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Exploration, collaboration, and innovation are key components of our value proposition – we work with companies not only in response to but in anticipation of industry challenges. In today's ever-evolving global marketplace, that is the only way to stay competitive.

Point of View: The Internet of Things for Manufacturing (IoTfM)

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Introduction

The Internet of Things is predicted to have a huge impact on the future of manufacturing. According to the Industrial IP Advantage resource center, the Internet of Things has an estimated value of $14.4 trillion for the global economy over the next ten years. Manufacturing is forecast to realize 27% of the total and Smart Factories alone will generate almost $2 trillion of value. As another example of how digital information is affecting manufacturing, in 2010 manufacturing produced 1.8 exabyte of data—more than any other industry sector.

With such large numbers involved, manufacturers, suppliers, equipment developers and researchers are obviously asking the question, "How do we take advantage of what IoTfM has to offer?" In order to answer this question, we must better define what IoTfM means since technology phrases are often overloaded and are used to describe a wide range of activities. For the purposes of this paper, IoTfM means the exchange, storage, processing and presentation of manufacturing information and the software and hardware that is used to accomplish these activities.

The big reason that IoTfM is impacting manufacturing in powerful ways is because sensors, processors, storage and bandwidth are plentiful, low cost and powerful. Whereas, Moore's law[2] has accurately predicted the evolution of semiconductors for several years, the combination of multiple technological improvements has increased the ability of an entire industry sector to transform itself. Using new, more powerful technology in innovative ways, today's manufacturers can optimize use of the internet and wireless capability.

Single board computers that run at 1Ghz clock speed are capable of hosting sophisticated operating systems, can easily access the internet and store gigabytes of data locally, can be purchased for less than $50. The speed and reliability of internet access to business and homes has greatly increased over the past 10 years—transitioning from dial-up to readily available 50 Mbps communication rates and gigabit fiber connections in some areas. These bandwidth improvement rates have crossed a performance threshold that now allows remote computer access through a graphical interface that is comparable to local access. As a result, computational resources no longer have to be co-located to users and can be placed in data centers where economies of scale can greatly reduce the cost, increase the flexibility and shorten deployment times of computational resourc-

es. Data storage costs have also plummeted. Consumer grade disk drives can be purchased for less than $50 per Terabyte. Most software developers consider the cost of disk space to be inconsequential with respect to other project costs.

With IoTfM's large potential impact and the low cost building blocks that are available to implement IoTfM, manufacturers, component suppliers, equipment builders, software developers and researchers are obviously asking questions about how they can take advantage of what IoTfM has to offer. There is evidence to demonstrate that companies capable of harvesting IoTfM will flourish while those that don't will likely find it more difficult to compete.

Planning Paves the Way for Success

The most important issue for manufacturers is to develop an IoTfM strategy for the company that relates to performance and profitability. Rather than developing a strategy that collapses under its own weight, an efficient plan should be developed that involves the various departments in the organization. An important first consideration is how using IoTfM can save money, enhance revenue, increase throughput and improve quality.

For most companies, developing an IoTfM strategy should be considered a process improvement project versus a technology implementation plan. Instead of thinking in general terms about implementing IoTfM, companies should identify specific goals for using IoTfM. For example, if reducing the amount of scrap is important, implement IoTfM to collect the necessary data and determine what technological improvements are needed to meet the goal. Companies should avoid searching for a "silver bullet" that will implement IoTfM, and rather articulate their high level goal. Simply, the goals should allow the organization to collect the appropriate data, turn it into information, act upon the information and measurement the results.

With the cost of IoTfM building blocks continuously dropping, the ability to collect and store large amounts of manufacturing data is becoming increasingly less difficult. An alternative to the top-level goal approach is to collect all possible data through all means and then determine the 'answer' by processing all of the data with an appropriate algorithm. Although it is easy to collect large sums of data, it is still challenging to process large amounts of data without using esoteric computational hardware and highly skilled data scientists in a short enough time period where the results can be meaningful.

Once IoTfM goals have been established, what technological issues must be addressed to achieve the goals? How long will the plan take to implement and what will it cost? It is prudent to conduct an informal return-on-investment analysis to determine if the project is warranted.

Architecture Document

Once the goals of an IoTfM implementation have been identified, an architecture document should be developed. The document serves as a roadmap and design for the implementation so that team members can coordinate their efforts. Some of the items included in an architecture document are as follows:

- The general purpose of the implementation.
- A list the goals (and non-goals) of the implementation
- Methods that will be used to reach the goals.
- The hardware, equipment, computers, software and applications that will be used in the implementation.
- Diagrams that show how the entities exchange information.

The architecture document should make use of consistent design patterns so a holistic and consistent methodology is used. This should help speed development, improve quality and reduce ambiguity. The document should be considered a living document and be modified as new information is discovered. Balancing a consistent approach with the flexibility needed to address unique circumstances is a unique skill. The primary system architect should maintain the document and referential integrity with input from the project team.

