

AWS Architecture Monthly



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Agriculture

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Editor's note

Worldwide Tech Lead for Agriculture, Karen Hildebrand (who's also a fourth generation farmer) refers to agriculture as "the connective tissue our world needs to survive." As our monthly expert, she also talks about what role cloud will play in future development efforts in this industry and why developing personal connections with our AWS agriculture customers is one of the most important aspects of our jobs.

You'll also buzz through the world of high tech beehives, milk some data analytics-savvy cows, and see what the reference architecture of a Smart Farm looks like.

This month, we're also asking you to take a 10-question survey about your experiences with this magazine. The survey is hosted by an external company (Qualtrics), so the below survey button doesn't lead to our website. Please note that AWS will own the data gathered from this survey, and we will not share the results we collect with survey respondents. Your responses to this survey will be subject to Amazon's [Privacy Notice](#). Please take a few moments to give us your opinions.

[Take the Survey »](#)

I hope you'll find this edition of Architecture Monthly useful, and my team would like your feedback. Please give us a star rating and your comments on the [Amazon Kindle](#) page. You can [view past issues](#) and reach out to aws-architecture-monthly@amazon.com anytime with your questions and comments.

In August's issue:

- **Ask an Expert:** Karen Hildebrand, AWS WW Agriculture Tech Leader
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Annik Stahl, Managing Editor



What are the general architecture pattern trends for agriculture industry?

Agriculture is more than just an industry; it's the connective tissue our world needs to survive. No more so than recently, food and the supply chain that makes it possible are essential to our global wellbeing. As consumers, we desire a safe food supply now and for future generations, and that focus drives our obsession with our customers in the agricultural industry.

Agriculture customers cover a wide swath, as diverse as the food on our plates, and they are building unique solutions on AWS for their customers. When we at AWS meet with agriculture customers globally, we typically approach the industry based on the following:

- Heavy equipment manufacturers (tractors, sprayers, and combines)
- Production at scale (seed, chicken, pork, poultry, viticulture, and perishables)
- Food processing (meat, fruit, veggies, and meat alternatives)
- Genomics workloads (plant, aquaculture, and animal)
- Startups (venture capital or early stage)

The most rewarding part of working with agricultural customers is hearing the personal connections each individual has, be it to a generational farm, a favorite food, or a question of how something is grown/made. This personal connection is the most important aspect when we work with agriculture customers: we take the time to hear those stories and connect the architecture in a customer-obsessed way.

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

There are three key considerations when solving business problems for agriculture:

1. **Seasonality:** Customers like [Yanmar](#), [AGCO](#), and [Hexagon Agriculture](#) collect data from the machinery that passes across millions of hectares each year, but they do so in very spikey workloads. This means that the workloads are very geographically focused, expanding significantly when tractors are in the field and contracting just as quickly outside key agronomic windows. Most major agricultural regions of the world produce one cycle per year, some two. Hence, unlike other industries where you can iterate your minimum viable product (MVP) multiple times a year for feedback, in

agriculture there is one chance per calendar year to “get it right.” That’s why enriching data with historical data sets, such as satellite or imagery data (like that available on the [Registry of Open Data on AWS](#)) helps agricultural customers deliver an MLP to market.

The elasticity of the cloud and pay-as-you-go pricing are critical in agriculture, making designing for auto-scaling critically important. Intra-day spikey workloads are seen in dairy and processing plant workloads. Customers designing workloads for dairy parlors, such as [TINE SA](#) from Norway, or [CattleEye](#) in the UK, or [Halter](#) in New Zealand often have milking windows in which Internet of Things (IoT), quality, and production data all increase dramatically, while outside milking windows, that infrastructure is not needed and can be scaled down. A cost-effective system can be best designed by understanding the seasonality, even within a day.

