ANALYST INSIGHT

IoT Analytics in Practice

Published: September 2015

Report Number: A0173

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What You Need To Know

The Internet of Things (IoT) presents an opportunity to collect real-time information about every physical operation of a business. From the temperature of equipment to the performance of a fleet of wind turbines, IoT sensors can deliver this information in real time. There is tremendous opportunity for those businesses that can convert raw IoT data into business insights, and the key to doing so lies within effective data analytics.

To research the current state of IoT analytics, Blue Hill Research conducted deep qualitative interviews with three organizations that invested significant time and resources into their own IoT analytics initiatives. By distilling key themes and lessons learned from peer organizations, Blue Hill Research offers our analysis so that business decision makers can ultimately make informed investment decisions about the future of their IoT analytics projects.

AT A GLANCE

Studied Organizations

- U.S. Municipality
- U.S. Oil & Gas Company
- International Truck Manufacturer

IoT Analytics Initiatives

- Smart utility meter monitoring
- Oil field performance monitoring
- Predictive maintenance on truck fleet

Key Business Outcomes

- $10 million capital savings
- Optimized oil field production
- Net-new revenue stream & enhanced truck manufacturing

Study Overview

During the course of the study, Blue Hill Research interviewed three organizations to get a deep understanding of their IoT analytics initiatives including: a U.S. based oil & gas company building a sensor network to track oil field performance, a U.S. municipality transitioning to automated water meter readings, and an international truck manufacturer optimizing fleet performance and manufacturing. The following table summarizes the key details and goals for each IoT initiative that Blue Hill studied.

Table 1: Case Summaries

	U.S. Oil & Gas Company	U.S. Municipality	International Truck Manufacturer
Primary Data Source	Sensors on oil injector wells	Water meter sensors	Sensors on truck fleets
Number of Monitored Devices	21,000	66,000	100,000
Primary Activities Monitored	Oil extraction rates, temperature, and well pressure (10 total activities)	Water usage rates	Engine diagnostic codes and function of mechanical parts
Frequency of Readings	90 x day x activity	1 x hour x day	10,000 x truck x day
Scale of Data Collected	~18,900,000 daily readings	~1,584,000 daily readings	~1,000,000 daily readings

Source: Blue Hill Research, September 2015

Characteristics of IoT Data and Analytics

Innovations such as in-memory computing and massively distributed processing frameworks (like Hadoop) are important IoT catalysts for organizations that don't want to compromise speed when analyzing millions of data points. As these technologies have progressed in tandem with reduced sensor and wireless network connectivity costs, IoT analytics initiatives have approached a threshold point making investments more accessible to a broader population of organizations.

The IoT data that organizations collect comes from machine sensors and logs that are not part of the traditional corporate data analysis lexicon. As such IoT data feeds tend to have a number of unique characteristics that must be accounted for. Given the persistent nature of IoT data feeds, successful streaming analytics is at the core of fundamentally unlocking value from connected devices. Table 2 details the most salient characteristics of IoT data.

Table 2: Characteristics of IoT Data

Characteristics of IoT Data	
Streaming	• Machine log data and human-generated data such as messages and news alerts • Emphasis on identifying deltas within data streams • High velocity of data requires new techniques for data capture, processing, and throughput • Importance is in rapid appropriate response
High-Volume	• Requires archiving, data management, and analytics at scale • Key is to productionalize large data environments • High performance analytics must bring reporting to near-real-time results to make data useful
Semi-Structured	• Not modeled to fit well into relational databases • Requires additional parsing, ensuring data quality, and context to fit into a structured environment • Language and keyword frequency analytics are needed to fully analyze
Non-Standard	• Images, videos, voice, binaries • Require image recognition or audio analysis to support • Requires transformation and parsing

Source: Blue Hill Research, September 2015

The persistent streaming of IoT data feeds presents a fundamental nuance between IoT analytics and more general Big Data analytics. Given the frequency and redundancy of the reported data, the vast majority of IoT data streams are not useful in a broader context. Instead, it is far more economical to focus on identifying deviations in data points rather than their value in absolute terms. Determining baseline levels of behavior allows data analysts to built alerts and take action when irregularities in optimal patterns occur.

There are both direct and opportunity costs associated with analyzing data. Given the immense scale of data and all of the possible avenues of analysis, it is imperative to identify what patterns and deviations are vital to transmit, store, and further analyze. This prioritization allows organizations to best allocate their financial and computational resources to only the highest-value opportunities by compressing data storage and analysis time.

Operational data must be used iteratively to create a feedback loop where errors and faults are reduced as the organization finds more predictive and prescriptive indicators. The analytical investigations themselves will identify what new sensors are needed to capture additional data points for addressing business priorities. In this way, companies can create a continuously improving new normal and drive enhancements across all workflows associated with an Internet of Things project.

