Overview of IoT Basic Platforms for Precision Agriculture

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Abstract. Nowadays, more than ever, agriculture area has to face difficult challenges due to numerous technological transformations used for increasing productivity and products quality. Due to the extended growth in agricultural product use, farmers and big companies operating in the "Big Data" area invest in precision agriculture by using sensor networks, drones, satellites and GPS tracking systems. Agricultural plants are extremely sensitive to climate change such as higher temperatures and changes in the precipitation area increase the chance of disease occurrence, leading to crop damage and even irreversible destruction of plants. Current advances in Internet of things (IoT) and Cloud Computing have led to the development of new applications based on highly innovative and scalable service platforms. IoT solutions have great potential in assuring the quality and safety of agricultural products. The design and operation of a telemonitoring system for precision farming is mainly based on the use of IoT platforms and therefore, this paper briefly presents the main IoT platforms used in precision agriculture, highlighting at the same time their main advantages and disadvantages. This overview can be used as a basic tool for choosing an IoT platform solution for future telemonitoring systems.

Keywords: IoT platforms · Precision agriculture · Cloud computing · Efficiency

1 Introduction

In the Cluster of European Research Projects (CERP) report, the Internet of Things (IoT) is defined as an integrated part of the future Internet, which ensures that 'things' with identities can communicate with each other. IoT will be applied in different areas, e.g. smart cities, agriculture, energy, environment protection, health, home automation, etc. [1]. The applications of IoT-based smart farming not only target conventional, large farming operations, but could also be new levers to uplift other growing or common trends in agricultural like organic farming, family farming (complex or small

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spaces, particular cattle and/or cultures, preservation of particular or high-quality varieties etc.), and enhance highly transparent farming.

In precision agriculture a key component is the use of IoT and various items like sensors, control systems, robotics, autonomous vehicles, automated hardware, variable rate technology, etc. [2]. Possible applications for wireless sensors networks include precision agriculture [3], agricultural production process management [4], greenhouses monitoring [5, 6], optimization of plant growth [7], farmland monitoring, crop protection to divert animal intrusions [8, 9].

More recently, the advent of aerial imagery systems, such as drones, has enabled farmers to get richer sensor data from the farms. Drones can help farmers map their fields, monitor crop canopy remotely and check for anomalies. Over time, all this data can indicate useful practices in farms and make suggestions based on previous crop cycles; resulting in higher yields, lower inputs and less environmental impact [10].

Considering the limitations of Wireless Sensor Networks (WSN) and drone use in precision agriculture [11], the design and operation of a telemonitoring system for precision farming is mainly based on the use of IoT platforms.

The rest of the paper is structured as follows: Sect. 2 presents state of the art for IoT platforms, Sect. 3 describe platform for precision agriculture and lastly, Sect. 5 concludes the paper.

2 State-of-the-Art: IoT Platforms

Cadavid et al. [12] proposes an extension of Thingsboard, a scalable platform for device management and for collecting, processing and visualizing telemetry data [13]. The authors intend to develop a MaaS (Monitoring as a Service) Smart Farming platform that is Cloud-based and that involves sensing devices, decision support system and remotely controlled actuators and devices as drones. As extensions, the work contributes to the default data model by adding concepts as Farm, Land Lot, Crop. It also integrates complementary database engines as MongoDB, GridFS and REDIS. Moreover, an API is provided for allowing the interaction with third-party platforms. The proposed architecture was tested by means of a simulation of a scenario that implies the detection of a potato pest determined by Phytophthora infestans fungus. Smith Period prediction model was used and 25 sensors in 5 different crops were simulated.

In [14] SmartFarmNet platform is emphasized and evaluated. The platform is aimed to support a plethora of IoT devices and enables do-it-yourself real-time statistical analysis, being able to handle high velocity data streams. Also, it uses semantic web technologies to allow the exchange of data with other IoT services and to tailor the platform to new domains.

