Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 10410 - 10420
Received 25 April 2021; Accepted 08 May 2021.

Leveraging Fog Computing for Smart Internet of Things Crop Monitoring Farming in Covid-19 Era

Shahidul Islam[1*] Sanjay Jamwal[2] Mahmood Hussain Mir[3]
[1,2,3]Department of Computer Sciences, Baba Ghulam Shah Badshah University, Rajouri 185234, Jammu &Kashmir, India.
* shahidulislam@bgsbu.ac.in

ABSTRACT

The Technology of the Internet of Things (IoT)offers anintelligent learning mechanism among internet-connected physical objects for serving billions of users worldwide.Internet of Things in combination with computing technologies Cloud, Fog, and Edge is becoming an exciting area among technology giants, business communities, and researchers with awide-ranging set of applications in different domains. Internet of things possesses the capability and capacity in achieving sustainable growth and provided a competent and structured approach for the observation of crops in the field with the assistance of sensors. The outbreak of the Covid-19 pandemic leads to the nationwide shutdown which further leads the serious unsolicited effects for farmers and the transport of agriculture commodities and production supply chains. Farming is the largest livelihood provider in many countries and the role of the Internet of things (IoT) for Crop monitoring is vital in the Covid-19 situation. The outbreak of Crop disease is a prone threat to fruitful production, as abundant diseases spoil the crop production to a large extent due to Lockdown situations, unawareness about crop growth, and insufficient utilization of technology in Farming fields. The IoT-based technology needs to collect a huge amount of information in the farming field and transferring data to the cloud server for disease classification and recognition is time-consuming and causing delays to diagnosis and treatment. This paper proposes an IoT-based framework for crop disease monitoring system with the assistant of fog computing, so that it will carry out timely monitoring of disease in crop with minimal delay.

Keywords: Internet of Things, Fog computing, Covid-19, Precision agriculture, Crop disease

1. Introduction

The Profile of the world has transformed within a short span of time and led to unpredicted consequences. Novel coronavirus outbreak disease, widely named COVID-19, first came into the world from China. The early information predicted the possible outbreak of virus caused by anovel coronavirus SARS-Cov-2. The World health organization has declared the ongoing epidemic as a global health emergency and the covid-19 epidemic has left no sectors untouched(1).Theglobal threat was formed by this COVID-19 and has affected over 100 countries in a short period (2).Thousands number of death affects the global economy, let the government across the world to formulate contingency strategies along with the observation about future.The severe lockdowns and shutdowns disturbedevery sector across the globe and haveaffected the companies, industrial unit, agricultural, and all other business and have led our world to improve itself(3).However, the Covid-19 pandemic and lockdown have heavily affected economic activities and production plans(4). The agriculture sector is facing significant hurdles due to the occurrence of the covid-19 pandemic and lockdown. Agriculture cultivation is generally depending on weather and the minimum delay in crop harvesting and planting can cause maximum production damagewhich can lead to an enormous loss for farmers that finally leads to food crunch. Climatic tragedies such as unpredictable rainfall, hotness, and drought, crop diseases outbreak are always the main fears to the farmers. Moreover, as the Covid-19 virus spreads in the public and cases mount,harshstoppage movement of public and control procedures are typically forced, caused a harmfulimpression on farming production. Since the covid-19, another major thread on farmer’s shoulders is rather heavy since the eruptions of pandemics.

