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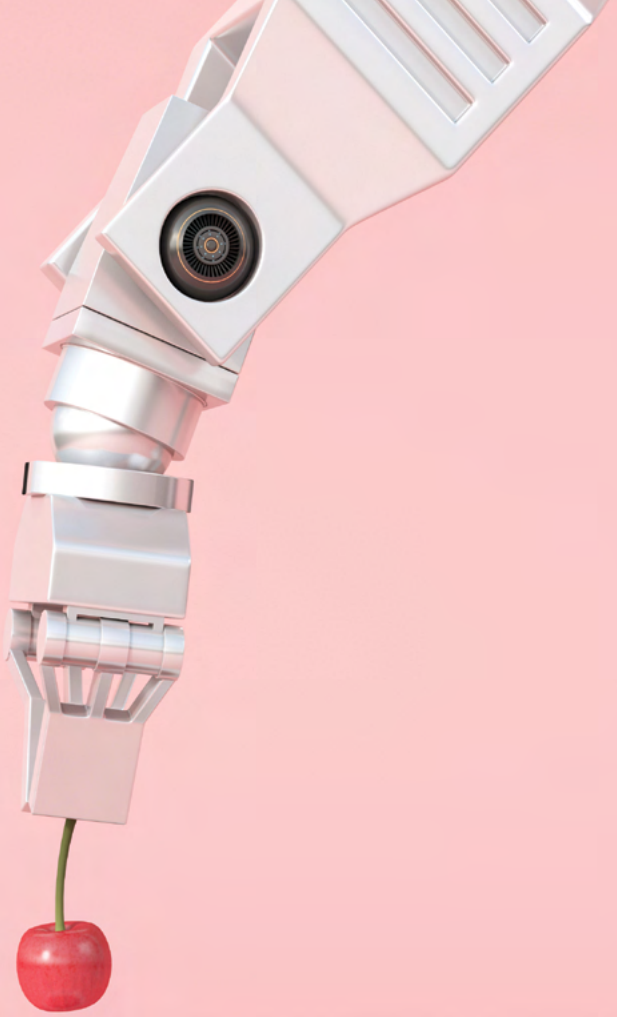

Connected food

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Dear Readers,

What's the last thing you ate? Unless you harvested it yourself, it's highly likely that positioning and wireless communication technologies were involved in the process of growing, processing, distributing, or selling it. Already today, digitalization is pervasive from the plantation to your pantry – and we're still at the entrée. Just wait till you see what's next!

In this sixth edition of our u-blox magazine, we explore the transformational impact digitalization has already had on the global food industry, as well as its future potential to tackle some of the challenges that lie ahead. Chief among them: increasing food production by 60 percent by 2050 to feed close to 10 billion people in an increasingly challenging environment.

Our in-depth expert interview offers a unique view from China on this fast-evolving industry. We then turn to Madagascar, where a project we've sponsored is leveraging food's central role in our lives to protect forests, promote health, and improve livelihoods. And we follow the technologically enhanced journey of a banana across the globe to a supermarket near you.

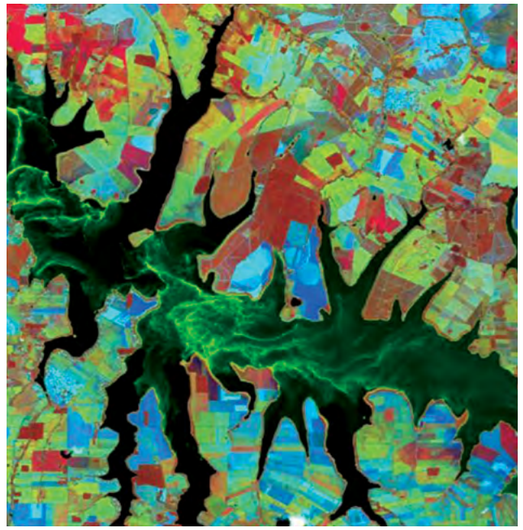
So how will the Internet of Food help us feed a growing global population? What's holding back vertical farms? What can we do to fight food fraud and neutralize contaminations before they cause harm? And what can brick-and-mortar stores do to stay relevant in the face of digital competition? These are just some of the questions explored in the following pages.

We wish you informative and smart reading.

Yours sincerely,

Thomas Seiler, CEO

Content



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Connected food

The Internet of Food

Deep-reaching digitalization of the food sector, from agriculture to processing to retail, is already bearing fruit.

Here are some food-facts to chew on: Three quarters of the world's food is made from just twelve plant and five animal species.[1] We already grow enough food to feed ten billion people, yet one in nine remains undernourished.[2] Leafy greens were the prime source of food poisoning in the US in the decade leading up to 2008 – far more common than fish and shellfish.[3] The Arab Spring can be traced back, in part, to a spike in food prices.[4] And, probably for the first time in history, more people are dying from the consequences of a bad diet than from hunger.[5] Now digest that for a minute.

[1] What is happening to agrobiodiversity, FAO, http://www.fao.org/docrep/007/y5609e/y5609e02.htm, retrieved August, 2018
[2] https://www.worldhunger.org/world-hunger-and-poverty-facts-and-statistics/
[3] Attribution of Foodborne Illnesses, Hospitalizations, and Deaths to Food Commodities by using Outbreak Data, United States, 1998–2008, Emerging Infectious Diseases, March 2013
[4] The State of Food Security and Nutrition in the World in Brief 2017. Building resilience for peace and food security. FAO, IFAD, UNICEF, WFP and WHO. 2017. Rome, FAO
[5] Trends in adult body-mass index in 200 countries from 1975 to 2014, The Lancet, April, 2016

If you are reading this, it's likely that you rely on the global food sector – a sprawling, highly complex, multi-trillion-dollar industry – to supply you with most of the calories you consume. From the farms, pastures, and plantations, the fisheries, greenhouses, and slaughterhouses to the supermarkets and convenience stores, the food sector plants, harvests, and processes ingredients and transports, packages, and distributes them in a web that spans all five continents. Soon, it might drone-deliver the end-products to your doorstep.

Already today, digital technology plays a role at every step of the journey. That said, it will be a few more years before we can reap the fruits of a fully digitalized food sector. And they are aplenty: increased agricultural productivity at a lower environmental cost, a more transparent supply chain with increased food safety, and reduced fraud. Smarter packaging for improved logistics, longer shelf-lives, and reduced waste, and new distribution systems for increased convenience. The smorgasbord of digital technologies and the resulting Internet of Food may prove instrumental to sustaining a world population that is expected to hit just under 10 billion by 2050.

Challenges old and new

At least since 1798, when Thomas Malthus predicted we humans would outbreed our planet's carrying capacity, population growth has been perceived as a challenge to global food supply. But in the 220 years since, humanity has proven him wrong time and again through major technological breakthroughs, from the industrial revolution at the turn of the 20th century to new and more resilient plant breeds, artificial fertilizers, and agrochemicals mid-century, to genetically modified organisms later on.

But could this time be different? By mid-century, global food demand is expected to increase by an estimated 60 percent.[6] And as more and more people are moving into the middle class, their dietary expectations are undergoing the well-documented demographic transition towards increased demand for a greater variety of more nutritious food, in particular energy and nutrient intensive livestock products such as meat, eggs, and dairy.

"Digital technologies and the resulting Internet of Food may prove instrumental to sustaining a world population that is expected to hit just under 10 billion by 2050."

On top of that, today, population growth is playing out on a backdrop of a changing climate with hard-to-predict consequences on our food system. Soils are becoming increasingly depleted of their nutrients, impacting global agricultural yields. And with underground aquifers drying up in water-stressed regions, groundwater resources are under threat. Global food systems, themselves, are exacerbating the problem, making up a startling 20-30 percent of global greenhouse gas emissions and 70 percent of freshwater withdrawals.[7]

The situation may be unprecedented, but so too is the technological arsenal at our disposal to address the challenges we're up against. Of the dozen emerging technologies identified in a report by the World Economic Forum[8] as promising to reshape our food sector, at least six – including precision agriculture, real-time supply chain monitoring, and food sensing – hinge directly on digital technologies.

60%

Estimated increase in food demand by 2050.

Source: FAO

[6] FAO, World Agriculture towards 2030/2050, The 2012 Revision, 2012
[7] Climate Change and Food Systems, SJ Vermeulen, BM Campbell, and JSI Ingram, Annual Review of Environment and Resources, 2012
[8] Innovation with a Purpose: The role of technology innovation in accelerating food systems transformation, WEF, 2018

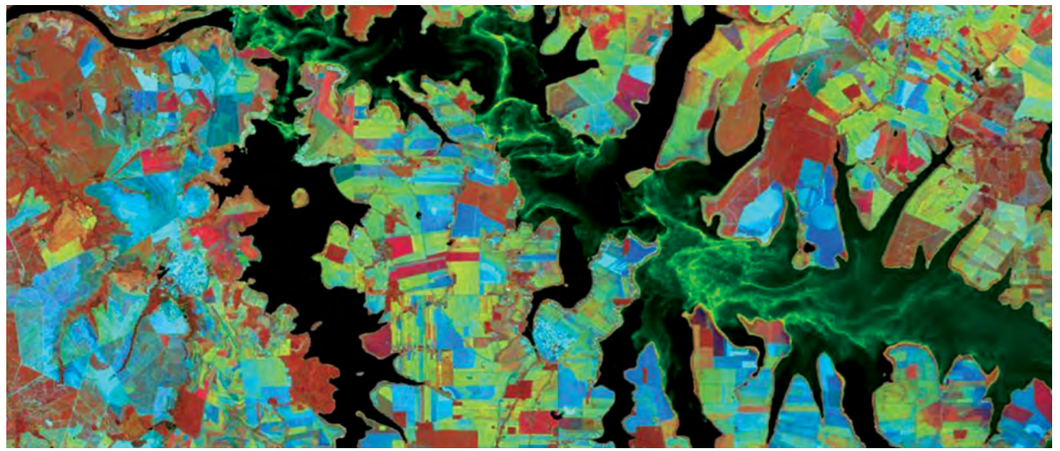
Enabled by the abundance of cheap sensors, virtually free analytical and storage capacity on the cloud, and emerging wireless communication and positioning technologies, digitalization promises to unleash a new spurt of agricultural productivity. It will also slash food waste, empower farmers, and revolutionize the food sector from the ground up.