In [10], the authors propose a low-cost IoT platform for agriculture which supports high bandwidth sensors via TVWS (low-cost, long range technology). Within the FarmBeats platform, data from low-cost sensors in soil and drones work together with machine learning algorithms and farmers' knowledge in order to gather and analyse data about specific farms (information regarding when, where and what to plant in order to obtain cost reductions and higher yields). FarmBeats system has the following components: sensors and drones, IoT Base Station which is weather aware solar powered, IoT Gateway that ensures availability of both Cloud and offline services, and the Cloud component. The advantages of the FarmBeats system are that the gateway implements a web service while providing offline operating capability. Also, having access to data gathered from multiple types of sensors enables unique summarization technologies for the sensor data and drone videos.

An IoT-enabled private platform dedicated to smart agriculture was designed in [15]. The proposed solution should comprise telemetry, intelligent systems, wireless communications and cloud computing. The platform should offer the possibility to add, remove, identify or modify sensor nodes. Also, it should allow the collection and calibration of raw data. Data collection and import are possible through communication protocols and API.

In [16], the authors propose a flexible platform in order to cope with soilless culture needs in greenhouses. Within the system architecture, Cyber-Physical Systems interact with crop devices in order to gather data and perform real-time actions.

3 IoT Basic Proprietary Platforms for Precision Agriculture

For data collection related to environmental monitoring, air quality and testing of monitoring parameters of interest parameters, existing IoT platforms such as uRADMonitor, Libelium, Vaisala, Kaa, etc. are considered. Their main features, advantages and disadvantages, as well as several use cases are detailed below.

3.1 Libelium – Waspmote

Waspmote Plug & Sense [17] line allows simple implementation of IoT networks in facile and scalable manner with low management costs. The platform consists of a waterproof carcass with a dedicated external socket to connect the sensors, the solar panel, the antenna and even the USB cable to reprogram the node. The main features of Libelium-Waspmote platform include [18]:

- External solar panel option;
- Radio technologies: 802.15.4/868 MHz/900 MHz/WiFi/4G/Sigfox/LoRaWAN;
- programming multiple nodes simultaneously (via WiFi or 4G interfaces);
- Graphical and intuitive interface Cloud Service Programming;
- External reset without contact with magnet;
- External battery module optional;

Libelium-Waspmote platform is used mainly in applications such as [19]: precision agriculture (lead moisture, fruit diameter), irrigation systems, greenhouses: (solar radiation, humidity, temperature), weather stations.

3.2 A3-uRADMonitor

uRADMonitor A3 is an advanced air quality monitoring station, enclosed in an aluminium body (robust design), it has gamma, formaldehyde, CO2, VOC, air quality + air temperature, barometric pressure, air humidity and sensor laser dispersion for

PM2.5 particles. A3 also comes in 4 forms, with the same sensors but with different connection options: Ethernet, Wi-Fi, GSM (with a SIM card) and LoraWAN. Most pollutants measured by the A3 model can have a negative impact on people's health and can cause mild illnesses (simple allergies) to serious illnesses (such as various types of cancer) [20]. The uRADMonitor A3 (Fig. 1) uses the Bosch BME680 to measure air temperature, barometric pressure, humidity and volatile organic compounds or VOC. A high-quality laser scattering sensor is used to detect the PM2.5 particle concentration in the air. There exists also a non-dispersive infrared sensor for measuring the CO2 concentration in air, and a Geiger SI29BG tube to detect gamma ionizing radiation and X radiation. An inbuilt fan provides an active air flow through the elements to detect.

Fig. 1. A3-uRADMonitor model [18]

The uRADMonitor A3 can be mounted both indoors and outdoors, but not directly exposed to the sun, to avoid overheating in warmer areas. uRADMonitor connects to the power supply using a DC adapter with voltage between 6 V and 28 V and the Internet router using the Ethernet cable. The Internet Router must have DHCP enabled. When powered, uRADMonitor automatically obtains an IP address through DHCP, and will appear on the map. It uses very little energy to function.