From Pandemic to lockdown, heavy rainfall, disease outbreak, rotten crops, financial crisis, etc. have brought farming activities stoppage and offered a solitary situation to farmer's strength, about crop production through the use of internet of things technology. The internet of things is a tool to provide the solution in different agriculture sector problems. The role of the Internet of things (IoT) in achieving sustainable growth has provided a competent and structured approach for the observation of crops in the field with the assistance of sensors to help in gathering information from farmers, such as crop health information and environmental constraints(5). The Internet of Things-based agriculture framework will be much supportive to monitor and analyses crop health remotely and can be applied in the field of agriculture to resolve the different problems of farmers. The role of IoT technologies as an instrument of intervention in farming is becoming progressively more. To conquer different farming issues that occur in the agriculture sector during the covid19 and lockdown times. The IoT structure will be beneficial and will provide the real-time information regarding the Crop growing stages and regarding various other factors that are directly and indirectly related to crop growth.The agricultural sector is facing different challenges when it comes to the deployment of modern AI technology in the farming domain for digital transformation and automation of tasks. The aim of developing sensors technology is to increase agricultural productivity and decreasing the number of time farmers spending in performingrepetitive tasks and optimal resource utilization. The IoT Sensors, drones are needs to gather a large amount of information in the fieldand transferring data to cloud server through the network for disease classification and recognition is time consuming, and is problematic tobring out for timely monitoring of disease in crop, which causing delays to diagnosis and treatment. Crop diseases outbreak is a prone threat to productive production so, data needs to be processed locally and delays should be minimized as crop are heavy effect by disease outbreak and pests attacks.
In this paper, we put forward the Internet of thing assisted fog-based system to explore the potentials of using IoT and fog computing with machine learning as a tool to handle many problems in the farming domain, such as crop monitoring, analyses of crop health, disease prediction, etc. The remaining part of this paper is prepared as follows: Section 2 provides background details while Section 3 describes the essential technologies. Section 4 discusses the process of Data mining while section 5 describes the Internet of Things-basedFarming Network.The proposed framework is briefly discussed in section 6 while crop monitoring based on fog-assisted cloud in IoT structure smart farming is discussed in section 7. The challenges are presented in section 8, while the paper conclusion is delivered in section 9.

2. Background

The usage of wireless sensor networks in agriculture fields will provide a hugequantity of information about farming to farmers**.** The role of Internet of Things-enabled technologies is a revolutionary technology that represents the future of computing and communication in Precision agriculture(6).The wireless sensor network is the key driving force that can change the agriculture sector into smart ways with minimal human effortsto boost agriculture production and with specific sensors and software, it ensures the requirements of the crop for optimal productivity(7).Prototype of the real-time sensor array is used in the system to measure the soil moisture and soil temperature to determine the real-time requirement of irrigation scheduling in the field(8).The estimate of water requirement for plants and then control the water stress of plants using internet of things technology while monitoring the variation of soil conditions in real-time using software dash board(9).Internet of Things provides the information for optimal

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 10410 - 10420
Received 25 April 2021; Accepted 08 May 2021.

usage of water and reducesthe chances of the disease spreading in the field, Sensing of moisture, controlling of water, and notifying the status of irrigation system status for the farmer through mobile communication(10). The Combination of the internet of things and image processing technology introduced in the agriculture field will determine the plant growing hindering factors to get satisfactory results (11). The leverages of the Internet of Things and Machine learning together can improve the production and automate the crop monitoring and will give an insight into the condition of the crop(12).Through machine learning the prediction of crop pests in farming,the domain can benefit the farms to reduce crop damages and raise their income(13).The multi-disciplinary agriculture system will get many benefits by adopting machine learning in different agriculture domains like Crop, livestock, Soil and Water management, etc. while applying machine learning to sensor data it will evolve the system into an intelligence system(14).The role of the wireless sensor network system for apple disease forecasting system is very beneficial for prediction of disease in apple crop and study provide detailed information about the variouskinds of diseases found in apple crop(15).The method of a Heterogeneous IoT system for the detection of leaf disease based on the identification of gesture of the leaf image will find out the leaf and fruit that are suffering maximum from disease and pointed out the disease in leaf(16). The Internet of Things and machine learning-based system can forecast the disease attack on mango crop in which the past weather data were taken into consideration with the current weather data for the prediction of the disease with machine learning techniques(17).

3. Technologies

3.1 Internet of Things

The Internet of things uses a sensor (physical objects/devices) and communication technologies, as well as pervasive computing, to advancethe objects into smart objects. The architectures of IoT consist mainly of three layers which include the physical layer, network layer, and application layer(18). The components of the Internet of things is to deliver smart services to users to improve the living standard. The structure of IoT systems consists of essential functions such as Sensing (sensors, actuators. RFID), Data Communication (routers, switches, gateways), Data Utilizing (analyzing, processing, Reporting)(19).

