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Manufacturing



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Editor's Note

This end-of-year edition of Architecture Monthly covers Manufacturing. For more than 25 years, Amazon has designed and manufactured smart products and distributed billions of products through its globally connected distribution network using cutting edge automation, machine learning and AI, and robotics, with AWS at its core. From product design to smart factory and smart products, AWS helps leading manufacturers transform their manufacturing operations with the most comprehensive and advanced set of cloud solutions available today, while taking advantage of the highest level of security.

We hope you'll find this edition of Architecture Monthly useful, and we'd like your feedback. Please give us a star rating and your comments on Amazon. You can also reach out to aws-architecture-monthly@amazon.com anytime. You can also view past issues at <https://aws.amazon.com/whitepapers/kindle/>.

For November's magazine, we've assembled architectural best practices about Manufacturing from all over AWS, and we've made sure that a broad audience can appreciate it. Note that this will be our last issue of the year. We'll be back in January 2020 with highlights and insights about re:Invent 2019 (December 2-6 in Las Vegas).

- **Case Study:** iRobot Ready to Unlock the Next Generation of Smart Homes Using the AWS Cloud
- **Ask an Expert:** Steve Blackwell, Manufacturing Tech Leader
- **Blog Post:** Reinventing the IoT Platform for Discrete Manufacturers
- **Solution:** Smart Product Solution
- **AWS Coffee Break:** IoT Helps Manufacturing Hit the Right Notes
- **Whitepaper:** Practical Ways To Achieve Smarter, Faster, and More Responsive Operations
- **Reference Architecture:** EDA on AWS with IBM Spectrum LSF

Annik Stahl, Managing Editor

Case Study:

iRobot Ready to Unlock the Next Generation of Smart Homes Using the AWS Cloud

Available online at: <https://amzn.to/AWS-mfg-iRobot>

“AWS offers powerful tools and integration capabilities that enable us to use a serverless architecture that saves us the headaches of learning to scale.” – Ben Kehoe, Cloud Robotics Research Scientist, iRobot

Tall Order for a Cleaning Robot?

The first Amazon Prime Day was a good one for iRobot. On that July day in 2015, the company sold 14,000 of its Roomba robotic vacuums. This one-day sales number underlined the reputation for innovation and value iRobot had built among its customers. It also underlined a challenge iRobot would face just a few months later, in September, when the company would release its first internet-connected Roomba vacuums.

“Roomba vacuums are popular Prime Day purchases and holiday gifts, and people want to try them out as soon as possible,” says Ben Kehoe, a cloud robotics research scientist at iRobot. “So there are certain days, particularly after big sales events like Prime Day, when a large number of customers send their newly purchased Roomba vacuums on their first cleaning missions.”

In July 2015, spikes in new Roomba use did not directly impact the company’s day-to-day operations. But starting that September, large numbers of people trying out the new connected Roomba vacuums would result in large volumes of traffic through the iRobot HOME App, the mobile app customers would be using to set up and control their connected robots. In other words, iRobot, which had so far operated primarily as a hardware vendor, was about to bet its central line of business on its ability to run a high-availability, customer-facing cloud application and an Internet of Things (IoT) backend platform.

It was a gamble that paid off. Today, iRobot reports that connected Roomba vacuums operate in more than 60 countries, with total sales of connected robots projected to reach more than 2 million by the end of 2017.

iRobot isn’t stopping there. Not only is the company sending its connected Roomba vacuums to save us from the drudgery of vacuuming; the company believes these robots can one day help solve a problem that has so far prevented the IoT industry from delivering on

the true promise of smart-home technologies: a house that simply knows what to do and reacts accordingly.

First Priority: Customer Focus

As always, however, iRobot remains focused on its central value proposition: leading-edge robots that relieve customers from menial chores and give them time for what's more important. That customer focus is why iRobot started offering connected Roomba vacuums. "Customers are demanding easier ways to interact with a growing number of products and technologies throughout the home," says Kehoe. "Cloud connectivity provides Roomba customers with even more convenience and control, so they can use their phones to manage their Roomba, wherever and whenever it's convenient."