Choosing the Right Analytics Solution

In each observed instance, value to the organization – whether from cost savings or new revenue opportunities – was unlocked from the analysis of the collected data. That is to say, the process through which individual signals from sensors becomes actionable is through analytics.

Broadly, Blue Hill observes four basic stages that represent the maturity of IoT analytics projects. These stages range from replacing manual data collection efforts with sensors to automatically making changes to operations without any human intervention. Each stage builds off of the previous one, and provides tradeoffs in terms of their complexity and their potential value to the organization.

Table 3: Analytics Value Maturity Framework

Stage	*Analytical Requirements*
Replacing Traditional Data Collection	• Transform and integrate IoT data with existing data • Investment in Big Data storage environment is necessary given scale of data, even if data is filtered in-stream
Descriptive Analysis	• Analyze stored data at rest to provide overview of historical outcomes and performance • Analyze data in-stream to provide real-time understanding of current state operations
Predictive Analysis	• Use advanced analytics and machine learning algorithms to identify probabilities of potential outcomes and/or likely results of specific operations • Provide real-time predictive indicators and likely portfolio of outcomes
Prescriptive Analysis (Automation)	• Contextualize live stream events within current business requirements • Provide specific recommendations based on live streaming data to an employee or to automatically initiate a process • Learn from past outcomes to optimize future recommendations

Source: Blue Hill Research, September 2015

Replacing Traditional Processes

Using sensors and wireless networks to replace data collection processes is foundational to any IoT analytics undertaking. In doing so, organizations must be aware of the scale of data in which they are invoking. Sensors generate a persistent stream of readings, a point that is magnified by the large number of monitored devices typically present in an IoT initiative. Even if data streams are filtered prior to storage, the scale of data still requires an investment in some form of Big Data storage environment. As such, the primary consideration for choosing an analytics software to support these initiatives is data storage capacity and the ability to integrate with existing systems.

While relatively straightforward from a conceptual standpoint, this stage's potential value-add should not be overlooked. For organizations that already invest significant time and effort into collecting and aggregating sensor data, the long-run cost savings can be substantial.

For instance, the U.S. municipality that switched to smart meters for its water usage monitoring saw immediate and sustained savings. Their data collection process evolved from a manually intensive process (in which field technicians traveled to every meter) to one where meter readings were automatically recorded and transmitted to a central database. This has enormous cost savings both in man-hours and in field equipment such as trucks. The town is projecting a total savings of $28 million. This equates to a net savings of approximately $10 million over the lifetime of the initiative.

Descriptive Analysis

Descriptive analysis offers an opportunity for organizations to understand the state of affairs of their operations. Whether through data discovery efforts or building dashboards, descriptive analysis allows business decision makers to drill into specific areas of the business to identify performance levels, anomalies, and root causes of top-line outcomes.

IoT initiatives present a distinction as this analysis can be handled both on 'at-rest' data and live 'in-stream' data. With IoT sensors, organizations have the opportunity to monitor key metrics and performance numbers in real-time by bringing the live data feeds directly into their analysis. This allows organizations to have the most up-to-date understanding of operations, and ensures that decisions are being made on the most relevant data points.

However, not all IoT analytics initiatives rely on real-time decision-making. Even if the analytics systems bring in live streams of data from the field, organizations may prefer to review the data in aggregate at the end of specified time periods. As an example, the California based oil & gas company is able to monitor the performance of oil wells at the end of every day or week. This allows them to identify opportunities for improvement (such as increasing production levels) and areas of potential concern. Ultimately, they are able to take this information and disseminate it to their field crew to make adjustments or repairs. The result is reduced downtime and increased production levels. The company estimates that they lose $500 for every hour that a single oil well is not in operation. After analyzing the initial impacts of sensor deployment they estimate that quicker oil well repairs saves approximately $145,000 in cost avoidance per month per field.

To take full advantage of descriptive analytics, companies must be able to analyze all relevant data. This can be a challenge, given the large number of disparate data sources and informational silos that organizations develop. New data sources must be integrated with existing repositories in a consistent and unified way to ensure that insights can be understood within the context of the organization as whole.

Predictive Analysis

Using available data to create forecasts and predict future outcomes presents a next step for extending the value proposition of analytics efforts. In this regard, Blue Hill observes important implications across a spectrum of outcomes, from increasing asset uptime to strategic decision-making.

For example, a manufacturer monitoring their production line can gain significant advantages by forecasting likely equipment failures before they happen. They may have sensors that monitor characteristics such as temperature, uptime, and output levels of a key piece of equipment. Predictive models built from these monitored sensor readings, combined with historical performance data, can identify leading indicators to future breakdowns. Making adjustments or repairs during scheduled downtime is far more cost-effective than disrupting planned production cycles. The result from predictive analysis in this sense is a reduced number of breakdowns and a higher level of production. This, in turn, may mean additional revenue as well as lower costs.