3.2 Wireless sensor Network

The Wireless Sensor Networks (WSN) is a collection of a finite set of spatially dispersed and dedicated sensors geographically dispersed in a given environment. Wireless sensor network aims to collect data from the sensor node in the field, in which they sense the data from the physical or environmental conditions and cooperatively pass the data over the network and bring together the collected data at a central location.(20)The structure of the WSNs comprises different nodes such as sensing devices, embedded processors, computation, and wireless communication.

3.3 Cloud Computing

Cloud computing, a computing-based paradigm that provideson-demand services andpermits the customers to access the computing resources through a network. Cloud computing provides the services such as infrastructure, networks, storage, applications, and services to the client in cost economical manner. Various services are offered such as software, platform, infrastructure through various models such as public, private, hybrid & community geographically across the world(21). In a cloud, the data is transfer to cloud data centers for processing, after analyzing and processing the data are being accessible by clients

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 10410 - 10420
Received 25 April 2021; Accepted 08 May 2021.

3.4 Fog computing

Fog computing a new distributed computing concept, which is an extended version of cloud computing in which the centralized Cloud is transforming into a distributed computing platform. The concept of fog is to extend the capabilities of cloud computing by transforming the computation to the edge network(22).In the near future, the huge number of sensors, devices, and applications are going to be online and will generate data in large volumeand might reduce some of the cloud computing limitations while accessing various time-sensitive services and applications.Fog is an intermediate layer between the cloud and edge devices and as the ideal model for application and services on the internet of thing environment.it allows computation tasks to take at the edge network i.e. nearer to the user's edge, rather than data transfer it to the cloud data centers(23). With the Introducing of the fog computing model, the computing power moves near the sources where the data are generated will acquire a unique character. Some of the features are real-time data processing services, flexibility, Smart Utility, federation, contextual location awareness, low latency and increased Quality of Service, etc.(24). Fig.1 shows the overview of fog computing hierarchical architecture.

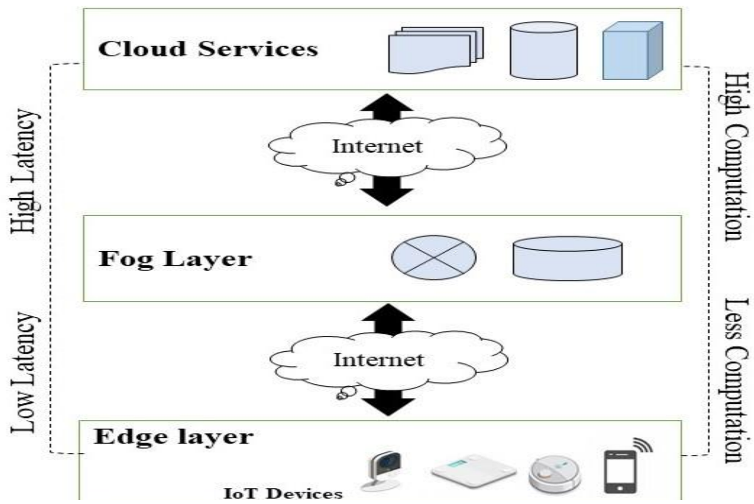

Figure 1. Fog computing hierarchical architecture

3.5 Edge computing

Edge Computing, enabling technology is about processing data streams directly at the user's endrather than transferring them to cloud datacenters. Edge computing takes over the abilities and functionalities to process the data closest to the data generation source which leads to reduction of latency and improves the performance of the edgedevices over the network.(25)(26).The large volume of data is generated by IoT devices and often transported to the remote cloud server for performing data analytics which leads to latency and energy implications. Hence, through the edge computing platform,the bulky data is being offloaded to the fognodes for processing that improves the real-time processing, and will reduce the latency to some extent. Edge computing is highly worthy for time-sensitive applications and allows the smart handling of applications and services to respond immediately. Some of the features that will be achieved are low latency, Scalability, Security, versatility, etc.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 10410 - 10420
Received 25 April 2021; Accepted 08 May 2021.

4. Data Mining

The data mining comprises of discovering interesting, innovative knowledge and valuable pattern from the bulky dataset and then applying algorithms for taking out the hidden information (27).The process of data mining includes the following steps shown in Figure 2.