Data + Analytics = greater efficiencies and higher yields

From its inception, agriculture has been empirical, progressing from season to season and generation to generation through a painstaking process of trial and error. But as agriculture evolved into a science and then into a business, the pace of progress picked up, with vastly increasing yields of sweeter and more uniform produce, often optimized for mechanical harvest and human consumption. As a result of targeted breeding and selection, today's selection of fruits and vegetables at the farmer's market would blow the mind of a visitor from the middle ages.

The methods have evolved as well. As anecdotal evidence was brushed aside by hard science, agricultural calendars based on lunar phases were replaced by more rational science-based methods. Wherever possible, manual labor required for sowing seeds, weeding fields, and spreading fertilizer and pesticides has been replaced by mechanized approaches. Today, distributed sensors, hyperspectral cameras, and satellite positioning combine to reduce the required agricultural inputs to a minimum. They also contribute to protecting the environment, saving water, and exposing consumers to less noxious chemicals.

Sensors, data, and automation have also transformed livestock farming. Some of today's connected cows feature step counters, bovine behavior tracking collars to monitor grazing time, and other sensors attached to their udders, their tails, or even inside their stomachs. Digital technology and the precision livestock



Hyperspectral imaging data proposed by start-ups such as Swiss-based Gamaya let farmers map anything from crop types, stress factors, water use, and biochemical quantities.

The instant a strawberry is picked, a fish pulled out of water, or an egg laid, a race against the clock begins.

farming it enables not only raises efficiency on the farm, it also makes it easier to ensure that high quality standards can be met.

Farmers have long relied on a broad skillset, but piloting drones was only recently added to the list. Equipped with hyperspectral cameras that capture light narrow frequency bands, farmers can fly drones over their fields to remotely monitor their crops. Solutions proposed by startups such as Swiss-based Gamaya, a leader in the field, let farmers map anything from crop types, stress factors, water use, and biochemical quantities. Armed with this information, farmers can further optimize the use of agricultural inputs, which, too, can be sprayed by drone with near-surgical precision.

And, finally, by connecting farmers with the global food market, digital technologies ensure that farmers get a fair price for their produce as it enters the food supply chain.

Transforming the food supply chain

Supply chains are at least as old as trade itself. A hallmark of the earliest traded goods was that they were non-perishable. Salt and dried spices, for example, were robust enough to cross the Sahara desert or the Silk Road without spoiling. Today, we have heightened expectations when it comes to the availability of goods in our stores. Whether they're perishable or not, we want them, and we will buy them, year round.
The instant a strawberry is picked, a fish pulled out of water, or an egg laid, a race against the clock begins. Perishables often need to find their ways through the food sector to an end-customer in days. If they don't, they'll risk going the way of roughly a third of all food produced globally, or 1.3 billion tons: become food waste.[9] Along the journey, they are transported, processed, quality tested, stored, packaged, and delivered, sometimes across the planet, before ending up in a grocery store or restaurant near you.
Digital technologies are making the supply chain more transparent than ever before. Wireless asset tracking devices, smart packaging, and RFID (radio-frequency identification) tags can all be used to ensure that goods make it through the food chain on time, intact, and without breaking the cold chain. By leveraging the Blockchain, a distributed ledger, compliance reporting can be largely automated to guarantee the accuracy of data describing every step along the supply chain. Food fraud, such as the horse meat scandal that befell Europe in 2013, could become a thing of the past, and consumers could be reassured that they are, indeed, buying the items described on the packaging.

"Digital technologies are making the supply chain more transparent than ever before."

[9] Innovation with a Purpose: The role of technology innovation in accelerating food systems transformation, WEF, 2018

Retail, preparation, and delivery

While the food supply chain is opaque to consumers, changes to supermarkets and other outlets rarely go unnoticed. It's likely that you still remember the first time you queued up in a single checkout line at the grocery store, scanned your articles yourself at the self-checkout, or ordered dinner using Uber Eats. These innovations pale in comparison to innovations currently in, or just out of, the pipeline.

If you haven't yet had the chance, wait till you go to an Amazon Go supermarket, the first to do away with the checkout altogether, or for your first encounter with Walmart's shelf-scanning robots. In the near future, the IoT, AI, and VR will combine to offer a fully revamped and augmented shopping experience, providing consumers with information on the provenance, the nutritional value, and waste-disposal instructions using interactive tables.[10]

You might miss these developments if, instead, you decide to buy your groceries from the comfort of your home. According to Tetra Pak, 14 percent of consumers purchase groceries online with 59 percent being open to doing so. By 2021, they forecast e-commerce to make up 10 percent of all food purchases.[11]

The products you purchase will still be recognizable, but the packaging will have undergone a facelift. By then, smart packaging will inform consumers when food is no longer fit to eat, reducing the amount of perfectly healthy but expired food thrown away just in case. And recognizing that customers are as much after an experience as they are after a meal, individualized packaging featuring some form of digital codes will invite customers to engage, learn, and be entertained. In return, producers can gain insight into their consumers.

New demands, new expectations

We've come a long way in a remarkably short time. Originally a means to survive, food has, where it is abundant, become a marker of identity, a source of emotional comfort, a contributor to global warming, and even a sometimes harmful, addictive substance. Societal trends all point in the direction of ever greater food diversity, as consumers personalize their diets to their tastes, their beliefs, and, soon, their DNA – influenced by social media influencers, marketing, friends, family, and, hopefully, science.

Accenture reports[12] that expectations regarding health are becoming the Holy Grail for consumers, who are willing to pay more for healthier foods, in the same way that they are prepared to fork out more for products with transparently and sustainably sourced ingredients.

So what will we find on our plates ten years from today? More or less the same thing we're eating today? Or might we be getting our macronutrients from highly nutritious and sustainable foods based on microbes? Technologically, we could be. Kiverdi[13], a US-based startup, is seeking to commercialize an initial product; a flour-like protein powder produced using batch-reactor-grown microbes, yielding 10,000 times more calories per square meter than soy beans. Technological innovations like this one could take us a long way towards meeting the projected 60 percent increase in global protein demand by 2050 – but at what cost?

Many questions remain. Will we, one day, come to crave tomorrow's Food X.0 in the same way that we craved festive family dinners in the past? Or will we, instead, stick to our culinary heritage, simply using more efficiently grown, processed, and distributed ingredients? One thing seems certain: the quantification, digitalization, and integration of every step along the food chain will only continue to accelerate. At the same time, new trends such as nutrigenomics and personalized nutrition, lab-grown "meat," and edible insects are cropping up on the horizon. From the plantation to the plate – and in food factories, labs, and stores – the Internet of Food has already overturned many long-established practices. And we can comfortably say that more disruption lies ahead. ■

[10] Food Shopping gets a Dash of Innovation. Coop Italia Reinvents Grocery Shopping. Case Study, Accenture
[11] The Tetra Pak Index: The Connected Consumer. Issue 10/2017
[12] The Future of Food: New Realities for the Industry, Accenture, 2018
[13] http://www.kiverdi.com/

Agriculture 4.0: the future of farming

With digital technology conquering farms and fields, agriculture is becoming more data-driven than ever.

The mechanization of agriculture was instrumental in scaling up global crop production, but it did so at a cost: overwhelmed by their size and aided by machines, farmers began treating fields as uniform units. Even though demand for water, fertilizer, and pesticides typically varies from one section of the field to another, farmers started to spray them uniformly. This blanket dispersal of inputs led to their overuse, wasting resources and harming the environment.

Driven by the spread of the Internet of Things (IoT), Ag 4.0 – the latest wave of digitalization of agriculture – promises to preserve the scale of today's farms while empowering farmers to tend to their needs with near-surgical precision. Not only that; the IoT delivers vast amounts of data, from sensor measurements of environmental parameters to weather forecasts to real-time insights on the supply and demand of crops, as well as to the artificial intelligence (AI) needed to make sense of them. With data and cloud-based predictive analytics to support them, farmers can make more informed – and better – decisions, increasing their yields and revenues while protecting the environment.

Robots on the field

One of the most visible impacts of Ag 4.0 is the automation and robotization of agricultural machinery. Such precision farming isn't all new. Self-guided GNSS (Global Navigation Satellite System) assisted tractors, such as those pioneered by John Deere[1], have been tilling, planting, watering, spraying, and harvesting fields for well over a decade, significantly increasing the agricultural efficiency at each stage. Not only do they take some of the drudgery out of farm work, they also reduce overlap as they cross the field, saving time, resources, and reducing soil compaction. Additionally, they can automatically respond to variable needs of the fields based on sensor data.

Now, technological innovation in high precision satellite positioning is bringing down the cost of ownership of the technology, democratizing it and enabling new use cases. The best part? The required infrastructure is already in place – in space! Driven by a new generation of multi-band satellite positioning hardware and GNSS correction services optimized for small size, versatility, and low power consumption, centimeter level positioning accuracy gives farmers a new tool to gather fine-grained quantitative data about their fields large and small, and, potentially, new strategies to manage them.

