LoRaWAN®

THE FARMING OF TOMORROW IS ALREADY HERE: HOW LoRaWAN® TECHNOLOGY SUPPORTS SMART AGRICULTURE & PRECISE ANIMAL PRODUCTION

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INTRODUCTION

Recent extreme incidents around the globe—famine, climate change, wildfires, tornados, droughts, floods, and pandemics—remind us that farmers are facing two major challenges: to feed the planet and sustain the environment. The balance between conducting intensive or extensive production to feed an ever growing population and respecting our environment and usage of natural resources is a line not to be crossed. In other words, Earth's resources are finite and we have to learn how to respect the planet if we want to keep living on it.

Meanwhile, in the last 50 years, we have witnessed major changes in agricultural processes leading to what we call "precision agriculture", or Smart Farming. Precision agriculture means that animals get precisely the food, care or treatment they need at the right moment, determined with great accuracy thanks to the latest technology. Precision agriculture allows actions to be taken per square meter or even per plant for optimal production and sustainable crops.*

In animal production, farmers have to increase their daily production with more environmentally friendly inputs and less manpower while ensuring less greenhouse gas emission, animal welfare, and answering the customer's need for complete traceability and quality assessment

from farm to fork. With approximately 1.5 million cattle and nearly 978 million pigs being bred around the world (source: http://www.fao.org/faostat/en/#data/QA), these complex demands cannot be met without the help of new technologies, such as the Internet-of-Things (IoT).

Here are a few examples of the wide variety of use cases implemented today:

- Connected scales can randomly weigh the animals in the building to get an idea of their average weight. Individual tracking is too expensive in this type of production and would not make sense as it is impossible or too costly to implement an individual correction per animal.

- In the swine industry, individual monitoring solutions can be implemented on sows for their welfare or to optimize the reproduction by pig/hog, but will generally be monitored at the group level; ambient monitoring, noise, behavior analysis, unless associated with automatic handling systems to scale and sort the animals according to, for instance, their weight.

- For beef production, when animals are only handled a couple of times per year and are left grazing in extensive pastures for most of the time, tracking solutions become very useful to monitor the location of the herd, to identify abnormal behavior of an animal compared to the herd or, in some cases, to detect theft.

Moreover, besides animals, there are plenty of assets to track on farms. From preventive maintenance on

*For more information on this, read our White Paper: WHY LoRaWAN IS THE LOGICAL CHOICE FOR CROP PRODUCTION MONITORING SOLUTIONS

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machinery, tools, and trailers to logistical optimization for fuel tanks, water tanks, sensitive products. Several security issues can also be attended to by door/gate or fence monitoring.

As cellular networks usually do not cover rural areas very well, the huge flexibility of LoRaWAN in covering buildings or large fields make this the de facto technology for Smart Agriculture applications.

In this White Paper, we give our readers an overview of real case studies of what can be achieved with LoRaWAN applications in the poultry, swine, beef, and dairy cattle industries. Several LoRa Alliance® members describe how their solutions help track and optimize animal production to make a farmer's jobs more efficient. In addition, we'll address bee monitoring solutions as bees play an essential role in the pollination of large fields, such as in California's almond and pistachio groves, where monitoring the activity of beehives becomes essential to ensure a quality production.

▮ Poultry Farming	▮ Pig Farming	▮ Cattle Farming	▮ Beekeeping
Tektelic & PrognostiX	Zenseio	AWS	Zenseio
Webee	Tensor IoT & AWS	Pessl Instruments	Beewise (AWS)
	Webee & Panasonic Food Retail Digital Center	FeedLive	
		Miromico	
		Chipsafer & Flex	
		smaXtec w/Kerlink + Repeater + Climate Sensor	
		Caravan Tech w/ Orbiwise	

POULTRY FARMING

TEKTELIC
communications

Real-time monitoring of environmental and health parameters with TEKTELIC & PrognostiX UK

PrognostiX designed its Poultry Sense IoT solution to capture accurate, real-time insights into birds and environmental conditions on poultry farms to improve bird performance and welfare. They use sensors for monitoring temperature, humidity, water consumption, and for wireless weighing platforms. Poultry Sense combines a wealth of evidence and expertise from specialist vets, engineers, and data analysts to bring together real-time data across both environmental and health parameters. The wireless system feeds accurate, live data into a bespoke analytics platform that uses artificial intelligence to produce insights for better-informed on-farm and supply chain decision making.