3.3 Observant

Observant™ is a world leader in providing Cloud-based hardware applications for accurately managing water used in agriculture. Use cases include: ***water level monitoring*** (with the possibility of updating every 30 min; graphical representation of data acquired during a day, week or month to better visualize water use trends; the ability to adapt to different heights of water tanks (from about 46 cm to 127 cm) and alarms sent by SMS or email if the water level is too low or if the upper threshold is exceeded [21], etc.); ***soil moisture monitoring*** (increase the efficiency of irrigation and to better manage the use of certain nutrients [22]: irrigation management; nutrient management; process programming on crops; water infiltration/leakage management [23]); ***irrigation programming*** (Fig. 2); ***pressure monitoring***, ***climate monitoring*** (useful for irrigation management, prediction of harvesting, frost prediction, pest management [24]); ***pumps management*** (capabilities of the Observant system: monitoring the pump's operating state, monitoring the pump's alarms (made by text messages alerting the farmer instantly so that he or she can know whether or not to take urgent action); ***pump***

input/output monitoring (pressure and flow switches are observed, pump inputs/outputs to ensure proper operation); turning on/off the pump remotely (commands that can be given on your computer, tablet, or smartphone)).

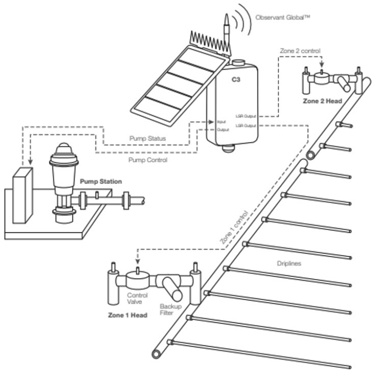

Fig. 2. Observant™ irrigation system [23]

Among the disadvantages of Observant™ solution there can be noticed: the need to use of certain proprietary devices, the relatively small number of electromagnetic locking valves that can be used in the irrigation system, the necessity of a qualified electrician (in this case an electrician) qualified to connect the electric pump to the C3 telemetry platform or to another telemetry platform and also the number of telemetry platform outputs causes other limitations [25].

3.4 Arable Mark (Pulsepod)

The Arable Mark (or Pulsepod) is a solar powered device [26] to monitor weather conditions and crops [27]. It provides real-time information. The Pulsepod Arable Device [28] (Fig. 3) has three types of sensors: ***acoustic disdrometer*** (it measures rainfall, observing the size and number of drops falling on the surface of the device); ***the differential radiometer*** (it helps determine the amount of sunlight the plants around the device receive by measuring short wave radiation (coming directly from the sun) and long wave radiation (sunlight that was reflected back by plants)); ***the spectrometer*** (it is used to monitor how much plants grow, the amount of plant chlorophyll and the use of water by plants). The Pulsepod sends data to a Cloud platform via WiFi, cellular or Bluetooth connectivity. An embedded GPS device allows data to be mapped to weather and ground images. Farmers can access data and reports created by Arable, allowing them to make decisions about irrigation and soil fertilization. Pulsepod measures over 40 parameters including rain, hail, leaf surface, crop water, environmental stress, and even air pollution.

Fig. 3. Surface of arable mark device [25]

3.5 Pycno Sensors and Platform for Agriculture

The Pycno Platform is designed to continuously monitor data and control the farming system. Pycno develops and integrates wireless sensors and a software platform that provides farmers with weather information and real-time soil information [29]. General characteristics and measurement areas include [30]: 2 W high power monocrystalline solar panel; internal battery; solar irradiation, between 300–1100 nm, and the accuracy is 16 bits; Air temperature between −40 and 125 °, with an accuracy of ±0.3 °C; air humidity, between 0–100% RH, with an accuracy of ± 2%; soil temperature, between −10 and 85 °C, with an accuracy of ±0.4 °C; soil moisture has a precision of 28bit.

3.6 Agri M2M [29]

According to GSMA Intelligence, cellular M2M connections (across all sectors) reached 146 million in Q4 2014, growing at a CAGR of 35% from 73 million in Q4 2010. M2M in agriculture has the potential to increase efficiencies in the following areas: improve availability of information about the condition of crops and livestock; through real-time monitoring and alert services; maximize efficiency and longevity of agricultural equipment through real-time remote control and monitoring; reduce losses during transportation of produce through distributors and retailers to the end users by monitoring the logistics. M2M can be used to send and receive data about temperature, weight, location and any number of other agricultural factors, as well as requests to each other and to central management systems, autonomously. The stakeholders in the M2M value chain include module vendors, connectivity providers, M2M platform and application providers, device platform providers, mobile operators, aggregators and mobile virtual network operators (MVNOs) (Fig. 4). The information is collected through M2M modules mounted on the assets and transmitted via connectivity providers (mobile operators in this case). This information is then received by system integrators and solution providers which gather and process the data, to be finally displayed via mobile or web applications to the end users.