One such strategy is to take to the sky. Yamaha Motor's pioneering unmanned agricultural helicopters[2] have long been used to spray rice paddies in Japan. Now these gas-powered unmanned aerial vehicles are being introduced to new locations including vineyards in California's Napa Valley. But while farmers operate their self-guided tractors themselves, Yamaha offers them its helicopter as a service, as it needs to be operated by certified professionals.

Drones are starting to do some of the heavy-lifting in the agricultural space as well, most prominently with the DJI Agras MG-1[3], a battery-powered octocopter with a carrying capacity of 10 liters. Benefiting from extensive experience in the consumer drone market, the Agras is designed to make operation as simple as possible, featuring a smart mode that makes it easy for farmers to plan and execute flights.

Meticulously micromanaged

As in most digital industries, data forms the backbone of precision farming. Distributed sensor networks that measure above- and below-ground environmental parameters are a common source of quantitative data. Uploaded to the cloud and mapped out using geographical information systems, these data let farmers diagnose crop diseases and fine-tune the delivery of water, fertilizer, and other inputs.

But technology is not the be-all and end-all of agricultural challenges. Data is only useful to

[1] How NASA and John Deere Helped Tractors Drive Themselves, NASA, Gina Andersen, 2018

[2] https://www.yamahamotorsports.com/motorsports/pages/precision-agriculture-rmax

[3] https://www.dji.com/mg-1

Yamaha Motor's pioneering unmanned agricultural helicopters have long been used to spray rice paddies in Japan.

the extent that it can be acted upon. Artificial systems such as IBM's Watson, which rose to fame after beating a human in the game show Jeopardy, can now be fed mixed datasets and glean lessons from them, helping farmers pick up on patterns that they would otherwise easily miss.[4]

Increasingly, data sensing is being carried out from a bird's eye perspective. Companies like Gamaya[5] and Flurosat[6] have developed drone mounted cameras that split the light reflected by plants into up to 40 frequency bands in the visible and infrared part of the electromagnetic spectrum. By applying machine learning techniques to analyze the high-resolution data, farmers can glean actionable insights into their fields, receiving an early heads-up on issues such as disease, nutrient deficiency, the presence of pests. They can detect the precise location of weeds, identify them, monitor their growth, and plan remedial actions.

The trend is clear: more data and better analytics leads to better decisions, allowing farms to grow more and healthier crops with less resources and a lower environmental impact. To find widespread applicability, solutions will need to be robust and easy to implement. High precision positioning and wireless connectivity are key to how they work, making the availability of GNSS correction services and wireless and cellular networks central to their uptake. And there's huge potential for both the developers of digital solutions as well as for farmers across the globe, whose operations and strategies will increasingly center around a new, abundant, and renewable resource: data. ■

"More data and better analytics leads to better decisions, allowing farms to grow more and healthier crops with less resources and a lower environmental impact."

[4] https://www.ibm.com/blogs/client-voices/feed-future-generations-cognitive-precision-farming/
[5] https://gamaya.com/
[6] https://www.flurosat.com/

Learn more:
www.u-blox.com/en/high-precision-positioning

With data and cloud-based predictive analytics to support them, farmers can make more informed – and better – decisions.

Livestock farming: reloaded

Precision livestock farming is proving its potential to improve animal welfare and food quality by plugging into the digital revolution.

76%

Increase in the total quantity of meat consumed by mid-century.

Source: FAO

Farms are about to get bigger. One of the drivers is clear: the rise of the global population, which is inching relentlessly toward a predicted 9.7 billion by 2050. At the same time, demand for food is changing too. Driven by GDP growth in low- and middle-income countries, wealthier populations are opting for “wealthier” diets, made up of increasing shares of meat and dairy. Compounded by the threats of climate change, resource depletion, and pests such as foot-and-mouth disease and the swine flu, societal expectations on livestock farmers are high.[1]

But there’s a second trend playing out at the same time: the continuing decline in the number of farmers – a trend that is unlikely to flip in the near future. In the decade leading up to 2010, the overall number of people working on French farms dropped by 26.7 percent. Overall, the number of cows, poultry, and pigs held in France decreased, as the percentage of farms holding livestock dropped from 70 to 61 percent. Meanwhile, the number of farms holding 500 animals or more increased by 20 percent.[2] The overall trend is similar in most developed countries.

Put two and two together and you get fewer farmers raising more animals. Less time per animal stretches farmers even further to manage their herds, monitor their health, and protect their welfare, raising the specter of more of the food scares we’ve seen in past years. As a result, “farming as usual” will, at some point, cease to be enough to ensure sufficient healthy pigs, hens, and cows to meet a global appetite of 350 million tons of pork, poultry, and beef by 2030.[3]

Automated monitoring, all the time

By transposing technologies used in connected industries, smart homes, and smart cities to the farm, the ongoing digital revolution offers farmers a powerful tool to deal with the current and future increase in herd size. Powered by data gathered by sensors, analyzed and stored in the cloud, and easily accessible via smartphones or computers, “precision livestock farming” gives farmers invaluable real-time insight into their operations.

Some of the applications of the technology, such as monitoring the microenvironment that the animals are raised in, are obvious. The productivity of laying hens, for example, can be made more consistent if they are shielded from seasonal temperature changes. Cloud connected sensors make it possible to monitor coop temperature and humidity and send out an alert when thresholds are crossed.[4]

Behavior, the key to wellbeing and welfare

But the most potent diagnostic information might, instead, come from continuously monitoring the animals' behavior, their physiology, and their performance individually or in groups. By detecting deviations from the norm, either using smart algorithms on the sensors themselves or in the cloud, precision livestock farming systems can help farmers to remotely monitor their operations.[5]

By visually tracking hens in a chicken coop and analyzing the images, the eYeNamic tool, developed by Fancom[6], a provider of control solutions for pig and poultry farms, lets farmers detect problems that can otherwise go unnoticed. If, for example, a feeder line is defective, the chickens will flock around the operational feeder lines, leading to an unusual spatial distribution that the image processing algorithm can detect, immediately triggering an alarm. Rather than noticing the defective feeder line hours later, the farmer can intervene immediately to remediate the situation.

Visual analysis of how a cow walks into a milking parlor has the potential to provide early diagnostics for the onset of lameness, an ailment associated with diseases or other factors. Monitoring the sounds in a pigsty using an array of microphones and analyzing them for coughs, farmers can treat the animals before the early symptoms lead to a massive outbreak. And back in the chicken coop, recording and analyzing

[1] The Future of Food and Agriculture, Trends and Challenges, FAO, 2017.
[2] Agricultural census in France, Eurostat, 2012, http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_France
[3] Livestock's long shadow, FAO, 2006, http://www.fao.org/docrep/010/a0701e/a0701e00.HTM
[4] Precision livestock farming in egg production, Hongwei Xin Kai Liu, Animal Frontiers, 01 January 2017
[5] ibid
[6] http://www.fancom.com/en/broilers/biometrics

pecking sounds can provide farmers a non-invasive means of determining the food intake of each individual chicken.[7]

Taking precision livestock farming outdoors
Swiss startup Anemon[8] has developed a wireless solution that alerts farmers when their cows are in heat. Made up of an intravaginal temperature sensor and a transmitter that communicates over the mobile network, the Anemon solution helps farmers increase the success of artificial inseminations, saving the time and cost of monitoring their herds manually. Others have commercialized solutions to track the locations of herds and collars that monitor the time they spend eating and ruminating.

By fitting grazing animals with a GNSS receiver, accelerometers, and a logging device, farmers can reap the benefits of the precision livestock farming on pasture and rangelands, which represent 91 percent of the area used for livestock farming. To establish a replicable method and prove its utility, researchers monitored three Merino sheep in a herd of 200 using the technology.[9] The insights they gained could potentially improve both flock management and landscape preservation.

The researchers tracked behaviors including grazing, search, walking, and vigilance. On pastures shared with other animal species, conflict between the domestic and wild animals can lead to stress in the animals, decreasing productivity. By combining vigilance levels with information on the presence of predators, farmers could potentially identify animals that respond sensitively to threats such as predators and redistribute their flock, relocating them away from their wild competition, increasing the productivity of the flock.

Shifting the focus to transparency
While the focus of precision livestock farming technology tends to be improving operations and increasing productivity, it also serves to ensure that animal health and welfare standards are met.[10] Given the surge in consumer awareness of these issues, demonstrated by the success of organic labels, farmers could leverage the technology to transparently showcase their compliance to both regulatory norms and heightened consumer expectations. Because in today's consumer-driven food market, farmers have a strong incentive to find ways to stand out. ■

[7] General introduction to precision livestock farming, Animal Frontiers, D. Berckmans, 2017
[8] http://www.anemon-sa.ch/
[9] Multi-dimensional Precision Livestock Farming, PeerJ, 30 May 2018
[10] Precision livestock farming for animal health, welfare and production, Wathes, C.

The journey of a banana

Today's global market is a non-stop supply chain. 24 hours a day, 7 days a week, raw materials, food, manufactured goods, and components are on the move. They are destined for factories, distribution centers, and retail outlets around the globe. Many goods, such as clothing, cars, and electronics, have a long shelf life.

Certain goods do not. For example bananas.

u-blox wireless communications and global positioning technology plays an important role in all of these processes, a role that hardly comes to mind when you peel a banana.

1 Once harvested, bananas need to be shipped immediately

but first plantation owners negotiate with buyers to get the best possible price. Low-cost mobile terminals let growers connect to the market without leaving their plantation.

2 Wireless communication depends on a vast network of cellular base stations.

Precision timing modules that rely on GNSS satellite-hosted atomic clocks synchronize base stations to ensure uninterrupted communication as the bananas travel from one cell to the next.

3 Hundreds of tons of bananas are shipped around in the world in refrigerated containers.

To delay ripening, each container needs a carefully controlled and monitored climate, typically using wireless sensor-equipped asset trackers.

