The Future of Farming through the Internet of Things perspective

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The Internet of Things (IoT) is transforming the agricultural industry and enabling farmers to contend with the enormous challenges they face such as water shortages, limited land availability, difficulties in managing costs, etc. Many IoT applications are addressing these issues and increasing the quality, quantity, sustainability and cost effectiveness of agricultural production.

Over the past 15 years, farmers have started using computers and software systems, mainly for organising their financial data and keeping track of commercial relationships. In the more recent years, farmers have started using digital technologies for monitoring crops, livestock and all elements of the farming process. Farming is becoming a very data-intensive sector; information comes from different devices located in the farm, sensors, farming machineries and weather stations.

The availability of vast amount of data, the ability of analysing data and making decisions are revolutionising the agriculture sector, transforming it in one of the most receptive and dynamic to technological innovation. These improvements have been deployed in farms with different extensions, which cultivates a wide range of crops, from large farms, farming research centres to small and medium-sized farms and greenhouses. The main reason is that the IoT and the benefits of technological investments are measurable for farmers.

What are the objectives and Drivers of the Smart Agriculture Revolution?

This attitude towards technological innovation is making the Smart Agriculture revolution real for farmers. Helping them to understand the huge possibilities that Precision Farming has in their daily work. The overall aim is to have a complete view of all the steps in the production chain, the transactional activities with other stakeholders involved and supporting transparency in the value chain. This objective is driven by some key factors like product safety, labour welfare, nutritional responsibility, plants and animals health, local and global market presence, sustainability, productivity and cost and waste reductions.

Smart Agriculture. Data Sensing – Data Communications – Data Storage and Processing

From a technological perspective, Smart Agriculture is based on four key steps: data sensing, data communications, data storage and processing. In other words, the farmers have to design a robust ubiquitous network of sensors, to be able to combine all the data and analyse it in order to achieve the objectives discussed before. Farm Management Information Systems (FMIS) also become a fundamental block. The predictive capabilities of an FMIS are also very critical because these techniques enable farmers to make better decisions at the right moment and prevent future risks or damages in farms. In light of all this, there is a necessary need to have an integrated solution that involves sensor networks, machine to machine communications, data analytic, management systems and applications development with predictive models. The number of applications in farming is then very vast. Here some examples, yield measurement systems, extraneous and foreign bodies identification, system for milk quota, collaborative spraying, plant disease monitoring and forecasting for spraying, weather monitoring and actions in that situation, remote machine control and diagnostic, greenhouse management, automated stable management and monitoring, livestock disease monitoring, increasing production through livestock biology monitoring. Traditionally, agronomists might have "feelings" about the progression of their crops from season to season,

but this is not objective data to enable them to determine which the best ways to cultivate are. With the IoT and applying Big Data technologies, the farmer has historical data to link which years produced the best yields (either in volume and/or quality) with the inputs of each season, allowing greater insight into why the harvest in a given year was so good.

Sensing Companies in Smart Agriculture –To give farmers the capability to control, plan and customize their monitoring and control systems.

In order to offer a Smart Agriculture solution as described above, the skills and the type of companies involved are very diverse. An essential building block for a Smart Agriculture solution is the sensing technology company. There are several approaches and propositions in the marketplace. Some of them are limited to the provision of sensors and networks with just an integration option or cloud solution so that developers have to decide everything before deploying the project, with no option to make any change in the future. Libelium, a company that designs and manufactures hardware for wireless sensor networks gives the choice to change any time the communication protocol or the cloud solution and offers a horizontal platform where others sensors can be easily add. Interoperability is the differentiating feature of the company giving all customers the capability to customize their monitoring and control systems. The white paper has discussed several case studies showing how a based Libelium solution has contributed to the development of very successful stories in different agriculture applications. That has enabled Libelium to be a leading player in sensing solutions for agriculture.

Smart Agriculture allows the monitoring of different key parameters that affect crops: soil moisture and temperature, humidity, leaf wetness, solar radiation, atmospheric pressure, stem, fruit and trunk dendrometers, anemometer, wind vane and pluviometer sensors which allow farmers the ability to control and plan outcomes. For example the amount of sugar in grapes, which affects the wine quality, or the growing cycle of specific crops, and the control of micro-climate conditions, to maximize the production of fruits and vegetables in greenhouses and prevent diseases. The three levels of depth of the soil moisture sensor are helpful to reduce waste of water by selective irrigation in dry zones. On the other hand, controlling humidity and temperature levels can prevent fungal and other microbial contaminants and diseases.

A ready to be deployed solution: Smart Agriculture Kit

With The IoT Marketplace, Libelium offers a comprehensive model that integrates the four key steps for Smart Agriculture: data sensing, communications, storage and processing. The company has followed that route becoming a key player in the Precision Farming market. The IoT Marketplace is the operational tool for these partnerships, bringing together a number of specialised players in the Smart Agriculture value chain, such as cloud-computing, data analytics and agri-tech solution providers. This approach will also enable Libelium to empower its presence in the Smart Agriculture market. It is complex due to the diverse set of applications, but it is getting a lot momentum among the agri-tech community and the IoT community. Organisations can exploit that momentum if they collaborate bringing different skills together. Libelium is doing that through The IoT Marketplace. There will be growth in the high-value crop farming, in precision livestock farming, and in smart fishing and aquaculture. Connected agriculture vehicles will also be top of the agenda and not only from the point of technological features, but also introducing service-based models such pay-as-you-use data models. The overall Smart Agriculture market is growing. Sensing and data management services are fundamental elements of that. Therefore, a company such as Libelium can have an important role in that growth.