The end users for M2M applications include crop and livestock farmers, cooperatives and agri-businesses. The individual or small-hold farmers typically use Agri M2M solutions for equipment and fleet monitoring in their farms.

However, given the high cost of M2M implementation (arguably the biggest barrier to the adoption of this technology), agribusinesses and cooperatives are better placed to make full use of the potential of M2M in agriculture.

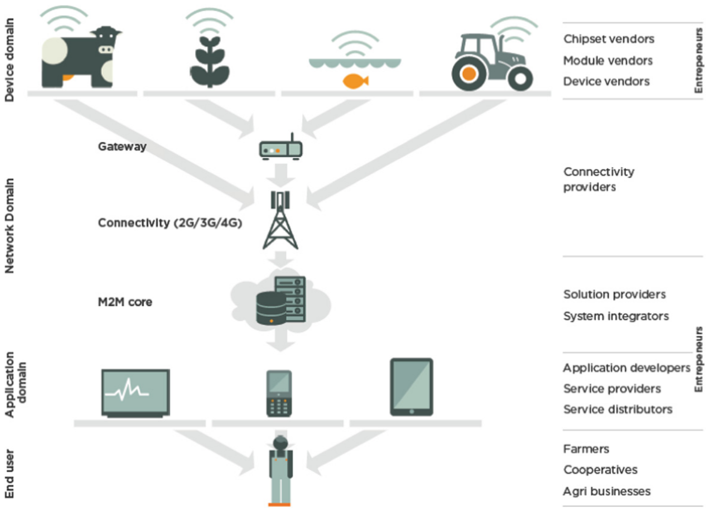

Fig. 4. Cellular M2M in agriculture (Agri M2M) – value chain [30]

Table 1 reveals the most important agriculture use cases and the suitability of each proprietary platform to these use cases.

Table 1. Comparison between precision agriculture platforms

Agriculture use case	A3-uRADMonitor	Libelium	Observant	Arable Mark	Pycno	Agri M2M
Weather monitoring	Yes	Yes*	Yes	Yes	Yes	Yes
Rainfall	No	Yes*	Yes	Yes	No	–
Crop monitoring	No	Yes*	No?	Yes	No	Yes
Irrigation	No	Yes*	Yes	No	No	Yes
Air quality/Pollution	Yes	Yes*	No	Yes	No	Yes
Pump management	No	Yes*	Yes	No	No	–
Soil information	No	Yes*	Yes	No	Yes	–
Equipment monitoring	No	No	Yes	No	No	Yes

The asterisk in the case of Libelium platform means that the platform is not able to respond to the use case in Table 1 by default, as it does not embed any sensor. The sensors must be purchased separately from the platform.

The communication protocols for platforms presented above are showed in the Table 2.

Table 2. Communication protocols

IoT platforms	Communication protocol
Libelium – Waspmote	4G
A3-uRADMonitor	Wi-Fi, GSM, LoraWAN
Observant	Wi-Fi
Arable Mark (Pulsepod)	WI-FI
Pycno sensors	4G
Agri M2M	4G

4 Research and Development Precision Agriculture Platforms

Other precision agriculture initiatives may be found in literature. The proposed platforms implement the intelligent control in agriculture, data reliable transmission and intelligent processing of data, leading to an increase in crop production and reducing the impact of the agriculture activities towards the environment [31].

In [31], Zhang et al. intend to develop a system that monitors the citrus soil humidity and nutrients. Another goal of the proposed solution would be the reduction of pollution caused by chemical fertilizers and the reduction of the costs associated to the physical labour. A decision support system will guide the farmers to adapt the fertigation system.

The IoT Platform (Fig. 5) is structured on 4 layers: (1) Perception layer, (2) Network layer, (3) Middleware layer and (4) Application layer.

Perception layer is composed of sensing and data acquisition devices as soil and humidity sensors, portable soil nutrients detector.

A wireless sensor network based on ZigBee protocol represents the shortrange component of the transmission of the Network layer. The core of the wireless sensor network is the Internet of Things Gateway which assures the connection with the public network and the protocol conversion.

