SMART AGRICULTURE WHITE PAPER

HOW TO MAKE THE RIGHT CONNECTION FOR PRECISION AGRICULTURE

INTRODUCTION

The growing global population coupled with increased awareness of the demands agriculture places on the environment is putting farmers under intense pressure. They're required to maximize yields to feed more people while simultaneously ensuring their practices are sustainable. In addition, consumers demand cheap food, necessitating greater automation to preserve margins.

There is a need to find a balance between intensive production and respect for nature and this cannot be achieved within the confines of traditional farming. Harnessing technology to enable smart agriculture has emerged to provide farmers with the tools they need to serve a 30% larger population in the future in a sustainable way that is in harmony with nature. Within smart agriculture, there are two main industries: crop production, which includes arable, orchard and vegetable farming, and animal husbandry. These have distinct requirements. This paper focuses on crop production exclusively.

To maximize production, resources need to be utilized effectively and, for many farms, this starts with ensuring soil quality is optimized and water is not wasted. Projections show that one-third of the world is set to be living in water stress and, with agriculture consuming up to 80% of the water in some countries while as much as 60% of water withdrawn for irrigation often does not reach the crop[1], the situation must change urgently.

Water and nutrient levels, therefore, need to be managed for farms to be successful but traditional approaches of irrigation and fertilizing according to seasonal or crop-based cycles are imprecise, relying on season-wide averaging and insights gleaned retrospectively from crop yields. In contrast, a soil monitoring system can enable water consumption to be reduced by around 20%, according to real experiences from current deployments.

Soil data is subject to variations in climate from year-to-year and to anomalies such as extreme weather or pest epidemics, so analyzing historical data doesn't provide all the benefits to farmers. More timely – and often real-time – information is required to enable farmers to react swiftly to changes in nutrient or moisture levels. Being able to irrigate when soil is too dry has obvious benefits in terms of yield size, but the same system can also advise that irrigation is not necessary when soil is at the right moisture level, thereby saving water.

Similarly, it's of no benefit to add nutrients to soil that already has reached the required level. However, to achieve this minimized usage of resources for maximized crop production requires far more granular detail than has previously been available. Data needs to be collected upon not on a farm-by-farm basis but on a field-by-field basis. Ideally, data collection should be even more granular, enabling insights into soil conditions in areas of fields in real-time so farmers can respond rapidly to clearly-presented data via mobile device applications.

Soil moisture is only one aspect of precision agriculture and this paper will detail a wide range of data inputs from across the crop production spectrum. These include pollination of trees in orchards, monitoring of greenhouse conditions for crops such as tomatoes.

This approach is called precision farming and enables highly granular insights to be collected, correlated, analyzed and acted upon from pinpointed areas. This is set to become an enormous market place. The precision agriculture market will grow to US$43bn by 2025[2], according to Grandview Research, but less than 2% of land is currently equipped for soil moisture measurement[3], demonstrating enormous headroom for growth. Other analyst firms also see precision farming techniques

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[1] http://www.fao.org/focus/e/speclpr/spro13-e.htm

[2] https://www.prnewswire.com/news-releases/precision-agriculture-market-analysis-by-component-hardware-software--services-by-technology-variable-rate-technology-remote-sensing-guidance-systems-by-application-by-region-and-segment-forecasts-2014---2025-300413062.html

[3] https://www.kerlink.com/blog/2019/06/13/kerlink-and-sensoterra/

taking off, analyst firm Berg Insight, the global market for precision agriculture solutions is forecasted to grow from €2.2 billion in 2016 at a compound annual growth rate (CAGR) of 13.6% to reach about € 4.2 billion in 2021[4].

Precision farming relies on connected sensors to regularly communicate data on soil moisture, acidity/pH, temperature and nutrient levels, among other indicators. However, because of the sheer number of sensors involved in enabling accurate data across large farms, costs have to be rigorously controlled. This paper sets out the challenges of enabling precision agriculture and assesses how to balance performance requirements with sustainable costs.

CONNECTIVITY

Precision agriculture is entirely reliant on connectivity so that the data collected by cost-effective sensors can be transmitted to a centralized data processing resource. The nature of agriculture means that hard-wired, fixed-line connections are not possible – plows and cables don't mix well. Therefore, wireless connections are the only practical option and there is a bewildering array of these for farmers to select from.

To an extent, this choice is confusing with options ranging from cellular networks to satellite connectivity in addition to low power wide area networks (LPWAN) such as LoRaWAN®. Importantly, precision agriculture doesn’t require large volumes of data or the low latency communication that higher speed cellular networks can provide. Typically, sensors will communicate small packets of data every few hours with simple messages such as percentage moisture level.