In 2013, as it planned the platform that would be the foundation of this new offering, iRobot decided to build it in the public cloud. For the initial launch, iRobot worked with a vendor that provided a turnkey solution for launching the first cloud-connected Roomba in September 2015. However, as iRobot began to build out its family of connected Roomba vacuums—and as the sheer number of connected customers and services quickly multiplied—iRobot recognized it needed a solution that could scale more quickly and allowed for more direct control.

"Following the launch of our first connected product, it became increasingly clear that we couldn't achieve the scale and extensibility we needed with the turnkey solution we were using," says Kehoe.

Getting Robots Right in the AWS Cloud

iRobot decided to move its mission-critical platform to the Amazon Web Services (AWS) Cloud. "The AWS Cloud offered an essential combination of scalability, global availability, and breadth of services," says Kehoe. "What really grabbed our attention is that AWS offers powerful tools and integration capabilities that enable us to use a serverless architecture that saves us the headaches of learning to scale."

To run the web applications that connect to the new Wi-Fi-connected Roomba vacuums, iRobot is using about 25 AWS services. At the core of the iRobot platform are AWS Lambda and the AWS IoT platform. AWS IoT, which can process trillions of messages between billions of devices and AWS or other endpoints, provides the connectivity layer between the robots and the iRobot cloud platform. AWS Lambda runs code in response to events to provide function-based compute services for the serverless backend that powers the iRobot cloud application. The solution also uses Amazon Kinesis, which ingests real-time data streams from robots, and the Amazon API Gateway, which can publish APIs and secure them at any scale.

According to Kehoe, connected robots like the Roomba hold the key. iRobot's Roomba 900 Series vacuums, for example, use visual simultaneous localization and mapping (vSLAM) technology to navigate an entire level of a home. As the Roomba vacuums, it builds a map of the home, and it is this map that could provide the foundational information needed to help a smart home understand itself and enable truly seamless, autonomous home automation. While today's Roomba is creating maps to clean more effectively, future generations of Roomba vacuums could combine these maps with additional sensors and supportive cloud services to manage the myriad smart devices within a home.

As straightforward as this vision is to state, it's quite challenging to achieve, but Kehoe says it's possible in the AWS Cloud. "The information pathways for something like this are incredibly complicated, security for customer information is crucial, and execution won't ultimately be possible without powerful artificial-intelligence and data-analysis tools. That's why we're building all this in the AWS Cloud. Amazon Web Services is the key to making this vision a reality."

Real-World Example

Watch Colin Angle, founder and CEO of iRobot, speak at the AWS Santa Clara Summit 2016.

<https://amzn.to/AWS-Mdq-iRobot-talk>

Ask an Expert:

Steve Blackwell: Tech Leader,
AWS Manufacturing

What are the general architecture pattern trends for manufacturing industry?

Manufacturing has always been an embracer of innovation to help drive and transform the industry over the years. From steam power to robotics driving automation within factories, we are now seeing data being used to drive the business as the next step in its transformation. This next advancement for the industry is generally contextualized as Industry 4.0. Some manufacturers refer to it as the “Industrial Internet” (<https://www.techopedia.com/definition/30044/industrial-internet>) or “Digital Manufacturing” (https://en.wikipedia.org/wiki/Digital_manufacturing), but in essence it’s the convergence of the operational technology realm of the factory floors with the Internet.

Over the past decade manufacturers have utilized automation, robotics, and computerization to drive improvements in performance on their factories to ensure efficiency, throughput, and quality. What we are seeing now as part of manufacturers’ digital transformation efforts is taking all those industrial data feeds and historical data from the last 10 to 20 years of production and using that data to provide information to the business so that it can make informed business decisions.