Interfaces

Prior to developing the individual portions of the IoTfM infrastructure, it is highly recommended that an architecture document, including application interface definitions, be written. In order for IoTfM implementations to be effective, data must be exchanged among the various software and hardware entities within an enterprise. However, because most factories and enterprises use of a myriad of special purpose systems, methods to exchange data with them varies widely. Examples include file processing, database connectivity, web services, file transfer protocol, hyper-text-transfer-protocol, application programmer interfaces, object methods, serial communication and a multitude of proprietary techniques. Even within a protocol or a version of a protocol, the data structures, behavior, timing and precedence can vary significantly.

The cost to develop the necessary connective infrastructure (i.e. brokers, adapters, state machines, translators and mappers) is much higher than the individual building blocks used for implementation. The lack of interoperability among devices participating in an IoTfM environment is often one of the biggest barriers to a successful IoTfM implementation. This is why the architecture document is so critical.

Developing a holistic architecture among entities can determine the success or failure of developing an IoTfM implementation. By clearly defining how entities will exchange data, engineers and developers can focus on adding value through IoTfM versus retrofitting wrappers once a piece of functionality has been developed.

Applications

There are a plethora of software applications capable of providing a wide variety of IoTfM functionality and the capability to implement an IoTfM project. Applications can range from a few lines of code that interface with a sensor to applications (such as enterprise resource planning) that are used to operate large portions of a business.

The ability of software companies to deliver software as a service (SaaS) via the cloud is having a profound affect on how software functionality is being delivered and consumed. Software companies are rapidly moving to cloud offerings because it allows them to provide functionality much faster and at a lower cost. The move to the cloud is driven by technologies such as HTML 5, operating system virtualization, highly reliable data centers, increased bandwidth, collaborative and open source software development, greatly enhanced browser performance, and a variety of standards and specifications. Manufactures can investigate new information technology paradigms because ideas can be quickly tested, implemented and scaled via the cloud. That hasn't been the case with many past legacy delivery platforms (i.e. shrink-wrapped software). The internet also greatly increases the ability of software development teams to collaborate since the access to common resources are nearly seamless.

The internet greatly reduces the barrier to software companies entering the market, which is fostering innovation, collaboration and opportunities at a much more rapid pace than in the past. This rewards flexible companies that are able to take advantage of new technologies to improve their business. As part of an IoTfM strategy, companies must stay aware of the new trends in software development, determine which technologies can be harvested to improve their business, possess the necessary skills needed to implement new software technologies and adroit leadership needed to navigate numerous offerings.

Network

In order to make use of the IoTfM, a network must be in place so that data can be exchanged among entities. Typically, the network is connected to the public internet so that systems that have been built by others can be easily used regardless of their location. As the cost of network components and internet access has dropped significantly over the past few years, organizations are able to make use of "best of breed" services around the world that can provide highly productive services.

Due to security reasons, some organizations may not wish to connect their manufacturing systems directly to the internet. Fortunately, companies can still make use of the "Internet" of Things for Manufacturing because company intranets make use of the same physical structure, transport mechanisms and protocols used on the internet.

Data Repositories

Developing effective, efficient and normalized data repositories that are used in IoTfM applications is another important aspect of an IoTfM implementation strategy. Modern hardware and software systems are capable of collecting and transferring large amounts of data from sensors and systems. In order to store, process and retrieve the vast amounts of data, good design principals must be incorporated into the database schemas, stored procedures and queries. High levels of normalization should be incorporated to minimize database table sizes and speed the exchange of information.

Talent

In order to implement an IoTfM strategy, the company must determine if it currently has the needed in-house expertise. The successful implementation of IoTfM requires high-level skills in software development and network implementation. It also requires knowledge of mechanical systems, electronics and industry domain expertise. If a company does not have the individuals with these skills in place, there are options. Consultants who bring specific expertise to the project team over a finite period are readily available. Hiring additional full time employees to implement the strategy over a long period is an option. Another choice is to encourage current employees to achieve the necessary skills needed to implement the strategy.

Conclusion

The Internet of Things for Manufacturing (IoTfM) has the potential to dramatically influence future manufacturing. Low cost information technology, software and hardware building blocks are allowing companies to easily collect, store and process vast quantities of data that can be used to improve productivity. In order to harness the data, convert it into information that is actionable, a carefully articulated strategy that leads directly to decreased costs, faster time to market and higher quality is needed. Large realizations won't come through serendipity; rather deliberate and directed investments must be made now to take advantage of all that IoTfM has to offer. Companies that are able of developing and implementing an effective IoTfM strategy can reap great benefits, while companies that are not able to fulfill a strategy will find it increasingly difficult to compete.

[1] Andrew Dugenske and Alain Louchez, August 2014, The Factory of the Future Will Be Shaped by the Internet of Things, Manufacturing.net, http://www.manufacturing.net/articles/2014/08/the-factory-of-the-future-will-be-shaped-by-the-internet-of-things

[2] http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html

[3] Von Campbell, February 2003, Speaking a Common Language, IPC Review, 44(2), 14-16.

[4] Andrew Dugenske, March 2001, The Framework Implementation Project, Circuits Assembly 12(3), 51-60.

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