2. **Connectivity:** Agriculture, is by nature, done in low population density areas and as a result, has been largely underserved in connectivity. In a truly disconnected state, which globally many agricultural settings are, options may be limited to devices like the like [AWS Snowball Edge](#), recently launched [AWS Snowcone](#), or creative edge deployments with over-the-air (OTA) updates requiring manual intervention. Key considerations for customers are the connectivity type (LoRa, Cellular, Satellite, WiFi, BLE), the latency of an action being taken on new data, and the frequency of model re-training when an artificial intelligence (AI) and machine learning (ML) component is part of the architecture.
3. **Sustainability:** Understanding customers in agriculture globally is to know the deep inter-generational model that motivates farmers desire to run sustainable businesses to hand down to the next generations. The largest assets for a farmers are their land, their livestock, and their operation. To run a sustainable business that produces our collective food supply, farmers need the latest knowledge, insights, and technology. In a recent workshop, a customer clearly articulated the intentions of the industry as being driven to “leave the world better than we found it,” whether that is soil health, connecting rural farmers in Africa (like the approach taken by [WeFarm](#)), efficient supply chains, or raising animals humanely. Customers like McDonald’s are partnering with veterinary research institutions like the [Foundation for Food and Agricultural Research](#) (FFAR) to gain insights on how farms and barns can better understand the health of their poultry flocks. Startups like [Aquabyte](#) are bringing innovation into aquaculture using computer vision to detect salmon lice in an effort to improve the health of the pen.

Do you see different trends in agriculture in the cloud versus on-premises?

Our customers are sending strong signals around edge inference, data enrichment, traceability, and genomics. The consistency around the value proposition in agriculture remains the same, the industry is highly time dependent and seasonally dependent. The elasticity of the cloud and the ease of auto-scaling are key differentiators to on-premises workloads. Having success on-premises often means over-provisioning for peak or accepting the inability to scale to demand. As the global supply chain flexes to meet the changing environment, agriculture customers are looking to technological innovation that is nimble and agile where costs are “pay-as-you-go.”

Migrations are critical workloads where our partners have helped customers succeed when building on AWS. For instance, SAP migrations can often take several years. Lemongrass has helped several agricultural customers deploy their SAP workloads on cloud infrastructure between growing seasons, moving [Growmark](#) in four months, and Royal Friesland Campina in less than nine months. [AgriDigital](#) chose AWS to migrate their .Net workloads from Azure to AWS, and were able to achieve 50% improvement in application response times while lowering licensing costs. These successful cloud deployments may begin with cost savings in mind, they but often lead to resiliency and scalability improvements.

What's your outlook for the agriculture industry and, what role will cloud play in future development efforts?

AWS is uniquely positioned to empower agriculture, to scale with the availability and global presence necessary. Be it small holder farms where blockchain technologies are unlocking commodity markets and ensuring payment upon delivery like Hara, or traceability for the discerning consumer of perishable products with a temperature controlled supply chain. The services and solutions we have today will have to expand to meet our customers' needs from connectivity, geospatial analytics, and genomics to robotics, all give way for new approaches to grow.



Karen Hildebrand, PhD, is the World Wide Tech Lead for Agriculture at AWS. She is a fourth generation farmer with over 15 years of leadership experience at Fortune 500 companies in Data Science and cloud adoption initiatives. Prior to AWS she ran a startup focused on precision agricultural practices and educating the next generation of farmers, and is passionate about closing the gap between producer and technology.

AWS Customer Success Story:

Tine & Crayon Revolutionize the Norwegian Dairy Industry Using Machine Learning on AWS

About TINE

[TINE SA](#), Norway's largest dairy cooperative, is creating new ways to combine technology, animal science, and age-old knowledge to create better dairy products. TINE is Norway's largest producer, distributor, and exporter of dairy products with 11,400 members (owners) and 9,000 cooperative farms.

Data analysis can lead to happier cows and better quality milk

Mette Øyen Roald, director for radical innovation at TINE, says the Norwegian farmers who work with TINE are technologically savvy and have understood the value of collecting data on their animals and dairy production for decades. "Over time and with technological advancements, TINE has conducted structured research to examine the 'optimal cow' for dairy production using collected data," she says. "We've found that focusing on the individuality of a cow enables farmers to discern when each cow is happy, stressed, anxious, and healthy. When our animals are healthier and happier, the quality of their milk is improved, which allows us to make even better dairy products while improving the welfare of the animal."