Cloud is not only providing a secure, reliable, and scalable platform that enables manufactures to naturally innovate, but it’s the lynchpin for manufacturers to experiment and take advantage of emerging technologies, such as machine learning and AI, as they look to drive insights from their data.

We are seeing this as three main architectural patterns. The first is around demand forecasting or more specifically bringing accuracy into the forecast to drive the business. It is not only about ensuring accuracy in the sales forecast that drives the business across the manufacturing value chain but also to ensure that the business can meet that demand. This comes down to having visibility into the factories and supply chains to ensure that the factories can build to the plan with the required quality and that the suppliers can supply the factories against the production schedule.

This then comes to the second main architectural pattern of smart factories, which is providing that visibility through data to ensure the factories can provide the required throughput at the needed quality levels to meet the production orders. This visibility is driven through the connectivity and ingestion of data from the factory machines and industrial devices into the manufacturing data lake in the Cloud and adding intelligence to the Edge through computer vision to drive quality as an example.

The third architectural pattern is around extending the manufacturing value chain with smart products. This extends the manufacturer's customer engagement by bring additional value through new function, features and revenue models but also having a feedback loop through field usage data. This is very prevalent within the automotive, aerospace and consumer goods segments but is now emerging with industrial customers as they can now have telemetry data on how the product is operating in the field. This helps the manufacturer then drive the rest of the business through analytics by identifying potential defects before they occur and providing engineers with information to help them create the next new product or iteration.

When putting together an AWS architecture to solve business problems specifically for manufacturing customers, do you have to think it all differently?

Absolutely, not only when architecting on AWS do you have to consider each manufacturing application workloads business criticality in isolation to ensure that you are providing the right level of availability, reliability and ensuring it's securely scalable to support the manufacturing production operations. For example, if a production system is unavailable, a manufacture can't manufacture, which directly affects the bottom line. But you also have to ensure that you are not over-architecting a solution and adding in cost and complexity when it's not required as margins can be razor thin on a per-product basis.

Additionally, when architecting for manufacturing workloads, factory system integration has to be considered. Historically automation equipment and factory machines have had a variety of industrial communication protocols that require low latency, logical segregation for security and high data processing, which are generally not Cloud-native. For these reasons when architecting industrial connectivity, Edge computing is paramount to provide an intermediate data integration point between the shop floor and the Cloud.

There are also instances where factories might have limiting or unreliable connectivity to the Cloud. In these cases, Hybrid Cloud comes in to play to provide a hosting platform for the mission-critical production application, enable integration with the

rest of the manufacturing enterprise, and provide protection through local disaster recovery and data protection.

Do you see different trends in manufacturing in cloud versus on-premise?

I would not say different trends, but Cloud is enabling manufactures to be more agile, go faster to market, and experiment compared to a typical on-premise environment.

As an example, if we look at product design and the use of High-Performance Compute (HPC) for computer aided engineering. A typical HPC environment has specialized infrastructure which takes at a minimum six months to design and stand-up and in some instances has a very unpredictable utilization, which means the assets are not always being fully utilized. With manufacturers moving their HPC workloads into the Cloud, it means that they can significantly reduce the time to stand up a cluster utilizing Cloud services while also reducing the cost of a Cluster by only paying for the infrastructure when jobs are running and taking advantage of compute services like Spot instances to optimize the cost through their job schedules.

Another example is Cloud is enabling manufactures to move their SAP environments to HANA in a fraction of the time it would traditionally take compared to on-premise equipment which enables the business to be testing quicker. Once the SAP workload is on the AWS Cloud, it allows the manufacturer to start to optimize costs by taking advantage of on-demand testing environments and auto scaling of their disaster recovery instances rather than having to stand up infrastructure on-premise which would be underutilized when it was not being used.