4 At the port, the bananas are unloaded and heated to 17°C and exposed to ethylene to induce ripening before being transported to shops.

Telematics devices track everything from each truck's position, its time of arrival, and the storage conditions to its speed and fuel efficiency.

5 After a long journey, the ripe bananas are ready for sale. With a swipe of a card, a wireless point-of-sale terminal transmits credit information to a distant computer.

Within seconds, the transaction is completed and the bananas embark on the last leg of their journey, to the fruit basket in your home.

Connected food

All eyes on food safety

Fully transparent and 100 percent traceable: digital technologies have the potential to catch the bad apples.

In a perfect world, you'd know everything about the food you put in your mouth. From its composition to the origin and quality of all its ingredients to its shelf-life, full transparency would reduce the risk for health-related incidents and food fraud. And when contaminations do occur, which they inevitably will, or when corrupt suppliers are caught splicing their ingredients with subpar products, recalls will be quick and easy to organize.

In a perfect world, food waste would be cut to near zero by reducing wastage along the entire production chain from farm to fork. Foods would be sold fresher, packaged to last longer, and expiration dates would reflect the actual state of the food, not some theoretical predetermined one.

Alas, reality is more complicated. On average, foods travel greater distances than ever before to reach our supermarkets, and often are composed of a bewildering list of ingredients in an equally bewildering series of processing steps, changing hands from one supplier to the next in the process. With such complexity, it is easy to lose track of where individual ingredients came from. Not only that, the fact that much of the food we eat is processed in centralized facilities means that contaminations at a single processing plant can impact multiple product lines in vast geographic regions.[1]

Some food panics have the potential to tarnish the reputation of food brands. The European horse meat scandal of 2013, caused by suppliers who managed to sell horse meat in place of beef, is a case in point.[2] Others pose a serious threat to human wellbeing. In 2003, 550 people were infected with hepatitis A from contaminated green onions served in a restaurant chain in the US[3], where, on average, 3000 people die of food poisoning each year.[4]

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[1] Intel: White Paper Making Food Safer for Everyone
[2] How the horsemeat scandal unfolded – timeline, The Guardian, 2013
[3] Hepatitis A Outbreak Associated with Green Onions at a Restaurant --- Monaca, Pennsylvania, 2003, CDC, 2003
[4] Centers for Disease Control and Prevention, Burden of Foodborne Illness: Findings, Retrieved Aug. 2018

Given these facts and the financial impact of business interruptions, disposal of products, and reimbursements to retailers, it is no surprise that even profit-driven stakeholders across the board hold high hopes for the digitalization of the food sector to move us closer to the perfect world scenarios outlined above.

Traceable end-to-end asset tracking
Traceability and transparency along every step of the process is key to locating the source of tainted ingredients, in particular when multiple suppliers are involved.[5] Already today, companies such as Kagome, in Australia, are using the IoT to track their produce, tomatoes, from the plantation to the plate.[6] Using RFID tags and GNSS technology to track harvests, smart production lines to produce the products their customers are seeking, and RFID tags to track shipments, all relevant stakeholders, including food safety authorities, gain access to the data.

The approach can be scaled up for products that go through more complex supply chains. Companies, like US-based Roambee[7], are providing such asset monitoring solutions that monitor shipments and provide data – with a variety of actionable alerts – in real time. Their sensors can detect environmental parameters such as temperature, humidity, and pressure, as well as quantities reflecting product handling, including shocks, light, motion, and tampering, even as goods leave one production site to another one.

“Traceability and transparency along every step of the process is key to locating the source of tainted ingredients, in particular when multiple suppliers are involved.”

Visual quality control
Quality control is a critical but costly step in any food supply chain. Most produce undergoes visual inspection. When there are signs of possible internal defects, fruits need to be cut and analyzed to quantify the damage. The process takes time and labor, and leads to the destruction of often perfectly flawless and comestible produce.

Hyperspectral imaging offers a new approach to automate non-invasive visual inspection of produce, with the added benefit of new insights, such as a product’s potential shelf life or its ripeness. The technology uses cameras that detect reflected light across a broad range of frequencies and correctly interpreting the sensed data, often using machine learning.

According to ImpactVision, a provider of hyperspectral imaging tools for the food sector, the technology allows retailers to detect darkened meat that consumers typically reject, so that they can process it as minced meat, for instance. And, it can detect the ripeness of avocados, so that you can enjoy its smooth, creamy flesh the day you buy it at the store.[8]

“Hyperspectral imaging offers a new approach to automate non-invasive visual inspection of produce.”

From the last mile to the final bite
Roughly a third of the food we produce for human consumption, or 1.3 billion tons, is lost in processing or ends up in the trash[9]. And in developed countries, more than 40 percent of discarded foods are thrown out by retailers and consumers.[10] While addressing this involves changing attitudes towards foods in societies spoiled by abundance, significant progress could be made by improving the way we package food and communicate expiration dates.

A low-tech smart label may be paving the way towards more accurate expiration dates that account for the history of a product. The Mimica Touch label, which, in 2017 won its 24-year old developer, Solveiga Pakštaite, the John Dyson design award, incorporates a gel that degrades at the same rate as the food inside the packaging. The object of a trial with Arla, Scandinavia’s largest dairy producer, it’s a first step towards ensuring that the food in your fridge is fit for consumption, even beyond the expected expiration date.[11] And isn’t it comforting to know that the next generation is already cooking up solutions to guarantee the safety of our meals? ■

[5] https://www.foodlogistics.com/safety/article/12374972/supply-chain-complexity-the-catalyst-for-food-safety-failure
[6] https://www.iothub.com.au/news/how-kagome-uses-iot-for-food-quality-454599
[7] https://www.roambee.com/

[8] https://agfundernews.com/hyperspectral-imaging-sets-new-standards-food-monitoring.html
[9] Food Loss and Food Waste, FAO, Retrieved Aug. 2018
[10] SAVE FOOD: Global Initiative on Food Loss and Waste Reduction
[11] Arla to launch Mimica Touch “bumpy” labels capable of minimizing food waste, Food Ingredients First, Joshua Poole 2018

Not your gramma's grocery store

By ushering in a revolution in retail, technology is forcing brick-and-mortar supermarkets to get smart.

Picture yourself walking into a store, browsing the aisles, grabbing your groceries, and leaving without even pulling your wallet. It sounds an awful lot like shoplifting, but when Amazon opened its first Amazon Go store in Seattle early this year and then later in Chicago, checkout free shopping became a reality. To the 85 percent of people[1] who don't enjoy grocery shopping, no lines, no wait, and full convenience are a breath of fresh air.

Grocery store chains are a fiercely competitive business, well accustomed to constant innovation to keep customers from switching to the competition. But the parallel rise of discounters with e-commerce and its new platforms, brands, and retail models, as well as fundamental changes in consumer behavior present an unsavory pickle for food retailers. While discounters have proven successful at resetting price expectations, new niche retailers have been welcomed by a fragmented and highly demanding consumer base that rewards swift innovation and early access to products that respond to the latest trends.

Scaling up without a middleman

At the same time, online direct-to-consumer models that cut out the middleman – and the need for brick and mortar stores – are gaining ground. Packaged consumer goods brands, in particular those behind higher margin products, are leveraging direct access to a nationwide or even global customer base offered by the Internet, and are settling into this new lucrative niche.[2] And companies like Blue Apron, Home Chef, and others in the meal delivery cohort are taking advantage of consumers' desire for convenience and options that meet their ever-evolving food preferences, with an ever-growing market share.

It is, therefore, no surprise that both budding and established retailers are looking to technology, including drone delivery, to help attract and retain customers by putting them front and center, and to optimize operations, through automation and creative innovation. The benefits of going cashier-free, for instance, are substantial. With 30 percent of labor[3] going into checkout, freed up personnel resources can be used to generate higher value. Similar benefits could be achieved in the backend. But much of the battle will be fought in marketing and communication. According to a report by Intel[4], the winners will be those that successfully leverage technology to create an engaging, personalized in-store experience through a deep understanding of each shopper.

The quickest path through the aisles

Indoor location services, in particular, could offer a variety of transformative benefits to retailers. Just think how much time, pain, and nerves you'd save if you were guided through the grocery store and its inventory by your smartphone and managed to tick off all the items on your list without having to go back and look for, say, mouth wash. Conversely, data analytics on the trajectories of shoppers through the stores bear insights on shopper behavior that could be used to improve shop layout.

As a customer, you obviously need an app to benefit from these features. Such an app is a huge foot in the door for retailers as well, giving them a means of smartening their game through advanced data analytics and of individualizing the shopping experience at the customer level. It may also provide a portal for increasingly customizable products, which are likely to be expected by consumers.

In its report, Intel introduces the smart shelf, a key element in the technology mix.[5] Smart shelves can be tailored to the needs of the customer, engaging with them to provide interactive product information, or to the needs of

[1] The future of grocery—in store and online, McKinsey, Louise Herring, Jessica Moulton, Monica Toriello, June 2017, Podcast transcript
[2] ibid
[3] The future of grocery—in store and online, McKinsey, Louise Herring, Jessica Moulton, Monica Toriello, June 2017, Podcast transcript
[4] The second era of digital retail, Steve Brown, Futurist and Senior Industry Advisor, Intel
[5] ibid

the product supplier, feeding back information on the shoppers and their behavior. Regardless of their design and precise function, which will vary starkly as a function of the context, smart shelves will channel and leverage vast amounts of data they gather, potentially fueling a broad range of new business models.