PrognostiX utilizes TEKTELIC's (Calgary-based supplier of LoRaWAN gateways and devices) KONA Macro and Micro Gateways to provide the LoRaWAN connectivity needed for their innovative Poultry Sense solution. LoRaWAN is the ideal technology to provide cost-effective, scalable, long-range, low power, and secure bi-directional communication between devices and gateways. The KONA Macro IoT Gateway is designed to be compact and lightweight, and is targeted at rugged outdoor installations which require a small form factor and low power consumption. The KONA Micro IoT Gateway was built for indoor applications that require Always On connectivity for their IoT solutions, and comes equipped with reliable LTE backhaul and a built-in four-hour battery backup to ensure continuous data collection.

webee®

Increasing animal fertility rates with Webee

Webee, a California-based startup providing an end-to-end IoT toolset that allows connectivity through sensors and devices, has partnered up with a local systems integrator

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to improve egg hatching results to ensure an 88% birth rate for large scale poultry producers. The solution uses LoRaWAN sensors to monitor industrial egg incubators and capture critical real-time information on temperature, humidity, doors (open/close), ventilation and environmental conditions.

LoRaWAN, the obvious choice for Webee, enables one gateway to cover a very extensive area including multiple incubators without the need for complex installations, and low consumption sensors that will last for years without a battery replacement. Therefore, the customer doesn't need to purchase expensive new incubator equipment and sees no disruption in the current process. This solution provides the producer with real time actionable insights in the form of alerts, like SMS, in cases when the temperature is out of range or the doors are left open for several minutes. The producer was also able to see all information in real time, combining the data coming from SAP, the LoRa sensors and the manual forms filled by employees, which enables them to track progress, find failures that result in a lower egg hatching rate and forecast production. Webee's No Code IoT Solution Builder, was key to integrating the data from the LoRa sensors, SAP and other sources, and allows a complete customization without needing to hire software engineers.

SWINE/PIG FARMING

A platform for animal health, production and environmental monitoring with Zenseio

Similarly to other animal production, the pork production industry is extremely sensitive to herd health. Strict processes and mechanisms are necessary to avoid viral infections that can result in health diseases transmitted through the animal, as well as substantial losses for producers.

Animals that are well cared for lead a higher quality of life and are healthier, reducing the use of antibiotics and increasing meat quality.

For example, LoRaWAN Alliance member Zenseio, founded in 2014 in Texas, developed an industrial-grade hardware platform for smart agriculture applications where durability, long-range and low-power are key requirements. In addition to Zenseio's versatile LSMP and CSMP telemetry devices for irrigation and water management, its LoRaWAN sensors are used for monitoring feed and water fill levels, as well as environmental conditions to alert farmers to adverse or stressful conditions that may be experienced by hogs.

Furthermore, Zenseio devices are piloted to help automate the recordkeeping of animal conditions, caretaking routines, and input costs. Zenseio sensor devices are designed to provide years of service in tough environments. Since there are many sensors of various types inside several metal and concrete buildings, LoRaWAN radio technology allows reliable and cost-effective coverage with just a single gateway, even in remote rural areas with spotty cellular coverage.

Animal tracking with Tensor IoT and AWS

Tensor IoT and Amazon Web Services have collaborated on a solution developed for animal management that accurately tracks animal counts. One of these solutions is object detection that can accurately identify weaned pigs. An algorithm uses detections to track weaned pigs across the frames to increase/decrease the count based on pigs leaving/entering the view respectively. An AWS Greengrass infrastructure can be deployed and run inferences at the edge. Finally, a website shows the video and counts in real-time for easy readable data.