About our expert



Steve Blackwell is the Worldwide Technical Leader for Manufacturing at Amazon Web Services. He leads the AWS Manufacturing Technical Community and defines the technical strategy and solutions for manufacturing working with the AWS service, sales enablement, training, and partner teams. He is responsible for understanding the use cases for the manufacturing industry and developing the AWS-based technical solutions that address those needs working with customers, partners, and integrating third-Party solutions. He is the author of the “Manufacturing Reference Architecture,” which is a blueprint of how to build Smart Factories, Smart Products, and Manufacturing Data Lakes on AWS.

Blog:

Reinventing the IoT Platform for Discrete Manufacturers

Available online at: <https://amzn.to/AWS-mfg-blog>

By David Westrom, VP of Business Development at MachineMetrics and Graham Immerman, Director of Marketing at MachineMetrics

The Industrial Internet of Things (IoT) space is hot right now, as manufacturing represents perhaps the largest greenfield opportunity left for digitization. Yet, IoT platform implementations have historically had a high rate of failure within this vertical.

What's contributing to these failure rates, and what needs to change?

In this post, we examine common approaches for enabling Industrial IoT initiatives, the pros and cons, and their culpability for the high failure rate. We then introduce a new approach that's already driving rapid, continuous value creation for discrete manufacturers and the companies that provide and service their manufacturing assets.

First, a bit about us—MachineMetrics is manufacturing's first Industrial IoT platform designed for discrete manufacturing. We like to think of ourselves as the machine data component of the Amazon Web Services (AWS) digital factory.

[MachineMetrics \(http://www.machinemetrics.com/\)](http://www.machinemetrics.com/), an [AWS Partner Network \(APN\)](https://aws.amazon.com/partners/) (<https://aws.amazon.com/partners/>) Advanced Technology Partner with the [AWS Industrial Software Competency](#), has developed a hybrid solution for manufacturers and machine builders that combines machine connectivity and rapid value creation of packaged software-as-a-service (SaaS) applications with the innovation enablement of an IoT platform.

Right now, hundreds of manufacturers and machine builders are using the MachineMetrics platform to measure and analyze the performance of thousands of machines across global factories.

Our solutions are providing these companies the necessary real-time data they need to optimize machine performance and productivity, increase capacity utilization, and ultimately win more business to remain globally competitive.

The IoT Platform “Revolution”

The term Industry 4.0 encompasses a promise of a new industrial revolution—for the industrial sector, one that marries advanced manufacturing techniques with the Internet of Things to create systems that are not only interconnected, but communicate, analyze, and use information to drive further intelligent action back in the physical world.

Today is the internet moment for manufacturing, and with it comes the gold rush of providers ready to enable the industry’s digital transformation.

At this point, it would be impossible to work within the manufacturing space and not have spent the past few years bombarded by pitches for Industrial IoT platforms claiming to best support the Industry 4.0 revolution.