Figure 2. Data mining process

- **Preprocessing** Preparation of data for mining in which combination of data from various sources is been cleaned and remove the noisy data, by eliminating those data that are redundant, erroneous, or faulty.
- **Mining** finding the patterns and discovering the interesting information about data while applying algorithms.
- **Presentation** visualizes and represents the data mined information to the user.

Data mining, phase of observation to get new insights of information from a bulky basket of data.Various techniques contain the integration of handlingdata and machine learning so that we can get the finest assumptions fromthe data through several techniques, such as Classification, Association, Clustering, Regression, Prediction, etc.(28)

5. Internet of Things based Farming Network

Farming is one of the utmost important sectors in any part of society and nation development**.** The farming although has not been modernized vastly in terms of absence of awareness, inadequate technology utilization and old-fashioned mechanism of handling diseases leads to average damage of crop. Traditionally agriculture methods are not technically systematic and are tedious processes, as the world is advancing towards using new technologies, it is necessary to use the technologies in the agriculture sector also. The Internet of things (IoT) has provided a knowledgeable and structured approach for the observation of crops in the field with the assistance of sensors in achieving sustainable growth. The application of IoT-based systemsin the Farming system is schematized in Fig. 3. Including the use of sensor-based technology for sensing the field data and environmental conditions, cloud service, agriculture expert, and farmer for the intervention and management.

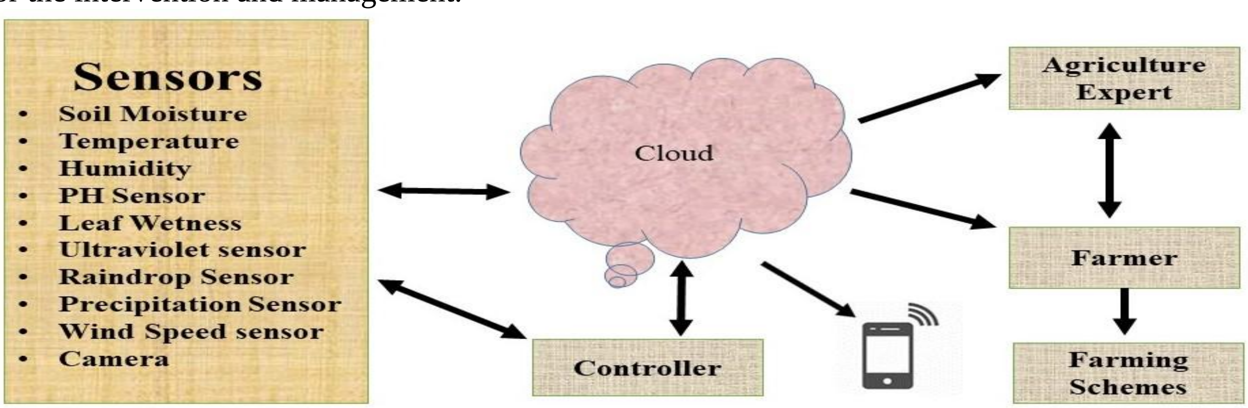

Figure 3. Internet of Things in Farming system

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 10410 - 10420
Received 25 April 2021; Accepted 08 May 2021.

Internet things-based farming can be the solution to different farming applications Such as crop monitoring, disease prediction, irrigation, climate monitoring, soil monitoring,etc.(29) The internet of things in agriculture sector uses the drones, remotes sensors, and imaging procedure in joint with analytical tools and machine learning for the crop, environmental condition, and field monitoring and provide the information to the farmers for management of field with minimum time and cost. The application of IoT-based farming in the farming sector can be processed from different layers which include the use of sensor-based technology for the collection of datathrough the sensor nodes. The various types of data collected transfer through the internet to the cloud service and further make it necessary to do some processing such as like data analytic, storage and data visualization. The data that is stored in the cloud can be accessed by the agriculture expert for crop intervention and management and will provide important suggestions to the farmer about crop care such as spray type and schedules, disease diagnosis, and soil-plant nutrients. Finally,on the application side, the end-user can monitor the farming field and control the various tasks in the field and also will take the important decisions through a prediction system.