Coming out as a leader

Smart shelves and mobile apps are but two of the many means for in-store data collection. Some lighting manufacturers have developed Bluetooth mesh-based beacon solutions that fit into the lighting infrastructure already in place in stores. Used in combination with a mobile app, their solutions offer shoppers a personalized in-store experience, with tailored promotions and loyalty programs. Store managers, on the other hand, can use them to gain insight into the makeup of their customers, target specific ads to predefined customer segments, and get real-time analyses of the campaigns they run.

It takes bold thinking and audacious action to come out of the ongoing digital transformation of retail as a leader. It is, then, perhaps no surprise that the most disruptive proposal to date comes from a company that is more at home in online retail that in physical stores. With Amazon Go and its in-and-out cashier-free experience, the online retailing giant may be giving us a taste of what's in store for the future of retail.

The "Just Walk Out" technology that makes it work is heavily based on a dense network of cameras that tracks every item that is removed from – or returned to – a shelf. It further leverages sensor fusion, the melding of data from different types of sensors. According to an article in Wired[6], this might, for instance, include combining image data with data collected by scales built into the shelves. It's a proof of concept that solidly moves the connected store out of the realm of hype.

But how do customers decide what goods to purchase? As of today it's a complex interplay between planned and spontaneous decisions, often more influenced by advertising that we would like to admit. But according to a report by Accenture[7], our personal smart devices might end up linking up with our healthcare provider to help us improve the health benefits of what's on our shopping list. So long, wine. Unless we're lucky, and wine becomes recognized as the superfood we wish it was. ■

[6] The technology behind Amazon's surveillance-heavy Go store, Matt Burgess, Wired, January 2018
[7] The Future of Food, New Realities for the Industry, Accenture and Kurt Salmon, Steven Pinder, Pat Walsh, Michele Orndorff, Erica Milton, Jenna Trescott, 2017

Some lighting manufacturers have developed Bluetooth mesh-based beacon solutions that fit into the lighting infrastructure of a store. Used in combination with a mobile app, their solutions offer shoppers a personalized in-store experience.

Growing crops sky high

Vertical farms combine a green thumb, a healthy dose of engineering, and a pinch of IoT to produce unprecedented agricultural yields per square meter. But will they stand the test of time?

It sounds like a techno-optimist's fever dream: floor upon floor of indoor agricultural space illuminated by artificial light, the whole thing stacked up into tall skyscrapers. But go no further than London, New York, or Singapore, and you'll get to experience some flavor of vertical farm first hand. Consuming but a minute fraction of the water needed in conventional agriculture, entirely indifferent to climate, isolated from pests, and designed to fit snuggly in, outside, or even beneath any city, vertical farms have the wind – and ample capital – in their sails.

Take Plenty, a Silicon-Valley startup that recently raised US$ 200 million in venture capital to finance its expansion. Measuring just over six meters, it would be a far stretch to call their farming units sky-scrapers, but who cares: Plenty's design has a lot going for it. In particular, a 350-fold increase in the amount of produce that can be grown on a given land footprint with only one percent of the water needs.[1]

Plenty is not alone. A multitude of startups and other companies are testing and developing their own solutions that rely heavily on sensing, wireless connectivity, big data, and analytics to solve the challenge that all indoor farms face: artificially providing their crops with otherwise "free" ingredients such as water, nutrients, and sunlight. Their success depends on whether they are able to do so better than, or at least as good as, nature, offsetting costs incurred at one step of the process by savings made at another.

You grow *what* in there?

Imagine planting an apple tree in a vertical farm and you quickly understand some of the technology's limits. The time it would take for the tree to mature to the point of bearing fruit, the amount of electricity needed to provide artificial sunlight, and the amount of water that would have to be provided (and pumped), just to sell apples at a few cents apiece make vertical fruit orchards economically unviable. Also disqualified

[1] https://www.vox.com/energy-and-environment/2017/11/8/16611710/vertical-farms

Over

180

indoor farms nationwide Japan.

are grains and other commodity crops, which could hardly compete with today's cheap and highly efficient large-scale approaches.

But if the crops grow quickly or if they have a high yield, vertical farms start to make more sense. Leafy greens, herbs, mushrooms, and tomatoes, eggplants, cucumbers, and the like are all fast growers that efficiently convert artificial light, water, CO_2, and nutrients into consumable crops, thereby increasing the farm's bottom line. Alternatively, vertical farms can settle into a potentially lucrative niche by specializing in high-value crops, such as branded products, so-called botanicals, or, since recently, and where legal, cannabis.[2]

Finding viable business models

With over 180 indoor farms nationwide, Japan has embraced vertical farming systems to grow lettuce and other crops indoors where they are less exposed to natural disasters such as typhoons and volcano eruptions. The country's largest "plant factory" alone has a daily output of 21,000 heads of lettuce.[3] While vertical farms make up but a small fraction of the total Japanese agricultural production, the success the approach has had in Japan adds credence to claims that vertically grown produce can compete with its horizontally grown competition in supermarkets.

Another region where vertical farming stands more than just a fighting chance to succeed is the Middle East, where water is scarce, energy is abundant and affordable, and demand for fresh produce is high. Emirates Flight Catering and Crop One Holdings recently announced plans to build the world's largest vertical farm to supply Emirates Airlines and other airlines that depart from Dubai International Airport.[4] Be sure to stop over in Dubai after November 2019 to sample their produce for yourself.

[2] https://www.verticalfarming.com/food-crops/
[3] https://spectrum.ieee.org/energy/environment/the-green-promise-of-vertical-farms
[4] http://uk.businessinsider.com/dubai-emirates-airlines-world-largest-vertical-farm-2018-7?r=US&IR=T

Vertical farming is still a young idea, very young compared to outdoor agriculture's ten millenia of progress.

Back to the roots

Rather than relying on expensive artificial lighting, Sky Greens, based in Singapore, runs a patented vertical farming system that grows plants on a giant slowly rotating Ferris wheel with 38 tiers of troughs. The plants circle up towards the natural sunlight, where their chloroplasts can load up on photons, and then down, where they are sprinkled with gravity-driven H_2O to replenish their roots. The ingenuity of the hydraulic-driven design reduces power consumption for each nine-meter tower to that of a 40 Watt light bulb. It has proven its success in sunny Singapore since 2011, when the first prototype was built.

Clever approaches abound, yet questions remain. Will vertical farming ever displace a significant fraction of conventional farming? Will it significantly contribute to the 60 percent increase in food production reportedly required by 2050[5]? Or will it simply add another arrow to the food industry's quiver that it can draw when the local circumstances permit?

Vertical farming is still a young idea, very young compared to outdoor agriculture's ten millenia of progress. But today's fast-paced "build, measure, learn, repeat" mentality, enabled by the agricultural Internet of Things, means that lessons learned growing one batch of produce can be applied growing the next one, dramatically accelerating the pace of progress. And investment in AgTech is booming, even though no one has yet cracked the code to scalable success. Time will tell, but if vertical farming offers an economically feasible way to grow specific crops, locally, year-round, and 100 percent pesticide free, it does, indeed, have a lot going for it. ■

[5] FAO, World Agriculture towards 2030/2050, The 2012 Revision, 2012

Supporting a smart fight against deforestation in Madagascar

When Regula Ochsner returned to Madagascar in 1998, two decades after having worked there, she was shaken. Entire forests had all but disappeared. While some had been cleared for farming, most – roughly 80 percent – had been harvested for firewood. Cleared of its forest cover, the fragile soil was exposed to the elements, resulting in irreversible erosion that left behind a scarred landscape and destroyed habitats.

Determined to protect what remained of Madagascar's forests, Mrs. Ochsner returned to the island in 2000. A shipping container followed her, filled with 500 kits to build solar ovens. ADES, the Association for the Development of Solar Energy, was born, and the shipping container was transformed into its first workshop.

ADES has since grown into a 140-person business active in nine centers across the island that has spawned hundreds more part time and fulltime jobs. Its portfolio has since expanded from the solar cooker they began with to include energy-efficient briquette and wood stoves.

Rice, cassava, sweet potatoes, or beans, staples of Malagasy cuisine, can be prepared with a fraction of the wood or briquettes needed on traditional open stoves. In addition to cutting the need for firewood by 50 percent the stoves each save 3000 square meters of forest per year and dramatically reduce the amount of harmful smoke people, in particular the cooks, are exposed to.

All in all, ADES has sold 170,000 stoves, impacting close to one million people. But Regula Ochsner wanted to reach more of the country's 25 million inhabitants, who live spread across vast areas often serviced by poor infrastructure. The answer was a sales platform on wheels. Equipped with a kitchen, dormitories, and a sales room, the ADES truck, inaugurated in 2017, travels from site to site with a total staff of ten, spending a few weeks or months in a region demonstrating and selling stoves at markets before moving on.

As part of our long-term CSR strategy, u-blox has been supporting ADES since 2011, and we again renewed our commitment to the project this year, sponsoring three-months of the mobile sales platform's activity as it travelled from Moramanga to Ambatondrazaka to Tamatave on the east coast. During that time, they sold stoves to 1500 households made of 8250 individuals, collectively saving 4500 tons of wood and CO_2 emissions. ■

Learn more:
www.adesolaire.org/en
www.u-blox.com/en/our-work-community-making-difference

Emerging technologies promise new generation of applications

High precision positioning, low power wide area (LPWA), short range mesh networks, and edge intelligence promise to extend the range of applications for the IoT in the food sector and beyond.

If data is a primary driver of industrial digitalization, the technologies used to gather, transmit, store, and process it are its key enablers. This is also true in the food sector. From the farm, field, or plantation, through the entire supply and production chain, to retail – even into our homes – digitalization is always about the acquisition of data, analytics at the edge or on the cloud, and leveraging the data to optimize development. Improvements in the quality of the data and the technologies used to gather, transfer, and analyze it typically translate into improved processes. In some cases, however, they can enable entirely new applications, opening brand new markets.