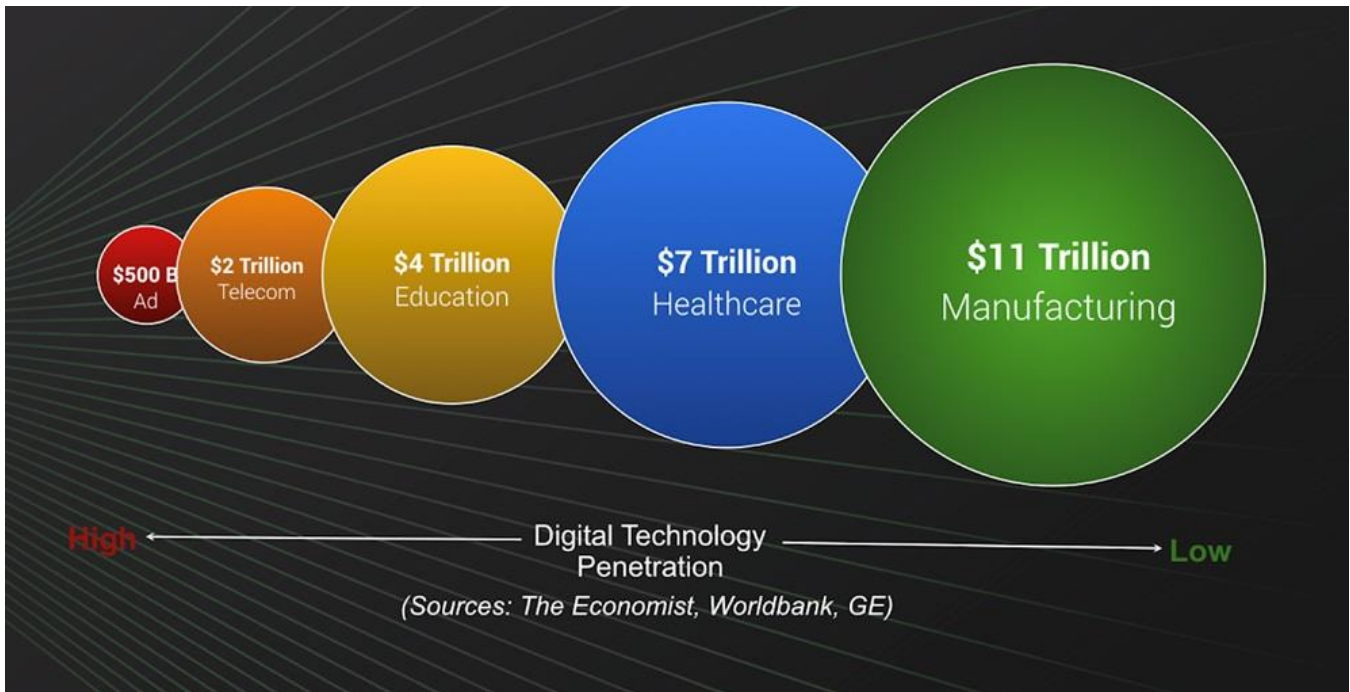


Figure 1 – Despite manufacturing being the largest industry in the U.S. and producing perhaps the most raw data, it has the least amount of digitization of any major industry.

These magical platforms market their unique machine learning (ML), artificial intelligence (AI), and edge/cloud/fog technologies to enable the fabled digital transformation of any industry through predictive models, digital twins, and fully-automated workflows.

There are more than 450 IoT platforms to choose from, according to IoT Analytics, and it can be easy to think Industry 4.0 has indeed arrived and manufacturing’s digital transformation is finally at hand. The data, however, tells another story.

IoT implementations have had a historically high rate of failure. Cisco produced a report of survey results indicating that companies considered 76 percent of their Industrial IoT initiatives failures. This has led to greater hesitation on the part of manufacturers to embark on digital transformation journeys.

So what's driving companies to fail at such a high rate when a majority said that IoT initiatives looked good on paper?

We explore some of the organizational causes in our eBook *Why Industrial IoT Projects Fail*. In this post, however, we focus on the story's technology component and IoT platforms specifically, with the goal of both identifying and proposing a solution to manufacturing's platform problem.

Read the full blog post: <https://amzn.to/AWS-mfg-blog>

Real-World Example

Industrial IoT Use Cases and Robotics are Transforming Workflows

AWS IoT provides device software, control services, and data services. Device software enables you to securely connect devices, gather data, and take intelligent actions locally, even when Internet connectivity is not available. Control services allow you to control, manage, and secure large and diverse device fleets. Data services help you extract value from IoT data.

<https://amzn.to/AWS-mfg-industry-robotics>

AWS Coffee Break:

IT Helps Manufacturing Hit the Right Notes

AWS IoT provides device software, control services, and data services. Device software enables you to securely connect devices, gather data, and take intelligent actions locally, even when Internet connectivity is not available. Control services allow you to control, manage, and secure large and diverse device fleets. Data services help you extract value from IoT data.

Sarah Cooper, GM of IoT Solutions, AWS and Michael Spandau, CIO and SVP for Global IT at Fender Musical Instruments Corporation discuss how Fender uses IoT technology for manufacturing their guitars.

