Agricultural Machine Cloud

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I. Introduction

Agriculture is one of the largest sectors in the United States. There are over 2.2 million farms that cover over 922 million acres of land. About 40% of US land is used for agriculture. Research demonstrates that farmers and ranchers receive only 15 cents out of every dollar spent on food at home and abroad. The rest is required for processing, marketing, materials for production, distribution and transportation. Hence, a system with reasonable rates as well as access is required for the transportation of agricultural products and to carry out other agriculture related activities.

The objective is to develop and implement a smart cloud based IOT-edge agriculture machine service platform, AG-Machine, that provides a range of services to farmers. These services are managed by machine controllers and service carrier staff.

Agricultural Cloud Machine is the system that provides convenient solution to perform harvesting. It also configures the requirements depending on the crops to harvest. Agricultural Machine Cloud can be defined as the system of designing, planning, controlling and keeping track of the agricultural goods. These phases in Agricultural Machine Cloud are implemented in vast areas of logistics, operation control and management. Agricultural Cloud Machine is the technique that manages the harvesting of agricultural goods and can control management activities. Traditionally, such harvesting was handled manually and it led to problems like uncertainty, high labour cost, vulnerabilities exposed.

To Solve the mentioned problem, the Agricultural Machine Cloud should become smart and self-sufficient system that can work without much intervention of humans. The absence of smart control over Agricultural Machines could result into extra cost overhead and human efforts. The introduction of Cloud Technologies and Internet of Things (IOT) in Agricultural Machines can help us eliminate these problems and make our system smarter.

We proposed an Agricultural Cloud system that monitors machines using different types of sensors to make better use of Cloud Technologies. We used temperature, fuel and GPS sensors for machines in work and in the warehouses. This enabled us keeping efficient track of machines. We prepared website for different types of users: Farmers, Service Carrier Staff and Machine Controllers who can monitor working of Agricultural Machine system. We can keep track of machines through various sensors installed and this adds transparency to the Agricultural Cloud Machine Management System.

The AG-Machine is an on-demand SaaS service deployed on AWS. The farmers can subscribe to machines provided on demand by the machine controllers, track the locations of these machines on a map, add the desired types of sensors and also makes service requests. This gives an opportunity for IOT based smart agriculture having advantages of easy scalability, automation and reliability. AWS leads in providing services in cloud computing related applications. The instances are deployed on AWS using the AWS EC2 providing features such as load balancing, scalability and multi-tenancy.

The remaining project is structured as: Section II gives description of related work. Section III describes Cloud-based infrastructure and components. Section IV presents large-scale IoT data design and implementation. Section V demonstrates IoT-based cloud system design and services in brief. Section VI provides system GUI design and implementation. Edge station design and simulation is described in section VII. Section VIII details out system application examples. Section IX focuses on system performance evaluation and experiments. Finally, section X provides conclusion for the project report.

II. Related Work

The Internet of Things (IOT) along with cloud computing offers a wide scope for applications in various domains like agriculture, transportation, mobile testing and many others. Each of these domains includes real-time processing of large volumes of data, storage of the collected data and secure usage of this data to carry out various critical activities.

Major Agricultural Machine providing companies have started using robotics for operations in handling machines and thus providing key roles to them.

Organizations like Dell and Walmart have successfully reduced costs of logistics by putting goods handling assets in smart Agricultural Machines, thereby expanding speed to react to customer request with efficiency.

Walmart, Safeway like many organizations make use of RFID technology to better keep track of goods in storage and sales. The monitoring and billing has become fast and accurate without involvement of labour work.

The next invention that will help in providing efficient solution for optimization of Agricultural Machines can be smart sensors along with cloud computing technologies and large-scale data. Smart sensing devices like GPS, RFID, temperature and humidity sensors, Laser tags, high end camera and Bluetooth can be useful for effective management of machines in Agricultural Cloud Machine systems. This will result in anytime availability of real-time data updates which can be accessed on different devices, thereby enhancing the level of performance delivery and thus providing consistent workflow to a firm.