“If data is a primary driver of industrial digitalization, the technologies used to gather, transmit, store, and process it are its key enablers.”

The latest generation of high precision positioning technology is doing just that, leveraging multi-band GNSS (Global Navigation Satellite Systems) combined with GNSS correction data. By dramatically bringing down the cost of ownership of the technology, high precision positioning is not only becoming accessible to a broader market, it is also paving the way for the development of new autonomous solutions. Whether they are autonomous agricultural vehicles or unmanned delivery drones, the small, lightweight, and low-cost high precision positioning technology robustly delivers positioning accuracies down to a few centimeters. Is it disruptive? It will be a game changer.

The cost of cellular data transmission and hardware have long been bottlenecks for the deployment of extensive wireless sensor networks. Offering enhanced geographical coverage, low-cost hardware and data plans, as well as over 10 years of battery life in some use cases, the latest generation of licensed low power wide area networks, including LTE-M and NB-IoT, are quickly brushing aside these limitations. Applications such as crop monitoring, livestock monitoring and fleet tracking will be among the first to benefit from these technologies.

Mesh networks offer a way to efficiently scale up wireless sensor networks by having individual nodes relay messages across the network, thereby expanding their reach and enabling wide-ranging applications from irrigation networks to smart processing plants to connected supermarkets. Standardized platforms such as Bluetooth® mesh ensure that devices remain interoperable, even if they come from different suppliers. And by including nodes capable of transmitting information using mobile communication networks – forming so-called capillary networks – mesh networks can be extended to enable cloud based applications.

Because of the massive amounts of data they generate, many IoT applications would run into a bottleneck: bandwidth. Edge computing, yet another technological innovation, offers one solution to that problem. Rather than streaming all of the gathered data to the cloud for analysis, smart sensors, gateways, or a local server take over some of the analytics, only transmitting an aggregate value, such as an average, an alert, or a message to the cloud. Machine learning algorithms run on the “edge” – i.e. before data is sent to the cloud – can detect outliers and other abnormal behavior the farmer, plant manager, or store manager should be aware of. ■

Learn more:
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Expert opinion

The IoT should revolutionize the entire food industry

Interview between Haiao DING, Associate Chief Editor, Digital Business Times, China, and Perry ZHANG, Principal, Strategic Partnerships, u-blox

The whole food supply chain has evolved dramatically in recent years, especially thanks to technological innovations such as mobile connectivity, wireless communications and location-based services – in one word: the Internet of Things (IoT). But what does it mean concretely, in particular in China?

Perry ZHANG
Principal
Strategic Partnerships
u-blox

Haiao DING
Associate Chief Editor
Digital Business Times

What's new about the whole food supply chain, compared with the past?

Perry ZHANG - New technologies are driving the food industry to develop, innovate, and transform. The Internet of Things, or IoT, will bring revolutionary changes to the entire food industry.

Haiao DING - In the past, information technology could only play its role at the end points of the food supply chain. But now IoT, big data and cloud computing have connected the food supply chain as a whole, empowering it with more intensified management.

P.Z. - Indeed new technologies, such as big data, cloud computing, and AI, can be introduced to the food industry, guaranteeing a technological revolution in this industry.

" IoT, big data and cloud computing have connected the food supply chain as a whole, empowering it with more intensified management."

Can the IoT can help prevent food loss and waste across the food supply chain?

P.Z. - Food loss is a big problem in the food industry. Statistics show that more than 30 percent of food is spoiled in the entire production and transportation process. New technologies, such as IoT technologies, can help the industry save food and improve efficiency.

For example, one of our customers has developed a box for frozen food that allows them to monitor the temperature, humidity, and light conditions throughout the entire logistics process. The frozen food box is equipped with a u-blox 4G LTE communication module that periodically sends information about ambient temperature changes to a server. If at any time in the logistics process the temperature goes beyond a preset range, an alarm is triggered, followed by corresponding behaviors to adjust ambient temperature and conditions.

H.D. – IoT can hardly eliminate the so-called food waste. Instead, it can greatly improve the food utilization rate. Data shows that only about one-third of all food around the globe is consumed every year[1]. Will the food utilization rate be increased if food supply chain management becomes more precise? For example, if the food

supply chain can feed data on transportation or purchasing and sales back to production, producers will know the demands of the end customers and prevent waste.

There is another way to reduce waste in the logistics industry. I know a domestic company engaged in intelligent logistics that recently launched a new product to control the temperature, humidity, and quality of fresh products and minimize food loss during transportation. If such technology allows every point at every link of the food supply chain to be recorded, controlled, and adjusted without human intervention, companies will be able to improve their efficiency and reduce food loss during transportation. When this reduction reaches a threshold, the food waste in the whole food supply chain will become negligible. I think this might happen after IoT application becomes very mature.

P.Z. - Some foods, especially high-end fresh foods, such as seafood and fish, as well as processed foods like milk and yogurt, have very stringent requirements for ambient temperature. If in the transportation process there is any deviation in temperature or humidity, the food might be spoiled completely, impacting either suppliers or customers. This greatly damages the reputation and credit of the food supplier.

This is why a lot of countries, especially Europe and America, as well as Japan, are implementing end-to-end control of fresh foods, from the factory to delivery to the customer end, which is clearly a global trend. This process has to depend on wireless communication technology, which enables the reporting of real-time transportation data to the server and the back-end accessed by the client, who then manages and controls the process.

What technology innovations do you see as particularly important for a smart food supply chain?

P.Z. - I work in the communications industry, the IoT sector in particular. In my view, low power wide area (LPWA) wireless technology has brought the greatest benefits to the food industry. Its low power feature supports scenarios that could not have been realized in the past. Some traditional pre-sales industries, for example, need to install many trackers or monitors, which are very power-consuming if they apply traditional 2G, 3G, or 4G technologies. With LPWA technology, we can significantly reduce the size and power consumption of the batteries, greatly prolonging the life cycle of traditional monitors or trackers.

"Low power wide area (LPWA) wireless technology has brought the greatest benefits to the food industry."

China Telecom's NB-IoT network has realized numerous commercial applications, one of which is related to dairy cows. Dairy cows produce milk only after giving birth to calves. It is, therefore, important to know when each cow is in heat, to minimize the time during which it is not productive. With LPWA technology, we can place a collar with an embedded LPWA module around the neck of each dairy cow to monitor its physical status and send data, including its body temperature and breath count, to the server to determine when is the right timing. One of our customers, a diary enterprise in Ningxia, has applied such a NB-IoT-based solution, greatly increasing their milk production.

H.D. - In China's food industry, Industrial IoT technologies are applied in different scenarios, such as in the agricultural, retail, and sales sectors. Different scenarios require different technologies, such as IoT, AI, cloud computing, or big data, which will all be widely applied across the entire food supply chain.

There's an e-commerce company that is using AI technologies in an experimental project involving unmanned delivery vehicles. Universities abroad are also conducting similar projects, indicating that AI technologies may be most important in logistics. Big data plays a similar enabling role in marketing: both Alibaba and JD have collected massive data about consumers, but how can these data be leveraged to increase sales? Unmanned supermarkets and emerging self-retail aim to tap into the value of data. We can see all kinds of technologies playing roles in the IoT of the food industry, but each is applicable to different IoT scenarios.

[1] The Food and Agriculture Organization (FAO) of the UN, 2015

How and by when do you think these technologies could be globally implemented?

P.Z. - So far, operators around the world have widely deployed licensed LPWA technologies, especially NB-IoT and LTE-M. According to the GSMA[2], 30 operators in the world have deployed 60 NB-IoT and LTE-M commercial networks. Most operators in Asia-Pacific and Europe are deploying NB-IoT commercial networks, while those in North America are deploying LTE-M. China's three major operators, China Mobile, China Telecom, and China Unicom, have announced plans to commercialize their NB-IoT networks. In particular, in the second half of last year, China Telecom announced that it would commercialize its NB-IoT networks throughout China. It has deployed 300,000 base stations, covering 99 percent of the country. We can say that the IoT technologies, especially LPWA, are ready for a burst of application growth.

Therefore, we believe that the infrastructure is ready, and many industries, including the chip industry have introduced their NB-IoT chips and achieved mass production. Whether they are network operators, terminal suppliers, or chip designers, our partners are ready with mature products. The next step is to customize these products to meet the food industry's special demands.

H.D. - Let's say you represent IoT applications in a 2D space, with the horizontal coordinate representing technologies, including the chip, communication, and platform layers, and industrial applications from left to right. The vertical coordinate represents application types, including agricultural plantations, food production and processing, logistics, sales, and cooking from the bottom up. So, how can IoT can achieve the greatest development in the food industry? We should pay attention to the point where IoT technologies, on the horizontal axis, can maximize the business value of a company, and help the company minimize costs. This point is where IoT technologies will have a burst of application growth. So far we have seen wide applications of IoT in logistics and processing. These will guide all application types, including every point of the food supply chain, to pay attention to this new technology.

From a technological perspective, the platform layer might have wider applications because it is the closest to end users, and will be the first to achieve explosive growth. But the chip and

[2] Global System for Mobile Communications Association

communication layers, as the foundation of the entire industry, have attracted more attention from relevant government departments, and more investment from vendors.

This technology is being applied by the entire food industry. But if you want to know which application type will first usher in explosive growth in LPWA, I would tell you that in China, logistics and production will lead the food industry onto an IoT fast track. This is in line with the laws of commercial development, as the most fundamental purpose of applying new technologies is to launch larger projects to reduce costs for enterprises.

"In China, logistics and production will lead the food industry onto an IoT fast track."

But it is difficult to predict when this burst of application will arrive, because new technologies keep emerging. Recently, many people proposed to apply blockchain technologies in IoT, especially in the food industry to ensure the security of data all the way from processing to transportation and sales. New technologies will continuously stimulate new dynamics in the industry to develop solutions tailored to different applications.