As TINE considered the future of dairy production at both the farm and national level, its data science team realized there would be changes to the breadth and depth of its data sources, types of data, and data analysis capabilities available to develop decision-making tools for farmers to use in production.

Working with Crayon and AWS technologies for better predictions

To identify the technologies and platforms that would help improve TINE's insights, predictions, and analyses, TINE brought in the experts at [Crayon](#), an AWS Partner Network (APN), Advanced Consulting Partner, and AWS Machine Learning (ML) Competency Partner. Inmeta, a subsidiary of Crayon, worked directly with the customer, providing ideas for data-driven innovation.

“We deliver expertise in three distinct areas through our practice: AI consultancy, data engineering, and data science,” says Lars Joakim Nilsson, managing director of advanced analytics and big data at Inmeta. “When we began working with the TINE team, we wanted to help them identify the business challenges they could address by using ML. After starting by gathering feedback and insights from farmers themselves, TINE then identified the importance of helping farmers become more autonomous and self-driven by monitoring all aspects of the farm, including continuous monitoring of each individual cow.”

Resource-intensive processes like running its applications and storing data on-premises wasn’t a viable option for TINE if it wanted to continually evolve as a data-driven organization, so TINE, working with Crayon, conducted a technology review to identify a cloud provider that could help them move into the modern technology space.

“Based on the analysis, the TINE team chose to build on AWS,” says Nilsson. “They felt that the continuous innovation of AWS in technologies like IoT and ML, its cost models, and its flexibility would empower them to speed up their own innovation.”

The teams from TINE and Crayon first focused on prediction of milk production and deliveries from each cow, farm, and national level with a 24-month forecast—information that is critical for planning dairy production capacity and logistics.

“We knew that we had collected and would continue collecting data that could be used for good. We started with one simple question when evaluating the evolution of our organization and the technology we use: What benefits the farmer? We wanted to develop the next generation of tools for farmers to enable data analysis and decision-making that could lead to happier cows and better quality milk,” says Volden.

TINE knew it would have to change its approach to data and technology by becoming more data driven as an organization; that, in turn, would lead to better predict milk production and surface key data points related to a cow’s health and the quality of milk produced. Historically, TINE has used basic models to attempt to predict milk production and delivery per farm but faced problems with production predictability over different periods of time. This lack of long-term visibility and predictability could lead to significant problems. For example, in 2011, the entire country experienced a butter shortage because farmers underestimated the fat content that would be needed as a part of that year’s production.

([Read the full story](#) to learn more about the multi-phase approach for greater predictability, how it led to better treatment of animals, and more.)

Video: Crayon Helps TINE Dairy Co-Op Leverage AWS Machine Learning

TINE, a Norwegian dairy cooperative owned by farmers, worked with AWS Machine Learning Competency Partner Crayon to gather more than 2.5 million data points from the co-op's cows to improve their health, fertility, and production. Crayon's technologies helped TINE use ML to increase production, and the happiness of its cows.

<https://amzn.to/AWS-agri-crayon-video>





Prior to Beewise, the latest beekeeping technology—if you could call it that—was created in the 1800s. The “tech stack” was a literal stack of wooden boxes called a beehive, filled with honeycomb, not to mention bees. To harvest honey and check the health of their colony’s residents, beekeepers would have to go to a hive, don protective gear, send a bit of smoke into the hive to calm the buzzing little buggers, and then examine the findings.

Most beekeepers around the world still use this process today. Beewise hopes to change that, using the actual latest technology, including artificial intelligence and advanced robotics.

Updating a 150-year-old process

The automation of manual labor isn’t new, but in the world of beekeeping, it is practically unheard of. For Saar Safra, Beewise’s CEO and co-founder, the more he learned about commercial beekeeping from his co-founder, Eliyah Radziner, the more the numbers didn’t add up. “Globally, 71% of all fruit, vegetables, seeds, and nuts are pollinated by bees,” he says. “Think about avocados and almonds and cucumbers and berries and coffee and cotton. We’re dependent on bees—they are essential to our global food supply.”