Watch the video: <https://amzn.to/AWS-mfg-coffee-break>



Solution:

Smart Product Solution

Available online at: <https://amzn.to/AWS-mfg-smart-product>

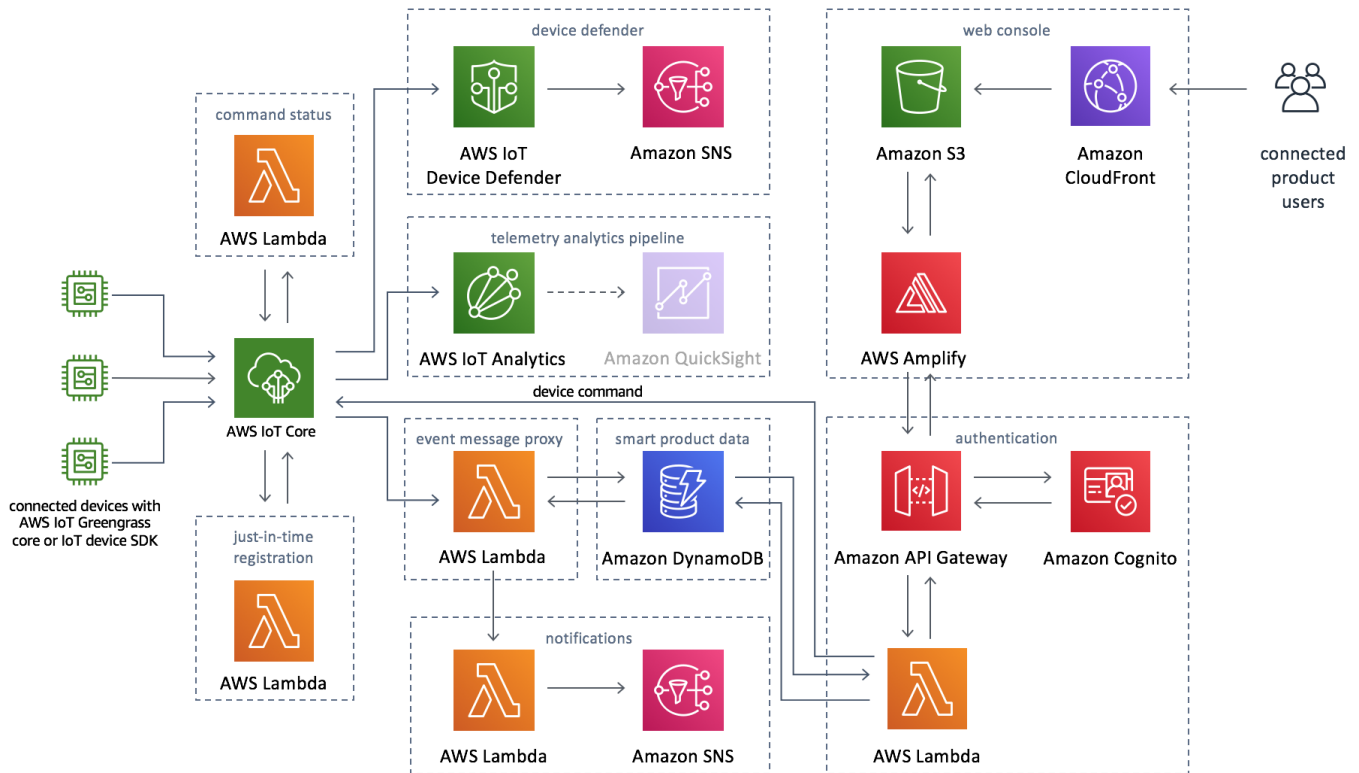
What does this AWS Solution do?

The Smart Product solution provides secure product connectivity to the AWS Cloud, and includes capabilities for local computing within products, sophisticated event rules, and data processing and storage. The solution features fast and robust data ingestion; highly reliable and durable storage of product telemetry data; simple, scalable big data services for analyzing the data; and global messaging and application services to connect with customers.