6. Proposed Framework

Smart agriculture, assistances the farmers to raise the yield production by using minimal resources, and through IoT technology farmerswill start to recognize their crops on a micro-scale, surveying, mapping the fields, and conservation of resources. In the era of COVID-19 lockdown, the farmers can't go to their farming fields because of the restrictions. In this proposed system,the internet of things and fog-based framework for the fog-based farming system is shown in figure 4. In which the IoT sensors are installed into the field for the collected data. The sensor nodes in the agriculture field will continuously sense the variables such as soil moisture, temperature,leaf wetness, soil nutrients,soil pH Concentration, etc.The datacollected from the sensors is referred to as the fog environment. The analysis of data is being performed on data collected from sensors and based on result and evaluation, the sensitive information and alert signal are sent to the farmers that will provide the needful information regarding the crop. The outcome of the analysis with information is transferred to the cloud environment for back-end storage and future reference.

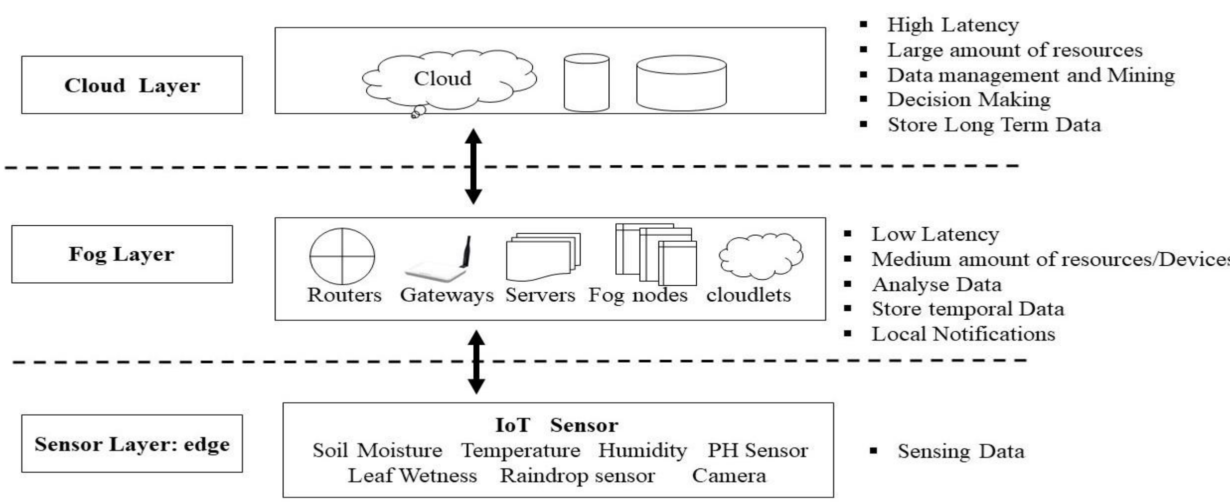

Figure 4. Framework for fog-based farming system

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 10410 - 10420
Received 25 April 2021; Accepted 08 May 2021.

Sensor Environment

The data collected from the different sensor node in the field to sense the parameters and they provide the insight detail about the crop and environment conditions. This collected data is then communicated through a communication protocol to the fog layer.

Fog Environment

The environment of fog comprises fog gateways that offer various services such as, data processing, data fusion and are linked to the cloud server. Since the fog environment is nearer to the device and moving the processing abilities closer to the source of data generation, the latency will be lower(30). The information collected from the sensors istransfer to fog nodes and is processed by the fog environment. The IoT fog-based computing will convey more effective crop information to the farmer. The fog gateway at the fog layer will be boosting for a crop monitoring system that requires fast processing with minimal delay.The farmer will get the information if there is any certain state/condition that is the cause of crop disease, waterstress, etc. the detail will be notified. The fog environment will be connected with the cloud service and the information associatedwith the crop will be transferred. The crop condition is predicted based on the data received from the IoT device continually. The service of fog computing will diminish the volume of data that is transmitted to the cloud services for processing and analysis.

Cloud environment

The cloud environment consists of various cloud servers and services such as huge data processing capability and capacity, data analytics, data storage, and other services**.** The data collected from IoT sensors aretransferred to the data store in the cloud for further processing. The analysis result and data visualization gives detail about the crop and will specify the condition and the advance action to be initiated and the information will be shared with the farmer and agriculture expert that will guide and provide the suggestions to the farmers and to find out the present condition of the crop.