Yet beekeepers must physically go to fields that are sometimes hours away so they can check on the health of their colonies and harvest their honey. To a strategic thinker and tech entrepreneur like Safra, this was a clear inefficiency and an obvious opportunity to use technology to improve not only the health and output of bees but also the health of the planet.

Healthy hives

Safra’s plan for beehive optimization is two-fold: keeping bees healthy and increasing the amount of honey and pollination they’re able to produce.

Between 30% and 40% of bees die every year worldwide, so real-time feedback on colony health is crucial. Beewise’s hives, called Beehomes, boast precision robotics, cameras, computer vision, and AI to help large-portfolio beekeepers monitor the internal workings of their colonies from afar.

Special sensors flag diseases, pests, hunger, and more. Commercial beekeepers, who have anywhere from 1,000 to 10,000 hives, get pinged on an app when a poor condition is discovered. “They can see the entire hive, they can see what we identify, and they can apply our treatment, or use the data to come up with their own,” Safra says.

Honey at scale

A healthy bee is a productive bee. The more productive bees in the world making honey and pollinating crops, the more secure the global food supply.

Safra and his colleagues know that in such a numbers game, true scale can only be achieved when hives run autonomously. To that end, Beehomes detect when honey is ready to be harvested, do so automatically, and then alert beekeepers when it’s time to collect the windfall. Each of Beewise’s six-by-eight-foot hives house 40 boxes, and each box can hold around 50 thousand bees, together totaling about 2 million moving, buzzing bees per device.

The 13-employee startup, which started in August 2018 and raised a seed round in mid-2019, is almost exclusively focused on R&D, says Safra. The team has experts on applied math, physics, machine learning, distributed systems, convolutional neural networks, and more.

To manage the complexity behind an automated beehive, the experienced team at Beewise turned to AWS, per Safra.

“Having built various startups over the years, I’ve been a big fan of AWS for years now. Each company had varying needs, but AWS always seems to have them covered. At Beewise, we need to be able to reliably connect with our network of distributed in-field boxes that are all interconnected. The amount of data each box generates is immense. Our team leverages services including AWS IoT Core and AWS IoT Device Management to securely connect all the devices, as well as RDS, Elastic Beanstalk, and SageMaker to manage and analyze the mass amount of data.”

So far, Safra says, Beewise has seen success in helping bees live longer, healthier lives. “They pollinate better and they produce more honey. And for us, there’s no greater satisfaction, because we’re doing well by doing good.”

[See the architecture.](#)

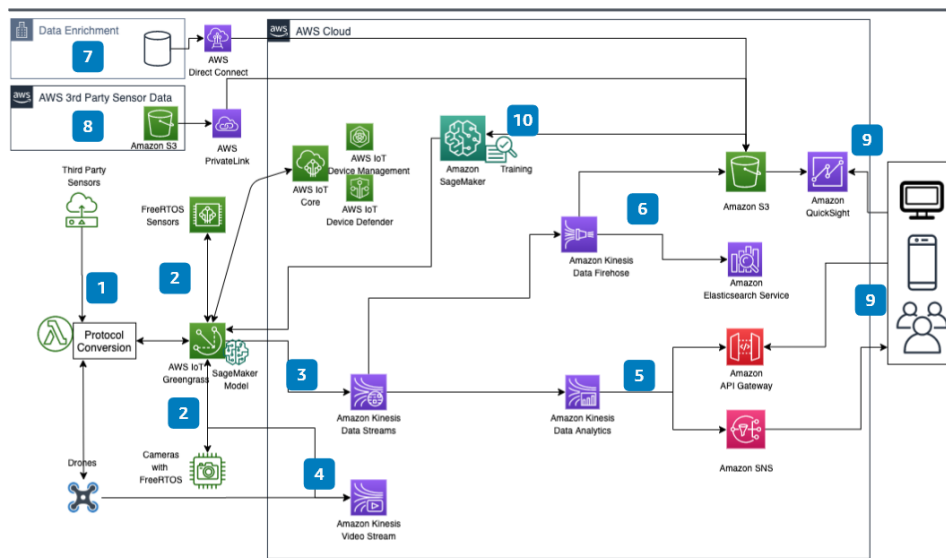
Reference Architecture

Smart Farm. Enabling Sensor, Computer Vision, & Edge Inference in Agriculture

See a [larger image](#) of the reference architecture online.