This solution is designed to provide a framework for connected product services, allowing you to focus on extending the solution's functionality rather than managing the underlying infrastructure operations. You can build upon this framework to address a variety of use cases.

AWS Solution Overview

AWS offers a solution that uses AWS IoT services to collect data from smart products, to send that data to the cloud, and to analyze the data. The diagram below presents the components and functionality you can build using the solution implementation guide and accompanying AWS CloudFormation template.



Smart Product Solution Architecture

The smart product solution leverages AWS IoT services to ingest and process messages from connected products according to business rules. When you launch the solution, a continuous integration/continuous delivery (CI/CD) pipeline is deployed that uses the AWS Cloud Development Kit (AWS CDK) and AWS CloudFormation to deploy the solution's architecture.

The solution's CI/CD pipeline deploys AWS IoT Core, which authenticates messages from smart products and routes those messages to the solution's microservices (AWS Lambda functions); AWS IoT Device Defender to continuously audit your devices to ensure they don't deviate from security best practices; and AWS IoT Analytics to analyze data from your smart products.

The template also deploys Amazon DynamoDB tables that store various details about the smart products; Lambda functions that provide the business logic to perform operations and collect data on smart products; and Amazon Simple Notification Service (Amazon SNS) to publish messages from your smart products and deliver those messages to subscribers and other applications.

The solution creates a web console powered by AWS Amplify, and deploys it into an Amazon Simple Storage Service (Amazon S3) bucket configured for web hosting. Amazon CloudFront is used to provide public access to the bucket.

The solution also configures Amazon API Gateway to host the solution's RESTful APIs, and deploys an Amazon Cognito user pool, which you can use to add user registration and sign-in for included web console.

View the deployment guide: <https://amzn.to/AWS-mfg-solution-deployment>

Real-World Example

Factory Optimization in the Cloud (Infographic)

Amazon distributes billions of products using cutting edge automation, machine learning and AI, and robotics, with AWS at its core. Transform your manufacturing operations with the most comprehensive and advanced set of cloud solutions available today, while taking advantage of the highest level of security.

<https://amzn.to/AWS-mfg-smart-factory-info>



Whitepaper:

Practical Ways to Achieve Smarter, Faster, and More Responsive Operations

Available online at: <https://amzn.to/AWS-mfg-whitepaper>

Overview

Cloud is at the heart of digital transformation in manufacturing. Many manufacturers suspect they need to move to the cloud, but are unclear of the value and the path. Through interviews with AWS cloud experts and top manufacturing companies who are mature in their manufacturing transformation efforts, learn practical ways to embrace the cloud today, and how industry leaders recommended best-practices in moving to the cloud to drive business operations excellence. Moving beyond the traditional IT infrastructure benefits and savings from moving to the cloud, see how leading cloud providers can help operations teams extract siloed production data on the plant floor, move that data securely to the cloud, and leverage Artificial Intelligence and Machine Learning to glean valuable insights from their data to speed innovation, lower cost, and improve OEE.

Executive Summary

A manufacturer's technological progress is typically hamstrung by significant operational challenges. They confront data silos, high operational costs, lack of skilled workforce availability, weak operational technology/information technology integration, high-speed computing needs, and machine downtime. While manufacturers may take multiple approaches to overcome these obstacles, their overall goal is to achieve enterprise visibility through a single pane of glass. However, most legacy infrastructures are not adequately prepared for this long-term digital transformation journey. Industrial firms are turning to cloud service providers to bridge the widening performance capability gap. The cloud's ability to assist with dynamic scaling in storage and to support cost efficiencies positions it as the linchpin for resolving current and emerging manufacturing challenges.

The market is awash with several cloud platform solution providers, but there is a clear market leader—Amazon Web Services (AWS). AWS has an annual cloud revenue of \$27 billion and over 46% in YoY growth ('17-'18). Its cloud solutions portfolio contains over 140 highly reliable, secure, scalable services and solutions — from data warehousing to deployment tools to directories and content delivery. Customers often choose AWS to access a range of differentiated cloud-based capabilities, such as database, compute, security, and storage.