Middleware layer is responsible for service management, data storing and decision making, whereas Application layer comprises a sensor network management system, a monitoring data analysis and querying system based on WEB-GIS and a fertigation decision support system.

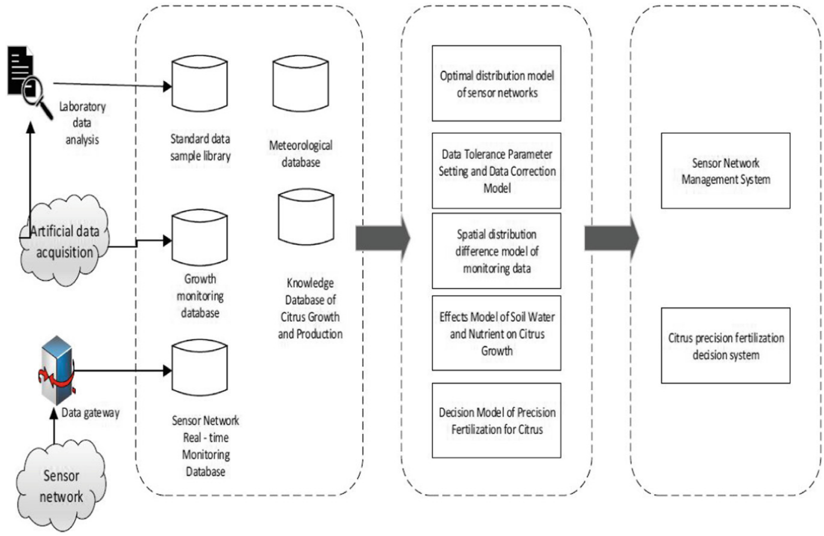

Fig. 5. IoT architecture for soil humidity and nutrients monitoring [31]

In [32], the authors describe an IoT architecture dedicated to prediction of a disease specific to a Korean strawberry variety, Seolhyang.

They proposed an integrated Cloud-based system following a new paradigm, *Farming as a Service* (FaaS). The system allows data collection, analysis and the prediction of the information concerning agriculture practices.

This initiative is based on other paradigm, called PaaS (Platform as a Service). In Fig. 6, the IoT system's four-layer architecture was represented. The available sensors are greenhouse environmental sensors, growth monitoring sensors and nutrient solution sensors.

The system is able to predict the infection with Botrytis cinerea bacteria based on an algorithm that uses images and environmental data collected from the greenhouse.

Another model was presented in [33]. The platform is based on a 5-layer architecture depicted in Fig. 7 and is aimed to irrigation control. Among these 5 layers, Thing, Edge and Fog layers will be described.

The Thing layer comprises the monitoring and environmental conditions control devices specific to a greenhouse: soil temperature, humidity electrical conductivity and pH sensors, water temperature, electrical conductivity and pH sensors, air temperature, relative humidity and light sensors for greenhouse environment monitoring, temperature, humidity and wind sensors for outdoor monitoring. In addition, the system includes water valves and pumps.

Edge layer may be responsible for data filtering, predictive data computing for climate conditions, classification services.

Fog layer, as extension of Cloud, facilitates real-time application, reducing system latency and triggering the actuators without being necessary that the information arrives firstly in Cloud.

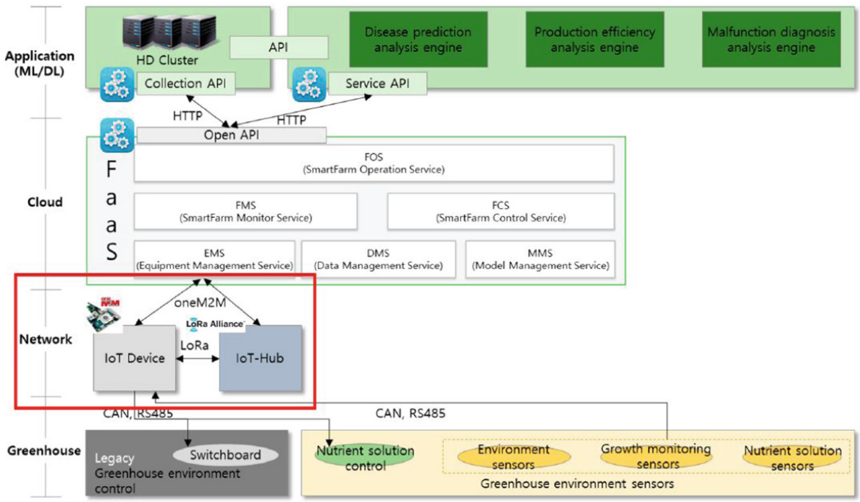

Fig. 6. R&D Precision agriculture platform for strawberry crop monitoring [32]