Smart Farm

Enabling sensor, computer vision, and edge inference in agriculture



- 1 Third-party sensors or drones not using FreeRTOS send data through AWS Lambda for protocol conversion.
- 2 Sensors or cameras running FreeRTOS send data to AWS IoT Greengrass providing protection from intermittent connectivity.
- 3 AWS IoT Greengrass streams enables ingestion from edge devices to Amazon Kinesis Data Streams.
- 4 Use real-time video via Amazon Kinesis Video Streams for streaming and replay of video content.
- 5 Derive real-time insights with Amazon Kinesis Data Analytics and notify users via Amazon SNS.
- 6 Enable analytics with Amazon Elasticsearch Service and use Amazon S3 for a data lake strategy.
- 7 Transfer owned data like planting records or farm finances securely into your data lake with AWS Direct Connect.
- 8 Consume data from a sensor ecosystem hosted on AWS securely with AWS PrivateLink.
- 9 Empower users with insights delivered via Amazon API Gateway or visualizations with Amazon QuickSight.
- 10 Build and deploy Machine Learning (ML) models for edge inference with Amazon SageMaker.



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AWS Reference Architecture

AWS Customer Success Story:

Farmobile: Empowering the Agricultural Industry through Data

With each step in the planting and harvesting process, farmers collect massive amounts of data that can provide individuals and companies with insights into what's produced and how to make it better.

However, farmers are frequently hampered in their efforts to curate their content, which can help drive crop-growing improvements, create new revenue streams through the ability to organize, visualize, and license up-to-date field data, and provide the agricultural industry with real-time insights.

"Agriculture is one of the largest and most important markets in the world with one of the least amounts of digitalization," says Jason Tatge, chief executive officer at Farmobile, an opinion supported by the McKinsey Global Institute's Digitization Index, which shows that agriculture is the least digitized of all major industries.

The agriculture industry has widely adopted precision technologies to drive farming efficiencies and outcomes. But data generated from machines has not been consistently collected and stored in order to help drive improvements for farmers and the agriculture industry. Technologies such as IoT, cellular connectivity, and cloud computing help generate large amounts of precise data, but there are gaps in connectivity to data repositories with data standardization.

Farmobile aims to change the industry's approach to, and interaction with, data by making it one of a farmer's most valuable commodities.

Driving new revenue streams for farmers

Consequential decisions must be made when growing a crop, such as: What type of crop are you going to plant? How many seeds per acre should be planted? What type of applications are being used to prevent yield loss or promote yield growth? The outcomes stemming from these decisions as well as events outside a farmer's control, such as weather, directly affect a crop's success.

Farmobile believes that helping farmers and other stakeholders in the agriculture industry

to visualize and use real-time farming data can drive better “in season” decision-making. Farmobile’s hardware is an in-cab IoT device called a passive uplink connection (PUC) that’s installed on farm machinery that automatically collects machine and agronomic data every second. Data is securely transferred to Farmobile’s data repository and standardized into Electronic Field Records (EFRs), capturing individual data layers field-by-field. Farmers can view the data they’ve collected via smart device, computer, or laptop with the Farmobile DataEngine User Interface (UI) and App.

Farmobile seeks to help farmers not only use data collected by its PUCs as a learning tool, but also an additional source of revenue. So the company created the Farmobile DataStore as a revenue sharing model to provide farmers an opportunity to sell single-use licenses of data to interested buyers.

Using Farmobile empowers farmers to drive new revenue sources and valuable insights from the data they collect every day

“We’re empowering farmers through data,” says Tatge. “We help farmers use data to understand best practices and increase productivity and profitability. And we help farmers organize the data they produce in an interoperable way for others to accelerate agriculture’s learning base and understand how crops interact with their environments and the soil.”