III. Cloud-Based System Infrastructure and Components

The system consists of following users:
1) Farmers: Farmers can add/delete or update their requests and can decide the payment methods and time. They can track the location and working status of the subscribed machine.
2) Machine Controllers: Machine Controllers can add/delete/update or configure the applied sensors.
3) Service Carrier Staff: Services Carrier Staff can view location on of all the machines and admin services for all the deployed service machines as well as other operational services. Their responsibility is to manage resources, billing, operations and schedules.
The AG-Machine Cloud has following Components:
1) A Simulated AG Machine Station:

- It consists of a smart AG machine node with related sensors.
  Its function are as follows:
- Collecting sensor data from different sensors
- Transferring the data to cloud.
- Monitoring and tracking the edge station.
- Adding/updating/deleting a list of sensors. Each sensor can be either connected, active, inactive, Turn on/off or in maintenance.

2) A Backend AG-Machine Server:

- AG Machine Resource Management: It manages all the AG machines.
- AG Machine Server Management: It manages scheduling, resource selection and delivery services.
- Contract, billing and Payment: It provides billing and payment services for each request processed.
- System Database: A database is required to store all the machine resources, billings and records.
- System Dashboard: The detailed online dashboard provides a map view to support all the different types of users.
- Cloud: The clouds stores the data generated from the infrastructure and the sensors.
- GUI: The GUI component has a separate dashboard for each user provisioning them to their functionality.

IV. Large Scale IOT Data Design implementation

All the information collected through a sensors is stored in a database. We have used both relational and a NoSQL database. The data related to users like the farmers and Machine controllers is stored in MySQL and all the sensor collected

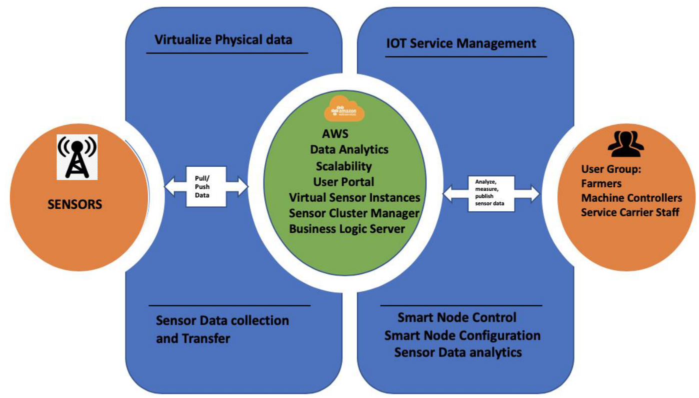

Fig. 1. Cloud-based System Infrastructure

data is stored in MongoDB.The DB provides functionalities like addition/deletion/displaying of data read from sensors, displaying sensor description (NAME/VALUE/DATA TYPE) and 3. Getting sensor data for a smart node and displaying it in a tabular form.

A. DataBase Design and Implementation

Following guidelines have been followed while designing the database: a)Avoidance of over-indexing the tables. d)Using composite indexes.

The query algorithm used is:

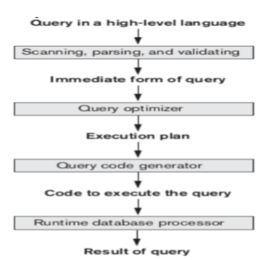

Fig. 2. Query algorithm

B. IOT sensor DB design and implementation

We have designed and implemented the database in following way:

The DB design consists of nine tables: smart sensors, cluster node, node sensor mapping, machine controller, AG machine, Smart node, Cluster node mapping, user and role. These tables share a one to many relation. The tables have a primary key and are related through a foreign key. For example, Cluster_id is the primary key for cluster node, Sensor_id is the primary key for smart sensors while machine_controller_id is foreign key for smart sensors. This DB design has been created using ”Vertabelo”, an online tool to draw the database design.