Animal and supply chain monitoring and tracking with Webee and Panasonic Food Retail Digital Center

Webee, in collaboration with Panasonic Food Retail Digital Center (FRDC), collaborated to test an end-to-end solution to improve pork production and obtain traceability to track meat from production to the grocery store. Powered by IoT, AI, and blockchain, LoraWAN sensors were installed across pig farms to track vital signs (via ear tags attached to over 600 pigs per zone), control environmental conditions such

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as ventilation, air quality, lighting and energy consumption, and track and trace meat during transportation. To accomplish the latter, Webee used LoRaWAN asset and vehicle tracking sensors installed in pallets, and Panasonic CRBs (cold roll box) to monitor conditions, shock, temperature/humidity and location. The project also included the deployment of monitoring sensors in retail stores to maintain meat temperature end-to-end, from farm to table.

CATTLE FARMING

Modern dairy cows are bred and fed for high productivity (with udders that are highly productive bioreactors) and whose high metabolisms produce a lot of heat, which must be transferred away from the cow as farmers are increasingly aware of their animals' susceptibility to heat-stress. Optimum temperatures range below 18°C, but if the temperature rises above 24°C, significant reductions in herd productivity can be anticipated. In addition, there is a shortage of quality labor in dairy farming as it is challenging for farmers to find skilled workers. Coupled with a lack of precise tools to manage their operations, farmers are not generating as much milk (revenue) as they could.

Several companies have developed solutions to monitor the welfare of cattle.

aws

Cattle and farm management via smart devices with AWS

Amazon Web Services (AWS) gives farmers the ability to shift and manage their herd remotely from a smart device. Each cow is fitted with a smart collar which is coupled with a mobile app. This allows the farmer to create virtual paddocks, physically shift cows, and monitor the well-being of each cow. The AWS Customer can easily push new functionality to customers by updating the app and pushing a firmware update using OTA to the smart collar. The AWS Customer gives farmers back control of their assets, their farms, and their lives. The system reduces labor requirements, increases milk production, makes compliance easy, and improves animal welfare.

Pessl INSTRUMENTS

Effective, comprehensive farm monitoring with Pessl Instruments

Pessl Instruments has been offering a complete range of wireless, solar-powered monitoring systems under the brand METOS operating in various industries, including agriculture.

LoRaWAN low power radio communication allows for the placement of numerous sensors throughout the dairy farm. With all data transmitted through one gateway, connected to the farm's internet connection, the cellular cost is reduced to nothing.

This enables monitoring temperature and relative humidity in different areas of the stables—important at organic dairy farms. Several LoRATH devices, measuring temperature and relative humidity, have been placed in stables. To monitor moisture, soil and food temperature, a LoRAIN system has been placed in the pasture or free-range area of the farm. Mobile apps for Android and IOS allow farmers to access the LoRaWAN data from wherever they are. Models for the well-being of the animals are calculated on the website. The outputs are available for weather forecast and for measured data.

The use of LoRaWAN technology allows a highly cost effective and nearly real-time monitoring of environmental issues on dairy farms. By using the internet, it permits fast warning if a stress problem (i.e. heat stress) occurs. The monitoring of outdoor weather with the help of LoRaWAN technology results in optimal harvesting and cattle feed.

itk PREDICT AND DECIDE

Optimizing cattle health and well-being for cattle with ITK's FarmLife

Feed'Live, a feeding disorder detection service for cattle developed by ITK, has enabled cows to be treated in record time. Thanks to a connected collar, disorders can be detected four days earlier, leading to faster recovery. Furthermore, it can detect limping as well as effective treatment provided to the cow by the farmer. The IoT technology's proven advantages for smart agriculture, including long range communication and ultra-low power

consumption, were key characteristics for ITK to develop its cattle monitoring sensors. LoRaWAN devices' flexibility in deployment makes a key difference for connecting animals and offers the potential for a significant ROI.