For a potato farmer in Scotland, for example, it’s cost-prohibitive to have a cellular connection that incorporates a SIM card with a monthly bill for each sensor in the field. The cost of the bill and the billing will outstrip the potential yield advantage. It’s also important to recognize that crop production is performed over large geographical areas, often far from consumer cellular coverage and certainly in areas where there is no nearby power supply. It's obvious that you can't run electrical cables through a rice paddy or a potato field safely and cost-effectively but more routinely, it's also impractical to change a battery several times during a crop cycle.

Therefore, a solution that is easy to deploy, offers a long battery life of at around five years and can be cost-effectively integrated into a device is the ideal. This means precision agriculture's connectivity options center on LPWANs which can provide the last miles of extension to cellular or fixed networks that are necessary for connecting sensor networks over large geographies and supporting devices that are out of reach of traditional network options. Within the LPWAN category, there are several options ranging from proprietary or regional options, such as Sigfox, and newly-

[4] http://www.berginsight.com/News.aspx?m_m=6&s_m=1

developed cellular offerings, such as narrowband-IoT (NB-IoT), to open standard offerings such as LoRaWAN.

WHY LoRaWAN?

When it comes to precision agriculture, farmers' goals for deployments are that devices are easy to install, simple to operate and do not rely on wires. Also, it's understood that solar power is ineffective because, as plants grow, their leaves obscure panels and dust and mud which are unavoidable in most types of farming have similar effects.

Deployments also need to be able to feature long-term power that is cheaply embedded in the device. Being able to operate for years using something as simple as a traditional AA battery is convenient because expensive battery technologies are cost-prohibitive while solutions that require battery recharging or replacement require too much human interaction – this is too expensive and takes up too much time for crop producers.

Finally, deployment requirements are relatively simple. Connections need to be long-distance so devices can communicate back to a gateway that may be a few kilometers away. They also need only low data rates because of the small quantity of data transmitted.

LoRaWAN is a great fit, matching all of the above requirements. It is optimized for lower data rates and can transmit data over many kilometers. In addition, it is low power and because it relies on universal protocols, the costs of the connectivity can be shared across multiple devices. For example, LoRaWAN connectivity can be shared by soil sensors, agricultural machines, and other applications.

Even so, there are some challenges associated with LoRaWAN deployment that need to be considered and addressed. It's necessary to pay attention to how the infrastructure is deployed. This requires the right tools to make sure the infrastructure works properly once installed, for example, and explains why many users will choose to have LoRaWAN infrastructure installed by a service provider.

Several LoRaWAN service providers such as Paige Wireless, KPN, Orange, or Objenious propose a nationwide coverage with the option to expand this coverage with an extra gateway that can be installed on the farm. They run a business model based on a connection fee *per device*. Other operators like Comcast charge a fee *per gateway*. Innovative network deployment and management approaches, such as Senet's Low Power Wide Area Virtual Network (LVN™), provide extensive coverage options in rural areas, allowing for a multitude of agriculture and precision farming applications to be deployed today. Easy LoRaWAN gateway deployment and cloud-based network management allow for applications to be implemented at a low cost and rapidly expanded based on unique customer requirements. This modern approach to deploying and managing IoT connectivity cannot be matched by traditional cellular models or proprietary technologies.

USE CASES

Weather stations
Weather knowledge plays the most important role in the planning of the majority of agricultural activities and helps farmers decide when to seed, when and how much to irrigate, when and how much to spray fertilizers and pesticides and whether it is necessary to protect crops from frost.

Providers such as Pessl Instruments and MCF88 provide connected weather stations that record temperature, humidity, atmospheric pressure, rainfall, and wind speed and transmit data every 15 minutes. Reliable, LoRaWAN connectivity means farmers can know the weather across their farms in a highly granular way and have full traceability over time.

Soil moisture
Wirelessly-connected soil moisture sensors enable farmers to make better irrigation decisions for increased yield, with smart soil moisture measurements. Providers such as Sensoterra provide cost-effective sensors that measure at the active root zone to ensure crops are optimally irrigated. Probes are compatible with all soil types, including clay, clay-loam, saline clay, sand, and peat. Watertight and weatherproof, probes are robust and meant to be left in the field. With wireless LoRaWAN connectivity, probe placement is flexible and installation is simple so devices can easily be moved around fields based on irrigation needs.

Soil fertilization
In addition to understanding soil moisture, it's a significant improvement for farmers to know the fertilization status of their fields. Precision agriculture powered by sensor data enables farmers to collect and access soil quality data in the form of salinity, aeration, respiration, air temperature, light, humidity, and nitrogen, phosphorus, and potassium (NPK) levels. Vendors offer sensors that take readings at multiple depths in the soil and that are simple to set up, enabling real-time alerts to be sent to farmers' phones and laptops. The days of blanket fertilizing an entire farm and the wasted cost and effort that entails are gone. Instead, farmers can target areas for increased fertilization or minimize fertilization in areas that already have suitable levels to deliver good yields.