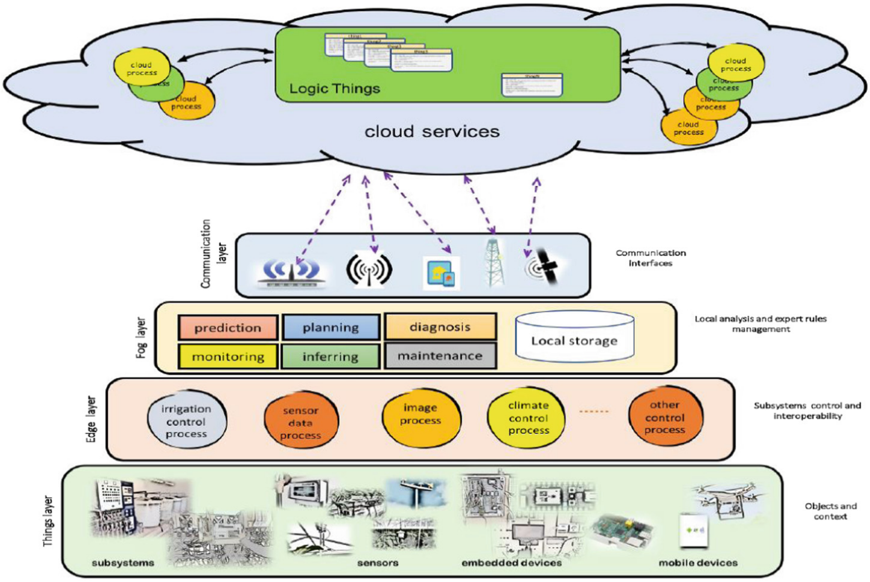

Fig. 7. A 5-layer IoT precision agriculture platform [33]

In [34], the authors have proposed a system that monitors a crop, providing a method to enhance the decision making process by analysing the crop statistics and by correlating them with the information regarding the monitored crop.

The system (Fig. 8) includes three main components: crop monitoring subsystem, statistic prediction subsystem and text-mining analysis block.

The monitoring subsystem is aimed to acquire the data for creating reliable data. The Perception layer is represented by an IoT sensor Group component that includes soil temperature, humidity, electrical conductivity and pH. They are connected through wireless technology. Moreover, video cameras were mounted to monitor the crop.

All data acquired (sensor data, video flux) are sent to and used by the prediction server that is able to process them and to transmit afterwards to the farmers, through Internet, forecasts concerning domestic production, harvest and seeding time, delivering time.

The architecture proposed in [34] has as main advantage the possibility to enhance the quality of agriculture products by providing to the farmers significant and valuable information about the entire cycle seeding-delivery. Moreover, such a system can analyze present conditions and forecast future crops.