Livestock location tracking with Miromico

Asset tracking is one of the most promising verticals of Internet-of-Things (IoT) and challenging in implementation from a technological point of view. Determination of geolocation parameters are power hungry and the development of integrated sensors requires novel solutions. Semtech recently introduced the first product of its new LoRa Edge platform that will enable indoor and outdoor asset management. The LoRa Edge multi-technology asset management solution (LR1110) is a game-changing geolocation solution that significantly reduces the cost and complexity of locating and monitoring IoT assets. The new module of Miromico FMLR-LR1110-X-STL0Z is based on the LR1110 chip of Semtech and allows fast prototyping. Miromico is currently working on a proof-of-concept (PoC) using the FMLR-LR1110-X-STL0Z module together with its partner Compsesa. Within the PoC, sensors are developed to monitor around 15 thousand cattle in Ecuador.

Monitoring movement and defining geofencing areas with Chipsafer and Flex

Chipsafer, founded in Uruguay in 2013 and it moved its headquarters to Singapore in 2020, developed a product suitable for volume manufacturing. The design iterations included multiple stages of DFX which incorporates Design for Manufacturing (DFM), Design for Testing (DFT), and Design for Cost (DFC). After further analysis, it was clear that LoRaWAN would be the best choice for Chipsafer in terms of range, power consumption, and cost for rural areas.

Using Chipsafer's portal, a farmer knows where his/her animals are at all times, can access insights and actionable information to better manage the herd and can define geofencing areas to monitor the movements of the animals.

The farmer will receive warnings if cattle leaves the specific area or if there is any abnormal movement. Once detected the farmer receives detailed information about the animals and can immediately react in the most appropriate way.

Chipsafer collaborated with Flex to develop a hardware solution for the data collection. Flex has five decades of experience creating devices, and deep understanding of technology which helped guide Chipsafer to choose the most suitable technologies for its use case.

Farmers now monitor their cows from the inside with smaXtec

In the last few decades, herd sizes, farms, and their structures, have changed significantly. This does not always allow for the ideal level of individual animal care. Price pressure is constantly increasing and production efficiency is becoming even more important. Consumers tend to be more sensitive about animal welfare, from where their milk comes from to the conditions in which cows live. That's why farmers have started using technologies like smaXtec for support.

SmaXtec was founded as a research project and is now a technology leader in its field. The company has collected over 5 billion data points on cows and sold 70,000+ pieces. Their unique device, in the form of a bolus, constantly measures inner body temperature, activity, and pH values in the rumen, the most accurate point in the dairy cow's body. The system informs farmers about signs of heat and calving, and diseases are detected several days prior to clinical symptoms.

Furthermore, this allows for early treatment and a drop in antibiotic usage of up to 30%. The system includes boluses, as well as the carrier grade Base Station provided by Kerlink, Repeater, and Climate Sensor. The hardware is connected via LoRaWAN, making continuous data transmission possible. The partnership with Kerlink, a world-leading LoRaWAN infrastructure provider, is essential to smaXtec in order to scale the solution all around the world with technically proven solutions at minimum risk. The data collected by the bolus is transferred to the Kerlink Base Station from where it is uploaded to the cloud. Farmers receive notifications on their smartphones if

measures need to be taken, making their daily work easier and more efficient.

A comprehensive ecosystem for tracking and monitoring both cattle and farm with Caravan Tech

Caravan Tech is an ecosystem of devices that were created based on the needs and challenges in the livestock sector. Featured products include the Ear Tag (Caravan Tag), the intra-ruminal bolus and the Caravan Chat. The first two devices transmit vital animal data used for the total management and control of livestock on a farm, thus significantly improving its overall performance. Caravan Chat is a unique chat system that allows parties to communicate through the LoRaWAN network, even in areas without cellular coverage.

