BSQUARE

A Blueprint for Intelligent Asset Performance

Manufacturers of large, complex machines don't ship their equipment and forget about it. They remain responsible for the machines' smooth and trouble-free operation at customer sites, which can include widely dispersed and harsh environments, where equipment often operates around the clock for months or years on end.

Manufacturers and users alike are concerned with maximizing asset performance and reliability in the field. Preventing failures before they occur helps avoid expensive and possibly catastrophic downtime without over-servicing equipment. When a failure does occur, getting the machine fixed right the first time, as quickly as possible, is the top concern.

The organizations responsible for the ongoing health and performance of these expensive machines, from reliability engineers who are intimately acquainted with the nuances of the machines' operation to field services organizations tasked with repairing and maintaining the machines after deployment, need better ways to avoid costly downtime and meet Key Performance Indicators (KPIs).

Evolving Industrial Internet of Things (IIoT) technologies give manufacturers new ways to collect, understand, and act on data created by their connected equipment. Solutions abound that can help manufacturers gain greater insight into machine operation and health.

But how do you know what approach is likely to provide the most benefit, as soon as possible, and throughout the asset's lifecycle?

The answer lies within the varying states of health that each machine goes through during its effective life.

> ***Devices fail. Their firmware and software need to be updated occasionally. Even when everything is working right, these devices need to be monitored and managed to ensure that they keep working right to prevent system downtime. With potentially hundreds or thousands of devices in a solution, it is not feasible to fix and update devices after they are deployed.***
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> **- ABI Research**

State Models: The Key to Insight

Machines don't go from perfectly healthy to broken without providing ample clues about deteriorating conditions. Manufacturers have a keen understanding of a new machine's state when it is first put into service. Reliability engineers have a wealth of information about the expected performance of the various components that comprise expensive, complex equipment such as pumps, drilling rigs, commercial vehicle engines, vending machines, elevators, and many others; however, once those machines are deployed, it's difficult to accurately ascertain changes in their states before an issue causes a failure.

Data from connected equipment provides important clues about changing machine states, but the sheer volume makes parsing through it a challenge on its own. A state model approach can provide insight into changing conditions by capturing relevant data and pairing it with rules and expertise created by reliability engineers and other subject matter experts (SMEs). For example, extreme vibration occurring while other operational indicators remain normal may be a state that uses rules to trigger an alert for a technician to evaluate the machine. An IIoT system based on state models provides timely, relevant information that allows appropriate corrective action to be taken to ward off potential failures and optimize equipment performance.

The state model allows machine data to be operationalized by service organizations responsible for repair and maintenance for more effective responses and business processes. Such a system provides more accurate identification of the cause of a failure, enabling a dramatic reduction in service calls as technicians receive the information they need to have the correct parts and repair information to fix the problem right the first time. In addition, call centers can provide more accurate information to support personnel at customer sites for more timely, effective servicing.

State Models in Practice

A pump manufacturer has implemented a state model-based IIoT system that integrates with its existing maintenance management system (MMS) to notify its technicians as soon as an asset experiences a state change so the issue can be identified and resolved before a failure occurs. Within the asset's state model, the reliability engineer has defined several states based on known poor performance scenarios. As the company continues to identify additional states to further reduce downtime, they are already seeing improvements in asset performance and reliability.

Consider the following scenario. John, a pump technician, gets an email notification because the state of a complex pump has changed – the vibration level on the radial stator on the drive end of pump 73 is higher than the defined norms. John accesses pump 73's telemetry dashboard, which has several visualizations for the different sensors on the pump, as well as for the calculations that the company tracks based on the pump's sensors. The vibration visualization shows that the radial stator vibration has increased significantly over the last several minutes, while the vibration of the axial stator on the drive end of the pump has remained consistent over the same time period.

John surmises that there is a bad bearing on the radial stator but wants to perform additional analysis to confirm. He creates an ad-hoc visualization separate from the telemetry dashboard and adds a new visualization where the x-axis is time and the y-axis represents radial stator vibration along with the pump's speed. Even though those two y-axis components are of different values – frequency for vibration and rpm for speed – by overlaying them on the same line chart, John can see if there is any correlation between the sensors. As he expected, there was no change in the pump's speed even as the vibration increased significantly. Just to triple check his hypothesis, John then adds a third y-axis - pump #73's temperature. As he expected, the temperature began to increase as the vibration increased, confirming John's prediction that a bad bearing is the root cause and needs to be replaced.