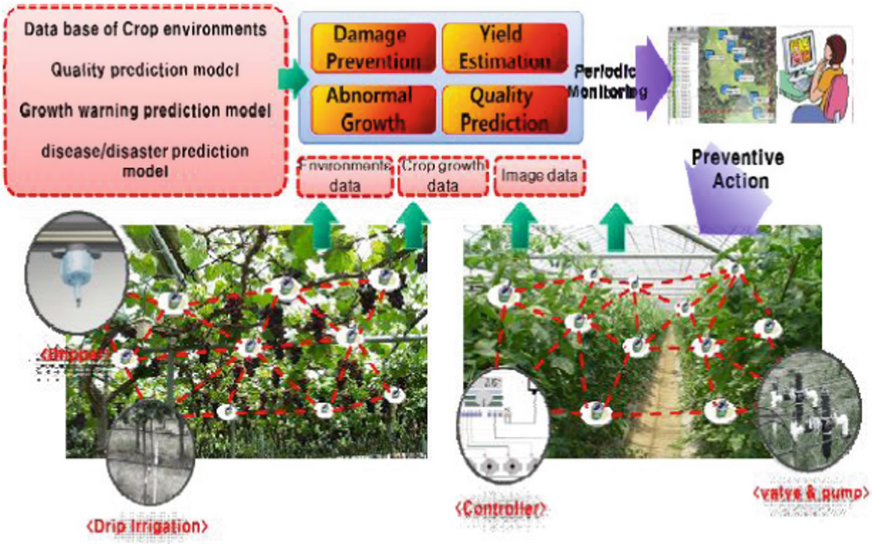

Fig. 8. Sistem IoT pentru producția în agricultură [34]

In [35], the authors compare Libelium and Adcon telemetry solutions deployed in agriculture use cases. The parameters that could be measured with both platforms were atmospheric pressure, solar radiation, rainfall, relative humidity, soil moisture, wind speed and wind direction. The results presented by the authors reveals the high correlation between all the datasets, although the platforms and the sensor probes are different from the point of view of the structure.

To conclude Sects. 4 and 5, one can observe that an end-to-end precision agriculture platform is very necessary, as many efforts were focused in this direction. This platform should include several important components and concepts as: soil, weather and, in general, environmental parameters monitoring, yield forecasting, product quality monitoring, disease prediction, environment preservation methods, agriculture asset management.

5 Conclusions

The introduction of the IoT platform helped people to analyse all the information from the different type of fields. Integration of IoT in agriculture field brings benefits regarding monitoring of crops, weather conditions, and pollution of the environment and finally the right decision can be taken in order to increase yield and agricultural production. Considering the climate change context, the introduction of IoT in the agriculture brings a dramatic progress. Using precision agricultural platforms, the farmers can reduce the production costs and increase the sales because they can fight diseases by applying the suitable type and amount of treatment at the right time, reducing in this way the use of pesticide or other toxic treatments, which leads to healthy crops. Also the usage of IoT platforms will reduce the water consumption by watering the crops only when is needed and with the adequate amount of water. So, in function of the Internet connection, place of implementation, the type of crops etc. the farmers can choose from a large diversity of platforms, which will improve their work. The scope of the paper was to achieve a comparative study between the most common agriculture platforms, highlighting various aspects like knowledge base, monitoring modules, efficiency etc. We can say that the role of these platforms is to bring together the users (farmers) and professional suppliers. Using the smart agriculture, the farmers will receive guidance at the right time and at the end of the season will have an improved harvest.

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References

1. Ganchev, I., Ji, Z., O'Droma, M.: A generic IoT architecture for smart cities. In 25th IET Irish Signals & Systems Conference 2014 and 2014 China-Ireland International Conference on Information and Communications Technologies (ISSC 2014/CIICT 2014), Electronic ISBN: 978-1-84919-924-7, Ireland, 2013
2. IoT Applications in Agriculture 2018. https://www.iotforall.com/iot-applications-in-agriculture/
3. Deepika, G., Rajapirian, P.: Wireless sensor network in precision agriculture: a survey. In: 2016 International Conference on Emerging Trends in Engineering, Technology and Science (ICETETS), ISBN: 978-1-4673-6725-7, India, 2016
4. Khairnar, P., et al: Wireless sensor network application in agriculture for monitoring agriculture production process. In: International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), ISSN: 2278–1323, vol. 5, Issue 5, May 2016
5. Ahonen, T., Virrankoski, R., Elmusrati, M.: In: Greenhouse monitoring with wireless sensor network. In: IEEE/ASME International Conference on Mechatronic and Embedded Systems and Applications (2008)