Although cloud computing is one of the critical pivot points of Industry 4.0 and the Industrial Internet of Things (IoT), a sizeable portion of manufacturers have yet to adopt it. Many delay adoption due to integration challenges, lack of congruence on value derived versus capital investment, data privacy and/or security concerns, and change management anxiety. However, the imperative to embrace cloud and begin their transformational journey is more pronounced now than ever. The purpose of this paper is to explain the eight practical ways (outlined below, but in no particular order) manufacturing organizations can embrace the cloud and achieve smarter, faster, and more responsive operations:

Read the full whitepaper here: <https://amzn.to/AWS-mfg-whitepaper>

Real-World Example

PGS Software: How AWS Serverless Has Streamlined a Car Factory's Supply Chain

Learn how PGS Software built a cost efficient and resilient solution to process and analyze 22.5 billion records per day.

<https://amzn.to/AWS-mfg-video-PGS>

Reference Architecture:

EDA on AWS with IBM Spectrum LSF

Available online at: <https://amzn.to/AWS-mfg-ref-arch>

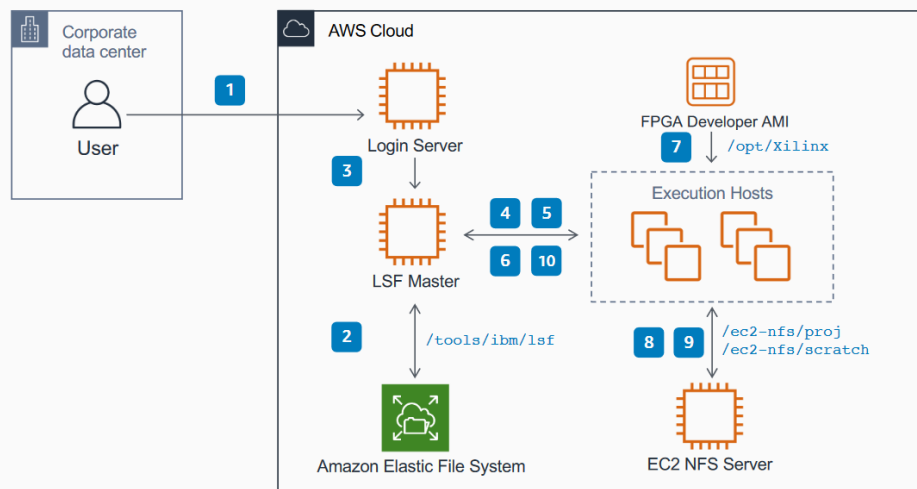
Workshop location on AWS Samples: <https://amzn.to/AWS-mfg-Sample>

EDA on AWS with IBM Spectrum LSF

Running EDA workloads on AWS with LSF Resource Connector

Workshop location is on AWS Samples:

<https://github.com/aws-samples/aws-eda-workshops/blob/master/workshops/eda-workshop-lsf>



- 1 User logs into the login server from from within the corporate network.
- 2 IBM Spectrum LSF binaries, configuration, and logs are read from and written to Amazon EFS.
- 3 User submits simulation jobs from the login server.
- 4 IBM Spectrum LSF provisions Amazon EC2 instances to satisfy workload in the queue.
- 5 Provisioned Amazon EC2 instances join the cluster as dynamic execution hosts.
- 6 Jobs are dispatched to new execution hosts.
- 7 Jobs load pre-licensed Xilinx Vivado Design Suite from FPGA Developer AMI.
- 8 Vivado loads example IP and design from /ec2-nfs/proj
- 9 Vivado writes job runtime data and results to /ec2-nfs/scratch
- 10 Amazon EC2 instances are terminated by LSF after jobs finish.



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AWS Reference Architecture

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