After evaluating its business model and long-term growth goals, Farmobile transitioned its infrastructure to AWS for speed and efficiency. It uses Intel’s Hyperledger Sawtooth distributed ledger for the Farmobile DataStore to give farmers transparency and control over their data transactions with approved buyers. Blockchain tracks the actual transaction, including account set up, creation, confirmation, execution of the offer, and delivery of the digital asset.

Using AWS for first-ever data store for farmers

“When I came on board, our IT infrastructure was on physical hardware that needed to be upgraded for the long-term vision of the organization,” says Chris Schibi, chief technology officer at Farmobile. “Buying hardware when your business is seasonal, like farming, doesn’t make sense. We aim to become a global provider and needed assurance that we can scale on a level required to increase our volume over time.”

After evaluating multiple platforms, Schibi re-architected the Farmobile application on AWS. “When I started looking at short- and long-term priorities for Farmobile such as blockchain development, machine learning, geospatial analytics, scalability, security, and disaster recovery models, the decision to go with AWS was straightforward,” says Schibi. “AWS is

aggressive in its investment in serverless technologies and DevOps best practices and has built a strong ecosystem of solution partners. AWS security and compliance standards are also key for us. When I looked to our future needs, migrating to and building on AWS was our choice for growth.”

Farmobile took a three-phase migration approach on AWS, starting with a proof of concept (PoC) that lasted three months. “We took a step back and said, ‘What are the foundational technologies and services within AWS we want to build on to deliver an optimized, scalable, secure, and reliable solution for the agriculture industry?,’” says Schibi. The team decided to migrate its existing system as-is to AWS to ensure it could handle volume projections for harvest in 2017, while simultaneously designing its new Farmobile DataEngine platform and blockchain solution to run on AWS.

Farmobile uses multiple AWS services to run its application, including AWS IoT and Kinesis Streams to collect and process data collected from PUCs. The new system is built for speed, efficiency, and scalability, and can handle tens of thousands of concurrent PUC devices in use during peak periods of seasonality.

By running the Farmobile DataStore on AWS with elements of Intel’s Hyperledger Sawtooth distributed ledger platform, farmers can seamlessly sell single-use licenses of their farm data to buyers while keeping the farmer’s identity completely anonymous in the process. Farmers have full visibility into the identities of potential third-party data buyers, such as agronomists, equipment producers, and ag retailers, and can decline an offer to anyone. “We’re building trust and helping farmers monetize their data in a way in which they’re comfortable,” says Tatge.

Helping farmers on their own terms

For Farmobile, the launch of its new exchange based on blockchain is only the beginning. “It’s foundational technology that will continue to grow in adoption and allow us to gain more trust within the entire industry,” says Tatge. Next steps for the team include migrating more of its infrastructure to a microservices-based model on AWS and expanding its global reach.

“Our mission has always been to do whatever we can to keep farmers farming and rural America strong,” says Tatge. “I believe the technology we’re building, powered by AWS, is vital for the future of agriculture. Using data consistently and in real-time impacts many stakeholders in the industry. Through precision data, farmers gain insights on micro and macro levels that can be easily tracked, disseminated, and used. Companies providing services and products to farmers become better informed and more efficient in their ability to improve their offerings.”

Read the full story online.



By Tanmoy Sen and Arun Viswanathan

[Halter](#), based in New Zealand, is an agri-tech original equipment manufacturer (OEM) that focuses on cattle herd management. Halter creates GPS enabled, solar powered smart collars for cows. The collar hardware allows farmers to interact with an easy-to-use app to remotely set geographic boundaries for cattle or virtual fences. Farmers use Halter's system to avoid physically herding cows, maximizing farmer time and productivity.

Halter uses microcontrollers (MCU) in their cow collars to shift cows, collect and send data to AWS IoT, and upgrade firmware and features over-the air (OTA). The connectivity protocols used, LoRA and Wi-Fi, are well-thought out. LoRA provides low power, low data rate connectivity for small sensor data packets in rural areas with spotty cellular connectivity. On the other hand, Wi-Fi provides high bandwidth connectivity to quickly update device firmware.

What problem is Halter solving for farmers?