Irrigation controllers and actuators
Irrigation scheduling and control enable farmers to avoid starting an irrigation cycle too early or too late and to save time going around large farms turning irrigation equipment on manually. Vendors such as Strega have wirelessly-connected solutions to ensure water pumps can be synchronized with valves to pressurize water pipes only when needed. AonChip’s Watersens device controls four latch valves simultaneously and includes a pulse meter that can be placed onto an existing water meter to make sure that once the valves are open the water starts to flow. Waterbit or Robeau’s devices make it possible to monitor and manage water

consumption on farms, enabling farmers to set up alerts via text message or email in case of a leak.

Ambient monitoring for greenhouses
Crop yields for tomatoes or flowers, for example, in greenhouses are highly reliant on the ambient conditions in the growing environment. In addition to irrigation and fertilization, these comprise the air humidity, temperature, and CO2 levels. Solution providers in this area include Nemeus, NKE Watteco, Ursalink, and mcf88.

Pest detection and pollination in orchards
With the US Food and Agriculture Organization (FAO) estimating that 20–40% of global crop yields are lost annually due to pests and diseases[5], the need to control pests is clear. However, over-use of pesticides can contaminate ecosystems and ultimately result in pesticides becoming less effective. Traditional farming relies on traditional calendar-based pest control procedures that use pesticides regardless of whether pests have been detected. Wirelessly-connected intelligent devices are radically transforming this area of agriculture by enabling real-time monitoring, modeling of pest movements and disease forecasting, thereby enabling farmers to pinpoint when and how much pesticide to use.

However, there are good pests and bad pests and some farmers, notably wine growers, orchard producers, and almond farmers, require their plants to be pollinated. In fact, according to the FAO, approximately 75% of crops that produce fruit or seeds for human consumption depend on pollinating insects, such as bees or flies[6]. Farmers, therefore, need to be able to ensure the number of pollinators on their land is sufficient to pollinate their trees and enable them to achieve high yields. Wirelessly connected devices offer the ability to do this monitoring bee activity at hives, for example. Other types of sensors can count the number of moths of flies in insect traps.

DATA MANAGEMENT AND LEVERAGING INSIGHT

This paper has introduced examples and solutions from across the entire landscape of precision agriculture, demonstrating the breadth and scale of the opportunities that are locked-up in farming-related data. However, many of the current solutions, based on satellite and drone images, suffer from being retrospective in that they merely report what has happened and this reporting is used to add to records and put in place strategies to avoid the same issues recurring in future years. Solutions are siloed so data gathered from a water management solution isn't integrated with data from a temperature or fertilization solution. The only way to integrate this different data is by engaging the farmer's knowledge.

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[5]http://www.fao.org/news/story/en/item/1187738/icode/

[6] https://www.cropscience.bayer.com/en/blogs/2019/05/marnix-doorn-transforming-bee-health

Aggregation is needed to bring together all the data points and do so in a timely way so insights can be acted on immediately. Remember, farmers will not be able to sit in their tractors and cycle through six or eight different applications to access this hour's data, then analyze it and decide to decrease irrigation and increase fertilization, for example. These individual data points only become useful once they are integrated and put into the entire context, along with historical data from previous years.

Applications that can aggregate these disparate data, ideally into a simple graphical user interface on a mobile device, will enable farmers to evaluate all the data and take action in the moment, thereby enabling greater crop yields and more efficient usage of resources such as water and fertilizer.

There is space in the market for service providers who can invest in monitoring equipment to be deployed at farms and then derive value from the data and insights they collect to farmers as a service. For example, a co-operative of 1,500 potato farmers could deploy 300 weather stations, thereby covering the co-operative's entire territory to get better information on the temperature and humidity and analyze the risk of potato blight with greater granularity.

Such a service would enable farmers to estimate the type or quantity of products to be used on the different areas of their farms and, in the event of an outbreak of disease, allow them to alert their neighbors. In this example, beyond connectivity, the co-operative can use the high-performance algorithm to analyze the data collected and cross-compare all the information from weather stations and air temperature and humidity sensors to create a real prediction service for disease propagation. This provides a level of data integration that was previously not possible as now the same information arrives on the farmers' cellphones. The co-operative also benefits from the data collected so it can manage its stock of treatment products and improve the accuracy of the production forecast before harvest time.

CONCLUSION

LoRaWAN is the ideal technology for precision agriculture because of its ease of deployment, ability to provide coverage over large geographical areas and the capacity it offers being more than adequate for the needs of farming applications. The continued maturing of the ever-expanding LoRaWAN ecosystem of developers means that the vision of applications that aggregate data from different devices, all connected over LoRaWAN, is coming to fruition. Just as for the farmers, the yields will be impressive. Moreover, it will also revolutionize the ecosystem with cooperatives, ag retailers, food processors, and even supermarkets who can also benefit from the technology to feed their database and their algorithms to create high value-added services and to secure the food chain from farm to fork.