7. Crop Disease Monitoring

In this study, we present a scenario for a Crop monitoring system with integration of IoT-fog and machine learning. Sensors and actuators play an important for crop monitoring and disease prediction system. The stages that involve in the process are Data collection, pre-processing at edge network (filtering, fusion), and analysis of data for generation of needful information for prediction, and alertsystem. Decision-making procedure to be applied on local data at edge network for real-timeinformation and will be sent to the farmer. Fog Nodes at the fog layer will be used. The process flow in Fig. 5 shows the data management at the fog layer and communicating with the cloud for the result.

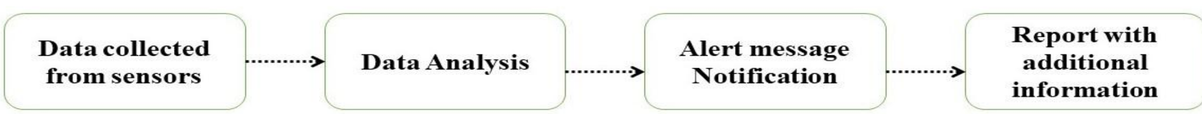

Figure 5. Process flow

The system comprisesthree layers such as the sensor data layer, the fog layer, and a cloud layer. Figure 6 describes the architecture of the crop disease monitoring system architecture. The sensor layer consists of the network of sensors that consistently sense the data parameters and integration all data capturing devices to collect Crop and environment data. The data is transfer

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 10410 - 10420
Received 25 April 2021; Accepted 08 May 2021.

to the middle fog layer. The layer of fog comprises fog gateways that offer various services such as, data processing, data fusion, and distributed data storage. The data transfer to the fog layer to perform processing diagnosing and prediction with minimum delay. The local data analysis when applying on the edge of the network, the limited quantity of highly granular data will provide needful information to the system. The system can send real-time information to the farmer and can predict the alert situations.Fog gateways should be located in reliable Internet areas where there is connectivity. They analyze a small amount of data and make fast decisions. Fog gateways are connected to cloud servers.The processed information, analyzed results are sent to the cloud layer.Then these data will be shared with the agriculture expert, farmers and for future course of action.Cloud resources are distant away from sensors, where processing tasks requiring a large number of resources. The cloud layer consists of global cloud services such as huge data processing capability and capacity, data analytics, data storage, and other services.

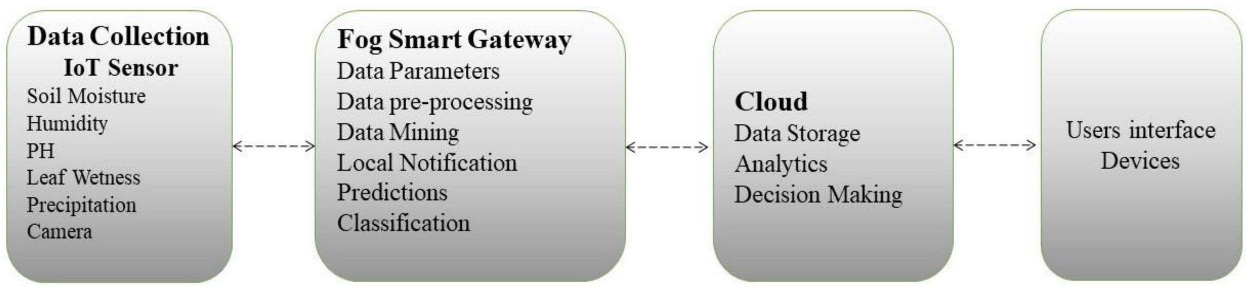

Figure 6. Disease monitoring system

The system willget real-time data from the sensors and effective decision-making can be performed. The key benefit of this system is that farmers can remotely monitor the crop and environmental variables. With the help ofa machine learning algorithm,the infection level in the crop will be noticed and accordingly, they will calculate the right amount of time for a spray with high accuracy.The early disease prediction will be in an optimal way with the level of disease infection on the crop and necessary steps will be taken with the advice of an agriculture expert.