Overview of Libelium Smart Agriculture Projects Worldwide and in the Mediterranean

Libelium is involved in a very wide range of IoT projects, including all types of agriculture in many countries (see Annex 1). In all of these, Libelium's Waspmote Plug & Sense Smart Agriculture is deployed in different configurations, in order to collect data appropriate to the application. Libelium's Meshlium serves as a gateway to store and forward the data to the cloud. Here we resume several examples of horticulture and one example of water management. Water management is an important adjunct to farming, which also ties in with environmental management which is becoming increasingly important in areas adjacent to farmland.

The improvement of agricultural production is strategic specifically in the Mediterranean. Faced with demographic, environmental and climatic challenges, the integration of information and communication technologies in the agricultural sector is crucial. The IoT

can be used both to improve yields (improving the quality of products, developing pest resistance, improved labour efficiencies, reducing product losses ...) and at the same time to preserve the environment.

Libelium *designs and manufactures hardware for wireless sensor networks and a complete software development kit (SDK) so that system integrators, engineering, and consultancy companies can deliver reliable Internet of Things (IoT), M2M, and Smart Cities solutions with minimum time to market. Waspmote-Libelium's IoT platform is modular and ready to integrate with key Cloud systems and low-energy IoT connectivity protocols. Over 10,000 developers from 120 countries in companies ranging from startups to universities to large international corporations have adopted Libelium's technology for projects in five continents.*

http://www.libelium.com/

Annex 1

Libelium Smart Agriculture Projects in horticulture and water management

NAME & TYPE OF PROJECT	PARTNERS INVOLVED	DATA COLLECTION	VISUALISATION MECHANISM	RETURN ON INVESTMENT
VINEYARD HEALTH MONITORING Switzerland	Dolphin Engineering with University and government funding input from scientific research institutes, engineers, vintners, disease experts	Sensors from Waspmote Plug & Sense! Smart Agriculture monitor air temperature, humidity, leaf wetness and rainfall	**PreDiVine** dashboard displays messages with predicted dates of insect pest activities; this allows the growers to make ready and apply insecticides precisely when needed	Improved grape quality, management, lower costs; advice on just-in-time intervention; extend system to other areas
VINEYARD HEALTH MONITORING Slovenia	Elmitel with help from European private and public start-up accelerators	Sensors from Waspmote Plug & Sense! Smart Agriculture that collect environmental data including temperature and soil humidity	Elmitel's eViti application combines Elmitel Sensing and Libelium technology for a complete Cloud-based solution for managing vineyards.	Growers are more confident as to the best time for spraying; as a result, spraying has been reduced by around 20 percent from the previous season
OLIVE TREE MONITORING Italy	Team Dev working with Assoprol Umbria, a consortium of Italian olive producers	Through Waspmote Plug & Sense! Smart Agriculture specific weather conditions in each plot such as temperature, humidity, rainfall, atmospheric pressure, wind direction and speed, soil moisture and leaf wetness were measured	Waspmote Plug & Sense! Sensor Platform is connected by Meshlium to a cloud service of ArcGIS Online, an ESRI geographic platform, that collects all data and geolocates them in maps. Software creates the model of fly diffusion based on weather conditions	Better control of olive fruit fly pest through understanding of growing and environmental conditions; technology investment recovered in the course of one year
TOBACCO PLANTS MONITORING Italy	TeamDev in partnership with farmer association	Sensors from Waspmote Plug & Sense! Smart Agriculture collect key parameters including ambient temperature, humidity, rainfall, atmospheric pressure, wind direction, wind speed, soil moisture or leaf wetness	Waspmote Plug & Sense! Sensor Platform is connected by Meshlium to a cloud service of ArcGIS online, an ESRI geographic platform, that collects all data and geolocates them in maps. All data converge in a software for mananaging tobacco's crops which is part of AGRICOLUS suite	Project provided guidance as to how to adapt conditions for growing tobacco in Europe, as well as growing to comply with EU regulations to reduce toxicity to smokers
COCOA PLANTATION MONITORING Indonesia	Singapore-based solution provider in conjunction with various researchers and scientists located remotely. The project was part of Indonesia's Sustainable Cocoa Production Program	Temperature, humidity, photo-synthetically active radiation (PAR) and soil water potential were monitored through Waspmote Plug & Sense! Smart Agriculture	Because Internet connectivity in the rural site was unreliable, the collected data were sent to the Cloud for off-site researchers and collaborators to visualise and analyse the data from the on-going experiments	Project showed multiple benefits including such as reducing visits to remote site, developing pest resistant cocoa, rehabilitation of old trees and counteracted deforestation
STRAWBERRY PLANT MONITORING Italy	Famosa, specialist in crop management, worked with farmers growing strawberries in greenhouses	Sensors from Waspmote Plug & Sense! Smart Agriculture collect temperature and soil water content	The Web service portal esiFarm is the solution that combined collection and monitoring of parameters; both were connected via wireless system	Some of the benefits were losses reductions and better fruit quality; savings of money and energy; reducing water daily supply up to the 30% after planting and around the 15% during harvesting; more rapid time to market and constant production made possible stable pricing of the fruit
ENVIRONMENTAL IMPACT IN WASTEWATER IRRIGATION AREA Australia	AJ Bush Meat Manufacturer commissioned Pacific Environment to provide sensor network in a wastewater irrigation area	Soil moisture was measured through Waspmote Plug&Sense! Smart Agriculture and electrical conductivity, temperature and dissolved oxygen through Waspmote Plug & Sense! Smart Water	EnviroSuite software platform comprising monitoring, forecasting and reporting tools converted data into information as to what was happening in the soil and waterways	The real time system enabled effective management of operations and adherence to compliance processes The investment was recovered in 18 months, through reduced grab monitoring, improved labour efficiencies and laboratory costs and waiting time