Predictive modeling and machine learning algorithms are built and trained upon past observations, and must be continually refined based on realized outcomes. Again, IoT initiatives presents a distinction in that predictive analysis can be performed based on already-stored data at rest and with live in-stream data. Analytics environments that can stream data live enable dynamic forecasts to be delivered to critical decision makers in real time. This affords the potential for substantial competitive advantages and efficiency gains by reducing response times and generating more accurate predictions.

Predictive analytics requires both an understanding of what statistical insights are possible and the tools to create accurate projections. As a starting point, this means avoiding basic statistical fallacies associated with error, interpolation, extrapolation, and accurate regression modeling to build a portfolio of outcomes. This can also mean using predictive analytic tools not only for operational data, but also for relevant text inputs, work schedules, and other external data that can provide context to the prediction at hand. Predictive analytics also require the same clean data needed to conduct historical analysis as a starting point to accurately benchmark and project success.

Prescriptive Analytics (Automation)

The highest level of IoT analytics value is realized when incoming data is translated into action without human intervention. Doing so maximizes revenue and lowers costs through the support of instantaneous adjustments to business impacting events.

The international truck manufacturer provides a mature use case of operationalizing sensor data. Sensors in the trucks combined with predictive models detect when a mechanical failure is likely to occur. When such an event is identified, the system schedules a maintenance appointment for the truck based on the truck’s route and optimized for scheduled delivery times. Further, appropriate parts are ordered and shipped to the identified service center and the technicians are notified exactly what needs to be fixed. The result is an interconnected web of sensors and operational systems that communicate to save time and money across the operation.

Analytics software solutions supporting IoT endeavors must contextualize outputs for the larger business operation. To contextualize a decision, companies have to use an industry-specific analytics solution that translates mathematical outcomes into action. Rather than provide a recommendation that states “r=0.73,” devoid of useful context, the recommendation needs to provide a specific course of action such as shutting down a particular engine or scheduling a repair.

The following figure outlines the analytics initiatives and cost details of each organization. *Note: not all of the relevant data could be included due to privacy requests.*

Table 4: Analytics Initiative Summary

	U.S. Oil & Gas Company	U.S. Municipality	International Truck Manufacturer
Nature of Analytics	Descriptive Analysis	Descriptive Analysis	Prescriptive Analysis
State of Data	At rest and in-stream	At rest	At rest and in-stream
Requirements of Analytics Software	• Time-series data storage and retrieval • Real-time analytics • Exception-based notifications • Archive weeks of data for historical analysis and data discovery	• Monitor large data sets in near real time • Join with billing database	• Run real-time analytics on streaming data • Run predictive analysis to alert to potential mechanical failures • Integrate with operational systems to strategically route trucks
Cost of Individual Sensors	$500	$135	N/A
Expected Life of Sensors	N/A	17 years	Life of Truck
Size of Total Capital Investment	$30,000,000	$18,000,000	N/A

	U.S. Oil & Gas Company	U.S. Municipality	International Truck Manufacturer
Projected Financial Returns	N/A	$10,000,000 net-savings	N/A
Business Benefits	• Reduced asset downtime through proactive maintenance • Optimized production levels	• Reduced monitoring costs • Enhanced customer service and customer experience • Water conservation • Superior capacity planning	• Improvements in manufacturing truck designs • Reduced truck repair and maintenance costs • Ability to sell service subscription as net-new revenue stream

Source: Blue Hill Research, September 2015

Obtaining Value

Blue Hill observed consistently that organizations implementing IoT analytics were able to achieve transformative results in operating their business and making decisions.

Consider the U.S. municipality that gained the ability to automatically collect water meter readings 24 hours a day. This was a drastic change from the prior manual collection process, both because of the immense logistical cost savings and because the municipality made a fundamental shift to a proactive service-oriented organization. Now the town can identify issues within hours of them happening, rather than weeks or months. With better and more accurate data, the town proactively reaches out to households to mitigate overuse or unexpected fees. The billing and management teams have shifted from an internal reporting organization to a customer-facing hub that provides residents a markedly better experience.

Blue Hill Research finds a number of ways in which IoT analytics initiatives can impact top-line growth, reduce costs, and improve the customer experience.