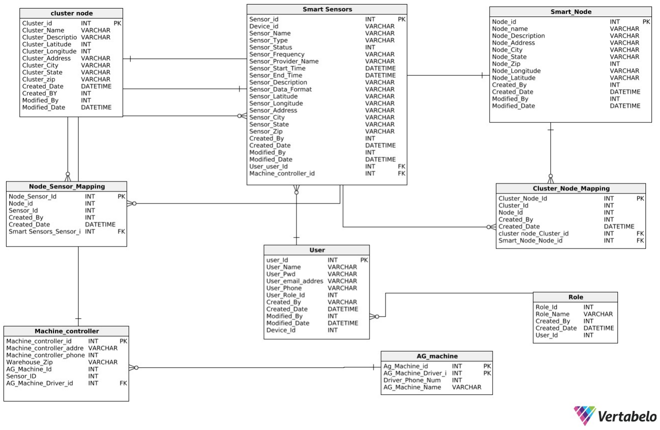

Fig. 3. DB design

V. IOT-BASED CLOUD SYSTEM DESIGN AND SERVICES

A. System Services

Agricultural Machine Cloud will provide following services: 1) Sensor Networks with Collection of Sensor data, Transfer of Sensor data, Sensor Node control and Sensor Node Configuration for Sensor Node.

- This component is responsible to simulate a smart node with the sensors that provides data.
- This data will be collected and transferred to the database as historical data.
- The Machine Controller will control the Smart Node by adding, deleting, updating as well as fetching the data or status of Nodes in the cluster.
- Machine Controller will also change the status of sensor nodes such as sensors to turn on, turn off, active or Inactive.

2) Sensor Networks should be capable of adding, deleting, updating and changing the status of the sensors. 3) Dashboard Component contains Farmer, Machine Controller and Service Carrier Staff dashboard.

3.1 Machine Controller Dashboard

- In Machine Controller dashboard, there is list of sensors in the warehouses and trucks.
- He/She can also see the number of machines in use and the location of machines in map.
- He can see the Temperature and fuel level details of the machine.
- They can also see the status of all the sensors in machines and warehouses.

3.2 Service Carrier Dashboard

- Services Carrier Staff can view location on of all the machines and admin services for all the deployed service machines as well as other operational services.
- Their responsibility is to manage resources, billing, operations and schedules.

B. System Scalability Design and Implementation

Agricultural Machine Cloud application is deployed in Amazon Web Services to get more storage and scalability. AWS uses advanced Ethernet networking technology, which, like all things AWS, is designed for scaling, security, high availability, and low cost. Agricultural Machine Cloud application is scalable, as we can add any number of sensors and smart nodes in the network. This provides on demand services to the users using this application. It also provides EC2 Auto Scaling option which a customer of AWS need not to pay for this option to use. It's easy to setup application scaling for multiple resources across multiple services in minutes. The service provides a simple, powerful user interface that build scaling plans for resources including Amazon EC2 instances. As this feature enabled right resources at the right time, Agricultural Machine Cloud application is scalable with respect to the sensors and Number of users using this application.

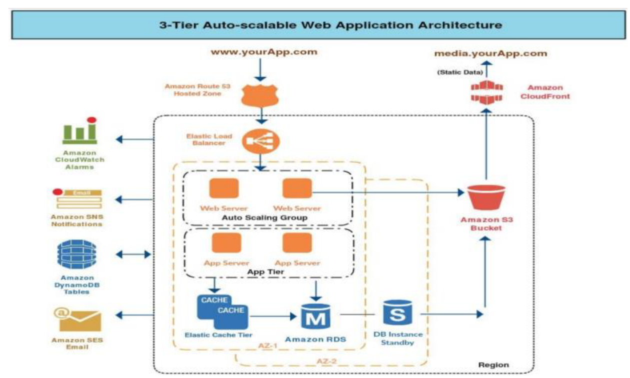

Fig. 4. AWS Scaling Architecture

C. System Load Balance Design and Implementation

Load Balancing automatically balances the traffic of the application. It automatically distributes incoming application traffic across multiple targets, such as Amazon EC2 instances, containers, IP addresses, and Lambda functions. Here, In Agricultural Cloud Machine application, EC2 instance load balancing is used. If there is more traffic to the application it automatically redirects traffic among different EC2 servers to balance the traffic. The minimum number of instances Auto Scaling Group has to keep active is 2 while maximum is 5. The criteria to add extra instance is if CPU_Utilization greater than 60%.