8. Challenges

Fog computing is delivering effective and advantageous progression of cloud computing for handling the Internet of Things associated matters over the edge of the network. The goal of fog computing is to operate and manage this excessive data volume by transferring the computation tasks nearer to the source of data accumulated through the heterogeneous and distributed environment. The Fog computing services also have challenges regarding the various features of the limited environment. Some challenges and issues are as follows.

Data Managing

Internet of things based sensor devices generates a hugeamount of data, thus fog based will also receivea huge amount of data

Energy consumption

Fog nodes in fog computing operate very high and require high energy for operations to perform, Techniques need to decrease the requirement of energy in fog nodes to make it further energy-efficient, and cost-efficient (31).

Computation
Data analysis and decision making in quicker time for deliveringthe actionable insight for that, some sort of intelligence at the edge of the network will optimize the amount the data transfer to Cloud.

Latency
Fog aims to reduce the latency in the cloud, so a data compression algorithm is desirable at the fog layer that allows bandwidth consumption efficiently while transfer data to the cloud for further analysis

Fog Servers
For providing the maximum service, the suitable placement of fog servers is necessary.

Security
Fog computing mightgo through several security problems due to the usages of the vast number of Internet of things devices/sensors(32).

9. Conclusion

Fog computing, an extended version of cloud computing elegantly boosts the inclusive advantages of the cloud, whichpreviously has a gigantic worldwide impression.The farming system is turning towards smart and dynamic farming as the usage of technologies to boost farming production. The adoption of technology by the farmers due to accessto low-cost sensors and management systems,makes it achieve sustainable growth. In this paper, we have presented a framework using a cloud-fog environment for crop monitoring system with a minimal delayso as it will boost the early warning and prediction system and will provide on-time information to the farmer so that,well-timed actions to address problems before they turn harmful to productivity.IoT Sensors in the farming field are producing a lot of data and processing of data at the edge of the network will analyze data with low latency and data analytics will be fast so that, they can, monitor, predict and trigger an event swiftly.

References

1. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. N Engl J Med. 2020;382(8):727–33.
2. Khanday AMUD, Rabani ST, Khan QR, Rouf N, Mohi Ud Din M. Machine learning based approaches for detecting COVID-19 using clinical text data. Int J Inf Technol. 2020;12(3):731–9.
3. Fernandes N. Economic Effects of Coronavirus Outbreak (COVID-19) on the World Economy. SSRN Electron J. 2020;
4. Khanday AMUD, Khan QR, Rabani ST. Identifying propaganda from online social networks during COVID-19 using machine learning techniques. Int J Inf Technol. 2021;13(1):115–22.
5. Aqeel-Ur-Rehman, Abbasi AZ, Islam N, Shaikh ZA. A review of wireless sensors and networks' applications in agriculture. Comput Stand Interfaces. 2014;36(2):263–70.
6. Mekala MS, Viswanathan P. A Survey: Smart agriculture IoT with cloud computing. In: 2017 International Conference on Microelectronic Devices, Circuits and Systems, ICMDCS 2017. 2017. p. 1–7.
7. Shafi U, Mumtaz R, García-Nieto J, Hassan SA, Zaidi SAR, Iqbal N. Precision agriculture techniques and practices: From considerations to applications. Vol. 19, Sensors (Switzerland). 2019.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 10410 - 10420
Received 25 April 2021; Accepted 08 May 2021.