The Ear Tag (Caravan Tag) for cattle is similar to current ear tags. This tag is capable of reporting every 15 minutes for more than 5 years using the LoRaWAN communication protocol. The main data reported is position by triangulation and GPS, external temperature, detection of steps, jumps, falls, and unusual movements.

The intra-ruminal bolus is a device that, once inserted, will remain in the animal rumen throughout its life. It is capable of transmitting data from inside the animal to nearby ear tags around it, regardless if it is associated with just one. The device transmits the internal body temperature, which helps to identify diseases, and efficient heat detection. It also measures the number of steps, movements, intake and provides geolocation in case of emergency. All data taken is sent through the LoRaWAN Network feed and the algorithms of the Caravan Tech Software providing a complete tool for agro-livestock management.

Caravan Tech has developed other types of sensors, including water level sensors, door and window open closed status sensors for barns or any other building, vehicle tracker, fuel level and consumption in tanks, horse collar, gates sensors and emergency button, among others. In addition, the company has developed a unique traceability tool, that allows complete tracking of the livestock throughout its whole life.

Through strategic partnerships, Caravan Tech is currently integrating existing third-party sensors to their open platform, such as weighing systems, meteorological stations, electrical fence status, opening of electrical fences, automatic electrical fence lifting, and opening or closing gates. They seek developers who have existing devices that want to be part of our ecosystem, facilitating management of farming operations, as well as improving producer's performance.

BEEKEEPING

Monitoring devices embedded within beehives with Zenseio

Zenseio devices are used to monitor the well-being of beehives to reduce bee mortality rates and to help sustain the beekeeping industry. A beehive colony is a collective organism, which, like a person, has vital signs indicating good health or sickness. Zenseio devices are embedded inside beehives to continually monitor key health parameters and alert beekeepers when the values move outside the normal range. Alert messages are also triggered when an unexpected outside disturbance to a beehive is detected, such as ransacking by a bear or thieves. Thanks to LoRaWAN radio, Zenseio devices can be low cost to manufacture and operate, allowing economies of scale to equip large numbers of beehives located in remote rural areas.

Inter-connected network of robotic beehives with Beewise

Beewise, by AWS, provides a robotic beehive that allows beekeepers to remotely treat their bees. They developed a network of these robotic beehives distributed in the field, monitoring millions of bees within a single device and

analyzing the outgoing data. Beewise needed to provide a centralized system that monitors and controls a significant amount of distributed sensors, in the field and in real-time, with little to no lag, while being accurate and secure.

Beewise deployed a wide inter-connected network of distributed devices and sensors using AWS IoT Core and AWS IoT Device Management. Additionally, using other AWS services, they achieved an astounding aggregate of large amounts of data to a centralized repository, where they analyzed the data, and sent back commands to distributed systems in real-time.

As a result, more bees have survived, thrived, and pollinated. Beewise was able to achieve a dramatic increase in plant pollination and honey production, while significantly reducing manual labor. Thanks to AWS IoT, Beewise lowered the average bee mortality rate from ~40% (in today's beehives) to less than 10% in Beewise's robotic AI-controlled beehives.

CONCLUSION

Today, every agricultural sector depends on farm data collection. By combining high flexibility with a variety of implementation modes in rural areas, the high performance and long duration of the sensors, and a wide range of proven devices and solutions available on the market, LoRaWAN is the de facto state-of-the-art technology for collecting data in the animal production industry.
Like major technology changes in the past—artificial insemination, genetics, nutrition, genomics—the monitoring of animal production is a game changer in the path to a sustainable and profitable food industry. Traceability from farm to fork is one of the biggest challenges for meat and dairy producers and LoRaWAN monitoring solutions are essential contributors to assisting the farmer on a daily basis.

By participating in the costs of monitoring solutions and openly sharing data with the full trust and confidence between all the stakeholders of the industry, farmers should overcome the biggest challenges of the next century: to feed the planet safely, sustainably, and profitably with respect to the welfare of both farmers and animals.