VI. GUI DESIGN AND IMPLEMENTATION

The Smart Agricultural Cloud application features 3 different types of users namely Farmers, Machine Controllers and Service Carrier Staff.They will have to register and login to use the application. Farmers can login to view their dashboard, add, delete and view their machines , and also pay for the services used. They can view and request already added sensors/ add new sensors. Machine Controllers can add/delete/update or configure the applied sensors. Service Carrier Staff can view location on of all the machines and admin services for all the deployed service machines as well as other operational services. Their responsibility is to manage resources, billing, operations and schedules. The following are the important features of the GUI: 1. Register and Login: Any type of user can login and register to the application. They can login using their registered user email and password.

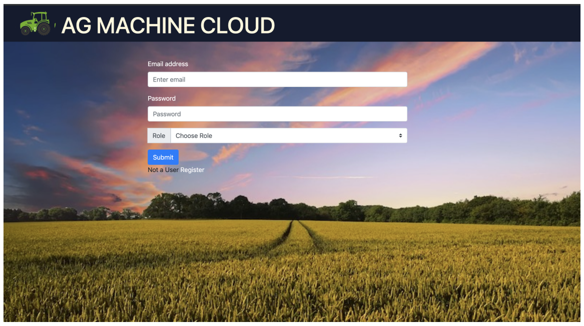

Fig. 5. Login/Signup

2. Homepage: This is the principle page of the application. On the left, there is a welcome sign with the name of the user. On the top right corner are the About Us and the Menu navigation. The page consists of Machines, My service requests and My machines view.

Fig. 6. Home Page

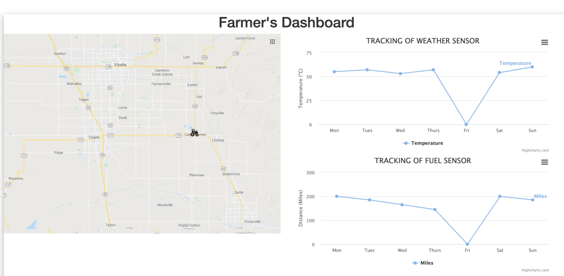

Fig. 7. Farmers Dashboard

3. Machines and Payment: The machines page has the functionalities to add/ delete and view their machines. It also has the functionality to make a payment.

4. Dashboard view: We have different types of dashboard views like farmer's Dashboard, Sensor view, Service requests view etc.

Fig. 8. Machines View

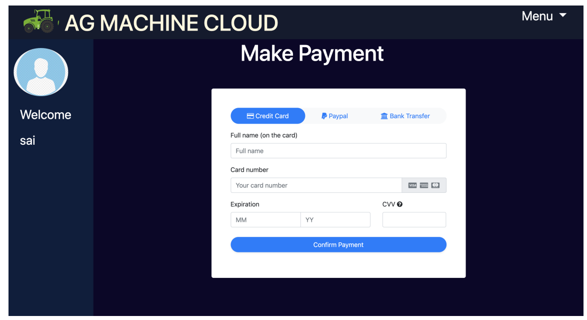

Fig. 9. Payments

We used HTML, CSS, and bootstrap to develop the front-tend GUI. We also used JavaScript (Node.js and express.js frameworks) to create various APIs that will enable a user to perform multiple actions. GUI has been connected to backend Databases (MongoDB and MySQL) using Node JS.