Cost Savings:

Blue Hill observes three primary ways in which IoT analytics initiatives drive cost savings:

- Elimination of manual data collection processes
- Greater production capacity planning and prescriptive maintenance
- More efficient service and warranty processes

Displacing manual data collection efforts presents an opportunity to simplify managerial oversight and field equipment costs required to collect data. Similarly, sensors provide improved insight into how production equipment is performing, so managers can know when machines operate most efficiently. As managers replace instinct with fact, they can optimize production capacity. A proactive identification of potential breakdowns can reduce a large cost center for any capital equipment intensive operation.

Planning and scheduling repairs during optimal times is much less costly for the business than disrupting production cycles. In addition, both parts and technicians can be routed intelligently to minimize the downtime of the actual repair. This also presents opportunities to better manage warranty processes as early indicators of potential failure can be used to proactively respond to customer claims or to resolve them before they occur. On a longer-term basis, this information can be used to flag usage patterns of products across different customer segments, as well as to identify the specific issues that occur most frequently. Organizations are then able to change warranty policies or enhance specific product features to minimize warranty claims.

Revenue Generation:

Blue Hill observes three primary avenues in which organizations increase revenue as a direct impact of their IoT analytics undertakings:

- Greater uptime for value-producing assets
- Net-new products and services from collected data

The implication of reduced needs for repair and shorter downtime of machinery is greater production capacity. Whether it is an oil well, manufacturing line, or generator, maximized productivity leads to potential for greater sales. Maximizing uptime has a significant impact on top-line performance.

Process improvements such as those mentioned above have been demonstrated to add value. However, business leaders would do well to ensure that their thinking is not constrained to just incremental changes. IoT is a sweeping technological movement that presents vast opportunities for organizations to explore. Businesses should audit the streams of data that they are or could obtain about their operations, and ask themselves if they can be repackaged for additional uses.

For instance, the international truck manufacturer first began using sensors on its trucks to monitor repairs and common points of failure. The analysis of this sensor data eventually evolved into notification and routing adjustments. Now the manufacturer provides this as an add-on service for customers as long as the truck is under warranty. After the warranty is up, customers can purchase the capabilities as a subscription service. In doing so, the truck manufacturer provides a value-added service and creates a new and recurring revenue stream.

Providing predictive maintenance 'as-a-service' could be broadly applied to any manufacturer of capital equipment. Alternatively, organizations collecting weather or geographic data may find willing buyers who would subscribe to their data feeds to improve their own business. As the IoT continues to emerge, expect to see continued business model innovation. Every company collects data in some way, and savvy business leaders will put themselves in a position to take advantage of this shift.

Enhanced High-Value Customer Ownership and Service

Although less direct than the immediate top- and bottom-line impacts discussed, the effect that IoT analytic initiatives can have on improving customer experiences should not be overlooked. By identifying potential occurrences before they become problems, organizations can stop issues from ever reaching the customer; the identification itself could provide a value-added service. For instance, the U.S. municipality, upon detecting an anomaly (such as heavy water usage at unusual hours of the day), reaches out to households and alerts them to a potential leak. This eliminates surprise spikes in customer utility bills, and results in an improved experience. In the case of the truck manufacturer, routing repairs and the continual improvement of their engineering process based on sensor feedback removes significant would-be headaches for their customers. Similar themes can be extended across any service model where monitored equipment performance has downstream customer implications.

Enhanced customer satisfaction and a higher value ownership experience manifests itself in better customer retention rates and increased customer lifetime value, which translates into revenue growth.

Conclusion

The advent of the IoT will continue to provide businesses with a myriad of opportunities to optimize their current operations as well as to create net-new business opportunities. But to do so, businesses must invest in a combination of people, processes, and technology that can transform individual sensor signals into action. The key to extracting sustained business value from IoT initiatives is, ultimately, sound business analytics practices.

IoT analytics initiatives must account for the unique streaming, high-volume, semi-structured, and non-standard data types that characterize IoT data. Businesses must also understand the level of maturity that their analytics operations require to gain value both from replacing manual data collection and building fully autonomous prescriptive analysis capabilities.

Decision makers can learn from the experiences of the studied organizations. These separate approaches each yielded significant and persistent business enhancements by bringing the Internet of Things and industrial-grade analytics together.

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James Haight is a research analyst at Blue Hill Research focusing on analytics and emerging enterprise technologies. His primary research includes exploring the business case development and solution assessment for data warehousing, data integration, advanced analytics and business intelligence applications. He also hosts Blue Hill's Emerging Tech Roundup Podcast, which features interviews with industry leaders and CEOs on the forefront of a variety of emerging technologies. Prior to Blue Hill Research, James worked in Radford Consulting's Executive and Board of Director Compensation practice, specializing in the high tech and life sciences industries. Currently he serves on the strategic advisory board of the Bentley Microfinance Group, a 501(c)(3) non-profit organization dedicated to community development through funding and consulting entrepreneurs in the Greater Boston area.

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