8. Vellidis G, Tucker M, Perry C, Kvien C, Bednarz C. A real-time wireless smart sensor array for scheduling irrigation. Comput Electron Agric. 2008;61(1):44–50.
9. Karim F, Karim F, Frihida A. Monitoring system using web of things in precision agriculture. In: Procedia Computer Science. 2017. p. 402–9.
10. Premkumar A, Thenmozhi K, Praveenkumar P, Monishaa P, Amirtharajan R. IoT Assisted Automatic Irrigation System using Wireless Sensor Nodes. In: 2018 International Conference on Computer Communication and Informatics, ICCCI 2018. 2018.
11. Kapoor A, Bhat SI, Shidnal S, Mehra A. Implementation of IoT (Internet of Things) and Image processing in smart agriculture. In: 2016 International Conference on Computation System and Information Technology for Sustainable Solutions, CSITSS 2016. 2016. p. 21–6.
12. Varghese R, Sharma S. Affordable Smart Farming Using IoT and Machine Learning. In: Proceedings of the 2nd International Conference on Intelligent Computing and Control Systems, ICICCS 2018. 2019. p. 645–50.
13. Kim YH, Yoo SJ, Gu YH, Lim JH, Han D, Baik SW. Crop Pests Prediction Method Using Regression and Machine Learning Technology: Survey. IERI Procedia. 2014;6:52–6.
14. Liakos KG, Busato P, Moshou D, Pearson S, Bochtis D. Machine learning in agriculture: A review. Vol. 18, Sensors (Switzerland). 2018.
15. Nabi F, Jamwal S, Padmanbh K. Wireless sensor network in precision farming for forecasting and monitoring of apple disease: a survey. Int J Inf Technol. 2020;
16. Pandiyan S, Ashwin M, Manikandan R, Karthick Raghunath KM, Anantha Raman GR. Heterogeneous Internet of things organization Predictive Analysis Platform for Apple Leaf Diseases Recognition. Comput Commun. 2020;154:99–110.
17. Jawade PB, Chaugule D, Patil D, Shinde H. Disease Prediction of Mango Crop Using Machine Learning and IoT. In 2020. p. 254–60.
18. Zhao K, Ge L. A survey on the internet of things security. In: Proceedings - 9th International Conference on Computational Intelligence and Security, CIS 2013. 2013. p. 663–7.
19. Atzori L, Iera A, Morabito G. The Internet of Things: A survey. Comput Networks. 2010;54(15).
20. Potdar V, Sharif A, Chang E. Wireless sensor networks: A survey. In: Proceedings - International Conference on Advanced Information Networking and Applications, AINA. 2009. p. 636–41.
21. Aazam M, Khan I, Alsaffar AA, Huh EN. Cloud of Things: Integrating Internet of Things and cloud computing and the issues involved. In: Proceedings of 2014 11th International Bhurban Conference on Applied Sciences and Technology, IBCAST 2014. 2014. p. 414–9.
22. Naeem RZ, Bashir S, Amjad MF, Abbas H, Afzal H. Fog computing in internet of things: Practical applications and future directions. Peer-to-Peer Netw Appl. 2019;12(5):1236–62.
23. Yousefpour A, Fung C, Nguyen T, Kadiyala K, Jalali F, Niakanlahiji A, et al. All one needs to know about fog computing and related edge computing paradigms: A complete survey. Vol. 98, Journal of Systems Architecture. 2019. p. 289–330.
24. Dar AR, Ravindran D. Fog computing resource optimization: A review on current scenarios and resource management. Baghdad Sci J. 2019;16(2):419–27.
25. Varghese B, Wang N, Barbhuiya S, Kilpatrick P, Nikolopoulos DS. Challenges and Opportunities in Edge Computing. In: Proceedings - 2016 IEEE International Conference on Smart Cloud, SmartCloud 2016. 2016. p. 20–6.
26. Shi W, Cao J, Zhang Q, Li Y, Xu L. Edge Computing: Vision and Challenges. IEEE Internet Things J. 2016;3(5):637–46.
27. Ud Din Khanday AM, Rayees Khan Q, Rabani ST. Analysing and Predicting Propaganda on Social Media using Machine Learning Techniques. In: Proceedings - IEEE 2020 2nd International Conference on Advances in Computing, Communication Control and Networking, ICACCCN 2020. 2020. p. 122–7.
28. Khanday AMUD, Khan QR, Rabani ST. Detecting textual propaganda using machine learning techniques. Baghdad Sci J. 2021;18(1):199–209.
29. Ray PP. Internet of things for smart agriculture: Technologies, practices and future direction. J

Ambient Intell Smart Environ. 2017;9(4):395–420.

30. Dar AR, Ravindran D, Islam S. Fog-based spider web algorithm to overcome latency in cloud computing. Iraqi J Sci. 2020;61(7):1781–90.
31. Dastjerdi AV, Gupta H, Calheiros RN, Ghosh SK, Buyya R. Fog Computing: Principles, architectures, and applications. In: Internet of Things: Principles and Paradigms. 2016. p. 61–75.
32. Yi S, Qin Z, Li Q. Security and privacy issues of fog computing: A survey. In: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). 2015. p. 685–95.