VII. EDGE STATION DESIGN AND SIMULATION

The IOT framework engineering is a 4-section system. These 4 sections establish the 4 phases of the procedure. All of the four sections are joined, usually bracing structures that pass on esteem loaded data from systems to generation and ordinary IT structures to pass on imperative business encounters. Stage 1 comprises of the sensors: GPS, Weather, Fuel and Speed sensors of the truck. Sensors gather ecological information under estimation and convert it into helpful information. The detecting stage comprises of the area of the truck, the climate, the temperature of the earth, the fuel spent and left finished and the speedometer, which shows the speed of the truck. The sensors aggregate this data. The subsequent stage incorporates sensor data collection systems and easy to-electronic change of data. The frameworks are in the vicinity of the sensors in this stage. In Stage 3, edge IT structures direct information before continuing to the server farm or cloud. The information should be prepared further before the last stage. Important outcomes are produced and given to the following stage. In the last stage, the data is explored, administered, and put away in ordinary back-end information server frameworks. The edge IT taking care of this zone might be situated at a far off area or closer to the data focus

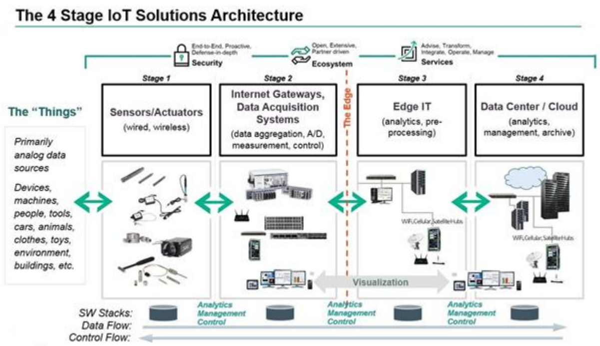

Fig. 10. Edge Station

The edge station forms the information in the system where the information is being produced. The information is created by the gadget itself by a nearby framework at the site. Edge application organizations reduce the volumes of data that must be moved, the resulting traffic, and the separation that data must travel. That gives lower torpidity and diminishes transmission costs. Handling this information closer to the edge of the plan gives affiliations the chance to investigate significant information continuously. The sensors are associated with the edge station which thus are associated with the edge hubs. There are various edge stations for our situation for every sensor. The edge hubs are associated with the cloud and the database.

VIII. System Application Examples

AG-Machine Cloud, a cloud based agriculture machine service platform, can be used by a group of users who are farmers. This system supports large scale on-demand agriculture machine services for farmers. The farmers can subscribe for a machine, can track the machines on a map and monitor the status of the selected sensors. Additionally, the farmers can make service requests to the machine controllers. The machine controllers can add or delete various types of sensors like a GPS sensor, temperature sensor, fuel sensor or all three of them. They can also monitor these sensors. The service carrier staff monitors all the admin services. The sensor data that is collected from these sensors on the machine is sent to the smart node. The smart node data is forwarded to smart cluster node which send it to the edge station. In AG-Machine scenario, edge station is basically a service on Amazon EC2 server. The APIs store data collected from edge station to MongoDB Atlas. Any abnormality in sensor values will be detected based on a threshold value compared by the business logic and this information will be made available to the machine controller and the user.

IX. System Performance Evaluation and Experiments

To evaluate system performance and check if all the components are working as intended and in the best efficient way possible, we conducted various system performance tests. The unit testing results showed that all the components are working as designed and each user is capable of performing functionalities corresponding to his role. All the functionalities are tested thoroughly to make sure that the system is not malfunctioning. The checks we performed are as follows:
1. Checked if all the three users can perform all but only functionalities corresponding to their role.
2. Checked if Machine Controller is able to setup and configure a new smart sensor and smart node.
3. Checked if the Machine Controller is able to view the dashboard intended for them and can check and track the current status of the machines.
4. Checked if Service Carrier Staff is able to view Machine Controller's dashboard with all the statistical data.
5. Checked if farmer has access to request, update and configure machines and is able to track them.

X. Conclusion

In this report, we have analysed the use of sensor based cloud network in agriculture related activities. This system is a cost effective solution to provide machines to farmers based on a pay-as-you-go model. We have implemented a map system where the farmers can track the machines and also a billing method that summarizes the usage time for machines and the cost incurred for the period of subscription. Through this report, we also discuss various use cases of this service and how it can handle real world scenarios. The AG-Machine is a scalable, extensible and cost effective agriculture machine service based on AWS.

XI. Acknowledgment

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