How do you think that we can guarantee safety, from food production to transportation?

P.Z. - Food safety incidents break out from time to time. Generally, we have no idea where food products come from. If you don't know the food source, you are unable to find what caused the incident. As a result, large amounts of food which should not be discarded have to be thrown away, because you don't know precisely where things went wrong. We believe IoT can make a difference in this industry by enabling end-to-end management and control, and realizing data transparency and authenticity across the entire industry chain. Only in this way can we achieve end-to-end food quality control and food traceability.

There is another very important factor. Many links of the food industry are isolated islands. For example, there is little interaction between agriculture, food processing, logistics, distribution, and sales, making it hard to trace where a product comes from, where it goes, and when. But these facts are directly related to our food safety. Therefore, we urgently need a set of technologies – including IoT – to connect these islands, and big data and the cloud to usher in new business models to realize whole-process control of the food supply chain. Some giants of the industry are making efforts in this regard, such as Alibaba's Hema Fresh. We are also exploring this area. Alibaba is integrating its subordinate suppliers to link the whole industry chain to trace the source of any product it sells, knowing when and where it was produced, by which enterprise and in which batch, and to visualize the entire process.

H.D. - To address the food safety issue, we should give priority to unifying standards across the food supply chain. Otherwise, different industries have different understandings about food safety. To make the whole supply chain, from the front-end to the back-end, reach a common understanding about food safety, some technological problems must be solved first, such as cloud computing for data sharing, and big data analysis.

Additionally, I believe data security is an important factor to ensure food safety across the food supply chain. Because if everybody in the industry chain can see and share the food data, and make sure it's exclusive, real-time, effective, and cannot be falsified, then food safety can be guaranteed from the front-end to the back-end. The IoT creates a virtual world to reflect the real world, using data to record everything that happens at every second in the real world. Its greatest value is that humans can manage real things in the real world via this virtual world. In this regard, all data in the virtual world has to be made secure and shared. The IT industry should, thus, be dedicated to ensuring that the data is authentic, effective, and exclusive. To sum up, I believe we should, first establish standards from an institutional perspective, and second guarantee the authenticity and effectiveness of data from a technical perspective.

P.Z. - We have seen a number of food safety incidents in enterprises that falsified food data. We are convinced that big data and blockchain, currently a hot topic, can play a very critical role here. We believe that blockchain will have bright application prospects across the food industry, because it offers unified and consistent data management across the food supply chain. With the blockchain, data can no longer be falsified, because one of the blockchain's main characteristics is data security and unmodifiability. Enterprises would not even be able to modify data like the production date or other parameters pertaining to their food products, since all enterprises in the food supply chain will have been informed on the day these data were released. Previous technologies allowed enterprises to save data to themselves, but the blockchain ensures data security, liability, and unmodifiability, thus protecting food safety.

"We believe that blockchain will have bright application prospects across the food industry"

How do you see the future of the smart food supply chain?

P.Z. - Blockchain can realize end-to-end control across the food chain. But to do so it needs data, which has to be collected via the IoT, especially using LPWA. As a result of its low power wide area feature, LPWA can be applied at every link of the food industry, from production to logistics to sales, to transfer data to the application server that controls and manages the whole blockchain.

Finally, I want to talk about 5G, which is currently on the rise. Two of 5G's key features are high bandwidth and low latency. We believe low latency will enable multiple scenarios in the food industry, especially the automation of food machinery. If you go visit food factories, you will notice that many of them are partly or fully automated. We believe that the future food industry will have to be fully automated to improve both quality control and production efficiency. 5G's low-latency feature can help achieve this. We believe these three technologies, blockchain, IoT, and 5G, will offer the food industry plenty of room for development.

"We believe that the future food industry will have to be fully automated to improve both quality control and production efficiency. 5G's low-latency feature can help achieve this."

H.D. - About 10 years ago, after QR codes were introduced, almost all food products sold in supermarkets started to carry QR codes overnight. All of the data collected via the mobile Internet is now ready to play a big role in any industry in need.

The technologies currently used by product manufacturers have reached a bottleneck and can hardly help them reduce costs, improve efficiency, or increase profits; therefore, new technologies are needed to bring new vitality. We can see some Chinese food enterprises pushing in this direction. For example, a Chinese refrigerator maker has now applied AI technology that alerts users when food has expired or needs to be replenished, etc. This is an example of applying data to products – a very critical part in the food supply chain, as it is closest to users.

Looking at the overall environment, I think the smart food supply chain will soon embrace explosive growth, with new technologies emerging to fill in gaps, making sure that the explosive growth is a sustainable process with rising momentum.

P.Z. - I think the application of new technologies in the food industry has just entered the initial stage. We can see that the IoT has been deployed in some links of the food industry. But in my view, its real explosive growth will arrive when all links of the food industry have deployed the IoT. Only after collecting all data of the entire food supply chain can we explore the applications behind these data and provide data support for business model innovation, which we are most excited about. I believe we are only at the beginning, and we have a long way to go before embracing the transformation of the entire food industry.

Is there anything else you would like to add?

P.Z. - We believe that technological innovation is boundless, but any technological innovation must center on an industry's characteristics. In particular, before we introduce a new technology to the food industry, we first need to be clear about what is of most concern and what provides the greatest value to the food industry. We've identified many problems in the food industry. Food safety, of course, is most important. Food waste and availability, as well as food sustainability, also require our attention. As the global ecological environment, including the climate, keeps changing, what the food industry should do to meet people's ever-changing need of food quality and quantity is a question for the IT industry to answer. However, as for the revolution in the food industry brought about by technologies, we need to think about it from the perspective of the food industry.

H.D. - In our view, Chinese companies have proven to be very enthusiastic about applying new technologies in the software and the cloud computing age. Therefore, we are optimistic about IoT application in the food industry. But before applying new technologies, we hope that the end users understand that technologies are just tools, not business, because only when they have a clear understanding of their offering, customer demand, and business goals can they truly integrate technologies to create business value. It is most important not to mistake technologies for business.

In addition, we believe that technological convergence needs to be further strengthened in the IT industry. The business scenarios we mentioned earlier are separate. In fact, different IT vendors are specialized in respective technology categories and lack standards or opportunities for cooperation. We believe that IT vendors should strengthen such cooperation in future technological applications so that there are no isolated islands or division of labor as mentioned earlier.

In my view, as the future prospect is bright, both users and IT vendors should do a good job in their respective specialties. Users ought to be clear about their business demands and apply technologies to solve their business problems. However, no one should expect that technology only can solve all problems. ■

What drives the IoT in the food supply chain?

Here are some facts & figures. Would you have known?

9.8bn

people on Earth by 2050

Source: UN Food and Agriculture Organization

60%

increase in food production needed by 2050 to feed the Earth's growing population

Source: UN Food and Agriculture Organization

1.3bn

tons of food produced for human consumption is lost or wasted globally per year

Source: UN Food and Agriculture Organization

80k

US$ in savings for ship operators by cutting berthing by one hour, thanks to the digitalization of the Rotterdam port

Source: Port of Rotterdam

75m

IoT device installations in agriculture by 2020, for a compound annual growth rate of 20%

Source: BI Intelligence

90%

of crop losses are due to weather events and 25% of weather-related crop losses could be prevented by using predictive weather modelling

Source: IBM Research

180bn m^3

of freshwater withdrawals reduced by 2030 thanks to precision agriculture for input and water use optimization

Source: World Economic Forum

240b

US$ addressable market: improving crop yields with precision farming technologies

Source: Goldman Sachs

13.5bn

US$ is the projected worth of the smart agriculture market by 2023, at a CAGR of 12.39% during the forecast period

Source: marketsandmarkets

3.2bn

US$ projected revenue for commercial-grade small unmanned aerial vehicles (sUAVs) for agriculture services by 2025

Source: ABI Research

IoT, vines, and sweet ice wines

It's true, winemaking may be an art. But like photography and music, it, too, stands to benefit from digital technology. BeWhere is showing us how.

Like many of humanity's greatest inventions, we most likely stumbled upon wine by chance, when, thousands of years ago, someone let a pile of wild fruits sit and ferment in a pot. Today, however, winemakers are doubling down to reduce to role luck plays in the value of their vintage. Experience and intuition have long formed two fundamental pillars of any viticulture operation. Now, they are increasingly being augmented and enhanced by a third: technology, in particular the Internet of Things (IoT).

Based in Toronto, Canada, BeWhere designs and manufactures hardware to track movable assets and monitor environmental sensors in real time. The company's industrial IoT solutions cater to the construction industry, utilities, connected logistics, and the government, on a worldwide scale. Clients in the food sector can use BeWhere's asset tracking technology to keep an eye on products from packing to retail and get real-time alerts when temperatures go above or below predetermined thresholds.

Getting the most out of each growing season

With Toronto located near the heart of Canada's ice wine production, it only seems fitting that BeWhere partnered with Huawei Technologies Co., Ltd, Bell Canada, and the nearby Henry of Pelham winery to test their rugged, self-powered M-IoT solution.

Growing grapes is tricky business, where a grower's decisions can make or break a harvest. Growing grapes for ice wine is arguably even trickier. Canadian regulations stipulate that grapes can only be harvested for ice wine production when the grapes freeze completely down to -8 degrees Celsius. Ideally this should be preceded by a series of freeze-thaw cycles that allow the color to stabilize and the flavor to mature. To achieve a perfect vintage, ice wine producers often go to lengths to control the temperature their vines are exposed to, achieved using frost fans or sometimes even helicopters.