John checks the maintenance schedule in the MMS and sees that this pump is scheduled for maintenance in four days. As long as the vibrations or the pump's temperature don't reach critical levels, which are captured by other states in the model, the bearing replacement can wait until the currently scheduled maintenance window to replace the bearing, avoiding unnecessary downtime.

> *Before diving into an IIoT technology solution, it is imperative that an organization establish one or more clear business goals, such as improving the efficiency of repair and maintenance processes. Experience has shown that executive support and buy-in is crucial to the success of these types of initiatives.*

Adopting a State Model System

Before diving into an IIoT technology solution, it is imperative that an organization establish one or more clear business goals, such as improving the efficiency of repair and maintenance processes. Experience has shown that executive support and buy-in is crucial to the success of these types of initiatives. Next, the team required to execute on achieving those goals must be identified and assembled. Typical participants will include trusted technology partners, IT, cross-organizational departments, and equipment SMEs such as engineers, technicians, and operations managers.

Once a strategy and team are in place, it's time to get to the nuts and bolts of building a state model-based system. Beginning with a piece of new equipment, the following progression will allow manufactures to gain immediate business value, with increasing benefit as additional states are defined and put into play.

State 1 - The first state is the machine in its as-shipped configuration.

States 2-3 - The next one to two states are defined at the outset of the project through a collaboration between the technology partner and the manufacturer's SMEs. These are normally reliability engineering teams and field service organizations who are intimately familiar with the machine's operation and what components or subsystems are likely to experience changes in the early stages of deployment. Each state is defined and characterized by specific machine data and rules so that appropriate action can be taken when the asset goes into a particular state.

> ***A study by Accenture says the IIoT could help reduce machinery breakdowns by 70% and reduce overall maintenance costs by 30%.***

Even at this early stage, the adoption of the initial states will provide manufacturers with improved insight into sub-optimal performance of their assets. As such, operations personnel will have the ability to recognize changes and possible issues before they lead to asset failure and unplanned downtime. Information collected about state changes will also give field services teams better information about why a problem is occurring and how to repair it correctly.

States 4-5 - Over the next several months, an additional two to three states are defined by partner data scientists analyzing historical machine data in conjunction with previous states. At this point in the project, most organizations are able to achieve complete return on their initial project investment.

State 6 and Beyond - Additional states continue to be developed after verifying the preceding states and applying additional data science in the form of analytics, modeling, artificial intelligence, and machine learning.

As additional states are defined, not only will manufacturers see improvements in identifying and repairing pending issues, but as state models provide more granular insight into machine health, performance can be optimized across entire populations of like assets.

BSQUARE

Changing the State of Your Business

Capturing state changes as a machine progresses from being in ideal health to the end of its useful life is the most effective way for manufacturers to maximize the performance and reliability of expensive, complex equipment. It allows companies to meet the goals of preventing equipment failure by allowing operations teams to be alerted to performance changes that signify a potential problem and, when failures do occur, enabling them to repair problems quickly and accurately.

With the insight gained from state models, reliability engineering teams can add value to their intimate knowledge of how a machine is designed to operate. Field services teams can drastically improve first-time fix rates, reduce unnecessary service calls, and optimize maintenance processes and intervals. Knowledge gained from the creation of state models can inform optimization processes that apply configuration information from higher-performing machines to entire populations of like equipment, improving business operations across the organization.

> The worldwide IoT device management market is projected to exceed
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> **$20**
>
> billion by 2023.
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> -ABI Research

A state model-based IIoT system delivers business benefit in short order, allowing companies to quickly prove the value of the approach and reap ongoing business benefit as the system gains knowledge over time.

About Bsquare

For over two decades, Bsquare has helped its customers extract business value from a broad array of assets by making them intelligent, connecting them, and using data collected from them to improve business outcomes. Bsquare software solutions have been deployed by a wide variety of enterprises to create business-focused Internet of Things (IoT) systems that can more effectively monitor assets, analyze data, predict events, automate processes and, in general, optimize business outcomes. Bsquare couples innovative software with advanced professional services that can help organizations of all types make IoT a business reality.