6. Gupta, G., Quan, V., In: Multi-sensor integrated system for wireless monitoring of greenhouse environment. In: 2018 IEEE Sensors Applications Symposium (SAS), ISBN: 978-1-5386-2092-2, South Korea (2018)
7. Kameoka, S., et al.: In: A Wireless Sensor Network for Growth Environment Measurement and Multi-Band Optical Sensing to Diagnose Tree Vigor, Sensors (Basel) (2017). https://doi.org/10.3390/s17050966
8. Bapat, V., et al.: WSN application for crop protection to divert animal intrusions in the agricultural land. In: Computers and Electronics in Agriculture, vol. 133, pp 88–96, Elsevier (2017)
9. Ojha, T.: Wireless sensor networks for agriculture: the state-of-the-art in practice and future challenges. In: Elsevier Computers and Electronics in Agriculture 118, 66–84 (2015)
10. Vasisht, D., et al.: FarmBeats: an IoT platform for data-driven agriculture. In: 14th USENIX Symposium on Networked Systems Design and Implementation (NSDI 2017), ISBN 978-1-931971-37-9, USA (2017)
11. Sharma, V.: Limitation associated with wireless sensor network, In: IJCST, vol. 5, Issue 1, ISSN: 0976-8491 (Online), Jan–March 2014
12. Cadavid, H.F., Garzón, W., Pérez, A., López, G., Mendivelso, C., Ramirez, C.: Towards a smart farming platform: from IoT-based crop sensing to data analytics. In: Proceedings 13th Colombian Conference, CCC 2018, Cartagena, Colombia, 26–28 September 2018
13. ThingsBoard Open-source IoT Platform. https://thingsboard.io/
14. Jayaraman, P.P., Yavari, A., Georgakopoulos, D., Morshed, A., Zaslavsky, A.: Internet of Things platform for smart farming: experiences and lessons learnt. Sensors **2016**, 16 (1884)
15. Popovic, T., Latinovic, N., Pesic, A., Zecevic, Z., Krstajic, B., Djukanovic, S.: Architecting an IoT-enabled platform for precision agriculture and ecological monitoring: a case study. Comput. Electron. Agric. **140**, 255–265 (2017)
16. Miguel, A., Antonio, F.: Skarmeta, smart farming IoT platform based on edge and cloud computing. Biosyst. Eng. **177**, 4–17 (2019)
17. Libelium Waspmote. http://www.libelium.com/products/waspmote/sensors/
18. Libelium Plug & Sense. http://www.libelium.com/products/plug-sense/technical-overview/
19. uRAD Monitor. https://www.uradmonitor.com/uradmonitor-model-a3/
20. Observant™, Observant™ water level monitoring brochure. https://observant.net/
21. Observant™, Observant™ Soil Moisture Monitoring brochure. https://observant.net/
22. Observant™, Observant™ solution datasheet - Soil Moisture Monitoring. https://observant.net/
23. Observant™, Observant™ Weather and Environmental Monitoring brochure. https://observant.net/
24. Observant™, Observant™ solution datasheet – Irrigation Scheduling. https://observant.net/
25. Takahashi, D.: https://venturebeat.com/2016/06/07/arable-labs-introduces-pulsepod-solar-powered-farm-sensor/
26. Arable: Decision Agriculture. www.arable.com
27. A complete water-budgeting solution. www.arable.com/solutions_irrigation
28. Turn raw data from your field into actionable analytics. www.pycno.co/sensors
29. Quick start guide. www.pycno.co/quick-start
30. GSMA, Agricultural machine-to-machine (Agri M2M): a platform for expansion. www.gsmaintellgence.com/research/?file=9186f77efc0a47fe7f127d79d789c64c&download
31. Zhang, X., Zhang, J., Li, L., Zhang, Y., Yang, G.: Monitoring citrus soil moisture and nutrients using an iot based system. Sens. J. **17**(3), 447 (2017)
32. Kim, S., Lee, M., Shin, C.: IoT-Based Strawberry Disease Prediction System for Smart Farming. Sens. J. **18**(11), 4051 (2018)

33. Ferrández-Pastor, F.J., García-Chamizo, J.M., Nieto-Hidalgo, M., Mora-Martínez, J.: Precision agriculture design method using a distributed computing architecture on internet of things context. Sens. J. **18**(6), 1731 (2018)
34. Lee, M., Hwang, J., Yoe, H.: Agricultural production system based on IoT. In: 2013 IEEE 16th International Conference on Computational Science and Engineering, pp. 833–837. Sydney, NSW (2013)
35. Suciu, V., et al.: Analysis of Agriculture Sensors Based on IoT. In: 2018 International Conference on Communications (COMM), pp. 423–427 (2018)