BeWhere's M-IoT solution takes some of the guess-work out of growing grapes, delivering hard data on environmental parameters such as temperature, humidity, and pressure – down to the temperature measured inside individual grapes. Accessible on any connected device, wine producers can use these data to track their grapes and get the most out of each growing season.

Tailored to global markets

BeWhere's low-cost and flexible monitoring solution builds on u-blox positioning and cellular communication technology. The company's self-powered and rugged M-IoT cellular beacons, officially commercialized in May 2018, are the first North American product to leverage the latest generation of u-blox low power wide area (LPWA) modules, optimized for wirelessly transmitting tiny datasets, keeping hardware and monthly data costs low. Initially designed for North American LTE-M networks, the u-blox SARA-R4 LTE-M/NB-IoT module they use allowed the company to increase its geographical footprint to Europe, where NB-IoT networks have been first to roll out, and to target customers worldwide.

"u-blox is known for producing high quality hardware, but most importantly, they constantly innovate to stay on the leading edge of the technology," says Margaux Berry, VP, Strategy and Growth at BeWhere. "Thanks to the great support and products that surpassed our expectations, it only took us about a year to get the M-IoT up and running." ■

Learn more:
www.bewhere.com
www.u-blox.com/product/sara-r4n4-series

Securing the IoT with Kudelski Group

By joining forces with Kudelski, we're setting a new industry benchmark for premium-grade, secure connectivity.

With Gartner analysts predicting a whopping 20 billion Internet of Things (IoT) devices to be connected by 2020, it's hardly a surprise that IoT security has become a prime concern of IoT device manufacturers and cellular network operators. While the IoT promises new features, new business models, operational efficiencies, and data-driven insights, organizations – both ours and, presumably, yours – must take the measures necessary to protect the pillars of their business, including monetization, safety, privacy, intellectual property, regulatory compliance, and reputation.

This IoT security challenge offered us an exciting opportunity - how do we make Trust and Integrity simple for our customers? Grabbing the bull by the horns, we decided to partner with the Swiss-based Kudelski Group, a world leader in digital security, with more than 30 years of expertise in protecting devices, data, and digital business models.

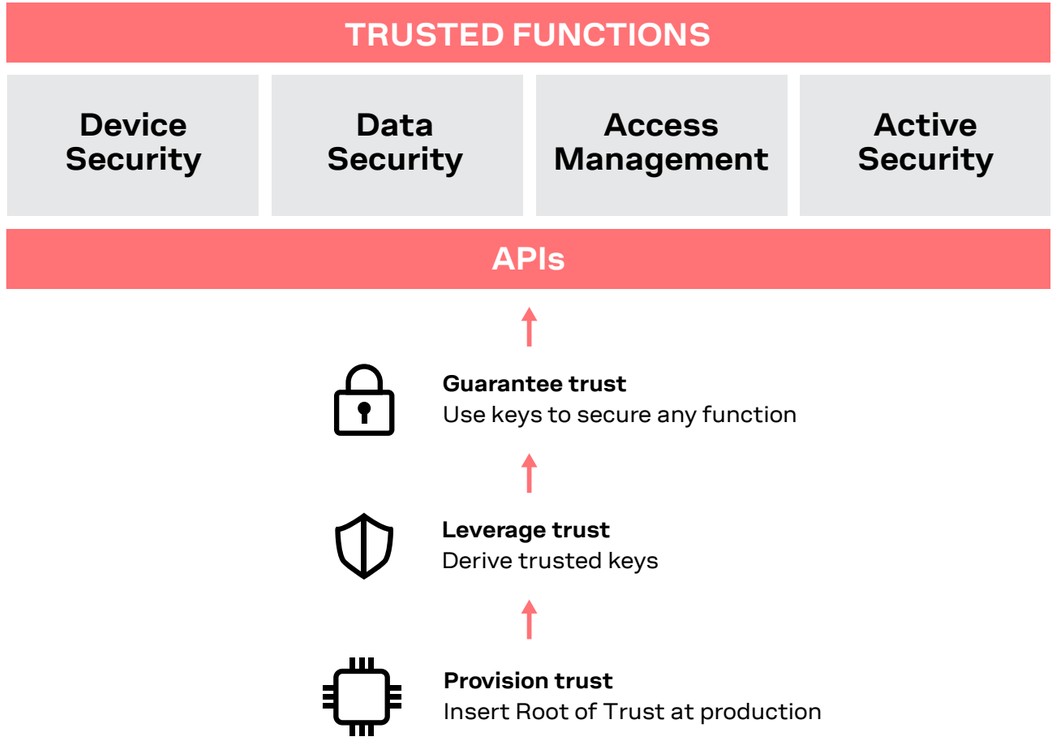
"At u-blox, we provide premium products – and security is no exception," said Andreas Thiel, u-blox co-founder and executive director, Product Center Cellular. "Combining our leading wireless communication technology with the Kudelski IoT Security Suite lets our customers benefit from our combined expertise and experience in dealing with high-volume, security-sensitive environments. Security is fundamental to the success of any business, and that's why we are delighted to build our security services with an experienced and proven security partner such as Kudelski."

u-blox and Kudelski teams are now hard at work integrating the Kudelski IoT into a number of u-blox products, with a focus on low power wide area (LPWA) technology. With Kudelski's security technology at the heart of our chips and modules, they provide a secure foundation for device protection, data protection, access management, and active security over the entire lifespan of the product they are built into.

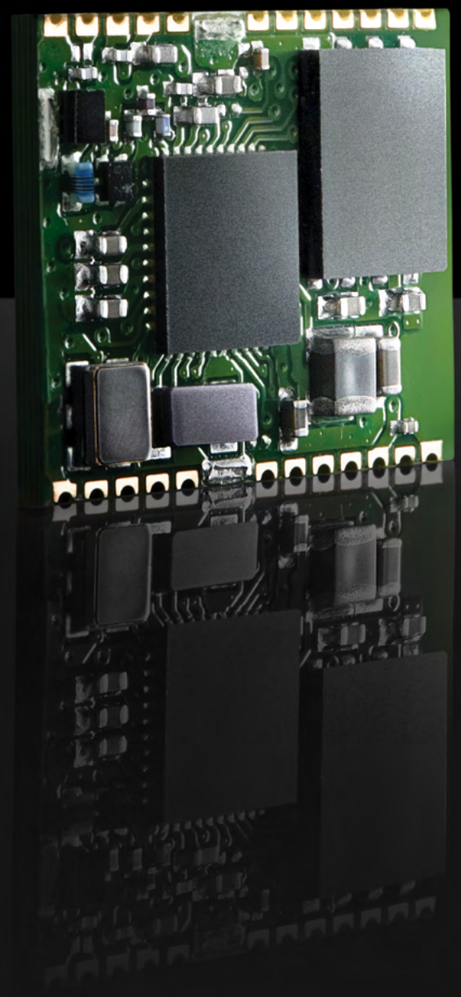
"IoT projects can only achieve their objectives if security is designed in from the start, and a long-term, security lifecycle management approach is taken," said Jean-Michel Puiatti, senior vice president of IoT security at Kudelski. "u-blox has pioneered positioning, connectivity, and short range communications solutions that underpin the connected Internet of Things. By establishing this relationship with them, we will work together to enable business owners to securely drive new business models, features, efficiency, and data analytics." ■

Learn more:
www.kudelski-iot.com
www.u-blox.com/en/our-work-community-making-difference

How we create trust to drive secure functions



In the spotlight



The latest in positioning and wireless communication technologies

Combining industry-leading quality, robustness, sensitivity, and performance with innovative features, u-blox delivers components and solutions that meet the needs of even the most demanding designs. We focus on business-critical applications where products need to perform 24/7 with maximum reliability, handling exceptions with minimal disruption to the overall system. Our customers expect improved productivity, quick turnaround, and a head start on their competition.

TOBY-L4

The TOBY-L4 slim modem series provides LTE 6 data speeds of up to 300 Mbit/s with carrier aggregation support. The series is designed to be connected with an external application via AT commands in order to provide the highest data rate, best user experience and utmost flexibility. With four different product variants, it is simple to create devices that provide global coverage. TOBY-L4 is based on an AECQ certified cellular chipset, available in automotive grade, and qualified according to ISO 16750. It is the perfect choice for vehicle infotainment systems, ruggedized mobile terminals, set top boxes, digital signage and remote video surveillance systems.

Learn more:
www.u-blox.com/product/toby-l4-slim-modem-series

ZED-F9P

Based on the u-blox F9 technology platform, the ZED-F9P multi-band GNSS receiver delivers robust centimeter-level accuracy in seconds. It is the first mass market multi-band receiver to combine GNSS signals from multiple frequency bands (L1/L2/L5), signals from four GNSS constellations concurrently, and multi-band Real Time Kinematics (RTK) technology, thereby maximizing the availability of centimeter-level accuracy even in challenging environments. Significantly smaller (22 x 17 x 2.4 mm) and more energy efficient than existing solutions, ZED-F9P enables new high precision positioning applications such as machine control, ground robotic vehicles, and high precision unmanned aerial vehicles (UAV) for the mass market.

Learn more:
www.u-blox.com/product/zed-f9p-module

UBX-P3

UBX-P3 chip is the smallest vehicle-to-everything (V2X) chip on the market offering a high level of integration. The chip co-packages a power management unit and a security engine, meeting all vehicle-to-vehicle and vehicle-to-infrastructure needs. Additionally, UBX-P3 supports simultaneous communication on two channels, guaranteeing no loss of safety messages. Optimized for minimal power consumption, UBX-P3 offers low cost options for deployments anywhere in the vehicle or the roadside infrastructure."

UBX-P3 is ideal for active traffic safety and traffic management and enables wide-ranging applications such as truck platooning and in areas including smart cities, mining, and agriculture.

Learn more:
www.u-blox.com/product/ubx-p3