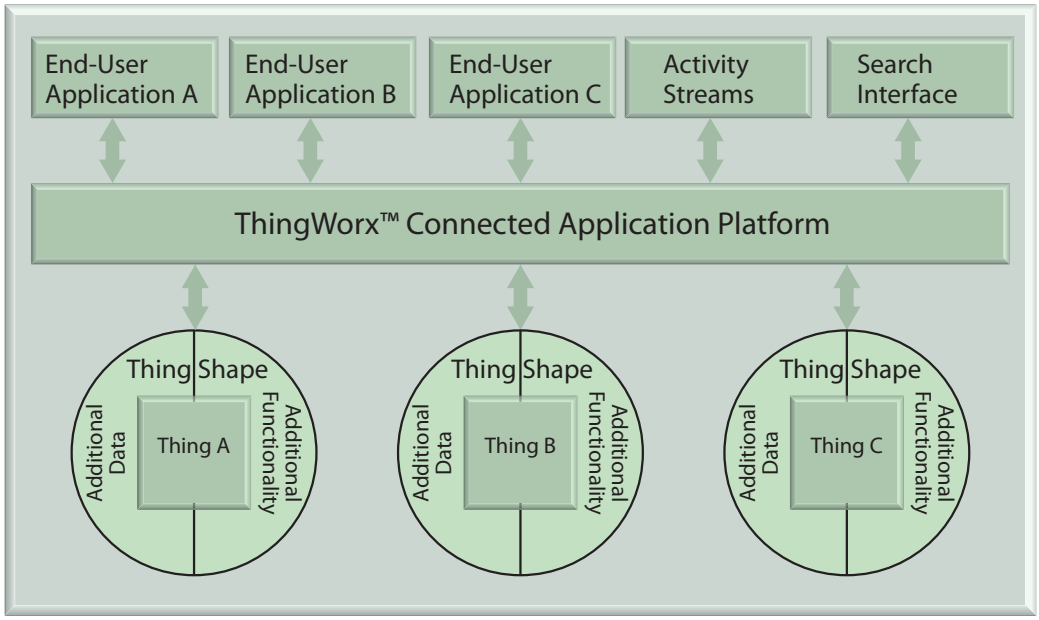


***Figure 4. The Distributed Architecture of a Connected Application***

Search is never far away in a connected application. Most traditional applications could be improved with better search. The problem is that the way data is stored in traditional applications and the capabilities of most search tools are not well matched. Search would be useful but it is hard to make it work.

In a connected application, search is always present. The things that are part of the application and the data it creates are tagged and recorded multiple ways. Do you want to see all warning messages from a certain type of device during a certain time period for devices located within 100 miles? That is a simple search for a beginning user.

In a connected application, search leads to greater insight and often to adding new capabilities to the application or to the functionality or data surrounding a thing.

**User interfaces are decoupled, leading to greater choice and adaptability.** In traditional applications, user interfaces are part of the black boxes. You may be able to configure them, but it is not easy to change them dramatically.

In a connected application, components such as things and people communicate in streams of messages. Other components monitor data, understand it, and send their findings out in messages. This means that applications and people decide which streams to listen to and how to make sense of them. If you add in the fact that these applications are much easier to build, it becomes affordable for each person in an operational process to have their own application.

Connected applications have a pulse; they come to you and say hello. One of the most valuable concepts in social networking is the news feed, which has been generalized for broader use as the activity stream. Users of connected applications get informed of important events by following activity streams that are relevant to their current interests.

## A Connected Way of Working

When a company starts using connected applications, many things change:

- The number of people involved in helping to manage tasks usually grows because the needed information is easier to assemble and provide through an application
- Things become repositories of information about specific types of equipment that may be scattered over many systems. By using a thing to assemble this distributed information, it becomes more useful
- The speed of application development increases because the population of developers is larger and the way things model activity in an operational environment means most applications have a running start. After building a few applications, it becomes much easier to build additional applications
- The number of applications grows, allowing more of the tribal knowledge of managing an operating environment to be captured in applications. Users can mash up their own apps, leading to an explosion in innovation
- Applications get better the more they are used, as they capture knowledge and activities from people and things. The density of the information shadow becomes greater and the information contained within it becomes more valuable, providing a foundation for collective intelligence

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- The details of what is happening are never far away nor is the information needed to diagnose problems and optimize processes. As a result, the speed of work increases

Connected applications work because they were built to meet the needs of today's operating environments and to incorporate the lessons learned about how to make technology provide the most value.

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*This paper was sponsored by ThingWorx and created by CITO Research.*