Halter allows farmers to remotely manage and monitor their herd, improving their work-life balance, providing tools to precisely manage farm operations and maximize milk production. The IoT data acquired from the cows can be fed into machine learning models to enable cattle management in real time and in production optimization strategies such as calving likelihood predictions as well as geo-fencing capabilities and animal movement patterns that ensure animal health and dairy productivity safety via temperature monitoring. Halter is able to perform machine learning through its data ingestion and enrichment pipelines with continued innovation and areas of opportunity available to its Data Scientists through a data lake strategy.

What was Halter's problem in building a solar powered cow collar?

1. High development time and cost: Updating millions of IoT devices with security patches, bug fixes and new features using the traditional method of calling technicians is expensive and impractical. Halter chose a cloud based over-the-air (OTA) update approach, but soon found it challenging and time-consuming to design

an end-to-end, secure, reliable, and trusted OTA solution for their microcontroller-based devices with limited compute power and memory. Halter wanted to send real time log shipping, diagnostic commands with a simple scripting interface. It is challenging to design a solution that stores device logs locally, only sending logs to the cloud when the device is turned on.

2. High power consumption: The cow collars are solar powered 24/7, with a very tight power budget. It's important to minimize power consumption in the microcontrollers and radios that constitute the cow collars.

Machine learning: The acquisition of IoT data and machine learning enables cattle management in real time and in production optimization strategies such as calving likelihood predictions as well as geo-fencing capabilities and animal movement patterns that ensure animal health and dairy productivity safety via temperature monitoring. Halter is able to perform machine learning through its data ingestion and enrichment pipelines with continued innovation and areas of opportunity available to its Data Scientists through a data lake strategy.

What is FreeRTOS?

[FreeRTOS](#) is an open source, real-time operating system for microcontrollers that makes small, low-power edge devices easy to program, deploy, secure, connect, and manage. There is no charge for using the MIT-licensed FreeRTOS, but customers may incur charges with FreeRTOS if their applications utilize other AWS services or transfer data.

Read the [full blog post](#) to learn about how FreeRTOS solved the problem for Halter and how other agriculture customers can benefit from FreeRTOS and other AWS service.

Related Videos

DuPont Pioneer: The Sun'll Come Out Tomorrow: Agronomy in the Cloud

Encirca Services by DuPont Pioneer partners with farmers in the field to help them deliver optimal crop yields. Watch and learn how they built a cloud based collaborative platform for farmers, leveraging AWS Step Functions, Amazon ElastiCache, EC2 Spot Fleet, and more to simulate crop growth and manage soil nitrogen levels.

<https://amzn.to/AWS-agri-dupont-video>

mPrest & Netafim: Smarter Irrigation with AWS IoT Core

Aviad Kaminsky from mPrest shows how his company helped Netafim build a multi-tenant SaaS solution for irrigation systems that uses AWS IoT Core and other AWS services. We'll explore how they leverage the LoRA and MQTT protocols along with on-site hardware units to handle intermittent connectivity and offline data collection. We'll also see how they use AWS IoT Core, S3, and Kinesis to capture and store data, plus other services such as Amazon Redshift to provide analytics.

<https://amzn.to/AWS-agri-smart-irrigation>

Veolia: Using Machine Learning for Water Filtering Membranes Maintenance

The partnership between AWS and Veolia Water Technologies produced unprecedented results during an unprecedented time in our world's history in eight short weeks. Anticipating when to clean or change water-filtering membranes in desalination plants is complex. Together, Veolia Water Technologies and AWS developed a prototype to optimize the timing of the maintenance. Historical time series data was fed into the Amazon DeepAR algorithm using Amazon SageMaker service, to learn from previous patterns and predict the future evolution of fouling indicators such as differential pressure or conductivity of the

water. This allows Veolia Water Technologies to reduce costs and prevent downtime while improving the quality of the water produced. The prototype is already in beta testing with plans to productize in the Middle East. It was developed during the COVID-19 pandemic, and the teams worked collaboratively from their home office. These results couldn't have been realized without the technical experience, absolute trust, and dedication of both teams to achieve one goal: an uninterrupted clean and safe water supply.

<https://amzn.to/aws-agri-veolia>